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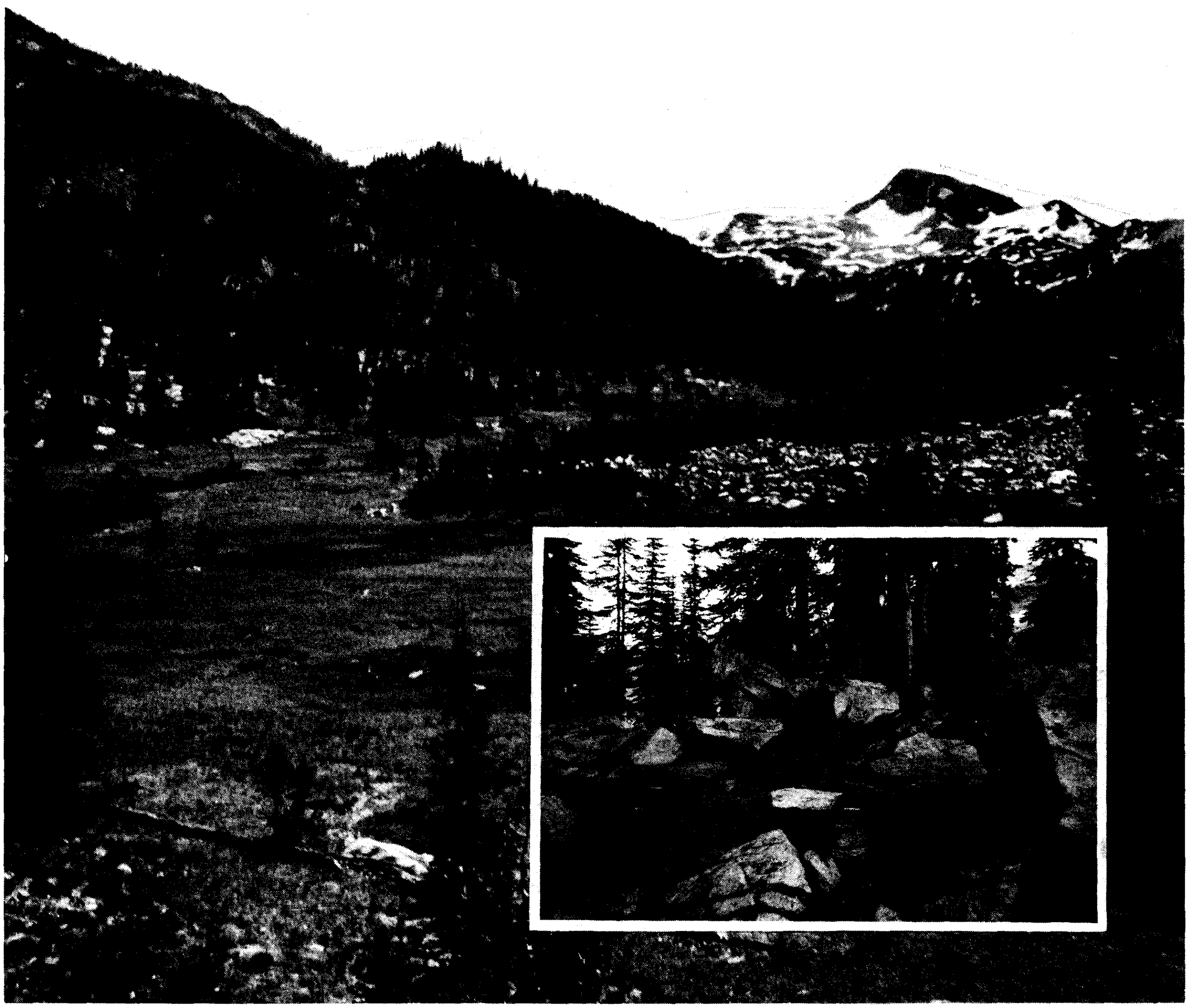
Wilderness Campsite Impacts:

Effect of Amount of Use

David N. Cole



THE AUTHOR

Dr. DAVID N. COLE is a research ecologist with the Intermountain Station's Wilderness Management research work unit at the Forestry Sciences Laboratory on the University of Montana campus, Missoula. He is on temporary loan to the Forest Service from the Geography Department, University of Oregon, Eugene. Dr. Cole received his B.A. degree in geography from the University of California, Berkeley, in 1972. He received his Ph.D., also in geography, from the University of Oregon in 1977. He has written several papers on the impacts of recreational use on wilderness soils and vegetation.

