

The Aldo Leopold Wilderness Research Institute: A National Wilderness Research Program in Support of Wilderness Management

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Abstract—The Aldo Leopold Wilderness Research Institute strives to provide scientific leadership in developing and applying the knowledge necessary to sustain wilderness ecosystems and values. Since its 1993 dedication, researchers at this federal, inter-agency Institute have collaborated with researchers and managers from other federal, academic and private institutions to support and conduct research on high priority topics related to recreation, natural disturbances and nonnative species. This paper gives an overview of the research conducted through the Leopold Institute and suggests future wilderness research directions for these issues. Leopold Institute staff strive to make research applicable to management through all phases of the research process.

Expanding recreation use and development pressures outside wilderness make it increasingly difficult for managers to preserve natural conditions and quality wilderness experiences. To protect and restore wilderness ecosystems and experiences, wilderness managers must understand wilderness resources, and the threats to those resources. Rigorous scientific research can help managers understand these, including: 1) wilderness ecosystems, 2) biological and social impacts of human activities to wilderness, 3) the role of wilderness in larger ecological and social systems and 4) potential consequences of alternative policy and management decisions.

The Aldo Leopold Wilderness Research Institute was established in 1993 as an interagency program to provide scientific leadership in developing the knowledge needed to protect and preserve wilderness, parks and other natural areas and to communicate and apply this knowledge to wilderness management. Located on the University of Montana campus in Missoula, the Leopold Institute is an outgrowth of the U.S. Forest Service's Wilderness Management Research Work Unit of the Intermountain Research Station (now the Rocky Mountain Research Station), which was created in 1967. The Leopold Institute operates under an interagency agreement among the four U.S. wilderness management agencies—Forest Service (USDA), National Park Service (USDI), Bureau of Land

Management (USDI), Fish and Wildlife Service (USDI)—and the U.S. Geological Survey (USDI).

The Leopold Institute's scientific staff include five full-time research scientists (social scientist, recreation ecologist, landscape ecologist, plant ecologist and zoologist), a biologist, data analyst and research application specialist. Research activities include in-house studies, as well as cooperative projects with researchers and managers from other agencies and universities across the United States. In addition to collaborative research, cooperative activities include exchange programs, support of visiting researchers, leadership in professional activities and societies and sponsorship of lectures, workshops and symposia.

This paper gives an overview of the types of research conducted through the Leopold Institute. It describes issues identified by Leopold Institute scientists and their collaborators as some of today's wilderness research priorities, illustrates these issues with examples of Leopold Institute-sponsored research and research application activities and suggests future wilderness research direction within the context of the established research priorities.

Priority Research Issues

Leopold Institute scientists conduct and support a variety of research projects to improve the understanding and preservation of wilderness ecosystems, and the associated human experiences and values. These include both ecological studies on how to define and maintain natural ecosystems and social studies on various aspects of wilderness experiences.

The Leopold Institute conducted a comprehensive issue identification and prioritization process during 1995-96 to identify core issues that would form the focus of the Institute's research efforts, and provide a wilderness research agenda within which scientists interested in these topics could work. Potential research topics were placed into three priority classes, or tiers.

The resulting tier-one priority issues were: 1) understanding natural disturbance regimes and the effects of their alteration by human actions, and developing strategies to manage and restore natural disturbances in wilderness ecosystems, 2) understanding the effects of recreation use and recreation management strategies on wilderness attributes and visitor experiences, and 3) understanding the effects of nonnative species and their management on wilderness. The majority of the Leopold Institute's past and current efforts and resources have addressed the first two

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issues. For each of these two issues, Institute scientists employed a systematic scoping process, gathering input from a wide cross-section of federal agency managers and scientists, university scientists and nongovernmental organizations, to identify important future research topics. The Leopold Institute has also supported initial investigations into the third issue.

Natural Disturbance Regimes, Impacts, and Ecosystem Restoration

Scientists at the Leopold Institute are currently investigating the critical issues of how to define and monitor natural conditions, how to restore fire disturbance regimes to wilderness ecosystems, and the causes of worldwide amphibian declines.

Defining and Monitoring Natural Conditions—The Wilderness Act mandates that each wilderness area be “protected and managed so as to preserve its natural conditions...affected primarily by the forces of nature.” Natural areas such as wilderness are valued by society for reasons including the provision of recreational opportunities, educational and philosophical values, protection of biodiversity and the economic benefits to areas near wilderness. However, before managers can preserve natural conditions, they must understand what is natural. Reviewing the complex issues that go into defining naturalness, Landres and others (1998) offered a working definition of naturalness, addressed ecological variability in nature and presented a strategy for setting management goals related to maintaining naturalness. Landres and others (1999) further reviewed the potential applications and limitations of using the concepts of natural variability to define ecologically appropriate management goals.

In addition to defining natural, managers strive to understand whether wilderness areas are diverging from natural conditions. Cole and Landres (1996) reviewed significant threats to wilderness ecosystems and identified critical research needs for these threats. Cole (1994) demonstrated how a wilderness threats matrix can be used to link specific threats to wilderness attributes. Managers can use such a matrix to assess the impacts of specific threats, assess the potential effects of alternative management decisions, develop indicators and standards and identify monitoring needs.

Because ecological monitoring is an important component of protecting and preserving wilderness character, Landres (1995) developed a conceptual model to help determine the goals of ecological monitoring programs. Once the goals of local, regional or national level monitoring programs are determined, managers can use lists of variables such as those developed by Landres and others at a recent workshop on monitoring terrestrial vegetation, wildlife and aquatic systems.

