AN ABSTRACT OF THE DISSERTATION OF

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Three studies were performed in Oregon wildernesses. The first used wilderness permit and trailhead registration data to evaluate trends in use of Three Sisters, Mt. Jefferson, and Eagle Cap Wildernesses from 1976 to 1994. Recreational visitor days were found to have declined, but the number of visits increased dramatically, because of large increases in the number of day users. These findings are counter to conclusions drawn in earlier research on national use trends and highlight the importance of the unit of measure to interpretation of trends. Trends implied by permit data differed from trends estimated by Forest Service personnel, and implications for Forest Service reporting are discussed.

The second study compared day and overnight visitors to three high-use destinations in terms of their perception of social and ecological impacts of wilderness recreation, evaluation of impacts, and support for management actions. Overnight users were more likely to notice impacts, but predicted differences in reaction to impacts and support for management actions were not found. The only exception was that overnight users were more likely to object to management actions that would target overnight users. Results showed significant differences among study sites.

The third study tested four methods of revegetating impacted campsites: scarification, importing organic material, transplanting, and transplanting with watering. These commonly used methods have not been systematically investigated previously. Six campsites in Three Sisters Wilderness were treated in 1991 and reevaluated in 1994. Importing organic material and scarification were found to improve vegetation recovery and species richness very little compared to controls, but both transplanting techniques had significant effects, often because of the presence of other species or propagules in the transplanted plugs. Watering was found to have no effect on the survival of transplanted mountain hemlock seedlings. Vegetative recovery was very slow with even the most effective treatments, which reinforces recommendations that managers adopt strategies of concentrating use.

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TRENDS IN WILDERNESS USE: SOCIAL AND ECOLOGICAL IMPLICATIONS

CHAPTER 1. INTRODUCTION

During this century, our nation's growing population and increasing standard of living have placed ever greater demands on our environment for amenity values and extractive resources. Outdoor recreational pursuits have increased in number and participation, so that in 1987, 89% of Americans reported participating in some form of outdoor recreation (Cordell and Siehl 1989). About half of these trips involved wildland activities. Although demand has increased, the supply of opportunities for some types of recreation has declined. For example, the size and number of lands remaining in a natural state have dwindled, and industrial and nonindustrial private lands that were once open to public use are now often closed (McLellan 1986).

Concurrent with increases in demand, the public has become increasingly well-informed about and involved in land management decisions. Since the 1960s, legislation has institutionalized public participation in federal planning efforts (Lunch 1987). Management objectives, decisions, and practices are scrutinized and challenged by those with widely diverging values and considerable political acumen (Blahna and Yonts-Shepard 1990; Gericke and Sullivan 1994; Gericke et al. 1992; Tipple and Wellman 1989). These same factors affect recreation managers on public lands and make their task increasingly challenging. Managers must understand and provide for the multitude of benefits and values that the public desires from recreation sites. They must achieve acceptable methods of balancing public input with technical knowledge to develop and carry out plans for managing recreational resources.

In recent years, as the field of recreation has matured, several planning frameworks have been developed for use by managers. Among the best known are Visitor Impact Management (Graefe et al. 1986; Graefe et al. 1990), Carrying Capacity (Shelby and Heberlein 1986), and Limits of Acceptable Change (Stankey et al. 1985). Although somewhat different in process and emphasis, all set forth steps for moving from general objectives to concrete, measurable goals and sensible management practices, in a rational and explicit manner. Each process recognizes the principles of the recreational opportunity spectrum (ROS), namely that a major objective of recreation is to provide a diversity of high quality recreational experiences. The manager cannot manipulate the visitor's experience directly, but can influence it indirectly through manipulation of the physical, social, and managerial settings.

Of these planning frameworks, the limits of acceptable change (LAC) has been the most widely adopted, especially by the US Forest Service. Briefly, the LAC planning process begins with developing and refining goals relating to the desired experience and the physical, experiential, and managerial attributes of a given setting. For each goal, indicators are selected, against which attainment of goals can be measured. Indicators should be measurable, responsive to changing conditions and management, and clearly related to the specific management goal (Whittaker 1992; Whittaker and Shelby 1992). Conditions are then inventoried to describe a baseline of the current situation. This step is critical if one is to be able to evaluate the effectiveness of any management actions taken. For each indicator, standards are developed which define a threshold of acceptable change. Where conditions are deemed to exceed acceptable levels, management actions are selected that will return conditions to an acceptable level. These actions are implemented and results are monitored to determine their effectiveness. The process is cyclic; the results of monitoring can trigger either new management actions or a reevaluation of goals, indicators, or standards.

On public lands, this planning process has numerous inputs, including legislative and policy direction, public involvement, and technical expertise. This diversity means that goals are multiple and sometimes conflicting. For instance, managers may be directed to extract commodity values such as timber while also providing amenity values such as wildlife viewing. Conflicts can arise even over small-scale, localized issues; for example, hikers and stock users may have different views about whether riders should be allowed on specific trails. The potential for such conflicts makes it critical that managers obtain public input and acquire a solid understanding of resource conditions, the relationship between resource conditions and public attitudes, and the responsiveness of conditions to management actions.

Wilderness management is in some ways less complex than recreation management on "multiple use" lands. Rather than having to try to balance resource extraction, divergent types of recreation, and other values, land managers have a relatively narrower mandate to provide for primitive recreation and natural conditions in wilderness areas. Extractive uses are largely absent, visitors are more similar in expectations and preferences than other public lands users, and policy direction is more uniform.

Chapters 2 to 4 of this dissertation describe the results of research conducted to assist in the planning process for two wildernesses in Oregon. The following discussion provides background on wilderness policy and wilderness research and sets the context for those chapters.

Wilderness Philosophy and Management Direction

Over one hundred million acres of public land are managed today as federally designated wilderness. Wilderness has always been a defining feature of the American landscape, but it was not until this century that wilderness areas became sufficiently scarce that widespread serious and systematic efforts were undertaken to protect them (Nash 1982). Wilderness first appeared as an official land classification of the United States Forest Service in the 1930s, and was largely restricted to large expanses of prime recreation land that had relatively little value for timber or range (Hendee et al. 1990). At that time, wilderness management was typically management by neglect; little need was perceived for active intervention.

Wilderness management began to move from passive to active with the passage of the Wilderness Act in 1964, which created a system of wilderness on federal lands and laid out the guiding philosophy for wilderness management. Although many other pieces of legislation have added to and clarified congressional intent regarding wilderness, the Wilderness Act is still the primary reference for managers today. According to the Wilderness Act, a wilderness is

> an area where the earth and its community of life are untrammeled by man, where man himself is a visitor who does not remain...an area of undeveloped Federal land retaining its primeval character and influence, without permanent improvements or human habitation, which is protected and managed so as to preserve its natural conditions and which (1) generally appears to have been affected primarily by the forces of nature, with the imprint of man's work substantially unnoticeable; (2) has outstanding opportunities for solitude or a primitive and unconfined type of recreation; (3) has at least five thousand acres of land or is of sufficient size as to make practicable its preservation and use in an unimpaired condition; and (4) may also contain ecological, geological, or other features of scientific, educational, scenic, or historical value. (PL 88-577)

The Act clearly states that wilderness is to be administered for public use and enjoyment, but in such a way that its value as wilderness will not be diminished. The general purposes of wilderness are listed as recreational, scenic, scientific, educational, conservation, and historical uses.

The Wilderness Act presented managers with two overriding tasks: to preserve wilderness ecosystems and to provide a unique form of recreational experience. The first of these directives has been interpreted to mean preserving the natural processes of ecosystem dynamics, as well as maintaining an environment which gives the appearance of having been unaltered by human influence (Nash 1983). The type of recreation to be provided is one dependent on such environments: solitude or a primitive and unconfined type of recreation (Hendee et al. 1990).

These fundamental objectives guide wilderness planning and management and require various types of knowledge. For example, to know whether opportunities for solitude exist, managers must understand how visitors define "solitude" (Cowley and Schreyer 1987). This requires knowledge of visitor attitudes and perceptions obtained through consultation with users. Maintenance of natural processes and ecosystems requires detailed knowledge of ecological functioning and the effects of human disturbance on such functioning.

To assist wilderness managers with their tasks, a body of research has developed, most of it since 1970. Much of this has been sociological, dealing with visitor characteristics, attitudes, motives, and perceptions (Lucas 1980, 1985, 1990; Roggenbuck and Lucas 1987; Roggenbuck et al. 1993; Stankey and Schreyer 1987; Watson et al. 1992). Much of the biological research has investigated the impacts to vegetation, soils, and trails caused by recreational use (Bratton et al. 1979; Cole 1983, 1985, 1987, 1991, 1992; Cole and Fichtler

1983; Cole and Hall 1992; Cole and Trull 1992; Hall and Kuss 1989; Helgath 1975; Marion and Merriam 1985; Summer 1980). More recently, research has begun to address wilderness ecosystem functioning and health, providing baselines against which to evaluate changes on other types of land (Landres 1994, 1995; Woodward et al. 1995).

Wilderness research has provided answers to many questions. We know, for example, who wilderness visitors are, why they come to wilderness, and what they do there. We know about their views on appropriate and inappropriate uses of wilderness and wilderness management practices. We know a great deal about the susceptibility of different plant associations to human impact, and we know the nature, extent, and location of most impacts caused by recreation. All these forms of knowledge are critical to the planning process in helping define objectives, select indicators, set standards, and choose management actions. Nevertheless, numerous gaps remain in our understanding.

The studies presented in this dissertation address three important gaps in our knowledge. Data for the studies were collected under a cooperative research agreement with the Willamette and Deschutes National Forests to assist in planning and management of Mount Jefferson and Three Sisters Wildernesses. The following discussion presents a more detailed look at the rationale behind each study.

Content of the Dissertation

The Willamette and Deschutes National Forests jointly manage Mount Jefferson and Three Sisters Wildernesses in the Cascade Mountains of Oregon. These have always been popular destinations for visitors from the

Portland, Salem, Eugene, and Bend areas, and they were incorporated into the National Wilderness Preservation System in 1964 as so-called "instant" wilderness. Since that time, managers have struggled with the need to balance recreational use against preservation of the naturalness of the wilderness ecosystems.

In 1991, the Forests began implementation of a modified form of the Limits of Acceptable Change planning process, with the objective of clarifying indicators for resource and social conditions, evaluating existing standards, and developing management actions to achieve desired goals. During this process, extensive evaluations of recreational impacts were conducted (Hall and Shelby 1993b; Shelby and Hall 1992), use levels were studied, and visitor surveys were carried out.

Use Trends

Managers of these wildernesses were concerned about high levels of use at some destinations. Data suggested that visitors could expect to encounter up to 100 other people a day on busy summer weekends (Hall and Shelby 1993a), and managers felt that opportunities for solitude were impaired. This led to discussion of potential actions that might be taken to reduce use levels. Any such actions are highly controversial and must be carefully considered. Planners naturally began to ask about use trends in these areas, because the decision about implementation of management actions depended in part on the current trend in use of these areas. A review of previous research and a study conducted for the Pacific Northwest Region (Hall et al. 1993) indicated that the question of use trends was of considerable interest and importance to all wilderness managers.

Recreational use of wilderness received much attention in the 1970s, when researchers were developing and testing methods managers could use to estimate levels of recreational use. Several articles written between 1987 and 1989 were the last serious treatment of this issue (Lucas 1989; Lucas and McCool 1988; Lucas and Stankey 1988; Roggenbuck 1988; Roggenbuck and Lucas 1987; Roggenbuck and Watson 1988). These articles generally concluded that recreational use had increased dramatically in the 1960s and 1970s, but was stabilizing or declining by the mid 1980s.

Nearly 10 years later, we felt it was worth reexamining the issue of trends in wilderness use from the standpoint of assessing whether predictions from the 1980s were correct for wildernesses in Oregon. However, it is important to managers for other reasons as well. For example, in their efforts to provide opportunities for solitude, managers often debate the merits of use-limitation systems (Fazio and Gilbert 1974; Hendee and Lucas 1973; Stankey and McCool 1991). Knowledge of use trends is one factor especially relevant to such decisions. Managers also decide where to allocate personnel and resources; these decisions, too, should be affected by an understanding of trends in use.

Chapter 2, then, looks at use levels between 1976 and 1994 in Three Sisters and Mount Jefferson Wildernesses, to evaluate whether national trends described in the late 1980s characterize use of these areas. Data from the Eagle Cap Wilderness in 1980 and 1993 are also included to allow comparison with a larger, more remote wilderness. Obtaining accurate data on wilderness use is difficult; we were fortunate to have access to data collected at various times in the past by means of permit systems that had known (and generally high) levels of compliance.

An issue relating to use, but not previously addressed, arises from the present study, and concerns the effect of changing composition of use on our estimates of use and understanding of trends. The traditional measure of use (the recreational visitor day, or RVD) combines group size with length of stay. If either or both of these change over time, projections of use may be in error.

Data presented in this chapter shows that use as measured by RVDs has declined or remained stable in the wildernesses studied. However, if measured in visits, use has increased. The discrepancy appears to result in part from a shift toward more day use in the areas studied.

Perceptions and Attitudes of Day Users

During the course of the planning process for Mount Jefferson and Three Sisters, it became clear that some central issues related to visitor attitudes remained unresolved. It was apparent that many locations within these wildernesses were visited primarily by day users and that the trend was toward more day use. The existing forest plan indicators and standards for ecological and social conditions that were under review had been adopted more than 10 years earlier, and were based on research conducted during the 1970s and 1980s in other parts of the country, where overnight use was more common (Smith and Higgins 1992). Thus, it seemed possible that the indicators and standards might more accurately reflect the attitudes of overnight users. As a result, the question arose whether day users in the Cascades have views about conditions and management similar to overnight users. If not, then perhaps indicators and standards needed to be revisited.

This issue is important to managers. The direction to provide unique wilderness-dependent recreational opportunities is challenging, because these experiences are usually defined in subjective ways. For example, the definitions of "solitude" or "primitive and unconfined" are created by visitors, not by managers, yet managers must try to provide opportunities for those experiences. Thus, as managers select indicators and set standards for experiences, they need a clear understanding of public perceptions, expectations, and preferences. Although much research has addressed these issues, it is important to know if day users have different views that can or should affect management of certain wildernesses.

Day use of wilderness has been largely ignored by researchers and managers. The finding in Chapter 2 that a large percentage of wilderness use in Oregon is by day users made the issue of potential differences all the more important. This question has been raised recently, as managers and researchers realize that urban-proximate wildernesses are now visited predominantly by day users and may attract visitors with different attitudes (Burde and Daum 1990; Ewert 1989; Ewert and Hood 1995; Roggenbuck et al. 1994).

The second study in this dissertation (Chapter 3) investigates the extent to which there are differences between day and overnight users in perception of impacts, evaluation of impacts, and attitudes toward management. On-site surveys at three trailheads in Three Sisters and Mount Jefferson Wildernesses were used to elicit information from day and overnight users.

Campsite Restoration

Management of the social component of recreation was hotly debated during the planning process for Mount Jefferson and Three Sisters. Dealing with the physical impacts of recreation, especially at campsites, was less controversial. Managers and public participants agreed that campsite impacts were excessive, and that actions should be taken to restore conditions at some sites.

Past increases in wilderness use nation-wide have led to numerous impacts to biological and physical resources, and these conditions are clearly present in Three Sisters and Mount Jefferson. Among the most prominent impacts is deterioration of vegetation at campsites (Bratton et al. 1978; Cole 1981, 1982, 1987, 1993; Cole and Fichtler 1983; Cole and Hall 1992; Cole and Trull 1992; Kellogg 1985; Marion 1991). Tens and sometimes hundreds of campsites have appeared at popular wilderness destinations. Managing these impacts is one of the wilderness manager's most pressing tasks.

In some areas, overnight use appears to be declining, and a great many more campsites exist than are needed to meet demand. The stable or declining rates of overnight use suggested that restoration efforts might be successful in some areas. One of the most effective tools to restore conditions is active campsite restoration and revegetation; leaving sites to recover on their own is generally ineffective (Cole and Ranz 1983; Stohlgren and Parsons 1986; Thornburgh 1986).

Although many wilderness managers have undertaken restoration efforts, the effectiveness of techniques rarely has been studied. This issue has been highlighted as a major research need in wilderness (Cole 1994). The third study in this dissertation tests four revegetation techniques to determine the ability of each to increase vegetation cover and composition. Six heavily impacted campsites in Three Sisters Wilderness were selected for study, and treatments were applied in a randomized block design in September, 1991. Three years later, in September, 1994, sites were revisited and experimental plots relocated. Measures of change in vegetation cover and species richness were made to determine the effect of each treatment.

Organization of the Dissertation

This dissertation follows the manuscript format of Oregon State University, and consists of three independent studies. Each study is presented as a single manuscript, suitable for publication in a scholarly journal. Chapter 5 summarizes findings, presenting management suggestions for the Willamette and Deschutes National Forests, and suggesting avenues for future research. The format of each chapter follows university guidelines. All references are included together in a single section after the body of the text.

CHAPTER 2. CHANGES IN USE OF THREE OREGON WILDERNESSES, 1976-1994

Designated wilderness makes up nearly one-sixth of all National Forest land and provides many important values for the American people. In many wildernesses, recreation is among the primary values, but at the same time presents a potential threat to the integrity of wilderness ecosystems and the quality of the wilderness experience. We have considerable information about visitor motives, behaviors, and attitudes, but it is surprising how little we know about the level and character of recreational use, and how unsuccessfully we have anticipated changes in use over time.

There are a variety of reasons that managers would want to understand levels and trends in wilderness use. At the national level, information about trends and demand provides useful input to forest planning and land allocation decisions; calls for wilderness have often been based on recreational demand. At the local level, such knowledge helps managers efficiently distribute scarce resources and design long-term projects. Managers who are aware of trends in their areas will make better decisions about how to handle use-related problems, may be able to anticipate and offset new problems, and can target their educational efforts more effectively.

Managers can use a variety of types of information about recreation use of wilderness (Lime and Buchman 1974; Lucas 1980; Plumley et al. 1978; Roggenbuck and Lucas 1987). Among the more helpful are total number of visits (groups and people), length of stay, method of travel, residence, past wilderness experience, and travel patterns of visitors within wilderness. Accurate information on total visitation allows comparison of use levels among wildernesses as well as over time, which in turn allows managers to focus on areas with the greatest real or potential problems. Information on length of stay has important implications for on-site visitor management and education; for example, managers of areas with mainly overnight use may want to target impacts related to camping. Knowledge of method of travel -- especially the extent and location of stock use -- is useful in addressing the impacts associated with livestock. Information on where visitors live can help managers plan educational programs in appropriate locations. Knowledge of how many visitors are repeat users can help in planning long-term educational projects and in anticipating lag times in behavioral changes. Understanding the distribution of use within a wilderness can narrow the focus to site-specific actions to deal with the effects of recreational use, balancing the need to manage impacts with the goal of maintaining a largely primitive and unconfined experience.

Unfortunately, few reliable data exist to evaluate current use levels and changes in use over time. Many wildernesses are large, remote, and have multiple access points, all of which make estimating use difficult and costly (Lucas et al. 1971; Petersen 1985; Roggenbuck and Lucas 1987). The earliest reliable sources of information are available from the 1970s. At that time, managers responded to rapidly increasing use by imposing a variety of regulations, often including mandatory wilderness permits (Hendee and Lucas 1973; Lime and Buchman 1974). The permits created a base of reasonably accurate use data during these years, at least for areas where compliance was high (Hendee and Lucas 1973; Leonard et al. 1978; Lucas et al. 1971; Parsons et al. 1982). During the 1980s, however, many permit systems were discontinued (especially at National Forest wildernesses), and estimates of use became less reliable (Roggenbuck and Lucas 1987).

Today, the Forest Service continues to report use figures annually for each wilderness, but the agency acknowledges that these numbers are based more often on educated guesses than on systematically collected data (Cole 1990, 1993; Hall et al. 1993; Washburne and Cole 1983). Even where measurement instruments (such as trailhead registers) exist, frequently there is no calibration for accuracy or noncompliance, and managers who fail to consider low and variable compliance rates often generate erroneous data (Lucas 1983). Many units simply rely on field-going managers or rangers for impressions of changes, but such intuitions may be unreliable in the many cases where field observations are not representative of typical use or where personnel turnover is too frequent to give managers a clear, accurate picture of long-term trends. In a study of 44 wildernesses in Oregon and Washington, most managers reported guessing at use figures, or simply adjusting the previous year's estimates by some inflation factor (Hall et al. 1993).

The Forest Service was criticized for its lack of baseline information and monitoring during a congressionally sponsored review by the General Accounting Office (1989). Eighty-one percent of managers nationwide reported that they measure or estimate use, but less than 4% require permits of all visitors and only 24% use trailhead registers. "According to some Forest Service officials, many estimates of wilderness recreational use are so poor that managers cannot use them for planning purposes or even to determine whether the use of an area is increasing or decreasing" (General Accounting Office 1989:15).

Despite the paucity and questionable accuracy of wilderness use data, a number of researchers have attempted to evaluate national trends, analyzing the aggregate figures provided by federal agencies. As they point out, "the patchy information is, unfortunately, the only game in town " (Lucas and McCool 1988:16). Based on such data, researchers generally conclude that use of the entire National Wilderness Preservation System increased dramatically during the 1970s, in part because of expansion of the system itself, but also because of increases in use of the original 1964 wilderness areas (Petersen 1981). However, most agree that since a peak during the 1970s and early 1980s, "the inescapable conclusion is that onsite recreational use is flattening or declining" (Lucas and Stankey 1988:365). In particular, total use of the original 1964 wildernesses appears to have declined about 20% between 1980 and 1987, from approximately 8.7 million recreational visitor days to approximately 7 million (Roggenbuck 1988).

Despite the agreement among researchers that wilderness use is declining, there are two reasons we might wish to reexamine the issue. First, the national scope of the 1980s summary papers may mask variations among individual wildernesses. It is possible that most or all wildernesses reflect the national trend, but it is also possible that increases in some areas are hidden by decreases in others.

The second reason to take another look at wilderness use involves the unit of measure employed. Studies of national trends (Lucas 1989; Lucas and McCool 1988; Lucas and Stankey 1988; Petersen 1981) generally have not considered how the unit by which use is measured can affect the interpretation of trends. Typically studies have relied on a single measure of use, the recreational visitor day (RVD), because this has been the standard measure of wilderness use reported by the Forest Service since the 1960s.

A recreational visitor day is equivalent to 12 person-hours. For example, either one person on a 12-hour trip or two people on a 6-hour trip would constitute one RVD. An advantage to using RVDs is that they take into account both the length of stay and the number of people in each group, and thus more accurately indicate the amount of direct contact with the resource than do visits. This may be useful in correlating use with ecological impacts, among other things. Unfortunately, RVDs are not intuitively meaningful for most people, and information on the number of visitors and length of stay is lost. (Knowing that a wilderness had 10,000 RVDs does not tell you whether this represents 20,000 day users or 1,000 people each on a 5-day trip.) Because of this, the choice of RVDs as the sole measure of use can conceal changes in the number of visitors over time. For example, if use is shifting from overnight to day use, RVDs could be declining while the total number of visitors is actually increasing.

This study used comprehensive data based on mandatory wilderness permits and voluntary registration from three Oregon wildernesses to evaluate how use changed over 18 years in Mount Jefferson and Three Sisters Wilderness and over 13 years in the Eagle Cap Wilderness. The objectives were to evaluate whether trends were uniform across these three areas and to see if the reported national trend of declining use was present in them. Examining the total number of visits, RVDs, and length of stay, we evaluated whether different units of measure offer different interpretations of changes for each area.

Methods

Study Areas

Mount Jefferson and Three Sisters are long, narrow wildernesses situated along the crest of the Cascade Mountains. They are readily accessible from the densely populated Willamette Valley on the west and the most rapidly growing county in Oregon (Deschutes County) on the east. Both contain large tracts of dense, low-elevation forest, but are especially popular for their scenic subalpine meadows near the crest. Although some interior destinations are remote, especially in the large lake basin in the south end of Three Sisters, most can be reached in a single day's trip from a trailhead. The 44,141-hectare Mount Jefferson Wilderness has 27 trailheads, of which five receive 69% of all visitors, while the 114,738-hectare Three Sisters receives 63% of all visitors through 10 of its 57 trailheads.

The Eagle Cap Wilderness lies in the Wallowa Mountains of northeast Oregon and is distant from large urban centers. This 147,773-hectare wilderness is suited for long pack trips, as many interior destinations are more than a day's journey from a road. The scenery in the Eagle Cap also is diverse, ranging from low-elevation dense forests, to basalt ridges forested with ponderosa pine, to high granite peaks, lakes, and meadows. This wilderness has approximately 30 access points, of which the top three received 61% of all use in 1993.

Measurement Techniques

The Cascades wildernesses have had mandatory, non-limiting permit systems at different times in the past, which have provided fairly reliable estimates of use after correction for noncompliance. From 1975 to 1983, each group was required to fill out a permit at the trailhead through which they entered, on which they recorded the number of people in the group, the length of stay, and their destination. They carried one copy with them and left one copy in a locked box at the trailhead. In the early 1980s, at least a dozen wilderness rangers patrolled these areas each year, contacting visitors and checking compliance with the permit system.

The permit requirement in Mount Jefferson and Three Sisters was discontinued after 1983, but was reinstated in 1991. This time, overnight visitors were required to go to a Forest Service office or cooperating commercial outlet to obtain their permits, while day users could obtain a permit at trailheads as before. Approximately 25 wilderness rangers patrolled these wildernesses in 1991, checking and enforcing compliance.

Different systems have been used in the Eagle Cap Wilderness. All visitors were required to obtain a permit from the late 1970s until 1982. These permits were available at ranger stations and commercial outlets, but not at most trailheads. Such a system usually results in low compliance; however, in this case volunteers were stationed seven days a week at the six most popular trailheads to issue permits to visitors.

In 1993, a voluntary registration system was implemented in the Eagle Cap, with registration stations at 24 trailheads. Compliance was assessed by observers stationed at 12 of the main trailheads, who unobtrusively watched visitors enter the wilderness over a total of 80 randomly selected days.