RESEARCH SUMMARY

Campsites that were located near subalpine lakes in the Eagle Cap Wilderness, Oreg., were studied. Research objectives were to determine what ecological changes had occurred on the sites, the extent to which amounts of change increased with increasing use, whether lakeshore sites had been more highly altered than sites set back from lakeshores at least 200 ft (61 m), and the sensitivity of selected indicators of ecological change.

Significant changes on campsites, as compared to adjacent control plots included various types of damage to mature trees; loss of seedlings; loss of undergrowth vegetation; change in the species composition of this undergrowth; an increase in bare mineral soil; decrease in duff depth; a reduction in infiltration rates; an increase in pH and the concentrations of magnesium, calcium, and sodium ions; an increase in soil organic matter; and an increase in soil bulk density. No difference in the concentrations of potassium, phosphate, nitrate, and total nitrogen or in soil texture could be established.

Of the 20 documented types of change, seven were more pronounced on more heavily used sites. Of these seven, loss of seedlings and loss of undergrowth vegetation were almost as pronounced on light-use sites as on moderate- or heavy-use sites, despite the statistical significance of the relationship. The change in species composition of the undergrowth, percent bare mineral soil, percent of trees with exposed roots, and size of the barren campsite core were significantly less on light-use sites than the moderate- or heavy-use sites which had experienced similar amounts of change. Heavy-use sites differ from moderate-use sites primarily in the depth of the duff. This implies that most of the change which is likely to occur on these campsites can result from use of the site just a few times-per-year.

Campsites set back from lakeshores had experienced as much change as lakeshore sites. This implies that lakeshore sites are not inherently more fragile. Where a lakeshore setback policy exists, other justifications for this policy should be given.

The campsite condition class rating developed by S. S. Frissell proved to be the most sensitive indicator of impact tested. Problems with this rating system, along with suggested modifications, are discussed.

CONTENTS

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INTRODUCTION

Along with recent increases in recreational use of wilderness has come an awareness that this use has already modified pristine ecosystems intended for preservation. In many areas, the most severe impacts occur on campsites where use is highly concentrated, both spatially and temporally. Managers are understandably concerned about the highly altered conditions of many campsites, as it is their responsibility, according to the Wilderness Act of 1964, to manage wilderness areas so that "natural conditions" are preserved and "the imprint of man's work (remains) substantially unnoticeable."

It is commonly assumed that campsite impacts are the result of excessive use and that predicted future increases in use will cause increasingly severe degradation. A common response to this situation is an attempt to disperse users from areas of concentrated use to less frequently visited parts of the wilderness. Currently, 53 percent of all designated wilderness units in the Forest Service and Park Service attempt to disperse use.[1] While dispersal may decrease campsite use and visitor encounter frequencies in areas of heavy use, it can also increase the number of areas where one can expect to encounter other parties, and the number of areas which show the effects of recreational use. This reduces the proportion of the wilderness that offers opportunities for solitude and shows no substantial evidence of human impact.

In order to evaluate the appropriateness of use dispersal in various wilderness situations, or to develop any other information-based wilderness campsite management policy, we need a better understanding of the changes occurring on campsites and the extent to which differences in amounts of use affect campsite condition. A study was designed to provide information of this kind for campsites in Eagle Cap Wilderness in northeastern Oregon. Permanent sampling plots were established on campsites so that long-term changes could be evaluated. This report describes results of the first year of study, an assessment of changes which have already occurred, and how these changes are related to the amount of use the site receives.

