Changing Conditions on Wilderness Campsites: Seven Case Studies of Trends Over 13 to 32 Years

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Abstract

This report brings together seven case studies of trends in the number and condition of wilderness campsites over periods ranging from 13 to 32 years. Case examples come from five mountainous wilderness areas in the western United States: Sequoia-Kings Canyon Wilderness in California, the Eagle Cap Wilderness in Oregon, the Frank Church-River of No Return Wilderness in Idaho and the Selway-Bitterroot and Lee Metcalf Wilderness in Montana, as well as Grand Canyon National Park in Arizona and Caney Creek Wilderness in Arkansas. The case studies used two different research designs. In one design, small samples of campsites were selected and studied in detail, making it possible to detect relatively small changes in condition. The other approach involved inventorying all campsites in an area and collecting rudimentary data on the condition of each campsite. This approach provides insight into landscape-scale change in the number and condition of campsites but the relatively imprecise measures of campsite conditions do not provide reliable information on campsite change at the scale of individual sites. Most of these studies suggest that aggregate campsite impact increased for much of the latter twentieth century, but that by the first decade of the twenty-first century, this trend reversed. Campsite impacts have recently plateaued or declined in most wildernesses in this compilation. In the most extreme cases, campsite improvement reflects (1) successful implementation of a use concentration or containment strategy, and (2) an active wilderness ranger program, involving obliteration of unnecessary or poorly located campsites and maintenance and cleaning of established campsites.

Keywords: campsite impact, recreation impact, wilderness management

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Contents

Introduction

The ecological changes that result from camping are probably the most intensive, widespread and obvious impacts of wilderness recreation. Since the first formal studies in the early 1960s (for example, Frissell and Duncan 1965), campsite impacts have been studied throughout North America and around the world (for example, Monti and Mackintosh 1979; Obua 1997). Most studies have surveyed impacts on established campsites, but a few studies have taken an experimental approach (Cole and Monz 2003) and one relied on conceptual modeling (Cole 1992). A few studies have examined newly created campsites (Marion and Cole 1996; Merriam and Smith 1974), while others have assessed campsites that are closed to use (Moritsch and Muir 1993; Stohlgren and Parsons 1986). Although impacts vary quantitatively among situations and, indeed, from campsite to campsite, campsite impacts are qualitatively consistent. As documented in a number of reviews (Cole 1987, 2004; Hammitt and Cole 1998; Leung and Marion 2000), camping substantially alters virtually all of the ecological attributes of a site. In forests, trees are damaged through root exposure, thoughtless mutilation and, in the extreme, when they are cut down for firewood. Trampling of the understory vegetation results in decreased vegetation height and cover, as well as change in species composition. Trampling abrades organic soil horizons and compacts the mineral soil. Loss of organic horizons and compaction leads to changes in the physical, chemical, and biological properties of soils. Camping impacts fauna on and around campsites and also creates aesthetic impacts, most notably those associated with camp fires and camping structures.

Wilderness managers have adopted a number of strategies designed to minimize these impacts (Leung and Marion 2004). Some actions, such as limiting amount of use through a permit system and limiting group size, although not designed specifically to reduce campsite impact, likely limit campsite impacts. The growing adoption of Leave No Trace practices (Brame and Cole 2011) must also be contributing to improved conditions on campsites. Campsite research suggests that impacts are likely to be less if camping is concentrated on a small number of sites rather than widely dispersed (Cole and Fichtler 1983) and contained in as small an area as possible on each campsite (Marion and Farrell 2002; Marion and Sober 1987). A few studies of campsite condition, before and after management actions have been taken, have found that concentration and containment of camping does reduce campsite impact (Marion 1995; Reid and Marion 2004). Temporary campsite closures, to allow recovery, have been shown to be ineffective, at least in places where recovery rates are low (Cole and Ranz 1983). However, where resilience is high and, more importantly, where there are open sites available for displaced campers, permanent closures can reduce impact (Cole and Ferguson 2009; Spildie and others 2000).

Further insight into wilderness campsite impact and management actions that can be effective in limiting them can be gained from studies of trends over time. Are campsite impacts increasing or decreasing and what characteristics of visitor use and management might account for observed trends? The purpose of this report on campsite trend studies conducted in designated wilderness or similar backcountry areas is to compile a number of individual case studies and then to seek generalizations that emerge from looking at them collectively. These studies represent most of the available empirical information on wilderness campsite trends. The only other long-term study in existence comes from a 28-year study conducted in Yosemite National Park, California. That study reported a general decrease in number of sites and particularly in the number of more highly impacted sites (Boyers and others 2000). They found, however, that the number of campsites increased both away from trails and in places that restoration crews did not visit.

This Compilation

This compilation brings together seven case studies. Five examples come from mountainous wilderness areas in the western United States: Sequoia-Kings Canyon Wilderness in California, the Eagle Cap Wilderness in Oregon, the Frank Church-River of No Return Wilderness in Idaho, and the Selway-Bitterroot and Lee Metcalf Wildernesses in Montana. The Frank Church case study explores boater campsites along the Middle Fork and Main Salmon Rivers, while the other case studies explore campsites used by hikers and groups traveling with stock. Another example comes from the desert backcountry of Grand Canyon National Park and the final example comes from the south-central United States, Caney Creek in Arkansas.

For four of the case studies, the baseline data are from the 1970s. The study lengths are 32 years for the Eagle Cap and Lee Metcalf, 31 years for Sequoia-Kings Canyon, and 27 years for the Selway-Bitterroot. At Grand Canyon, the original data were collected in 1984, providing a 21-year study length. The baseline data for Caney Creek and the Frank Church are from the 1990s, with a study length of 13 years. For some of these studies, previous reports describe trends over shorter time periods (Cole 1986, 1993; Cole and Hall 1992). Case study descriptions are more abbreviated where some of the data have been presented elsewhere.

The case studies used two different research designs. In one design, small samples of campsites were selected and studied in detail. With such precise measures, it was possible to detect relatively small changes in condition. These studies often involved stratifying sites by use level and/or ecosystem type to assess whether impact varied by these attributes. The other approach involved inventorying all campsites in an area, also collecting rudimentary data on the condition of each campsite. This approach provides insight into landscape-scale change in the number and condition of campsites but the relatively imprecise measures of campsite condition do not provide reliable information on campsite change at the scale of individual sites. In the Lee Metcalf, Selway-Bitterroot, and Sequoia-Kings Canyon studies, all sites were inventoried, but there was no detailed study of a sample of sites. In the Frank Church study, there was a detailed study of a sample of sites but no inventory of all sites. In the Eagle Cap, Grand Canyon, and Caney Creek studies, all sites were inventoried and a sample of sites was assessed as well.

Management regimes vary substantially across these case studies. At one extreme is the Salmon River in the Frank Church where use is limited and demand is so high that permits are allocated by lottery. Camping is only allowed on assigned designated sites. Floaters are given a lecture on Leave No Trace and required to carry such equipment as fire pans and porta-potties. Rangers patrol the river on a weekly basis. At Sequoia-Kings Canyon and Grand Canyon, overnight use is also limited and use of designated sites is required in a few popular places. At-large camping (camping wherever you want) is the norm. Substantial effort is put into Leave No Trace education and campfires are prohibited everywhere (in Grand Canyon) or at high elevations (in Sequoia-Kings Canyon). There is regular ranger patrol that involves substantial campsite cleanup and maintenance. In the other five places, there are no limits on amount of use and relatively little behavioral regulation. In addition, there is much less investment in regular ranger patrols.

Limitations

Although this compilation brings together much of the existing empirical data on trends in wilderness campsite condition, this approach is not without limitations. There are only eight case studies and the selection of places to study was opportunistic. While diverse, the case studies should not be considered a representative sample. Small sample size is a problem with some of the detailed studies of a sample of campsites. Samples are small to start out and then get smaller when campsites are washed away, burned over, or no longer used. As the sample dwindles, so does statistical power. This makes it more difficult to conclude with confidence that a real difference related to a variable such as amount of use is indeed a real difference. Finally, it is seldom possible to conclude with certainty the cause of an observed trend.

The Spanish Peaks Portion of the Lee Metcalf Wilderness, Montana: 1972-2004

The Spanish Peaks portion of the Lee Metcalf Wilderness, Montana, is typical of many Forest Service wilderness areas in the Rocky Mountains in receiving light to moderate use and a modest amount of management attention. In 1972, as part of a project to develop methods for judging campsite conditions (Frissell 1978), all identifiable campsites around 13 subalpine lakes were inventoried (Frissell 1973). This is perhaps the earliest systematic wilderness campsite monitoring data set. Since 1972, campsites around 10 of these lakes have been reassessed twice, in 1988 and in 2004. This paper reports trends in the number and condition of campsites around these 10 lakes during that period of time.

Study Area

The Spanish Peaks, in the Madison Range of southwestern Montana, was a 20,600-ha Forest Service Primitive Area until 1983, when it became part of the 100,000-ha Lee Metcalf Wilderness. The wilderness is located close to the university town of Bozeman and the resort community of Big Sky. Most overnight visitors are attracted to several subalpine lake basins, located within a 1-day hike or ride from trailheads, at elevations of 2,000 to 2,700 m (fig. 1). Over the years, campsites have developed in subalpine forests and meadows, mostly within 60 m of the lakes.

Figure 1—Upper Spanish Lake in the Spanish Peaks portion of the Lee Metcalf Wilderness, Montana.

Accurate use statistics have never been collected in the Lee Metcalf Wilderness, so trends in visitation since 1972 are uncertain. However, most wilderness areas in the western mountains experienced great increases in visitation during the 1960s and early 1970s, with comparatively stable overnight use thereafter. Since the mid-1970s, the overnight visitation of most western mountain wilderness areas has neither increased nor decreased greatly (Cole 1996); however, day use has increased substantially over this period in many wilderness areas. Since there is little reason to think that use trends in the Lee Metcalf Wilderness have been atypical, overnight use levels in 1972, 1988, and 2004 were probably not dramatically different. Parties with stock and hunting parties (many with stock) comprise a substantial minority of overnight visitors (Lucas 1980).

There are few behavioral restrictions and no limits on the amount of use in the Spanish Peaks area. Rangers patrol the area but patrols are very infrequent. Camping is prohibited within 200 feet of lakes but most of the campsites are within 200 feet (60 m) of lakes and they continue to be used. Stock are not to be confined within 200 feet (60 m) of lakes. There is also a group size limit of 15 people. These regulations have been in place since the 1970s. A ban on campfires and stock use has more recently been implemented at one of the study lakes (Lava Lake). One positive change is that visitors have become more adept at using Leave No Trace techniques.

Methods

In 1972, all the identifiable campsites around each lake were located on a map and each of these campsites was assigned a condition class based on amount of impact. The condition classes were defined as follows:

1. Ground vegetation flattened but not permanently injured. Minimal physical change except for possibly a simple rock fireplace.
2. Ground vegetation worn away around fireplace or center of activity.
3. Ground vegetation lost on most of the site, but humus and litter still present in all but a few areas.
4. Bare mineral soil obvious; tree roots exposed on the surface.
5. Soil erosion obvious; trees reduced in vigor and dead.

This assessment was repeated at 10 of the lakes in 1988 (Cole 1993) and again in 2004. The 10 lakes that were revisited are Lower, Middle, and Upper Jerome Rock Lakes, Upper Falls Creek Lake, Lake Solitude, Mirror Lake, Lower and Upper Spanish Lakes, “Champagne” Lake (the unnamed lake 1 km north of Lower Spanish Lake), and Lava Lake. Campsites were relocated and assigned a condition class. However, in these reassessments, classes 4 and 5 were combined because there were very few cases of obvious erosion and camping-related tree mortality. For comparability, all campsites rated class 4 or 5 in 1972 were given class 4 ratings. New campsites were noted and assigned a condition class. Where sites were no longer clearly identifiable as campsites, they were assigned a condition class of 0.

Results

In 1972, 46 identifiable campsites were found around these lakes (fig. 2). Campsites were relatively equally distributed across the four condition classes, although class 2 sites were most abundant. The lakes with the most campsites were Lake Solitude, with eight campsites, and Lower Spanish Lake, with seven campsites (table 1). Highly impacted (class 4) campsites were located at Lower Spanish Lake (three class 4 sites), Lava Lake (three class 4 sites), “Champagne” Lake (two class 4 sites), Upper Spanish Lake (one class 4 site), Mirror Lake (one class 4 site), and Lake Solitude (one class 4 site).

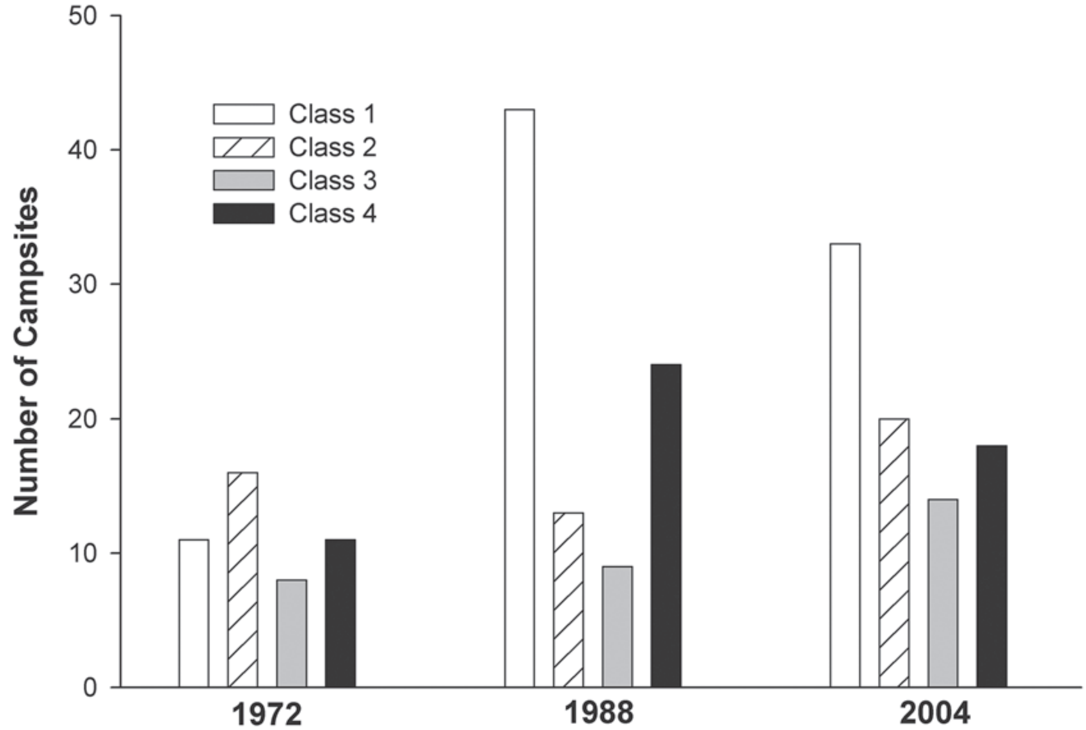

Figure 2—Change in the number of campsites, in different condition classes, in a portion of the Lee Metcalf Wilderness: 1972-2004.

Table 1—Number of campsites at each lake: 1972, 1988, and 2004.

Lake	1972	1988	2004
Lower Jerome Rock	5	9	10
Middle Jerome Rock	2	3	3
Upper Jerome Rock	4	8	9
Upper Falls Creek	2	7	5
Solitude	8	8	4
Lower Spanish	7	23	23
Upper Spanish	4	11	9
"Champagne"	2	2	3
Mirror	6	6	9
Lava	6	12	10
All Lakes	**46**	**89**	**85**

Changes Between 1972 and 1988

Between 1972 and 1988, the number of campsites at these 10 lakes increased from 46 to 89 (table 1). Of the original 46 campsites, 43 remained in 1988 and 46 new campsites were created. Of the sites that existed in 1972, 3 disappeared, 10 got better, 15 got worse and 18 stayed the same. As a caveat to this statement, seven of the sites that "stayed the same" were class 4 sites. Since class 4 sites cannot experience an increase in condition class, these sites could have deteriorated despite no increase in condition class. Of the 46 new campsites that developed between 1972 and 1988, 28 were class 1, 8 were class 2, 6 were class 3, and 4 were class 4. Due to the development of numerous new lightly impacted campsites, about 50 percent of all campsites in 1988 were class 1 sites. This contrasts with the 25 percent of campsites that were class 1 sites in 1972. The number of highly impacted class 4 sites increased from 11 in 1972 to 24 in 1988.

The proliferation of new campsites was most pronounced at Lower Spanish Lake (table 1). Number of campsites did not increase much at Middle Jerome Rock Lake, Lake Solitude, "Champagne" Lake, or Mirror Lake. The most pronounced increase in highly impacted sites occurred at Lower Jerome Rock Lake, which had seven class 4 sites in 1988, despite having none in 1972.

Changes Between 1988 and 2004

Between 1988 and 2004, the number of campsites at these 10 lakes declined slightly from 89 to 85 (table 1). Of the 89 sites that existed in 1988, 22 disappeared, 12 got better, 10 got worse, and 45 stayed the same. As noted earlier, the 18 campsites that were class 4 sites in both 1988 and 2004 could have deteriorated despite being assigned to the class "stayed the same." Eighteen of the 46 campsites that developed between 1972 and 1988 had disappeared by 2004. This was precisely offset by 18 new campsites that developed between 1988 and 2004. Of these, 14 were class 1, 3 were class 2, and 1 was class 3. The proportion of campsites that were class 1 sites was 38 percent—higher than in 1972 but less than in 1988. The number of highly impacted (class 4) campsites decreased from 24 in 1988 to 18 in 2004.

Conditions did not change dramatically at any of the lakes except at Lake Solitude, where there were fewer campsites in 2004 than there had been either in 1972 or 1988. At all other lakes, campsite density remains somewhat to much higher in 2004 than it was in 1972.

Trends Over the Entire Period

The creation of new campsites occurred continuously over the 32-year period. Of the 85 campsites present in 2004, 39 were created before 1972, while 28 were created between 1972 and 1988, and 18 were created after 1988. However, the rate of campsite creation declined over the period. More new campsites were created between 1972 and 1988 (46 sites) than between 1988 and 2004 (18 sites); in addition, campsite recovery increased over the period. More campsites disappeared between 1988 and 2004 (22 sites) than between 1972 and 1988 (3 sites). Most of the campsites that disappeared between 1988 and 2004 were newly created sites; 18 of the 22 sites that recovered had been created since 1972. Many of the new sites may have been used only once or a few times. Merely scattering the fire ring is often sufficient for recovery.

Table 2 provides detail on changes in the condition of campsites (read across rows to determine the fate of the original 1972 campsites). It shows the condition in 2004 of all campsites of a given condition class in 1972. For example, of the 16 sites that were class 2 in 1972, four had disappeared by 2004 and were recorded as class 0 in 2004. Three sites had improved to class 1; four were still class 2; one had deteriorated to

Table 2—The number of campsites in each condition class in 1972 and 2004. Sites that were class 0 in 1972 are newly created sites and sites that were class 0 in 2004 had disappeared.

1972 Campsite Condition	2004 Campsites					
	Condition Class					
	0	1	2	3	4	Total
0	18	23	15	6	2	64
1	2	6	1	2	0	11
2	4	3	4	1	4	16
3	0	1	0	2	5	8
4	1	0	0	3	7	11
Total	25	33	20	14	18	110

class 3, and four had deteriorated to class 4. In 2004, the condition of the 64 sites that were created after 1972 is shown in the row for a 1972 condition class of 0. Considering just the original 1972 campsites, conditions have not changed much. Nineteen of these sites have "stayed the same," while 14 have improved or disappeared and 13 have deteriorated. The primary change is a pronounced increased in the number of campsites, a change that mostly occurred between 1972 and 1988.

Table 2 also suggests the vulnerability of sites to change depending on their current condition. Class 1 sites were most likely to stay the same; if they changed, they were equally likely to improve or deteriorate. Class 2 sites were more likely to change, but they were equally likely to improve or deteriorate. Class 3 sites were most likely to deteriorate. For class 4 sites, we cannot tell if they deteriorated or stayed the same. Of the original 11 class 4 sites, 7 deteriorated or stayed the same, 1 disappeared and 3 improved.

Conclusions

The trend of pronounced deterioration in campsite impact that occurred in the 16 years between 1972 and 1988 has not continued in the subsequent 16 years. Since 1988, both the number and condition of campsites have been relatively stable. While it is good news that conditions are no longer deteriorating, the bad news is that conditions have stabilized at a relatively high level of impact that is much greater than is necessary for the area. Many individual campsites have levels of impact that exceed those that could exist if visitors would practice Leave No Trace techniques. The impacts associated with stock-holding (particularly trees with exposed roots) are severe on many sites. In addition, there are many more campsites than is necessary to accommodate the relatively modest amount of use that occurs around these lakes. The most extreme example is Lower Spanish Lake with 23 individual campsites, 16 of which have lost most of their vegetation cover (class 3 and 4).

Three Drainages in the Selway-Bitterroot Wilderness, Montana: 1977-2002

This case study reports on trends in the number and condition of campsites in three drainages in the Montana portion of the Selway-Bitterroot Wilderness in the quarter century between 1977 and 2002. The three drainages vary substantially in amount of use, although none are heavily used in comparison to the use of popular wildernesses.

Study Area

The Selway-Bitterroot Wilderness, one of the largest in the United States (540,000 ha), straddles the Montana-Idaho border. The Montana portion consists of a series of parallel valleys that extend from the crest of the Bitterroot Mountains to the Bitterroot Valley to the east. The distance from Bitterroot crest to the wilderness boundary is typically only about 10 km. Trails ascend most of the valleys, typically from an elevation of about 1,200 m, either to lakes in headwater cirques at elevations of 2,000 to 2,400 m or to passes that go over the crest into Idaho. Camping occurs around the cirque lakes and along the trails that access them, typically within a day's hike or ride (15 km).

Three drainages were selected for study. Big Creek was selected as a high-use drainage (fig. 1), Bear Creek was considered to be a moderate-use drainage, and Sweeney Creek was considered a low-use drainage. Each of these three drainages is accessed by trailheads within an hour's drive for the 120,000 inhabitants of the Missoula and Bitterroot valleys.

Figure 1—Big Creek Lake in the Montana portion of the Selway-Bitterroot Wilderness.

Accurate use statistics have never been collected in the Selway-Bitterroot Wilderness, so trends in visitation since 1977 are uncertain. However, most wilderness areas in the western mountains experienced great increases in visitation during the 1960s and early 1970s, with comparatively stable overnight use thereafter. Since the mid-1970s, the overnight visitation of most western mountain wilderness areas has neither increased nor decreased greatly (Cole 1996); however, day use has increased substantially over this period in many wildernesses. Since there is little reason to think that use trends in the Selway-Bitterroot Wilderness have been atypical, overnight use levels in 1977 and 2002 were probably not dramatically different. Parties with stock and hunting parties (many with stock) comprise a substantial minority of overnight visitors (Lucas 1980).

There are no limits on amount of use and few behavioral restrictions. There is ranger patrol in the area but the frequency of visitation is very low in most areas. A group size limit of 20 people and a limit of 20 head of stock are examples of a couple of restrictions. There are no restrictions on camping or camp fires, although visitors are encouraged to camp back from water and to use Leave No Trace techniques.

Methods

Beginning in the mid-1970s, the most likely places for camping in each drainage were searched and all campsites in these areas were located. In the Bear Creek drainage, we only searched along the Middle Fork of Bear Creek and the lower 7 km of the South Fork. In the early years, campsite monitoring consisted entirely of photography. Campsite overview photos and panoramic photos were taken at each site. In addition, vertical photographs of the groundcover were taken at three intervals along four transects radiating from a center point. This photography was the basis for assigning each campsite a condition class rating between 1 and 4, using a modification of the system proposed by Frissell (1978). Condition class ratings were as follows:

1. Minimal physical change except for possibly a simple rock fireplace. Ground vegetation may be flattened but not permanently injured.
2. Ground vegetation worn away around fireplace or center of activity.
3. Ground vegetation lost on most of the site, but humus and litter still present in all but a few areas.
4. Bare mineral soil widespread on the site (fig. 2).

While there may be some error in this translation, errors should be minimal given the coarseness of the condition class system and the ease of observing groundcover conditions on the photographs. Although monitoring was conducted several times in the mid-l970s, data from the year 1977 were selected as the baseline data.

In 1989, campsite inventories were repeated in each of these three drainages (Cole 1993). Each campsite located in 1977 was revisited and assigned a condition class rating. Campsites that had recovered to where they were virtually not evident were considered to have disappeared. New campsites were also located and monitored. This process was repeated in 2001 (Sweeney Creek) and 2002 (Big Creek and Bear Creek).

Results

Trends varied substantially between drainages. Of the three drainages, Sweeney Creek was the most infrequently used in the 1970s and was much less impacted than the other drainages. Campsite impact increased substantially in this drainage between 1977 and 2001. In 1977 there were only seven campsites in this drainage, three of which had pronounced impacts (classes 3 and 4) (table 1). By 1989, the number of campsites had increased to 16 and there were five sites with pronounced impact. By 2001, the number

Figure 2—This class 4 campsite has extensive exposed mineral soil.

Table 1—Changes in the number and condition of campsites in the Sweeney Creek drainage.

Condition class	1977	1989	2001
1	2	8	20
2	2	3	5
3	1	1	5
4	2	4	4
Total	7	16	34

of campsites had increased to 34 and there were nine sites with pronounced impact. Deterioration was most pronounced at Peterson Lake, the closest lake, just 8 km from the trailhead. Peterson Lake went from two campsites in 1977, one of which was a class 3 site, to 14 campsites, five of which were class 3 sites and 2 of which were class 4 sites. In addition, an extensive web of social trails developed between sites at the inlet to the lake between 1977 and 2001.

In 1977, the moderate-use Bear Creek drainage had 20 campsites, nine of which had pronounced impacts (class 3 or 4) (table 2). Although this drainage was more highly impacted than Sweeney Creek in 1977, campsite impact in this drainage declined somewhat between 1977 and 2002. By 1989, the number of campsites had increased to 35; however, there was no increase in the number of sites with pronounced impact. In 2002, the number of campsites in the portion of the drainage that we visited was 26—more than in 1977 but less than in 1989. Moreover, the number of campsites with pronounced impact was only 5—less than in either 1977 or 1989.

Table 2—Changes in the number and condition of campsites in the Bear Creek drainage.

Condition class	1977	1989	2002
1	3	14	17
2	8	13	4
3	6	7	4
4	3	1	1
Total	20	35	26

The most heavily used drainage, Big Creek, had 42 campsites in 1977, more than the Sweeney and Bear Creek drainages combined (table 3). Many of these campsites were substantially impacted. There were sixteen class 3 sites and seven class 4 sites. One-half of the campsites and a majority of the sites with pronounced impact were at the primary destination in the drainage, Big Creek Lake. Compared to the other drainages, however, campsite conditions in the Big Creek drainage were relatively stable after 1977. By 1989, the number of campsites had increased to 53, while the number of sites with pronounced impact (26) was little changed. In 2002, the total number of campsites was 49—more than in 1977 but less than in 1989. The number of campsites with pronounced impact was 20—less than in either 1977 or 1989.

Table 3—Changes in the number and condition of campsites in the Big Creek drainage.

Condition class	1977	1989	2002
1	6	10	13
2	13	17	16
3	16	19	11
4	7	7	9
Total	42	53	49

Overall Trends

In all of these drainages, the period between 1977 and 1989 was characterized by a pronounced increase in the number of campsites. The number of campsites increased from 69 in 1977 to 104 in 1989 (fig. 3). Of the original 69 campsites, 63 remained in 1989 and 41 new campsites were created. However, campsite condition did not change much. Of the sites that existed in 1977, 6 disappeared, 7 got better, 2 got worse and 54 stayed the same. Of the 41 new campsites that developed between 1977 and 1989, 23 were class 1, 12 were class 2, 5 were class 3 and 1 was class 4. Due to the development of numerous new lightly impacted campsites, 31 percent of all campsites in 1989 were class 1 sites, compared to 16 percent in 1977. The number of highly impacted class 4 sites was 12 both in 1977 and in 1989.

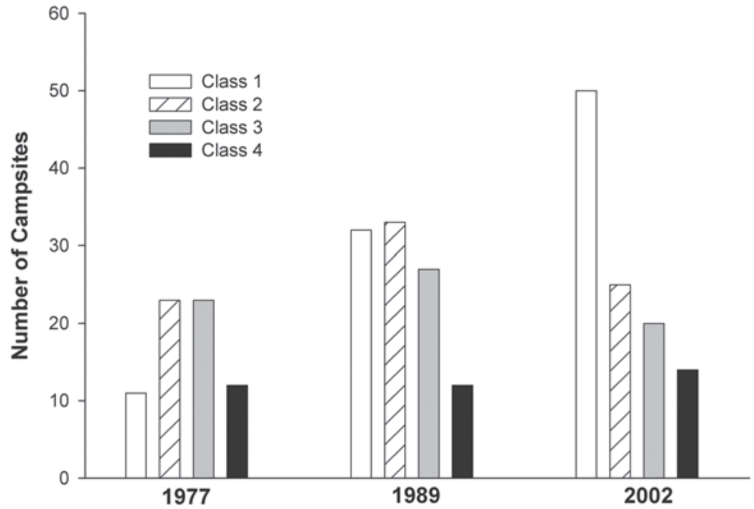

Figure 3—Change in the number of campsites, in different condition classes, in a portion of the Selway-Bitterroot Wilderness 1977-2002.

After 1989, campsite proliferation continued in the Sweeney Creek drainage, but the number of campsites declined elsewhere. By 2002, the total number of campsites in these three drainages was 109, little changed from 1989 (fig. 3). Of the 104 campsites that existed in 1989, 20 disappeared, 16 got better, 3 got worse and 65 stayed the same. Eleven of the campsites that developed between 1977 and 1989 had disappeared by 2002. This was more than offset by 25 new campsites that developed between 1989 and 2002. Of these, 19 were class 1, two were class 2 and four were class 3 sites. By 2002, the proportion of campsites that were class 1 sites was 46 percent, much higher than in 1977 or 1989. The number of highly impacted sites remained relatively unchanged.

The creation of new campsites occurred continuously over the 25-year period. Of the 109 campsites present in 2002, 54 were created before 1977, while 30 were created between 1972 and 1989 and 25 were created after 1989. However, the rate of campsite creation declined over the period. More new campsites were created between 1977 and 1989 (41 sites) than between 1989 and 2002 (25 sites). In addition, campsite recovery increased over the period. More campsites disappeared between 1989 and 2002 (20 sites) than between 1972 and 1988 (6 sites).

Table 4 provides detail on changes in the condition of campsites (read across rows to determine the fate of the original 1977 campsites). It shows the condition in 2002 of all campsites of a given condition class in 1977. For example, of the 23 sites that were class 2 in 1977, six had disappeared by 2002; they are recorded as class 0 in 2002. Six sites had improved to class 1; 10 were still class 2; and one had deteriorated to class 4. The condition in 2002 of the 66 sites created after 1977 are shown in the row for a 1977 condition class of 0. Considering just the original 1977 campsites, conditions improved substantially. Thirty-three of these sites have "stayed the same," while 17 have improved or disappeared and only 4 have deteriorated. However, this improvement on the original sites has been more than offset by the pronounced increase in the number of campsites, a change which was most pronounced between 1977 and 1989.