Units of Measure

For all years we have computed the number of people and groups entering each trailhead and the percent day use. Use estimates were obtained by correcting the number of permits collected from trailhead boxes by the overall noncompliance rate for each general destination area. We compared our RVD data to Forest Service estimates for the years 1984 to 1990 (when no use measurement system was in place) in order to evaluate possible problems with agency estimation in the absence of reliable measurement. Cascades data for 1976 and 1981 are taken from unpublished district records; for 1991 the data come from Shelby and Hall (1992), for 1992 from Hall and Shelby (1993), and for 1994 from Hall (1995). For the Eagle Cap Wilderness, the earlier data are from Bombaci (1980) and the later data from Hall and Shelby (1994).

In this analysis, we employed two units for measuring use: the recreational visitor day (RVD) and the visit.

Recreational Visitor Days

For 1976, 1980, and 1981, we used Forest Service reports of RVDs, because raw use data no longer exist. Forest Service reports contain summaries of the number of RVDs for each trailhead and for each user type. Although details of RVD calculations are not known, it appears that they were done carefully and with appropriate assumptions about the length of day trips.

For the 1990s data, we calculated RVDs in the following manner. Each day user was assumed to contribute 0.5 RVD, based on the observed average trip length of approximately 5-6 hours. Each overnight visitor was assigned one RVD for the first and last day of a trip, and two RVDs for each intervening day.

Visits

A visit is simply one trip into the wilderness, regardless of the length of stay. Visits can be computed for either groups or people, and when referring to groups are not sensitive to group size. For our purposes, we use both types of visits (groups and people). Information on visits was directly available for all years.

Results

Compliance with Permit and Registration Systems

District reports from the Cascades wildernesses characterize overall compliance between 1975 and 1980 at around 90% (USDA Forest Service 1977, 1980b). Most of the reports containing the raw data for compliance are no longer available, but those we could find appear to confirm the reports of high compliance. At the beginning of the permit system in 1975, for example, compliance in the west half of Mount Jefferson ranged from 76 to 89% (depending on location), based on ranger contacts with 692 individuals. Summaries of rangers' reports for this wilderness from the early 1980s give a compliance rate of over 80% overall. In 1981, rangers from the west side of Three Sisters Wilderness contacted 1,639 overnight campers, of whom 94% had a permit (USDA Forest Service 1980b).

For neither Cascades wilderness do we know the compliance rate of stock users versus hikers for the years prior to 1991, but ranger field records indicate that stock use was a small proportion (less than 5%) of total use. Thus, even if stock users complied at a lower rate (as has been found elsewhere), this is unlikely to have skewed the data substantially. We also cannot be certain whether there were differences between day and overnight users; in general both user types appear to have been combined in overall estimates of compliance. Despite these gaps in the data, we think that the early compliance figures for the Cascades are reasonably reliable. Permits were available at trailheads, reducing the likelihood of noncompliance. Furthermore, earlier experiments with unmanned voluntary registration stations in Three Sisters had found registration rates around 80% for both day and overnight hikers (Wenger 1964; Wenger and Gregerson 1964), and compliance probably increased after the system became mandatory and visitors became more accustomed to it.

In 1980, Forest Service personnel estimated that compliance with the mandatory permit in the Eagle Cap Wilderness was high (around 85%), but accurate calculations of compliance apparently were not made (Bombaci 1980). The presence of personnel at the major trailheads all week during the summer and fall hunting season undoubtedly improved compliance rates. In 1993, the top six trailheads accounted for 76% of all use; if the same was true in 1981, then it is likely that most visitors were contacted by a volunteer and issued a permit. Personnel who administered the system at the time feel confident that compliance was over 80% (Doris Tai, personal communication).

Compliance data for the 1990s are more complete for all three wildernesses (Figure 2.1). In 1991, rangers contacted 1,786 visitors in Mount Jefferson and 1,950 in Three Sisters (Shelby and Hall 1992). Compliance ranged from a low of 75% to a high of 95%, depending on the specific location, and was above 80% overall. Compliance did not vary significantly between day and overnight visitors, or between hikers and stock users. In subsequent years, compliance has increased slightly. In 1992, 12% of the 3,397 groups contacted failed to obtain a permit (Hall and Shelby 1993), and in 1994, 10.6% of 3,354 groups did not obtain a permit (Hall 1995). These compliance rates are unusually high and generate reliable use estimates.

In 1993, trained observers checked compliance with the new voluntary registration system in the Eagle Cap (Hall and Shelby 1994). They observed 538 groups entering the wilderness, one-quarter of whom traveled with stock. Compliance varied considerably, depending on length of stay and method of travel, and was similar to rates reported from other wildernesses in the intermountain west (Lucas 1981; Lucas et al. 1971; Petersen 1985). Overnight hikers complied at the highest rate, with 63% registering. Approximately one-quarter of day hikers and overnight stock users registered, while only 9% of stock users on day trips registered. Because of these large differences, separate projections were made for each user type based on its specific rate of compliance. The compliance rates for day riders were so low that the potential for error in the estimate is greater for this user type.

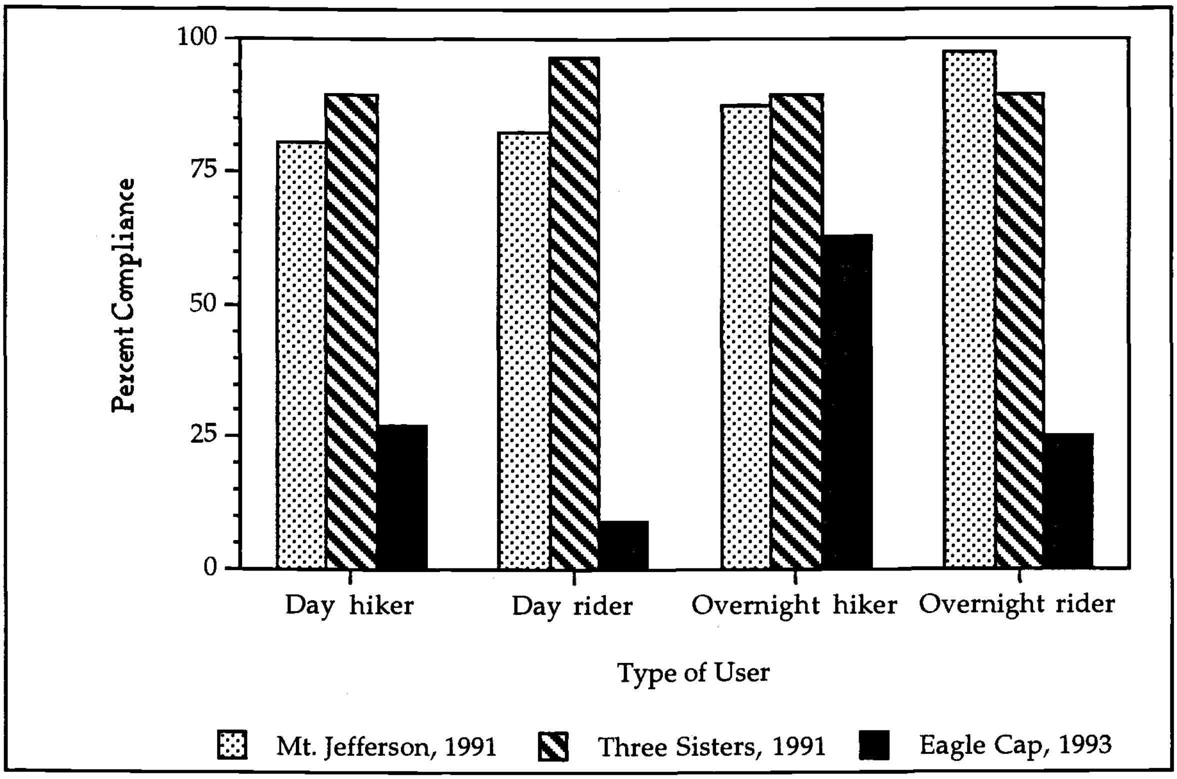

Figure 2.1. Compliance with Wilderness Permits

Use Changes Over Time

Recreational visitor days have declined substantially over the past 13 to 18 years in all three wildernesses; the solid lines in Figure 2.2 provide the more reliable data based on permits. In the Eagle Cap, use dropped from over 90,000 to approximately 33,000 RVDs. RVDs in Mount Jefferson and Three

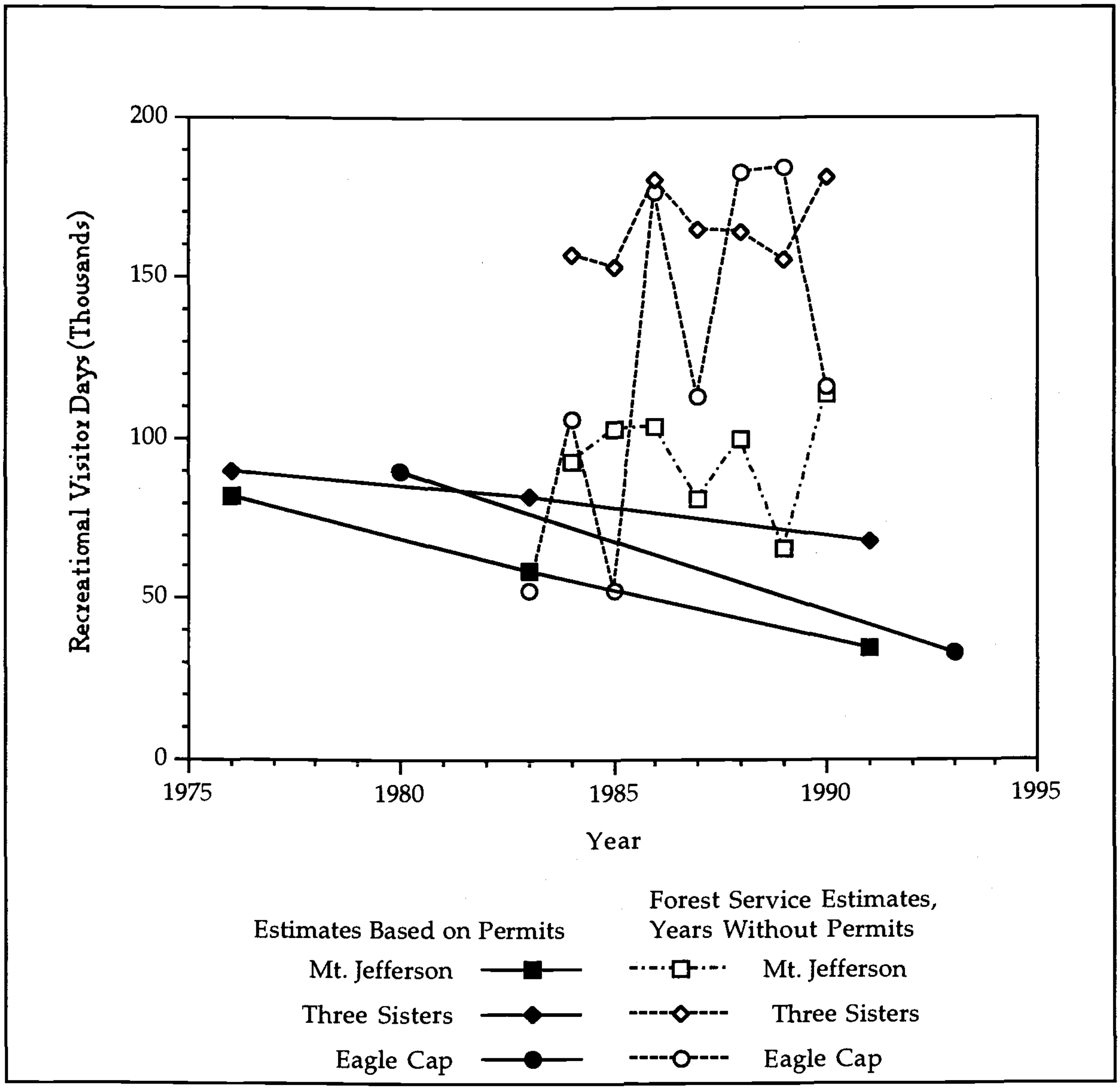

Figure 2.2. Changes in Recreational Visitor Days

Sisters together totaled 172,200 in 1976, but had dropped to approximately 103,000 in 1991. The 18-year decline in Mount Jefferson was comparable to the decline in the Eagle Cap, but in Three Sisters the decline was less pronounced.

The trend data based on permits are represented by only two data points for Eagle Cap and three for Three Sisters and Mount Jefferson, and changes in the intervening years are unknown. Undoubtedly, there was some yearly fluctuation. Forest Service estimates from years when no permit system was in place (open symbols and dashed lines) are usually higher than the trends suggested by the permit data, and vary widely year to year.

For visits, the picture was different (Figures 2.3 A and B). In the Eagle Cap, the number of groups approximately doubled, while the number of people increased more than 50%. Increases were generally consistent across all entry points. In Three Sisters, little difference was observed between 1976 and 1981, but in 1991 the number of visits was 50% higher than in 1981, owing to large increases in certain portions of the wilderness. Data from 1992 and 1994 show a continued increase in visitation. In Mount Jefferson, the overall number of visits remained relatively constant across all time periods, increasing from 8,331 to 10,145 groups over the time span. Increases in some areas within Mount Jefferson were offset by decreases in others. Thus, while RVD trends were similar in direction in all three areas, changes in visits were not.

The different trends in RVDs and visits may be partly the result of changes in group size and length of stay (Table 2.1). Overnight use has declined as a proportion of all use in all three wildernesses, from more than 60% of all visits in the earlier years to less than 40% in the 1990s. In Three Sisters, overnight use now makes up less than 25% of all visits. At the same time, overnight visits have shortened. In 1976, overnight campers stayed an

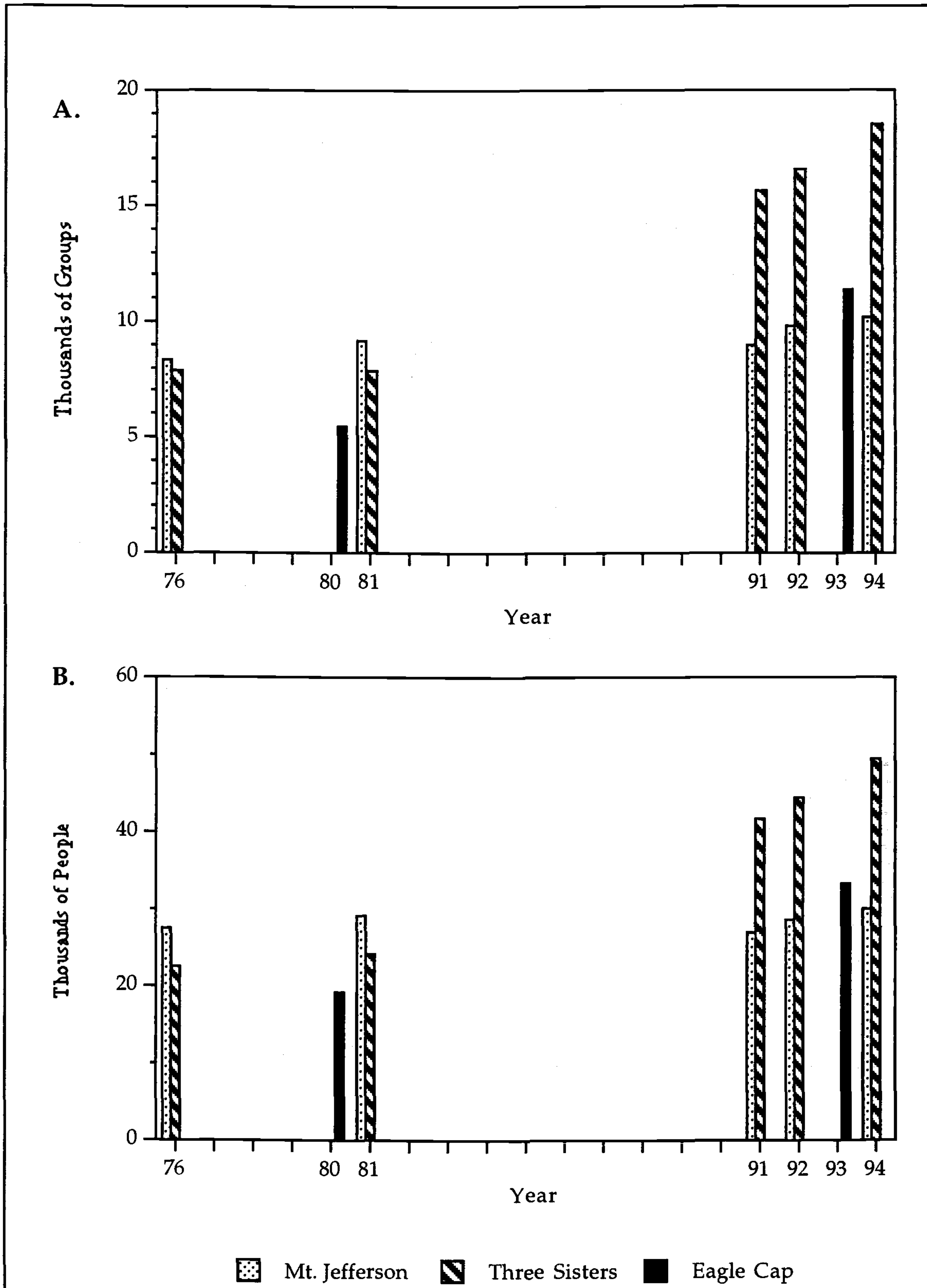

Figure 2.3. Changes in Visits: (A) Groups; (B) People

average of 3.4 days per trip in Three Sisters and 2.9 days in Mount Jefferson; today these averages are 2.5 and 2.3 days, respectively. Group size also declined slightly, from an average of 3.1 to 2.7 in Three Sisters, from 3.3 to 3.0 in Mount Jefferson, and from 3.5 to 3.1 in Eagle Cap. This appears to be a long-term trend; Wenger and Gregerson (1964) reported an average group size of 3.9 for Three Sisters in 1960 and 1961.

Table 2.1. Changes In Characteristics of Wilderness Use

	Year					
Wilderness	1976	1980	1981[1]	1991	1992	1993
	Percent Overnight Use					
Eagle Cap		74				30
Mt. Jefferson	66		50	37	39	
Three Sisters	61		50	23	24	
	Average Stay (Days) for Overnight Users					
Eagle Cap		2.6				2.4
Mt. Jefferson	2.9			2.3		
Three Sisters	3.4			2.5		
	Average Group Size					
Eagle Cap		3.5				3.1
Mt. Jefferson	3.3			3.0		
Three Sisters	3.1			2.7		

[1] Data for 1981 are taken from Forest Service reports and are approximate.

Discussion

Changes in Use

Many researchers have concluded that wilderness use is in decline and have attempted to explain this finding in terms of changes in leisure pursuits, demographics, or other factors (Hendee et al. 1990; Lucas 1989; Lucas and McCool 1988; Lucas and Stankey 1988). One explanation of this trend lies in the use of RVDs in most analyses. National aggregate figures show a decline of about 20% in RVDs from 1980 to 1987 (Lucas and McCool 1988), and our data concur. In the Oregon study areas, the declines over this interval were approximately 30% for Eagle Cap and Mount Jefferson and about 10% for Three Sisters.

For visits by groups or people, our data do not support the conclusion of declining use. In Mount Jefferson, the number of group visits increased 20%, while in the other two wildernesses it increased by more than 100%.

Why has the number of RVDs dropped so dramatically when the number of visits is stable or increasing? The answer lies partly in the changing user composition and nature. In 1976, less than one-third of all visitors to the Cascades wildernesses were day users; today up to three-quarters take day trips. Similarly, in the Eagle Cap Wilderness in 1980, less than one-third of all visitors were day users, compared to over 70% today. In these areas the average day trip is five or six hours, or about 0.5 RVD per person. The average overnight visitor, in contrast, contributes four to five RVDs. Thus, when overnight use declines, RVDs decline rapidly. Also contributing to a decline in RVDs has been the shift to smaller groups and shorter stays by overnight campers.

Data reported by Lucas and McCool (1988) for National Park Service overnight stays (based on permits and presumably reliable) show a leveling or decline in visits after about 1975 that continued until 1987 (the last year for which data were reported). This coincides with the decline in overnight visitation we found in Oregon.

Many researchers have commented on the significance of day use in wilderness, but few have investigated this type of use in depth (Burde and Daum 1990; Roggenbuck 1988; Roggenbuck et al. 1994; Washburne and Cole 1983). Trend studies are especially rare, although trends toward increasing day use and smaller groups have been observed by other researchers for wildernesses in the Rocky Mountains (Lucas 1989; Lucas and McCool 1988) and Great Smoky Mountains National Park (Burde and Curran 1986).

Shifts to day use and shorter overnight stays may have a variety of causes and are consistent with changes in outdoor recreation in general (Betz and Cordell 1988; Cordell and Siehl 1989). Available leisure time has declined substantially over the past few decades and increases in the number of two-income households makes coordination of leisure time difficult (Hartmann et al. 1988; O'Leary et al. 1988; Szwak 1988). Therefore, long vacations are replaced by long weekends or more numerous but shorter trips. An aging population may also account for declines in overnight wilderness use, which tends to be more strenuous than day hiking (Jackson 1994; Lucas and McCool 1988).

The trend toward more frequent trips closer to home may mean that urban-proximate wildernesses will experience increased visitation while more distant wildernesses could see less (Ewert and Hood 1995). This could explain findings for Three Sisters and Mount Jefferson, which are within 2 hours of several large cities. However it does not fit with trends in the Eagle Cap, which has increasing visitation despite its remote location.

Can demographic changes account for the increases in visits to Oregon wildernesses? As population grows, the number of wilderness visits should increase, if per capita visitation rates remain stable. If Oregon is growing more rapidly than other states, the trends seen in these three areas may not be repeated elsewhere. Between 1970 and 1980, Oregon's population grew 26%, compared to 11% for the nation as a whole, yet during this interval, the number of visits did not appear to increase greatly. Between 1980 and 1990, Oregon's growth slowed to 8%, compared to 10% for the nation. Oregon's population has increased more rapidly than the northeast or midwest (which have grown only a few percent since 1970), but has been comparable to or slower than that of California and the mountain west (US Bureau of the Census 1994). Thus, it seems unlikely that changes in wilderness use in Oregon are anomalous by reason of overall population changes.

This level of demographic analysis is coarse, and it would be more fruitful in the future to relate wilderness use trends to demographic trends of more relevant subpopulations. For example, we know that wilderness users tend to be somewhat younger than average, well-educated, affluent, white, and male (Hendee et al. 1990; Roggenbuck and Lucas 1987; Watson et al. 1992). Given this, it would be interesting to see how well changes in wilderness use could be predicted by changes in these populations near wilderness areas. Important demographic factors related to recreational use include age structure, rate of growth, percent minority, education, and socioeconomic status (Boothby et al. 1981; Murdock et al. 1990; Murdock et al. 1991; Shindler 1993; White 1975).

Management Implications

The divergent interpretations that arise from different measures of use have a variety of management implications. Trend information aside, managers need to understand what objectives might be served by using different measures of use. For instance, if the goal is to contact and educate individual visitors, then RVDs are not a particularly useful measure and will not tell managers how many groups there are to contact. Visits would be more appropriate. If managers' primary concern is relating ecological impacts to use, then RVDs, or perhaps RVDs generated from overnight use only, might be more appropriate. Managers are likely to find that different management issues are addressed by different measures of use, and they would probably benefit from assessing use in more than one way. We recommend that annual reporting include not only estimates of total RVDs, but also estimates of day and overnight use and number of visits. Some areas collect this information now, but usually only RVDs are reported. Methods of data collection should also be reported.

A review of some recent wilderness management plans suggests that managers have not understood or dealt with the decline in overnight use and shift to day use. Management plans often focus on impacts at campsites and restrictions pertaining to camping. Managers have not addressed the possibility that areas receiving much less overnight use now than in the past may be recovering on their own, and past intensive levels of site management may be unnecessary. At the same time, many managers continue to close popular sites to overnight camping, but not to day use, which can often be heavy enough to maintain levels of impact.

Management plans we have seen do not deal with social issues specific to day use. Increasing day use in concentrated areas can have major impacts on the quality of the wilderness experience. Popular day use destinations in the areas we studied are becoming more crowded, and few agency policies address these problems. Restricted use permit systems still deal almost exclusively with overnight use, even where overnight use now makes up only a fraction of all use. For example, in Colorado's Indian Peaks, overnight use is restricted to a few thousand groups per season, while day use, which is estimated at 80% of all use, is unregulated. To deal with crowding in Alpine Lakes Wilderness, managers are proposing to limit overnight use next year, despite the fact that most of the visitors are day users.

The importance of how we measure and report use extends beyond the boundary of the wilderness itself. If decisions are based on information about trends, and if different units of measure suggest different trends, then one must carefully choose the unit of measure. National leaders and decision-makers need to know about the public's interest in and demand for wilderness. A decision maker who reads that use (RVDs) is steadily declining may infer that interest is waning. However, one who reads that use (visits) has doubled over a decade may infer the exact opposite. Some researchers have concluded that declines in use mean that increasing demand should no longer be cited as a legitimate reason for increased allocation of wilderness (Lucas 1989). Our data suggest that this conclusion may not be warranted.

Wildland recreation provides major economic benefits to many western states, and wildland visitors tend to stay longer and spend more than other tourists (Yuan and Moisey 1992). Local communities could also be better served by more accurate reporting of wilderness use. Shifts from overnight to day use may mean more business for certain sectors of the local economy and less for others. For example, day users may provide more business for local motels and restaurants, but less for sporting goods stores that provide camping equipment.

Comparison with Forest Service Estimates

The data we collected allow a tentative assessment of the quality of Forest Service estimates for years when no permit or registration systems were in place. Agency estimates usually overestimated use and varied widely for unknown reasons. A similar pattern has been reported for wildernesses on the Gifford Pinchot National Forest in Washington, where a new mandatory permit system demonstrated that earlier figures probably overestimated use by as much as 300% (Mike Rowan, personal communication).

The consistent tendency to overestimate use when data are not available should cause us to question annual reporting as well as projections of use over time. Similarly, we should question the use of aggregate national figures in assessing trends in use. Some researchers have assumed that overestimates in some areas are offset by underestimates in other areas, leading to a reasonably accurate overall national picture (Lucas 1989). Our data do no support this assumption, because in each case we know of, the usual error was to overestimate use when a measurement system was not in place.