The study also compares the amount of change which has occurred on lakeshore campsites and campsites located more than 200 ft (61 m) from a lake. There is a common assumption that lakeshores are more fragile than sites set back from lakes. Currently, 34 percent of all designated wilderness units in the Forest Service and Park Service have regulations prohibiting camping within a certain distance of lakes. This is a sizable percentage, as only slightly more than half of the areas in the wilderness system contain bodies of water larger than 1 acre (McCurdy 1977). In the case of Eagle Cap Wilderness, a 200-ft (61-m) setback has been established.

The final objective was to test the sensitivity of indicators of impact that could be used to monitor overall site condition. Managers have increasingly recognized the value of monitoring systems for providing baseline information to help them evaluate their management programs and to identify areas where additional management actions need to be taken. Recently, monitoring has been mandated by Congress in the National Forest Mangement Act. In this study, we examined the ability of several individual measures to predict overall site conditions and amount of change.

PREVIOUS STUDIES

Most detailed studies of campsite impact have been conducted on developed campsites which are accessible by car and which receive much heavier use than most wilderness campsites. Backcountry campsites have been studied in northern Minnesota (Frissell and Duncan 1965; Merriam and others 1973), the mountains of the eastern United States (Rechlin 1973; Bratton and others 1978), Washington (Thornburgh 1962; Schreiner and Moorhead 1976), Idaho (Coombs 1976), and Montana (Fichtler 1980). Of these studies, only Coombs (1976) and Fichtler (1980) provide detailed data for a low-use area typical of most of the wilderness in the United States.

Most studies of backcountry campsites have documented a loss of vegetation cover and an increase in bare ground. Changes in species composition have been described in considerable detail (Thornburgh 1962;

[1]Data from a census of wilderness managers are on file at the Forestry Sciences Laboratory, Missoula, Mont.

Coombs 1976; Cole 1977), as have mechanical damage to mature trees (Merriam and others 1973, Rechlin 1973, Fichtler 1980) and the almost complete elimination of tree seedlings (Frissell and Duncan 1965, Coombs 1976, Cole 1977, Fichtler 1980). Other noted changes include an increase in soil compaction (Thornburgh 1962, Merriam and others 1973, Cole 1977, Fichtler 1980), a reduction in infiltration rates (Frissell and Duncan 1965), a loss of organic surface horizons (Frissell and Duncan 1965), and erosion resulting in the exposure of tree roots (Merriam and others 1973, Cole 1977, Fichtler 1980.)

In studies on developed campsites, an increase in pH also has been a consistent finding (Young and Gilmore 1976; Dawson and others 1978; Rutherford and Scott 1979). Changes in soil nutrient concentrations have been less consistent. Young and Gilmore (1976) found increases in calcium (Ca), potassium (K), phosphorus (P), sodium (Na), and nitrogen (N), and no change in magnesium (Mg) concentrations on campsites in Illinois. Working in southern Ontario, Rutherford and Scott (1979) found decreases in nitrate (NO_3), increases in chloride (Cl), and no change in phosphate (PO_4), Mg, K, and sulfate (SO_4) concentrations on campsites. Conflicting results have also been found where soil organic matter has been studied. Dotzenko and others (1967), Settergren and Cole (1970), Dawson and others (1978), and Rutherford and Scott (1979) found decreases on campsites, while Young and Gilmore (1976) and Monti and Mackintosh (1979) found increases.

In one of the few studies to relate amount of use to backcountry campsite condition, Frissell and Duncan (1965) found that more heavily used campsites in the Boundary Waters Canoe Area had less ground-cover vegetation and more tree root exposure than lightly used sites. They found no relationship, however, between amount of use and either vegetation loss (a measure based on a campsite-control comparison) or bare ground.

Fichtler (1980) compared impacts on lightly and heavily used sites in Montana. He found no statistically significant differences in amount of change in the understory, overstory, or soil compaction. The only significant difference was in the amount of bare soil exposed.

Merriam and others (1973), working in the Boundary Waters Canoe Area, found a poor relationship between amount of use and a summary measure of campsite impact. When sites were stratified by vegetation type, a more consistent relationship appeared; in each vegetation type, impact increased with use. The functional relationship was hyperbolic rather than linear, however, with the rate of increase in impact decreasing as use increased.