When identifying threats and/or monitoring wilderness attributes, if managers determine the naturalness of a wilderness area is in jeopardy, they are faced with the dilemma of whether to manipulate the area to restore natural conditions or to leave the area untrammled, and thus unnatural. This dilemma results from conflicting mandates of the Wilderness Act to maintain both natural

and untrammled conditions. Cole (1996a) described several options for solving this dilemma, including a compromise solution that would allow managers to manipulate some portions of wilderness areas to move these areas closer to the current understanding of natural conditions, while retaining other, untrammled areas as reference examples of wilderness without direct anthropogenic manipulation. The former option allows managers to protect and restore areas impacted by disturbances, such as introduced plants and fire suppression, that threaten naturalness while the latter recognizes the need for humility and the fact that manipulative restoration efforts may produce unanticipated, irreversible and undesirable changes. Cole and Hammitt (in press) identify the dilemma of whether to manage for naturalness or wildness as fundamental for wilderness managers, and address the need for additional research to help address this complex issue. Landres (in press) also explored questions of risk and uncertainty in managing for a natural or wild wilderness and concluded that “doing the right thing” is often, in the end, based on a philosophical choice.

Fire Restoration—Fire suppression during the 20th century has altered vegetative structure and increased hazardous fuel accumulations in many wilderness areas. This has led to recognition of the need to restore and maintain fire as a natural process in fire-dependent wilderness ecosystems. The potential consequences of not maintaining fire as a natural process include increased fuel accumulations, increased probability of extreme wildfire occurrence in and near wilderness, and altered ecosystem structure and function. Parsons (1991) cautioned that attempts to restore natural fire in wilderness must assure that fires burning under unnatural fuel conditions come as close as possible to approximating natural fire effects.

Leopold Institute scientists have recently reviewed efforts and constraints to restoring fire to wilderness. For example, Parsons and Botti (1996) noted the disparity between the acreage burned (mean of 173 acres/year) in a giant sequoia grove under current National Park Service management and the estimated historic acreage burned (mean 2,600 acres/year) for that grove. Reviewing the status of fire restoration across the wilderness system, Parsons and Landres (1998) reported that suppression continues to play a dominant role in fire policy for all four wilderness management agencies. Differences in agency program approaches and reporting methods make it extremely difficult to assess the status and progress of natural fire restoration across the agencies managing wilderness. Most recently, Parsons (in press, a) discussed the potential need for increased prescribed fire use in some wilderness areas.

When the Leopold Institute asked an interagency group of scientists and managers to prioritize disturbance issues for future research, respondents overwhelmingly emphasized the importance of understanding and mitigating the effects of fire suppression and changing fire regimes on wilderness. Wilderness fire research priorities identified included: 1) understanding the social, ecological and institutional factors that keep managers from restoring fire regimes, 2) improving methods of assessing fire risk (ecological and social) at wilderness boundaries, 3) developing strategies to

reduce fire risk, 4) understanding short- and long-term effects of alternative management strategies, and 5) improving strategies for communicating with the public about fire and the consequences of management choices.

Amphibian Decline—Toads, frogs and salamanders are disappearing from wilderness areas around the world, exhibiting a decline that has the potential to permanently alter wilderness ecosystems and wilderness experiences. There is no doubt that amphibian populations are declining, but in many cases, scientists still do not know why. It is unclear how much of the decline is a result of human actions and how much is a result of naturally changing global conditions. Steve Corn, a scientist working for the Biological Resources Division of the U.S. Geological Survey and stationed at the Leopold Institute, is an active member of the World Conservation Union's Declining Amphibian Populations Task Force. This task force works to determine the nature, extent and causes of amphibian declines throughout the world and to promote ways to halt or reverse these declines. Specifically, Corn works to understand the factors that contribute to amphibian distribution and status, the effects of global changes on breeding amphibians and to develop monitoring and conservation techniques.

Global changes, such as a warming climate and atmospheric ozone depletion, have the potential to alter future distributions of vegetation and wildlife that occur in wilderness. For example, increases in life-damaging UV-B radiation at the earth's surface, as a result of the depletion of the earth's ozone layer, has been suggested as a potential cause of worldwide amphibian declines. In a literature review of potential causes for declines, including climate change, habitat destruction, introduced predators, and UV-B radiation, Corn (in press) cited studies with contradictory results on the potential contribution of UV-B radiation. Although Corn (1998) himself found no relationship between UV-B exposure and boreal toad embryo mortality, he continues to investigate the relationship between UV-B radiation and amphibians in Glacier National Park. Other recent research includes documenting amphibian distributions and declines in Rocky Mountain National Park (Corn and others 1997) and reviewing knowledge about amphibian distributions and causes for decline across the western United States (Corn 1994).

Recreation Values, Impacts, and Management

Leopold Institute scientists have a long history of addressing wilderness recreation issues. Current research topics, which were prioritized during the recent scoping process, include understanding wilderness visitor experiences, identifying the ecological impacts of recreation and impacted site restoration, evaluating low-impact education message content and communication media and developing and evaluating other recreation management tools.

Definition of Wilderness Visitor Experiences—The Wilderness Act defines wilderness as having "outstanding opportunities for solitude or a primitive and unconfined type of recreation." The lack of commonly accepted definitions for terms such as solitude, primitive and unconfined recreation

has complicated the development of social standards and consistent management strategies for wilderness. In addition, as recreation use has increased (Cole 1996b, Cole 1996c), managers have noted an increasing expression of conflict among different wilderness user groups (such as stock users, hikers, commercial outfitters, long-term area residents). Thus, there is a need to better understand the range of desirable wilderness experiences that managers are trying to protect. Leopold Institute staff have conducted and supported research on visitor use by 1) developing methods to quantify use levels, 2) defining wilderness values and 3) investigating influences on wilderness visitor experiences.