Table 4—The number of campsites in each condition class in 1977 and 2002. Sites that were class 0 in 1977 are newly created sites and sites that were class 0 in 2002 had disappeared.

1977 Campsite condition	2002 Campsites					
	Condition class					
	0	1	2	3	4	Total
0	11	36	10	8	1	66
1	7	4	0	0	0	11
2	6	6	10	0	1	23
3	2	3	5	10	3	23
4	0	1	0	2	9	12
Total	26	50	25	20	14	135

Conclusions

Collectively across these drainages, campsite impacts increased dramatically between 1977 and 1989, but have been relatively stable since 1989. Changes in impact reflect changes in the number of campsites more than they reflect changes in the intensity at which individual campsites are impacted. However, trends varied substantially both among and within drainages. There was an inverse relationship between impact in 1977 and the amount of resource degradation that occurred between 1977 and 2002. Conditions in Sweeney Creek, the most lightly used and impacted drainage in 1977, have deteriorated substantially. Conditions in Bear Creek deteriorated between 1977 and 1989 but have been improving since then. Conditions have been relatively stable at Big Creek. There is also variability within drainages. Many of the new campsites were developed either at the more remote lakes (Holloway, Pearl, and South Fork Lakes) or close to the trailheads, in the first few km of trail.

The end result is that conditions are becoming more homogeneous since 1977. It appears that over time, new campsites continue to be developed to the point where eventually either all desirable places to camp have been developed into a campsite or the density of campsites is so great that there is little incentive to create a new campsite. This stage was reached at Big Creek Lake and throughout much of the Big Creek drainage before 1977. This stage may have been reached in Bear Creek by the end of the 1980s. Only with further monitoring will we know whether this stage has been reached in Sweeney Creek.

The variation in trend within and between drainages illustrates the importance of monitoring conditions everywhere. The fact that proliferation of sites is more problematic than deterioration of established sites illustrates the importance of doing a census of sites rather than just monitoring a sample of established campsites. Finally, the finding that proliferation was particularly pronounced at remote attractions points out the need to focus management attention on remote places as well as popular wilderness destinations.

The Wilderness of Sequoia and Kings Canyon National Parks: 30 Years of Change

Sequoia and Kings Canyon National Parks are among the premier destinations in the world for wilderness travel and camping. Wilderness recreation has a long history here; a number of scenic attractions have been popular destinations for over a century. Some of the earliest expressions of concern about the environmental effects of recreation use came from these parks. The impacts of grazing on meadows were prominent concerns, but so were the impacts associated with camping. In response to these concerns, Sequoia and Kings Canyon National Parks pioneered efforts to sustainably manage wilderness recreation generally and campsite impacts in particular. As early as 1961, camping was prohibited at Bullfrog Lake because of excessive impact (Parsons 1979). By 1970, restrictions were imposed at the popular Rae Lakes area; stays at the lakes were limited to one night and campfires were no longer allowed (Parsons 1983).

In support of the wilderness management program at the parks, an inventory of all campsites in the wilderness was conducted between 1976 and 1980. This was among the earliest attempts to monitor wilderness campsites anywhere in the world. During that inventory, conditions were recorded on a total of 7,732 wilderness campsites—2,973 in Sequoia and 4,759 in Kings Canyon (Parsons and Stohlgren 1987). The information collected provided a basis for determination of user capacities in the 1980s, including the trailhead quotas presented in the parks' 1986 Backcountry Management Plan (Parsons 1986). By the mid-2000s, the decision was made to reinventory campsites in a sample of the parks' wilderness to describe current conditions and assess trends. This paper reports the results of that reassessment of campsite distribution and condition.

Study Area

Sequoia and Kings Canyon National Parks are located in the southern Sierra Nevada of California. The wilderness of the two parks consist of the 311,000-ha Sequoia-Kings Canyon Wilderness and the largely contiguous 16,000-ha John Krebs Wilderness. These lands are bounded by Forest Service wilderness on the north, east, and south and portions of the west—making them part of one of the largest blocks of wilderness in the lower 48 states. These wildernesses are accessed by over 70 trailheads, both on park land and adjacent Forest Service land. The parks are home to the highest peak in the lower 48 states, Mt. Whitney (4,418 m), a 156 km stretch of the famous John Muir Trail and also 163 km of the Pacific Crest Trail. In all, there are more than 1,100 km of maintained trails in the parks, as well as numerous opportunities to travel off trails. Sites impacted by camping are located in a wide range of vegetation types, at elevations from below 1,500 m in the canyon bottoms of the west to over 4,000 m on the summit of Mt. Whitney. Most sites are located in the mixed coniferous forest of mid-elevations, the extensive coniferous forest of the subalpine zone or within the mosaic of forest and meadow that occurs close to timberline (fig. 1); however, there are also many campsites in the open alpine communities above timberline, as well as some below the coniferous forest.

Figure 1—Cirque lake basin in the Sequoia-Kings Canyon Wilderness.

Visitor Use

The long-term trend in overnight visitation can be characterized as one of increasing use, with a notable period of abnormally high use that began by the late 1960s and ended in the 1980s. Year-to-year, use levels have fluctuated dramatically; use increased greatly in the 1960s and early 1970s, decreased somewhat in the 1980s and 1990s and has generally been increasing recently. Permit data show a peak in overnight use of about 220,000 visitor nights in 1974, more than four times what it was a decade before and almost twice what it was in 2010 (fig. 2). However, there are reasons to mistrust this estimate of how much use has declined since 1974. According to the permit data, use only declined 22 percent between 1974 and 1994 and has increased 45 percent since 1995. Most of the reported decline in use since 1974 occurred in one year, between 1994 and 1995, suggesting a change in counting protocols. Obtaining accurate counts of visitor use is a challenge, due to the dispersion of access points, the need to share information across agency boundaries, and the number of people who do not obtain permits or who change their route or length of stay once on a trip. It seems sufficient to conclude that current use levels are much higher than they were prior to the 1970s and lower than they were in the early 1970s. It is important to note that the initial campsite inventory occurred late in the decade during which wilderness use increased most rapidly—at the peak of the backpacking boom. The repeat inventory came after a period of stable or slightly increasing use, at levels well below peak use of the 1970s. Unfortunately, there are no data for conditions prior to the backpacking boom.

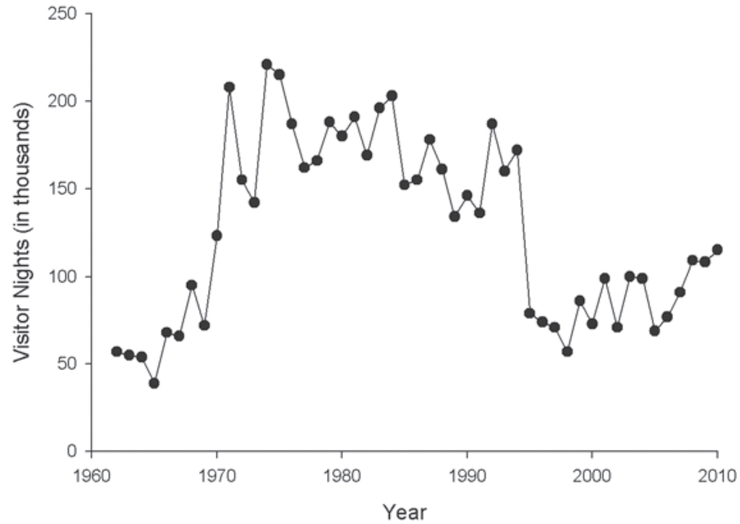

Figure 2—Trends in overnight use, as reported on wilderness permits.

Most wilderness use in these parks occurs during the summer—between Memorial Day and mid-September. Most use is backpacking; less than 4 percent of visitors travel with horses or mules. Mean party size is about three persons and the mean length of stay is 3 to 4 days. These use characteristics are little changed from what they were in the 1970s, although typical length of stay has declined somewhat. However, amount of stock use is substantially lower than it was in the 1970s. Total stock use nights during the decade of the 2000s were only about one-half of stock nights in the 1970s. Private stock use, in particular, has declined. The number of private stock use nights during the 2000s was only 38 percent of private stock nights in the 1970s.

Use of the wilderness has always been concentrated at a variety of spatial scales. The John Muir Trail, High Sierra Trail, and Rae Lakes Loop have been more heavily used than other trails for close to a century. Then, on any given route, there are locations that are particularly popular for camping—trail junctions, meadows with good feed, lakes with good fishing, and locations with outstanding scenery. In addition, most travel occurs on maintained trails, although there are abandoned trails and cross-country routes that receive regular use. Finally, there are often particular campsites that are used much more than other campsites in the vicinity. Various forces have influenced the degree to which and where use is concentrated. Guidebooks extolling cross-country routes, information about crowding on the John Muir Trail, quota systems and length-of-stay limits have served to disperse use more widely. Campfire restrictions, bear-proof food storage lockers, designated campsites, packstock restrictions, and a reduction in miles of maintained trail have served to concentrate use. So have guidebooks and information posted on the internet that gives the coordinates of campsites. Visitor education has also had an influence. During the 1970s, much of the message involved spreading out to avoid crowding and impact; more recently, concentrating use on sites that have already been well-impacted has been given more emphasis.

The distribution of use among trailheads has not changed dramatically since the 1970s. Nine of the 10 most popular trailheads in the 1970s are still among the most popular 10 trailheads today. The 10 most popular trailheads (out of more than 70 trailheads) accounted for 62 percent of overnight visits in the 1970s and 65 percent of overnight visits in 2007-2010. The use distribution among travel zones appears to have changed more dramatically, although these data are much more subject to inaccuracies resulting from reporting procedures. Only 8 of the 15 most heavily used travel zones in the late 1970s were still among the most popular travel zones in 2007-2010. Travel zone use distribution, like trailhead use distribution, has become slightly more concentrated. The 15 most popular travel zones accounted for 56 percent of total use in the late 1970s and 61 percent of total use in 2007-2010. Clearly, there has been a shift in use toward the John Muir Trail and travel zones close to Mt. Whitney.

Visitor Use Management

As noted above, some of the trends in use distribution reflect changes in management. Prior to the 1970s, visitor use management was largely confined to routine patrol and campsite clean-up. Considerable energy was consumed dealing with trash, particularly large can dumps remaining from the era when burying trash was advised. But the need for more active management in popular places was becoming clear. Bullfrog Lake was closed to camping in 1961 (Parsons 1979) and camping restrictions at Rae Lakes were implemented in 1970. By 1976, the time the initial campsite inventory was initiated, overnight use limits had been established throughout the wilderness. Quotas were established for every trailhead, limiting the number of people per day that could enter the wilderness (Parsons and others 1981). Once they gained access, they could travel wherever they wanted. These limits were first put into effect in 1972 for the Rae Lakes Loop and expanded to both parks in 1975 (Parsons 1983).

By the mid-1970s, camping was not allowed at four lakes and was only allowed at designated sites at two lakes. There was a one-night limit on camping in some popular areas and campfires were prohibited in seven specific locations. A number of stock use restrictions were also implemented (McClaran 1989). By the mid-1970s, all stock travel was prohibited in 4 places, 3 places were closed to overnight use, 10 places were closed to grazing, 5 meadows were closed to grazing before a particular date, and 11 meadows had length of stay limits. By the mid-1980s, the number of places with campsite, campfire and stock restrictions had increased. Site-specific campfire restrictions were generally replaced by elevational restrictions, generally above 10,000 feet (3,048 m) in Kings Canyon, above 11,200 feet (3,414 m) in the Kern Canyon, and above 9,000 feet (2,743 m) in the Kaweah drainage.

In addition, by the late 1970s the wilderness rangers gave increased emphasis to efforts to improve campsite conditions. Over time, this effort evolved into a program of reducing, relocating, and actively maintaining campsites. The latter program was facilitated by information gleaned from the initial campsite survey. In particular, campsites were eliminated if they were too close to water; ideally sites were to be at least 50 feet (15 m) from water. Sites were also eliminated if there were more than necessary in any location. Fire rings were eliminated in places where campfires were no longer allowed. In addition, developments such as tables and seats were eliminated and large fire rings were replaced with smaller fire rings. Attempts were made to reduce the size of extremely large campsites.

Another significant management change that occurred during the 1980s involved the installation of food storage devices to help visitors keep food away from bears. Initially, bear cables and poles were used. But these were quickly replaced by food storage lockers. Currently, there are 82 food storage lockers located at popular destinations along trails in the southern portion of Kings Canyon National Park and throughout Sequoia National Park. These lockers serve to concentrate use on campsites close to the lockers.

Substantial progress was made during the late 1970s and 1980s in reducing the number, size, and level of development of sites, as well as campfire evidence where fires are prohibited. This focus was a shift in emphasis from the 1960s and early 1970s, when trash removal was a much more significant task. Maintaining the fruits of these efforts requires constant vigilance. Despite increased knowledge about Leave No Trace techniques and general compliance with regulations, some visitors still build new campsites and have fires in places where they are prohibited. These sites need to be dismantled. Moreover at popular sites, where campfires are still allowed, ashes need to be removed. Wilderness rangers report that, ideally, popular sites need to be cleaned once every 2 weeks. This work is the responsibility of wilderness rangers who are diligent in providing these services, along with educating visitors in minimum impact practices.

Methods

The results reported here come from (1) an initial survey of all parts of the wilderness of both parks between 1976 and 1981 and (2) a repeat survey of almost one-half of these areas in 2006 and 2007. To facilitate reporting of campsite distribution and impact data, the parks' 52 travel zones were subdivided into 273 different subzones—originally referred to as management areas. Most travel zones have 4 to 6 subzones, though some have as few as 2 and one has 15. Subzones are smaller, more ecologically homogeneous areas that can be managed more consistently than the larger travel zones.

The Initial Survey, 1976-1981

Field crews attempted to locate all campsites along established trails, along many of the more popular cross-country routes, and at likely camping destinations, such as lakes without trails. They documented campsite attributes and conditions using the methodology described by Parsons and MacLeod (1980). Although the survey extended from 1976 to 1981, it was virtually complete after the 1979 season. Surveyors wandered around searching some distance from trails and water bodies in an effort to find as many campsites as possible. Campsites were defined as any sites showing evidence of past overnight use. These include sites with fire rings or with cleared areas suitable for sleeping. While some were small and lightly impacted, others were large and highly developed. In some popular areas, clusters of individual sites coalesce, making it difficult to determine whether there is one large site or a number of smaller sites. The number of individual sites in a cluster was based on a judgment of how many independent groups might camp there on a single night.

In the initial survey, each campsite was located on a sketch map of the immediate area. Back in the office, each campsite was represented by a dot on 1:62,500 scale USGS quadrangle maps. In addition, the condition of each campsite was assessed and other locational and descriptive information was noted. Campsite condition was assessed on the basis of eight criteria:

- Density of Vegetation: A relative measure of the extent of vegetative ground cover within the campsite compared to similar unimpacted area outside the site.
- Composition of Vegetation: A measure comparing the species composition and relative abundance in the campsite to surrounding unimpacted areas.
- Total Area of the Campsite: An estimate of the total area affected by trampling directly associated with use in and about the site.
- Barren Core: An estimate of the area that had been completely denuded of vegetation by trampling. This usually was confined to the central part of the campsite.
- Campsite Development: A rating based on the amount of man-made "improvement" in the campsite, such as tables, rock walls, fire rings, etc.

- Litter and Duff: Applied only on forested sites, this is a rating of the degree to which organic debris (needles, cones, and twigs) had been pulverized or removed by trampling and other use.
- Social Trails: A measure of impact on surrounding vegetation from trampling of informal access trails to such nearby destinations as water sources, main trails, other campsites, etc.
- Mutilations: Applied only in wooded areas, a measure of the number of permanent marks on trees, such as carving, axe marks, and nails.

Rating factors for each criterion are presented in table 1. Factors were based on a five point scale, with five representing maximum impact and one representing minimal impact. Values recorded for each of the applicable criteria (as applied to that site) were summed and divided by the number of criteria to produce an overall condition class rating. With practice, surveyors were able to assign a condition class rating without recording ratings for individual criteria. In the interest of saving time, this approach was taken on the majority of sites. Individual criteria were recorded for about 20 percent of the sites.

Table 1—Criteria and rating factors used to assess campsite condition.

Vegetation density	**Vegetation composition**
(with respect to surrounding vegetation)	**(with respect to surrounding vegetation)**
1 = Same as surroundings	1 = Same as surroundings
3 = Moderately less dense than surroundings	3 = Moderately dissimilar
5 = Considerably less dense thatn surroundings	5 = Significantly dissimilar
Total area of campsite	**Barren core area**
1 = Less than or equal to 20 ft^2 (2 m^2)	1 = Absent
2 = 21 to 100 ft^2 (2 to 9 m^2)	2 = 5 to 50 ft^2
3 = 101 to 500 ft^2 (9 to 46 m^2)	3 = 51 to 200 ft^2
4 = 501 to 1,000 ft^2 (93 m^2)	4 = 201 to 500 ft^2
5 = Greater than 1,001 ft^2	5 = Greater than 501 ft^2
Campsite development	
1 = Windbreaks and paraphernalia absent, trash and seats minimal; firerings absent or scarce	
2 = Trash, windbreaks, seats, and firerings minimal; paraphernalia absent	
3 = Trash, windbreaks, seats mostly moderate; firerings mostly minimal; paraphernalia minimal	
4 = Trash, windbreaks, seats, firerings, and paraphernalia mostly moderate, some heavy	
5 = Trash, windbreaks, seats, firerings, paraphernalia mostly heavily developed	
Litter and duff	
1 = Trampling barely discernible; some needles broken; scattered cones	
2 = Moderately trampled; needles broken; compacted; few cones	
3 = Heavily trampled; clumped, pulverized; cones absent	
4 = Litter more or less absent; pulverized; ground into soil	
5 = Litter, cones, and duff completely absent	
Social trails	**Mutilations**
1 = None	1 = None
2 = 1 trail discernible	2 = 1 to 2
3 = 2 trails discernible	3 = 3 to 5
4 = 1 to 2 trails well developed or >3 trails more or less discernible	4 = 6 to 10 or 1 to 2 highly obtrusive
5 = >3 well developed trails	5 = >11 or 3 more or less highly obtrusive

In addition, the following descriptive information was recorded: overstory and understory vegetation type and cover, distance to water, and the number of other class 3, 4, and 5 sites within 100 feet (an indicator of crowding potential). An evaluation was made of the site's potential for use by large groups and comments were recorded on such items as the number of fire rings and fire scars and the need for rehabilitation or other management action. In addition to campsite-specific data, descriptive information was recorded for each subzone. This included elevation, landform (lake, river valley, ridge, plateau, etc.), potential campable area (an estimate of the proportion of the area amenable to camping), the percent of campable area currently used for camping, overstory vegetation type and cover, whether meadows constitute a significant portion of the area, and a qualitative rating of firewood availability. In the office, maps and use data were consulted to identify the trail type that was used by most people to access the subzone (primary or secondary trail, unmaintained footpath, or cross-country). The distance to the nearest trailhead, the trailhead contributing the majority of use and the nearest ranger station were also recorded.

The Repeat Survey, 2006-2007

In 2006 and 2007, the campsite survey was repeated in 120 (44 percent) of the 273 subzones. In 2006, all 54 subzones in 9 purposely selected travel zones were surveyed. The travel zones selected were primarily popular zones where changes were expected based on management actions taken and/or changes in visitor behavior and use patterns. Another nine subzones, located in five different travel zones were surveyed in 2006; many of these were less popular locations. In 2007, this sample was supplemented with a random sample of 57 other subzones. So the repeat sample can be characterized as a very large sample that is slightly biased toward more popular use areas.

Perhaps the most fundamental change in procedure in the repeat survey regarded the treatment of sites that had not been recently used for camping. Instead of considering them to be campsites, they were recorded as restoration sites—sites that still showed the impacts of camping but had either been actively restored or appeared to be abandoned and not used for many years. For each restoration site, GPS coordinates were recorded and it was noted whether the site had been closed and actively restored by rangers or whether it was recovering on its own because nobody chose to camp there.

For the 2006-2007 survey, the same criteria were used to assign condition class ratings to each campsite. Individual criteria were assessed for all sites that appeared to have ratings of class 3 or higher, as well as some more lightly impacted sites. In all, individual criteria were recorded for 35 percent of sites, compared to 20 percent in the initial survey. For most sites, it was impossible to determine if the site was a new site or a particular site from the initial survey.

Field Trips and Ranger Interviews

In addition, two trips were taken to make observations of how conditions relate to data collected. Among other things, these trips allowed an assessment of the thoroughness of the reinventory and its comparability with the initial survey. We also interviewed long-term wilderness rangers and others with a long history of working and observing conditions in the wilderness of the parks, some dating from the 1970s. We asked questions about observed changes in conditions, potential reasons for the changes observed, types of management actions that were taken, and how management relates to change in conditions. These interviews informed the discussion and conclusions presented in this report.

Data Analysis

To compare campsite conditions in different subzones, a procedure for arriving at an aggregate impact rating for each subzone was needed. Although the mean condition class rating was one option, it was clear that the rating scale of one to five was not linear. A class five site is much more than five times as impacted as a class one site. To arrive at a more appropriate rating scale, it was decided to use campsite area as the basis for the weighting scale. Specifically, weights were the ratios between the campsite area midpoints from the five classes in table 1. The results were "weighted value" ratings of 1 for a class 1 site, 6 for a class 2 site, 30 for a class 3 site, 75 for a class 4 site and 150 for a class 5 site. Using these ratings, the aggregate impact for each subzone (total weighted value) was calculated by summing the weighted values of all the campsites in the subzone.

The second issue that had to be dealt with was the vastly different size of the subzones. A subzone with a large total weighted value might be either an area with unusually high levels of campsite impact or a very large subzone. For example, it was common to divide highly impacted places into smaller subzones. The comparability of subzones was increased by estimating the "campable miles" of each subzone. This metric was assessed by multiplying the proportion of the subzone considered capable of supporting camping (recorded in the field) by the linear distance of water bodies. This linear distance was the total perimeter of lakes in addition to two times the length of streams. In other words, it is the length of all lakeshores and streambanks, subtracting out places that are not suitable for camping, due to slope, rockiness, etc. For some areas, a high proportion was not deemed "campable." Total weighted value per campable mile provides an aggregate campsite impact metric that should be relatively comparable across subzones that differ greatly in size and camping suitability.

To compare the two different time periods, one possibility is to compare initial conditions to conditions on those sites still being actively used as campsites in 2006 and 2007. However, this ignores all the restoration sites that have not fully recovered from camping (or they would not have been found). Also, restoration sites would have been recorded as campsites in the initial survey, so they should be included at least in some of the impact assessments. The problem is that their condition class was not recorded. Fortunately, pictures of a substantial number of restoration sites and observations from field workers make it clear that most—but not all—of these sites would have been recorded as class 1 sites. Therefore, we decided to assign each restoration site a weighted value of 2. If 80 percent of restoration sites are class 1 and 20 percent are class 2 (a distribution likely to be close to the actual situation), this is an appropriate decision.

Most of the results report simple descriptive statistics, such as the number of sites and their condition. To assess the effect of use, environment, and management on campsite condition and change, we employed t-tests, analyses of variance and regression, depending on the characteristics of the explanatory variable. We used regression when the explanatory variable has an interval scale of measurement (for example where elevation is measured in feet or distance to the closest trailhead is measured in miles). Where the explanatory variable has an ordinal scale of measurement and there are more than two classes (for example access trail type, from cross-country to unmaintained path to secondary trail to primary trail), we used analyses of variance. Where the explanatory variable has just two classes (e.g. fires allowed or prohibited), we used t-tests. Differences were considered significant where p was less than 0.05.

Results

A total of 2,955 sites impacted by camping were located during the 2006-2007 surveys. Of these, 1,795 were considered active campsites and another 1,160 were restoration sites, apparently no longer being used for camping (table 2). The repeat sample included 44 percent of the subzones originally surveyed and 45 percent of the campsites found in the initial survey were in these subzones. This suggests that, had the entire wilderness been surveyed, we would have found about 6,600 impacted sites, of which about 4,000 are being actively used as campsites.

Most of the campsites in the wilderness are not highly impacted. Just considering campsites, 60 percent were rated as class 1 campsites (table 2). Class 1 campsites range from sites that are barely noticeable (fig. 3) to sites that, although small, have clearly been trampled and have fire rings. Another 30 percent of campsites were rated as class 2 campsites. Class 2 sites are obvious campsites that do not appear highly worn.

Table 2—Number of sites impacted by camping, by condition class for sites still being used and referenced as restoration sites for those no longer being used, 2006-2007.

	Number of sites	Percent of campsites	Percent of all sites
Class 1 campsites	1084	60	37
Class 2 campsites	549	31	19
Class 3 campsites	134	7	5
Class 4 campsites	28	2	1
Class 5 campsites	0	0	0
Total campsites	1795	100	-
Restoration sites	1160		39
Total impacted sites	2955		100

Figure 3—Barely noticeable class 1 campsite.

Only 7 percent of campsites were rated class 3. Class 3 sites are well-impacted popular sites, without any attributes of severe impact. Only 2 percent of campsites were rated as class 4 campsites and no campsites were rated class 5. Class 4 sites are highly impacted, with some aspects of extreme impact. They often have large areas completely devoid of vegetation, litter and duff (fig. 4). When restoration sites are considered as well, about 70 percent of sites can be considered lightly impacted (all class 1 campsites and most restoration sites). Only about 6 percent of sites (perhaps 350 sites in the entire wilderness) are substantially impacted (class 3 and 4 campsites) and no sites have the extreme levels of impact found on class 5 sites in the initial survey.

Of the 1,160 restoration sites, 616 (53 percent) were judged to have been actively restored. That is, rangers had worked to eliminate evidence of use and/or keep people from camping on the site. Another 544 (47 percent) of the restoration sites were judged to have recovered on their own, without human assistance. Most likely, many of these sites were only used a few times. Often breaking up the fire ring removed the only evidence that anyone had ever camped there.

Figure 4—Class 4 campsite with widespread severe impact.

Change in Campsite Conditions Since the 1970s

During the 30-year period between campsite surveys, campsite impact decreased profoundly. The number of campsites decreased and the condition of remaining campsites improved (table 3). The number of actively used campsites in 2006-2007 was only about one-half of the number of sites that existed in the late 1970s. Even more striking, the number of class 3 sites decreased 79 percent, the number of class 4 sites decreased 89 percent, and there were no class 5 sites at the time of the repeat survey. The mean condition class decreased 28 percent. The weighted value metric, which accounts for the non-linear nature of the condition classes and reflects both the number and condition of sites, suggests that aggregate impact on actively used campsites decreased 85 percent.

Table 3—Change in the number and condition of campsites and all sites impacted by camping, in the subzones sampled in 2006-2007.

	1976-1981	2006-2007	Change	Percent Change
Class 1 campsites	1,325	1,084	-241	-18%
Class 2 campsites	1,153	549	-604	-52%
Class 3 campsites	627	134	-493	-79%
Class 4 campsites	264	28	-236	-89%
Class 5 campsites	149	0	-149	-100%
Total campsites	3,518	1,795	-1,723	-49%
Mean campsite condition class	2.08	1.50	-0.58	-28%
Weighted value, campsites	69,203	10,498	-58,705	-85%
Restoration sites	0	1,160	1,160	∞
Total sites impacted by camping	3,518	2,955	-563	-16%
Weighted value, total sites	69,203	12,818	-56,385	-81%

However, these estimates do not account for the 1,160 restoration sites that still show evidence of impact from past camping. When these sites are added in, the decline in number of impacted sites is 16 percent (table 3). Extrapolating the sample data to the entire wilderness, there are currently about 1,250 fewer impacted sites than there were in the 1970s. If we assume that 80 percent of these restoration sites would be rated as class 1 and the rest as class 2, the number of lightly impacted sites actually increased over this time period (fig. 5). Nevertheless, aggregate camping impact has clearly decreased greatly. Based on the assumption above, we estimate that aggregate camping impact decreased 81 percent (table 3).

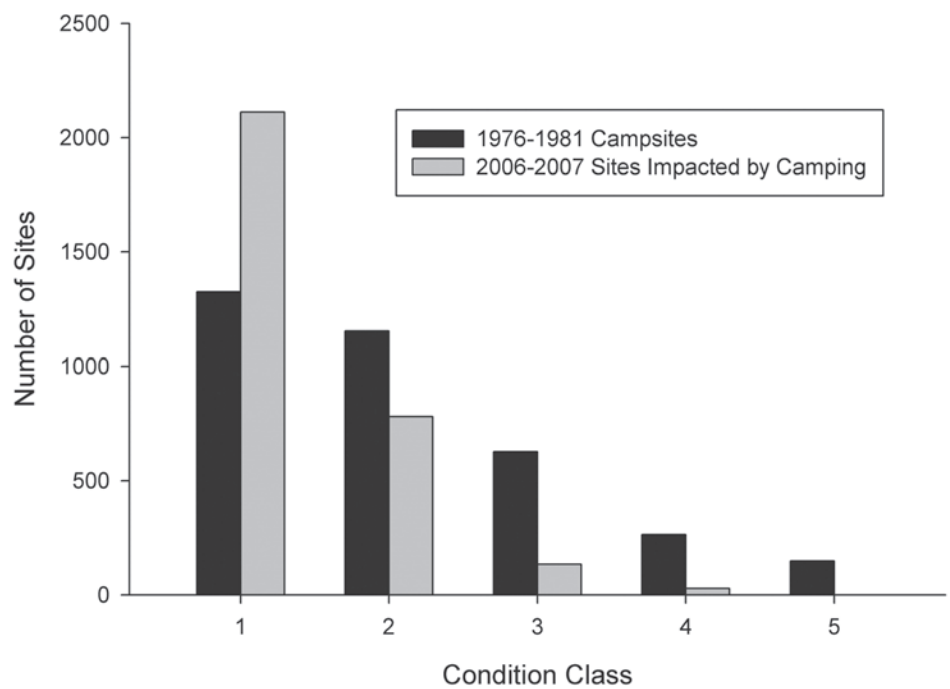

Figure 5—Change in number of sites impacted by camping, by condition class, between 1976-1981 and 2006-2007, assuming that 80 percent of restoration sites were class 1 sites and the rest were class 2 sites.

One of the management policies emphasized with increased vigor during the 1970s was to eliminate, to the maximum extent possible, camping close to water. Rangers attempted to obliterate campsites within 25 feet (8 m) of water and, if possible, campsites within 50 feet (15 m) of water. Survey data document the tremendous progress that was made. Between surveys, there was an 88 percent reduction in campsites within 25 feet of water and a 71 percent reduction in campsites 26-50 feet from water (fig. 6). Another change in management that has generated controversy is the placement of food storage lockers in popular locations. Sites in the immediately vicinity of food storage lockers are significantly more impacted (ANOVA, $p < 0.01$) than those further away (fig. 7). Some of the impact around the food storage lockers reflects the fact that lockers were typically placed in areas that were already highly impacted due to their popularity.