Similar conclusions about the nature of the relationship between use and impact are evident in the data presented by Rechlin (1973) for backcountry campsites in the Adirondacks and by Dotzenko and others (1967), LaPage (1967), Young and Gilmore (1976), Legg and Schneider (1977), Young (1978), and James and others (1979) for developed campsites. Although overall impact generally increases as use increases, changes in many variables, such as infiltration rates (James and others 1979), soil organic matter (Dotzenko and others 1967; Young and Gilmore 1976), and soil pH (Young and Gilmore 1976) are not significantly correlated with amount of use. For those variables in which amount of impact does increase with use, near-maximum levels of impact are usually achieved even with light use, and further increases in use do little to aggravate the severity of these impacts (fig. 1).

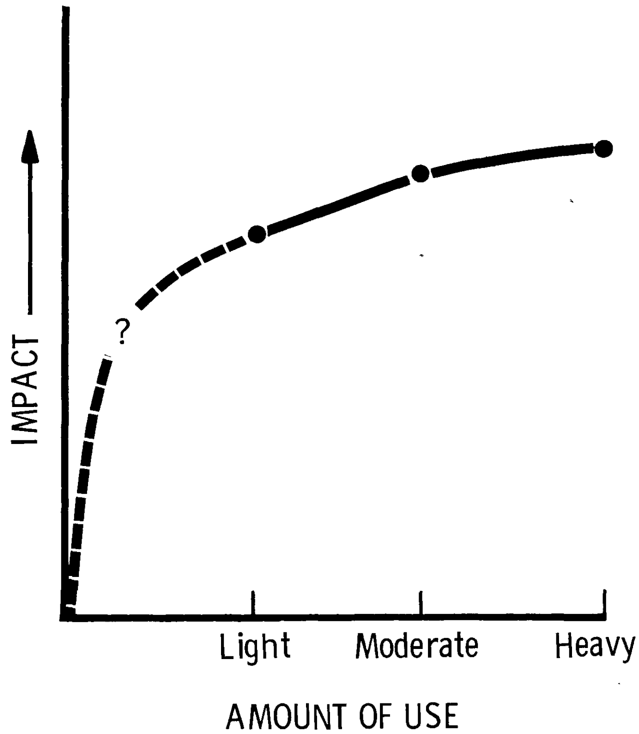

Figure 1.--Typical research results for the relationship between campsite impact variables and amount of use. The response of variables as use increases from no use to light use is poorly understood.

In support of this conclusion, some of the most pronounced differences between sites which receive different amounts of use were found in the lightly used Idaho Primitive Area (Coombs 1976). In comparison to light-use sites, heavy-use sites had considerably less vegetation cover and considerably more erosion pavement.

This study in Eagle Cap Wilderness differentiates between impact on lightly, moderately, and heavily used sites which would all have been considered lightly used sites in all of the studies other than those of Coombs (1976) and Fichtler (1980). This focuses attention on that part of the use spectrum which is most poorly understood (where use differences have the most pronounced influence on amount of impact) and which is most applicable to the wilderness situation.

STUDY AREA

The Eagle Cap Wilderness was selected for study because it contained numerous examples of campsites which receive light, moderate, and heavy use, in locations where at least ordinal estimates of use could be obtained.

Furthermore, in terms of both use and environment, the area seemed to be representative of many heavily glaciated, mountainous wilderness areas in the National Forest System.

The Eagle Cap Wilderness encompasses 293,735 acres (118 870 ha) of the Wallowa Mountains in northeastern Oregon (fig. 2). Jagged ridges tower more than 3,280 ft (1 000 m) above deep glacial valleys which radiate from the granitic central core of the range. Several peaks approach 10,000 ft (3 000 m) in elevation, while the lowest elevations in the area are under 3,600 ft (1 100 m).