We recommend that researchers not rely exclusively on aggregate national figures provided by the federal agencies, but rather use only those based on reasonably reliable estimate procedures, such as registration or permits with known and relatively high compliance. Similarly, we recommend that the Forest Service alter its measurement and reporting systems. Ideally, more accurate estimation procedures would be implemented, but failing this, the agency should report how it arrives at annual figures for each wilderness. This would allow researchers to separate more accurate data from less accurate estimates. We agree with Lucas and McCool, who point out that "professional wilderness management is seriously hampered if use trends cannot be tracked with confidence" (1988:20).

CHAPTER 3. DAY USERS OF WILDERNESS:
PERCEPTION OF IMPACTS AND ATTITUDES TOWARD MANAGEMENT

Introduction

When researchers and land managers began paying serious attention to wilderness recreation during the 1970s, overnight use was their dominant focus. Although some areas were popular as day use destinations, the majority of visitors to many wilderness areas were overnight travelers. Remoteness of access, characteristics of visitors, visitor preferences, and available leisure time contributed to this tendency. Even where day use made up the majority of use, researchers and managers paid more attention to the experience, impacts, and management of overnight use. Today, there is increasing recognition that day users make up a large portion of use in some areas, and they may have different experiences and attitudes than overnight users.

Background

Many early papers on wilderness management addressed use and use-related problems as if all visitors were overnight users. In part, this is because the numbers of users appeared to justify such an emphasis. During the 1970s, wilderness use was obviously increasing around the country, and Forest Service researchers devoted attention to developing instruments and procedures to estimate use accurately and reliably (Echelberger et al. 1981; James and Schreuder 1971, 1972; Leatherberry and Lime 1981; Leonard et al. 1980; Lime and Buchman 1974; Lime and Lorence 1974; Lucas 1980, 1983; Lucas and Kovalicky 1981; Lucas et al. 1971; Wagar 1969; Wenger 1964; Wenger and Gregerson 1964). Of 31 areas studied before 1980, 15 were predominantly overnight destinations, 9 were predominantly day use destinations, and 7 could not be clearly categorized (Table 3.1).

Not only did research show that overnight use was dominant in many areas, but managers of most wildernesses also believed this to be the case. A 1978 study by Washburne and Cole (1983) obtained data from 122 Forest Service wildernesses or primitive areas regarding day use. Respondents from 61% of the areas estimated day use to comprise less than half of all use, and only 20% reported day use to be more than 70% of all visits. In many cases these estimates represented best guesses and were not based on accurate use estimation techniques, but they indicate nevertheless that most managers in the late 1970s believed most wilderness use was by overnight visitors.

In part, the focus on overnight use arose from a relative inability to document day use accurately. In many wildernesses, overnight visitors have been required to obtain a permit, which can generate reasonably accurate use estimates. Day users are often excused from this obligation, especially in National Parks, leaving little reliable information to judge the number of day users for most wildernesses. Furthermore, most of the early research was conducted in the northern Rocky Mountain states. These areas may have had higher proportions of overnight use than areas closer to large urban centers.

A tacit assumption that overnight users are and should be the primary clientele for management may also have contributed to a focus on overnight use. The profile of the wilderness visitor as seeking solitude, opportunities for contemplation, escape, and self-reliance seems to fit the overnight visitor

Table 3.1. Proportion of Day Use Reported in Wilderness Studies

Location	State	Year	% Day	Source
Three Sisters	OR	1961	77	Wenger & Gregerson 1964
San Gorgonio	CA	1969	54	James & Schreuder 1971
Bob Marshall	MT	1970	14	Lucas 1980
Cabinet Mountains	MT	1970	67	Lucas 1980
Great Bear	MT	1970	25	Lucas 1980
Jewel Basin	MT	1970	80	Lucas 1980
Mission Mountains	MT	1970	62	Lucas 1980
Scapegoat	MT	1970	41	Lucas 1980
Spanish Peaks	MT	1970	63	Lucas 1980
Mission Mountains	MT	1970	80	Lucas et al. 1971
Superstition		1970	80	Lewis 1971
S. Appalachian Trail	VA,TN, NC, GA	1970-71	53	Murray 1974
Cranberry	W V	1972	51	Echelberger & Moeller 1977
Boundary Waters	MN	1972	44	Lime & Buchman 1974
Selway-Bitterroot	MT/ID	1971	48	Lucas 1980
Selway-Bitterroot	MT	1973	ca. 63	Lucas 1981
Desolation	CA	1974	40	Roggenbuck & Lucas 1987
Boundary Waters	MN	1974	41	Roggenbuck & Lucas 1987
Boundary Waters	MN	1976	55	Lime 1977
Great Gulf	NH	1976	70-75	Leonard et al. 1978
Boundary Waters	MN	1977	45	Lime 1977
Eagles Nest	CO	1977	36	Haas 1979
Rawah	CO	1977	12	Haas 1979
Weminuche	CO	1977	16	Haas 1979
Bridger	WY	1978	11	Manfredo 1979
Fitzpatrick	WY	1978	12	Manfredo 1979
Joyce Kilmer/Slickrock	NC	1978	29	Timm 1980
Linville Gorge	NC	1978	53	Timm 1980
Maroon Bells-Snowmass	CO	1978	38	Roggenbuck & Lucas 1987
Popo Agie	WY	1978	7	Manfredo 1979
Shining Rock	NC	1978	32	Timm 1980
Rattlesnake	MT	1978	93	Kelley 1979
Spanish Peaks	MT	1978	69	Lucas & Kovalicky 1981
Mt. Jefferson	OR	1979	34	Petersen 1980
Appalachian Trail	VT	1979	50	Potter & Manning 1984

Table 3.1. Proportion of Day Use Reported in Wilderness Studies (Continued)

Location	State	Year	% Day	Source
Pusch Ridge	AZ	1979-80	78	Roggenbuck & Lucas 1987
Eagle Cap	OR	1980	26	Bombaci 1980
Mt. Hood	OR	1980	71	USDA Forest Service 1980a
Bob Marshall	MT	1982	10	Roggenbuck & Lucas 1987
Bob Marshall	MT	1982	51	Petersen 1985
Scapegoat	MT	1982	34	Roggenbuck & Lucas 1987
Great Bear	MT	1982	37	Roggenbuck & Lucas 1987
Great Smoky Mt. NP	NC	1983	18	Burde & Curran 1986
Aravaipa		1987	35	Moore et al. 1989
Caney Creek	AR	1989	38	Watson et al. 1992
Cohutta	GA	1989	55	Watson et al. 1992
Upland Island	TX	1989	52	Watson et al. 1992
Shining Rock	NC	1990	46	Roggenbuck et al. 1994
Charles Deam hikers	IN	1990	51	Watson et al. 1993
Pusch Ridge		1991	90	Suriano 1992
Mt. Jefferson	OR	1991	63	Shelby & Hall 1992
Three Sisters	OR	1991	77	Shelby & Hall 1992
Mt. Washington	OR	1991	83	Shelby & Hall 1992
Dolly Sods	VA	1991	19	Hollenhorst & Stull-Gardner 1991b
Cranberry	WV	1991	22	Hollenhorst & Stull-Gardner 1991a
Cohutta		1992	43	Shafer 1993
Eagle Cap	OR	1993	71	Hall & Shelby 1994
Mt. Hood	OR	1994	87	USDA Forest Service 1995
Columbia	OR	1994	74	USDA Forest Service 1995
Salmon-Huckleberry	OR	1994	89	USDA Forest Service 1995

better than the day visitor, who may simply be out for a few hours of exercise in a pleasant setting (Ewert 1989). Furthermore, overnight visitors are often the main source of recreational impacts to the biophysical resources of wilderness, such as those associated with campfires or trampling around campsites. If overnight users are the main source of impacts as well as the primary clientele, then a focus on them to the exclusion of day users might be understandable.

Management actions in wilderness have often been geared exclusively toward overnight visitors. In many National Parks and some National Forest wildernesses, for example, overnight visitors face restricted entry, while day users do not (Parsons et al. 1981; Van Wagtendonk and Coho 1986). Similarly, regulations are created to limit campfires or camping; frequently campsites or impacted areas are closed to overnight use in attempts to minimize ecological impacts, but are left open to day users.

However, there is currently increasing recognition that day use is an important, growing, and undernoticed component of wilderness use (Burde and Daum 1990; Roggenbuck et al. 1994). In many areas, the majority of visitors today take trips of less than a full day. Table 3.1 shows some notable examples from the late 1980s and early 1990s, where more than half and sometimes more than three-quarters of all visitors are day users. Nevertheless, the published literature still contains little about who day users are or their preferences and attitudes regarding wilderness conditions. We know little about the demographic characteristics of day users, the experiences they desire or attain in the wilderness, or their attitudes toward management actions.

Importance of the Issue

Why should we care if there are differences between day and overnight visitors in experience or attitudes? One reason concerns our ability to understand trends accurately. Managers may study changes in visitor attitudes and perceptions over time as a way to evaluate the effectiveness of past management strategies and to help devise new ones (Watson & Cronn, 1994). If day and overnight visitors differ in their tendencies to notice impacts, at the same time that the proportions of each user type are changing, real changes in attitudes, perceptions, or conditions over time could be obscured by the changing use trends. Survey results could show "improvement" in conditions, where the real change is one of fewer sensitive overnight users and higher numbers of less-sensitive day users. Objective changes in resource conditions may or may not have occurred. Few reliable longitudinal data are available, but of the wildernesses listed in Table 3.1 for which multiple years of data are available, the proportion of day use appears to be stable (Bob Marshall, Spanish Peaks) or rising (Shining Rock, Great Bear, Mt. Jefferson, Pusch Ridge, Eagle Cap, Mt. Hood).

Second, managers whose major clientele consists of day users may have a different climate in which to work than managers of overnight users. If, for example, overnight visitors are more accepting of regulations than day users, regulations will be met more warmly in areas with more overnight use than areas with more day use. In today's world of vocal public participation and legal challenge, such differences may be important for managers to accommodate or at least comprehend.

Theory and Hypotheses

We might expect differences between day and overnight users to emerge along two lines: differences related to motivations for visiting wilderness, and differences related to the way each type of visitor uses the wilderness. Careful thought and suggestions from previous research generate hypotheses about potential differences between day and overnight visitors in terms of the impacts they notice, their assessment of those impacts, and their views about wilderness management strategies.

Impacts Noticed

Encounters with Other Groups

Most use of wilderness occurs along busy portal trails, within a few miles of the trailhead (Hendee et al. 1990). This is especially true of areas receiving high levels of day use. On their way in and out of the wilderness, day users generally travel only on these busy portions of trail, while overnight users have the opportunity to travel into more remote portions of the wilderness. Thus, day users should encounter more other groups than overnight users. Few studies have compared encounter rates for day and overnight visitors; however two studies in the Bob Marshall Wilderness Complex found that day users averaged meeting about three other groups per day, compared to about one for overnight users (Lucas 1985b).

Hypothesis 1: Day users will report more encounters per day with other parties than will overnight users.

Impacts Along Trails and Near Trailheads

Any impacts that occur within a few miles of trailheads (the area traveled by both day and overnight users) and that are near the trails should be observed equally by both user types. Since nearly all users travel on maintained trails, one would expect to find no differences in the trail-related impacts they observe, as long as those impacts occur on trails that both groups use. Similarly, if campsite impacts such as vegetation loss, erosion, or tree damage occur at day use destinations or along portal trails, both groups should notice these impacts equally. There seems to be no a priori reason to assume a differential propensity to notice impacts.

Hypothesis 2: There will be no difference between day and overnight users in perception of impacts that occur along portal trails or close to trailheads.

Impacts Away From Trails or at Interior Destinations

Differences in the way day and overnight visitors use the wilderness could generate differences in the impacts each notices at areas away from portal trails. Day hikers (who generally stay on trails) may be less likely to notice impacts associated with campsites, which are often away from trails. Overnight visitors, on the other hand, are more likely to explore campsites and their surroundings, leave the trail, traverse more area, and spend more time in the wilderness, and thus should have the opportunity to see more and different impacts. Any impacts that are found in the interior but not within a few miles of the trailhead would not be noticed by day users, but could potentially be noticed by overnight users.

Differences between day and overnight visitors in perception of impacts have not been systematically investigated; however some evidence has been reported. For example, Burde and Curran (1986) found day users less likely than overnight users to notice litter in Great Smoky Mountains National Park. Similarly, day users in the Desolation Wilderness were likely to notice fewer resource or social impacts than were overnight visitors

(Watson and Cronn 1994). Although Roggenbuck, Timm, and Watson (1979) found few differences in perception of social problems, where differences existed, overnight users were more likely to notice the problems.

Hypothesis 3: Overnight users will be more likely than day users to notice impacts that occur off main trails or far from trailheads.

Evaluation of Impacts

Differences in purpose and perception of wilderness values could create differences in the way day and overnight visitors react to the impacts they notice and in their attitudes toward various management actions (Ewert 1989; Ewert and Hood 1995). If the two types of users view the wilderness as a different type of resource, these motivations might be manifest in different attitudes (Manning 1985; Stankey 1973). This assumption is part of the ROS system used by managers for site planning; different managerial, social, and physical settings provide different kinds of recreational opportunities. If overnight visitors are seeking the "traditional" type of wilderness experience -- solitude and naturalness -- they may desire fewer encounters with others, less development, and more freedom to contemplate the spiritual values of wilderness in a primitive and unaltered environment. Findings from Grossa (1979), Roggenbuck et al. (1979), and Fazio (1979) suggest that overnight users may seek a more truly "wilderness" experience. The time and effort required is substantially greater for overnight trips, therefore the commitment to wilderness may be greater among overnight users. Day users may visit wilderness for the scenery, a chance to spend time with family or friends, or to get some exercise in a pleasant environment (Ewert and Hood 1995; Lucas

1980). If overnight visitors are more 'purist' than day users, they may be more sensitive to impacts, both social and ecological, and more supportive of management actions designed to protect the wilderness experience and the primitive setting.

The literature provides little guidance regarding reaction to impacts; the only discussions concern encounters and solitude. Overnight users are more likely to say they saw too many other people (Lucas 1985a; Watson 1993), or to express less satisfaction at higher levels of encounters (Roggenbuck et al. 1979). Day users in the Bob Marshall Wilderness Complex were less sensitive to issues of solitude (Lucas 1980).

Hypothesis 4: Overnight users will evaluate impacts they notice more negatively than will day users.

Support for Management

Evidence in the literature regarding support for management actions is mixed. Roggenbuck et al. (1979) reported almost no difference in support for restrictive actions, except in Linville Gorge, where overnight users were more amenable to use limits. Watson (1993) found that overnight users in the Desolation Wilderness were slightly more in favor of group size limits, limits on day use, and penalties for entering the wilderness without a permit. However, both user types equally supported restricting the number of visitors if the area were used beyond capacity. In the Bob Marshall, Yang (1986) found no differences in support for limits on use at overused areas or for group size limits. Here, however, overnight users were less likely to support restrictive actions such as assigned campsites, prohibitions on fires, and restrictions on camping near water. Grossa (1979) reported that day users are consistently more supportive of conveniences (bridges, toilets, tables, or signs) than overnight visitors. We found similar tendencies in the Eagle Cap Wilderness, where day users were more in favor of toilets, corrals, and the use of chainsaws (Hall and Shelby 1994).

These findings present a somewhat limited and confusing picture of visitor support for management actions; some suggest that overnight users look more favorably on restrictions, while others suggest that self-interest prevails. Noe and Hammitt (1992) found that recreationists may have opinions that are strongly environmental in response to general questions, but express less support for specific actions that would restrict their own behavior, even when the restrictions are consistent with their more general attitudes. Thus, the following two hypotheses were proposed.

H5a: Overnight users will be more supportive than day users of regulations or actions that affect all visitors equally.

H5b: Overnight users will be less supportive than day users of regulations or actions that adversely affect their own behavior more than that of others.

Study Areas and Methods

Mount Jefferson and Three Sisters Wildernesses lie along the spine of the Cascade Mountains in Oregon, close to the Portland, Salem, Eugene, and Bend metropolitan areas. These wildernesses are long and narrow, giving day users easy access to scenic subalpine areas. Mount Jefferson receives more overnight use, with several lake basins having nearly 50% overnight use.

Three Sisters, on the other hand, is mostly used by day visitors, especially on its eastern side.

In 1991, we studied visitors to two destinations in Three Sisters (Obsidian Falls and Green Lakes) and one destination in Mount Jefferson (Marion Lake). All three are among the most heavily used destinations of both wildernesses, and are easily accessible by day users. Green Lakes offers spectacular scenery on a relatively easy 14-kilometer round trip, while Obsidian Falls provides slightly more strenuous access to subalpine meadows and scenery on the west side of the Cascades. Marion Lake (146 hectares) lies at the end of an easy 4-kilometer hike through dense old growth forest, and provides the best native fishery in Mount Jefferson. In 1991, a mandatory permit system generated use estimates of over 6,000 people entering the Green Lakes trailhead, which accounted for 13% of all visits to Three Sisters (Table 3.2). Approximately 3,000 entered at Obsidian Falls trailhead. Marion trailhead had approximately 4,500 visitors, 16% of all visits to the Mt. Jefferson Wilderness (Shelby and Hall 1992).

Sample days were randomly chosen throughout the summer, between June 14 and September 28. Originally 10 weekend days or holidays and 15 weekdays were randomly selected for sampling. Personnel constraints ultimately generated the sample configuration presented in Table 3.3. On sample days, a researcher was present from 9 a.m. until 6 p.m. at the trailhead to contact all visitors leaving the wilderness and ask them to fill out a questionnaire. Occasionally the number of people present at the trailhead made it impossible to contact all individuals; the proportion contacted was 92% at Marion Lake, 86% at Obsidian Falls, and 62% at Green Lakes. At Obsidian Falls and Marion Lake, surveys were administered by an Oregon

Table 3.2. Use Levels, 1991

Study Area	Total People	% Day
Three Sisters		
Green Lakes	6045	79
Obsidian Falls	2974	51
Entire Wilderness	46732	77
Mount Jefferson		
Marion Lake	4457	55
Entire Wilderness	27890	63

Table 3.3. Response Rates and Sample Sizes

	Sample Days (n)		Sample Size (n)		Response Rate (%)	
Location	Weekday	Weekend	Day	Overnight	Day	Overnight
Green Lakes	16	7	341	115	67	75
Obsidian Falls	18	11	132	183	79	75
Marion Lake	10	9	153	168	77	70

State University employee, while at Green Lakes a uniformed Forest Service employee administered questionnaires.

Respondents were asked to complete a 3-page questionnaire on-site. Response rates were in the range of 70-75% for all locations (Table 3.3). Few individuals refused to participate outright; non-respondents were usually those who asked to take the survey home with them and return it by mail.

Questionnaires asked about the number of groups encountered on the day of the survey, as well as past experience at the study site and other wildernesses. Visitors were asked to report whether they noticed any of 10 social and ecological impacts. Those who noticed impacts were asked whether each impact detracted a lot, a little, or not at all from their experience. Two sets of questions investigated attitudes toward management actions. One presented a list of 9 actions currently in place, four of which affect all visitors and five of which target overnight users. Those who were aware of these actions were asked to report whether the action detracted a lot, a little, or not at all from their experience. The second question presented a list of 10 potential actions not yet in place, and asked visitors to state their support or opposition toward the actions on a 5-point Likert-type scale.

In the text, p-values of .05 or less are taken to indicate statistical significance. However, given the number of tests conducted (32 for perception of imipacts, 35 for evaluation of impacts, and 55 for attitudes toward management actions), one would expect such values to appear about six times by chance.

Results

Past Wilderness Experience

Several studies have suggested that past experience and commitment to an activity are related to desired site attributes and perceptions of conditions, with more specialized users being more sensitive and demanding

Table 3.4. Past Wilderness Experience

Variable	Day	Overnight	p
Number of other wildernesses visited[1]			
Green Lakes	10.5	9.7	.58
Obsidian Falls	11.9	9.9	.17
Marion Lake	13.5	6.7	.0015
Years since first visit to this wilderness[1]			
Green Lakes	4.5	5.8	.15
Obsidian Falls	5.9	4.8	.19
Marion Lake	8.3	6.1	.06
Frequency of all trips (6 categories)[2]			
Green Lakes	3.5	3.7	.33
Obsidian Falls	3.8	3.6	.55
Marion Lake	3.8	3.3	.012
Number of previous visits to this area[1]			
Green Lakes	2.7	2.7	.91
Obsidian Falls	5.5	2.7	.01
Marion Lake	12.0	5.1	.008
Number of days per year spent in wilderness[1]			
Green Lakes	6.7	9.0	.022
Obsidian Falls	8.2	7.6	.59
Marion Lake	8.7	6.5	.057

1 T-test
2 Chi-square test

(Bryan 1977; Ewert, 1994; Schreyer and Beaulieu 1986). To control for this factor in our study, we investigated past wilderness experience (Table 3.4). Few differences were observed at Green Lakes or Obsidian Falls, where visitors averaged about 5 years of experience in Three Sisters Wilderness and about 10 other wildernesses visited. Frequency of wilderness use was measured with a categorical variable (6 categories), and there were no differences between day and overnight users. The only statistically significant difference in these areas was for past visits to the study site; day users at Obsidian Falls had on average made about twice as many visits to that site as overnight users. At Marion Lake, on the other hand, day and overnight users appear to differ considerably in experience, with day users being more experienced. Day users have been to twice as many other wildernesses and to Marion Lake more than twice as many times. They also visit wilderness more frequently. It is possible, therefore, that the characterization of overnight users are more committed and concerned than day users may not fit visitors to our study areas.

Impacts Noticed

Encounters with Other Groups

Hypothesis 1 predicted that day users would report more encounters per day than overnight users. This was supported at two of the three study areas (Table 3.5). At Green Lakes, day users reported an average of 12.4 encounters with other groups, while overnight users reported 9.5. At Marion Lake, day users reported an average of 10.8 encounters, while overnight users

Table 3.5. Encounters with Other Groups

Variable	Day	Overnight	p^1
Number of groups met per day (mean)			
Green Lakes	12.4	9.5	.007
Obsidian Falls	7.6	7.0	.43
Marion Lake	10.8	5.1	.0001

[1] T-test

reported 5.1. At Obsidian Falls, reported encounter rates were not significantly different.

Impacts Along Trails and Near Trailheads

Hypothesis 2 predicted no differences between day and overnight users in perception of impacts to trails or for impacts occurring near trails at day use destinations. At Obsidian Falls and Green Lakes, most campsite impacts occur away from trails and more than 7 kilometers from the trailhead. Manure on trails, noise, and trail impacts all occur near trailheads. At Marion Lake, on the other hand, all impacts are within 4 to 5 kilometers of the trailhead and are very apparent from the trails. Thus, we expected equally high proportions of day and overnight users to notice all impacts at this location. Table 3.6 presents results for impacts where no differences were expected.

Of 17 comparisons where we predicted no difference, 9 statistically significant differences emerged. Thus our hypothesis was not supported. In all 9 cases, overnight users were more likely to notice the impacts.

Table 3.6. Perception of Impacts Occurring Along Trails and Near Trailheads

Variable	Day	Overnight	p[1]
	Percent	*Who Notice*	
Trails worn down or too wide			
Green Lakes	52	78	<.0001
Obsidian Falls	58	66	.14
Marion Lake	53	64	.027
Development of side trails			
Green Lakes	42	65	.0035
Obsidian Falls	50	61	.053
Marion Lake	54	61	.14
Horse manure on trails or in camps			
Green Lakes	86	95	.0057
Obsidian Falls	82	87	.27
Marion Lake	83	93	<.0001
Noise from other groups			
Green Lakes	31	37	.26
Obsidian Falls	41	51	.09
Marion Lake	45	65	.0009
Litter left behind by people			
Marion Lake	59	79	<.0001
Campsites which have lost vegetation			
Marion Lake	62	77	.003
Trees damaged or cut down by people			
Marion Lake	50	60	.06
Streambanks or lakeshores eroded by people			
Marion Lake	43	47	.98
Inappropriate disposal of human waste			
Marion Lake	20	41	<.0001

[1]Chi-square test

Table 3.7. Perception of Impacts Away from Trails or at Interior Destinations

Variable	Day	Overnight	p[1]
	Percent	*Who Notice*	
Litter left behind by people			
Green Lakes	35	55	.0001
Obsidian Falls	31	50	.0005
Campsites which have lost vegetation			
Green Lakes	32	71	<.0001
Obsidian Falls	37	74	<.0001
Trees damaged or cut down by people			
Green Lakes	27	33	.20
Obsidian Falls	28	63	<.0001
Streambanks or lakeshores eroded by people			
Green Lakes	33	48	.002
Obsidian Falls	27	37	.07
Inappropriate disposal of human waste			
Green Lakes	15	23	.034
Obsidian Falls	13	18	.26
Trees or vegetation damaged by horses			
Green Lakes	28	41	.006
Obsidian Falls	21	38	.001

[1]Chi-square test

Impacts Away From Trails or at Interior Destinations

Hypothesis 3 predicted that overnight users would be more likely to notice impacts away from main trails or relatively distant from trailheads where day users are unlikely to go. Most impacts at Obsidian Falls and Green Lakes fit this description, being away from trails and more than 7 kilometers from the trailhead.

Of 12 comparisons where we predicted a difference, 9 showed overnight visitors more likely to notice impacts (Table 3.7). Thus hypothesis 3 was generally supported. For the prevalent and obvious impacts of litter and vegetation loss at campsites, predicted differences were found in 6 of 6 cases. The differences were especially pronounced for vegetation loss, where over 70% of overnight visitors but only 32 and 37% of day users noticed the impact. The less common or noticeable impacts of human waste, shoreline erosion, and tree damage generated significant differences in 3 of 6 cases.

Evaluation of Impacts

Hypothesis 4 predicted that overnight users would evaluate impacts they notice more negatively than would day users. Visitors who noticed each of the impacts in Tables 3.6 and 3.7 were asked to indicate the extent to which the impact detracted from their experience. For purposes of analysis, respondents who answered "a little" or "a lot" were grouped into one category and compared to those who said the impact did not detract (Table 3.8). In addition to the 10 impacts, visitors' evaluation of the number of encounters they had is also included.