Variation in Campsite Number and Condition—To explore whether environmental attributes affected trends in campsite impact, we compared change in the number of impacted sites (both campsites and restoration sites) in subzones located in different elevation zones. We also compared change in the total weighted value of subzones located in different elevation zones. Decreases in both the number of impacted sites and weighted value did not differ significantly among elevation zones (regression, $p = 0.86$ and 0.87). Change in the number of sites varied significantly with distance from the closest trailhead, but not in a linear fashion (fig. 8) and differences were not statistically significant (regression, $p = 0.28$). The change in weighted value decreased with distance from the closest trailhead, suggesting there was more improvement closer to trailheads. Differences were small and not statistically significant, however (regression, $p = 0.11$). In the 1970s, subzones located closer to trailheads were substantially more impacted than those located further from trailheads, which is no longer the case (fig. 8). A similar pattern was observed for distance to the closest ranger station.

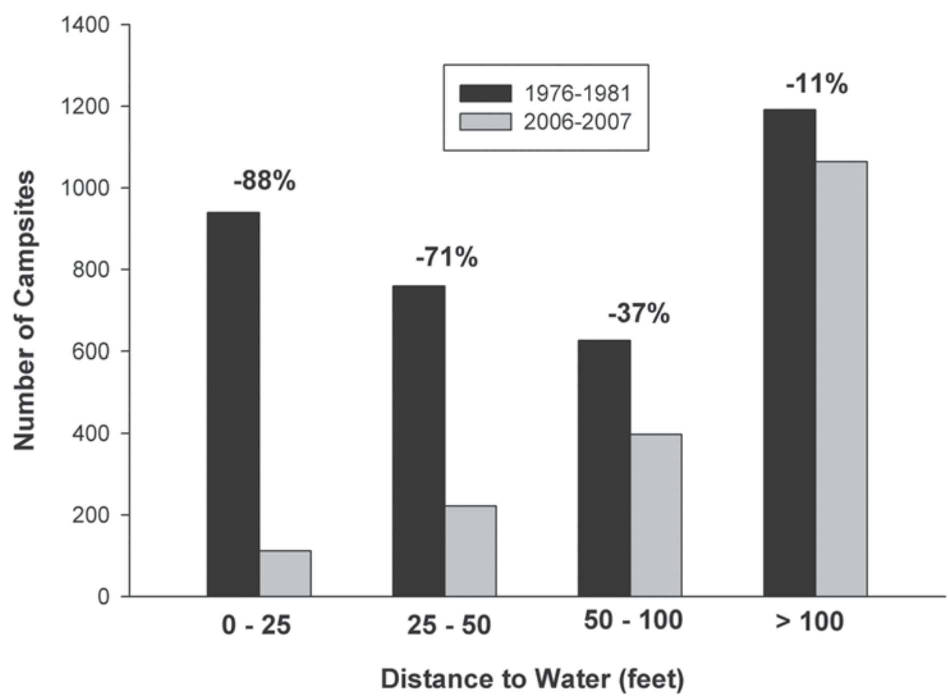

Figure 6—Change in number of campsites between 1976-1981 and 2006-2007, with distance of campsite from water. Numbers above bars are the percent change.

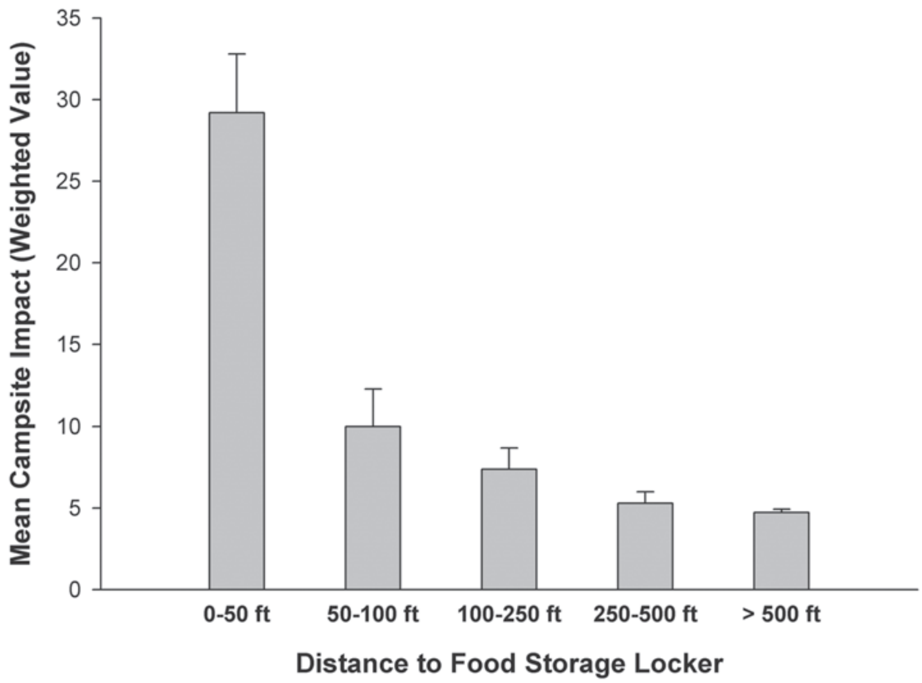

Figure 7—Variation in campsite impact with distance from food storage lockers, 2006-2007 (mean weighted value and standard error).

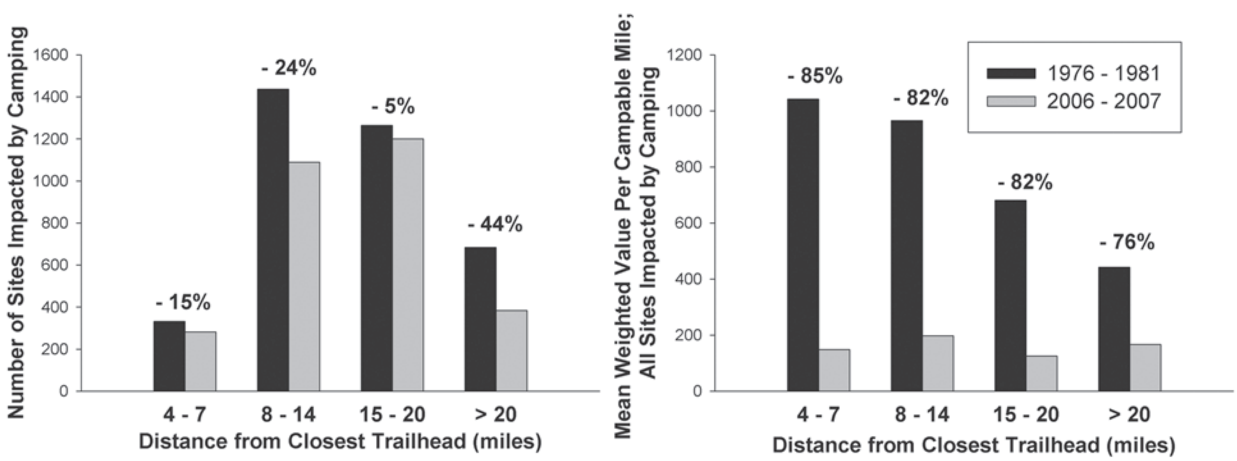

Figure 8—Change in number of sites impacted by camping and weighted value per campable mile, between 1976-1981 and 2006-2007, by distance from the closest trailhead. Numbers above bars are the percent change in number of sites and in total weighted value (not weighted value per campable mile).

Change in number of sites was variable but not in a linear manner (regression, p = 0.13), while change in weighted value decreased with distance from the closest ranger station. In this case, the amount of improvement in conditions was significantly greater closer to ranger stations (regression, p < 0.01). In the 1970s, subzones located closer to ranger stations were substantially more impacted than those located further from stations. By 2006-2007, this was no longer the case.

Decrease in the number of sites was greatest in subzones accessed by unmaintained paths (26 percent) and least in cross-country subzones (7 percent) (fig. 9); however, these differences were not statistically significant (ANOVA, p = 0.57). The change in weighted value was similar in subzones accessed by primary trails, secondary trails, and unmaintained paths (81-85 percent). It was significantly lower in cross-country subzones (56 percent)(ANOVA, p <0.01), suggesting there has been less improvement in areas not accessed by trails and paths. In the 1970s, impact was much greater in subzones accessed by primary trails; cross-country subzones were relatively unimpacted. In 2006-2007, differences were less pronounced (fig. 9). Subzones accessed by primary trails were still most impacted but impacts in cross-country subzones were similar to those in subzones accessed by secondary trails and unmaintained paths.

The number of sites decreased substantially (16-23 percent) in subzones with little or no overnight stock use. In subzones with moderate to high overnight stock use, the number of sites impacted by camping either did not change or increased slightly (2 percent). However, this difference was not statistically significant (ANOVA, p = 0.15). Moreover, change in weighted value did not differ significantly with level of overnight stock use (ANOVA, p = 0.20). There was no consistent relationship between level of campsite impact and amount of overnight stock use, either in the 1970s or more recently.

Whether or not campfires were allowed had little influence on change in either the number of sites (t-test, p = 0.32) or weighted value (t-test, p = 0.67) (fig. 10). This is somewhat surprising in that there is a widespread opinion that campfire restrictions have contributed significantly to the improvement in campsite conditions. There are more campsites in subzones where campfires are not allowed but mean weighted value

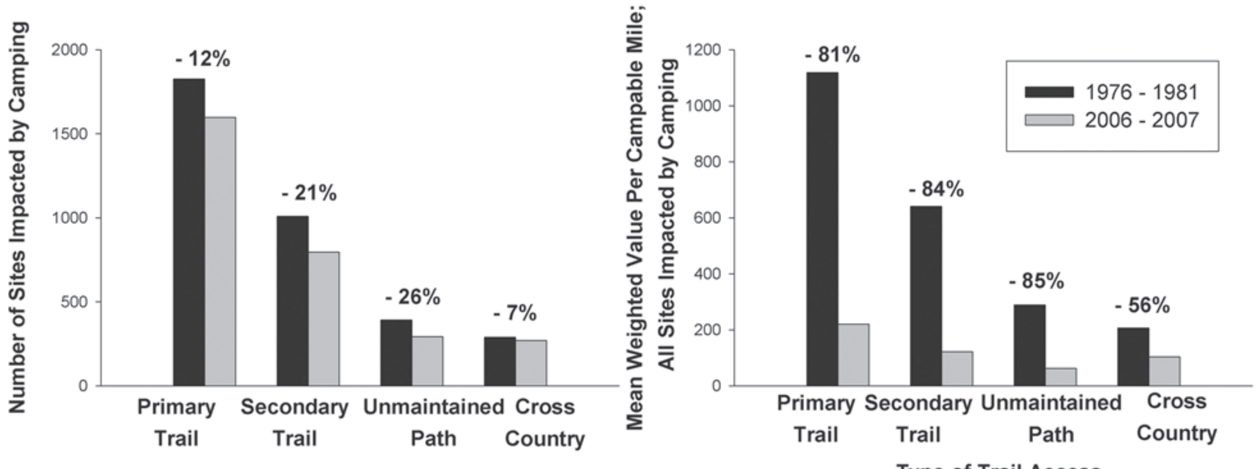

Figure 9—Change in number of sites impacted by camping and weighted value per campable mile, between 1976-1981 and 2006-2007, by type of trail access. Numbers above bars are the percent change in number of sites and in total weighted value (not weighted value per campable mile).

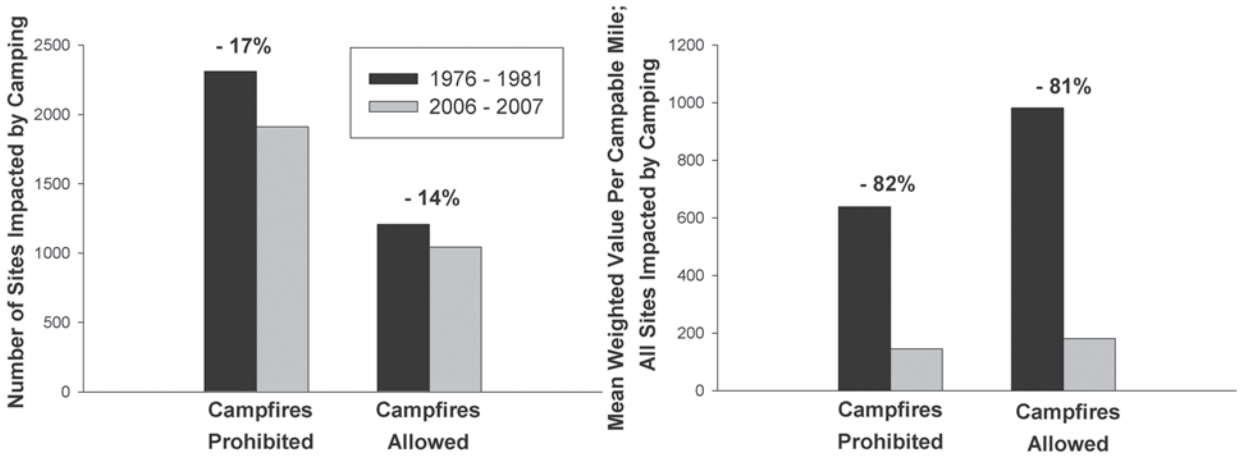

Figure 10—Change in number of sites impacted by camping and weighted value per campable mile, between 1976-1981 and 2006-2007, by whether or not campfires are allowed. Numbers above bars are the percent change in number of sites and in total weighted value (not weighted value per campable mile).

per campable mile is greater in subzones where campfires are allowed (fig. 10), indicating that campsites are typically more impacted in subzones that allow campfires. This might reflect the impacts associated with having campfires or it might reflect the amount or type of use that occurs at lower and mid-elevations or even differences in environmental durability.

Finally, whether or not food lockers are provided also had little influence on change in either the number of sites (t-test, p = 0.31) or weighted value (t-test, p = 0.56), at the scale of the subzone (fig. 11). This suggests that while food storage lockers may concentrate use on certain sites within subzones (see fig. 7), they do not have much effect on how use is distributed among subzones. This finding suggests that the oft-observed

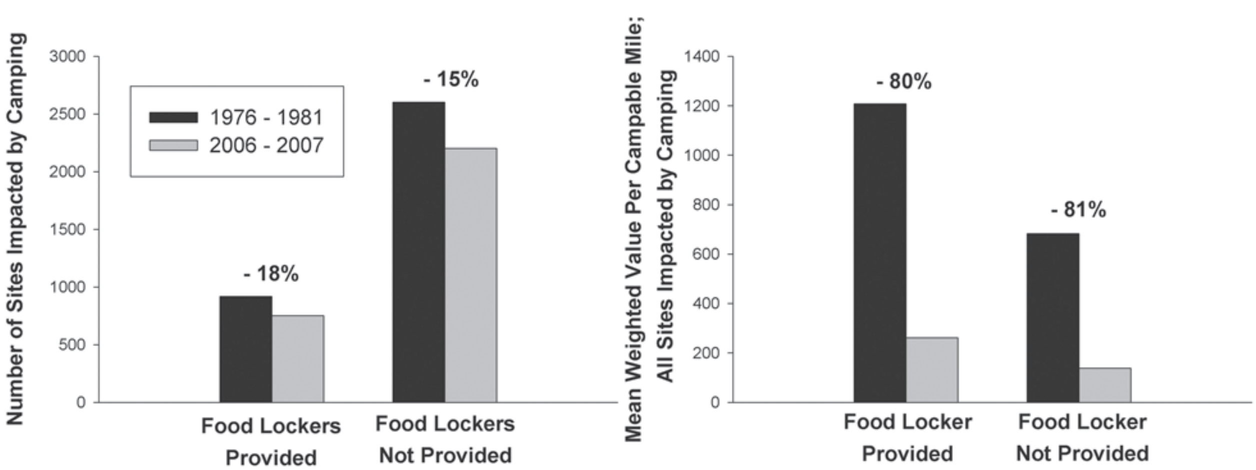

Figure 11—Change in number of sites impacted by camping and weighted value per campable mile, between 1976-1981 and 2006-2007, by whether or not food lockers are provided. Numbers above bars are the percent change in number of sites and in total weighted value (not weighted value per campable mile).

concentration of use and impact around food lockers is highly localized, with little meaningful effect on either the number of campsites or aggregate campsite impact at larger scales. There are more campsites in subzones where food lockers are not provided but mean weighted value per campable mile is greater in subzones where food lockers are provided (fig. 11), indicating that campsites are typically more impacted in subzones that provide food lockers. This likely reflects the fact that lockers were located in highly impacted places as much as the tendency for food lockers to concentrate use and impact.

Why Some Subzones Improved More Than Others—The preceding discussion suggests that the greatest improvement in conditions occurred on campsites close to water and in places that were close to ranger stations, with good trail access, without much overnight stock use, and in some of the upper subalpine forests. Substantially less improvement occurred in remote cross-country locations above timberline. While this conclusion is correct it misses the more fundamental observation that the places that improved the most were the places that were most highly impacted in the past. A simple regression model with 2006-2007 weighted value as the dependent variable and weighted value at the time of the initial survey had an r^2 of 0.42 (table 4; fig. 12). That is 42 percent of the variation among subzones in how much they are currently impacted is explained by the initial amount of impact. The places that were most impacted originally improved the most, while those that were least impacted changed the least. Once this source of variation is accounted for, factors such as elevation, vegetation type, trail access, distance to the nearest trailhead, and distance to the nearest ranger station no longer have any significant effect. Level of overnight stock use has a statistically significant but minor effect.

The story of campsite impact distribution and change seems to be that, as wilderness use increased in the parks, the most severe campsite impacts developed within spectacular subalpine lake basins, along primary trails. These places were at variable distances from trailheads. At many of these popular destinations, existing structures were adapted to serve as ranger stations. These were not places characterized recently by heavy overnight stock use, because forage is often limited. These same places that

Table 4—Multiple regression results for variables that influence change in total campsite impact (weighted value).

Model	Source	df	MS	F	R	Adjusted R^2
1	Regression	1	552522	88.13[a]	0.65	0.42
	Residual	118	6269			
2	Regression	2	295210	49.21[a]	0.68	0.45
	Residual	117	5999			

Model	Variables entered	Unstandardized coefficients	Beta coefficients	t value
1	Weighted value; 1976-1981	0.12	0.65	9.4*
2	Weighted value; 1976-1981	0.12	0.62	9.0*
	Level of stock use	18.62	0.17	2.5*

[a] $P < 0.05$. Variables that did not enter the equation at the $p = 0.05$ significance level: elevation, distance to the nearest trailhead, distance to the nearest ranger station, and access trail type.

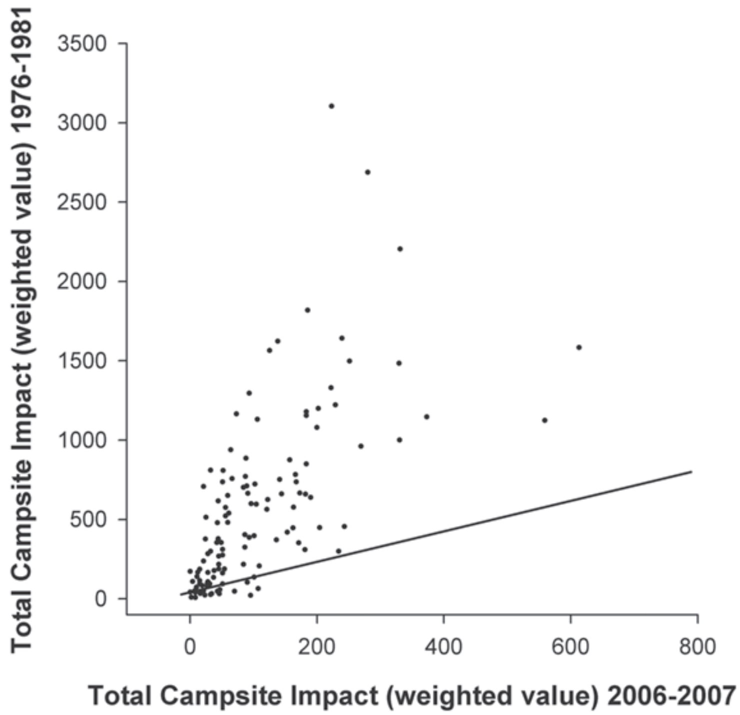

Figure 12—Scatterplot relating total campsite impact in 2006-2007 to initial campsite impact for each subzone. Subzones above the reference line improved; those below the line deteriorated. The magnitude of change is the perpendicular distance between the plot and the line.

were initially so highly impacted are the places where conditions have improved the most since the 1970s. Although many of these places are still among the places most impacted by camping, they are in much better condition than they were in the 1970s. The difference among subzones, in magnitude of impact, has decreased over the past three decades.

Study Limitations

Our estimate of the magnitude of change in campsite condition is subject to at least four potential sources of error. First, it is dependent on the weights assigned to each condition class. However, even if the weights were all decreased by 50 percent (so that a class 2 site is three times as impacted as a class 1 site and a class 5 site is seventy-five times as impacted as a class 1 site), the effect on our estimate of change would be minor. With this change in weighting, our estimate would be a 79 percent improvement rather than an 81 percent improvement. Based on this lack of sensitivity and our belief that the weights still seem reasonable, we conclude that this is not a significant source of error.

The other three sources of error reflect the comparability of the reinventory. First is the issue of not recording the condition class of sites considered to be restoration sites rather than active campsites. Our assumption that 80 percent of these sites would have been given a rating of class 1, with the rest assigned to class 2, seems reasonable. Field visits and examination of photographs indicate that the vast majority of restoration sites are class 1 and none appear to be higher than class 2. However, if restoration sites are more highly impacted, our estimate of improvement may be slightly too high. A second issue is the comparability of search behavior. On this account, the reinventory appears to have been slightly more thorough than the initial inventory. There are clearly a few places (portions of seven different subzones) that were missed in the initial inventory and our field checks suggest that search behavior was very thorough during the reinventory. Given this, our estimate of improvement may be slightly too low. Again, we conclude that these sources of error are negligible.

The only source of error that we believe might have had a substantial effect on our estimate of change is the degree to which different evaluators made similar judgments about campsite condition. Every effort was made to ensure comparability, by investing substantially in training and in spending field time with one of the people involved in the 1970s inventory. Moreover, it is not possible to objectively test the degree to which repeat evaluations were consistent with original evaluations and that park employees went to great lengths to ensure comparability. That said, it appears that condition class ratings from the 2006-2007 inventory were somewhat lower than ratings given in the 1970s. For example, in the 1970s inventory, class 1 sites were "usually no more than a small sleep site and possibly a small fire ring with little or no sign of trampling or vegetation impact" (Parsons and Stohlgren 1987, p. 14). Some of the campsites rated class 1 in the 2006-2007 inventory had experienced long-lasting impact, including substantial disturbance of vegetation and duff. If this is correct—and there is no way to be sure—this does not change the overall conclusions of this report. It would only change our quantitative estimate of the magnitude of improvement.

In an attempt to provide a more conservative magnitude of improvement, assume that one-half of the campsites were assigned a condition rating one class lower than in the 1970s inventory. We cannot imagine the discrepancy between the two evaluations being larger than this. Even with this adjustment, the number of class 3, 4 and 5 sites decreased by 46 percent, 69 percent and 91percent, respectively, over the past 30 years. Based on weighted value, aggregate campsite impact has decreased 62 percent since the 1970s. While this magnitude of improvement is less than the 81 percent improvement estimate based on the 2006-2007 inventory ratings, it does not change the overall conclusion of this report. Campsite conditions have improved profoundly since the 1970s, with aggregate campsite impact decreasing somewhere between 60 and 80 percent, depending on assumptions and the comparability of the inventories.

Discussion and Management Implications

The most important finding of this study is that campsite conditions in the wilderness of Sequoia and Kings Canyon National Parks have improved dramatically since the late 1970s. Depending on assumptions and the comparability of the two surveys, aggregate campsite impact in 2006-2007 is almost certainly less than one-third what it was in the 1970s. The second fundamental finding of this study is that the improvement in conditions that has occurred over the past 30 years has been remarkably uniform. Virtually without exception, conditions have improved throughout the wilderness of Sequoia and Kings Canyon National Parks. When the repeat survey was initiated, the primary question of interest—beyond how conditions have changed since the 1970s—was what factors have influenced the patterns of change that have occurred? That is, have some places changed much more, or in different ways, than others and, if so, why? Visitor use, management activity, and site fragility are all spatially variable. Consequently, it is reasonable to expect that some places—perhaps those most heavily used and most fragile—would deteriorate more than others. Many people felt, for example, that the placement of food storage lockers at select locations would increase impact nearby. Or alternatively, some expressed concern that near-pristine portions of the wilderness might disappear because they are particularly vulnerable to degradation (Cole 1993). Since a given increment of use causes most impact when it occurs where there has been little prior use (Hammitt and Cole 1998), even slight increases in the use of previously unused places could result in substantial deterioration. Questions that were asked when the reinventory was initiated included, are impacts spreading more than intensifying? Is near-pristine wilderness slowly disappearing?

The answers to these questions are surprisingly simple. Impacts are not spreading or intensifying; they have retreated and diminished in magnitude. Near-pristine wilderness is not disappearing; it may be expanding. The food storage lockers may have intensified use on a few sites in the immediate vicinity, but they were placed on sites that were already highly impacted. Given increased use of minimum impact techniques, including Leave No Trace (Leave No Trace n.d.), these sites are often in better condition now than they were in the past, even if use intensity has increased. Food storage lockers have had no apparent effect on campsite impact at the scale of the subzone.

Campsite impacts are not equitably distributed. They are more substantial along primary trails, particularly the John Muir Trail, and they are concentrated both in particularly popular subzones (such as, the Rae Lakes) and within subzones, at trail junctions, creek crossings, and along lakeshores. However, because the most highly impacted places are the ones that have improved most, the disparity between more and less impacted places has decreased. In the 1970s, campsite impact decreased significantly with increases in elevation, distance from the trailhead, and distance from the closest ranger station. Campsite impact no longer varies with any of these factors.

Why Have Conditions Improved So Much?

There are several competing potential explanations for the decrease in campsite impact over the past 30 years. There is evidence that use levels are not as high today as they were in the 1970s. There is also evidence that use is more concentrated in space than it was in the 1970s. Although the relationship between impact and the spatial distribution of use is complex, impacts are most often less pronounced in areas where use is concentrated rather than more widely distributed (Hammitt and Cole 1998). Visitor behavior has also changed. There has been widespread adoption of Leave No Trace techniques and some of the activities with high impact potential (such as campfire building and traveling with larger packstock groups) are more tightly regulated. Finally, conditions might have improved as a result of management actions taken to reduce campsite impacts.

It is our contention that all of these factors have contributed to improvement in conditions and that they are often synergistic in their effect. However, campsite conditions have not improved as much in other wildernesses that have experienced declining use, more concentrated use, and widespread adoption of Leave No Trace techniques (Cole 1993). The most unique aspect of the situation at Sequoia and Kings Canyon is the investment in a relatively large cadre of highly experienced wilderness rangers that remain in the field throughout the summer season. Consequently, we believe that the primary reason for success has been the concerted effort and hard work of wilderness rangers to reduce campsite impact throughout the wilderness, guided by approaches developed by wilderness management staff. Below, we explain how we arrived at this conclusion.

Amount of Use—Everything else being equal, impact should increase as amount of use increases and use statistics indicate that, in 2006-2007, overnight use (visitor use nights) of Sequoia and Kings Canyon Wilderness was only about 50 percent of peak use in the 1970s. However, as noted earlier, while use is currently lower than it was in the 1970s, the magnitude of decline is probably not as great as is suggested by these statistics. The decline in use by groups with packstock has been even more dramatic than the decline in overall use. Since the 1980s, the annual number of stock use nights for all types of use (administrative, commercial, and private) has declined almost 30 percent and private stock use has declined almost 60 percent.

Reductions in use levels do not necessarily result in reduced impact. Once impacted, a high degree of campsite impact can be sustained by relatively low levels of ongoing use. This is particularly true at higher elevations where recovery rates are low (Hammitt and Cole 1998; Stohlgren and Parsons 1986). Reductions in use can lead to reductions in impact if visitors camp on fewer sites. But this requires management action, such as a designated campsite policy or action by rangers to reduce the number of sites. In other words, reductions in use can supplement the effectiveness of management actions and the efforts of rangers to reduce the number of campsites; but the primary reason for improvement is management action and ranger effort.

Distribution of Use—During the 1970s, trips that followed unmaintained paths and cross-country routes increased in popularity. Guidebooks were published advertising these paths and routes and more people seemed inclined to put the effort into visiting more pristine places in the wilderness. This was a change from the period prior to the 1970s and is a change that seems to have reversed in recent decades. As was mentioned earlier, the distribution of use among trailheads and among travel zones is slightly more concentrated today than it was in the 1970s. Wilderness travel has become increasingly goal-oriented; there is much less wandering about or going to one favorite place for an extended stay. Interest in climbing Mount Whitney (and to a lesser extent other mountains over 14,000 feet) or hiking the entire John Muir Trail has skyrocketed. The number of people hiking the entire John Muir Trail has increased six-fold since 1998 to where, by some estimates, these hikers may constitute as much as 10 percent of total wilderness use. In contrast, rangers and other experienced observers think that cross-country travel has declined greatly. There has been a particular decrease in the use of places with less spectacular or iconic scenery. Consequently, use is more concentrated than it was in the 1970s.

Use concentration has also been the unintended consequence of a number of management actions. Variable trail budgets and shifting trail maintenance priorities may have concentrated use on a smaller network of trails. Fish stocking was curtailed in 1987-1988, such that fish are no longer reproducing in about one-half of the parks' water bodies. Moreover, in order to protect the frog population, fish have been removed from a number of lakes. This concentrates use by people interested in angling.

Campfire prohibitions have sometimes pushed use by those interested in having a campfire down to lower elevations. Camping use is often concentrated just below the lower limit of the no-fire zone. Moreover, as these limits have been lowered, use patterns have shifted. For example, when campfires were allowed, visitors staging a climb of Mount Whitney from the west would often camp among the highest trees; today they cannot have a campfire anywhere within an easy day of the Whitney summit. So, large numbers of people have started camping along drainages above Guitar Lake, one of the few places that is more highly impacted now than it was in the 1970s. The provision of food storage lockers in select locations has concentrated use, as have restrictions on where packstock can travel and graze. Camping is also confined to designated sites in a few places, none of which were reinventoried.

If use has become more concentrated, there is less impetus for making new campsites and many of the campsites of the 1970s must be used much less frequently today. Sites that are being used more often tend to be in popular places that are already highly impacted; increased use is unlikely to damage them further. Consequently, aggregate impact should be reduced. However, as noted before, even infrequent use is often sufficient to limit campsite recovery. Therefore, without active closure and restoration of campsites, increasingly concentrated use is not likely to cause a rapid reduction in impact. As was the case with reductions in amount of use, use concentration supplements the effectiveness of site management efforts by the wilderness rangers.