Over 13,000 visitors entered the Wilderness in 1978 and accounted for about 83,000 visitor-days of use. The distribution of use was highly concentrated, with most visitors attracted to the more than 50 lakes scattered through the subalpine zone (fig. 3). One area of about 2,500 acres (1 000 ha), the Lake Basin, contains 10 major lakes and was visited by one of every three visitors to the Wilderness in 1978. Other lakes are more isolated and reached by less frequently traveled trails. A few lakes are still trailless. Twenty-two of the 26 campsites selected for study were located at subalpine lakes where it was possible to obtain an ordinal estimate of amount of use. The forest overstory at all sites was dominated by *Abies lasiocarpa*[2] (subalpine fir), in conjunction with *Picea engelmannii* (Engelmann spruce), *Pinus contorta* (lodgepole pine), and *Pinus albicaulis* (whitebark pine); the understory was usually dominated by *Vaccinium scoparium* (grouse whortleberry). By confining the sample to campsites near lakes located between 7,050 and 7,800 ft (2 150 and 2 400 m) in an *Abies lasiocarpa/Vaccinium scoparium* forest type on soils derived from granitic bedrock, environmental differences were kept to a minimum. Controlling environment in this manner permits the effects of differences in amount of use to be more precisely delineated. Four additional campsites, two in sedge meadows above 7,800 ft (2 400 m) in elevation and two in forests below 6,500 ft (1 981 m) in elevation, were studied for comparative purposes.

[2] All nomenclature follows Hitchcock and Conquist (1973).

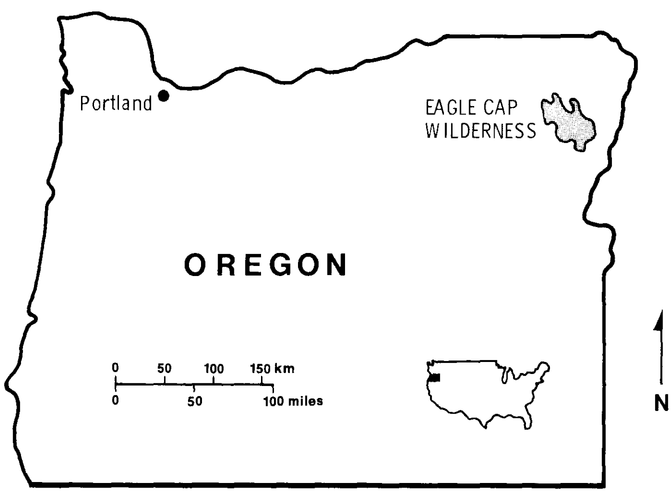

Figure 2.--The Eagle Cap Wilderness is in northeastern Oregon.