Traditionally, managers have measured use and encounter levels as a way to assess whether opportunities for solitude are being maintained (Cole 1997a). Watson and others (in press) recently summarized techniques for estimating use levels that will help managers determine which use estimation technique to use. Watson and others (1998a) also reviewed methods to estimate intergroup encounter rates and offered direction on when to use which methods. In addition to monitoring use levels and encounter levels, managers need to understand how numbers of people encountered relate to experiences achieved during and after wilderness visits. Borrie and Roggenbuck (1998) found that different factors influenced visitor experiences during high-use and low-use periods.

Wilderness managers and users often focus on issues of solitude. Based on the results of a study of Grand Canyon visitors, Stewart and Cole (1997) found that solitude means different things to different wilderness visitors and can be experienced in settings with different levels of remoteness. Researchers have helped managers understand that other psychological, social, spiritual and inspirational factors, in addition to solitude, motivate people to visit wilderness (Dawson and others 1998). Thus, managers can more effectively address visitor needs by understanding the array of physical and social influences on wilderness trip expectations and trip evaluations. Watson and others (1992) lumped potential indicators of trip quality into five categories: site impacts, seeing wild animals, sound and sight intrusions, horse encounters and people encounters. Watson and Roggenbuck (1998) recently added challenge, primitive route finding and the opportunity to experience feelings of timelessness as important components of wilderness experiences.

With the increasing expression of conflict among wilderness user groups, managers must also understand the impacts of conflicting values among users on the quality of wilderness experiences. Recent research on user conflict supported by the Leopold Institute have found that 1) most visitors reported livestock detracted from their wilderness experiences (Johnson and others 1997), 2) horse users and llama users often had different opinions (Watson and others 1998b) and 3) different types of river floaters reported different experiences and attitudes (Watson and others 1998c). In the latter study, private floaters found more enjoyment in challenge, primitive skills, camping and cooking, while commercial floaters found more enjoyment in escaping from civilization, learning about people and

local history, and being with people. Watson's (in press) recent synthesis of knowledge on wilderness visitors and their visits included a discussion of trends in use and user characteristics, as well as how and why values and attitudes have changed. One long-term comparison of visitors to Oregon's Eagle Cap Wilderness found that visitors in the 1990s tend to be better educated, belong to conservation organizations and be more supportive of actions to maintain wilderness character than visitors were in the 1960s.

In addition to the topics mentioned above, research needs identified during the recreation scoping process include 1) understanding human relationships with the natural world, including the contribution of wilderness experiences to larger life issues, 2) developing strategies to incorporate different user values into management direction, 3) understanding the impact of management actions, such as use limits or use fees, on the wilderness user experience, 4) understanding user support for management alternatives and 5) developing and evaluating innovative methods to help managers identify important influences to visitor experiences.

Ecological Impacts of Recreation—Recreation use has the potential to cause substantial impacts to areas that are used repeatedly, such as campsites and trails, as well as portions of wilderness that are used less frequently. Research that helps managers protect natural conditions and quality wilderness experiences by understanding and minimizing these impacts includes identifying the biophysical impacts of recreation use to resources such as to water, soil, vegetation and animals, at various spatial scales, and identifying which factors influence the magnitude of these impacts. Leopold Institute researchers have a long history of studying the site-specific ecological impacts of recreation on vegetation and soil. Cole and others (1987) summarized the nature of ecological problems resulting from recreation use, including tactics for dealing with common wilderness recreation problems.

The Leopold Institute has recently contributed to several synopses related to the ecological impacts of recreation to soil, vegetation, animals, and water. Hammitt and Cole (1997) provided an in-depth look at these topics when they revised their textbook, *Wildland Recreation: Ecology and Management*, to offer detailed descriptions of problems that arise in wildland areas as a result of recreation use, as well as factors affecting these impacts and methods to manage these problems. Because campground impacts are pervasive and often receive management emphasis, McEwen and Cole (1997) reviewed types of impacts, factors influencing these impacts, patterns of impact development, strategies to minimize impacts and impact monitoring approaches. Cole's (1989a) source book describing techniques to monitor backcountry campsite impacts continues to be a valuable tool for wilderness managers.

Recent research has shown that factors influencing the magnitude of recreation impacts to campsite and trail vegetation include trampling intensity (Cole 1995a), resistance and resilience of different vegetation types (Cole 1995b), use intensity and duration by campers (Marion and Cole 1996) and packstock (Olson-Rutz and others 1996) and use type (Cole and Spildie 1998, DeLuca and others 1998). Other recent studies include a summary of the effects of recreation on wildlife (Knight and Gutzwiller 1995) and recreation

impacts to songbirds (Riffell and others 1996). Additional studies on the topic of ecological impacts of recreation can be found by searching the Leopold Institute's publication list, obtainable from the Institute directly or through the Institute's web page (www.wilderness.net/leopold).

Future research priorities identified during the scoping process include studying the impacts of recreation to belowground soil systems, wildlife and aquatic systems, as well as the significance of recreation impacts over broad spatial scales. Research priorities related to the restoration of impacted sites include, 1) identifying factors that limit natural recovery on damaged sites such as trails, campsites and old roads, in different ecoregions and in different vegetation zones, 2) population biology, demography and reproductive ecology of plants used in restoration efforts, 3) effectiveness of existing restoration techniques to soil conditions, biotic diversity and vegetative cover and 4) how to improve restoration techniques, such as the addition of fertilizer, soil amendments, mulching, plant propagation and mycorrhizal inoculation used to accelerate restoration.

Low-Impact Education—Education is a tool commonly used by managers to promote low-impact behaviors in wilderness. This topic is a priority for wilderness researchers due to the facts that 1) extensive resources are already devoted to low-impact education, 2) many experts consider education as key to solving recreation problems and 3) little is known about the effectiveness of existing education programs.