Visitor Behavior—Regulations have curtailed some of the more high-impact camping behaviors. In particular, campfires are now prohibited in more than one-half of the subzones that were reinventoried. As a result, campsites are less developed and there is less impetus for damaging trees. Group size limits have been reduced, so there is less need for very large campsites. Packstock groups are more tightly controlled. More importantly, most visitors have become aware of the adverse impacts they can cause if they behave inappropriately and have voluntarily adopted Leave No Trace behaviors. This change in behavior is most reflected in the relative lack of litter and lack of campsite developments (e.g. tables, chairs, etc.). Tree damage also seems much less problematic than in the past. Many visitors avoid camping on vegetation and they have learned that their impact can often be minimized by camping in places that are already highly impacted.

These behavioral changes have probably contributed much more to improvement of conditions than changes in either the amount or distribution of use. However, there are still some visitors who have campfires where they are prohibited and who resist adopting Leave No Trace behaviors. Unfortunately, substantial impact can be caused by even a small minority of users unless rangers can constantly be vigilant about dealing with newly created impacts and maintaining camping conditions that encourage low impact behaviors. Visitors to wildernesses that have experienced increases in campsite impact have also adopted Leave No Trace techniques. Lack of improvement there is likely more reflective of the degree of management presence than the ethic of the majority of visitors.

Campsite Management Implemented by Wilderness Rangers—Although campsites were managed before the initial campsite survey, park management adopted a greater sense of urgency regarding reducing campsite impact and developed a more consistent and aggressive management strategy. The fundamental strategy that evolved over time involved concentrating use on a smaller number of campsites, in appropriate locations, working to reduce campsite size and development, more actively maintaining campsites and educating visitors. Specific actions taken to implement this strategy included:

- obliterating unnecessary campsites when there are plenty of others around,
- eliminating sites too close to water, particularly those within 25 feet,
- eliminating campsite developments, such as built up tables, rock walls, etc.
- building small fire rings (often 3 rocks set in the ground) at certain campsites and maintaining them,
- reducing the size of very large sites,
- constantly eliminating campfire evidence where fires are illegal, and
- educating visitors about how to minimize their impact.

If these actions had not been taken, campsite conditions would probably have improved very little, despite reductions in use levels, changes in use distribution, and improved visitor behavior.

The scope and magnitude of this effort was gleaned from interviews with long-time wilderness rangers, end-of-season ranger station logs, and other documents. In 1981, the Rae Lakes ranger reported eliminating or rehabilitating 847 fire rings in the area between Mather Pass and Forester Pass. The number of sites removed or cleaned up by the Rae Lakes ranger was 132 in 1982, 108 in 1983, 66 in 1984, 78 in 1986, 100 in 1987, and 168 in 1988. This would have dramatically reduced the number of campsites in that area and reduced impacts on those sites that remained. The ranger commented on the hard work required; it was necessary to remove rocks, any ash and trash and then to cover the area with clean soil, and ongoing maintenance is required. However, once the initial work is done, subsequent work is easier. As an example, the Rae Lakes ranger described removing 45 fire rings at Bench Lake in 1982, many of which were quite large. Three weeks later, seven new fire rings had appeared, but they were small and easy to remove.

In 1988, rangers kept careful track of their campsite removal and maintenance efforts. Across the entire wilderness, they eliminated 206 campsites and 1014 fire sites. In addition, they cleaned up another 88 campsites and another 348 fire sites. Let's assume that this level of effort is reflective of efforts today on the approximately 4,000 active campsites in the wilderness. This would mean that rangers are annually working to eliminate about 5 percent of campsites and about 25 percent of fire sites. They are diligently maintaining conditions on more than 10 percent of sites, probably those that are most frequently used. The most common reason for doing this work was fire sites located in areas where wood fires are prohibited. This was the case for 569 of the fire sites that were eliminated. Other reasons for action were campsites within 25 feet (7.5 m) of water (225 sites), overly large sites (299 sites), and either multiple fire rings on individual sites or more sites than necessary in a particular location (218 sites).

As these numbers attest, substantial effort goes into limiting campsite impact and maintaining campsite conditions. Fire rings have to be removed when people build fires in places where fires are not allowed or on sites where there is no established fire ring. Campsites need to be removed when established too close to water, in other sensitive locations, or in areas where there are already enough other campsites. Developments occasionally need to be dismantled; rock walls built as wind breaks at high elevation sites may be the most common example these days. Where fires are allowed, fire rings need to be maintained, as frequently as every 2 weeks in popular places. Rangers also attempt to keep campsite size from expanding and to keep use and campfires concentrated on sites where such use will not cause further impact.

Conclusions

The reinventory, in 2006-2007, of campsites first surveyed in the 1970s found that campsite conditions in the wilderness have improved greatly in the past 30 years. Current impacts are probably no more than one-third what they were in the 1970s. This improvement has occurred throughout the wilderness and is primarily the result of programs put in place by wilderness managers and implemented through the significant and ongoing efforts of field-located wilderness rangers. By concentrating use, maintaining established sites, eliminating new sites and impacts, and educating users, rangers have succeeded in substantially improving the wilderness character of the Sequoia and Kings Canyon Wilderness.

The Eagle Cap Wilderness, Oregon: 1975-2007

In order to assess trends in recreation impact, the first of two studies of campsites in the Eagle Cap Wilderness, Oregon, was initiated in 1974 and 1975. This study (referred to henceforth as the Campsite Survey) sought to document trends in the number, distribution, and condition of campsites in a portion of the wilderness. In 1979, this study was supplemented by a second study (referred to as the Campsite Sample). This second study, using more precise assessment procedures, followed conditions on a sample of campsites. Each of these studies has been replicated several times since the 1970s. This case study reports findings from those two studies over a period of more than 30 years.

Study Area

The Eagle Cap Wilderness, in the Wallowa Mountains of northeastern Oregon, is the largest wilderness in Oregon (145,000 ha). Much of the wilderness is lightly used and frequented by horse users and hunters as much as by summer backpackers. However, the centrally located Lakes Basin and the trails that access it are highly popular with backpackers. Consequently, the Lakes Basin and two of the three drainages that provide access to it (about 15,000 ha) were selected for the Campsite Survey study. Trails up Hurricane Creek and the West Fork of the Wallowa River begin at elevations of about 1,450 m and ascend 15 to 20 km to the basin of 14 named lakes, lying at an elevation of 2,100 to 2,500 m. Several other cirque lakes are located up steep trails that leave the main trail 5 to 8 km from the trailheads.

The sites included in the Campsite Sample were geographically more widespread than the survey, although 10 of the 26 sites were within the area of the campsite survey. The sample was more environmentally homogeneous than the survey, however. Twenty-two of the 26 campsites were in similar environmental situations—subalpine forests around lakes (fig. 1).

Figure 1—The campsites included in the sample are in subalpine forest close to lakes, such as Tombstone Lake.

Since the early 1990s, visitor use of the Eagle Cap Wilderness has typically been 30,000 to 40,000 recreation visitor days per year. Accurate older use data are not available. Observations suggest that use levels, particularly in the Lakes Basin, have not changed greatly since the mid-1970s. This is in marked contrast to the pronounced increase in use that occurred in the decades preceding the mid-1970s.

There are no limits on amount of use but a number of behavioral restrictions have been implemented since the 1970s. Camping is generally prohibited within 100 feet (30 m) of lakes. Starting in the 1970s and continuing through the 1990s, this camping setback was 200 feet (60 m), a regulation that was widely ignored. Stock are not to be confined within 200 feet (60 m) of lakes. There is also a group size limit of 12 people and 18 head of stock. In the Lakes Basin, group size is confined to 6 people and 9 head of stock. Campfires are prohibited within ¼ mile (400 m) of 22 high elevation lakes. Another change that has occurred is that visitors have become more adept at using Leave No Trace techniques.

Methods

Campsite Sample

In 1979, this study was initiated on 26 campsites, 22 of which were located between 2,150 and 2,400 m elevation in a subalpine *Abies lasiocarpa/Vaccinium scoparium* forest type (subalpine fir with an understory of grouse whortleberry) on soils derived from granitic bedrock. Four additional sites were in different environments—two in timberline meadows (2,500 m elevation) and two in mid-elevation forests (2,000 m elevation) along riverbanks. The sites located in the subalpine forest varied by use level as follows: six low-use sites, six moderate-use sites, and 10 high-use sites. Although campsite-specific use data are lacking, we originally estimated that low use sites were used less than 5 nights per year, while moderate use sites were used 10-25 nights per year and high use sites were used more than 25 nights per year. As will be discussed in the results below, the number of campsites in the Eagle Cap has increased greatly since this study was initiated. Consequently, use is spread across more sites, reducing use frequencies from what they were 30 years ago. Five of the high-use campsites were located close to lakeshores where camping is now prohibited. Enforcement of these closures has been spotty and day use occurs except on the three sites that have been roped off and actively revegetated.

Campsite conditions have been assessed four times so far, in 1979, 1984, 1990, and 2005/2006. In 1990, only 20 of the campsites were reexamined. In 2005/2006, 23 of the campsites were reexamined and one additional site was assessed in 2011. One of the low use sites (Olive Lake) had been burned in a fire and was no longer recognizable as a campsite. One of the mid-elevation sites (Ice Lake Bridge) had been washed away in a flood. Results will be presented for the 24 sites that still existed in 2006, recognizing that data for 1990 excludes six of the ABLA/VASC campsites. Results from earlier studies can be found in Cole 1982, Cole 1986, and Cole and Hall 1992.

Each sample site consisted of both a campsite and an undisturbed control site in the vicinity. We established a permanent point (buried nail) near the center of the campsite and measured the distances from this point to the first significant amount of vegetation along 16 cardinal directions. "Significant" vegetation was defined as 15 percent cover in a 0.67- by 1.0-m quadrat. This defined the devegetated core area (fig. 2). We also measured the distance to what we judged to be the edge of the campsite, defining the camp area. Within the camp area, we counted tree "seedlings" (15- to 140-cm tall) and assessed damage to larger trees. Trees were considered damaged if they had trunk scars, nails, or broken branches. We also noted felled trees and trees with exposed roots.

Figure 2—The campsite at Steamboat Lake illustrates a central barren core with disturbed vegetation beyond the core.

These procedures were repeated in subsequent measurement periods. The nail at the center of the campsite was relocated; changes in size of devegetated core and camp area were assessed along the 16 transects and trees were assessed within the original 1979 campsite boundaries.

On each campsite, approximately 15 quadrats, 1-m by 1-m, were located along four transects, originating at the center point and oriented perpendicular to each other. The canopy cover of total ground vegetation, exposed mineral soil, and each plant species was estimated for each quadrat. Coverages were estimated to the nearest percentage if under 10 percent; if over 10 percent, coverages were estimated in 10 percent coverage classes. The thickness of soil organic horizons was measured at four points between 1 and 2 m from the center point, along each transect.

On the circular control plots, which varied in size from 91 to 201 m^2, coverage of total ground vegetation, exposed mineral soil, and each plant species was ocularly estimated for the entire plot. Seedlings were counted on a 50-m^2 subplot placed at the center of the control. Organic horizon thickness was measured at four regularly distributed points.

Change in species composition was estimated by comparing the species composition of the campsite and the control. To quantify differences, the following coefficient of floristic dissimilarity was calculated:

$$FD = 0.5 \sum |p_1 - p_2|,$$

where p_1 is the mean relative cover of a given species on the campsite and p_2 is the relative cover of the same species on the control. Relative cover is the percent of total cover accounted for by a given species (that is, one species' cover divided by the total cover of all species).

Results will be presented (1) for all 24 sites still present in 2005/2006, regardless of use or environmental situation; (2) for low-, moderate-, and high-use subalpine forest campsites open to use; and (3) for open and closed high-use subalpine forest campsites.

The magnitude of change over the 27 years is expressed in two ways: (1) median conditions in 1979, 1984, 1990, and 2005/2006; and (2) the amount of change, which is calculated by subtracting conditions in 1979 from conditions in 2005/2006. In addition, for each parameter, we report the number of sites on which that parameter increased, decreased, or stayed the same (between 1979 and 2005/2006). Sample sizes were so small that we used non-parametric statistics. We evaluated the statistical significance of differences between conditions in 1979 and 2005/2006 with the Wilcoxon matched-pairs, signed-ranks test. We tested differences in magnitude of change among use levels with Kruskal-Wallis test and differences between open and closed high-use sites with the Mann-Whitney tests. Given the small sample size, the power of these tests is low and the likelihood of incorrectly accepting the null hypothesis of no difference is relatively high.

Campsite Survey

In 1974 and 1975, all campsites were located along main trails, around lakeshores and popular cross-country routes in the drainages of Hurricane Creek and the West Fork of the Wallowa River (Cole 1977). Although a few remote places that provided reasonable opportunities for camping were not visited, it seems safe to assume that more than 95 percent of campsites were located. The only information that was collected on each campsite was location and the number of firerings. In 1990, campsites were resurveyed (Cole 1993) and current conditions were assessed using a modified version of the condition class rating system developed by Frissell (1978). Ratings were as follows:

1. Minimal physical change except for possibly a simple rock fireplace. Ground vegetation may be flattened but not permanently injured;
2. Ground vegetation worn away around fireplace or center of activity;
3. Ground vegetation lost on most of the site, but humus and litter still present in all but a few areas; and
4. Bare mineral soil widespread on the site.

On campsites where conditions reflected the definitions of two adjacent classes, the campsite was assigned a mid-point rating (for example, 2.5). Campsites were surveyed again between 2005 and 2007 and data collected in the past were recollected. The thoroughness of the inventory probably increased with each measurement period, although not enough to reduce the accuracy of trend estimates by more than a couple percent.

Results

Campsite Sample

Campsite area, the area visibly disturbed by camping activities, increased significantly and steadily from a median of 196 m^2 in 1979 to 249 m^2 in 2005/2006 (table 1). The median campsite increased 28 m^2, approximately 1 m^2 per year. Although most campsites increased in size, three sites decreased and four were essentially unchanged. In contrast to campsite area, the size of the central devegetated portion of the campsite decreased from a median of 85 m^2 in 1979 to 61 m^2 in 2006 (table 1). This decrease was not pronounced and consistent enough to be statistically significant; eight of the sites experienced increases in devegetated core area. Devegetated area was greatest in 1984 and least in 1990, suggesting that there is substantial annual variation in this attribute.

Results for tree damage are encouraging. The number of damaged trees and felled trees decreased significantly, while the number of trees with exposed roots was essentially unchanged (table 1). This improvement in conditions occurred primarily after 1990. Prior to 1990, the number of trees with exposed roots had increased significantly and

Table 1—Median change between 1979 and 2005/2006 in size and tree damage on all 24 campsites.

	Camp area (m^2)	Devegetated core area (m^2)	Damaged trees (#)	Trees with exposed roots (#)	Felled trees (#)
Median					
1979	196	85	9	3	3.5
1984	202	95	8	3	5
1990	206	52	10	4	3
2005/2006	249	61	6	3.5	1
Change[a]	28	-16	-2	0	-1
# of Sites					
Decreased	3	13	15	9	13
Increased	17	8	2	7	3
Unchanged	4	3	7	8	8
Significance[b]	**<0.01**	0.37	**<0.01**	0.96	**<0.01**

[a] Median change is the difference between 1979 and 2005/2006 on the median campsite.
[b] Difference between 1979 and 2005/2006, using Wilcoxon matched-pairs signed ranks test (α = 0.05).

other types of tree damage were steady. In their report on 1979-1990 changes, Cole and Hall (1992) commenting on increased tree damage noted that "tree damage is cumulative—new damage is not offset by recovery from damage" as it is for many other types of impact, such as vegetation loss. However, as long as new damage does not occur, evidence of tree damage can decline as scars heal, trees die, and stumps disintegrate.

Changes in tree seedling density were highly variable, but the median site experienced no change in density and change over time was not statistically significant. The primary conclusion is that the density of tree seedlings on campsites continues to be very low compared to control sites (table 2).

Table 2—Median change between 1979 and 2005/2006 in seedling density and ground cover conditions on all 24 campsites.

	Tree seedling density		Vegetation cover		Mineral soil cover		Organic horizon thickness	
	Camp	Control	Camp	Control	Camp	Control	Camp	Control
	- - - - - (#/ha) - - - -		- - - - - (%) - - - - -		- - - - - (%) - - - - -		- - - - - (cm) - - - - -	
Median								
1979	271	1327	6.4	60.0	32.8	1.0	0.2	0.6
1984	273	1239	5.7	60.0	46.3	2.5	0.1	0.6
1990	391	2300	10.0	60.0	52.0	2.0	0.2	0.6
2005/2006	194	5804	7.8	60.0	32.4	2.0	0.2	1.6
Change[a]	0	3596	1.0	0.0	1.8	0.0	0.0	0.9
# of Sites								
Decreased	11	1	9	7	10	5	5	1
Increased	8	18	13	5	13	6	9	16
Unchanged	5	5	2	12	1	13	10	7
Significance[b]	0.55	**<0.01**	0.46	0.55	0.37	0.86	0.96	**<0.01**

[a] Median change is the difference between 1979 and 2005/2006 on the median campsite.
[b] Difference between 1979 and 2005/2006, using Wilcoxon matched-pairs signed ranks test (α = 0.05).

Changes in groundcover conditions on campsites were minimal (fig. 3). Vegetation cover increased from a median of 6.4 percent in 1979 to 7.8 percent in 2006, while mineral soil cover decreased from a median of 32.8 percent in 1979 to 32.4 percent in 2006 (table 2); neither change is statistically significant. Groundcover on the control sites also did not change significantly over this 27 year period. The primary conclusion is that vegetation cover on campsites continues to be very low compared to control sites, while mineral soil exposure remains high. Mineral soil exposure had been increasing prior to 1990, but this trend reversed during the 1990/2006 period. Soil organic horizon coverage in 2006 approximated conditions in 1979. Soil organic horizon thickness also did not change substantially over the period, but organic horizons on campsites remained thin in comparison to control sites, where thickness increased (table 2).

The surviving vegetation on campsites often has a different composition from that on control sites. We quantified compositional change with measures of species richness (the number of species found in the 15 m^2 of campsite quadrats) and the floristic dissimilarity index, the compositional difference between campsites and controls, which can range from 0 (identical composition) to 100 (completely different composition). Results suggest that compositional trends were variable, but more campsites experienced an increase in compositional change than a decrease. Species richness declined from a median of 11 species in 1979 to 8 species in 2006, while the median site lost 5 species over the 27 years (table 3). However, species richness increased on eight of the campsites and this change was not statistically significant. Floristic dissimilarity increased on 14 of the campsites and it increased 7 percent on the median site. However, median floristic dissimilarity was 57 percent both in 1979 and in 2006. To investigate campsite compositional change further, we calculated the floristic dissimilarity, between years, for campsites and for control sites. The median dissimilarity between 1979 and 2006, on campsites, was 37 percent; median dissimilarity on controls was only 19 percent. This indicates that species composition on campsites is more variable over time than it is on controls. However, the trajectory of change on campsites is not away from the composition of undisturbed sites.

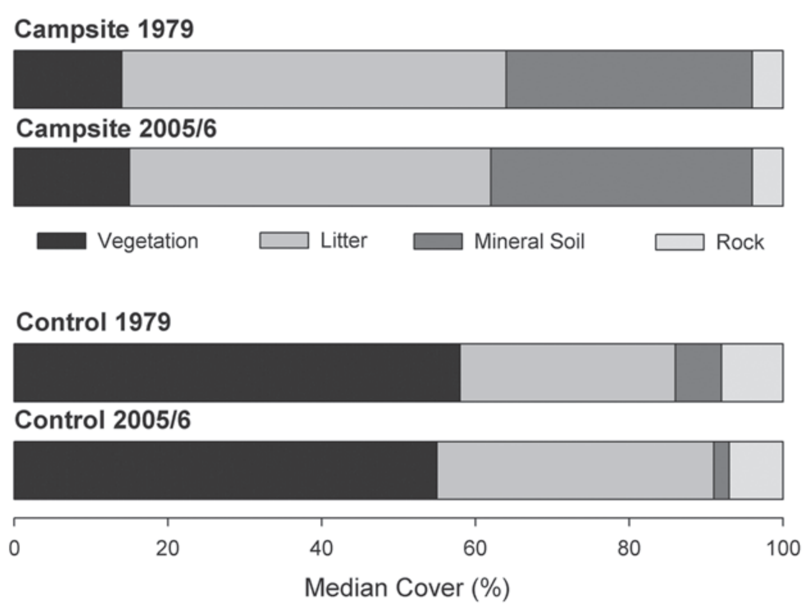

Figure 3—Change between 1979 and 2005/2006 in median cover of ground cover categories on campsites and control sites.

Table 3—Median change between 1979 and 2005/2006 in species richness and species compositional change on all 24 campsites.

	Species richness (#)	Floristic dissimilarity (%)
Median		
1979	11	57
1984	11	63
1990	11	56
2005/2006	8	57
Change[a]	-5	7
# of Sites		
Decreased	12	6
Increased	8	14
Unchanged	4	3
Significance[b]	0.22	0.41

[a] Median change is the difference between 1979 and 2005/2006 on the median campsite.
[b] Difference between 1979 and 2005/2006, using Wilcoxon matched-pairs signed ranks test ($\alpha = 0.05$).

The response of four common vascular plant species to camping is portrayed in figure 4. *Juncus parryi* and *Carex rossii*, two graminoids, increased in relative cover on campsites; they are among the species most resistant to camping disturbance. *Vaccinium scoparium* and *Phyllodoce empetriformis*, two short shrubs, decreased in relative cover on campsites; they are relatively fragile species. None of these species experienced substantial changes in relative cover on either campsites or control sites.

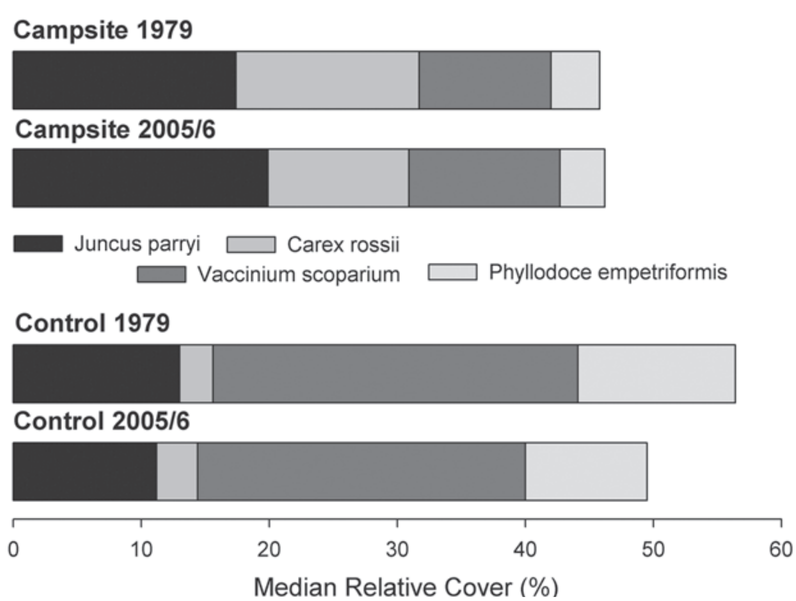

Figure 4—Change between 1979 and 2005/2006 in median relative cover of four common vascular plant species on campsites and control sites.

Differences between campsites and control sites increased slightly for *Juncus parryi* but decreased for the three other species. This suggests that the trend toward increasing compositional change over time must result from impact to the less common species.

In sum, most of these types of campsite impact had already reached peak levels by 1979, a few types peaked between 1979 and 1990, and only campsite area continued to increase after 1990. The impacts that had already stabilized by 1979 are generally those that occur to groundcover vegetation: devegetated core area, seedling density, vegetation cover, and species composition. Groundcover is so fragile that damage occurs quickly (Cole and Monz 2003). Therefore, conditions are unlikely to change greatly unless there is a dramatic change in amount of use. The two types of impact that peaked between 1979 and 1990 are exposure of tree roots and increase in mineral soil exposure. These impacts result from erosion of organic horizons and mineral soil, impacts that are caused only by frequent use or a high-impact style of use (such as tying horses to trees) or that occur only after long periods of use. The fact that these impacts are no longer increasing is encouraging. But the area disturbed by camping continues to grow on most of these sites, continuing a trend in spatial expansion of impact that begins with initial use of campsites (Cole and Monz 2004).

Factors That Influence Amount of Impact—Because we assessed campsites that vary greatly in how frequently they are used, we can explore the effect of amount of use on amount of impact. We can also compare open and closed heavily used campsites to describe how campsite conditions respond to campsite closure. Finally, we can explore whether amount of change varies with the initial condition of the campsite. However, readers are reminded that sample sizes are small and statistical power is low. For a number of variables, there were substantial differences in condition between high and low use sites and between open and closed sites, but large within-sample variation did not allow us to conclude that differences were statistically significant. In these situations, it is more prudent to conclude that it is unclear whether these impacts vary with amount of use or closure than to conclude that impact does not differ with these variables.

Effect of Amount of Use: Campsite impact did not differ significantly with amount of use for any of the impact parameters we assessed, either in 1979 or in 2006 (table 4); nor, with the exception of tree root exposure, did the magnitude of change vary significantly with amount of use over the 27-year period. That said, given the small sample size, differences would have to be very large and consistent to be statistically significant. In 1979, with a larger sample, high-use sites had significantly larger devegetated core areas, more trees with exposed roots, less vegetation cover, more dissimilar species composition, more mineral soil exposure, and thinner organic horizons than less frequently used sites (Cole 1982). Moreover, the magnitude of all these differences between low- and high-use sites increased between 1979 and 2006. This leads us to suspect that, with a larger sample size, more of the 2005/2006 impact parameters would have varied significantly with amount of use. However, devegetated core area was the only parameter for which the magnitude of change, between 1979 and 2006, is substantial.

Among our small sample of sites, then, more frequently used campsites were typically somewhat more impacted than infrequently used sites. In particular, they tended to have a larger devegetated core and more trees with exposed roots. They had less vegetation cover, although even low-use sites had little vegetation cover. They had experienced a more substantial change in species composition. They also tended to deteriorate slightly over time, while the more infrequently used sites improved slightly. Nevertheless, these differences in amount of impact and magnitude of change are relatively small relative to differences in frequency of use.

Table 4—Median change in campsite conditions on high (n = 5), moderate (n = 6) and low use (n = 5) campsites.

	Amount of use			
	High	**Moderate**	**Low**	**p[b]**
Camp area (m^2)				
1979	221	224	75	0.21
2005/2006	280	389	143	0.50
Change[a]	57	66	60	0.88
Devegetated core area (m^2)				
1979	93	122	55	0.17
2005/2006	117	104	12	0.44
Change	32	-32	2	0.39
Damaged trees (#)				
1979	6	18	10	0.29
2005/2006	8	9	5	0.15
Change	-2	-9	0	0.26
Trees with exposed roots (#)				
1979	7	10	1	0.15
2005/2006	8	8	0	0.07
Change				
Vegetation cover (%)	2	-2	0	**0.05**
1979	7.6	6.3	8.2	0.78
2005/2006	3.3	13.2	7.6	0.63
Change	-1.7	3.9	1.1	0.77
Mineral soil cover (%)				
1979	23.8	24.2	46.1	0.60
2005/2006	41.4	27.3	38.4	0.23
Change	1.1	4.4	-3.5	0.80
Organic horizon thickness (cm)				
1979	0.1	0.5	0.1	0.15
2005/2006	0.2	0.2	0.0	0.96
Change	-0.1	-0.2	0.0	0.67
Floristic dissimilarity (%)				
1979	50	62	55	0.82
2005/2006	72	48	58	0.32
Change	11	0	6	0.31

[a] Median change is the difference between 1979 and 2005/2006 on the median campsite.
[b] Significance was tested with the Kruskal-Wallis test.

Campsite Closure: Between 1979 and 2006, all impact parameters deteriorated on open sites, while many parameters (devegetated core area, damaged trees, vegetation cover and floristic dissimilarity) improved on closed sites (table 5). However, differences in amount of change were only statistically significant for camp area, devegetated core area, and floristic dissimilarity. Again, the small sample size means that differences need to be extremely large and consistent to be judged statistically significant. In 1979, less than a decade after sites were closed, there were no significant differences between open and closed sites. At that time, closed sites had more devegetated area than open sites, less vegetation cover, higher floristic dissimilarity, and more mineral soil exposure. This should not be surprising since the sites that were closed were favored ones close to lakeshores. By 2006, median conditions on the sample of closed sites were less impacted than those on the sample of open sites, for all parameters other than mineral soil exposure and organic horizon thickness. Although some of these differences were substantial, the only statistically significant difference was for floristic dissimilarity.

Table 5—Median change in campsite conditions on open (n = 5) and closed (n = 5) high use campsites.

	Open	Closed	p[b]
Camp area (m^2)			
1979	221	191	0.35
2005/2006	280	191	0.12
Change[a]	57	14	**0.03**
Devegetated core area (m^2)			
1979	93	141	0.92
2005/2006	117	30	0.12
Change	32	-19	**0.05**
Damaged trees (#)			
1979	10	9	0.60
2005/2006	8	7	0.60
Change	-2	-2	0.40
Trees with exposed roots (#)			
1979	7	3	0.34
2005/2006	8	3	0.17
Change			
Vegetation cover (%)	2	0	0.24
1979	7.6	2.9	0.12
2005/2006	3.3	3.9	0.92
Change	-1.7	1.7	0.47
Mineral soil cover (%)			
1979	23.8	40.8	0.35
2005/2006	41.4	59.8	0.18
Change	1.1	6.5	0.60
Organic horizon thickness (cm)			
1979	0.1	0.2	0.66
2005/2006	0.2	0.0	0.58
Change	-0.1	0.0	0.75
Floristic dissimilarity (%)			
1979	50	66	0.60
2005/2006	72	50	**0.05**
Change	11	-30	**0.04**

[a] Median change is the difference between 1979 and 2005/2006 on the median campsite.
[b] Significance was tested with the Mann-Whitney U test.

One explanation for closure not having more effect on campsite conditions is the fact that people continued to camp on and walk through these sites, although not nearly as frequently as they had prior to closure. However, by the 1990s, three of the five closed sites had been roped off and/or actively revegetated, using transplants. This likely explains the dramatic decrease in devegetated core area, despite a much smaller increase in vegetation cover. Even with active restoration, growing conditions are such that recovery will take many years. Extrapolating recovery rates on actively restored campsites (including two of the campsites included in this study), Cole and Spildie (2007) suggest that, even if camping was effectively eliminated, vegetation recovery may take as much as 1000 years. This requisite recovery period could be reduced to about 50 through soil treatment and to about 20 years by augmenting soil treatments with transplanting (Cole and Spildie 2006) and seeding (Cole 2007).