Table 3.8. Evaluation of Impacts Noticed

Variable	Day	Overnight	p[1]
	Percent	*Detract* [2]	
Trails worn down or too wide			
Green Lakes	42	61	.002
Obsidian Falls	49	61	.09
Marion Lake	52	50	.76
Development of side trails			
Green Lakes	63	66	.65
Obsidian Falls	63	66	.67
Marion Lake	69	55	.047
Campsites which have lost vegetation			
Green Lakes	73	80	.23
Obsidian Falls	77	80	.59
Marion Lake	73	73	.93
Trees damaged or cut down by people			
Green Lakes	67	76	.047
Obsidian Falls	68	72	.66
Marion Lake	74	84	.08
Streambanks or lakeshores eroded by people			
Green Lakes	64	93	<.0001
Obsidian Falls	79	77	.83
Marion Lake	65	61	.65
Inappropriate disposal of human waste			
Green Lakes	47	73	.03
Obsidian Falls	55	73	.16
Marion Lake	43	76	.001

[1] Chi-square test

[2] Figures are percent who say impact detracts somewhat or a lot.

Table 3.8. Evaluation of Impacts Noticed (Continued)

Variable	Day	Overnight	p[1]
	Percent	*Detract* [2]	
Horse manure on trails or in camps			
Green Lakes	70	81	.025
Obsidian Falls	69	80	.04
Marion Lake	73	77	.50
Trees or vegetation damaged by horses			
Green Lakes	74	86	.09
Obsidian Falls	66	84	.03
Noise from other groups			
Green Lakes	50	61	.20
Obsidian Falls	56	66	.007
Marion Lake	52	67	.06
Litter left behind by people			
Green Lakes	72	77	.47
Obsidian Falls	64	83	.01
Marion Lake	82	88	.21
Number of groups met			
Green Lakes	32	35	.52
Obsidian Falls	32	41	.10
Marion Lake	19	18	.79

[1] Chi-square test
[2] Figures are percent who say impact detracts somewhat or a lot.

With the exception of trail impacts, disposal of human waste, and encounters, high percentages of both day and overnight visitors said that impacts detracted from their experience at least a little. Although the differences were generally in the direction predicted (for 26 of 32 comparisons), they were staistically significant ($p<.05$) in only 11 cases, or about one-third of the time. In all but one case of statistically significant difference, more overnight than day users said the impact detracted. Yet for none of the 11 impacts was there consistent support for the hypothesis across all study sites. The only impacts that seem consistently more problematic to overnight users were human waste and manure.

Visitors were also asked a general question about their sense of crowding, using a 9-point crowding scale (Table 3.9). Overnight users felt more crowded at Green Lakes and Obsidian Falls, but there were no differences at Marion Lake.

Table 3.9. Crowding

	Day[1]	Overnight[1]	*p*[2]
Green Lakes	2.6	4.1	<.0001
Obsidian Falls	2.6	3.7	<.0001
Marion Lake	2.7	2.6	.79

[1]Figures are means from 9-point scale, where 1= not at all crowded and 9 = extremely crowded.
[2] T-test

Support for Management

Our expectation (hypothesis 5a) that overnight users would be more supportive of actions that benefit the wilderness resource (affecting all visitors equally) received little support (Tables 3.10 to 3.12). In only 4 of 27 comparisons were there statistically significant differences, and in two of those cases it was day users who supported the action more. There were essentially no differences between day and overnight users in their reactions to actions that they observed on their trips, such as bulletin boards, regulatory signs, and wilderness rangers (Table 3.10). Similarly, there were no differences in support for hypothetical actions that would affect all visitors (Table 3.11). In a general question about support for use limits, overnight users were more supportive only at Marion Lake (Table 3.12).

Table 3.10. Effect of Management Actions Noticed on Quality of Experience: Actions Affecting All Visitors

Management Action	Day	Overnight	p[1]
	Percent Detract[2]		
Trailhead bulletin boards			
Green Lakes	6	3	.15
Obsidian Falls	5	4	.82
Marion Lake	10	10	1.0
Regulatory signs within wilderness			
Green Lakes	13	11	.52
Obsidian Falls	9	15	.13
Marion Lake	18	14	.40
Wilderness rangers			
Green Lakes	9	7	.66
Obsidian Falls	15	37	.003
Marion Lake	12	14	.50
Use of string to close areas to traffic			
Green Lakes	23	31	.31
Obsidian Falls	25	33	.25
Marion Lake	26	18	.16

[1] Chi-square test.
[2] Note: Figures are percent who say action detracted somewhat or a lot.

Table 3.11. Support for Potential Management Actions Affecting All Visitors

	% Day[1]		% Overnight[1]		
	Support	Oppose	Support	Oppose	p^2
Prohibit dogs					
Green Lakes	40	33	35	31	.79
Obsidian Falls	33	36	34	39	.88
Marion Lake	34	46	29	32	.47
Prohibit horses in some areas					
Green Lakes	64	17	63	18	.75
Obsidian Falls	62	16	73	15	.67
Marion Lake	56	22	51	20	.97
Require all dogs to be on leashes					
Green Lakes	53	30	47	26	.90
Obsidian Falls	35	29	35	39	.39
Marion Lake	50	32	45	28	.002
Provide information on high use times, places					
Green Lakes	73	1	73	3	.19
Obsidian Falls	76	3	80	2	.34
Marion Lake	54	10	67	4	.013

1 Neutral responses are not included. Strongly support and support are combined; strongly oppose and oppose are combined.
2 Chi-square test

Table 3.12. Attitudes Toward Use Limits

User Type	Limits to lower use[1]	Limits to hold use	No limits now	No limits ever	p^2
	-----Percent-----				
Green Lakes					
Day	12	21	51	16	
Overnight	19	28	43	11	.06
Obsidian Falls					
Day	9	23	50	17	
Overnight	13	32	44	11	.17
Marion Lake					
Day	8	6	50	35	
Overnight	11	19	40	31	.004

1 Response to question: Do you feel that a limit is needed on the number of people using this wilderness, recognizing that such limits might reduce your opportunity to visit this area in the future?
2 Chi-square test, performed on counts.

Hypothesis 5b predicted that management actions targeting overnight users would receive less support from overnight users than from day users. Table 3.13 presents results for 5 actions currently in place. In only 3 of 13 cases did overnight users report that the actions detracted significantly more than did day users, and all three cases were at Obsidian Falls. These results provide little support for the hypothesis.

Table 3.13. Effect of Management Actions Noticed on Quality of Experience: Actions Affecting Overnight Visitors

Management Action	Day	Overnight	p^1
	Percent	*Detract*	
Campsites closed			
Green Lakes	35	32	.62
Obsidian Falls	29	41	.07
Marion Lake	27	23	.56
Revegetation of disturbed sites			
Green Lakes	17	16	.88
Obsidian Falls	15	12	.50
Marion Lake	20	17	.52
No camping within 100 ft of trails or water			
Green Lakes	11	16	.28
Obsidian Falls	8	20	.02
No fires within 100 ft of water			
Green Lakes	9	11	.50
Obsidian Falls	10	21	.04
Marion Lake	15	23	.31
No campfires at some destinations			
Green Lakes	8	14	.15
Obsidian Falls	9	33	.002

1 Chi-square test

However, for 5 potential management actions aimed at overnight users, 6 of 15 cases generated significant differences in support (Table 3.14), with overnight users more opposed to requiring camping at designated campsites and providing separate areas for day and overnight use. No differences were found for closing overused sites for recovery or revegetation of heavily impacted sites.

Table 3.14. Support for Management Actions Affecting Overnight Users

	% Day[1]		% Overnight[1]		
	Support	Oppose	Support	Oppose	p^2
Close overused sites					
Green Lakes	67	13	69	13	.88
Obsidian Falls	58	17	65	15	.43
Marion Lake	48	20	51	20	.88
Use string, stakes to confine traffic					
Green Lakes	50	25	51	22	.53
Obsidian Falls	52	21	44	32	.047
Marion Lake	46	23	46	27	.50
Revegetate sites impacted by use					
Green Lakes	89	2	88	5	.16
Obsidian Falls	85	5	86	6	.67
Marion Lake	77	5	78	7	.54
Allow camping in designated sites only					
Green Lakes	70	14	38	34	<.0001
Obsidian Falls	59	23	30	54	<.0001
Marion Lake	64	20	42	36	.0001
Provide separate areas for day and overnight use					
Green Lakes	36	25	26	34	.018
Obsidian Falls	25	29	16	44	.011
Marion Lake	32	34	27	33	.68

[1] Neutral responses are not included. Strongly support and support are combined; strongly oppose and oppose are combined.
[2] Chi-square test

<u>Discussion</u>

Our findings suggest that the major difference between day and overnight users of wilderness is one in perception of impacts. In terms of reactions to impacts and attitudes toward management actions, day and overnight users are more similar than the literature would suggest. The following discussion is organized according to hypotheses, followed by some general observations.

Impacts Noticed

Encounters With Other Groups

The fact that day users encounter more other visitors than overnight users is not surprising, given the high numbers of day users who travel in and out of the study areas and the time they spend in high use portal areas. The finding is all the more significant when one takes into account the fact that day users spend less time in the wilderness (usually around five hours) than overnight users, and thus have more encounters in a shorter period of time. The anomalous finding for Obsidian Falls may reflect the nature of that study area; while use at Green Lakes and Marion Lake is concentrated on a single access trail, most day visitors to Obsidian Falls travel a large loop, and therefore may be less likely to encounter others.

Other Impacts

Hypothesis 2 predicted that ecological and social impacts occurring near trailheads would be experienced equally by day and overnight visitors, and therefore would be noticed to the same degree. Conversely, hypothesis 3 predicted that impacts occurring away from trails or at interior destinations not visited by day users would be noticed more often by overnight users. Taken together, the Oregon data suggest that overnight users are simply more likely to notice impacts than day users, regardless of the location of the impacts. This was true in 18 of 29 comparisons.

Marion Lake provides the most convincing evidence for this conclusion. Here, vegetation loss is significant and very obvious, due to the location in low elevation Douglas fir forest. Surrounding ground vegetation is very dense, and trampling has removed most of it from most campsites. Tree damage is extensive, with many mutilations and cut stumps. The main trail passes through large campsites near the lakeshore, 4 kilometers from the trailhead. Despite the fact that all visitors are exposed to these impacts, more overnight visitors reported noticing impacts.

One potential explanation of differences could lie in visitors' past experience; some authors have suggested that more experienced and/or specialized users may be more sensitive to conditions (Ewert 1989, 1994; Manning 1985; Vaske et al. 1980). The Oregon data are not consistent with such an explanation; by the experience measures used here, day users were as or more experienced than overnight users, but were less perceptive of impacts.

Perhaps the fact that overnight users spend more total time in the wilderness accounts for some of the differences in perception. More time may mean more opportunities to observe impacts.

Evaluation of Impacts

The wilderness management literature has suggested that overnight users may be more sensitive to impacts than day users. Often these suggestions are based on a presumption that different motives underlie the visitation by overnight and day users, and make overnight users more sensitive to impacts they notice.

Our hypothesis that overnight users would react more negatively than day users to impacts received mixed support. In general, large proportions of all users, regardless of length of stay, reported that impacts detract from their experience. About a third of the time, significantly larger proportions of overnight users reported impacts to be detracting. The most pronounced differences were for human waste, manure, and noise from other groups. In theory, campsite-related impacts should affect the experience of overnight users disproportionately, but there was no difference in evaluation of these impacts. Thus, overnight users are somewhat more sensitive, but not universally so.

Support for Management

Hypotheses based on the literature predicted that day users would be less supportive than overnight users of management actions that affect all users and that overnight users would be less supportive of actions targeting overnight use specifically. In general, the first was not supported and the second received mixed support. Actions currently being implemented did not adversely affect members of either user group. Similar findings have been reported by Rupe et al. (1979), Echelberger et al. (1974), and Noe and Hammitt (1992), who observed that visitors object more to hypothetical than in-place management practices. This conclusion warrants further investigation.

It is clear that potential actions that would significantly restrict the freedom of overnight users were much more likely to be opposed by overnight users than day users. Two of the five hypothetical actions targeting overnight use were strongly supported by both user groups: closing overused sites and revegetating heavily impacted sites. These actions would retain a large degree of freedom for overnight users and are not as restrictive as closing certain destinations to all camping. Such reactions are consistent with Noe and Hammitt's (1992) findings that recreationists become increasingly less supportive as actions come closer to restricting their own actions. Evidently, overnight users' self-interest overrides their commitment to wilderness purism when management actions would severely limit their behavior.

One might be tempted to conclude from these findings that day users are more "purist" than overnight users. However, it is important to note that we did not ask questions about purism, nor did we propose other types of management actions that are considered inappropriate in wilderness, such as the use of chainsaws or construction of toilets. Other studies have found day users to be more positive toward such facilities and uses than overnight users (Grossa 1979; Hall and Shelby 1994). Perhaps it is more accurate to conclude that day users support management actions that benefit them or that affect only overnight visitors. Watson (1993) found that overnight users were more supportive of limiting day use, and it would have been informative to include some actions that would negatively affect only day users, to see if they were similarly favored.

General Observations

The differences between day and overnight users have implications for the way we present and use the findings of research. A substantial literature has been developed concerning visitor perceptions of impacts and attitudes toward management in wilderness. Usually these reports pool respondents in drawing conclusions about the typical wilderness visitor (Echelberger et al. 1974; Hollenhorst et al. 1994; Lucas 1980, 1985a; Roggenbuck et al. 1982; Roggenbuck et al. 1993; Schomaker and Glassford 1982; Stankey 1973; Tarbet et al. 1977; Watson et al. 1985). To the extent that differences between day and overnight users exist, combining all respondents can create problems in comparing results from areas in which the proportions of day and overnight use are quite different, or where samples are drawn from one type of user only. If day users have different experiences or attitudes, their unique views are left unacknowledged. Many studies of wilderness visitors have failed to raise the possibility of differences, even when samples are drawn only or disproportionately from overnight visitors. Results are tacitly assumed to apply to all wilderness visitors, as evidenced by the lack of discussion of the issue. This frequently occurs when respondents are selected from wilderness permits, because overnight users are more likely to comply, or in some cases only overnight users are required to obtain permits (Bultena et al. 1981; Fazio and Gilbert 1974; Hammitt 1994; Hammitt and Patterson 1993; Lime 1977;

Manfredo and Bright 1991; Plager and Womble 1981; Shelby et al. 1988; Stankey 1979; Twight et al. 1981; Van Wagtendonk 1981; Virden and Schreyer 1988; Watson et al. 1993).

An example helps show how pooling respondents hampers managers' efforts to apply research. Important early work by Stankey (1973) on visitor perceptions and desired experiences in four western wildernesses is widely used as a basis for setting social standards and discussing changes over time. However, given the areas chosen for study (Rocky Mountain wildernesses) and the year (1969), the research probably included mainly overnight visitors. It may therefore be inappropriate to apply those results today to other wildernesses that receive mostly day use.

One finding to emerge from this study is that differences between areas can be striking, even when areas seem similar to managers. Obsidian Falls and Green Lakes have similar access, scenery, impacts, and management. Yet Green Lakes showed a clear tendency for overnight users to be more perceptive of impacts than day users; of the ten impacts investigated, eight showed significant differences. At Obsidian Falls, on the other hand, significant differences were observed for only four of the 10 impacts. This suggests that users at Obsidian Falls and Green Lakes may differ in some other dimension not investigated here. Only two impacts -- vegetation loss and litter -- had the same results in all three study areas. Virden and Schreyer (1988) have drawn attention to such diversity among visitors to different wildernesses in the Rocky Mountains.

Differences among the study sites emerged in terms of visitors' reaction to impacts as well as the likelihood of noticing impacts. At Green Lakes, for five of the 10 impacts, overnight users were more likely to say the impact detracted from their experience. At Marion Lake, on the other hand, only two of the ten impacts generated significant differences.

There were fewer differences observed among areas in support for potential management actions, although in-place management actions generated different responses among areas. At Green Lakes and Marion Lake there were no differences between day and overnight users in reaction to actions noticed, but at Obsidian Falls overnight users were significantly more likely than day users to say that the regulations they encountered detracted from their enjoyment.

Our general conclusion regarding perception of impacts, then, is that the likelihood of a difference between day and overnight users varies depending on the particular impact and the particular destination.

We investigated only three high-use areas in this study, and caution should be used in extrapolating to other areas. These popular areas may draw visitors who are less sensitive to impacts (Stewart and Carpenter 1989). If overnight visitors who desire solitude and pristine conditions have been displaced, their views are not represented in this study.

Overall, we found few differences in reaction to impacts among those who notice impacts. However, for some impacts, many more overnight users are likely to notice the impact in the first place, meaning that in all, a larger proportion of the total overnight population is bothered by the impacts than of the day population. Thus, in areas with high overnight use, more visitors will say that impacts detract from their experience. In areas with similar levels of impact but higher proportions of day use, the general consensus may be that there is no problem.

Finally, it is important to consider carefully the definition of day use. In this analysis we categorized people as day users if they were on a day trip when contacted by us. However, some overnight users take day trips, and vice versa, and opinions about management and evaluation of impacts are probably formed on the basis of all past trips. It might be more meaningful to discern whether visitors would classify themselves as typically day users or typically overnight users. Preliminary analysis of data from the Eagle Cap Wilderness (Hall & Shelby 1994), and results reported by Roggenbuck et al. (1979) suggest that the distinction between "typical day" and "typical overnight" users may be more productive than the distinction used in this study. This area needs further work.

CHAPTER 4. ASSISTED REVEGETATION OF WILDERNESS CAMPSITES: A TEST OF FOUR METHODS

Introduction

Wilderness managers are faced with a large and increasing number of heavily impacted campsites. Many wilderness programs include extensive efforts to restore some of these sites to a more natural state, using a variety of techniques. Few of these techniques have been carefully tested, however, and success is often determined through repeated trial and error. This study evaluates four common techniques of site restoration through experimental application on six campsites in Three Sisters Wilderness, Oregon.

Management Context

The cumulative impacts of recreation on vegetation in wilderness have been well documented (Bratton et al. 1978; Cole 1982b, 1986; Cole and Marion 1986; Frissell and Duncan 1965; Merriam and Smith 1974). Although not always significant from an ecological standpoint, such impacts are an eyesore to many and may detract from the visitor's sense of being in a pristine, untouched wilderness environment where human impacts are "substantially unnoticeable," as prescribed by the Wilderness Act of 1964.

Recreational impacts are especially obvious at campsites, where impacts to vegetation are more pronounced. Many species and growth forms are quickly trampled and slow to recover, and even low levels of use suffice to maintain impacts such as vegetation loss and soil exposure. Increases in recreational use of wilderness over the past few decades have led to a great number of sites in many areas. Past management actions have also contributed to the number of sites; policies designed to disperse use and management systems such as rest rotation have failed because closed sites take much longer to recover than new sites deteriorate (Cole 1982a; Cole and Ranz 1983; Thornburgh 1986). Recent research has suggested that one of the more pressing concerns regarding campsites is their continual proliferation over time (Cole 1993).

In some areas, the proliferation of unnecessary sites and a fall-off in the amount of overnight use have created a situation in which there are more campsites than needed to accommodate even peak demand. For instance, at Russell Lake in Mt. Jefferson Wilderness, more than 40 impacted campsites have been identified, even though no more than eight groups are found camping at this lake on the busiest weekend nights. In the same wilderness, Marion Lake has over 130 campsites, but rarely more than about 20 groups present overnight (Hall and Shelby 1993).

Some managers are beginning to consider strategies of concentration rather than dispersal of use, following persistent recommendations from many researchers (Cole 1988, 1993; Cole and Benedict 1983; Cole and Krumpe 1992; Stohlgren and Parsons 1986; Weaver and Dale 1978). National Park Service managers have acknowledged the wisdom of concentrating use and often require camping at designated or assigned sites, but Forest Service managers have been slow to adopt such practices. Such strategies of concentrating use at a few sites present an opportunity for the majority of sites to recover, either on their own or with assistance.

Campsite restoration projects have long been common in wildernesses across the west, because managers take seriously their charge to maintain wilderness in the most pristine condition possible. In 1988, for example, 17% of Forest Service wilderness managers reported closing campsites (General Accounting Office 1989). Unfortunately, such efforts have usually been unsystematic and undocumented, impeding our ability to learn from them. Even when methods and results are recorded, they are usually not published and therefore not easily accessible to others (Cole n.d., 1987).

The National Park Service, especially in the Pacific Northwest, has led the way in restoration work (Davis 1991; Miller and Miller 1977; Rochefort 1989, 1990). However, its techniques are usually labor intensive and require large quantities of materials such as gravel, peat, topsoil, excelsior or other mulches, and plant propagules to be brought in from off-site. For example, at Mount Rainier National Park, approximately 517,000 square feet of impacted area were slated for restoration at Paradise Meadows (Rochefort 1989). As of 1992, half of this work had been accomplished, at a cost of $670,000 and over 19,000 work hours (Rochefort and Gibbons 1992). In these times of declining budgets, wilderness managers need techniques that are cheap, minimally labor intensive, and that can be carried out by staff with the skills and knowledge of seasonal wilderness rangers.

Among the most common techniques used in Forest Service wilderness restoration efforts are spading to loosen compacted soils (often called scarification), importation of organic material to replace what has been lost, and transplanting small trees or plugs of vegetation. An understanding of the ecological changes on campsites will help explain the ecological underpinnings of these techniques.

Site Changes Associated With Camping

Loss of vegetation is the first impact to occur on campsites. This begins as bruising, breaking of stems, and crushing of foliage (Holmes 1979; Kuss 1986; Kuss et al. 1986; Liddle 1975; Price 1985). Greater use can eliminate some or all species from the main camp area. In more fragile vegetation types, even a few nights of camping a year will result in the loss of most vegetation from a site (Cole 1988). Loss of vegetation cover has a number of repercussions. Not only is the source of new vegetation lost, but reestablishment can be impeded because of changes in surface temperature regimes. Vegetation insulates the soil surface, moderating temperature fluctuations (Johnson and Bradshaw 1979). When vegetation is lost from sunny sites, soil surface temperatures can rise to levels lethal to the seedlings of many species (Johnson and Bradshaw 1979; Miller and Miller 1979). For example, at 1600 m in the Cascades Mountains in British Columbia, Ballard (1972) recorded soil temperatures as high as 35°C. On cold sites, temperatures can drop to lethal levels.

Organic material can be lost from sites in two ways: through collection of firewood and by destruction from trampling. Many wilderness sites are located in relatively harsh subalpine or alpine climates, in which soils can be hot during the day, cold during the night, and dry during late summer. In such environments, obstacles such as logs or stones may ameliorate the microclimate sufficiently to allow germination or establishment (Edwards 1979; Ellison 1949; Van Vechten 1960). Wood collecting can remove the small and medium-sized woody material from a site, eliminating potential microsites for germination, establishment, and growth. Removal of wood may also reduce available water, which is held in decaying tissues (Geier-Hays 1994).

Heavily used sites lose unconsolidated organic litter and organic soil horizons, largely through trampling. Trampling breaks down surface organic material, which is then lost from the site through erosion by wind or water (Legg and Schneider 1977; Monti and Mackintosh 1979). Loss of intact or decomposing surface organic material removes an insulating layer from the soil surface, which changes the temperature regimes of the surface and alters the natural infiltration and runoff of water (Klock and McColley 1979). Thicker organic layers cushion the surface, reducing the compactive forces brought on soils beneath, as well as reducing the compactibility of the soil itself (Marion and Merriam 1985). Extended trampling will reduce the organic content of subsurface soils, which in turn reduces their ability to retain nutrients and water (Munshower 1994; Waring and Schlesinger 1985).

Loss of organic material from sites is correlated with significant changes in soil properties. Soil changes include increased bulk density (Dotzenko et al. 1967; Legg et al. 1980; Marion and Merriam 1985; Monti and Mackintosh 1979; Stohlgren and Parsons 1986; Young and Gilmore 1976), reduced porosity and infiltration rates (Ellison 1949; Legg et al. 1980; Marion and Merriam 1985; Monti and Mackintosh 1979; Waring and Schlesinger 1985), loss of mycorrhizae and nutrients, and lowered moisture (Klock and McColley 1979; Moorman and Reeves 1979; Reeves et al. 1979). Compaction restricts the movement of oxygen, carbon dioxide, and water through the soils. The end result of compaction for many species is delayed or reduced germination, emergence, or growth (Harper et al. 1965). To compound problems at high elevation sites, low temperatures reduce the permeability of root membranes, which further reduces a plant's ability to take up water (Waring and Schlesinger 1985).

Severely impacted sites may lose a large percentage of their soils (Cole and Benedict 1983; Marion and Merriam 1985). Soil depths affect water and nutrient pools, and when soil is lost, a site becomes less hospitable to regeneration (Klock and McColley 1979).

Some species germinate better on bare soils (Geier-Hayes 1994), but compaction usually prevents establishment of many species through impairment of root growth (Cole and Benedict 1983; Klock and McColley 1979; Minore et al. 1969; Waring and Schlesinger 1985). Sites with extremely compacted soils will recover vegetation only very slowly. High levels of compaction are associated with loss of species diversity and vegetation cover (Kuss and Hall 1991).

It seems likely that changes to soil properties are the major impediment to site recovery after closure (Klock and McColley 1979), although on large sites, the lack of nearby seed sources or the slow process of invasion through vegetative reproduction from surrounding areas may also be limiting factors.

Treatments Used in Site Restoration

The treatments used in restoration, such as loosening compacted soils, scattering organic material, and transplanting vegetative plugs are aimed at reversing the changes created by camping. It is reasonable to expect that each of these should increase recovery rates, all other things being equal.

Scarification

Digging up soils, or scarification, has been recommended (Dalle-Molle 1977; Miller and Miller 1977; Rochefort 1990; Sater 1988) or practiced (Lester and Calder 1979; Mann and Dull 1979; Moritsch 1992; Rochefort and Gibbons 1992; Smith 1979) by many managers and researchers. Scarification loosens soils, allowing greater infiltration of air and water, and easing root penetration. Cultivation serves to reduce bulk density, improve soil structure, and increase porosity (Legg et al. 1980; Rochefort 1990). Soils should be loose enough for good water infiltration and retention, but firm enough to ensure a good contact between seeds and soil, so that germination and establishment can occur without desiccation (Munshower 1994). In addition to ameliorating soil structural constraints, some researchers have suggested that scarification may bring subsurface seeds into a better microenvironment for germination or establishment. This could be especially true for species requiring light to germinate.

Mulches and Organic Amendments

Organic material may be added to impacted sites in two ways: incorporated into the soil (amendment) or applied at the surface as a mulch. When mixed with soils, organic material improves soil structure and increases the number of cation exchange sites, thereby increasing the nutrient retention ability of the soil (Waring and Schlesinger 1985). It also increases the ability of the soil to hold water (Munshower 1994).