Cole (1989b) described a variety of practices that managers can use to educate visitors to reduce impacts. These practices and existing educational programs such as Leave No Trace, which work to increase public awareness of practices they can use to minimize resource damage, require constant reevaluation of whether they are teaching the most appropriate messages based on current scientific understanding. Hampton and Cole (1995) revised the book *Soft Paths* to incorporate Leave No Trace messages and current research on minimum-impact techniques. Hendricks and Watson's (1999) recent investigation showed that the Impact Monster, a wilderness education skit designed in the late 1970s to teach minimum impacts techniques to children, is still widely used for third through sixth grade students. Suggestions for improving this program included avoiding stereotypes, being sensitive to cultural differences and emphasizing positive behavior.

Research priorities for education include developing the content of educational messages, as well as the success of media used to communicate these messages. In a recent study, Cole (1998) found that posting a banner reading, "Please take time to read these messages" at educational trailhead bulletin boards almost doubled the time that visitors allocated to reading posted messages. However, once hikers stopped to read the bulletin boards, their ability to retain the content of individual messages decreased with an increasing number of posted messages (Cole and others 1997a).

The scoping process on recreation concluded that additional understanding is needed on 1) which low-impact practices are most effective, 2) the factors that limit visitor compliance with low-impact recommendations and 3) the effectiveness of alternative messages and media methods.

Other Recreation Management Tools—Managers trying to protect wilderness visitor experiences, and minimize biophysical impacts of recreation, often consider imposing use restrictions. Leopold Institute researchers have contributed to the development and comparison of tools to help managers decide whether and when to initiate use restrictions and to determine whether these restrictions are accomplishing desired goals (Parsons 1986, Stankey and others 1985). Stankey and others (1985) developed the Limits of Acceptable Change (LAC) process in an attempt to address the conflict between recreation use and the resulting degradation of natural resource conditions and visitor experiences. In the decade since its development, wilderness managers have implemented the LAC process in a variety of situations. To reevaluate and increase the utility of the LAC and other similar planning processes, the Leopold Institute co-organized and published the results of a workshop on this topic (McCool and Cole 1997).

Other Leopold Institute investigations of use and resource allocation include 1) Cole's (1997b) questioning of whether low-use areas are currently receiving adequate protection from degradation, 2) Cole's (1995c) discussion of the problems related to use limits, 3) Watson and Niccolucci's (1995) investigation of the reasons behind visitor support of use restrictions and 4) Cable and Watson's (1998) comparison of alternative approaches for determining recreation use allocation for a large wilderness complex. Addressing management issues specific to high-use wilderness destinations, Cole and others (1997b) provided information on social and biophysical impacts, visitor responses and management options for such areas. They found that visitors to high-use areas were highly supportive of heavily impacted site closures and revegetation programs and were not bothered by the high encounter levels they experienced.

Leopold Institute staff conduct research to help managers assess other management tools. For example, Congress authorized a three-year Recreation Fee Demonstration Program in 1996 to examine the feasibility of generating funds from users for the operation, maintenance and improvement of public recreation areas, including wilderness areas. Under this program, federal land managers around the country have initiated fee projects such as permit reservations and fees for the use of campsites, trails and vehicle parking. Alan Watson has coordinated a variety of studies to help managers understand visitor responses to user fees. A number of papers on this topic have been published in theme issues of the *Journal of Leisure Research* (1999) and the *Journal of Park and Recreation Administration* (1999).

Nonnative Species

Although the issue of nonnative species has not yet been developed into a full research agenda, the Leopold Institute has supported recent investigations into the distribution and management of nonnative plants and the effects of nonnative fish stocking in wilderness.

Plants—In spite of legal mandates to maintain natural conditions, many wilderness areas have been impacted by the introduction of nonnative plant species. Some of these have the potential to drastically alter native ecosystem structure and function. In an effort to understand exotic

plant issues related to wilderness, the Leopold Institute supported a survey of wilderness managers about the extent and control of nonnative plant invasions in the National Wilderness Preservation System (Marler, in press). Responses from wilderness areas across the country were used to develop a database of nonnative plant presence and management control efforts in wilderness. Current Institute-supported research projects attempt to understand how weeds spread into wilderness, the conditions that favor or discourage weed growth and reproduction and the influx of weeds after prescribed burning.

Fish—Over the past century, sport fish have been introduced into most of the naturally fishless lakes in U.S. wilderness areas. Fish introductions have changed entire lake ecosystems and communities, often with detrimental impacts to native fish and amphibians. Wilderness managers must make difficult and controversial decisions about how to balance the recreational opportunity created by historic nonnative fish stocking with the preservation of native fauna and flora in wilderness lakes. The Leopold Institute currently supports several ongoing studies related to this issue, including studies on the impacts of exotic trout to amphibians in wildernesses lakes in Idaho, California and Montana, and a study of exotic trout impacts to native invertebrates in Utah. The Leopold Institute co-organized a workshop, entitled "Effects of Fisheries Management on the Amphibians and Other Biota of Wilderness Lakes," to provide managers with the latest research results on this topic and to facilitate discussion among managers, scientists and wilderness users (Corn, in press). The results of this workshop are in preparation for publication as a compilation of research results and management recommendations.