Initial Conditions: For three parameters (campsite area, devegetated core area, and mineral soil cover), we explored whether the magnitude of change over 30 years varied with the magnitude of impact on the site in 1979. We found no difference in the magnitude of change; however, the future condition of less impacted sites was more variable than the future condition of more impacted sites. Magnitude of change was not significantly correlated with initial impact for any of these parameters (kendall's tau). Comparing the eight sites that were initially most impacted with the eight sites that were least impacted, there also were no significant differences in amount of change (Mann-Whitney U test). However, for each of these parameters, the standard deviation for change was much higher for the sites that were less impacted in 1979. For example, on the sites with the least devegetated core area in 1979, the mean change was an increase in area of 3 percent, with a standard deviation of 127 percent. On the sites with the most devegetated core area, the mean change was a decrease in area of 27 percent, with a standard deviation of just 55 percent.

Campsite Survey

Between 1975 and 1990, the number of campsites in these drainages increased greatly; there were more than twice as many campsites in 1990 as there were in 1975 (table 6). Between 1990 and 2007, the number of campsites decreased. There were only about two-thirds as many sites in 2007 as there were in 1990. Despite this recent decline in number of sites, the trend over the entire 33-year period has been one of increasing campsite density. There are currently almost 200 more campsites in these two drainages than there were in 1975. This represents a 59 percent increase in number of campsites. Assuming the 1975 inventory was slightly less thorough than succeeding inventories, it seems safe to conclude that between 1975 and 1990, the number of campsites doubled; recently, campsite density has decreased and in 2007 was about 50 percent higher than it was in 1975.

Information on campsite condition is only available for 1990 and 2007. At both time periods, there were more lightly impacted campsites than heavily impacted campsites. Number of sites was inversely related to condition class (table 6). Change in condition was not dramatic between 1990 and 2007. The number of campsites in each condition class declined over this period. However, the decline was least pronounced for the most heavily impacted class 4 sites. Consequently, median condition class increased slightly from 2.46 in 1990 to 2.53 in 2007. Since this increase in the magnitude of impact per campsite is small relative to the decrease in number of campsites, we can conclude that aggregate campsite impact in these drainages has decreased since 1990.

Table 6—Change in the number (percent) of campsites, by condition class: 1975-2007.

Condition class	1975	1990	2007	1990-2007 Change[b]
1	[a]	282 (37)	185 (35)	-34%
2	[a]	212 (28)	144 (28)	-32%
3	[a]	172 (22)	105 (20)	-39%
4	[a]	102 (13)	88 (17)	-14%
Total	329	768	522	-32%
Median condition class		2.46	2.53	3%

[a] Condition class was not assessed in 1975.
[b] Change is the difference between 1990 and 2007, as a percent of 1990 condition.

Conclusions about trends since 1975 are hampered by the lack of condition class data from the 1970s. Observations and campsite photographs from this period suggest that a larger proportion of campsites at that time were more highly impacted; if so, median condition class would have been higher at that time. The magnitude of the increase in campsite density since the 1970s is so large, however, that it is safe to conclude that aggregate campsite impact in these drainages continues to be much greater than it was in the 1970s. But, the magnitude of this increase in campsite impact is probably not as great as is suggested by the increase in campsite density of 133 percent between 1975 and 1990 and of 59 percent between 1975 and 2007.

The trends observed overall generally apply to all locations within the wilderness. Campsite density increased between 1975 and 1990 at all lakes and also away from the lakes (table 7). Density declined between 1990 and 2007 in all locations with the exception of Ice Lake. Density was greater in 2007 than in 1975 in all locations. However, the magnitude of change varied among locations. For example, in 1975, Mirror and Moccasin Lakes had about twice as many campsites as Glacier Lake, 4 km away. Mirror and Moccasin Lakes collectively cover a larger area than Glacier Lake and offer more desirable places to camp. Between 1975 and 1990, many of these desirable camping places were used as campsites for the first time and many of them developed into campsites. While this occurred at all lakes, the pioneering of new campsites was particularly pronounced at Mirror and Moccasin Lakes. By 1990, Mirror and Moccasin Lakes had more than 4 times as many campsites as Glacier Lake. By 2007, these lakes had almost 5 times as many campsites as Glacier Lake.

Differences among popular lakes, remote lakes and trail corridors are more apparent in table 8. Campsite density and median campsite impact are greatest at the popular lakes. The remote lakes have a higher campsite density than the trail corridors, but median campsite impact is less at remote lakes than along trail corridors.

Increase in campsite density, since 1975, has been greater at lake destinations than along the trail corridors that provide access to those destinations. Although campsite densities are greater at popular lakes than at remote lakes, density has increased more since the 1970s at the remote lakes (table 8). In 1990, when campsite density was greatest, campsite density at popular lakes was only 19 percent higher than density at remote lakes.

Table 7—Change in the number of campsites in particular locations: 1975-2007.

Campsite location	1975	1990	2007
Popular lakes			
Ice Lake	36	41	42
Horseshoe-Lee Lakes	41	74	54
Douglas-Crescent Lakes	34	86	54
Moccasin-Mirror Lakes	62	232	161
Glacier Lake	29	55	33
Frazier-Little Frazier Lakes	13	34	27
Remote lakes			
Echo-Billy Jones Lakes	11	45	19
Unit-Razz Lakes	7	18	16
Pocket Lake	1	10	7
Prospect Lake	3	15	8
Trail corridors away from lakes			
Hurricane Drainage	41	90	49
West Fork Wallowa Drainage	51	68	52

Table 8—Variation in the number, density and condition of campsites among popular lakes, remote lakes, and trail corridors: 1975-2007.

	1975	1990	2007	1975-1990 Change[a]	1990-2007 Change[a]	1975-2007 Change[a]
Number of campsites						
Popular Lakes	215	522	378	143%	-28%	76%
Remote Lakes	22	88	43	300%	-51%	95%
Trail corridors	92	158	101	72%	-36%	10%
Campsite density (sites/ha)[b]						
Popular Lakes	0.86	2.09	1.51	143%	-28%	76%
Remote Lakes	0.44	1.76	0.86	300%	-51%	95%
Trail corridors	0.20	0.35	0.22	72%	-36%	10%
Median condition class						
Popular Lakes		2.70	2.64		-2%	
Remote Lakes		1.88	2.03		8%	
Trail corridors		2.17	2.25		4%	

[a] Change is the difference between time periods as a percent of the original condition.
[b] Site densities were based on estimates of the area of the basin around each lake and, for the trail corridors, an area extending 60 m on either side of the trail.

Since 1990, median campsite impact has increased slightly at remote lakes and in trail corridors while remaining largely unchanged at popular lakes (table 8). Since this increase in impact per campsite is small in relation to the decrease in campsite density, it appears that, since 1990, aggregate campsite impact has declined somewhat. Moreover, the magnitude of improvement in conditions has been roughly equivalent at popular lakes, remote lakes, and along trail corridors. Although campsite density declined least at popular lakes, those sites did not experience the slight increase in median campsite impact that sites at remote lakes and along trail corridors experienced (table 9).

Table 9—Variation in the number of campsites, by condition class, among popular lakes, remote lakes, and trail corridors: 1990-2007.

Campsite location	1990	2007	Change[a] 1990-2007
Popular lakes			
Class 1	160	120	-25%
Class 2	142	104	-27%
Class 3	132	78	-41%
Class 4	88	76	-14%
Remote lakes			
Class 1	50	21	-58%
Class 2	32	16	-50%
Class 3	5	4	-20%
Class 4	1	2	100%
Trail corridors away from lakes			
Class 1	72	44	-39%
Class 2	38	24	-37%
Class 3	35	23	-34%
Class 4	13	10	-23%

[a] Change is the difference between 1990 and 2007, as a percent of 1990 condition.

We can conclude with a high degree of confidence that aggregate campsite impact in the drainages of Hurricane Creek and the West Fork of the Wallowa River is greater in 2007 than it was in 1975. However, the lack of condition class data makes it more speculative to generalize about the relative magnitude of change in aggregate campsite impact at popular lakes, remote lakes, and trail corridors. Since 1975, density has increased most at remote lakes and least along trail corridors. Since 1990, median impact per campsite has increased most at remote lakes and least at popular lakes. Unless there was pronounced variation among popular lakes, remote lakes and trail corridors in change in median impact per campsite between 1975 and 1990, it seems safe to conclude that aggregate campsite impact has increased since the 1970s in all these locations. Impact has most likely increased most at the remote lakes and least along the trail corridors.

Conclusions and Implications

The primary conclusion of the study of a sample of campsites is that conditions on long-established campsites in the Eagle Cap Wilderness are relatively stable, even over periods as long as 27 years. In 1990, Cole and Hall (1992) reported that the trend on these sites was one of slight deterioration; this is no longer true. The only impact parameter that continued to get worse, since 1990, was the total area disturbed by camping. This stability might reflect relatively steady to possibly declining use levels on these particular campsites or management actions such as a prohibition on campfires on many of these sites. It suggests that regularly used campsites in this environment reach a state where, under normal conditions of use, they are unlikely to either deteriorate or recover rapidly.

As was reported by Cole and Hall (1992) on our small sample of sites, differences in amount of impact between low-use and high-use sites increased modestly with time. However, some of the high-use sites improved in condition, while some of the low-use sites deteriorated. Amount of use was not a consistently important determinant of amount of impact. Differences between open and closed sites slowly increased in magnitude. The slow pace of recovery on closed sites suggests the importance of keeping impact from occurring in the first place and actively restoring closed sites.

When the scale of analysis is expanded to that provided by the campsite survey, different conclusions must be drawn about impact trends. Campsite conditions have changed greatly over the 30 years, despite being quite stable on long-established individual campsites. Aggregate campsite impact increased greatly between 1975 and 1990; however, since 1990 impact has decreased somewhat. These trends are reflective more of changes in campsite density than in the magnitude of impact on individual campsites. During the late 1970s and 1980s, campsites proliferated widely across the landscape. Dispersal of use was promoted during this period and camping was prohibited on many long-established campsites located close to lakes. Many of these old campsites have not recovered, while new campsites further from the lake were established. Meanwhile, many of the new campsites were never regularly used. However, firerings and other signs of impact will often remain evident for decades without active restoration of sites. Factors that have probably contributed to the improving trend in recent years include (1) Leave No Trace messages that stress using established campsites; (2) campfire prohibitions at many of the lakes in the Lakes Basin; (3) efforts by wilderness rangers to restore campsites, particularly lightly used ones; and (4) less effort to keep visitors from camping on long-established sites close to lakes.

The Backcountry of Grand Canyon National Park: 1984-2005

In order to assess trends in ecological impacts associated with backcountry camping in Grand Canyon National Park, conditions on a sample of campsites have been periodically monitored since 1984. The sample consists of 24 campsites that vary in how frequently they are used and in the vegetation type in which they are located. Campsite conditions have been assessed three times so far, in 1984, 1989/1990 and 2005. Results of this study (referred to henceforth as the Campsite Sample) from the 1980s can be found in Cole (1986) and Cole and Hall (1992). In addition, the Campsite Sample study was supplemented by a second study (referred to as the Campsite Survey) that involved inventorying all campsites in the late 1980s and again in 2003-2004. This case study provides a synopsis of trends discovered by following both the sample of sites and by surveying sites over large areas. More detail is reported in Cole and others (2008).

Study Area

Grand Canyon National Park is one of the great natural wonders of the world. Although not designated wilderness, about 96 percent of the 493,077-ha park is classified and managed as backcountry. Most of the backcountry hiking occurs below the rim. Most of the backcountry is without trails and extremely lightly used. There are about 50 km of developed trails in what is referred to as the "corridor." Although there are at least another 500 km of largely unmaintained trails (designated as either threshold or primitive trails), most use occurs on the developed corridor trails and less than 100 km of the threshold and primitive trails. Much of the camping occurs in three developed campgrounds, the only places where camping is allowed in the developed corridor. Camping is only allowed at designated campsites within three of the most popular areas outside of the developed corridor (the Hermit Loop, Horseshoe Mesa, and Tapeats-Deer Creek). Elsewhere, people are allowed to camp "at-large," wherever they want. Because water is so scarce, camping is highly concentrated around water sources.

The developed campgrounds were not included in either of the studies. The campsite sample was confined to sites along the threshold trails and a few of the more popular primitive trails accessed by trailheads along the South Rim. The campsite survey consisted of the 23 most popular threshold and primitive use areas, about one-quarter of the backcountry-use areas in the park.

During the 1970s, the popularity of the Grand Canyon backcountry increased greatly and by the 1980s substantial numbers of people were leaving the developed corridor trails, hiking down long-abandoned trails built by miners and pioneering routes cross-country. By the early 1980s, use levels in the backcountry, outside the corridor, averaged about 32,000 visitor nights (one person spending one night) per year, with more than one-half of this use occurring between March and May. Use has continued to increase; recent estimates of use levels outside the corridor exceed 40,000 visitor nights.

Overnight use in the Grand Canyon backcountry has been limited since 1974. Since 1983, there has been a limit on the number of groups allowed to spend the night in each of close to 100 use areas. As use has increased, limits at the more popular use areas have displaced more use into less popular use areas that previously were lightly used and lightly impacted.

Each use area is assigned to one of three backcountry zones, each with a different management setting: threshold (the most heavily-used), primitive, and wild (the least heavily-used). These are in addition to a "developed corridor" zone (the zone with hardened trails, developed campgrounds, and park infrastructure below the canyon rim). In most threshold use areas (which vary in size from about 300 to 2,000 ha), camping is only allowed on designated sites at one specific location in the use area, although as many as four individual designated sites were clustered at each location (fig. 1). Designated sites are long-established, user-built campsites, denoted by a sign. Management modification of sites is minimal, although many of these sites have primitive toilets. Campfires are prohibited throughout the backcountry, so there are no fireplaces. Campers have to reserve a site prior to their trip, with the daily use limit for the use area set by the number of designated campsites.

Most primitive use areas are larger (typically 1,000 to 8,000 ha) than threshold use areas and hikers are usually allowed to camp wherever they want, on dispersed campsites (a strategy referred to as at-large camping). In terms of appearance and impact, some of these dispersed sites are similar to the designated campsites in threshold areas, but most are less highly impacted. No facilities are provided. Hikers are required to reserve a permit for the use area for the night they will be camping there. Nightly quotas for primitive use areas are typically about three groups per use area. In the very lightly used wild use areas, hikers are allowed to camp wherever they want and encouraged to camp where they will leave no trace. Little use occurs in these areas and campsite impacts are minimal. We did not study any of these use areas.

Figure 1—The location in the Monument Creek use area (threshold zone) where camping is allowed has four individual designated campsites (high use; catclaw vegetation type).

Use levels differ substantially between threshold use areas and primitive use areas. Using data for 2000-2004, from 24 use areas, the median annual number of user nights per ha was 1.46 in threshold use areas and 0.40 in primitive use areas. Differences between use areas with designated sites and at-large camping were more substantial. The median annual number of user nights per ha was 1.75 in areas with designated sites and 0.27 in areas with at-large camping.

No groups larger than 11 people are allowed and many permits are only available for groups of no more than six. Although visitors are not required to obtain their permits in person, user surveys indicate that 70 percent get their permit from the backcountry office in the park. There are numerous educational displays, among other things about low-impact camping methods and regulations. Rangers go through both Leave No Trace education principles and camping regulations with each group and the group leader is required to sign a statement that they understand all regulations. Those who obtain their permits through the mail are sent a package of educational material, including a video, a bulletin about policies for the specific area they are visiting and must sign the statement that they understand the regulations. Surveys of backcountry visitors suggest that virtually all overnight visitors understand park camping policies.

Methods

Campsite Sample

In 1984, we assessed conditions on 24 campsites (table 1), widely distributed along "primitive" trails in the park's backcountry. All campsites were within 40 km of each other; several were clustered, with two to four sites within 50-200 m of each other. We selected 12 high-use and 12 low-use sites. The high use sites include many of the most heavily used campsites in the backcountry, most of which are designated campsites. Limited data suggests that most of these sites are used about 100 nights per year, with some being used more than 200 nights per year. The low-use sites ranged from several that are virtually unused to others that are regularly used but at low levels, probably no more than 20 nights per year. None of these sites had been modified substantially by management. There were no fireplaces (campfires were prohibited) and for those with toilets, the facilities were located at least 50 m away.

Table 1—Location of campsites.

Vegetation type	High-use sites	Low-use sites
Pinyon-Juniper	Horseshoe Mesa [a]	Bass Trail Esplanade
	Horseshoe Mesa [a]	Bass Trail Esplanade
	Horseshoe Mesa [a]	Boucher Trail (in Supai)
	Horseshoe Mesa [a]	Boucher Trail (in Supai)
Catclaw	Monument Creek [a]	Hance Creek (at Tonto Trail)
	Monument Creek [a]	Hance Creek (at Tonto Trail)
	Boucher Creek	Boucher Creek-Topaz Canyon
	Boucher Creek	Serpentine Canyon (at Tonto Trail)
Desert Scrub	Cedar Spring [a]	Bass Canyon (at Tonto Trail)
	Salt Creek [a]	Serpentine Canyon (at Tonto Trail)
	Horn Creek [a]	Ruby Canyon (at Tonto Trail)
	Lonetree	Turquoise Canyon (at Tonto Trail)

[a] Designated site.

Within each use stratum, four sites each were located in pinyon-juniper, catclaw, and desert scrub vegetation types. The pinyon-juniper sites were at higher elevations (1,400-1,600 m). Natural vegetation is characteristically open woodland of *Pinus edulis* (Colorado pinyon) and *Juniperus osteosperma* (Utah juniper) with an understory dominated by evenly spaced evergreen sclerophyllous shrubs and succulents. About one-half of the ground surface, under undisturbed conditions, is mineral soil. The catclaw sites were on alluvial terraces above drainages with permanent or seasonal water, at elevations of 850 to 1,100 m. Undisturbed vegetation consists of closely spaced *Acacia greggii* (catclaw acacia) trees and a highly variable understory of shrubs and grasses. Vegetation cover is high (typically >80 percent); organic litter horizons are thick and exposed mineral soil is minimal. The desert scrub sites are located on drier sites than catclaw, but at similar elevations (900 to 1,100 m), mostly on colluvial deposits or bedrock. Undisturbed vegetation consists of diverse regularly spaced shrubs and a groundcover of grasses. In terms of vegetation, organic litter and mineral soil cover, these sites are intermediate between pinyon-juniper and catclaw sites.

Each sample site consisted of both a campsite and an undisturbed control site in the vicinity. We took separate measurements in the campsite core (the central portion of the campsite that was largely devoid of vegetation and, therefore, easy to define) and along the campsite perimeter—the area several meters beyond the core.

A point was established near the center of the disturbed core of the campsite. The distances from this point to the first significant amount of vegetation (a clump of vegetation at least 1-m^2 in area) were measured along 16 cardinal directions. This defined the central core area. Within this core, four 1-m^2-quadrats were located along north, south, east, and west transects, halfway to the edge of the core. Percentage cover of vegetation (usually absent) and organic litter were recorded in the following coverage classes: <1, 1-5, 6-25, 26-50, 51-75, 76-95, and 96-100 percent.

About 25 1-m^2-quadrats were randomly located along transects in the campsite perimeter. Within each quadrat, cover of live vascular vegetation, organic litter, mineral soil and rock were estimated. The cover of each vascular plant species was estimated and the number of shrubs rooted in each quadrat was counted by species.

Control sites were circular, with an area of 50 m^2. They were located close to the campsite in an area undisturbed by camping but similar to the campsite in terms of vegetation, substrate, slope, rockiness, and distance from water. Instead of using quadrats, we made ocular estimates of live vascular vegetation cover, organic litter cover, mineral soil cover and rock cover, for the entire 50 m^2 control.

In 1989 and 2005, measurements were repeated. Since two sites were not assessed in 2005, the results presented in this paper will apply to only 22 of the campsites. The magnitude of change is expressed in two ways: (1) median conditions in 1984, 1989, and 2005; and (2) the median amount of change, which is calculated by subtracting conditions in 1984 from conditions in 2005 for each site and then reporting this difference for the median site. Readers should note that this estimate of change on the median campsite is not the same as the difference between median 1984 conditions and median 2005 conditions for all campsites. In addition, for each parameter, we report the number of sites on which that parameter increased, decreased, or stayed the same (between 1984 and 2005). Finally, we evaluated the statistical significance of differences between conditions in 1984 and 2005 with the Wilcoxon matched-pairs, signed-ranks test.

The effect of camping on the species composition of the campsite perimeter was estimated by comparing the species composition of the perimeter and the control. To quantify differences, the following coefficient of floristic dissimilarity was calculated:

$$FD = 0.5 \sum |p_1 - p_2|,$$

where p_1 is the mean relative cover of a given species on the campsite perimeter and p_2 is the relative cover of the same species on the control. Relative cover is the percent of total cover accounted for by a given species (i.e., one species' cover divided by the total cover of all species). Both native and non-native species were included.

Campsite Survey

To assess trends in overall campsite impact, we used some of the data collected in two censuses of all the campsites in different use areas in the Grand Canyon backcountry. The first of these censuses, the Rapid Campsite Assessment (RCA), was initiated in 1985 and continued until 1992. Each year, park staff surveyed about 5 of the 66 threshold and primitive use areas, with an emphasis on the 30 use areas that contained established trails or routes. In total, approximately 40 use areas were surveyed between 1985 and 1992 and over 300 campsites were assessed. For each campsite, the RCA recorded the number of barren areas and the size of each of these. Each campsite typically contains one to several barren areas, places used for cooking or sleeping, where all the vegetation has been eliminated and the soil is highly compacted. In addition, data on soil compaction, access trails, perimeter vegetation and tree damage, and permanent impacts from fires were also collected, along with an ordinal assessment of overall impact. These data are not reported in this paper.

The second survey, the Rapid Site Inventory (RSI), was conducted by Northern Arizona University, under the direction of Dr. Pam Foti, mostly in 2003 and 2004, with some additional data collection in 2005. This survey covered the 32 most frequently visited backcountry use areas in Grand Canyon National Park. As in the earlier survey, the goal was to locate and assess the condition of most campsites. Although the effort expended locating sites was roughly equivalent for each of the surveys, the RSI collected information on a wider array of variables than the RCA but with less quantification. This survey also included an ordinal assessment of overall impact. A total of 757 backcountry sites were located and assessed in the 2003-2004 RSI survey.

In this paper, we simply report change in the number of campsites and in the number of barren areas in the 23 most heavily used use areas in the park (about 60,000 ha). These indicators were consistent across the two studies, except in how tightly packed clusters of campsites were handled. At some popular destinations, individual campsites merge into clusters of sites where it is impossible to determine where one site ends and the next begins. Estimates of the number of campsites in such a cluster are imprecise. In the early inventory, evaluators used their best judgment to decide how many individual campsites were in a cluster. For the later inventory, all the campsites in a single cluster were simply reported as one cluster. Consequently, the later inventory underestimates the total number of campsites. The number of barren areas is directly comparable between the two inventories.

Results

Campsite Sample

Results are discussed in more detail in Cole and others (2008). Generally, conditions on campsite cores changed very little over the 20 years between 1984 and 2005 (table 2). Over that period, vegetation, litter, mineral soil, and rock cover all increased significantly on campsite perimeters while they were stable on controls (table 3). This suggests there was no general tendency for site conditions to deteriorate, despite the general increase in use that has occurred.

Table 2—Change on the core of the 22 campsites.

	Core area (m^2)	Vegetation cover (%)	Litter cover (%)
Median			
1984	44	0	0
1989	38	1	2
2005	46	5	4
Change[a]	-2	5	2
Number of Sites			
Decreased	12	0	1
Increased	10	19	16
Unchanged	0	3	5
Significance[b]	0.66	**<0.01**	**<0.01**

[a] Median difference between conditions in 1984 and 2005 (1984 value subtracted from 2005 value).
[b] Wilcoxon matched-pairs signed ranks test (p = 0.05), difference between 1984 and 2005.

Table 3—Groundcover change on campsite perimeters and controls.

	Vegetation cover		Litter cover		Mineral soil cover		Rock cover	
	Perimeter	Control	Perimeter	Control	Perimeter	Control	Perimeter	Control
Median								
1984	54	63	51	63	16	27	7	3
1989	46	63	46	63	30	27	5	3
2005	62	63	62	63	16	27	8	3
Change[a]	7	0	5	0	4	0	1	0
Number of Sites								
Decreased	4	5	4	7	7	5	5	1
Increased	15	4	16	3	14	5	13	5
Unchanged	3	13	2	12	1	12	4	16
Significance[b]	**<0.01**	0.90	**<0.01**	0.47	**0.05**	0.38	**0.03**	0.20

[a] Median difference between conditions in 1984 and 2005 (1984 value subtracted from 2005 value).
[b] Wilcoxon matched-pairs signed ranks test (p = 0.05), difference between 1984 and 2005.

The data we collected on cover of individual species on campsite perimeters and control sites provide the opportunity to gain more insight into impacts on the species composition of vegetation. In 1984, mean floristic dissimilarity (the index of difference in species composition between campsite perimeters and controls) was 33 percent. Dissimilarity increased between 1984 and 1989 to 42 percent and decreased between 1989 and 2005 to 36 percent. These index values suggest only slight differences in composition between perimeters and controls and little change over time. Differences between 1984 and 2005 did not quite meet the 0.05 criterion for statistical significance (p = 0.06).

Species richness (number of species) was higher on campsite perimeters than on control sites (table 4), despite the fact that the area sampled on campsite perimeters (typically

Table 4—Changes in species richness [a] on campsite perimeters and controls sites.

	Perimeters				Controls			
	1984	1989	2005	p [b]	1984	1989	2005	p [b]
Species richness	18	15	26	**<0.01**	16	12	21	**<0.01**
Nonnative species richness	1.8	1.5	2.8	**<0.01**	1.5	1.2	1.8	**0.04**

[a] Richness is the number of different species found on the sampled portion of campsite perimeters (typically 25 m^2) and controls sites (50 m^2).
[b] Difference between 1984 and 2005, using Wilcoxon matched-paairs signed ranks test (p = 0.05).

25 m²) was smaller than the area of control sites (50 m²). Richness should generally increase as the area included increases. On both campsite perimeters and control sites, richness decreased from 1984 to 1989 and increased from 1989 to 2005. Some of the increase in 2005 might be accounted for by having more botanists on the sampling crew with a higher level of botanical experience in Grand Canyon. Richness of nonnative species also increased over the period, both on campsite perimeters and control sites.

In 2005, campsite perimeters differed from control sites primarily in having less grass cover: both less annual grass cover and less perennial grass cover (table 5). Perimeters also had less cover of nonnative species than controls sites did.

Effect of Amount of Use—The median core area of high use sites was about 2.5 times as large as the median core area of low-use sites (table 6). Although high use sites were larger, they did not change more than low use sites over the 20-year period. Perimeter

Table 5—Change in mean cover of different growth forms on campsite perimeters and control sites.

	Perimeters				Controls			
	1984	1989	2005	p [a]	1984	1989	2005	p [a]
Shrubs-trees	40	37	32	**<0.01**	44	43	39	0.19
Cacti	<1	<1	<1	0.92	<1	<1	<1	0.17
Shrubs	27	25	21	**<0.01**	27	30	23	0.23
Trees	13	12	11	0.18	17	14	16	0.47
Grasses-total [b]	29	13	35	**<0.01**	37	17	52	0.10
Annuals [b]	26	10	33	**<0.01**	34	15	46	0.07
Perennials [b]	3	3	1	0.08	3	2	6	0.94
Forbs-total	4	4	17	**<0.01**	5	2	17	**<0.01**
Annuals	3	2	15	**<0.01**	3	1	15	**<0.01**
Perennials	1	2	2	0.14	2	1	2	0.93
Nonnatives [b]	26	10	33	**0.04**	33	15	44	0.18

[a] Paired t-tests (p = 0.05), difference between 1984 and 2005.
[b] Growth forms for which 2005 cover differed significantly between perimeters and controls.

Table 6—Median change on campsite cores on high (n = 12) and low use (n = 10) campsites.

	Amount of Use		
	High	Low	p [a]
Core area (m²)			
1984	59	23	**<0.01**
1989	56	23	**<0.01**
2005	54	21	**0.01**
Change**	-3.5	0.3	0.60
Vegetation cover (%)			
1984	0	0	**0.01**
1989	0	1	**0.04**
2005	4	12	0.11
Change [b]	4	11	0.32
Litter cover (%)			
1984	0	3	**<0.01**
1989	1	4	0.09
2005	2	12	0.11
Change**	1	10	0.37

[a] Mann Whitney U test.
[b] Median difference between conditions in 1984 and 2005 (1984 value subtracted from 2005 value).

conditions on high-use sites were not significantly different from perimeter conditions on low-use sites, nor did the amount of change on the perimeter of high-use sites differ from that on low-use sites (table 7).

Differences Among Vegetation Types—Campsite cores in pinyon-juniper were typically larger than those in acacia and desert scrub, although size was highly variable and sample size was small, making differences statistically significant only in 1984 (table 8). Campsites in pinyon-juniper also typically had less vegetation and litter cover, although differences were both small and statistically insignificant. On the campsites we studied, vegetation and litter cover increased more on acacia and desert scrub sites between 1984 and 2005 than it did on pinyon-juniper sites. Differences are not statistically significant, however, and probably represent short-term response to the abnormally moist conditions in 2005.

Table 7—Median change on campsite perimeters on high (n = 12) and low use (n = 10) campsites.

	Amount of use		
	High	**Low**	**p [a]**
Vegetation cover (%)			
1984	55	41	0.28
1989	52	32	0.07
2005	67	60	0.62
Change [b]	7	5	0.74
Litter cover (%)			
1984	54	50	0.48
1989	46	52	0.78
2005	62	68	0.94
Change [b]	4	6	0.37
Mineral soil cover (%)			
1984	15	24	0.40
1989	29	31	0.99
2005	17	13	0.57
Change [b]	5	1	0.09
Shrub density (#/m2)			
1984	1.28	1.00	0.46
1989	0.72	0.88	0.50
2005	0.48	0.62	0.44
Change [b]			
Floristic dissimilarity (%)	-0.32	-0.24	0.36
1984	36	31	0.36
1989	42	44	0.82
2005	33	37	0.35
Change [b]	2	10	0.11

[a] Mann Whitney U test.
[b] Median difference between conditions in 1984 and 2005 (1984 value subtracted from 2005 value).

Table 8—Median change on campsite cores on campsites in the pinyon-juniper (n = 8), acacia (n = 6), and desert scrub (n = 8) vegetation types.

	Vegetation type			
	Pinyon-juniper	Acacia	Desert scrub	p [a]
Core area (m^2)				
1984	81	27	40	**0.05**
1989	77	28	38	0.22
2005	75	31	47	0.10
Change [b]	5.2	-2.8	0.3	0.87
Vegetation cover (%)				
1984	0	0	3	0.17
1989	0	3	1	0.12
2005	3	9	5	0.18
Change [b]	2	9	5	0.17
Litter cover (%)				
1984	0	1	3	0.11
1989	0	5	3	0.09
2005	1	7	5	0.06
Change [b]	0	6	4	0.07

[a] Significance was tested with the Kruskal-Wallis test.
[b] Change between 1984 and 2005 (1984 condition subtracted from 2005 condition).