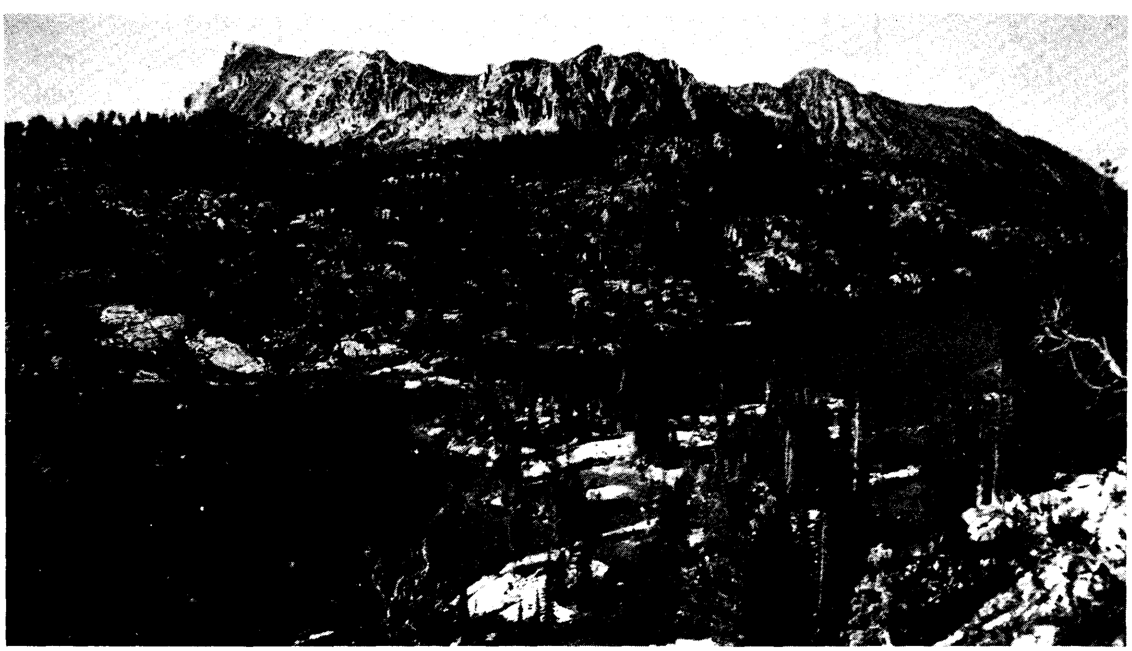

Figure 3.--Subalpine lakes are the primary destination of most visitors to the Eagle Cap Wilderness.

The amount of use each site receives had to be estimated because no campsite-specific use data existed. This was accomplished by assigning each lake to either a heavy-, moderate-, or light-use category on the bases of observations and travel zone use data. The most prominent[3] forested site at each lake, usually located close to where the main trail first reaches the lake, was chosen as the site most representative of the amount of use the lake receives. The study sites consisted of six light-use sites, six moderate-use sites, and 10 heavy-use sites, five within 200 ft (61 m) of a lake and five more than 200 ft (61 m) from a lake (fig. 4-7). Sites within 200 ft (61 m) of a lake have traditionally been the most popular and are still frequently used, despite their having been officially closed to camping for the last few years.

Although all analyses treated these use differences as merely ordinal estimates, an estimate of actual amount of use is valuable for comparative purposes. Observations suggest that most of the light-use sites are used less than five nights per year, with some of them receiving no use during some years. Most moderate-use sites probably are used 10 to 20 nights per year, while most heavy-use sites are used 25 to 50 nights per year.

[3] Prominence was defined primarily in terms of location. We chose the site we subjectively determined to be the site most arriving parties would choose. We avoided automatically choosing the most heavily impacted site on the lake to avoid the common circular argument in which heavily impacted sites are subjectively assigned to the heavy-use category and then heavy-use sites are found to be heavily impacted.