Additional Research Issues

As a result of the 1995-96 issue prioritization process, tier-two issues were also identified. Although tier-two priority issues haven't been developed into full research programs, the Leopold Institute opportunistically supports research that addresses these issues. Tier-two issues include, 1) understanding the effects of livestock and livestock management on wilderness ecosystems, 2) understanding the relationships between wilderness and larger ecological systems and 3) understanding the role of wilderness in larger social systems. For example, recent Leopold Institute research on the value of wilderness within broader social systems includes 1) a study that found a seven-day wilderness experience program empowered and strengthened the skills and motivation of participating youth-at-risk, and reduced early terminations from the Federal Job Corps (Russell and others 1998) and 2) an investigation of wilderness values in the urban area of Los Angeles, California where ethnically and economically diverse survey respondents showed significant support for wilderness (Parker and Koesler 1998). Managing wilderness within broader ecological and social systems necessitates recognizing and overcoming the impacts of administrative boundaries and adjacent lands on wilderness management (Knight and Landres 1998).

The Leopold Institute also addresses broad issues related to science and wilderness, such as clarifying the role

of science in defining wilderness management objectives (Parsons 1998a), and addressing the appropriateness and conduct of scientific and management activities within wilderness (Parsons 1998b, Parsons, in press, b).

Research Application to Management

Part of the Leopold Institute's mission is to make research results directly useful and readily available to managers, educators, policymakers, user groups, and other scientists. In addition to publishing research results, Institute research is disseminated through the research application program. Examples of current research application activities include: 1) developing information sources such as databases, bibliographies, and libraries containing research relevant to wilderness management, 2) summarizing research findings and management implications for managers (Wright 1998a, Wright 1998b), 3) developing and implementing protocols to help managers make decisions, 4) conducting and participating in workshops, site visits and training sessions, and 5) developing partnerships between scientists and the users of knowledge gained through wilderness research.

Internet Web Site

The Leopold Institute web site (www.wilderness.net/leopold) includes introductory and background information on the Leopold Institute and its staff, research activities, a current publication list, and conference announcements. Over the past year, this web page has become the Leopold Institute's primary means of distributing the publication list, as well as the databases developed through the Institute. The web site is being expanded to provide additional scientific information on a variety of wilderness issues.

Databases

Leopold Institute staff recently updated and revised a database of the National Wilderness Preservation System, which was initially developed by the Bureau of Land Management. This database includes each wilderness area's correct legal name, establishing public law, date established, modifying laws, current acreage and administering unit(s), and state(s) where it is located. The database is currently accessible in a hard-copy publication (Landres and Meyer 1998) and the Leopold Institute's web site. Meyer and Landres are also developing a database of the legislative history on a variety of wilderness issues; that database will also be available through the Internet.

Conferences

The Leopold Institute staff organize conferences, symposia, workshops and technical sessions to summarize state-of-knowledge research on wilderness issues and provide opportunities for managers to interact with scientists over these issues. Recent workshop topics include the Limits-of-Acceptable Change process (McCool and

Cole 1997), nonnative fish stocking in wilderness lakes and the uses (Corn, in press) and limitations of historical variability concepts for managing ecosystems (Parsons and others 1999). The Leopold Institute cosponsored and co-organized the 1999 Wilderness Science Conference published in this proceedings (Cole and McCool, in press), as well as the science program for the Sixth World Wilderness Congress in India (Watson and others 1998d, Watson and others 1999).

Site Visits

Leopold Institute researchers conduct site visits to assist natural area managers with issues of national relevance. This includes working with Forest Service managers to develop a national strategy for wilderness recreation management that will prevent the degradation of near-pristine low-use areas, while maintaining high-use wilderness areas within acceptable levels of resource impacts. Other examples of site visits include consulting with BLM managers at the new Grand Staircase-Escalante National Monument to help refine monitoring protocols, consulting with managers on how to monitor fire impacts and how to initiate collaborative processes for reintroducing fire into wilderness, and meeting with managers from state and federal agencies to discuss the conflicts around enhancing wildlife habitat within wilderness. Additional recent site visits have been made to assess the need and options for restoring fire to mixed severity fire regime forests (Arno and others, in press) and to identify potential studies in wilderness areas containing extensive tree blowdown.

Conclusion

The Aldo Leopold Wilderness Research Institute provides a focal point for the development and application of scientific information necessary to understand and manage wilderness ecosystems. Specifically, the Leopold Institute provides a national center for scientists from different disciplines and backgrounds to address the wilderness research needs of land management agencies and organizations. Leopold Institute staff have worked with other wilderness experts to identify high priority research issues and specific research agendas related to recreation management and ecological disturbances. Past research has included topics related to recreation impacts, visitor experiences, and fire, vegetation and wildlife ecology. Results of some Institute research projects are applied directly to local management dilemmas, while others provide the theoretical background to answer broader wilderness management questions. Leopold Institute staff are dedicated to providing the quality, peer-reviewed research and application necessary to develop policy guidelines and management practices that assure sustainable wild ecosystems and their benefits and values endure for generations to come.

References

Arno, Stephen F.; Parsons, David J.; Keane, Robert E. In Press. Mixed-severity fire regimes in the Northern Rocky Mountains: Consequences of fire exclusion and options for the future. In:

- Cole, David N.; McCool, Stephen F. Proceedings: Wilderness Science in a Time of Change. Proc. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.
- Borrie, William T.; Roggenbuck, Joseph W. 1998. Describing the wilderness experience at Juniper Prairie Wilderness using experience sampling methods. In: Kulhavy, David L.; Legg, Michael H., eds. 1998. Wilderness & natural areas in eastern North America: research, management and planning; 1996 May 19-23; Gatlinburg, TN. Nacogdoches, TX: Arthur Temple College of Forestry, Stephen F. Austin State University: 165-172.
- Cable, Suzanne; Watson, Alan E. 1998. Recreation use allocation: alternative approaches for the Bob Marshall Wilderness Complex. Res. Note RMRS-RN-1. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 7 p.
- Cole, David N. 1989a. Wilderness campsite monitoring methods: a sourcebook. General Technical Report INT-259. Ogden, UT: USDA For. Serv., Intermountain Research Station. 57 p.
- Cole, David N. 1989b. Low-impact recreational practices for wilderness and backcountry. Gen. Tech. Rep. INT-265. Ogden, UT: USDA For. Serv., Intermountain Research Station. 131 p.
- Cole, David N. 1994. The wilderness threats matrix: a framework for assessing impacts. Res. Pap. INT-475. Ogden, UT: USDA For. Serv., Intermountain Research Station. 14 p.
- Cole, David N. 1995a. Experimental trampling of vegetation. I. Relationship between trampling intensity and vegetation response. *Journal of Applied Ecology*. 32: 203-214.
- Cole, David N. 1995b. Experimental trampling of vegetation. II. Predictors of resistance and resilience. *Journal of Applied Ecology*. 32: 215-224.
- Cole, David N. 1995c. Wilderness management principles: science, logical thinking or personal opinion? *TRENDS/Wilderness Research*. 32(1): 6-9.
- Cole, David N. 1996a. Ecological manipulation in wilderness—an emerging management dilemma. In: *International Journal of Wilderness*. 2(1): 15-19.
- Cole, David N. 1996b. Wilderness recreation use trends, 1965 through 1994. Res. Pap. INT-RP-488. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station. 10 p.
- Cole, David N. 1996c. Wilderness Recreation in the United States—Trends in Use, Users, and Impacts. *International Journal of Wilderness*. 2(3): 14-18.
- Cole, David N. 1997a. Solitude: Researchers Continue to Delve into the Solitude Component of Wilderness. *Signpost for Northwest Trails*. January: 33-34.
- Cole, David N. 1997b. Recreation Management Priorities Are Misplaced: Allocate More Resources to Low-Use Wilderness. *International Journal of Wilderness*. 3(4): 4-8.
- Cole, David N. 1998. Written appeals for attention to low-impact messages on wilderness trailside bulletin boards: experimental evaluations of effectiveness. *Journal of Park and Recreation Administration*. 16(1): 65-79.
- Cole, David N.; Petersen, Margaret E.; Lucas, Robert C. 1987. Managing wilderness recreation use: common problems and potential solutions. Gen. Tech. Rep. INT-GTR-230. Ogden, UT: USDA For. Serv., Intermountain Research Station. 60 p.
- Cole, David N.; Landres, Peter B. 1996. Threats to wilderness ecosystems: impacts and research needs. In: *Ecological Applications*. 6(1): 168-184.
- Cole, David N.; Hammond, Timothy P.; McCool, Stephen F. 1997a. Information Quantity and Communication Effectiveness: Low-Impact Messages on Wilderness Trailside Bulletin Boards. *Leisure Sciences*. 19: 59-72.
- Cole, David N.; Watson, Alan E.; Hall, Troy E.; Spildie, David R. 1997b. High-Use Destinations in Wilderness: Social and Biophysical Impacts, Visitor Responses, and Management Options. Gen. Tech. Rep. INT-RP-496. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station. 29 p.
- Cole, D. N.; Spildie, D. R. 1998. Hiker, horse and llama trampling effects on native vegetation in Montana, USA. *Journal of Environmental Management*. 53: 61-71.
- Cole, David N.; McCool, Stephen F. In Press. Proceedings: Wilderness Science in a Time of Change. Proc. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.
- Cole, David N.; Hammitt, William E. In Press. Wilderness management dilemmas: fertile ground for wilderness management research. In: Cole, David N.; McCool, Stephen F. Proceedings: Wilderness Science in a Time of Change. Proc. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.
- Corn, P.S. 1994. What we know and don't know about amphibian declines in the West. Pages 59-67 In: Covington, W. W.; DeBano, L. F., technical coordinators. Sustainable ecological systems: implementing an ecological approach to land management. Ft. Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. General Technical Report RM-GTR-247.
- Corn, Paul Stephen. 1998. Effects of ultraviolet radiation on boreal toads in Colorado. *Ecological Applications*. 8(1): 18-26.
- Corn, Paul Stephen. In Press. Fish stocking in protected areas: summary of a workshop. In: Cole, David N.; McCool, Stephen F. Proceedings: Wilderness Science in a Time of Change. Proc. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.
- Corn, Paul Stephen. In Press. Amphibian declines: review of some current hypotheses. In: Sparling D.W., Bishop, C.A., Linder, G., eds. *Ecotoxicology of amphibians and reptiles*. Pensacola FL: Society of Environmental Toxicology and Chemistry.
- Corn, Paul Stephen; Jennings, Michael L.; Muths, Erin. 1997. Survey and Assessment of Amphibian Populations in Rocky Mountain National Park. *Northwestern Naturalist*. 78: 34-55.
- Dawson, Chad P.; Newman, Peter; Watson, Alan. 1998. Cognitive dimensions of recreational user experiences in wilderness: an exploratory study in Adirondack wilderness areas. In: Vogelson, Hans G., comp., ed. 1998. Proceedings of the 1997 northeastern recreation research symposium; 1997 April 6-9; Bolton Landing, NY. Gen. Tech. Rep. NE-241. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 287 p.
- DeLuca, T. H.; Patterson, W. A., IV; Freimund, W. A.; Cole, D. N. 1998. Influence of llamas, horses, and hikers on soil erosion from established recreation trails in western Montana, USA. *Environmental Management*. 22(2): 255-262.
- Doucette, Joseph E.; Cole, David N. 1993. Wilderness visitor education: information about alternative techniques. Gen. Tech. Rep. INT-295. Ogden, UT: USDA For. Serv., Intermountain Research Station. 37 p.
- Gutzwiller, Kevin J.; Marcum, Heidi A.; Harvey, Henry B.; Roth, James D.; Anderson, Stanley H. 1998. Bird tolerance to human intrusion in Wyoming montane forests. *The Condor*. 100: 519-527.
- Hammitt, William E.; Cole, David N. 1987. *Wildland recreation: ecology and management*. New York: John Wiley & Sons. 341 p.
- Hampton, Bruce; Cole, David. 1995. *Soft paths: how to enjoy the wilderness without harming it*. Harrisburg, PA: Stackpole Books. 173 p.
- Hendricks, William W.; Watson, Alan E. 1999. Wilderness educators' evaluation of the Impact Monster Program. Res. Pap. RMRS-RP-15. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 12 p.
- Johnson, Laura C.; Wallace, George N.; Mitchell, John E. 1997. Visitor Perceptions of Livestock Grazing in Five U.S. Wilderness Areas—A Preliminary Assessment. *International Journal of Wilderness*. 3(2): 14-20.
- Journal of Leisure Research*. 1999. Volume 31, Number 3.
- Journal of Park and Recreation Administration*. 1999. Volume 17, Number 3.
- Knight, Richard L.; Gutzwiller, Kevin J., eds. 1995. *Wildlife and Recreationists—Coexistence Through Management and Research*. Washington, DC: Island Press. 372 p.
- Knight, Richard L.; Landres, Peter B., eds. 1998. *Stewardship across boundaries*. Covelo, CA: Island Press. 371 p.
- Landres, Peter B. 1995. The role of ecological monitoring in managing wilderness. *TRENDS/Wilderness Research*. 32(1): 10-13.