Differences among vegetation types on the perimeter are similar. Pinyon-juniper campsite perimeters had less vegetation and litter and more exposed mineral soil than was the case on campsites in acacia and desert scrub (table 9). Pinyon-juniper perimeters also had fewer nonnative plant species, but control sites in pinyon-juniper also had less vegetation and litter, more exposed mineral soil, and fewer nonnative species (table 10). Vegetation and litter cover increased more on acacia and desert scrub perimeters than on pinyon-juniper perimeters, while mineral soil increased more on pinyon-juniper perimeters. Similar patterns of change were observed on control sites, however, suggesting that these differences reflect general differences between these vegetation types rather than differences in vulnerability to camping impacts.

Initial Conditions—For three parameters (core area and the percent of vegetation and mineral soil in perimeter plots), we explored whether the magnitude of change over time varied with the magnitude of impact on the site in 1984. Magnitude of change was not significantly correlated with initial impact for any of these parameters (kendall's tau). Comparing the 10 sites that were initially most impacted with the 10 sites that were least impacted, there also were no significant differences in amount of change (Mann-Whitney U test). In contrast to what was found in the Eagle Cap study, the variability of change (indicated by the magnitude of the standard deviation) was not consistently related to initial conditions.

Campsite Survey

In contrast to our finding that individual campsites did not change much over 20 years, changes at larger scales were dramatic. In the 23 most popular use areas in the park, 332 campsites were found in the late 1980s. In 2003-2004 in these same use areas, 514 individual campsites were found, as were 70 clusters of campsites. Although the number of campsites in a cluster varied from two to perhaps five or six, the average was about three. This suggests a total of more than 700 individual campsites in 2003-2004, more than double the number in the late 1980s. The number of barren areas almost tripled, from 523 in the 1980s to 1,466 20 years later.

Table 9—Median change on campsite perimeters on campsites in the pinyon-juniper (n = 8), acacia (n = 6), and desert scrub (n = 8) vegetation types.

	Vegetation type			
	Pinyon-juniper	**Acacia**	**Desert scrub**	**p [a]**
Vegetation cover (%)				
1984	32	64	60	**<0.01**
1989	31	59	53	**0.04**
2005	27	74	71	**<0.01**
Change [b]	0	10	13	**0.03**
Litter cover (%)				
1984	21	70	51	**<0.01**
1989	24	60	64	**<0.01**
2005	23	71	73	**<0.01**
Change [b]	2	8	10	0.31
Mineral soil cover (%)				
1984	57	9	11	**<0.01**
1989	57	18	29	**<0.01**
2005	66	11	11	**<0.01**
Change [b]	8	2	2	0.15
Shrub density (#/m^2)				
1984	1.08	0.90	1.50	0.80
1989	0.92	0.72	0.63	0.31
2005	0.56	0.74	0.41	0.65
Change [b]				
Floristic dissimilarity (%)	-0.32	-0.24	-0.56	0.54
1984	36	20	40	0.08
1989	42	40	69	0.26
2005	38	26	40	**0.05**
Change [b]	7	8	0	0.65
Species richness (#)				
1984	15	17	22	0.24
1989	15	13	18	0.40
2005	20	29	32	0.08
Change [b]	6	12	5	0.28
Nonnative species richness (#)				
1984	1.0	2.0	2.0	**0.01**
1989	1.0	2.0	2.0	**0.01**
2005	2.0	4.5	3.0	**0.01**
Change [b]	1.0	1.5	1.0	0.41

[a] Significance was tested with the Kruskal-Wallis test.
[b] Change between 1984 and 2005 (1984 condition subtracted from 2005 condition).

Change in the number of campsites and the number of barren areas were slightly greater in the more heavily used threshold zone than in the primitive zone. We calculated an index of change by dividing the number of campsites in 2003-2004 by the number of campsites in the late 1980s. This ratio (larger numbers mean more campsite proliferation) had a mean of 2.4 in threshold-use areas and 2.1 in primitive-use areas. The mean ratio of barren areas in 2003-2004 compared to the late 1980s was 3.1 in threshold-use areas and 2.7 in primitive use areas.

The proliferation of campsites is not surprising where at-large camping is allowed; however, it should not occur where a designated camping policy is in place. Our data show that proliferation was as great in use areas with designated site camping as it was in use areas with at-large camping (fig. 2). The mean ratio of campsites in 2003-2004 compared to the late 1980s was 2.2 both in areas with designated sites and in areas with at-large camping. The mean ratio of barren areas in 2003-2004 compared to the late 1980s was 2.9 in areas with designated sites and 2.8 in areas with at-large camping.

Table 10—Median change on controls adjacent to campsites in the pinyon-juniper (n = 8), acacia (n = 6), and desert scrub (n = 8) vegetation types.

	Vegetation type			
	Pinyon-juniper	**Acacia**	**Desert scrub**	**p [a]**
Vegetation cover (%)				
1984	38	85	74	**<0.01**
1989	38	74	63	**0.02**
2005	38	74	63	**<0.01**
Change [b]	0	0	24	**0.01**
Litter cover (%)				
1984	38	85	63	**<0.01**
1989	38	85	63	**<0.01**
2005	27	85	63	**<0.01**
Change [b]	-12	0	0	**0.04**
Mineral soil cover (%)				
1984	38	3	27	**<0.01**
1989	38	3	27	**<0.01**
2005	63	2	21	**<0.01**
Change [b]	13	0	0	**0.03**
Shrub density (#/m^2)				
1984	0.76	0.64	0.93	0.16
1989	0.92	0.56	0.44	**0.01**
2005	0.66	0.41	0.60	0.07
Change [b]	-0.22	-0.22	0	0.90
Species richness (#)				
1984	15	18	18	0.41
1989	13	11	12	0.40
2005	18	20	25	0.19
Change [b]	3	8	5	0.25
Nonnative species richness (#)				
1984	1.0	2.0	1.0	**0.01**
1989	0.5	2.0	1.0	**0.01**
2005	1.0	2.5	1.5	**0.01**
Change [b]	0	0.5	0	0.25

[a] Significance was tested with the Kruskal-Wallis test.
[b] Change between 1984 and 2005 (1984 condition subtracted from 2005 condition).

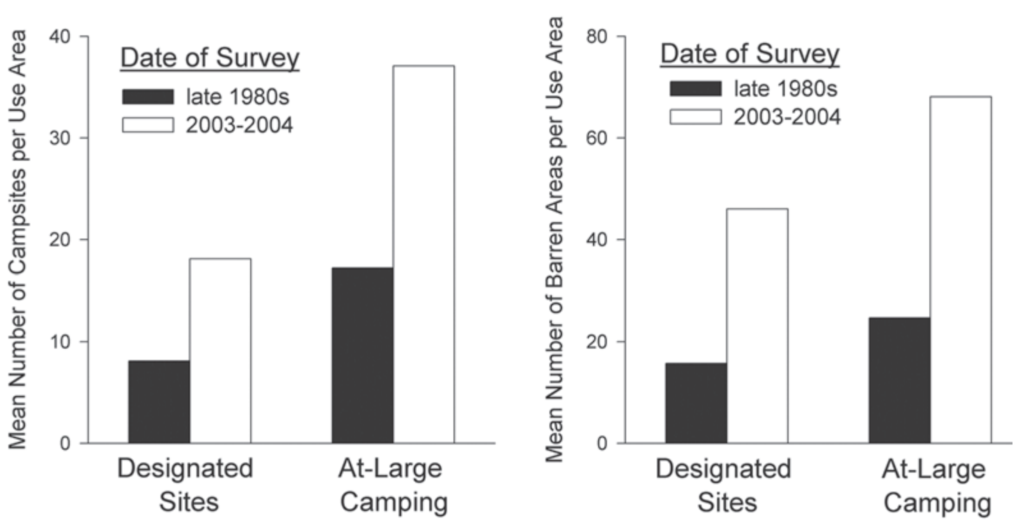

Figure 2—Change in the mean number of campsites and barren areas on campsites in use areas with designated sites and use areas with at-large camping.

Conclusions and Implications

From these studies we can conclude that most of the sites that were well-established in 1984 were not that different 20 years later. Stability was as characteristic of high-use sites as it was of low-use sites. There was relatively little change in the size of most campsites in our sample between 1984 and 2005. Core area size was unchanged and there was little evidence of increased impact on campsite perimeters. Vegetation cover (mostly annual species) increased and decreased, apparently in response to annual variation in amount of winter rainfall. Vegetation composition also fluctuated greatly between years, both on campsites and on controls.

Despite the relative stability of individual sites, the number of campsites increased more than two-fold over the 20-year period. Since the area and intensity of impact on individual sites has been stable, this suggests that aggregate campsite impact has more than doubled in the past 20 years.

These studies suggest that a strategy of concentrating use on designated campsites in popular places and dispersing it elsewhere can help limit impact while also maintaining visitor freedom. In popular places, designated sites do not deteriorate substantially and proliferation of sites, in places with designated sites, is less than it would be without site designation. The primary problem on designated sites is the increase in number of barren areas, due primarily to people setting tents up in new places beyond the perimeter of the main designated site. Where this is occurring, managers need to either accept larger sites or lower group size limits, although some site expansion might be avoided by incorporating campsite design and maintenance techniques that limit this behavior (Marion and Farrell 2002; Marion and Sober 1987).

The problem in more remote places with at-large, dispersed camping, where people can camp wherever they want, is the creation of numerous new campsites. Over the past 20 years, pioneering of new sites has continued and even abandoned campsites recover extremely slowly on these arid sites. Consequently, the area disturbed by camping has approximately doubled in zones where at-large camping is allowed, despite the fact that use has only increased about 25 percent and these places are not the most popular destinations in the backcountry. Keys to reducing this problem include inventory and monitoring, education and maintenance, and restoration.

Surprisingly, campsite proliferation was equally pronounced in zones with designated sites, places where pioneering a new campsite is illegal. Although a designated site policy should preclude the development of new campsites, substantial illegal camping still occurs. Earlier studies have suggested that problems with proliferation can be solved by implementing a designated site policy (Reid and Marion 2004). Our results suggest that such policies may reduce problems and may be the most practical management option, but we should not assume they will solve the problem entirely.

Caney Creek Wilderness, Arkansas: 1994-2007

In 1994, as part of a study of campsites in four wildernesses in the states of Illinois, Missouri, and Arkansas (McEwen and others 1996), all campsites in Caney Creek Wilderness were located and their condition was evaluated. A similar survey was repeated in 2007. This case study reports on trends in the number and condition of campsites throughout the Caney Creek Wilderness over the period between 1994 and 2007. Additional details are reported in Cole and Ferguson (2009).

Study Area

Caney Creek Wilderness covers 5,830 ha of the Ouachita Mountains of west-central Arkansas (fig. 1). Vegetation is a dense cover of oak-hickory-pine forest. Topography is dominated by two parallel creeks, Caney Creek and Short Creek, separated by long ridges with local relief of more than 300 m. Although there are about 32 km of trail in the wilderness, most use occurs along the 15-km trail that follows Caney Creek. Most of the Short Creek drainage is without trails, but not difficult to traverse. Use is quite heavy in the wilderness, estimated at over 12,000 visitor days in the early 1990s. Although measures of use are lacking, long-term ranger observations suggest relatively stable use levels over the past few decades.

Neither visitation nor behavior is regulated beyond the general wilderness prohibition on motorized use. However, following the 1994 campsite inventory, local managers decided that the number of campsites and degree of impact was excessive, so they developed a management strategy to reduce the number of campsites and, thereby, the magnitude of camping impact. Trail relocation, education, campsite closure, and site restoration were all employed.

Figure 1—Overview of the Caney Creek Wilderness from the Tall Peak trail.

More than 3 km of creek bottom trail were rerouted. This reduced the number of trail-accessible desirable places to camp. For example, the original Caney Creek Trail, east of Katy Creek, had 11 creek crossings in about 5 km and was in the creek for substantial distances in several places. The relocated trail crossed in four places and the trail was up the sideslope away from the creek most of the time. Trail relocation meant that many former campsites were no longer visible from the trail.

In addition, between 1994 and 1996, 16 well-established campsites were closed to use and restored. Soil was scarified and planted with seed and locally collected transplants. Large rocks were buried in tent pads to make the site less conducive to camping. Plantings were watered and mulched. Ribbon was tied between trees to cordon off the site and a "No Camping" sign was posted. In addition, fire rings and fire remains were scattered at 26 lightly impacted sites. Education programs emphasized camping at already impacted sites and staying off closed sites. Although camping on closed sites was prohibited, camping on existing sites was not mandatory (as in a designated campsite program).

Most of the closed campsites did not require ongoing work. However, two of the 16 closed sites required additional work every year for 5 years and another two require ongoing work 10 years after closure. "No Camping" signs have been left at six of the campsites.

Methods

There were 91 campsites in the Caney Creek Wilderness in 1994. On 48 of these sites, the primary impact was campfire remains, with or without a fire ring. There was little if any long-term disturbance. The only information collected on these "trace sites" was their location. A rapid assessment form was filled out on each of the 43 well-established campsites, while more detailed measurements were taken on a sample of 12 sites. The rapid assessment, which took less than 10 minutes per site, quantified nine parameters: campsite area, devegetated area, vegetation loss, increase in mineral soil exposure, damage to tree trunks, exposure of tree roots, social trails, developments, and cleanliness (McEwen and others 1996). For each parameter, a rating of 1, 2, or 3 was assigned to the site, depending on the level of impact. These ratings were summed to obtain the overall impact index.

In addition, each site was assigned a modified Frissell (1978) condition class rating. Condition classes, ranging from 1 to 4, were (1) minimal impact (assigned to trace sites as well), (2) vegetation loss confined to the central portion of the site, (3) vegetation lost over most of the site but little mineral soil exposure, and (4) vegetation lost and mineral soil exposed over most of the campsite (fig. 2). Where it was difficult to decide between adjacent condition classes, midpoints were used.

On the 12 campsites evaluated more precisely, permanent plots were established. Buried nails made it possible to relocate the sites. About an hour was spent on each site using techniques first used in the Eagle Cap Wilderness, Oregon, to take careful measurements of campsite area, groundcover conditions, and tree damage (Cole 1982).

Campsite measurements were repeated in 2007. Rapid assessment procedures were done on all campsites, except the trace sites, which were simply given a condition class rating of 1. Detailed measures were taken on six of the 12 sites studied in detail in 1994. Permanent markers could not be found on two of the original 12 sites and the other four sites were closed, restored, and no longer recognizable as campsites. This sample of six long-established campsites is small and results should be treated cautiously. However, the six campsites in the sample represent 38 percent of the 16 campsites that were well-established (not trace sites) in both time periods. Moreover, results are consistent with studies of long-term trends with larger sample sizes (for example, Cole and Hall 1992).

Figure 2—Class 3 campsite that has lost substantial vegetation cover but with little mineral soil exposure.

Results

Between 1994 and 2007, the number of campsites declined 40 percent, from 91 in 1994 to 54 in 2007 (table 1). Both trace and well-impacted sites decreased in number, but the largest decrease was in the number of highly impacted campsites. The number of sites with a condition class rating of 3.5 or 4.0 (sites that had experienced widespread loss of vegetation and organic litter cover) decreased from 15 to 3 (table 1). Based on the impact index ratings, the number of sites in the highest impact index class (22-27) decreased from 7 to 0 (table 2) and the mean impact index decreased from 13 to 12.

Table 3 can be used to describe the fate of individual sites in the period between 1994 and 2007. Read down columns to determine the condition in 2007 of all campsites of a given impact index class in 1994. For example, of the 15 campsites in the 10-15 impact index class in 1994, ten disappeared (index = 0), four improved to become trace sites (index = 9) and one deteriorated (index = 16-21). No sites in this class were stable. From this table we can conclude that between 1994 and 2007:

- 16 campsites improved, but were still campsites;
- 58 campsites improved so much that they were no longer recognizable campsites;
- 14 campsites were unchanged in condition;
- 3 campsites deteriorated; and
- 21 new campsites were created.

Of the new campsites, 16 were minimally impacted trace sites, but five were more substantially disturbed.

Table 1—Condition class of campsites in 1994 and 2007.

Condition class[a]	1994	2007
	- - campsites- -	
1.0	48	29
1.5-2.0	11	13
2.5-3.0	17	9
3.5-4.0	15	3
Total	91	54

[a] Modified Frissell condition class (refer to text for definitions).

Table 2—Impact index of campsites in 1994 and 2007.

Impact Index[a]	1994	2007
	- - campsites- -	
9	48	31
10-15	15	13
16-21	21	10
22-27	7	0
Total	91	54

[a] Sum of ratings for nine parameters (refer to text for details).

Table 3—The number of campsites in each impact index class in 1994 and 2007[a].

		1994 Impact index					
		0	9	10-15	16-21	22-27	Total
2007 Impact index	0		37	10	7	4	58
	9	16	9	4	2	0	31
	10-15	4	2	0	7	0	13
	16-21	1	0	1	5	3	10
	22-27	0	0	0	0	0	0
	Total	21	48	15	21	7	112

[a] Campsites with an impact index of 0 in 1994 are new sites in 2007, while those with an index of 0 in 2007 disappeared. Sites above the shaded boxes improved, while those below the shaded boxes deteriorated.

Most of the sites that improved or disappeared were in places that were no longer readily accessible once the trail was rerouted or were sites that were closed and restored. None of the sites that deteriorated were in the more popular destinations along Caney Creek. Two were located on the Buckeye Mountain trail that had been recently improved. The 21 new campsites were widely distributed throughout the wilderness but they were particularly abundant along Short Creek, which has no trails. However, the new campsites that developed in more popular places along Caney Creek generally were more highly impacted than those along Short Creek.

Although limited in quantity, the data from detailed measures on the sample of sites also suggest a dramatic decrease in campsite impact. On the six original sites that were not closed to camping, the median area of campsite disturbance decreased from 232 m^2 in 1994 to 85 m^2 in 2007. This difference is statistically significant (Wilcoxon signed ranks test, $Z = 2.2$, $p = 0.03$). Devegetated area decreased significantly from a median of 80 m^2 in 1994 to 47 m^2 in 2007 ($Z = 2.0$, $p = 0.05$). These declines would be even greater if we included data from the four campsites that almost completely disappeared. The number of mutilated trees decreased significantly from a median of 7.5 to 3.0 ($Z = 2.0$, $p = 0.04$) and vegetation cover increased significantly from a median of 13 percent in 1994 to 21 percent in 2007 ($Z = 2.0$, $p = 0.04$).

Conclusions and Implications

Clearly, campsite conditions in Caney Creek Wilderness have improved dramatically since the early 1990s. The number of campsites has decreased greatly, as has the magnitude of impact on the most severely disturbed campsites in the wilderness. Although it is not possible to know for sure, it seems that this improvement is largely the result of the management actions that were taken to reduce campsite impacts. There is no reason to think that, without these actions, conditions in 2007 would have been better than in 1994. This illustrates the potential for even indirect, non-regulatory actions to be effective in environments as resilient as these.

Impacts were reduced not by implementing restrictions requiring the use of designated campsites as has been done elsewhere (Marion 1995; Reid and Marion 2004). Rather, the strategy involved reducing the number of places where visitors are likely or allowed to camp. This was accomplished using multiple approaches. Trail relocation, education, permanent closure of selected campsites and assisted site restoration all contributed to success. It was particularly important to ensure that staff were available for education and monitoring during the times when most visitors were in the wilderness. The high resilience of these sites (i.e., they can recover rapidly) was an important factor, as was the decision not to close so many sites that people had a hard time finding an open campsite.

The Middle Fork and Main Salmon River, Frank Church-River of No Return and Gospel-Hump Wildernesses, Idaho: 1996-2009

In order to assess ecological impacts associated with recreational use by boaters, conditions have been monitored on a representative sample of campsites along both the Middle Fork and Main Salmon Rivers since 1995-1996. Conditions on these sites have been reassessed twice since then—in 2001-2004 and in 2008-2009. This case study describes the changes that occurred over this 13-year period.

The Study Area

The Middle Fork and Main Salmon Rivers, in central Idaho, are two of the premier whitewater wilderness rivers in the United States. The Middle Fork of the Salmon runs north for about 165 km through the middle of the 957,822-ha Frank Church-River of No Return Wilderness—the largest contiguous wilderness outside Alaska. There it enters the Main Salmon, which flows west for about 135 km through and along the boundary between the Frank Church and Gospel-Hump Wildernesses. There are trails along these rivers for much of their length, but they receive little use. Most of the use is by groups who travel by raft and kayak, with or without commercial guides. Each day 7 or 8 groups (depending on the river) are allowed to launch, in groups as large as 30 people on the Main Salmon.

Much of the camping occurs on large sandy beaches, which are scoured most years during high water. However, particularly on the Middle Fork, some campsites are on benches above high water and most campsites have satellite sleeping pads and trails above high water. Many of the popular campsites are used by very large groups every night during the 2-month-long high-use floating season and less frequently during the increasingly popular shoulder seasons. However, each group is lectured regarding Leave No Trace practices and required to carry fire pan, porta-potty, and garbage bags, so no campfire remains, garbage, or human waste is left behind.

Methods

In 1995-1996, a 10 percent sample of the campsites on the Middle Fork (11 campsites) and Main Salmon (13 campsites) was established. Every 10th campsite going downriver was assessed. We adapted established techniques used to assess campsite impacts in terrestrial wilderness (such as Cole 1983; Cole and Hall 1992) to campsites along this wilderness river. Challenges in doing so included the large size of river campsites, the complex maze of social trails and satellite tent pads and difficulty in defining the edge of the camp. One edge is a river that fluctuates in height through the season. We quickly realized that, for groundcover parameters (such as vegetation cover), it would be impossible to assess the amount of impact that had already occurred. Normally, impacts to such parameters are assessed by comparing campsites with adjacent control sites, judged to be similar to the campsite prior to use. Good controls are lacking along these rivers, because any place with the characteristics of a campsite is a campsite. We did establish control sites (six on the Middle Fork and four on the Main Salmon) but did not attempt to associate them with specific campsites.

On each campsite, we established one (or more) center point(s)—a buried nail, located above high water and referenced to three distinctive features. Walking the campsite perimeter, we placed 15-25 flags at places where the boundary changed direction. Then, from the center point, we recorded azimuth and distance to each flag. Such measures are replicable and can be used to calculate campsite area (Marion 1995). We estimated the approximate area of any undisturbed vegetation within the campsite and subtracted these from the campsite area.

Within the campsite perimeter, delimited by straight lines drawn between flags, we estimated the proportion of the site in the following groundcover classes: vegetation, litter, mineral soil, sand, and rock. For each live tree within campsite boundaries, we assessed tree damage as either none/slight, moderate (two or more nails, numerous small trunk scars or exposed roots), or severe (numerous substantial trunk scars or girdled trunks or roots). We counted tree snags and "natural stumps," as well as stumps clearly cut by recreationists. We counted the number of fire rings, ash piles, human waste sites, and constructed structures or piles (including piles of firewood) and we quantified the volume of garbage, in liters.

We walked each user-created social trail that left the campsite perimeter. We mapped and measured the length of each trail, dividing each into segments according to the following condition classes: (1) worn, but with vegetation in the tread; (2) well-worn, with no vegetation in the tread; and (3) deeply worn, no vegetation and tread eroding. At each satellite site these trails accessed (usually a tent pad), we estimated area, as well as percent cover of vegetation, litter, mineral soil, sand, or rock.

Techniques for taking repeat measurements were generally identical to those used for the initial assessment. The original boundaries of the main camp were used, unless there was a compelling reason to believe that they had changed. This criterion was necessary because there were so many arbitrary decisions that needed to be made regarding site boundaries. Social trail systems were reassessed, as were the satellite sites.

On the control sites we established two 15 m long transects, parallel to each other and to the river and about 6 m apart. The endpoints of each transect were permanently marked with buried nails. A 1-m^2-quadrat was placed each 2 m along each transect, for a total of 14 quadrats at each control site. The percent cover of vegetation, litter, soil, sand, and rock were estimated in each transect. Changes on controls were primarily used to gain insight into how much change in groundcover conditions on campsites might reflect natural changes not related to camping activities.

In addition to reporting the mean and median for each parameter, we also report the number of sites on which that parameter increased, decreased, or stayed the same (between 1995-1996 and 2008-2009). We evaluated the statistical significance of differences between conditions in 1995-1996 and 2008-2009 with Wilcoxon matched-pairs, signed-ranks tests.

Results

Eleven campsites on the Middle Fork were initially assessed in 1996 (table 1). They were reassessed in 2002 or 2004 and again in 2009. In addition, conditions on six control sites were assessed in 1996, 2002, 2004, and 2009. Thirteen campsites on the Main Salmon were initially assessed in 1995 or 1996 (table 2). They were reassessed in 2001 or 2002 and again in 2008. In addition, conditions on four control sites were assessed.

Table 1—Sample campsites on the Middle Fork Salmon River.

Campsite name	River mile
Gardell's Hole	2.4
Elkhorn	8.2
John's Camp	15.2
Pistol Creek	26.2
Sunflower Flat	32.6
Culver Creek	45.6
Hospital Bar	52.1
Pool	61.1
Little Pine	71.4
Last Chance	78.0
Tumble Creek	88.8

Table 2—Sample campsites on the Main Salmon River.

Campsite name	River mile
Fawn Creek	56.6
Lower Devil's Teeth	59.6
Big Squaw	64.3
Sandy Hole	70.2
Magpie Creek	76.1
Bargamin Creek	78.5
Twin Snags	84.0
Ruff Creek	89.3
Five Mile Creek	99.2
South Fork	103.2
Warren Bar	107.5
California Creek	117.5
Johnson Creek	122.8

Middle Fork Campsite Conditions

The most notable characteristic of these campsites was their large size (fig. 1) and their web of social trails and satellite sites. On the mean campsite, the main site was 882 m^2 in 1996 and satellite sites added another 203 m^2. There were over 317 m of social trails. These conditions can be compared with typical camp areas of 200 m^2 in the Eagle Cap Wilderness, Oregon (Cole and Hall 1992) and 200-300 m^2 along several rivers in the eastern United States (Cole and Marion 1988). The larger sites are similar to the huge horse outfitter camps in the Bob Marshall Wilderness, Montana, where the combined area disturbed by cooking, tenting, and holding pack stock ranged from 400 to10,000 m^2 (Cole 1983).

As notable as the huge area disturbed by camping is the degree to which these campsites are clean and lacking in tree damage. These impacts—the ones most responsive to visitors following Leave No Trace guidelines—are virtually absent. Most campsites had no evidence of fire-related impacts, no user-built structures, no evident human waste or toilet paper, virtually no garbage and no significant tree damage. In contrast, most campsites in terrestrial wilderness—if fires are permitted—will have fire rings (often more than one), ash piles and structures. Along several eastern rivers (Cole and Marion 1988), sites typically had evident human waste, more than 10 liters of garbage, and more than 20 damaged trees.

Figure 1—The Elkhorn campsite is typical of a large campsite on a bench above the Middle Fork of the Salmon.

Changes Between 1996 and 2009—The size of campsites was relatively stable over the 13-year period. The mean size of the main camp declined, but the median size increased; fewer campsites increased in size than decreased (table 3). The campsites that experienced the largest increases in main camp size were Tumble Creek (227 m^2) and Culver Creek (101 m^2). The main camps that decreased most were Hospital Bar and Pistol Creek. Both of these sites were burned over, resulting in shifts in use patterns, particularly at Pistol Creek. Most of the groundcover on most main camps was sand or bare soil, depending on whether most of the site was above or below the high water line. None of the changes on the main camp were substantial and consistent enough to be statistically significant (paired t-tests, $p < 0.05$).

Table 3—Changes on the main camp, Middle Fork, 1996-2009.

	Area (m^2)	Sand (%)	Rock (%)	Bare (%)	Vegetation (%)	Litter (%)
Mean						
1996	882	27	12	34	14	13
2002/4	550	39	6	32	12	12
2009	820	26	17	34	12	12
Median						
1996	544	2	13	35	13	14
2002/4	522	35	3	35	14	13
2009	574	3	14	44	14	14
Number of sites						
Decreased	7	2	2	3	2	3
Increased	4	3	6	3	4	4
Unchanged	0	6	3	5	5	5
Significance[a]	0.42	0.76	0.53	0.18	0.42	0.48

[a] Difference between 1996 and 2009, Wilcoxon matched-pairs, signed-ranks tests (α = 0.05).

All of these campsites had satellite sites (usually small tent pads) connected to the main camp by social trails. In 1996, Hospital Bar and Little Pine each had 20 or more separate satellite sites; by 2009, the number of satellite sites on each had decreased to 14. The median number of satellite sites per campsite decreased between 1996 and 2009 and most campsites experienced a reduction in number of satellite sites (table 4). Most campsites also experienced a decrease in area of satellite sites. Only the decrease in number of satellite sites was statistically significant, however. Compared to the main camp, more of the groundcover on satellite sites was vegetation and litter and less was sand and bare soil. This probably reflects less severe camping disturbance on the satellite sites. None of the groundcover categories changed significantly between 1996 and 2009 (table 4). This mirrors what happened on control sites, where groundcover categories did not change significantly over the period (table 5).

Table 4—Changes on satellite sites associated with each main camp, Middle Fork, 1996-2009.

	Number	Area (m^2)	Sand (%)	Rock (%)	Bare (%)	Vegetation (%)	Litter (%)
Mean							
1996	8.2	203	23	5	23	28	20
2002/4	7.7	144	36	5	20	13	26
2009	5.1	152	16	10	21	13	20
Median							
1996	5	126	17	3	19	22	18
2002/4	6	66	32	4	9	8	15
2009	4	41	0	4	20	11	23
Number of sites							
Decreased	8	7	3	3	3	5	4
Increased	2	4	3	4	4	4	5
Unchanged	1	0	5	4	4	2	2
Significancea	0.05	0.25	0.67	0.66	0.26	0.42	0.48

[a] Difference between 1996 and 2009, Wilcoxon matched-pairs, signed-ranks tests (α = 0.05).

Table 5—Changes on control sites, Middle Fork, 1996-2009.

	Sand (%)	Rock (%)	Bare (%)	Vegetation (%)	Litter (%)
Mean					
1996	0	6	4	56	33
2002	0	5	9	43	43
2004	0	5	10	42	43
2009	0	5	14	49	33
Median					
1996	0	6	3	58	34
2002	0	6	2	41	50
2004	0	5	2	44	45
2009	0	5	6	50	27
Number of sites					
Decreased	0	3	0	4	1
Increased	0	0	3	1	3
Unchanged	6	3	3	1	2
Significance[a]	1.00	0.35	0.06	0.35	0.75

[a] Difference between 1996 and 2009, Wilcoxon matched-pairs, signed-ranks tests (α = 0.05).