Applied as a mulch, organic material may replace lost surface materials, which insulates soils, increases moisture retention, and cushions soils against compactive forces, as well as slowing erosion by wind, rain-splash, and runoff (Miller and Miller 1977; Rochefort 1990; Sater 1988). Organic material may also provide safe sites for germination or establishment and can trap soil particles or seeds (Harper et al. 1965). At the surface, organic material has relatively little effect on soil structure or nutrient cycling (Johnson and Bradshaw 1979; Munshower 1994). On hot, dry sites, the shade created may increase emergence and survival of seedlings (Ellison 1949).

Despite these theoretical benefits, the results of different types of mulching have been mixed, and the explanation of their success or failure has varied. Mann and Dull (1979) reported that mulching with rotten logs was unsuccessful. They hypothesized that the wood kept the soil surface temperatures too low, and may have immobilized nitrogen. Similarly, Smith (1979) found that 1-2 inches of bark spread over spaded soils was unsuccessful in enhancing germination, and Kidd and Haupt (1968) found that mulching with 1 inch of wood chips depressed establishment. On a high alpine plateau, straw mulch had no discernible effect on water potential, soil temperature, or growth of seedlings, but in this case naturally high water potentials combined with the movement of the straw by wind may have masked any potential effects (Chambers et al. 1990).

On the other hand, Gates (1962) found that covering the soil surface with conifer boughs increased grass germination two to three times over areas without such treatment. Similar results were reported for piling brush by Mann and Dull (1979). On mine sites with saline soils and high clay content, sawmill wood residue increased aboveground biomass significantly (Smith et al. 1986). Good results have been reported by Van Horn (1979) and Rochefort (1990) for straw mulch, Rochefort and Gibbons (1992) for excelsior mulch, and Geier-Hayes (1994) for conifer needles. Straw mulch has been shown to reduce frost heave, a significant cause of seedling mortality at some sites (Heidmann 1976). These authors and other researchers argue that the main benefit of the mulch derives from its effect in preventing loss of soil moisture and controlling erosion (Johnson and Bradshaw 1979; Smith et al. 1986).

Large pieces of organic material such as logs may be analogous to large rocks in ability to ameliorate the microclimate. In alpine areas, rocks have been shown to provide favorable microsites by providing shade, cooler ambient and soil temperatures, and more moisture (Edwards 1979; Rochefort 1990). Large organic material probably serves much the same function.

Transplanting

Transplanting has often been successful, insofar as large proportions of transplants of some species will survive if handled and planted properly (Brown et al. 1976; Cole and Schreiner 1981; Douglas 1974; Schreiner 1977; Scott 1977). This is especially true for cuttings and rootings propagated in greenhouses (Densmore 1977; Miller and Miller 1979; Rochefort and Gibbons 1992). Little research has tested the survival of transplants imported directly from nearby areas, although for trees it appears necessary to take small individuals with sufficient quantities of soil. Among the primary causes of mortality appear to be moisture stress and frost heave (Douglas 1974; Klock et al. 1975; Scotter 1978). Most research has found that, although survival is high, transplants usually fail to spread significantly, at least in the short term of research projects. Thus, their contribution to reestablishment of vegetation cover may be limited.

Many researchers advocate watering transplants prior to and after moving (Moritsch 1992; Sater 1988). Several claim that this increases survival, although the evidence appears largely anecdotal (Dalle-Molle 1977; Lester and Calder 1979; Miller and Miller 1977; Schreiner and Moorhead 1979; Van Horn 1979). Watering enhanced the survival of *Luetkea pectinata* transplants on dry, exposed sites (Campbell and Scotter 1975, cited in Cole and Schreiner 1981). To the extent that transplant stock are stressed, watering would reduce moisture stress; it therefore seems reasonable to assume watering would increase survival. Nevertheless, Munshower (1994) reports that one-time irrigation of transplants on mine sites may produce benefits in the first few years, but has no long-term effect on vegetation.

Hypotheses

This study tests four techniques: (1) surface dispersal of organic matter, (2) scarification with surface addition of organic matter, (3) transplanting without watering, and (4) transplanting with watering. Changes in vegetation cover and species richness after three years are compared to untreated control plots to determine the effect of treatments. The above discussion generates several hypotheses:

H1. All treatments will show a greater increase in vegetation cover than controls after three years.

H2. All treatments will have more new species appear than controls after 3 years.

H3. Both transplant treatments (3 and 4) will have more new species present than treatments 1 and 2.

H4. Watered transplants will have a higher survival rate than unwatered transplants.

Previous research on site restoration has suggested that in some instances, variations in recovery result more often from site-specific topographic, edaphic, or biological factors than from treatments themselves (Kuss et al. 1986; Mann and Dull 1979; Weaver et al. 1979). For instance, Moritsch (1992) found that a mesic site recovered significantly more than drier, shadier sites. Usually the factors leading to such differences cannot be precisely identified. Therefore, we propose the following additional hypothesis:

H5. Significant differences will be observed between sites in change of vegetation cover and species richness.

Study Area and Methods

Study Sites

Six well-established, heavily impacted sites in the subalpine parkland zone of Three Sisters Wilderness were selected for experimental restoration. This area receives annual precipitation between 150 and 250 cm, most of which falls as winter snow. Freezing temperatures can occur at any time during the year. These elevations in the western Cascades are snow-covered from about November through sometime in July, and are subject to summer drought.

Nomenclature follows Hitchcock and Cronquist (1973). The dominant overstory species in this area is mountain hemlock (*Tsuga mertensiana*) with subalpine fir (*Abies lasiocarpa*) and silver fir (*A. amabilis*) present in the understory (Franklin and Dyrness 1973; Van Vechten 1960). The study sites are located in communities identified by Vander Schaaf (1982) as mountain heather (*Phyllodoce empetriformis*) moist meadow and cascade blueberry (*Vaccinium deliciosum*) dry meadow. All sites are located on slightly convex topography, raised above the moist meadows, on slopes of less than 5%.

Two of the sites (Sunshine 10 and Linton Meadows 13) are on relatively deep organic soils, under mostly closed canopy of *T. mertensiana* (Table 4.1). Both are in tree clumps bordering moist subalpine meadows. Sunshine 10 is more shaded, with the understory dominated by smooth woodrush (*Luzula hitchcockii*), dwarf bramble (*Rubus lasiococcus*), brewer's mitrewort (*Mitella breweri*), and partridgefoot (*Luetkea pectinata*). Linton Meadows 13 receives more sunlight over parts of the site, which is reflected in the presence of species such as fan-leaf cinquefoil (*Potentilla flabellifolia*), Gray's lovage (*Ligusticum grayi*), long-stalked clover (*Trifolium longipes*), and sedges (*Carex* spp). Under the canopy, the forbs are similar in composition to Sunshine 10, with grouse whortleberry (*Vaccinium scoparium*) and *V. deliciosum* also present in the shrub layer.

Two sites (Obsidian Camp 01 and Sunshine 01) are in tree "islands" within meadows, but are more exposed and have shallower soils than Sunshine 10 and Linton Meadows 13. Both sites are bordered by small creeks and contain several meadow species, such as Holm's sedge (*Carex scopulorum*), black sedge (*C. nigricans*), and *Ligusticum grayi*. Moist site

Table 4.1. Characteristics of Study Sites

	Site					
Variable	OC01	OC04	SS10	SS01	HL15	LM13
Elevation (m)	1960	1960	1960	1960	1873	1786
Campsite area (m^2)	139	279	388	191	556	214
Barren core area (m^2)	53	122	231	134	131	44
Mean canopy cover (%)	52	30	61	51	18	65
Mean mineral soil (%)	62	22	6	18	35	2
Median vegetation cover (%)	2	0	0	0.25	0.5	2
Median # species/m^2	2	1	1	1.5	1	2
Total # species on site	17	10	6	13	5	13

species such as arrow-leaf groundsel (*Senecio triangularis*) and Sitka valerian (*Valeriana sitchensis*) are also present. The central denuded portions of these sites have species normally found in sunny, dry, harsher locations, especially Newberry's knotweed (*Polygonum newberryi*), pussypaws (*Spraguea umbellata*), and broadleaf lupine (*Lupinus latifolius*). Neither site has shrubs within the campsite proper.

Obsidian Camp 04 is situated on a more xeric rocky rise within a subalpine meadow, under tall, but well-spaced *Tsuga mertensiana*. Vegetation is sparse, with no shrubs present. The dominant species are *Luzula hitchockii* and *Luetkea pectinata* near trees in shady sites, and *Carex* spp, *Juncus parryi* (Parry's rush), *Lupinus latifolius*, and *Hieracium gracile* (slender hawkweed) in open areas.

Husband Lake 15 is the most xeric of the sites, located on an exposed and elevated lakeshore. This site has almost no canopy cover and poorly developed soils. The most common species are three species of huckleberry (*Vaccinium deliciosum, V. membranaceum,* and *V. scoparium*) and *Polygonum newberryi. Luetkea pectinata* is present in shaded microsites near the base of trees. A few whitebark pine (*Pinus albicaulis*) are present on this site.

The study sites are all fairly large, with the total area of observable impacts to vegetation (the camp area) ranging from 139 to 556 m^2. In most cases, the completely devegetated part of each site (the barren core) was substantially smaller than the total impacted area (Table 4.1). None of the study sites had a significant amount of vegetation at the onset of this study, although the surrounding vegetation was often greater than 75%. Sites varied in species richness; the total number of species found within quadrats on any of the sites ranged from 5 to 17. The amount of exposed mineral soil varied among sites, but was relatively low on four of the six sites, reflecting either deep organic horizons or the presence of a surface needle layer.

Methods

In September, 1991, a centerpoint was established in what was subjectively determined to be the center of each site. From this point, the distance to the edge of the impacted area was measured along 16 evenly spaced radial transects following Cole (1989). A series of 1-m^2 quadrats was distributed on each site, evenly spaced along the combined transect distance (see Figure 4.1). An attempt was made to place at least 40 plots on each site (8 of each treatment and 8 controls). This was possible except on sites Obsidian

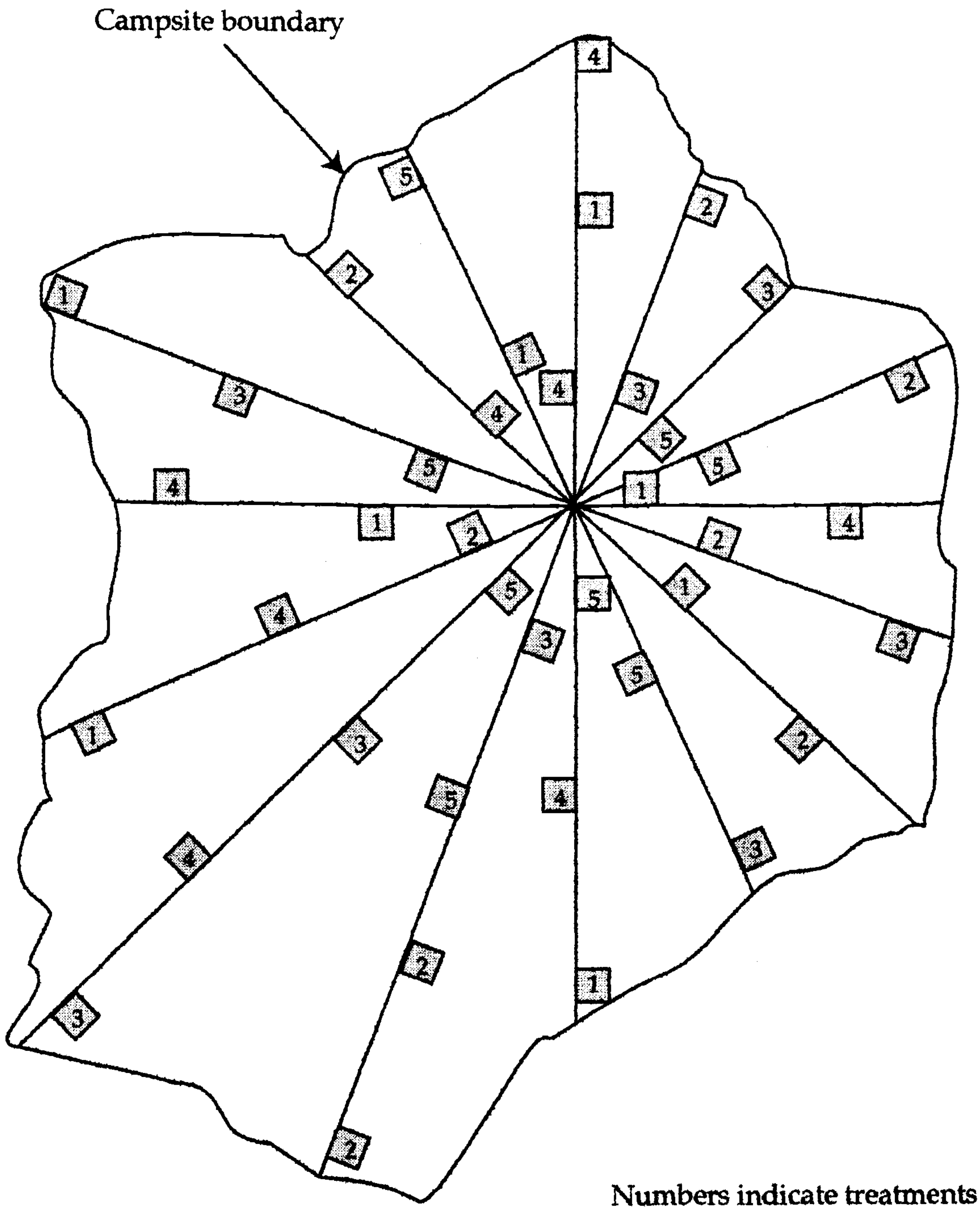

Figure 4.1. Hypothetical Arrangement of Treatments

Camp 01 and Husband Lake 15, which received seven quadrats of each treatment. Obsidian Camp 04, a larger site, received 10 of each treatment. On each quadrat, measurements were taken of the percent cover of each shrub and forb species, total vegetation cover, percent mineral soil exposed, percent cover of rock, and percent cover of roots or trees, following methods described by Cole (1989). In addition, the percent canopy cover was visually estimated directly above each quadrat.

Treatments were randomly assigned to plots, and methods were as follows:

1. Organic material. Approximately 10 to 20 liters of organic material (needles, cones, twigs, small limbs, or rotten wood) were gathered from an undisturbed area nearby and spread over the plot. This was generally enough to provide a shallow layer of needles over the quadrat. Large material was placed haphazardly over the plots.

2. Scarification plus organic material. The plot was dug to a depth of 15 to 20 cm and clods were broken up, without turning over the soil (Rochefort 1990). This loosened the soil in the rooting zone; the rooting depth of most species in this area is about 15 cm (Vander Schaaf 1982). The surface was left uneven following scarification, and organic material was applied as in treatment 1.

3. Transplant. A hole was dug in the plot, deep enough to more than accommodate the rootball of a transplant. A mountain hemlock (*Tsuga mertensiana*) seedling between 15 and 30 cm in height was located in a similar site in the surrounding area. A rootball larger in diameter than the dripline of the seedling and 20 to 25 cm deep was dug up along with the

seedling (Rochefort 1990; Sater 1988). Transplants were moved immediately (to prevent desiccation) and placed in the hole, set slightly below the surface of the ground. This was done to allow water to pool around the seedling rather than run off the site (Munshower 1994). Soil was tamped down firmly around the transplant.

4. Transplant plus water. The selected transplant and the hole into which it was put were watered several hours prior to transplanting. The transplanting procedures were the same as in treatment 3. After planting, approximately 10 liters of water were administered to each seedling.

After applying treatments, measurements of vegetation cover, mineral soil exposure, and species composition were repeated. The center point and end of each radial transect were marked with a metal spike inserted into the ground. Sites were then fenced with twine and posted with small cards stating that walking through or camping in the site was prohibited.

In the years following treatment, these sites were kept closed to use. The local ranger district maintained wilderness ranger patrols in the area 5 days a week throughout the high-use season. None of the sites appeared to have been used between 1991 and 1994.

In September, 1994, the sites were revisited and the center and end points of each transect relocated with a metal detector. All measurements were repeated, and transplants were examined for survival and growth. The presence and cover of any species not previously present were recorded. The number of volunteer tree seedlings in each quadrat was also counted.

Analysis

As part of our assessment of change in vegetation over time, we examined floristic dissimilarity. An index of floristic dissimilarity is a measure of the similarity of overall vegetation composition between sites or across time that takes into account the relative dominance of individual species within plots. It was calculated as

$$FD = .5 \sum | p1 - p2 |$$

where p1 is the relative cover of species 1 at time 1 and p2 is the relative cover of this species at time 2. Relative cover is calculated as the cover of species 1 divided by the sum of the covers of all species within the plot.

The data are not normally distributed. This, together with the presence of a large number of observations with zero values, suggests that distribution-free tests of statistical significance should be used (Sprent 1993). Therefore, nonparametric Kruskall-Wallis Analysis of Variance tests were used to assess the effects of treatments on change in total vegetation cover, change in number of species present, total vegetation cover after three years, floristic dissimilarity between 1991 and year 1994, and number of volunteer tree seedlings present. This test performs ANOVA on mean ranks instead of mean values, making it insensitive to violations of normality. Where overall significant differences were detected, pair-wise post hoc comparisons on mean ranks were performed using Tukey's HSD statistics to detect significant differences among treatments (Shavelson 1988). The effect of watering on survival of transplants was evaluated using a chi-square test.

Due to the extreme violations of normality, tables present median values as measures of central tendency and semi-interquartile ranges as measures of variation, instead of means and standard errors. The semi-interquartile range is the range of the middle 50% of observations.

Results

Changes in Vegetation Cover

Hypothesis 1 predicted that each treatment would cause a larger 3-year increase in vegetation cover than would occur on controls. Prior to treatment, more than half of all quadrats had no vegetation at all (Figure 4.2), so that median vegetation cover was 0 for all treatments (Table 4.2). The absolute growth of vegetation was quite small; nevertheless, by 1994, median total vegetation cover had increased on all treatments except controls. Increases were modest for organic material and organic material with scarification (median cover was 0.5% in 1994), but were larger for both transplant treatments, where median vegetation rose to 3.0% by 1994. Our hypothesis was only partially supported, because the median changes for organic material and scarification with organic material were not significantly different from change on controls. However, increases on both transplant treatments were significantly greater than controls, as predicted.

The overall changes in median cover were small, but examination of changes on individual quadrats helps display the effect of treatments more clearly (Table 4.3). Approximately 10% of all quadrats lost vegetation, while about one-third experienced no change and the rest increased in vegetation.

Table 4.2. Change in Vegetation Cover by Treatment

Percent Cover[1]	OM	S+OM	T	T+W	C
Pretreatment	0.0 (0-2)	0.0 (0-2)	0.0 (0-2)	0.0 (0-4)	0.0 (0-6)
Post-treatment[2]	0.0[a] (0-0)	0.0[a] (0-.5)	2.0[b] (2-4)	3.0[b] (2-6)	0.0[a] (0-6)
1994[2]	0.5[a] (0-2)	0.5[a] (0-1.5)	3.0[b] (1-6)	3.0[b] (1-8)	0.0[a] (0-4)
Change[2]	0.0[a] (0-.5)	0.0[a] (0-1)	2.0[b] (.5-4)	2.0[b] (.5-5)	0.0[a] (0-0)

[1] Figures in parentheses are semi-interquartile ranges. OM = organic material; S+OM = scarification and organic material; T = transplant; T+W = transplant with watering; C = control.

[2] $p<.0001$, Kruskall-Wallis analysis of variance. Values with different alphabetic superscripts are significantly different at alpha=.05.

Table 4.3. Gain and Loss of Vegetation on Quadrats

Percent of Quadrats[1]	OM	S+OM	T	T+W	C	p[2]
Losing vegetation	9	10	4	8	23	
Gaining vegetation	35	42	78	78	23	.01

[1] OM = organic material; S+OM = scarification and organic material; T = transplant; T+W = transplant with watering; C = control.

[2] Chi-square test, performed on counts.

Control quadrats were substantially more likely to lose vegetation than other quadrats; 23% lost vegetation and only 23% gained vegetation. Quadrats on all other treatments were much less likely to lose vegetation and much more likely to gain vegetation. Taken together with the findings concerning median vegetation cover, these data indicate that all treatments stimulated growth of vegetation, but that the growth associated with organic material and scarification with organic material was too slight to create an overall significant increase in median percent cover.

Inspection of vegetation cover immediately after treatment (Figure 4.2) shows that much of the increase associated with transplanting occurred at the time of treatment, while most of the change that occurred on plots treated with organic material or scarification with organic material happened later. Transplanted plots changed relatively little between treatment and 1994, compared to the changes brought about by transplanting. Changes on transplanted quadrats were obviously derived from the presence of vegetation in the soil surrounding transplants.

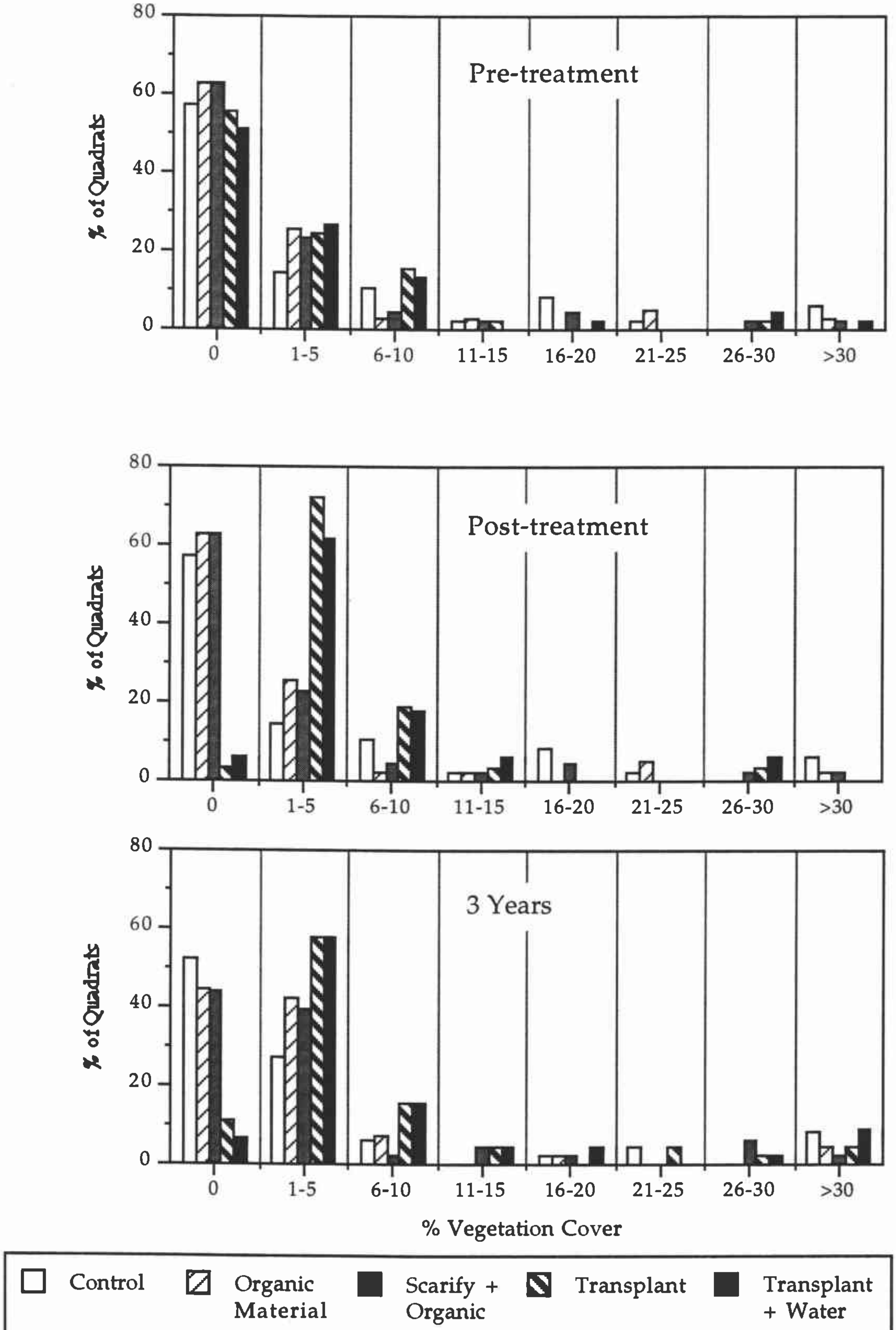

Figure 4.2. Change in Vegetation Cover by Treatment and Time

Changes in Species Richness

Hypothesis 2 predicted that all treatments would have more new species appear than controls after 3 years. More specifically, hypothesis 3 predicted that both transplant treatments would have more new species present (not including the tree seedling itself) than treatments with organic material and scarification with organic material.

Results for species richness mirror those for vegetation cover. The median number of species per quadrat in 1991 was zero, reflecting the overall lack of vegetation on these sites (Table 4.4). By 1994, the median number of species had increased on all treatments, but not on controls. However, the median change for organic material and scarification with organic material was zero, the same as on controls, and only transplanted treatments showed significant increases. These data support hypothesis 3.

The findings for median change in species richness suggest that treatments 1 and 2 have little positive effect, but inspection of changes on individual quadrats suggests that there is a small beneficial effect (Table 4.5). On controls, 13% of quadrats lost species, while only 17% gained species. On quadrats treated with organic material, 33% gained species, and on those scarified with organic material, 40% gained species. When organic material and scarification with organic material are compared in a separate chi-square test to controls, the differences in the number of quadrats that increased in species richness were statistically significant. Transplanted treatments showed the most significant changes: no quadrats lost species, and over 80% gained species.

Table 4.4. Change in Species Richness by Treatment

	OM	S+OM	T	T+W	C
	------------------------# *Species/square meter*[1]-----------------------				
Pretreatment	0 (0-1)	0 (0-1)	0 (0-1)	0 (0-1)	0 (0-2)
Post-treatment[2]	0^a (0-1)	0^a (0-1)	2^b (1-2)	2^b (2-3)	0^a (0-2)
1994[2]	1^a (0-2)	1^a (0-2)	2^b (1-4)	2^b (1-5)	0^a (0-2)
Change[2]	0^a (0-1)	0^a (0-1)	2^b (1-3)	2^b (1-3)	0^a (0-0)

[1] Figures in parentheses are semi-interquartile ranges. OM = organic material; S+OM = scarification and organic material; T = transplant; T+W = transplant with watering; C = control.
[2] $p<.0001$, Kruskall-Wallis analysis of variance. Values with different alphabetic superscripts are significantly different at alpha=.05.