- Landres, Peter B. In Press. Protecting naturalness and wildness: a management dilemma and a social irony. In: Cole, David N.; McCool, Stephen F. Proceedings: Wilderness Science in a Time of Change. Proc. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.
- Landres, Peter; Meyer, Shannon. 1998. National Wilderness Preservation System database: key attributes and trends, 1964 through 1998. Gen. Tech. Rep. RMRS-GTR-18. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 97 p.
- Landres, Peter B.; White, Peter S.; Aplet, Greg; Zimmermann, Anne. 1998. Naturalness and natural variability: definitions, concepts, and strategies for wilderness management. In: Kulhavy, David L.; Legg, Michael H., eds. 1998. Wilderness & natural areas in eastern North America: research, management and planning; 1996 May 19-23; Gatlinburg, TN. Nacogdoches, TX: Center for Applied Studies, Stephen F. Austin State University: 41-50.
- Landres, Peter B.; Morgan, Penelope; Swanson, Frederick J. 1999. Overview of the use of natural variability concepts in managing ecological systems. *Ecological Applications*. 9(4): (in press).
- Marion, Jeffrey L.; Cole, David N. 1996. Spatial and temporal variation in soil and vegetation impacts on campsites. *Ecological Applications*. 6(2): 520-530.
- Marler, Marilyn J. In Press. A survey of exotic plants in federal wilderness areas. In: Cole, David N.; McCool, Stephen F. Proceedings: Wilderness Science in a Time of Change. Proc. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.
- McCool, Stephen F.; Cole, David N., comps. 1997. Proceedings--Limits of acceptable change and related planning processes: progress and future directions; 1997 May 20-22; Missoula, MT (Lubrecht Experimental Forest). Gen. Tech. Rep. INT-GTR-371. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 84 p.
- McEwen, Douglas; Cole, David N. 1997. Campsite Impact in Wilderness Areas. *Parks and Recreation*. February: 24-32.
- Olson-Rutz, K. M.; Marlow, C. B.; Hansen, K.; Gagnon, L. C.; Rossi, R. J. 1996. Packhorse Grazing Behavior and Immediate Impact on a Timberline Meadow. *Journal of Range Management*. 49: 546-550.
- Parker, Julia Dawn; Koesler, Rena. 1998. Urban populations as an impact on wilderness: a study of values in the Los Angeles Basin. In: Kulhavy, David L.; Legg, Michael H., eds. Wilderness & natural areas in eastern North America: research, management and planning. Nacogdoches, TX: Stephen F. Austin State University, Arthur Temple College of Forestry, Center for Applied Studies: 245-249.
- Parsons, D.J. 1986. Campsite impact data as a basis for determining wilderness use capacities. In: Lucas, Robert D., compiler. Proceedings National Wilderness Research conference: current research; 1985 July 23-26; Fort Collins, CO. Gen. Tech. Rep. INT-212. Ogden, UT: USDA For. Serv., Intermountain Research Station: 449-455.
- Parsons, D.J. 1991. Restoring fire to the Sierra Nevada mixed conifer forest: reconciling policy, science and practicality. In: Hughes, H.G.; Bonnicksen, T.M., eds. Proceedings, First Annual Meeting of the Society for Ecological Restoration. Madison, WI: Society for Ecological Restoration: 271-279.
- Parsons, David J. 1998a. Integrating science into natural resource planning and management. In: Hill, Linda M., ed. 1998. Learning from the land: Grand Staircase-Escalante National Monument science symposium proceedings; 1997 November 4-5; Cedar City, UT. BLM/UT/GI-98-006+1220. [Publisher's location and name unknown]: 37-40.
- Parsons, David J. 1998b. Scientific activities in wilderness—a workshop to address issues and concerns. *International Journal of Wilderness*. 4(1): 10-13.
- Parsons, David J. In Press, a. The challenge of restoring natural fire to wilderness. In: Cole, David N.; McCool, Stephen F. Proceedings: Wilderness Science in a Time of Change. Proc. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.
- Parsons, David J. In Press, b. The challenge of scientific activities in wilderness. In: Cole, David N.; McCool, Stephen F. Proceedings: Wilderness Science in a Time of Change. Proc. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.
- Parsons, David J.; Botti, Stephen J. 1996. Restoration of fire in national parks. In: Hardy, Colin C.; Arno, Stephen F., eds. The use of fire in forest restoration. Gen. Tech. Rep. INT-GTR-341. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station: 29-31.
- Parsons, David J.; Landres, Peter B. 1998. Restoring natural fire to wilderness: how are we doing? In: Pruden, Teresa L.; Brennan, Leonard A., eds. Proceedings: 20th Tall Timbers Fire Ecology Conference: Fire in ecosystem management: shifting the paradigm from suppression to prescription; 1996 May 7-10, Boise, ID. Lawrence, KS: Allen Press: 366-373.
- Parsons, David J., Swetnam, Thomas W. and Christensen, Norman L. 1999. Uses and limitations of historical variability concepts in managing ecosystems. *Ecological Applications* 9(4).
- Patterson, Michael E.; Watson, Alan E.; Williams, Daniel R.; Roggenbuck, Joseph R. 1998. An hermeneutic approach to studying the nature of wilderness experiences. *Journal of Leisure Research*. 30(4): 423-452.
- Riffell, Samuel; Gutzwiller, Kevin J.; Anderson, Stanley H. 1996. Does Repeated Human Intrusion Cause Cumulative Declines in Avian Richness and Abundance? *Ecological Applications*. 6(2): 492-505.
- Russell, Keith; Hendee, John C.; Cooke, Steve. 1998. Social and economic benefits of a U.S. wilderness experience program for youth-at-risk in the Federal Job Corps. *International Journal of Wilderness*. 4(3): 32-38.
- Stankey, George H.; Cole, David N.; Lucas, Robert C.; Petersen, Margaret E.; Frissell, Sidney S. 1985. The limits of acceptable change (LAC) system for wilderness planning. Gen. Tech. Rep. INT-176. Ogden, UT: USDA For. Serv., Intermountain Forest and Range Exper. Stn. 37 p.
- Stewart, W; Cole, David. 1997. Truths About Solitude in Grand Canyon. In: Harmon, David, ed. Proceedings - Ninth Biennial George Wright Society Conference; 1997 March 17-21; Hancock, MI: The George Wright Society: 21-24.
- Watson, Alan E. In Press. Wilderness use in the year 2000. In: Cole, David N.; McCool, Stephen F. Proceedings: Wilderness Science in a Time of Change. Proc. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.
- Watson, Alan E.; Williams, Daniel R.; Roggenbuck, Joseph W.; Daigle, John J. 1992. Visitor characteristics and preferences for three national forest wildernesses in the South. Res. Pap. INT-455. Ogden, UT: USDA For. Serv., Intermountain Research Station. 27 p.
- Watson, Alan E.; Niccolucci, Michael J. 1995. Conflicting goals of wilderness management: natural conditions vs. natural experiences. In: Chavez, Deborah J., tech. coord. Proceedings of the second symposium on social aspects and recreation research; 1994 February 23-25; San Diego, CA. Gen. Tech. Rep. PSW-GTR-156. Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station: 11-15.
- Watson, Alan E.; Hendee, John C.; Zaglauer, Hans P. 1996. Human values and codes of behavior: changes in Oregon's Eagle Cap Wilderness visitors and their attitudes. *Natural Areas Journal*. 16(2): 89-93.
- Watson, Alan E.; Roggenbuck, Joseph W. 1998. Selecting human experience indicators for wilderness: different approaches provide different results. In: Kulhavy, David L.; Legg, Michael H., eds. Wilderness & natural areas in eastern North America: research, management and planning. Nacogdoches, TX: Stephen F. Austin State University, Arthur Temple College of Forestry, Center for Applied Studies: 264-269.
- Watson, Alan E.; Cronn, Rich; Christensen, Neal A. 1998a. Monitoring inter-group encounters in wilderness. Res. Pap. RMRS-RP-14. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 20 p.
- Watson, Alan E.; Christensen, Neal A.; Blahna, Dale J.; Archibald, Kari S. 1998b. Comparing manager and visitor perceptions of llama use in wilderness. Res. Pap. RMRS-RP-10. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 7 p.
- Watson, Alan E.; Hunger, Don; Christensen, Neal; Spildie, Dave; Becker, Kurt; Comstock, Jeff. 1998c. Wilderness boaters: protecting unique opportunities in the Frank Church-River of No Return