Considering both main camp and satellite sites together, conditions were remarkably stable. Median campsite area declined from 671 m^2 in 1996 to 538 m^2 in 2002/2004 (table 6), but differences were not statistically significant. More campsites decreased in area than increased. For the entire campsite, both main camp and satellite sites, none of the changes in groundcover categories were statistically significant (table 6). The decline in vegetation that occurred on campsites was smaller than the decline that occurred on control sites. The most sizeable change was an increase in rock. It is not clear whether this reflects a natural change or is a result of recreation use.

Further insight into main camp conditions and change over time can be gleaned from figures 2 and 3. Figure 2 shows boxplots for camp and satellite area in 1996, 2004, and 2009. The boxes show the distribution of sites from the 25th to the 75th percentiles, with the median site portrayed as a line within the box. Fifty percent of the campsites had areas within the range defined by the box; 50 percent had areas larger than the median;

Table 6—Changes on the entire campsite, main camp and satellite sites, Middle Fork, 1996-2009.

	Area (m^2)	Sand (%)	Rock (%)	Bare (%)	Vegetation (%)	Litter (%)
Mean						
1996	1085	28	11	32	16	14
2002/4	693	37	6	31	12	13
2009	971	28	16	31	12	13
Median						
1996	671	17	12	33	15	14
2002/4	598	31	4	34	14	14
2009	538	15	14	41	14	15
Number of sites						
Decreased	7	3	2	4	4	5
Increased	3	5	5	4	2	6
Unchanged	1	3	4	3	5	0
Significance[a]	0.21	0.95	0.59	0.16	0.29	0.33

[a] Difference between 1996 and 2009, Wilcoxon matched-pairs, signed-ranks tests (α = 0.05).

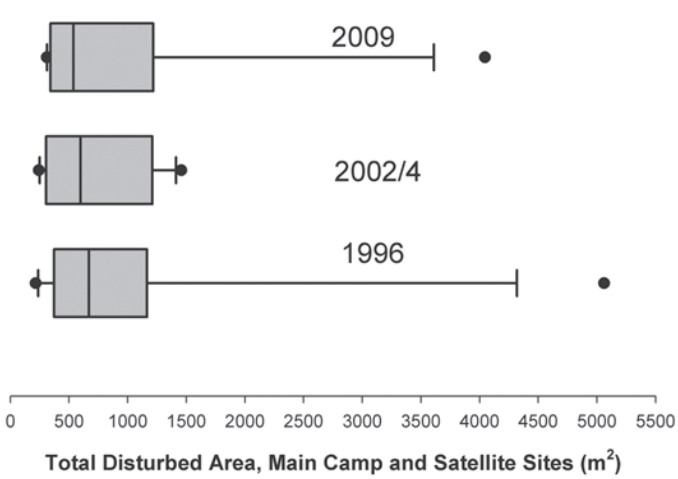

Figure 2—Change in total area of the camp, main camp and satellite sites, Middle Fork, 1996-2009. Boxes portray the 25th, 50th and 75th percentile campsites. The "whiskers" portray the 10th to 90th percentiles and the dots show the maximum and minimum.

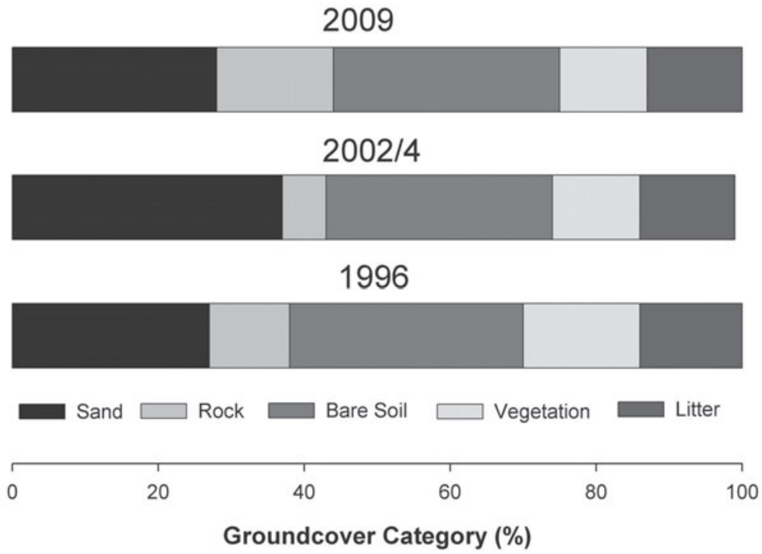

Figure 3—Change in groundcover of the total site, main camp and satellite sites, Middle Fork, 1996-2009.

and 50 percent had areas smaller than the median. The "whiskers," the vertical lines at the end of the horizontal line, portray the 10^{th} to 90^{th} percentile campsites. Dots show the maximum and minimum area. Figure 3 shows the mean proportion of each groundcover class (sand, rock, bare soil, vegetation, and litter) on the camp and satellites in 1996, 2004, and 2009.

We assessed various attributes of the "cleanliness" of these campsites—the number of firerings, the number of ash piles, the number of built structures or firewood piles, the number of instances of improper human waste disposal and the volume of garbage. All of these attributes were highly changeable, being largely eliminated each time the river rangers patrol the river. All of these attributes were found in low quantities and did not differ significantly between the two observation times (table 7).

Table 7—Changes in cleanliness of the campsites, Middle Fork, 1996-2009.

	Firerings (#)	Ashpiles (#)	Structures/ piles (#)	Human waste (#)	Garbage (l)
Mean					
1996	0	0.5	0.7	0.2	0.01
2002/4	0.1	0.1	0.8	0.2	0.07
2009	0	0.1	0.5	0.1	0.09
Median					
1996	0	0	0	0	0.01
2002/4	0	0	1	0	0.01
2009	0	0	0	0	0.01
Number of sites					
Decreased	0	1	3	2	0
Increased	0	1	1	1	3
Unchanged	11	9	7	8	8
Significance[a]	1.00	0.65	0.26	0.56	0.08

[a] Difference between 1996 and 2009, Wilcoxon matched-pairs, signed-ranks tests ($\alpha = 0.05$).

We also assessed the magnitude of camper-inflicted damage to each tree on the main camp. The "slightly damaged" category also includes trees that were not damaged at all; this category decreased significantly (table 8). Tree damage was minimal compared to the damage that typically occurs on wilderness campsites away from the river. Changes resulted more from wildfire and management response than from recreational use.

All of these camps had social trails connecting the main camp to tent pads, toilet sites, the river, and so on. Several of the campsites had more than 20 social trails. The number of social trails decreased between 1995 and 2009, as did the total length of trails, but neither decrease was statistically significant (table 9; fig. 4). The proportion of the trail system given a class 1 rating (the lowest level of impact) decreased between 1996 and 2009, while the proportion given a class 3 rating (deeply incised) increased (table 9; fig. 5). Neither change was statistically significant, however. Moreover, such a change likely reflects recovery of class 1 trails that are no longer used (a result of the decrease in number of trails).

Table 8—Changes in tree damage on the campsites, Middle Fork, 1996-2009.

	Slightly damaged (#)	Moderately damaged (#)	Severely damaged (#)	Stumps (#)	Damaged trees (%)
Mean					
1996	9.1	0.9	0.1	1.1	9
2002/4	6.1	0	0.1	0.2	14
2009	4.3	0.9	0.4	1.4	26
Median					
1996	5	0	0	0	3
2002/4	1	0	0	0	0
2009	1	0	0	0	0
Number of sites					
Decreased	5	3	0	0	1
Increased	0	3	2	2	5
Unchanged	6	5	9	9	5
Significance[a]	**0.04**	1.00	0.18	0.18	0.12

[a] Difference between 1996 and 2009, Wilcoxon matched-pairs, signed-ranks tests (α = 0.05).

Table 9—Changes on social trails associated with campsites, Middle Fork, 1996-2009.

	Number	Length (m)	Class 1 (%)	Class 2 (%)	Class 3 (%)
Mean					
1996	17.2	317	47	42	10
2002/4	14.3	279	24	59	17
2009	11.8	261	42	42	15
Median					
1996	22	257	45	44	8
2002/4	12	298	20	64	14
2009	8	136	43	46	18
Number of sites					
Decreased	6	5	7	6	2
Increased	3	5	3	5	5
Unchanged	2	1	1	0	4
Significance[a]	0.08	0.48	0.72	0.29	0.37

[a] Difference between 1996 and 2009, Wilcoxon matched-pairs, signed-ranks tests (α = 0.05)

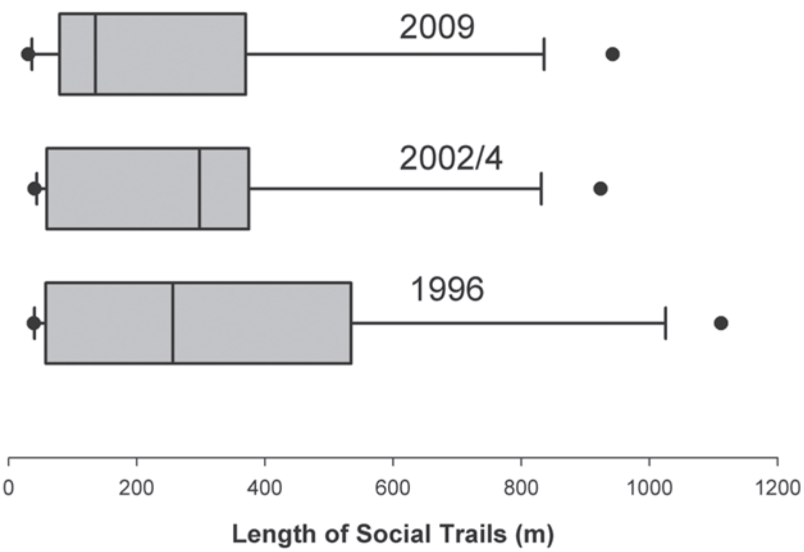

Figure 4—Change in the total length of social trails per campsite, Middle Fork, 1996-2009. Boxes portray the 25th, 50th and 75th percentile campsites. The "whiskers" portray the 10th to 90th percentiles and the dots show the maximum and minimum.

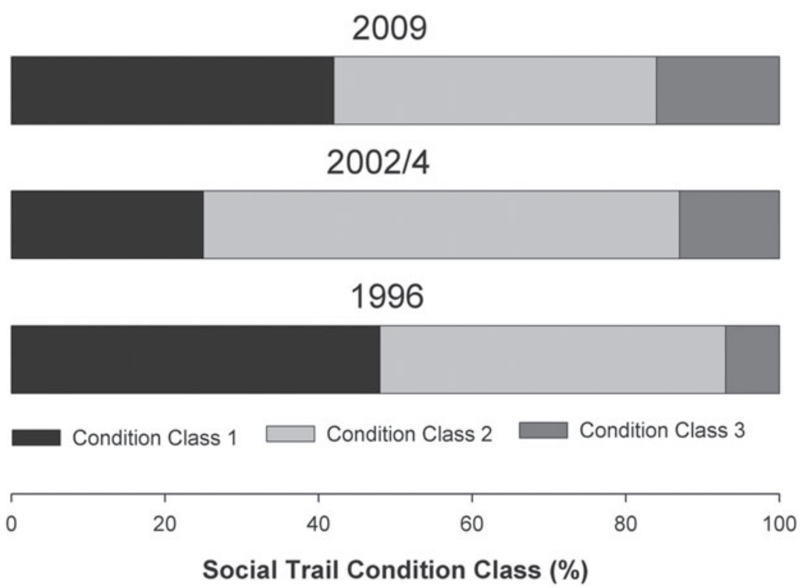

Figure 5—Change in the condition class of social trails, Middle Fork, 1996-2009.

Main Salmon Campsite Conditions

Like the Middle Fork campsites, the most notable characteristic of these campsites was their large size and their web of social trails and satellite sites. On the mean campsite, the main site was 1,182 m^2 in 1996 and satellite sites added another 110 m^2. There were over 112 m of social trails. Main Salmon campsites are typically even larger than Middle Fork sites, although they have fewer satellite sites and social trails. Although vegetation cover is sparse on these campsites, vegetation was probably sparse on these sites prior to recreation use. The typical site is mostly sand and rock below the high water line. Such substrates are highly durable. They can be frequently used without substantial impact.

Changes Between 1996 and 2008—The size of campsites was relatively stable over the 12-year period. Both the mean and median size of the main camp declined slightly; a few more campsites decreased in size than increased (table 10). The campsites that experienced the largest increases in main camp size were Lower Devil's Teeth, California Creek, and Johnson Creek. Increases reflected sand deposition after high water years more than recreation use. Most of the groundcover on most main camps was sand and rock, in 1996, 2002 and 2008 (table 10). Between 1996 and 2009, none of the groundcover categories changed significantly.

All but one of these campsites had satellite sites in 1996. Although the median number of satellite sites per campsite was unchanged between 1996 and 2008, seven campsites experienced a reduction in number of satellite sites (table 11; fig. 6). This decrease in number of satellite sites was statistically significant. Satellite area also decreased,

Table 10—Changes on the main camp, Main Salmon, 1996-2008.

	Area (m^2)	Sand (%)	Rock (%)	Bare (%)	Vegetation (%)	Litter (%)
Mean						
1996	1182	49	21	9	14	7
2001/2	1154	53	21	12	5	8
2008	1160	64	10	9	7	10
Median						
1996	905	53	15	3	5	3
2001/2	837	59	16	3	3	3
2008	715	80	14	0	3	3
Number of sites						
Decreased	7	3	7	7	5	2
Increased	5	7	1	2	1	5
Unchanged	1	3	5	4	7	6
Significance[a]	0.42	0.43	0.06	0.20	**0.03**	0.97

[a] Difference between 1996 and 2008, Wilcoxon matched-pairs, signed-ranks tests ($\alpha = 0.05$).

Table 11—Changes on satellite sites associated with each main camp, Main Salmon, 1996-2008.

	Number	Area (m^2)	Sand (%)	Rock (%)	Bare (%)	Vegetation (%)	Litter (%)
Mean							
1996	4.8	110	25	5	21	31	18
2001/2	4.0	73	31	6	19	12	33
2008	3.7	74	24	7	15	15	22
Median							
1996	3	41	19	3	5	27	13
2001/2	3	32	35	3	8	10	24
2008	3	36	4	3	10	14	14
Number of sites							
Decreased	7	7	3	5	6	9	3
Increased	3	6	5	5	5	3	5
Unchanged	3	0	5	3	2	1	5
Significance[a]	**0.04**	0.15	0.89	0.21	0.43	0.06	0.81

[a] Difference between 1996 and 2008, Wilcoxon matched-pairs, signed-ranks tests ($\alpha = 0.05$).

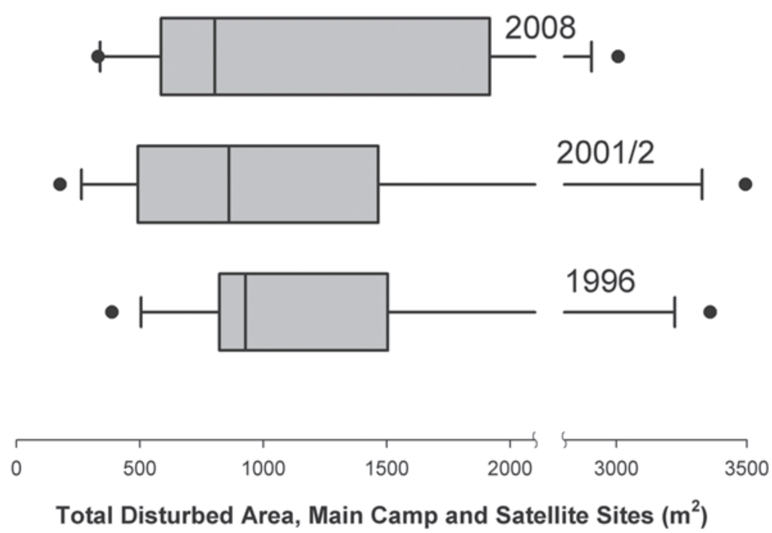

Figure 6—Change in total area of the camp, main camp and satellite sites, Main Salmon, 1996 to 2008. Boxes portray the 25th, 50th and 75th percentile campsites. The "whiskers" portray the 10th to 90th percentiles and the dots show the maximum and minimum.

although not significantly (table 11). The satellite sites are more likely than the main camp to be located above high water. Consequently, less of the groundcover is sand and rock. Vegetation cover on satellite sites declined between 1996 and 2008 (table 11), but the decline in vegetation cover was not much greater than occurred on undisturbed control sites (table 12). This suggests that more of this change was a result of climatic fluctuation (extended drought) than recreational use.

Considering both main camp and satellite sites together, conditions were quite stable (table 13; fig. 6). Median campsite area declined from 929 m^2 in 1996 to 804 m^2 in 2008 (table 13), but differences were not statistically significant. For the entire campsite, both main camp and satellite sites, sand increased over the 12-year period, while rock and vegetation cover decreased (table 13; fig. 7). Again, these changes likely reflect deposition of sand after high water years. Moreover, the magnitude of these changes was similar to some of the changes that occurred on undisturbed control sites (table 12).

Table 12—Changes on control sites, Main Salmon, 1996-2008.

	Sand (%)	Rock (%)	Bare (%)	Vegetation (%)	Litter (%)
Mean					
1996	13	7	10	43	29
2001/2	24	6	4	31	36
2008	36	10	1	34	20
Median					
1996	5	6	2	42	31
2001/2	27	6	<1	27	38
2008	36	9	0	31	14
Number of sites					
Decreased	0	1	2	3	2
Increased	3	3	0	1	2
Unchanged	1	0	2	0	0
Significance[a]	0.11	0.27	0.11	0.14	0.47

[a] Difference between 1996 and 2008, Wilcoxon matched-pairs, signed-ranks tests (α = 0.05).

Table 13—Changes on the entire campsite, main camp and satellite sites, Main Salmon, 1996-2008.

	Area (m^2)	Sand (%)	Rock (%)	Bare (%)	Vegetation (%)	Litter (%)
Mean						
1996	1292	49	20	9	13	8
2001/2	1178	55	22	10	6	7
2008	1201	66	10	8	6	10
Median						
1996	929	51	15	3	13	4
2001/2	861	56	23	3	3	4
2008	804	75	14	3	4	4
Number of sites						
Decreased	11	1	7	6	7	1
Increased	2	9	1	3	0	6
Unchanged	0	3	5	4	6	6
Significance[a]	0.06	0.22	**0.03**	0.10	**0.02**	0.65

[a] Difference between 1996 and 2008, Wilcoxon matched-pairs, signed-ranks tests (α = 0.05).

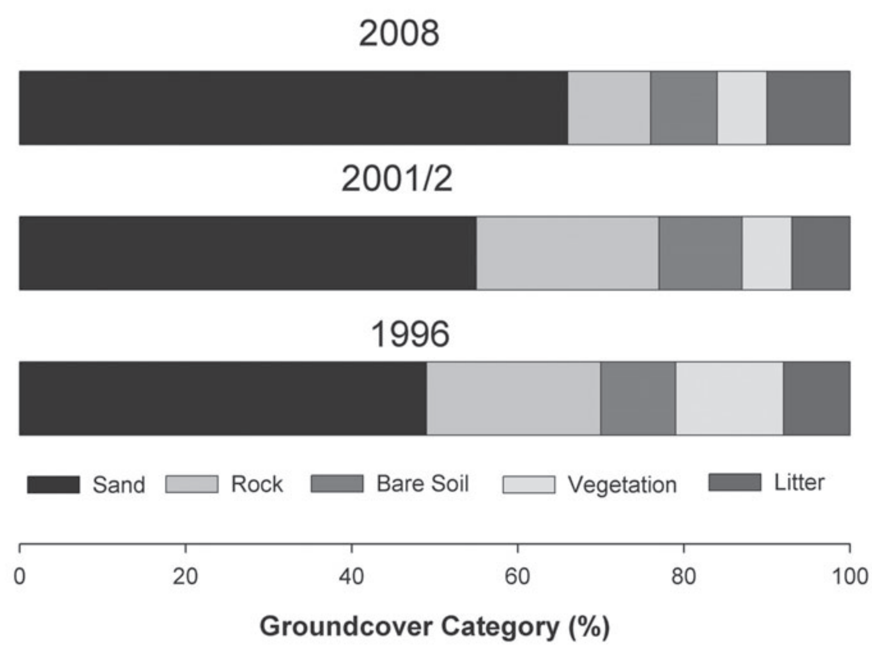

Figure 7—Change in groundcover of the total site, main camp and satellite sites, Main Salmon, 1996 to 2008.

The attributes of "cleanliness" that we assessed were highly changeable, being largely eliminated each time the river rangers patrol the river. All of these attributes were found in low quantities and did not differ significantly between the two observation times (table 14). Tree damage was also minimal compared to the damage that typically occurs on wilderness campsites away from the river and did not change significantly between 1996 and 2008 (table 15).

Table 14—Changes in cleanliness of the campsites, Main Salmon, 1996-2008.

	Firerings (#)	Ashpiles (#)	Structures/ piles (#)	Human waste (#)	Garbage (l)
Mean					
1996	0.2	0.6	0.3	0.2	0.5
2001/2	0.1	0.1	0.8	-03	0.3
2008	0.2	0.2	0.6	0.2	0.2
Median					
1996	0	0	0	0	0.3
2001/2	0	0	1	0	0
2008	0	0	0	0	0
Number of sites					
Decreased	1	5	3	2	6
Increased	1	2	5	2	2
Unchanged	11	6	5	9	5
Significance[a]	1.00	0.16	0.35	1.00	0.10

[a] Difference between 1996 and 2008, Wilcoxon matched-pairs, signed-ranks tests (α = 0.05).

Table 15—Changes in tree damage on the campsites, Main Salmon, 1996-2008.

	Slightly damaged (#)	Moderately damaged (#)	Severely damaged (#)	Stumps (#)	Damaged trees (%)
Mean					
1996	3.0	0.5	0.2	0.3	23
2001/2	3.2	0.2	0.2	0.2	22
2008	2.5	0.7	0.2	0.3	32
Median					
1996	1	0	0	0	15
2001/2	2	0	0	0	13
2008	2	0	0	0	25
Number of sites					
Decreased	6	0	1	2	2
Increased	2	2	1	2	3
Unchanged	5	11	11	9	8
Significance[a]	0.40	0.16	1.00	1.00	0.21

[a] Difference between 1996 and 2008, Wilcoxon matched-pairs, signed-ranks tests (α = 0.05).

All but one of these camps, with the exception of Johnson Creek, had social trails in 1996. Although the number and length of social trails did not change significantly between 1996 and 2008 (table 16), the number and length of social trails did increase on a number of sites (fig. 8). The most consistent increase in impact, between 1996 and 2008, was deterioration in the condition of the social trails. The proportion of the trail system given a class 1 rating (the lowest level of impact) decreased significantly (table 16; fig. 9). The proportion of both class 2 and class 3 trails increased, although only the increases in class 2 trails was statistically significant.

Table 16—Changes on social trails associated with campsites, Main Salmon, 1996-2008.

	Number	**Length (m)**	**Class 1 (%)**	**Class 2 (%)**	**Class 3 (%)**
Mean					
1996	5.9	112	47	46	7
2001/2	6.1	121	25	65	11
2008	6.2	136	17	71	11
Median					
1996	4	89	46	51	0
2001/2	3	71	21	64	2
2008	4	97	7	66	0
Number of sites					
Decreased	5	6	12	2	1
Increased	6	7	0	10	4
Unchanged	2	0	1	1	8
Significance[a]	0.72	0.46	**0.04**	**0.02**	0.08

[a] Difference between 1996 and 2008, Wilcoxon matched-pairs, signed-ranks tests ($\alpha = 0.05$).

Figure 8—Change in total length of social trails, Main Salmon, 1996-2008. Boxes portray the 25th, 50th and 75th percentile campsites. The "whiskers" portray the 10th to 90th percentiles and the dots show the maximum and minimum.

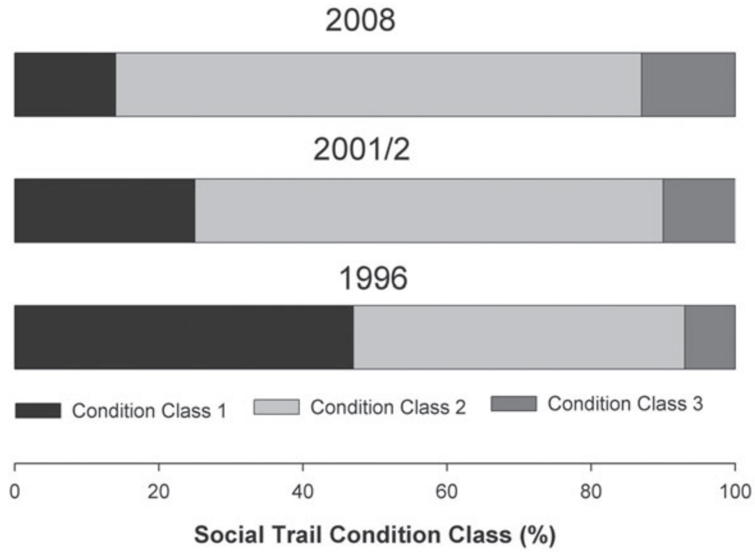

Figure 9—Change in the condition class of social trails, Main Salmon, 1996-2008.

Change in Relation to Initial Conditions

For seven parameters (main camp area, satellite area, total area, percent vegetation on the total area, number of satellites, number of trails, and trail length), we explored whether the magnitude of change over time varied with the magnitude of impact on the site in 1996. Magnitude of change was not significantly correlated with initial impact for any of these parameters (kendall's tau). Comparing the 11 sites that were initially most impacted with the 11 sites that were least impacted, there also were no significant differences in amount of change (Mann-Whitney U test). In contrast to what was found in the Eagle Cap study, the variability of change (indicated by the magnitude of the standard deviation) was not consistently related to initial conditions.

Conclusions and Implications

Results for the period of 1996 to 2008/2009 were largely similar to those for the period of 1996 to 2002/2004. Most campsites were relatively stable over this 13-year period. Indeed, differences between 1996 and 2008/2009 were generally less than differences between 1996 and 2002/2004 or between 2002/2004 and 2008/2009. There was some evidence from both river segments that total area of disturbance might be decreasing slightly, primarily a result of a reduction in the use and number of satellite sites dispersed away from the main camp area. On the Middle Fork, there was also some evidence of a decrease in social trailing, a trend not evident on the Main Salmon. Although generally stable and perhaps improving slightly, these campsites remain highly disturbed.

As noted after the 2002/2004 assessment, these results illustrate four points about recreation impacts and management along popular rivers like the Middle Fork and Main Salmon Rivers. First, use levels—and therefore impact potential—are extremely high. Use and impact would be even higher if management had not restricted use. Without proper management and visitor behavior, popular campsites can degrade severely. Even with proper management, certain types of impact will inevitably be severe.

Second, campsite conditions are strongly affected by the type of use these rivers receive. In particular, the large size of many groups results in extremely large campsites.

Large groups cannot be accommodated in a small centralized campsite. They spread out over a large central site and—more problematically—disperse to satellite tent sites above the high water line, creating a web of trails. Moreover, sites above high water have vegetation and soil that is more seriously impacted by trampling. Impact here is longer lasting because higher terraces are not "rejuvenated" by frequent floods. Impacts above high water and the proliferation of satellite sites and trails is more problematic on the Middle Fork than on the Main Salmon. Education and regulations should promote concentrating use on the main camp area and below high water to the extent possible.

Third, on high volume rivers, extensive beach deposits below high water create highly durable camping surfaces. This favorable attribute compensates substantially for the high impact potential of heavy use by large groups. River managers might consider limiting group size such that tent sites are unnecessary above the high water mark.

Finally, Leave No Trace education and behavioral restriction (firepan and porta-potty requirements) are readily accepted by river floaters. Their implementation has succeeded in nearly eliminating the impacts that are most responsive to behavioral characteristics. Campfire remains and improperly disposed waste have largely disappeared along rivers. Such efforts should be continued. Frequent river patrols are also highly effective in removing evidence of the infrequent aberrant behavior that does occur (littering, campfires).

Campsite Impact and Management: Lessons From Trend Studies

In the 1960s, the first systematic studies of wilderness campsites were begun (such as Frissell and Duncan 1965). The motivation for such studies was concern that wilderness use was increasing and that increasing use would mean that problems with wilderness campsite impacts would intensify in the future. Given the lack of information on campsite impacts, trends in impact, and the factors that influence magnitude of impact, managers and scientists were uncertain how best to manage campsites. Some attempted to disperse use across a large number of campsites to reduce the amount of use any individual site endured. Conversely, others attempted to concentrate use, in the most extreme cases by only allowing camping on designated sites that had to be reserved for each night of a trip. Some proposed temporary campsite closures, a rest-rotation system that would allow site recovery before reopening campsites. Some of the most unsightly impacts occurred in meadows, causing some to disallow camping in “fragile” meadows. Others, concerned about the concentration of impacts close to water, prohibited camping within some distance of water, most often 200 feet.

By the 1970s, baseline studies were initiated that, when replicated, provided an ability to assess trends in campsite conditions and determined whether impacts had increased over time. Most of the longest-term trend studies are presented in this report. These studies have been conducted at two different scales. Several studies have focused on impact at the scale of the individual campsite, asking the question “how have individual campsites changed over time?” Other studies have assessed impacts at the scale of the entire wilderness or a portion of it, asking the question “how has the aggregate impact of camping changed over time?”

Prior Research

The lessons gained from the trend studies in this compilation are best considered in the light of other campsite impact research conducted since the 1960s. Over this period, much has been learned about both the factors that influence the magnitude of campsite impact and how individual campsites develop and change over time. The factors that most influence campsite impact are (1) amount of use, (2) the type and behavior of campers, (3) environmental attributes of the sites that are camped on, and (4) the distribution of use both within and between campsites (Cole 1987). For example, campers who refrain from having campfires and/or who practice Leave No Trace will typically cause less impact than those who do not. Assuming no difference in behavior, camping groups that are large and groups that travel with pack stock will cause more impact than small groups and hiking groups. In one of many studies regarding the effects of environmental attributes, Cole and Monz (2003) found that the central portion of forested sites camped on 4 nights per year for 3 years lost 95 percent of their vegetation cover; nearby meadow sites, receiving the same amount of camping, only lost 20% of their cover.

The influential factors most relevant to interpreting the results of trend studies are the amount and distribution of use. Since the pioneering work of Frissell and Duncan (1965), numerous studies have found that many of the most obvious campsite impacts, particularly vegetation loss, occur at very low levels of use. Although the magnitude of impact increases as amount of use increases, it does so at a diminishing rate. That is, there is an asymptotic relationship between amount of use and amount of impact (Cole 1987). For example, in the meadow campsites studied by Cole and Monz (2003), an increase in use frequency from 1 night per year to 4 nights per year resulted in only a two-fold increase in vegetation loss. Since near-maximum levels of impact often occur on moderately used sites, there often is very little difference in impact between moderately and heavily used sites. Not all environmental attributes are profoundly affected at low use levels. Although not well-studied, many soil chemical and biological properties are likely to remain unchanged until use levels are substantial. For such parameters, the use-impact relationship approximates a logistic curve[1].