Table 4.5. Gain and Loss of Species on Quadrats

Percent of Quadrats[1]	OM	S+OM	T	T+W	C	p^2
Losing species	5	4	0	0	13	
Gaining species	33	40	89	84	17	.01

[1] OM = organic material; S+OM = scarification and organic material; T = transplant; T+W = transplant with watering; C = control.
[2] Chi-square test, performed on counts.

Inspection of the distribution of number of species across quadrats at different times (Figure 4.3) shows that transplanting caused the percentage of quadrats with no species to drop from over 50% to near zero at the time of

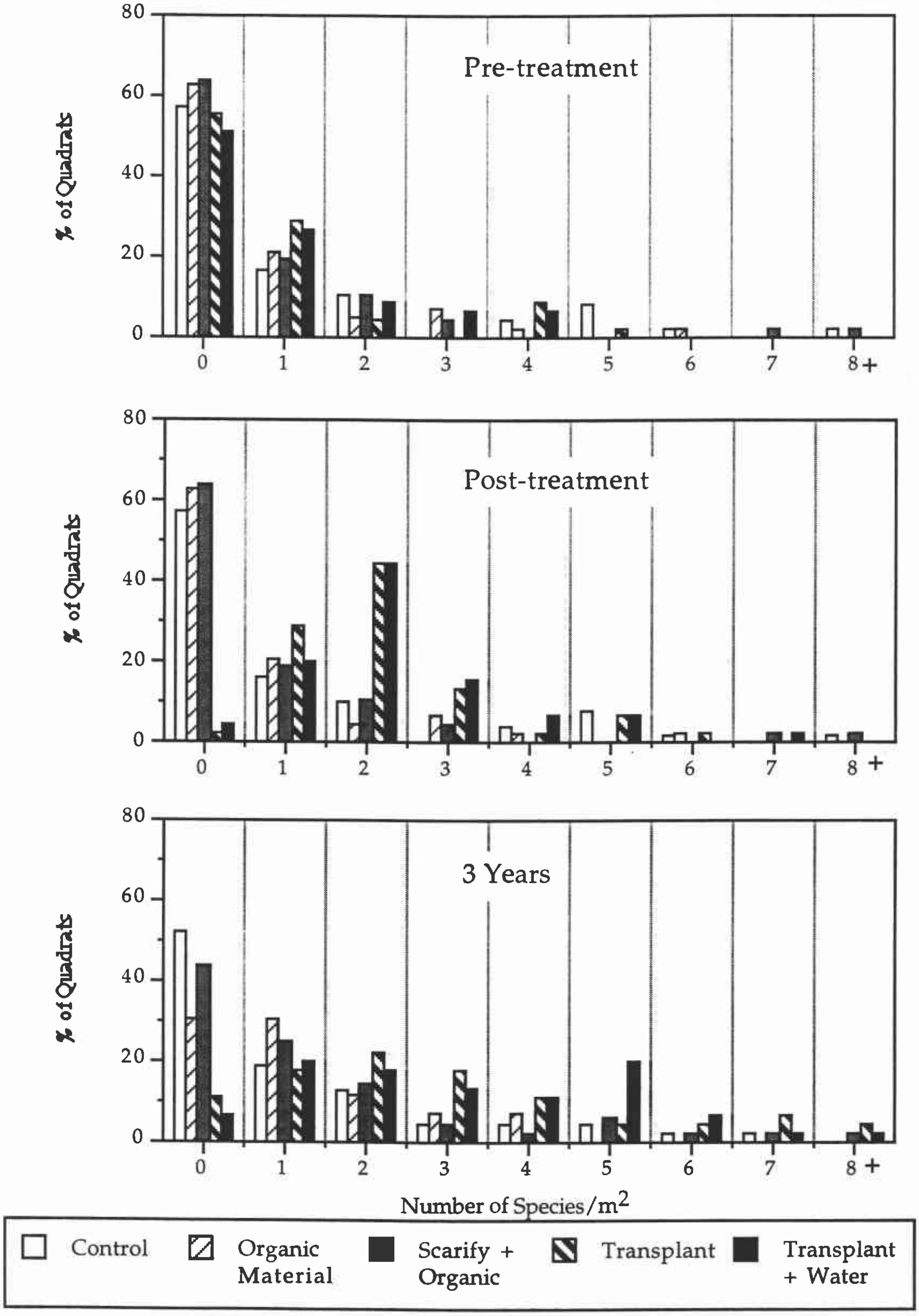

Figure 4.3. Change in Species Richness by Time and Treatment

treatment. Unlike the responses of vegetation cover (most of which changed at the time of transplanting), species richness continued to increase over time, creating noticeable differences for transplanted quadrats between time of treatment and 1994.

Floristic dissimilarity after three years highlights the changes associated with transplanting (Table 4.6). Median dissimilarity did not change on controls, quadrats treated with organic material, or quadrats scarified with organic material. However, the median dissimilarity on both transplant treatments was .5, suggesting a relatively high degree of change. (The maximum potential value of 1.0 would indicate a complete turnover in number of species on the site.)

Table 4.6. Floristic Dissimilarity, Pre-treatment Versus 1994

	OM[1]	S+OM	T	T+W	C	p^2
Floristic dissimilarity	0^a	0^a	$.5^b$	$.5^b$	0^a	.0001
Semi-interquartile range	0-.5	0-.5	.2-.5	.3-.5	0-.4	

[1] OM = organic material; S+OM = scarification and organic material; T = transplant; T+W = transplant with watering; C = control.
[2] Kruskall-Wallis analysis of variance. Values with different alphabetic superscripts are significantly different at alpha=.05.

Effect of Watering on Seedling Survival

Hypothesis 4 predicted that watering would increase survival of transplanted seedlings. This hypothesis was not supported. Roughly half of all seedlings died, regardless of watering regime (Table 4.7). About three-quarters of the surviving watered seedlings showed measurable growth, compared to less than half of the surviving unwatered seedlings.

Table 4.7. Survival of Transplanted *Tsuga mertensiana* Seedlings

Treatment	Not Survive	Survive/No Growth	Survive/Growth	p^1
No water	27 (60%)	10 (22%)	8 (18%)	
Water	24 (53%)	6 (13%)	15 (33%)	.19

[1] Chi-square test.

Site Differences

Vegetation recovery could be expected to vary depending on site characteristics (hypothesis 5). More mesic sites such as Linton Meadows 13 and Obsidian Camp 01 were expected to show greater recovery than more xeric sites such as Obsidian Camp 04 and Husband Lake 15. Densely shaded sites like Sunshine 10 were expected to recover less quickly than sites with more sunlight such as Obsidian Camp 01 and Linton Meadows 13.

Sites differed initially in vegetation cover and number of species (Table 4.8). Obsidian Camp 01 and Linton Meadows 13 had more species and higher total vegetation cover at the outset of the study, while Obsidian Camp 04 and Sunshine 10 had the least vegetation cover and fewest species. Changes in vegetation cover and species richness were independent of site, contrary to expectations. The only differences observed among sites were in establishment of volunteer tree seedlings. Over three-quarters of the quadrats on Linton Meadows 13 and over half of those on Obsidian Camp 04 had seedlings between 1 and 3 years old in 1994. Approximately 30% of quadrats on Obsidian Camp 01 and Sunshine 10 had seedlings, while seedlings were relatively rare on Sunshine 01 and Husband Lake 15.

Table 4.8. Differences Among Sites

	OC04	OC01	SS10	SS01	HL15	LM13	*p*
	--------------*Percent*	*Vegetation*	*Cover*--------------				
Pretreatment	0.0^{a}	2.0^{bc}	0.0^{ab}	0.3^{bc}	0.5^{bc}	2.0^{c}	.0001[1]
1994	0.5^{a}	4.0^{b}	2.0^{ab}	1.0^{ab}	1.0^{ab}	3.0^{b}	.008[1]
Change	0.5	0.5	.05	.05	0.0	0.0	.27[1]
	----------*Species*	*Richness*	*(Number/m²)*----------				
Pretreatment	0^{a}	1^{b}	0^{a}	$.5^{ab}$	1^{ab}	2^{b}	.0001[1]
1994	1^{a}	2^{b}	1^{a}	1.5^{ab}	1^{ab}	2^{ab}	.0006[1]
Change	1	1	1	0	1	0	.43[1]
	--------------*Presence*	*of Tree*	*Seedlings*--------------				
Number/m^2	1^{bc}	0^{ab}	0^{a}	0^{a}	0^{a}	2^{c}	.0001[1]
% Quadrats	55	30	24	10	20	78	<.0001[2]

[1] Kruskall-Wallis analysis of variance. Values with different alphabetic superscripts are significantly different at alpha=.05.
[2] Chi-square test, performed on counts.

<u>Discussion</u>

Transplanting accelerated vegetative recovery, while organic material and scarification with organic material achieved relatively little after three years. Although the changes in vegetation cover and species richness were small in an absolute sense (generally less than a few percent or one to two species), relative to the pretreatment absence of vegetation, they are marked. Control plots appeared to change very little after three years of disuse, and over half of all these plots remained without vegetation.

Scarification

Scarification enhanced recovery only slightly in this study. This is true even though the treatment has been regarded as necessary for recovery of impacted campsites, and all sites studied here were heavily used and significantly compacted compared to the surrounding area. In individual comparisons, scarification did not improve median vegetation change, median change in species richness, or emergence of volunteer tree seedlings statistically more than controls. However, for all three changes taken together, the average scarified quadrat gained more than the average control, suggesting a small positive net effect.

There may be several explanations for the lack of a substantial improvement from scarification. First, our study design had no separate treatment of scarification without application of organic material. We believed that newly exposed soils would be prone to erosion and desiccation, and therefore felt that mulching with native organic materials would be more advisable than leaving soils exposed. If there was an adverse interaction between mulching and scarification, this could account for the failures of scarification.

Second, it is possible that site conditions in this area did not fit the conditions under which scarification shows the most promise. For instance, it is possible that soils in this area are incapable of becoming compacted to a density sufficient to impair vegetation growth. In particular, Husband Lake 15 and Obsidian Camp 04 had medium textured sandy soils, which may make them less prone to harmful levels of compaction. We did not perform soil structure or compositional analyses, and therefore cannot evaluate this possibility.

Third, the benefits of scarification may have been offset by natural decreases in density that may have occurred on the other treatments. Some studies have suggested that bulk density declines on sites not in use, even without intervention, and perhaps scarification was unnecessary to bring about this change (Legg and Schneider 1977; Stohlgren and Parsons 1986). In experimental compaction of soils, Thorud and Frissell (1969, cited in Cole and Schreiner 1981) estimated that about six years would be necessary for complete recovery of surface bulk density. Parsons and DeBenedetti (1979) found that after 15 years, closed campsites in the Sierras had returned to pre-impact levels of compaction. Because we did not measure bulk density or penetration resistance, we are unable to evaluate this possibility.

Another potential explanation for the meager benefits of scarification could relate to the presence of propagules. For vegetation to recover, propagules must be present in scarified plots. Scarification may have created microsites conducive to germination and establishment, but there may have been no suitable seed sources nearby. Little is known about the dispersal patterns of species found in these areas, although work in alpine areas in the northeast found that virtually no seed rain falls more than 1 meter from the parent plant (Marchand and Roach 1980). If Cascades species have similar dispersal patterns, then a lack of seed may explain the failure of scarification. Some of the studies that have reported positive effects have also seeded species into the scarified sites (Ahlstrand 1973; Kidd and Haupt 1968).

Finally, scarification may disrupt soil communities and root systems. The benefits of loosening compacted soil could be outweighed by disturbances to subterranean plant organs. Legg et al. (1980) reported a similar finding for tilling soils at developed campground sites. The treatment had no effect on bulk density, and the authors speculate that it damaged soil structure unless organic material was incorporated into the soil as part of the process.

Organic Material

Organic material applied to sites had very small positive effects on vegetation cover, number of species present, or emergence of tree seedlings. The reasons are unclear. As a mulch, the material probably served to retain higher levels of soil moisture than plots without such mulch, which should have been beneficial. Because we did not measure soil moisture or plant water potential we do not know whether moisture stress was an issue at these sites or not. If it was not, the potentially beneficial effect of mulch would not be apparent. Chambers et al. (1990) reported that at high elevations in the Beartooth Plateau, no plots experienced water potentials low enough to cause moisture stress, which may explain the lack of results associated with straw mulch in their study.

Other researchers have shown that bare soils in the sun can reach temperatures as much as 30°C hotter than soils under vegetation (Ellison 1949). These temperatures can be lethal to seedlings (Miller and Miller 1979). The dark organic material used in this study (mainly needles, cones, and partially decomposed litter from surrounding areas) probably increased soil temperatures on sunny plots over those on the surrounding bare ground during the day. On very exposed, dry quadrats, temperature increases could have been detrimental, but on cooler quadrats, temperature moderation could have been beneficial. Further research should be done to evaluate the effect of organic mulches on soil moisture and temperature to help determine where and when they would be useful.

It is possible that the material chosen had properties that did not enhance recovery. Similarly unsuccessful results were reported by Mann and Dull (1979) for rotten logs and Smith (1979) for bark. However, piling brush has proven beneficial on some sites (Gates 1962; Mann & Dull 1979) and conifer needles on others (Geier-Hays 1994). One possibility that has been mentioned occasionally in the literature but not systematically investigated on wilderness campsites is the effect of organic mulches on nutrient availability. Mulches with high carbon content may stimulate microbial decomposition, however if their C:N ratio is higher than 20 or 30:1, microbes will immobilize nitrogen during decomposition, and may actually remove nitrogen from the soil solution. This loss of nutrients may impede plant growth (Munshower 1994; Waring and Schlesinger 1985). Many of the mulches used in restoration, including those used in this study, have high C:N rations (Johnson and Bradshaw 1979). For example, needles of Scot's pine have a ratio of 134:1 (Waring and Schlesinger 1985), and straw has a ratio of 140:1 (Munshower 1994). Rotting logs are especially low in nitrogen and "immobilization of N is especially evident during log decay" (Waring and Schlesinger 1985:188). Therefore, application of rotting woody material and needles may have improved soil water retention at the expense of nutrient availability.

It is also possible that the loss of organic litter or organic soil horizons on these sites was insufficient for mulching to make a difference to plant growth. Several sites had relatively little mineral soil exposed. Although the unconsolidated surface material was largely gone, upper soil horizons still appeared to have a relatively high organic content on at least two sites.

Transplanting

Seedling Survival

We opted to use trees for transplanting because tree seedlings are among the most susceptible vegetation at wilderness campsites. This susceptibility to trampling means that trees are not being replaced in the overstory as they die. A single species was used in experimental treatments to allow adequately large sample sizes for statistical analysis without introducing confounding variables.

Reported survival rates for transplants have varied considerably, and appear to depend on species, site, transplant method, and stock (Brown et al. 1976; Douglas 1974; Lester and Calder 1979; Rochefort and Gibbons 1992; Schreiner 1977). Few results have been published for transplanted tree seedlings; often graminoid species or vegetatively-reproducing forbs are used, which are more likely to survive. Survival of *Tsuga mertensiana* on our study sites was lower than reported by Miller and Miller (1976) or Scott (1977). However, other studies have often used nursery stock, which appears to increase survival rates for all species. The 50% survival rate in this study seems comparable or superior to rates reported for subalpine sites using transplants taken from on-site in Yosemite National Park (Moritsch 1992).

The choice of *Tsuga mertensiana* may have been poor. Although this species is known to be resistant to frost and snow damage, it was found to be the least drought tolerant of 23 species of northwest trees (Minore 1979). If drought is a problem on these sites, this may have accounted for the high mortality. Further studies should investigate whether transplant death occurs immediately after planting, during the dry summer months, or during the winter, and should experiment with other species.

Some researchers have pointed out that transplants may fail to establish on disturbed sites because of the lack of mycorrhizae in soils of these sites (Moorman and Reeves 1979; Reeves et al. 1979; Waring and Schlesinger 1985). This is most often a problem with nursery stock, and is unlikely to have been a cause of transplant death in this study, because of the large quantities of soil imported with the seedlings.

Watering transplants had no effect on survival. However, observations suggest that watering may have improved the vigor of those individuals that do survive. Our results are inconclusive in this regard, and further research should be done to investigate this possibility.

Effects on Vegetation

The increases in vegetation cover and species richness associated with transplanting *T. mertensiana* seedlings from the surrounding area were the most striking finding in this study. Most of the increases in vegetation cover associated with transplanting occurred at the time of transplant. However, a significant proportion of the increase in species richness came from seeds or rhizomatous material present in soil moved with the transplants. The soil plugs were on average about 20-25 cm in diameter and often contained vegetation present in the above-ground biomass or as seed or subsurface organs. Other studies have reported that on-site transplants of various species are more likely to survive in plugs larger than 20 cm than in plugs smaller than 10 cm in diameter (Campbell and Scotter 1975; Miller and Miller 1976; Schreiner and Moorhead 1979; Scotter 1978). Thus, the increases in vegetation observed in this study may have been a fortuitous result of taking large amounts of soil with tree seedlings.

A few species appeared the most often with transplants. Partridgefoot (*Luetkea pectinata*), white heather (*Cassiope mertensiana*), red heather (*Phyllodoce empetriformis*), and grasses were the most common species present at the time of transplant. Of these, grasses and *C. mertensiana* showed the highest survival rates (over 60%), *L. pectinata* had 50% survival, and *P. empetriformis* had poor survival (36%). Smooth woodrush (*Luzula hitchockii*) and brewer's miterwort (*Mitella breweri*) were present in only a few transplants, but survived well.

Several species appeared by 1994 that were not present in the above-ground vegetation at the time of transplant. Grasses (especially *Agrostis variabilis*) and sedges were the most common, although slender hawkweed (*Hieracium gracile*), alpine willow-herb (*Epilobium alpinum*), *Luzula hitchcockii*, Parry's woodrush (*Juncus parryi*), fan-leaf cinquefoil (*Potentilla flabellifolia*), alpine agoseris (*Microseris alpestris*), and Newberry's knotweed (*Polygonum newberryi*) were also common. It is not surprising that species appeared that were not previously present in the established vegetation, because persistent seed banks can contain seed of uncommon species (Thompson and Grime 1979). Transplanting thus has the added benefit of increasing species diversity on impacted sites.

Site-specific Differences

Site-specific differences can often account for most of the variation in site recovery according to other studies (Mann and Dull 1979; Moritsch 1992). Our data do not support this contention, although the hypothesis remains inherently plausible. Perhaps our sites were sufficiently similar, overall recovery rates were sufficiently low, or recovery time was too short for statistically significant results to appear. The differences in emergence of tree seedlings may be a result of site differences, but undoubtedly also has to do with seed availability.

Conclusions

Overall, the sites treated in this study recovered very little over three years, regardless of treatment. Wilderness managers have expended a great deal of time and energy scarifying soils, finding and moving organic material from surrounding locations onto sites, and watering transplants. The findings of this study suggest that this energy would be best spent on transplanting, if the objective is to hasten vegetative recovery.

However, the slow rate of recovery should make managers rethink management goals for subalpine wilderness campsites. Once sites become severely impacted, they will be slow to recover. Perhaps the objective should be to slow the rate of increase of new sites rather than trying to restore heavily impacted, popular sites. This leads to the consideration of practices that will concentrate use on a few sites (such as requiring camping at designated campsites), rather than encouraging the dispersal of use. This advice is not new, but managers have been slow to accept it.

CHAPTER 5. CONCLUSION

Effective recreation management involves management of physical resources and social settings to provide diverse and high quality recreational experiences. Thus, the recreation manager must understand the dynamics of the resource, visitor attitudes and perceptions, and the interactions between the two.

Effective management is premised on effective planning. The planning process must define clear, attainable, and measurable goals, and develop indicators to be used in measuring goal attainment. For each indicator, standards must be developed to judge whether conditions are acceptable. Inventory of physical resources and visitor perceptions tells one whether conditions are within the acceptable range set by standards. Where conditions are not acceptable, management actions must be developed to return conditions to an acceptable level. Monitoring of indicators tells managers whether their actions are having the desired effect.

This overall recreation planning framework applies to wilderness. Because wilderness management is mainly guided by a single piece of legislation that sets out a relatively narrow range of goals, wilderness management is in some ways simpler than management of recreation on other types of federal lands. Nevertheless, it remains challenging.

The studies presented in this dissertation were conducted as part of the planning process for Mount Jefferson and Three Sisters Wildernesses. They fit into the overall process by providing needed information and monitoring the effectiveness of actions. Understanding visitor use and visitor attitudes are prerequisites to developing indicators, setting standards, and selecting management actions. Evaluating the effectiveness of restoration techniques is a fundamental part of monitoring.

The following pages summarize the major findings of each study, describe implications for Mount Jefferson and Three Sisters planning and management, and conclude with a discussion of future research possibilities.

Summary

Changes in Wilderness Use

Effective planning and management begin with an accurate knowledge of baseline conditions. This baseline is often neglected in the rush to implement new management actions, but is essential if one is to be able to evaluate the effectiveness of those actions. Two elements of the baseline often neglected in wilderness planning and management are the amount and type of visitor use.

Chapter 2 examined changes in use of three large Oregon wildernesses between 1976 and 1994. Wilderness managers at each of these areas were considering taking steps to reduce wilderness use, and wanted to understand the nature of recent trends in use. Additionally, research summaries from the late 1980s had indicated that wilderness use levels were stabilizing or declining nationally, and it was important to determine if this was the case for specific wildernesses in Oregon.

Using data derived from wilderness permits and registration (and corrected for noncompliance), we found that one's conclusions about use trends depended on the measure of use employed. Using recreational visitor days (RVDs), the traditional Forest Service measure of use, we concluded that use had declined between 10 and 30% in our study areas over 13 to 18 years. However, using visits as the measure of use, we concluded that use had remained relatively stable in one area and had more than doubled in the other two areas. The disparity was largely the result of a shift from overnight to day use.

These findings have a number of implications for wilderness planning and management nationally. Trends were different enough in each wilderness, even though Mount Jefferson and Three Sisters are almost adjacent to each other, that it appears necessary for managers to study use patterns in each individual wilderness. More importantly, comparing our data with estimates made during years when no use measurement systems were in place indicated that estimates are often wildly inaccurate. It therefore appears advisable for managers who are about to embark on ambitious management programs to take the time to determine baseline levels of use so that they will be able to evaluate the effects of their management programs on use levels. This is especially important wherever management actions might be expected to alter use patterns, for example if access is changed or if areas are closed to camping.

Perceptions and Attitudes of Day Users

Congressional direction to provide a unique type of personal experience in wilderness means that public input is especially important in wilderness planning. Perhaps the clearest example relates to solitude; provision of solitude is a central goal, but solitude is an inherently personal state. Thus, the views of visitors are critical to developing indicators for this goal. However, visitor attitudes are relevant in many other ways as well, in developing indicators, setting standards, choosing the best management actions, and evaluating the effectiveness of actions.

A large body of research has investigated wilderness visitor perceptions of conditions, evaluation of impacts, and attitudes toward management actions. However, an unresolved question involves the existence of differences between day and overnight users. Studies sometimes report divergent findings among wilderness areas, which may in part result from different make up of the respondent pools. For example, findings from an area used mostly by overnight visitors might not be applicable to day use areas if substantial differences exist. The literature suggests there may be reason to expect differences in perceptions and attitudes between the two user types. The issue is particularly relevant to managers of Mount Jefferson and Three Sisters, because these wildernesses have up to 80% day use in the most heavily used areas.

Chapter 3 investigated this possibility using samples of visitors to three destinations in Mount Jefferson and Three Sisters Wildernesses. Visitors were asked to report whether they noticed any of a variety of social or ecological impacts, and for those they did notice, to report the extent to which the impacts detracted from the quality of their trip. They were also asked to indicate whether management actions currently in place adversely affected them, and to express support or opposition toward several potential management actions.

The major differences between day and overnight users to emerge in this study involved perception of impacts: overnight users are significantly more likely to notice impacts, regardless of the location or severity of those impacts. However, all users, regardless of length of stay, found impacts to detract from their experience, so that the expected differences between day and overnight users usually did not emerge in this regard. There were also few differences in reactions to management actions. Neither user type reported that practices currently in effect detracted from their enjoyment, and both supported a variety of potential management actions. The only difference relating to management was a tendency of overnight users to object more strongly to highly restrictive actions targeted at overnight users, such as closing some destinations to camping or requiring camping at designated sites.

These findings suggest that managers in areas of high overnight use may find their clientele reporting more impacts than managers of day use areas, even if there are no objective differences in the level of impact. However, managers of all areas should expect day and overnight users to express similar levels of support for management actions that affect everyone equally, but may meet opposition from those specifically targeted by proposed actions. Our study found substantial differences among the three study areas, despite the fact that they are all relatively near to each other and all experience high levels of use. This reinforces the need for independent planning and assessment on individual units.

Restoration of Wilderness Campsites

Monitoring of recreation management practices to determine effectiveness is rarely done. Often, baseline surveys are not performed, so that adequate monitoring is not possible. Even where baseline surveys exist, funds are rarely available to conduct monitoring. The inadequacy of monitoring is as prevalent in wilderness as in any other recreation setting.

One practice commonly carried out but rarely monitored is campsite restoration. The Willamette and Deschutes National Forests identified excessive vegetation loss at campsites as a significant problem, and plan to undertake restoration projects in the future. Chapter 4 contributes to our understanding of the effectiveness of campsite restoration by experimentally testing four methods at six campsites in the subalpine zone of Three Sisters Wilderness. Organic debris scattered over the soil surface, scarification prior to importing organic material, transplanting mountain hemlock (*Tsuga mertensiana*) seedlings with watering, and transplanting without watering were compared to control plots after three years, to determine their effect on total vegetation cover, species richness, and germination of tree seedlings.