- Wilderness, Idaho, U.S.A. In: Watson, Alan E.; Aplet, Greg H.; Hendee, John C., comps. 1998. Personal, societal, and ecological values of wilderness: Sixth World Wilderness Congress proceedings on research, management, and allocation, volume I; 1997 October; Bangalore, India. Proc. RMRS-P-4. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station: 151-158.
- Watson, Alan E.; Aplet, Greg H., Hendee, John C., comps. 1998d. Personal, societal, and ecological values of wilderness: Sixth World Wilderness Congress proceedings on research, management, and allocation, volume I; 1997 October; Bangalore, India. Proc. RMRS-P-4. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 158 p.
- Watson, Alan E.; Aplet, Greg H.; Hendee, John C., comps. 2000. Personal, societal, and ecological values of wilderness: Sixth World Wilderness Congress proceedings on research, management, and allocation, volume II; 1998 October 24-29; Bangalore, India. Proc. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. (in press).
- Watson, Alan E.; Cole, David N.; Turner, David L.; Reynolds, Penny S. In Press. Wilderness recreation use estimation: a handbook of methods and systems. Gen. Tech. Rep. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.
- Wright, Vita. 1998a. News from the Aldo Leopold Wilderness Research Institute, Missoula, Montana, USA. *International Journal of Wilderness*. 4(2): 12.
- Wright, Vita. 1998b. News from the Aldo Leopold Wilderness Research Institute: non-native fish stocking in wilderness. 5(1): 14.