The asymptotic relationship between amount of use and the magnitude of impact on regularly used individual campsites explains why the distribution of camping among individual sites has such a profound effect on campsite impact at larger spatial scales. When use is concentrated on a small number of sites that are heavily used, rather than a larger number of moderately used sites, the total number of impacted sites is reduced with little change in the magnitude of impact to individual sites. This insight is the foundation for campsite management strategies such as confining camping to designated sites. In the Shenandoah Wilderness, the total area of camping disturbance was reduced by about 50% within 2 years of shifting from at-large camping (where people are allowed to camp wherever they want) to restricting camping to a limited number of established campsites (Reid and Marion 2004). Concentrating use within sites—making it difficult for the site to expand—is also an effective means of limiting impact (Cole 1992; Marion and Farrell 2002; Marion and Sober 1987). Given these findings, we would expect trends in campsite impact to differ with variation in the amount and distribution of use.

Valuable insights regarding the interpretation of trends in campsite impact have also been gleaned from studies of newly created campsites and campsites that have been closed to use. Several studies show that, once a site is opened for camping, impacts develop quickly. Near-maximum levels of impact typically occur within the first couple of years of use and remain relatively constant thereafter (Cole and Monz 2003; Merriam and Smith 1974; Marion and Cole 1996). Most long-established sites that receive consistent use change little over time (Cole and Hall 1992). Once campsites are closed to camping, recovery rates are highly variable, depending on environmental conditions and how impacted the site was. For example, low elevation campsites on resilient floodplains in the eastern United States have been found to recover substantially within a few years (Cole and Ferguson 2009; Marion and Cole 1996; Reid and Marion 2004). In the western mountains, moist high-elevation sites have been found to recover somewhat over a few years (Spildie and others 2000), while drier high-elevation sites may require centuries to recover (Cole and Spildie 2007; Moritsch and Muir 1993). Despite this variability, recovery rates are always slower than deterioration rates. This typical campsite "life history" is portrayed in figure 1.

Trends on Individual Campsites

The studies that assessed trends on individual campsites are those conducted in the Eagle Cap (OR), Grand Canyon (AZ), Frank Church-River of No Return (ID) and Caney Creek (AR). In an earlier report on some of these same studies, Cole and Hall (1992) stated that:

> "There is no simple answer to the question, how are wilderness campsites changing over time? As these case studies show, certain campsites are getting

[1] It is likely that a logistic curve best describes the general relationship between use and impact. Whether a study reports a linear or a curvilinear relationship probably depends on the impact parameter being examined and the range of use included in the study. If the range of use examined is not sufficient to include one of the points where the tangent to the curve equals 1.0, then the relationship will appear more linear than exponential or asymptotic. Moreover, for attributes that are affected greatly by low levels of use, such as vegetation cover, it is difficult to study use levels low enough to characterize the initial exponential portion of the curve.

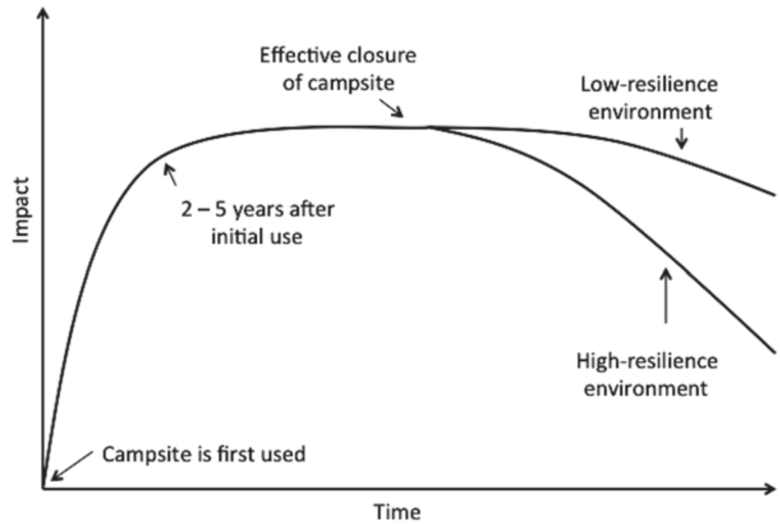

Figure 1—The “life history” of a typical campsite.

better, while others are getting worse, and many are relatively stable. Moreover, on a single campsite, certain types of impact may be getting worse, while other types are improving.”

Adding another 20 years to the time series, this conclusion remains true. Nevertheless, despite considerable variation among individual sites, the mean change on the sample of campsites in most of these case studies was negligible. Only at Caney Creek, with its highly resilient environment and shift in use distribution away from some of the sample campsites, was change pronounced. At Caney Creek, mean conditions improved. At Eagle Cap, some important parameters deteriorated, for example, campsite area increased significantly; however, other parameters, such as tree damage, improved.

In some of these case studies, more frequently used campsites were somewhat more highly impacted than less frequently used campsites. However, the magnitude of change over time typically did not vary substantially with use frequency. High-use sites did not deteriorate more than low-use sites over time, as was feared 50 years ago when campsite impact research began. Similarly, impact varied with site attributes such as vegetation type, as was most carefully studied at Grand Canyon, but the magnitude of change over time typically did not vary substantially.

In the Eagle Cap study, analysis of results after 5 years suggested that lightly impacted campsites were more likely to deteriorate over time than heavily impacted sites (Cole 1986). After 10 years, however, this conclusion was only partially supported (Cole and Hall 1992). With the benefit of a longer time series, the most prominent conclusion regarding initial conditions is that the magnitude and direction of change on more lightly impacted sites was more variable than on more heavily impacted campsites. Some lightly impacted sites deteriorated noticeably, while others improved substantially; heavily impacted sites were less likely to either deteriorate or improve substantially. This makes sense in light of past research on both the relationship between amount of use and amount of impact and the “life history” of campsites. Lightly impacted campsites may be new sites or sites that have never been heavily used. Continued or increasing use of such sites is likely to result in substantial deterioration. Conversely, lightly impacted sites that are no longer used retain the potential to recover rapidly. Sites that are heavily impacted are generally long-established sites with near-maximum levels of impact. If efforts are made to ensure that they do not continuously expand, they are not likely to deteriorate much with continued or even increasing use. Moreover, they are not likely to recover rapidly when use is curtailed, except in highly resilient environments such as Caney Creek.

Larger Scale Trends in Campsite Impact

The studies that assessed trend at larger scales are those conducted in the Lee Metcalf (MT), Selway-Bitterroot (MT), Sequoia-Kings Canyon (CA), Eagle Cap (OR), Grand Canyon (AZ), and Caney Creek (AR) Wildernesses. As was the case with the studies of trend on individual campsites, trends vary among these case studies, with differences in use history, management regime, length of time series, environment and other factors. Nevertheless it is possible to compare results from each study to look for commonalities and possible explanations for differences. This is facilitated by the application of a simple relatively consistent method that involved conducting a census on all sites and assigning each site an impact rating. This makes it possible to calculate, for each case study, a campsite density, a mean campsite impact rating and an estimate of aggregate impact based on campsite density weighted by impact rating.

There are two important limitations to these comparisons, however. First, the impact ratings that were used in the Sequoia-Kings Canyon and Grand Canyon studies differed from the modified Frissell condition classes used in the other areas. The Grand Canyon ratings appear comparable to the modified Frissell ratings, but the Sequoia-Kings Canyon ratings, particularly those assigned in 2006-2007, are clearly lower (less impact) than Frissell ratings. In addition, no impact ratings were assigned to campsites during the 1975 evaluation at the Eagle Cap. For comparison purposes, I assumed that the distribution of impact ratings for Eagle Cap sites in 1975 was similar to that in 1972 of sites in the Lee Metcalf, which is similar in terms of environment, use, and management.

The second limitation concerns the size and character of the study area. For Caney Creek and Sequoia-Kings Canyon, the entire wilderness was studied, although the repeat measures in Sequoia-Kings Canyon were confined to a representative 50 percent sample of the wilderness. In the other studies, only popular portions of each wilderness were studied. Therefore, estimates of campsite density and impact are higher than they would be if the entire wilderness had been studied. In the figures that follow, data are first presented without taking this disparity into account (figs. 2-4). These figures accurately portray within-wilderness trends but comparisons across wildernesses can be misleading.

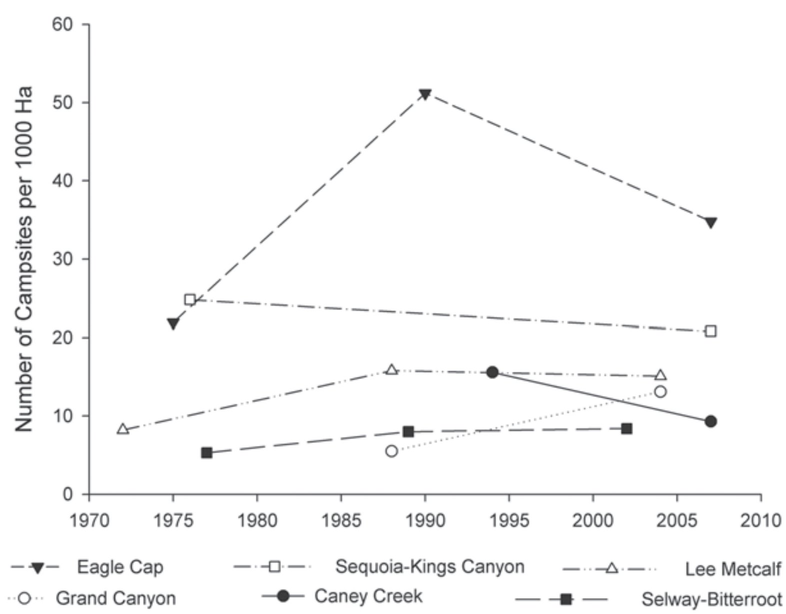

Figure 2—Campsite density (#/1000 ha) in the Eagle Cap, Sequoia-Kings Canyon, Lee Metcalf, Grand Canyon, Caney Creek, and Selway-Bitterroot.

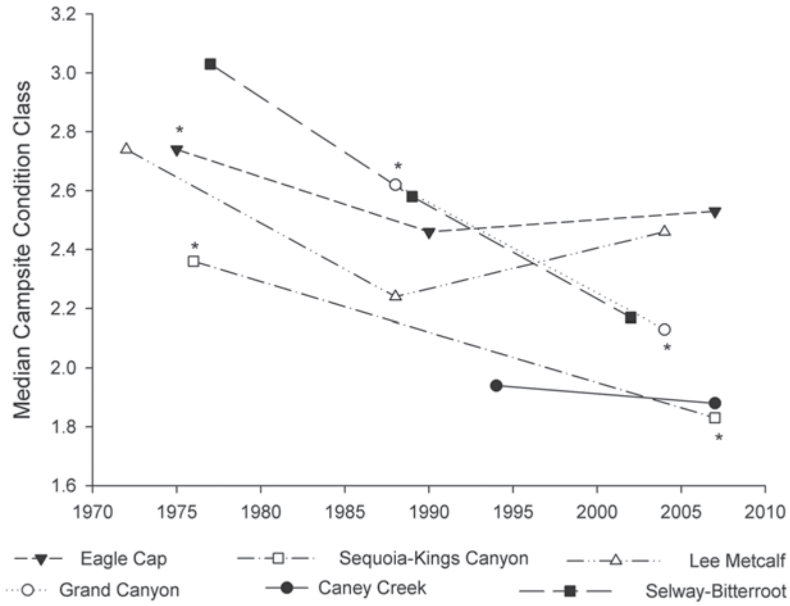

Figure 3—Median campsite condition class in the Eagle Cap, Sequoia-Kings Canyon, Lee Metcalf, Grand Canyon, Caney Creek, and Selway-Bitterroot. * indicates use of a condition class rating that differs slightly from a modified Frissell rating.

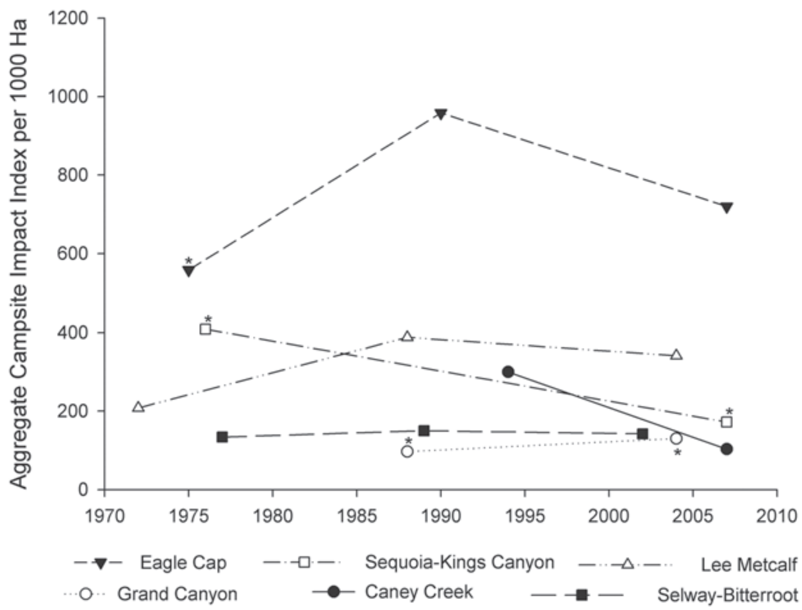

Figure 4—Aggregate campsite impact (weighted index/1000 ha) in the Eagle Cap, Sequoia-Kings Canyon, Lee Metcalf, Grand Canyon, Caney Creek, and Selway-Bitterroot.

This is followed by figures (figs. 5-6) in which data are conservatively adjusted in an attempt to account for limitations to the representativeness of the sample. To the degree that adjustments are reasonable, these figures allow for comparison among wildernesses.

In the Selway-Bitterroot case, the drainages studied are probably not that different from somewhat less popular drainages, so no adjustments were made. However, in the Eagle Cap, the 10 percent of the wilderness that was surveyed includes most of the areas popular with backpackers; much of the remaining 90 percent of the wilderness is less heavily used and less impacted. Hall and Shelby (1994) estimated that 36 percent of the campsites in the wilderness are in the study area (the Lakes Basin and the trails that access it). This estimate was used to adjust campsite densities to apply to the entire wilderness; I did not adjust mean condition class ratings, assuming the distribution of ratings in the study area was the same as in the entire wilderness. In the Grand Canyon, the 13 percent of the backcountry that was surveyed accounts for the majority of backcountry use away from the Colorado River. To account for this, I assumed that there were twice as many campsites in the entire Grand Canyon backcountry and did not adjust mean condition class ratings. Similarly, I assumed that the 27 percent of the Lee Metcalf that contained the surveyed lakes had one-half of the campsites in the entire wilderness and adjusted densities to reflect this.

In figure 2, which shows campsite densities without adjustment for study area representativeness, recent campsite densities (after 2000) are generally higher than they were in the 1970s. Sequoia-Kings Canyon, which had the highest campsite density in the 1970s, is the one exception. At Sequoia-Kings Canyon, the era of campsite proliferation preceded the 1970s. The most pronounced increases in density in most places occurred between the 1970s and the 1980s-1990s. Campsite proliferation was particularly pronounced in the Eagle Cap Wilderness, where campsite dispersal was encouraged during the late 1970s and early 1980s (Cole 1982). Since, the late 1980s and early 1990s, campsite density declined in the Eagle Cap and Caney Creek and was constant in the Lee Metcalf and Selway-Bitterroot. Only at Grand Canyon, which had the lowest initial campsite density, has campsite density increased recently.

Figure 3, which shows median condition class, indicates that individual campsites, on average, were less impacted after 2000 than they were in the 1970s. This does not mean that the sites that existed in the 1970s were less impacted, however. Median impact can decline simply by creating additional lightly impacted campsites. Indeed, given the increase in campsite densities that occurred in the 1980s and 1990s, this is probably what happened. At Caney Creek and Sequoia-Kings Canyon, however, median condition class decreased along with campsite density, suggesting a real decline in campsite impact. Median condition class declined in all study areas into the 1990s. Since then, condition class declined in the Grand Canyon, Caney Creek, and Selway-Bitterroot and increased slightly in the Eagle Cap and Lee Metcalf.

Since aggregate campsite impact reflects both the number of campsites and how intensely each site is impacted, figure 4 provides an aggregate campsite impact index, not adjusted for study area representativeness. This index was calculated by first multiplying the number of campsites in each condition class by a weighting factor reflective of impact magnitude. Class 1 sites were assigned a weight of 1, class 2 a weight of 6, class 3 a weight of 30 and class 4 a weight of 75. In other words, class 4 sites were assumed to be 2.5 times as impacted as a class 3 site, 12.5 times as impacted as a class 2 site, and the equivalent of 75 class 1 sites. These weights, taken from Stohlgren and Parsons (1992), seem as reasonable as any. These products (number of sites by weight for each condition class) were summed and then divided by the number of hectares in the study area.

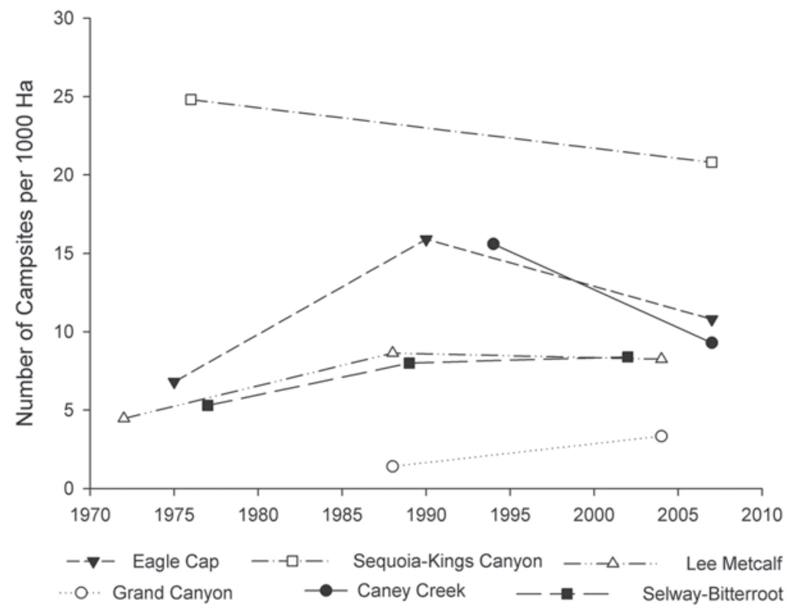

Figure 5—Adjusted campsite density (#/1000 ha) in the Eagle Cap, Sequoia-Kings Canyon, Lee Metcalf, Grand Canyon, Caney Creek, and Selway-Bitterroot (see text for adjustments).

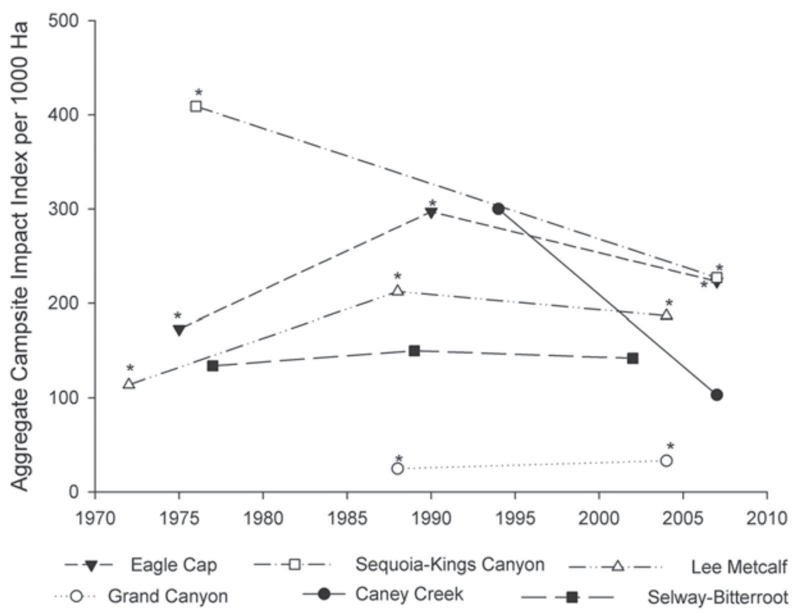

Figure 6—Adjusted aggregate campsite impact (weighted index/1000 ha) in the Eagle Cap, Sequoia-Kings Canyon, Lee Metcalf, Grand Canyon, Caney Creek, and Selway-Bitterroot (see text for adjustments). * Indicates use of a condition class rating that differs slightly from a modified Frissell rating.

The temporal patterns in figure 4 are more similar to those in figure 2 than figure 3. This indicates that the number of campsites has changed more than the magnitude of impact on individual campsites. We can conclude from this that, at least in the past, change in the number of campsites has been the primary determinant of trends in campsite impact. Limiting the number of campsites should be a primary concern of management. With the exception of Sequoia-Kings Canyon, aggregate impact is greater after 2000 than it was in the 1970s. The greatest increases in impact occurred in the 1970s and 1980s in the Eagle Cap and Lee Metcalf. These are the wildernesses with numerous potential campsites and the least intensive recreation management programs. The Selway-Bitterroot also lacks an intensive management program, but the scarcity of good places to camp inhibited campsite proliferation. The 1990s and 2000s have been a period of improving conditions, except in the Selway-Bitterroot, where little change occurred, and in Grand Canyon, which has seen some deterioration.

Figures 2 and 4 make it appear that campsite impacts are much more problematic in the Eagle Cap and Lee Metcalf than elsewhere. However, as noted above, this may reflect the focus of those studies on the most popular locations in those wildernesses. Figures 5 and 6, subject to the accurateness of the assumptions made in adjusting data, compensate for limitations to the representativeness of the samples.

Variation in campsite density has decreased over time (fig. 5). Campsite density has decreased substantially at Sequoia-Kings Canyon, the wilderness with the highest initial campsite density, while it has increased at Grand Canyon, the wilderness with the lowest initial density. Campsite density appears to be a function of amount of use, the number of desirable places to camp, policies that promote the concentration of use on particular sites, and the resilience of the environment. Campsite density remains highest at Sequoia-Kings Canyon, which has very high use, numerous good places to camp, and no regulations that limit camping to particular sites. Density is lowest at Grand Canyon, which also has high use but where desirable campsites are limited by the availability of water and the roughness of the terrain and where policies confine camping to designated sites in popular places. The wildernesses with intermediate densities have less use than Sequoia-Kings Canyon and, in some cases, either fewer desirable places to camp (Selway-Bitterroot) or management programs that promote concentration of use and resilient environments (Caney Creek).

Variation in aggregate campsite impact has also decreased over time (fig. 6). Again, impact has decreased most at Sequoia-Kings Canyon, the wilderness with the highest initial aggregate impact. Despite increasing impact and high use along trail corridors, aggregate campsite impact remains much lower at Grand Canyon than elsewhere. This illustrates the importance of the number of desirable places to camp in determining aggregate campsite impact. It suggests the potential effectiveness of a designated campsite policy or other efforts to concentrate use, such as encouraging the use of well-established campsites. Such policies artificially constrain the number of acceptable places to camp. The relative impact of the Eagle Cap, Lee Metcalf, and Selway-Bitterroot parallels their relative use intensity, with impact in the Selway-Bitterroot being further limited by available places to camp. Finally, the low level of impact at Caney Creek and the fact that impact at Sequoia-Kings Canyon is not much higher, given its very high use, reflects the more aggressive management programs in those places. Sequoia-Kings Canyon has as many as ten wilderness rangers located in the wilderness all summer long, obliterating new and unnecessary campsites, as well as cleaning and maintaining long-established campsites. At Caney Creek, a highly resilient environment contributed to the success of a program of trail relocation, education, permanent closure of selected campsites, and assisted site restoration.

Discussion and Management Implications

To the degree that these case studies are representative of the National Wilderness Preservation System, the trend of ever-increasing campsite impact that paralleled the rise of wilderness recreation use has ended. In all cases but the Grand Canyon, where impact levels remain abnormally low but are increasing, aggregate campsite impact has plateaued or is decreasing. Fifty years or more ago, most wildernesses had a relatively small number of campsites, many of which were seriously impacted, characterized by numerous mutilated trees, large garbage dumps, elaborate facilities, and developments (large and multiple fireplaces, stoves, tables, chairs, and so on). Conditions on these sites have improved over time. However, in the 1970s and 1980s in many wildernesses, this improvement was more than offset by increases in the number of campsites. Site proliferation resulted from people spreading out across the landscape to get away from heavily used places, to explore new places, to travel off-trail, and even in response to policies that promoted dispersal.

Today, all these trends have subsided. Overnight use is not increasing much in most wildernesses. Visitors are increasingly attracted to popular, often iconic trails and places (short hikes, long-distance trails, the tallest peaks). Off-trail travel is declining. Moreover, Leave No Trace educational messages and most management policies promote concentration rather than dispersal of use. This is reflected in declining aggregate campsite impact in all our case studies other than the Grand Canyon (fig. 6).

These findings simply validate the management implications that have frequently been articulated in earlier studies of factors that determine campsite impact intensity (Cole and Fichtler 1983), short-term trends on campsites (Cole and Hall 1992; Cole 1993) and campsite management experiments (Marion 1995; Reid and Marion 2004). Aggregate campsite impact is more reflective of the number of campsites than the magnitude of impact on individual campsites (Cole 1993); on individual campsites, campsite expansion can be particularly problematic (Marion 1995; Marion and Farrell 2002). Consequently, a key strategy for minimizing campsite impact in regularly visited places is to concentrate camping use both among and within campsites.

Actions That Have Improved Conditions

To some degree, concentration of use can be accomplished through visitor education by asking people to choose campsites that are already well-impacted and to concentrate their activities on portions of the site that are already well-worn, which is one of the primary principles of Leave No Trace (Brame and Cole 2011). The success of such a strategy can be furthered if there is regular maintenance by field rangers, who obliterate newly established sites and work to keep established sites clean, functional, and as small as is appropriate (Marion and Sober 1987). Impacts can be further reduced through regulation, by only allowing camping on designated sites and by locating designated sites in durable places where the potential for campsite expansion is limited. For example, Marion and Farrell (2002) discuss how locating sites on side hills rather than flat areas limits the potential for expansion. However, the Grand Canyon case study, where impact increased even in places with designated campsites, shows that designated campsites are not without problems. One key to success is to ensure that there is an adequate number of campsites to accommodate use, allowing for some non-compliance and some inability to find available sites. Occupancy rates for designated sites need to be lower in places, such as the Boundary Waters Canoe Area Wilderness, that limit the number of trailhead entrants but then allow free movement within the wilderness than in places like the threshold zones at Grand Canyon where a particular camping area must be reserved for each night of one's trip. Limiting use, in conjunction with a concentration strategy, will also serve to limit campsite impact.

Some of the improvement in campsite conditions can be attributed to positive changes in visitor behavior, again in line with behaviors promoted by Leave No Trace. Fewer visitors have campfires or, if they do have fires, they are smaller and used for shorter periods of time. Damage to trees resulting from such activities as vandalism, firewood cutting, and tying horses to trees has declined. There are fewer developments and there is less trash. Trends in visitor use characteristics also have contributed to improvements in conditions. For example, use by large groups and groups traveling with pack stock has declined in many wildernesses.

Actions That Were Generally Unsuccessful

A number of management actions taken in some places to improve campsite conditions have been generally unsuccessful and in many cases have exacerbated impact problems. Foremost among these was the policy of encouraging dispersal of use. Although generally applied through education rather than regulation and most common in the Forest Service, in the 1970s and 1980s Shenandoah National Park required visitors to disperse. The result was a profound proliferation of campsites (Reid and Marion 2004), similar to the proliferation of sites reported in the Eagle Cap Wilderness case study, again largely a result of policies that encouraged dispersal. Use dispersal can be effective in remote places where people can be encouraged to camp lightly on durable sites without evidence of prior use rather than on well-worn or developing campsites. However, such a recommendation only applies to those few visitors who go to remote places and have the ability and commitment to stringent Leave No Trace practices. For most visitors and the places most people visit, concentration of use and regular ranger patrol and campsite maintenance or obliteration are the key practices.

Campsite proliferation has been exacerbated by management programs in which certain campsites are closed to use, without much thought being given to where people will camp instead or to the effective rehabilitation of closed sites. The widespread adoption of regulations making it illegal to camp within 200 feet of water, is the most prominent example. Where enforced, this often resulted in a new set of campsites being developed further from lakeshores (for example Cole 1982). Meanwhile, impacts on the original lakeshore campsites seldom improved because people continued to picnic on the sites or even camp on them, if ranger patrol and enforcement was inadequate. Such action can be extremely costly, and only with effective closure and assisted site restoration can this action be successful (Cole and Spildie 2007). Many wildernesses have relaxed this regulation, in some cases simply asking visitors to camp away from lakeshores where possible and closing just the sites closest to lakeshores. Less-coordinated efforts include casually closing sites by simply placing a sign saying the campsite is closed, which can simply shift use to another site. One attempt to temporarily close campsites to allow them to recover (a rest-rotation strategy), resulted in a 50 percent increase in the number of campsites and campsite impact in just a few years (Cole and Ranz 1983). Again, when campers were confronted with not being allowed to camp where they wanted to, they simply created new campsites that offered many of the same attributes.

Conclusions

Fifty years ago, wilderness use was increasing rapidly and severely impacted campsites were commonplace. Researchers and managers feared a future of ever-increasing impact and began campsite impact studies, some of which have been replicated so that trends in impact can be identified. Most of these studies suggest that aggregate campsite impact increased for much of the latter twentieth century, but more from the proliferation of campsites than the deterioration of long-established sites. Indeed, many of the most severely impacted long-established campsites have improved, at least in terms of having fewer developments, less trash and less tree damage. However, by the first decade of the twenty-first century, this trend of ever-increasing impact has reversed. In most wildernesses in this compilation, campsite impacts have plateaued or declined recently. In the most extreme cases, campsite improvement reflects (1) successful implementation of a use concentration or containment strategy and (2) an active wilderness ranger program involving obliteration of unnecessary or poorly located campsites and maintenance and cleaning of established campsites.

Further Research

As always, the future is uncertain. Therefore, continued replication of these studies to identify future trends would be desirable. To facilitate that, the data from all these studies have been archived by Forest Service research, both though the Aldo Leopold Wilderness Research Institute (http://leopold.wilderness.net/) and Forest Service Research (http://www.fs.usda.gov/rds/archive/). Also in the archives are data from unreplicated studies conducted in the following wildernesses: Bob Marshall, MT (1981), Upper Buffalo, AR (1994), Hercules Glades, MO (1994), Garden of the Gods, IL (1994), San Rafael, CA (1999), Superstition, AZ (2005), and Miller Peak, AZ (2008). Future researchers should be able to access these data, allowing them to extend these trend studies.

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