At the outset, the experimental sites were heavily impacted, with most of their vegetation removed by trampling. Increases in median vegetation cover and species richness were significant only for the two transplanted treatments, although all treatments caused the number of plots totally devoid of vegetation to decline more than controls. The effects of transplants on vegetation cover resulted from above-ground vegetation present in transplant plugs. Transplanting effects on species richness resulted from the presence of above-ground vegetation, but also from the presence of vegetative fragments, rhizomes, and propagules in the soil moved with transplanted tree seedlings. Watering prior to and immediately after transplanting did not decrease the mortality of transplanted mountain hemlock seedlings.

These findings have implications beyond restoration itself. They demonstrate that expending the effort for monitoring can save time and resources in the long run. Here, the time-consuming practices of scarification and importation of organic debris did not substantially improve revegetation rates. It was less costly to reach this conclusion than it would be to continue scarifying and applying organic debris to additional sites in the future.

The findings also indicate that management practices may not work in all situations, despite their widespread support and practice in literature and research. Managers who wish to restore sites to pre-impact conditions may be quite dissatisfied with the slow recovery rates observed in this study. This may cause them to rethink their entire approach to campsite impacts.

Implications for Mount Jefferson and Three Sisters Wildernesses

Use Trends

The most immediate and important implications of our findings about use trends are for the provision of solitude in these wildernesses. During the course of planning for Mount Jefferson and Three Sisters, managers developed two indicators for opportunities for solitude: the number of encounters between groups per day and the number of groups camped within sight and sound of each other. In most locations, the maximum acceptable number of encounters was set at 10 per day, and the maximum acceptable number of groups that could be camped within sight or sound of each other was 2. Data collected during 1991 and 1992 indicated that the standard for encounters is greatly exceeded in several parts of the wilderness, while most groups are able to camp out of sight and sound of others (Hall and Shelby 1993; Shelby and Hall 1992). After careful review of various management actions, managers concluded that direct limits on use would be the only truly effective means to reduce encounter levels in popular destinations.

The question then naturally became one of understanding recent trends in use. If use was declining on its own, use limits might be unnecessary, but if use was increasing, limits might be unavoidable.

The relevant measure of use when considering encounters is visits. Our data indicated that visits are increasing, sometimes dramatically. (Had we looked only at recreational visitor days, we would not have reached this conclusion.) This clearly suggests that the problem of encounters is not going to take care of itself. The shift toward day use has additional implications in this regard. Day users tend to congregate in smaller areas than overnight users, so that for any given use level, day users would have more encounters than overnight users. Additionally, the level of day use forced managers to reconsider their approach to limiting use. In most wildernesses with use limits, the restrictions apply only to overnight users, and managers of Mount Jefferson and Three Sisters originally considered a similar program. However, it quickly became clear that to address the issue of encounters effectively, any limits would have to extend to day users as well as overnight users.

Perceptions and Attitudes of Day Users

The Willamette and Deschutes National Forests worked with a public focus group to evaluate indicators, standards, and management actions for the two wildernesses. Although this group gave valuable input, the members were not representative of the user public at large. Most members represented organizations and were sufficiently committed to wilderness values that they were willing to volunteer one day each month for 8 months to attend meetings. Thus, there was some concern about obtaining information about the views of the general public on management issues. Two surveys were carried out: our survey at three high-use destinations and a representative survey of all visitors (Cronn et al. 1992).

Our findings suggest that day users are less likely to notice impacts that managers and overnight users perceive. Thus, to raise support and awareness, managers might consider educational efforts targeted at day users. This presents a challenge, in that day users are less likely to belong to organizations and less likely to visit agency offices, so that opportunities for contacting them are limited.

The generally similar levels of support for management actions indicate that mangers may not need to be concerned about different proportions of use when considering management actions for different areas. The only caveat to this generalization would be that managers should expect to meet more opposition to restrictions on camping from overnight users. Possibly actions directed at day users would raise similar objections. This should be researched.

Campsite Restoration

Over 2,000 campsites were identified, evaluated, and mapped in Mount Jefferson and Three Sisters during the planning process. Many exceed the Forest Plan standards for vegetation loss, and in several locations there are many more sites than needed to accommodate demand. Previous regulations intended to disperse use had unwittingly led to an increase in the number of sites at many destinations. Both managers and focus group members were concerned about these impacts. Managers began to rethink their approach to managing campsite impacts, and implemented two new policies in 1995: fire bans in selected subalpine areas and designated campsites at several destinations. Fire bans were not controversial, but it will be interesting to see how well designated sites have been accepted, given the strong opposition to this action from overnight users identified in our surveys.

Where designated campsites have been established, most sites are now closed to camping. The next step will be restoration of these closed sites. Rehabilitation projects using the techniques described in Chapter 4 have been common in these wildernesses, but efforts have been haphazard and poorly documented. Our data indicate that sites closed to camping (at least in the subalpine areas) may not recover appreciably in the short term without active treatment. Unfortunately, the improvements resulting from treatments are themselves only meager. Managers will have to consider the tradeoffs of expensive rehabilitation versus slow (but free) natural recovery. Survival rates of transplanted trees in our study were 50%, and varied for other species. Although not ideal, these rates are probably high enough to warrant working with on-site transplants (which are cheap, numerous, and have no transportation costs) as opposed to costly and unwieldy nursery stock.

Future Research

The studies presented here suggest numerous possibilities for additional research.

Use Trends

The findings regarding use trends are restricted to Oregon. It would be interesting to investigate trends for other parts of the country. This would be especially valuable in light of the relatively few data points we have for the Oregon wildernesses.

In attempting to explain our findings, we investigated the relationship between county population change and changes in wilderness use. Although this endeavor was unprofitable, more refined studies looking at the most relevant subpopulations might be more fruitful. Most wilderness users are white, male, somewhat younger than average, very well-educated, and have higher than average incomes (Moore et al. 1989; Vaux 1975; Watson et al. 1992). Tracking changes in these populations might allow one to account more clearly for changes in wilderness use.

The shift away from overnight use toward day use has not been adequately explained. Several researchers have offered speculations and hypotheses, but these should be systematically investigated. The most direct way to investigate this question would be to survey wilderness visitors about their trips and ask them to explain any changes in their use patterns. Among the potential explanations may be changes in available leisure time, a shift to other activities, family constraints, or aging.

Use limits on both day and overnight users were implemented at one trailhead in Mount Jefferson and one trailhead in Three Sisters in 1995. The quotas were only slightly lower than demand, so that visitors were only turned away on peak weekends. The limits provide an opportunity to study displacement. Many researchers and managers have feared that use limitations in specific areas will only serve to shift use to other areas, and we have the opportunity to investigate this possibility.

Day Users

The most interesting avenue of further research on day users would be to investigate differences between self-defined day and overnight users, as opposed to the researcher-defined classifications used in our study. Findings reported by Roggenbuck et al. (1979) and preliminary inspection of data from Eagle Cap Wilderness (Hall and Shelby 1994) suggest that our hypotheses regarding perception of impacts, evaluation of impacts, and attitudes toward management actions may fit better when visitors are classified by their "typical" use, rather than what type of trip they were on the day they were contacted for the study.

Another intriguing finding that suggests future research possibilities was respondents' general acceptance of management practices already in place, but strong objections to some proposed actions. It has often been suggested that people acclimate to whatever situation they become familiar with; if this is true, it suggests that opposition to practices will die down sometime following a change in management. It would be useful to determine if this is the case, perhaps using a long-term panel or cross-sectional study in one location. The new quota system provides an opportunity to investigate this phenomenon, because one of the two trailheads with use limits was one of our study sites. We have the opportunity to obtain longitudinal data on visitor perceptions in this area.

It would also be valuable to know if the changing acceptance of actions is the result of one or more of the following factors: (1) a strategic bias that leads people to overstate their degree of opposition to hypothetical actions; (2) displacement of those who opposed the action following its implementation;

or (3) change in attitude from one of opposition to one of acceptance or support among users.

Campsite Restoration

A number of additional studies were suggested by the findings of our revegetation experiments. First, the study might be replicated, taking measures of soil bulk density or penetration resistance and predawn water potential of plants at intervals during the season. Measures of bulk density would help explain the marginal benefits of scarification in this experiment. It is possible that soils were insufficiently compacted at the outset for scarification to make any difference, or it is possible that bulk density was high, but decreased anyway on plots that were not scarified. Explaining the failure of scarification is important, given how often it is recommended and practiced. Measures of predawn water potentials would indicate the degree of moisture stress experienced by plants. It is possible that the failure of organic material to have a large beneficial effect could be the result of favorable moisture regimes on these sites; beneficial effects may appear only on very xeric sites. If, however, the mulch is acting to prevent desiccation, then its failure must have other explanations.

Studies should be conducted using species other than mountain hemlock. Other tree species should include subalpine fir (*Abies lasiocarpa*). Observations of individual species responses suggest that among shrubs, dwarf bramble (*Rubus lasiococcus*), partridgefoot (*Luetkea pectinata*), and white heather (*Cassiope mertensiana*) could be used. Among forbs, grass species, woodrush (*Luzula hitchockii*), Gray's lovage (*Ligusticum grayi*), and brewer's miterwort (*Mitella breweri*), would be good candidates, as long as the sites were matched to their light and moisture requirements. One experiment should test the effect of pruning on transplant survival. Pruning may reduce moisture stress by reducing the amount of surface area for evapo-transpiration.

The study plots established here should be followed over time. It is possible that effects of treatments such as scarification may not appear within three years, but might become apparent sometime in the future. Additionally, it would be useful to determine if the rate of change in vegetation cover and species richness increases over time. As site conditions ameliorate, the rate of recovery might increase.

Many researchers have viewed the slow rate of growth and spread of transplants as a limitation of this technique. However, we do not know whether the rate of spread is any less on campsites than in surrounding vegetation. A useful study would be to compare the rate of growth and phenology of various species in their natural setting versus as transplants on campsites.

BIBLIOGRAPHY

Ahlstrand, G. M. 1973. *Microenvironment modification to favor seed germination in disturbed subalpine habitats, Mt. Rainier National Park*. Ph. D. dissertation, Washington State University.

Ballard, T. M. 1972. Subalpine soil temperature regimes in southwest British Columbia. *Arctic and Alpine Research* 4:139-146.

Betz, C. J. and H. K. Cordell. 1988. Trends in recreation participation on public lands. In, *Outdoor recreation benchmark 1988: Proceedings of the national outdoor recreation forum*. General Technical Report SE-52. USDA Forest Service, Southeast Forest Experiment Station.

Blahna, D. J. and S. Yonts-Shepard. 1990. Preservation or use? Confronting public issues in forest planning and decision making. *Outdoor recreation policy: Pleasure and preservation*, eds. J. D. Hutcheson Jr., F. P. Noe, and R. E. Snow. New York: Greenwood Press.

Bombaci, R. 1980. *A statistical analysis of visitor patterns in the Eagle Cap Wilderness*. Unpublished report, USDA Forest Service, Eagle Cap Ranger District, Wallowa-Whitman National Forest.

Boothby, J., M. F. Tungatt, and A. R. Townsend. 1981. Ceasing participation in sports activities: Reported reasons and their implications. *Journal of Leisure Research* 13(1):1-14.

Bratton, S. P., M. G. Hickler, J. H. Graves. 1978. Visitor impact on backcountry campsites in the Great Smoky Mountains. *Environmental Management* 2:431-442.

Bratton, S. P., M. G. Hickler, J. H. Graves. 1979. Trail erosion patterns in Great Smoky Mountains National Park. *Environmental Management* 3:431-445.

Brown, R. W., R. S. Johnson, B. Z. Richardson, and E. E. Farmer. 1976. Rehabilitation of alpine disturbances: Beartooth Plateau, Montana. *Proceedings, High altitude revegetation workshop No. 2*, eds. R. H. Zuck and L. F. Brown. Fort Collins, CO: Environmental Resources Center, Colorado State University.

Bryan, H. 1977. Leisure value systems and recreational specialization: The case of trout fishermen. *Journal of Leisure Research* 9:174-187.

Bultena, G., D. Field, P. Womble, and D. Albrecht. 1981. Closing the gates: A study of backcountry use-limitation at Mount McKinley National Park. *Leisure Sciences* 4:249-267.

Burde, J. H. and K. A. Curran. 1986. User perception of backcountry management policies at Great Smoky Mountains National Park. *Wilderness and natural areas in the eastern United States: A management challenge*, eds. D. Kulhavy and R. Conner. Nacogdoches, TX: S. F. Austin State University, Center for Applied Studies.

Burde, J. H. and B. L. Daum. 1990. Day hiker visits to the backcountry at Great Smoky Mountains National Park. *Managing America's enduring wilderness resource: Proceedings of the conference, Minneapolis, MN, Sept. 11-17, 1989*, ed. D. W. Lime. St. Paul, MN: University of Minnesota.

Campbell, S. E. and G. W. Scotter. 1975. *Subalpine revegetation and disturbance studies, Mount Revelstocke National Park.* Unpublished Report, Canadian Wildlife Service.

Chambers, J. C., J. A. MacMahon, and R. W. Brown. 1990. Alpine seedling establishment: The influence of disturbance type. *Ecology* 7:1323-1341.

Cole, D. N. nd. Wilderness restoration: Toward a broad and long-term perspective. Unpublished paper.

Cole, D. N. 1981. Vegetational changes associated with recreational use and fire suppression in the Eagle Cap Wilderness, Oregon: Some management implications. *Biological Conservation* 20:247-270.

Cole, D. N. 1982a. Controlling the spread of campsites at popular wilderness destinations. *Journal of Soil and Water Conservation* 37:291-295.

Cole, D. N. 1982b. *Wilderness campsite impacts: Effects of amount of use.* Research Paper INT-248. USDA Forest Service, Intermountain Research Station.

Cole, D. N. 1983. *Assessing and monitoring backcountry trail conditions.* Research Paper INT-303. USDA Forest Service, Intermountain Research Station.

Cole, D. N. 1985. *Recreational trampling effects on six habitat types in western Montana.* Research Paper INT-350. USDA Forest Service, Intermountain Research Station.

Cole, D. N. 1986. Recreational impacts on backcountry campsites in Grand Canyon National Park, Arizona, USA. *Environmental Management* 10:651-659.

Cole, D. N. 1987. Research on soil and vegetation in wilderness: A state-of-knowledge review. In *Proceedings--National Wilderness Research Conference: Issues, State-of-Knowledge, Future Directions*. General Technical Report INT-220. USDA Forest Service, Intermountain Research Station.

Cole, D. N. 1988. *Disturbance and recovery of trampled montane grassland and forests in Montana*. Research Paper INT-389. USDA Forest Service, Intermountain Research Station.

Cole, D. N. 1989. *Wilderness campsite monitoring methods: A sourcebook*. General Technical Report INT-259. USDA Forest Service, Intermountain Research Station.

Cole, D. N. 1990. Wilderness management: Has it come of age? *Journal of Soil and Water Conservation* 45:360-364.

Cole, D. N. 1991. *Changes on trails in the Selway-Bitterroot Wilderness, Montana, 1978-1989*. Research Paper INT-450. USDA Forest Service, Intermountain Research Station.

Cole, D. N. 1992. Modeling wilderness campsites: Factors that influence amount of impact. *Environmental Management* 16:255-264.

Cole, D. N. 1993a. *Campsites in three western wildernesses: Proliferation and changes in condition over 12 to 16 years*. Research Paper INT-463. USDA Forest Service, Intermountain Research Station.

Cole, D. N. 1993b. Wilderness recreation management: We need more than bandages and toothpaste. *Journal of Forestry* 91(2):22-24.

Cole, D. N. 1994. Backcountry impact management: Lessons from research. *Trends* 31(3):10-14.

Cole, D. N. and J. Benedict. 1983. Wilderness campsite selection -- What should users be told? *Park Science* 3(4):5-7.

Cole, D. N. and R. K. Fichtler. 1983. Campsite impact on three western wilderness areas. *Environmental Management* 7(3):275-288.

Cole, D. N. and T. E. Hall. 1992. *Trends in campsite condition: Eagle Cap Wilderness, Bob Marshall Wilderness, and Grand Canyon National*

Park. Research Paper INT-453. USDA Forest Service, Intermountain Research Station.

Cole, D. N. and E. E. Krumpe. 1992. Seven principles of low-impact wilderness recreation. *Western Wildlands* 18(1):39-43.

Cole, D. N. and J. L. Marion. 1986. *Wilderness campsite impacts: Changes over time*. General Technical Report INT-212. USDA Forest Service, Intermountain Research Station.

Cole, D. N. and B. Ranz. 1983. Temporary campsite closures in the Selway-Bitterroot Wilderness. *Journal of Forestry* 81:729-732.

Cole, D. N. and E. G. S. Schreiner. 1981. *Impacts of backcountry recreation: Site management and rehabilitation--an annotated bibliography*. General Technical Report INT-122. USDA Forest Service, Intermountain Research Station.

Cole, D. N. and S. J. Trull. 1992. Quantifying vegetation response to recreational disturbance in the North Cascades, Washington. *Northwest Science* 66(4):229-236.

Cordell, H. K. and G. Siehl. 1989. Wildland recreation use trends. *Trends* 26(3):4-8.

Cowley, J. and R. Schreyer. 1987. "The visitor experience" -- What do we really mean? *Park Science* 7(3):16-17.

Cronn, R., A. E. Watson, and D. N. Cole. 1992. Unpublished report, USDA Forest Service, Intermountain Research Station.

Dalle-Molle, J. 1977. *Resource restoration*. Unpublished report, USDI National Park Service.

Davis, C. 1991. *Mount Rainier National Park native plant propagation program: Nursery and greenhouse manual*. Unpublished report, Mount Rainier National Park.

Densmore, R. 1977. *Methods for regeneration of man-disturbed areas in Mt. McKinley National Park*. Unpublished report, Denali National Park.

Densmore, R. V. and K. W. Holms. 1987. Assisted revegetation in Denali National Park, Alaska, USA. *Arctic and Alpine Research* 19:544-548.

Dotzenko, A. D., N. T. Papmicoa, and D. S. Ramine. 1967. Effects of recreational use on soil and moisture conditions in Rocky Mountain National Park. *Journal of Soil and Water Conservation* 22:196-197.

Douglas, G. 1974. *Revegetation studies at Cascade Pass, Washington.* Unpublished report, National Park Service, North Cascades National Park.

Echelberger, H. E., D. Deiss, and D. Morrison. 1974. Overuse of unique recreation areas: A look at the social problems. *Journal of Soil and Water Conservation* 29(4):173-176.

Echelberger, H. E., R. E. Leonard, and H. J. Plumley. 1981. Validation of trailside registration boxes. *Journal of Soil and Water Conservation* 36(1):53-54.

Echelberger, H. E. and G. H. Moeller. 1977. *Use and users of the Cranberry backcountry in West Virginia: Insights for eastern backcountry management.* Research Paper NE-363. USDA Forest Service, Northeastern Forest Experiment Station.

Edwards, O. M. 1979. Vegetation disturbance by natural factors and visitor impact in the alpine zone of Mt. Rainier National Park: Implications for management. *Conference Proceedings, Recreational Impact on Wildlands,* eds. R. Ittner, D. R. Potter, J. K. Agee and S. Anschell. Report R-6-001-1979, USDA Forest Service, Pacific Northwest Region.

Ellison, L. 1949. Establishment of vegetation on depleted subalpine ranges as influenced by microenvironment. *Ecological Monographs* 19:95-121.

Ewert, A. 1985. Why people climb: The relationship of participant motives and experience level to mountaineering. *Journal of Leisure Research* 17:241-250.

Ewert, A. 1989. Wildland recreation: Bone games of the past or salvation of the future? *Trends* 26(3):14.18.

Ewert, A. 1994. Playing the edge: Motivational and risk-taking in a high-altitude wilderness-like environment. *Environment and Behavior* 16:3-24.

Ewert, A. W. and D. Hood. 1995. Urban-proximate and urban-distant wilderness: An exploratory comparison between two "types" of wilderness. *Journal of Park and Recreation Administration* 13(2):73-85.

Fazio, J. R. 1979. Information and education techniques to improve minimum impact use knowledge in wilderness. *Conference Proceedings, Recreational Impact on Wildlands,* eds. R. Ittner, D. R. Potter, J. K. Agee and S. Anschell. Report R-6-001-1979, USDA Forest Service, Pacific Northwest Region.

Fazio, J. R. and D. L. Gilbert. 1974. Mandatory wilderness permits: Some indications of success. *Journal of Forestry* 72:753-756.

Franklin, J. F. and C. T. Dyrness. 1973. *Natural vegetation of Oregon and Washington.* General Technical Report PNW-8. USDA Forest Service, Pacific Northwest Forest and Range Experiment Station.

Frissell, S. S. and D. P. Duncan. 1965. Campsite preference and deterioration in the Quetico-Superior canoe country. *Journal of Forestry* 63:256-260.

Gates, D. H. 1962. Revegatation of high altitude, barren slopes in northern Idaho. *Journal of Range Mangement* 15:314-318.

Geier-Hayes, K. 1994. *Natural regeneration in two central Idaho grand fir habitat types.* Research Paper INT-472. USDA Forest Service, Intermountain Research Station.

General Accounting Office. 1989. *Wilderness preservation: Problems in some National Forests should be addressed.* Report GAO/RCED-89-202. Washington, DC: US General Accounting Office.

Gericke, K. L. and J. Sullivan. 1994. Public participation and appeals of Forest Service plans -- An empirical examination. *Society and Natural Resources* 7:125-135.

Gericke, K. L., J. Sullivan, and J. D. Wellman. 1992. Public participation in National Forest planning. *Journal of Forestry* 90:35-38.

Graefe, A. R., F. R. Kuss, and L. Loomis. 1986. *Visitor impact management in wildland settings. In Proceedings -- National Wilderness Research Conference: Current Research.* General Technical Report INT-212. USDA Forest Service, Intermountain Research Station.

Graefe, A. R., F. R. Kuss, and J. J. Vaske. 1990. *Visitor impact management: The planning framework.* Washington, DC: National Parks and Conservation Association.

Grossa, J., Jr. 1979. *Recreation preferences and patterns among users of wilderness and backcountry areas in western Montana.* Ph. D. dissertation, Michigan State University.

Haas, G. E. 1979. *User preferences for recreational experience opportunities and physical resource attributes in three Colorado wilderness areas*. Ph. D. dissertation, Colorado State University.

Hall, C. N. and F. R. Kuss. 1989. Vegetation alteration along trails in Shenandoah National Park, Virginia. *Biological Conservation* 48:211-227.

Hall, T. E. 1995. *Analysis of 1994 data: Three Sisters, Mt. Washington, and Mt. Jefferson Wildernesses*. Unpublished report, Willamette National Forest.

Hall, T., M. Rowan, and J. Laing. 1993. *Wilderness monitoring in Region 6: Report of the wilderness indicator assessment team*. Unpublished report, USDA Forest Service, Pacific Northwest Region.

Hall, T. and B. Shelby. 1993a. *Monitoring encounters in wilderness. Report submitted to Intermountain Research Station*. Corvallis: Oregon State University.

Hall, T. and B. Shelby. 1993b. *Wilderness monitoring report: Mt. Jefferson, Mt. Washington, Three Sisters Wildernesses, 1991-1992*. Corvallis: Oregon State University.

Hall, T. and B. Shelby. 1994. *Eagle Cap Wilderness: Recreational use and impacts*. Report to Eagle Cap Ranger District, Wallowa-Whitman National Forest. Corvallis: Oregon State University.

Hammitt, W. 1994. The psychology and functions of wilderness solitude. In *International wilderness allocation, management, and research*, eds. J. C. Hendee and V. G. Martin. Fort Collins, CO: International Wilderness Leadership (WILD) Foundation.

Hammitt, W. E. and M. E. Patterson. 1993. Use patterns and solitude preferences of shelter campers in Great Smoky Mountains National Park, USA. *Journal of Environmental Management* 38:43-53.

Harper, J. L., J. T. Williams, and G. R. Sagar. 1965. The behavior of seeds in soil. I. The heterogeneity of soil surfaces and its role in determining the establishment of plants from seed. *Journal of Ecology* 53:273-287.

Hartmann, L. A., H. K. Cordell, and H. R. Freilich. 1988. The changing future of outdoor recreation activities. *Trends* 25(4):19-23.

Heidmann, L. J. 1976. *Frost heaving of tree seedlings: A literature review of causes and possible control.* General Technical Report RM-21. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station.

Helgath, S. F. 1975. *Trail deterioration in the Selway-Bitterroot Wilderness.* Research Note INT-193. USDA Forest Service, Intermountain Research Station.

Hendee, J. C. and R. C. Lucas. 1973. Mandatory wilderness permits: A necessary management tool. *Journal of Forestry* 71:206-209.

Hendee, J. C., G. H. Stankey, and R. C. Lucas. 1990. *Wilderness management.* Golden, CO: North American Press.

Hitchcock, C. L. and A. Cronquist. 1973. *Flora of the Pacific Northwest.* Seattle, WA: University of Washington Press.

Hollenhorst, S., A. Watson, and D. Olson. 1994. *An integrated model of wilderness solitude.* In *Proceedings, Sixth National Wilderness Conference.* Santa Fe, NM.

Hollenhorst, S. J. and L. Stull-Gardner. 1991a. *Cranberry Wilderness study: Draft report.* Unpublished report, West Virginia University.

Hollenhorst, S. J. and L. Stull-Gardner. 1991b. *Dolly Sods Wilderness area study: Draft report.* Unpublished report, West Virginia University.

Holmes, D. O. 1979. Experiments on the effects of human urine and trampling on subalpine plants. In *Conference Proceedings, Recreational Impact on Wildlands,* eds. R. Ittner, D. R. Potter, J. K. Agee and S. Anschell. Report R-6-001-1979, USDA Forest Service, Pacific Northwest Region.

Jackson, E. L. 1994. Activity-specific constraints on leisure participation. *Journal of Park and Recreation Administration* 12(2):33-49.

James, G. A. and H. Schreuder. 1971. Estimating recreation use on the San Gorgonio Wilderness. *Journal of Forestry* 69:490-493.

James, G. A. and H. T. Schreuder. 1972. *Estimating dispersed recreation use along trails and in general undeveloped areas with electric-eye counters: Some preliminary findings.* Research Note SE-181. USDA Forest Service, Southeast Forest Experiment Station.

Johnson, M. S. and A. D. Bradshaw. 1979. Ecological principles for the restoration of disturbed and degraded lands. *Applied Biology* 4:141-200.

Kelley, M. D. 1979. *Individual and social motive factors influencing recreation participation in the Rattlesnake backcountry.* M.S. thesis, University of Montana.

Kellogg, E. A. 1985. Indicator species for assessing overuse of campsites. *Northwest Science* 59(2):115-121.

Kidd, W. J., Jr. and H. F. Haupt. 1968. *Effects of seedbed treatment on grass establishment on logging roads in central Idaho.* Research Paper INT-53. USDA Forest Service, Intermountain Research Station.

Klock, G. O. and P. D. McColley. 1979. Soil factors influencing the quality of wilderness recreation impact. In *Conference Proceedings, Recreational Impact on Wildlands,* eds. R. Ittner, D. R. Potter, J. K. Agee and S. Anschell. Report R-6-001-1979, USDA Forest Service, Pacific Northwest Region.

Klock, G. O., A. R. Teidemann, and W. Lopushinsky. 1975. *Seeding recommendations for disturbed mountain slopes in North Central Washington.* Research Note PNW-244. USDA Forest Service, Pacific Northwest Forest and Range Experiment Station.

Kuss, F. R. 1986. A review of major factors influencing plant responses to recreation impacts. *Environmental Management* 10:637-650.

Kuss, F. R., A. R. Graefe, and L. Loomis. 1986. Plant and soil responses to wilderness recreation: A synthesis of previous research. In *Proceedings--National Wilderness Research Conference: Current research.* General Technical Report INT-212. USDA Forest Service, Intermountain Research Station.

Kuss, R. F. and C. N. Hall. 1991. Ground flora trampling studies: Five years after closure. *Environmental Management* 15:715-727.

Landres, P. 1994. *A framework for assessing the integrity of wilderness ecological systems.* Unpublished report. Missoula, MT: Aldo Leopold Wilderness Research Institute.

Landres, P. B. 1995. The role of ecological monitoring in managing wilderness. *Trends* 32(1):10-13.

Leatherberry, E. C. and D. W. Lime. 1981. *Unstaffed trail registration compliance in a backcountry recreation area.* NC-214. USDA Forest Service, North Central Forest Experiment Station.

Legg, M., K. Farnham, and E. Miller. 1980. Soil restoration on deteriorated campsites in Texas. *Southern Journal of Applied Forestry* 4:189-193.

Legg, M. H. and G. Schneider. 1977. Soil deterioration on campsites: Northern forest types. *Soil Science Society of America Journal* 41:437-441.

Leonard, R. E., H. E. Echelberger, H. J. Plumley, and L. W. Van Meter. 1980. *Management guidelines for monitoring use on backcountry trails.* NE-286. USDA Forest Service, Northeast Forest Experiment Station.

Leonard, R., H. Echelberger, and M. Schnitzer. 1978. *Use characteristics of the Great Gulf Wilderness.* Research Paper NE-428. USDA Forest Service, Northeast Forest Experiment Station.

Lester, W. and S. Calder. 1979. Revegetating the forest zone of North Cascades National Park. In *Conference Proceedings, Recreational Impact on Wildlands,* eds. R. Ittner, D. R. Potter, J. K. Agee and S. Anschell. Report R-6-001-1979, USDA Forest Service, Pacific Northwest Region.

Lewis, J. W. 1971. *Perception of desert wilderness by the Superstition Wilderness user.* M.A. thesis, University of Arizona.

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

Lime, D. W. 1977. When the wilderness gets crowded...? *Naturalist* 28(4):2-7.

Lime, D. W. and R. G. Buchman. 1974. Putting wilderness permit information to work. *Journal of Forestry* 72:622-626.

Lime, D. W. and G. A. Lorence. 1974. *Improving estimates of wilderness use from mandatory travel permits.* Research Paper NC-101. USDA Forest Service, North Central Forest Experiment Station.

Lucas, R. 1980. *Use patterns and visitor characteristics, attitudes, and preferences in nine wilderness and other roadless areas.* Research Paper INT-253. USDA Forest Service, Intermountain Research Station.

Lucas, R. C. 1981. *Redistributing wilderness use through information supplied to visitors.* Research Paper INT-277. USDA Forest Service, Intermountain Research Station.

Lucas, R. C. 1983. *Low and variable compliance rates at voluntary trail registers.* Research Note INT-326. USDA Forest Service, Intermountain Research Station.

Lucas, R. C. 1985a. *Recreation trends and management of the Bob Marshall Wilderness Complex.* 1985 National outdoor recreation trends symposium II, Atlanta, GA. USDI National Park Service.

Lucas, R. C. 1985b. *Visitor characteristics, attitudes, and use patterns in the Bob Marshall Wilderness Complex, 1972-1982.* Research Paper INT-345. USDA Forest Service, Intermountain Research Station.

Lucas, R. C. 1989. A look at wilderness use and users in transition. *Natural Resources Journal* 29:41-55.

Lucas, R. C. 1990. *How wilderness visitors choose entry points and campsites.* Research Paper INT-428. USDA Forest Service, Intermountain Research Station.

Lucas, R. C. and T. J. Kovalicky. 1981. *Self-issued wilderness permits as a use measurement system.* Research Paper INT-270. USDA Forest Service, Intermountain Research Station.

Lucas, R. C. and S. F. McCool. 1988. Trends in wilderness recreational use: Causes and implications. *Western Wildlands* 14(3): 15-20.

Lucas, R. C., H. T. Schreuder, and G. A. James. 1971. *Wilderness use estimation: A pilot test of sampling procedures on the Mission Mountains Primitive Area.* Research Paper INT-109. USDA Forest Service, Intermountain Research Station.

Lucas, R. C. and G. H. Stankey. 1988. Shifting trends in wilderness recreational use. In *Proceedings, Benchmark 1988: A national outdoor recreaton and wilderness forum.* USDA Forest Service, Southeast Forest Experiment Station.

Lunch, W. M. 1987. *The nationalization of American politics.* Berkeley: University of California Press.

Manfredo, M. J. 1979. *Wilderness experience opportunities and management preferences for three Wyoming wilderness areas.* Ph. D. dissertation, Colorado State University.

Manfredo, M. J. and A. D. Bright. 1991. A model for assessing the effects of communication on recreationists. *Journal of Leisure Research* 23:1-20.

Mann, D. L. and K. Dull. 1979. Six years of site restoration at Lyman Lake. In *Conference Proceedings, Recreational Impact on Wildlands,* eds. R. Ittner, D. R. Potter, J. K. Agee and S. Anschell. Report R-6-001-1979, USDA Forest Service, Pacific Northwest Region.

Manning, R. E. 1985. Crowding norms in backcountry settings: A review and synthesis. *Journal of Leisure Research* 17:75-89.

Marchand, P. J. and D. A. Roach. 1980. Reproductive strategies of pioneering alpine species: Seed production, dispersal, and germination. *Arctic and Alpine Research* 12:137-146.

Marion, J. L. 1991. *Results from the application of a campsite inventory and impact monitoring system in eleven wilderness areas of the Jefferson National Forest.* USDI National Park Service, Cooperative Park Studies Unit. Blacksburg, VA: Department of Forestry, Virginia Polytechnic and State University.

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

McLellan, G. 1986. The future of outdoor recreation: What the trends tell us. *Parks and Recreation* 21(5):45-48, 63.

Merriam, L. C., Jr. and C. K. Smith. 1974. Visitor impact on newly developed campsites in the Boundary Waters Canoe Area. *Journal of Forestry* 72:627-630.

Miller, J. W. and M. M. Miller. 1976. Revegetation in the subalpine zone. *University of Washington Arboretum Bulletin* 39(4):12-16.

Miller, J. W. and M. M. Miller. 1979. Propagation of plant material for subalpine revegetation. In *Conference Proceedings, Recreational Impact on Wildlands*, eds. R. Ittner, D. R. Potter, J. K. Agee and S. Anschell. Report R-6-001-1979, USDA Forest Service, Pacific Northwest Region.

Miller, M. M. and J. W. Miller. 1977. *Suggested revegetation practices.* Unpublished report, USDI National Park Service.

Minore, D. 1979. *Comparative autecological characteristics of northwestern tree species -- A literature review.* General Technical Report PNW-87. USDA Forest Service, Pacific Northwest Forest and Range Experiment Station.

Minore, D., C. E. Smith, and R. F. Wooland. 1969. *Effects of high soil density on seedling root growth of seven northwestern tree species.* Research Note PNW-112. USDA Forest Service, Pacific Northwest Forest and Range Experiment Station.

Monti, P. and E. E. Mackintosh. 1979. Effect of camping on surface properties in the boreal forest region of northwestern Ontario, Canada. *Soil Science Society of America Journal* 43:1024-1029.

Moore, S. D., S. K. Bricker, J. W. Shockey, and D. A. King. 1989. *Sociological aspects of recreation at Aravaipa Canyon Wilderness, Arizona.* Report for Safford District Office, BLM. University of Arizona, School of Renewable Natural Resources.

Moorman, T. and F. B. Reeves. 1979. The role of endomycorrhizae in revegetation practices in the semi-arid west. II. A bioassay to determine the effect of land disturbance on endomycorrhizal populations. *American Journal of Botany* 66:14-18.

Moritsch, B. J. 1992. *Subalpine revegetation on backcountry campsites near Tuolumne Meadows, Yosemite National Park, California: Third year results.* M.S. thesis, Oregon State University.

Munshower, F. F. 1994. *Practical handbook of disturbed land revegetation.* Boca Raton: Lewis Publishers.

Murdock, S. H., K. Backman, E. Colberg, Md. N. Hoque, and R. R. Harman. 1990. Modeling demographic change and characteristics in the analysis of future demand for leisure services. *Leisure Sciences* 12:79-102.

Murdock, S. H., K. Backman, Md. N. Hoque, and D. Ellis. 1991. The implications of change in population size and composition on future participation in outdoor recreational activities. *Journal of Leisure Research* 23: 238-259.

Murray, J. B. 1974. *Appalachian Trail users in the southern national forests: Their characteristics, attitudes and management preference.* Research Paper SE-116. USDA Forest Service, Southeast Forest Experiment Station.

Nash, R. 1982. *Wilderness and the American mind.* New Haven, CT: Yale University Press.

Nash, R. 1983. Sorry, Bambi, but man must enter the forest: Perspectives on the old wilderness and the new. In, *Proceedings -- Symposium and Workshop on Wilderness Fire.* USDA Forest Service, Intermountain Research Station.

Noe, F. P. and W. E. Hammitt. 1992. Environmental attitudes and the personal relevance of management actions in a park setting. *Journal of Environmental Management* 35:205-216.

O'Leary, J. T., F. D. Dottavio, and F. A. McGuire. 1988. Participative shifts in outdoor recreation activities. *Trends* 25(4):14-18.

Parsons, D. J. and S. H. DeBendetti. 1979. Wilderness protection in the High Sierra: Effects of a 15-year closure. In, *Proceedings, First Conference on Scientific Research in the National Parks.* USDI National Park Service.

Parsons, D. J., T. J. Stohlgren, and P. A. Fodor. 1981. Establishing backcountry use quotas: An example from Mineral King, California. *Environmental Management* 5:335-340.

Parsons, D. J., T. J. Stohlgren, and J. M. Kraushaar. 1982. Wilderness permit accuracy: Differences between reported and actual use. *Environmental Management* 6:329-335.

Petersen, M. 1981. *Trends in recreational use of National Forest wilderness.* Research Note INT-319. USDA Forest Service, Intermountain Research Station.

Petersen, M. E. 1980. *User perceptions of rationing in the Mt. Jefferson and Eagle Cap Wilderness areas.* M.S. thesis, Oregon State University.

Petersen, M. E. 1985. *Improving voluntary registration through location and design of trail registration stations.* Research Paper INT-336. USDA Forest Service, Intermountain Research Station.

Plager, A. and P. Womble. 1981. Compliance with backcountry permits in Mt. McKinley National Park. *Journal of Forestry* 79:155-156.

Plumley, H. J., H. T. Peet, and R. E. Leonard. 1978. *Records of backcountry use can assist trail managers.* Research Paper NE-414. USDA Forest Service, Northeast Forest Experiment Station.

Potter, F. I., III and R. E. Manning. 1984. Application of the wilderness travel simulation model to the Appalachian Trail in Vermont. *Environmental Management* 8:543-550.

Price, M. F. 1985. Impacts of recreational activities on alpine vegetation in western North America. *Mountain Research and Development* 5(3): 263-277.

Reeves, F. B., D. Wagner, T. Moorman, and J. Kiel. 1979. The role of endomycorrhizae in revegetation practices in the semi-arid west. I. A comparison of incidence of mycorrhizae in severely disturbed vs. natural environments. *American Journal of Botany* 66:6-13.

Rochefort, R. 1989. *Paradise Meadow Plan.* Unpublished report, Mount Rainier National Park.

Rochefort, R. M. 1990. *Mount Rainier National Park restoration handbook.* Unpublished report, Mount Rainier National Park.

Rochefort, R. M. and S. T. Gibbons. 1992. Mending the meadow: High-altitude meadow restoration in Mount Rainier National Park. *Restoration and Management Notes* 10(2):120-126.

Roggenbuck, J., W. N. Timm, and A. E. Watson. 1979. *Visitor perception of the recreational carrying capacity of three wilderness areas in North Carolina.* Unpublished report, School of Forestry and Wildlife Resources, Virginia Polytechnic and State University.

Roggenbuck, J. W. 1988. Wilderness use and user characteristics: Ending some misconceptions. *Western Wildlands* 14(3): 8-14.

Roggenbuck, J. W. and R. C. Lucas. 1987. Wilderness use and user characteristics: A state-of-knowledge review. In *Proceedings, National wilderness research conference: Issues, state of knowledge, future directions.* General Technical Report INT-220. USDA Forest Service, Intermountain Research Station.

Roggenbuck, J. W., J. L. Marion, and R. E. Manning. 1994. Day users of the backcountry: The neglected National Park visitor. *Trends* 31(3):19-24.

Roggenbuck, J. W. and A. E. Watson. 1988. Wilderness recreation use: The current situation. *Benchmark 1988.* USDA Forest Service, Southeast Experiment Station.

Roggenbuck, J. W., A. E. Watson, and G. H. Stankey. 1982. Wilderness management in the Southern Appalachians. *Southern Journal of Applied Forestry* 6:147-152.

Roggenbuck, J. W., D. R. Williams, and A. E. Watson. 1993. Defining acceptable conditions in wilderness. *Environmental Management* 17:187-197.

Rowan, Mike. 1993. Packwood Ranger District, Gifford Pinchot National Forest. Personal communication.

Rupe, M. L., R. E. Leonard, and J. J. Lindsay. 1979. *Hikers' views of backcountry management.* Unpublished report, University of Vermont, School of Natural Resources.

Sater, S. 1988. *Linton Meadows plant association and revegetation methods report.* Unpublished report, USDA Forest Service, Willamette National Forest.

Schomaker, J. H. and T. R. Glassford. 1982. Backcountry as an alternative to wilderness? *Journal of Forestry* 80:358-360, 364.

Schreiner, E. 1977. *Evaluation of the 1976 plant restoration project at Lake Constance after one year.* Unpublished report, USDI National Park Service, Olympic National Park.

Schreiner, E. S. and B. B. Moorhead. 1979. Human impact inventory and management in the Olympic National Park backcountry. In *Conference Proceedings, Recreational Impact on Wildlands,* eds. R. Ittner, D. R. Potter, J. K. Agee and S. Anschell. Report R-6-001-1979, USDA Forest Service, Pacific Northwest Region.

Schreyer, R. and J. T. Beaulieu. 1986. Attribute preferences for wildland recreation settings. *Journal of Leisure Research* 18:231-247.

Scott, R. L. 1977. *Revegetation studies of a disturbed subalpine community in Olympic National Park, Washington.* Unpublished report, Seattle Pacific University.

Scotter, G. W. 1978. *Subalpine revegetation study, Mount Revelstoke National park.* Unpublished report, Canadian Wildlife Service.

Shafer, C. S. 1993. *The relationships among wilderness experience dimensions, conditions of concern, and coping behaviors: Applying descriptors of designated wilderness.* Ph. D. dissertation, Clemson University.

Shavelson, R. J. 1988. *Statistical reasoning for the behavioral sciences.* Boston: Allyn and Bacon, Inc.

Shelby, B. and T. Hall. 1992. *Wilderness monitoring in 1991: Mt. Jefferson, Mt. Washington, and Three Sisters Wildernesses.* Report submitted to Willamette and Deschutes National Forests. Corvallis, OR: Oregon State University.

Shelby, B. and T. Heberlein. 1986. *Carrying capacity in recreation settings.* Corvallis, OR: Oregon State University.

Shelby, B., J. J. Vaske, and R. Harris. 1988. User standards for ecological impacts at wilderness campsites. *Journal of Leisure Research* 20:245-256.

Shindler, B. A. 1993. *Management implications of displacement and product shift: Longitudinal research on the Rogue River*. Ph. D. dissertation, Oregon State University.

Smith, B. A. 1979. Image Lake rehabilitation project, Glacier Peak Wilderness. In *Conference Proceedings, Recreational Impact on Wildlands,* eds. R. Ittner, D. R. Potter, J. K. Agee and S. Anschell. Report R-6-001-1979, USDA Forest Service, Pacific Northwest Region.

Smith, B. A. and J. F. Higgins. 1992. *The genesis of wilderness standards for the Pacific Northwest Region*. General Technical Report PNW-GTR-305. USDA Forest Service, Pacific Northwest Region.

Smith, J. A., E. J. DePuit, and G. E. Schuman. 1986. Wood residue and fertilizer amendment on bentonite mine spoils. II. Plant species response. *Journal of Environmental Quality* 15:427.

Sprent, P. 1993. *Applied nonparametric statistical methods*. London: Chapman & Hall.

Stankey, G. H. 1973. *Visitor perception of wilderness recreation carrying capacity*. Research Paper INT-142. USDA Forest Service, Intermountain Research Station.

Stankey, G. H. 1979. Use rationing in two southern California wildernesses. *Journal of Forestry* 77:347-249.

Stankey, G. H., D. N. Cole, R. C. Lucas, M. E. Petersen, and S. S. Frissell. 1985. *The limits of acceptable change (LAC) system for wilderness planning*. General Technical Report INT-176. USDA Forest Service, Intermountain Research Station.

Stankey, G. H. and S. F. McCool. 1991. Recreation use limits: The wildland manager's continuing dilemma. *Western Wildlands* 16(4):2-7.

Stankey, G. H. and R. Schreyer. 1987. Attitudes toward wilderness and factors affecting visitor behavior: A state-of-knowledge review. In *Proceedings--National Wilderness Research Conference: Issues, State-of knowledge, future directions*. General Technical Report INT-220. USDA Forest Service, Intermountain Research Station.

Stewart, W. P. and E. H. Carpenter. 1989. Solitude at Grand Canyon: An application of expectancy theory. *Journal of Leisure Research* 21:4-17.

Stohlgren, T. J. and D. J. Parsons. 1986. Vegetation and soil recovery in campsites closed to visitor use. *Environmental Management* 10:375-380.

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

Suriano, J. M. 1992. *Applicability of the "Limits of Acceptable Change" approach in "urban" wilderness planning.* M.S. thesis, University of Arizona.

Szwak, L. B. 1988. Social and demographic trends affecting outdoor recreation. In *Outdoor recreation benchmark 1988: Proceedings of the national outdoor recreation forum.* General Technical Report SE-52. USDA Forest Service, Southeastern Forest Experiment Station.

Tai, Doris. 1995. Gifford Pinchot National Forest. Personal communication.

Tarbet, D., G. H. Moeller, and K. T. McLoughlin. 1977. Attitudes of Salmon River users toward management of Wild and Scenic rivers. In *Proceedings: River recreation management and research symposium.* General Technical Report NC-28. USDA Forest Service, North Central Forest Experiment Station.

Thompson, K. and J. P. Grime. 1979. Seasonal variation in the seed banks of herbaceous species in ten contrasting habitats. *Journal of Ecology* 67:893-921.

Thornburgh, D. A. 1986. Responses of vegetation to different wilderness management systems. In *Proceedings, National Wilderness Research Conference: Current Research.* General Technical Report INT-212. USDA Forest Service, Intermountain Research Station.

Thorud, D. B. and S. S. Frissell. 1969. *Soil rejuvenation following artifical compaction in a Minnesota oak stand.* Minnesota Forest Research Note 208.

Timm, W. N. 1980. *A comparison of the carrying capacity perceptions of eastern and western wilderness users.* M.S. thesis, Virginia Polytechnic Institute and State University.

Tipple, T. J. and J. D. Wellman. 1989. Life in the fishbowl: Public participation rewrites public foresters' job descriptions. *Journal of Forestry* 87(3):24-30.

Twight, B. W., K. L. Smith, and G. H. Wassinger. 1981. Privacy and camping: Closeness to the self vs. closeness to others. *Leisure Sciences* 4:427-441.

US Bureau of the Census. 1994. *Statistical abstract of the United States, 1994. (114th Edition)*. Washington, DC: US Department of Commerce, Economics and Statistics Administration.

USDA Forest Service. 1977. *Mt. Jefferson Wilderness management plan.* USDA Forest Service, Pacific Northwest Region.

USDA Forest Service. 1980a. *Unpublished use data.* On file at Zigzag Ranger District, Zigzag, OR.

USDA Forest Service. 1980b. *Unpublished use data.* On file at McKenzie Ranger District, McKenzie Bridge, OR.

USDA Forest Service, Mount Hood National Forest. 1995. *Unpublished use data.* On file at Zigzag Ranger District, Zigzag, OR.

Vander Schaaf, D. 1982. *The ecological effects of recreational use on subalpine meadow plant communities in Jefferson park, Mt. Jefferson Wilderness Area, Oregon.* M.S. thesis, University of Oregon.

Van Horn, J. C. 1979. Soil and vegetation restoration at the Sunrise developed area, Mt. Rainier National Park. In *Conference Proceedings, Recreational Impact on Wildlands*, eds. R. Ittner, D. R. Potter, J. K. Agee and S. Anschell. Report R-6-001-1979, USDA Forest Service, Pacific Northwest Region.

Van Vechten. 1960. *Ecology of timberline in Three Sisters Wilderness.* Ph. D. dissertation, Oregon State University.

Van Wagtendonk, J. W. 1981. The effect of use limits on backcountry visitation trends in Yosemite National Park. *Leisure Sciences* 4:311-323.

Van Wagtendonk, J. W. and P. R. Coho. 1986. Trailhead quotas: Rationing use to keep wilderness wild. *Journal of Forestry* 84(11):22-24.

Vaske, J. J., M. P. Donnelly, and T. A. Heberlein. 1980. Perceptions of crowding and resource quality by early and more recent visitors. *Leisure Sciences* 3:367-381.

Vaux, H. J., Jr. 1975. The distribution of income among wilderness users. *Journal of Leisure Research* 7:29-37.

Virden, R. J. and R. Schreyer. 1988. Hiker diversity in backcountry areas -- Implications for planning and management. *Western Journal of Applied Forestry* 3(2):49-52.

Wagar, J. A. 1969. *Estimation of visitor use from self-registration at developed recreation sites.* Research Paper INT-70. USDA Forest Service, Intermountain Research Station.

Waring, R. H. and W. H. Schlesinger. 1985. *Forest ecosystems: Concepts and management.* Orlando, FL: Academic Press.

Washburne, R. and D. N. Cole. 1983. *Problems and practices in wilderness management: A survey of managers.* Research Paper INT-304. USDA Forest Service, Intermountain Research Station.

Watson, A. E. 1993. *Characteristics of visitors without permits compared to those with permits at the Desolation Wilderness, California.* Research Note INT-414. USDA Forest Service, Intermountain Research Station.

Watson, A. E., H. K. Cordell, and L. A. Hartmann. 1985. *Characteristics of wilderness users in outdoor recreation assessments.*

Watson, A. E. and R. Cronn. 1994. How previous experience relates to visitors' perceptions of wilderness conditions. *Trends* 31(3):43-46.

Watson, A. E., M. J. Niccolucci, and D. R. Williams. 1993. *Hikers and recreational stock users: Predicting and managing recreation conflicts in three wildernesses.* Research Paper INT-468. USDA Forest Service, Intermountain Research Station.

Watson, A. E., D. R. Williams, J. W. Roggenbuck, and J. J. Daigle. 1992. *Visitor characteristics and preferences for three National Forest wildernesses in the South.* Research Paper INT-455. USDA Forest Service, Intermountain Research Station.

Weaver, T. and D. Dale. 1978. Trampling effects of hikers, motorcycles and horses in meadows and forests. *Journal of Applied Ecology* 15:451-457.

Weaver, T., D. Dale, and E. Hartley. 1979. The relationship of trail condition to use, vegetation, user, slope, season and time. *Conference Proceedings, Recreational Impact on Wildlands.* eds. R. Ittner, D. R. Potter, J. K. Agee and S. Anschell. Report R-6-001-1979. USDA Forest Service, Pacific Northwest Region.

Wenger, W. D. 1964. *A test of unmanned registration stations on wilderness trails: Factors influencing effectiveness.* Research Paper PNW-16.

USDA Forest Service, Pacific Northwest Forest and Range Experiment Station.

Wenger, W. D. and H. M. Gregerson. 1964. *The effect of non-response on representativeness of wilderness-trail register information.* Research Paper PNW-27. USDA Forest Service, Pacific Northwest Forest and Range Experiment Station.

White, T. H. 1975. The relative importance of education and income as predictors in outdoor recreation participation. *Journal of Leisure Research* 7:191-199.

Whittaker, D. 1992. *Selecting indicators: Which impacts matter more?* General Technical Report PNW-305. USDA Forest Service, Pacific Northwest Region.

Whittaker, D. and B. Shelby. 1992. *Developing good standards: Criteria, characteristics, and sources.* General Technical Report PNW-305. USDA Forest Service, Pacific Northwest Region.

Woodward, A., E. G. Schreiner, and D. G. Silsbee. 1995. Climate, geography, and tree establishment in subalpine meadows of the Olympic Mountains, Washington, U.S.A. *Arctic and Alpine Research* 27(3):217-225.

Yang, W.-T. 1986. *Visitor attitudes toward use control, wilderness regulations, and wilderness policies in the Bob Marshall Wilderness Complex.* M.S. thesis, University of Montana.

Young, R. A. and A. R. Gilmore. 1976. Effects of various camping intensities on soil properties in Illinois campgrounds. *Soil Science Society of America Journal* 40:908-911.

Yuan, M. S. and N. Moisey. 1992. The characteristics and economic significance of visitors attracted to Montana wildlands. *Western Wildlands* 18(3):20-24.