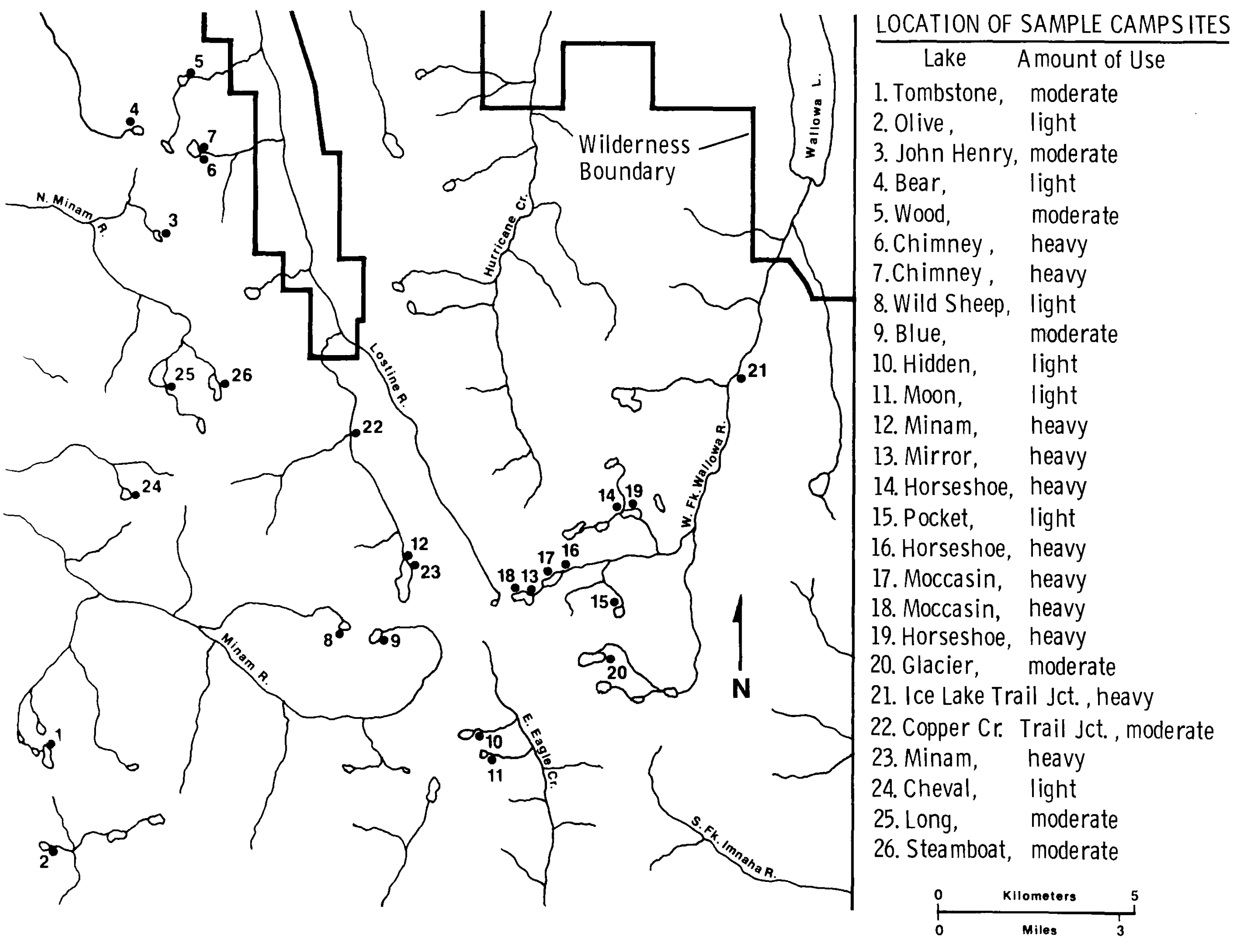

Figure 4.--Location of sample campsites and their level of use.

Figure 5.--Light-use site number 8, located at Wild Sheep Lake.

Figure 6.--Moderate-use site number 1, located at Tombstone Lake.

Figure 7.--Heavy-use site number 7, located at Chimney Lake.

FIELD METHODS

To a great extent, study methods were determined by the need to establish permanent sampling points. This reflected the primary goal of the study--to measure change in campsite conditions on permanently located sites over a 5-year period. The results presented here, relating current conditions to amount of use, were an additional product of the study.

Each sample site consisted of both a campsite and a similar undisturbed site in the vicinity which could serve as a control. In each campsite, 16 linear transects were established, radiating from a central point in 16 cardinal directions. The distances to the edges of the campsite and the first significant amount of vegetation were recorded for each transect (fig. 8). The amount of vegetation was considered significant when cover exceeded 15 percent in a 1.09- by 3.28-ft (0.67-by 1.00-m) quadrat, oriented perpendicular to and bisected by the tape.

Within the camp area (the polygon enclosed by straight lines connecting transect end points), all trees greater than 55 inches (140 cm) tall were recorded. If damaged by recreational use, the type of damage was recorded. Seedlings between 6 and 55 inches (15 and 140 cm) tall were counted within the camp polygons, exclusive of any "islands" of undisturbed vegetation (fig. 8).

Four additional transects were established, originating at each center point. The first transect was randomly oriented, with each subsequent transect oriented perpendicular to the preceding one. Approximately 15 quadrats, 3.28 by 3.28 ft (1 by 1 m) were located along these transects (fig. 9). The exact location of these quadrats was taken from a table prepared prior to field work, and was designed to maximize the probability that all distances from the central point would be sampled with equal intensity (that is, the distance between successive quadrats on a transect decreased with distance from the central point). This assured that (1) the entire disturbance gradient, from central point to the undisturbed periphery, would be equitably sampled; and (2) there was a chance that all parts of the campsite, except the central point, would be sampled.

In each quadrat, the coverage of each of the following variables was estimated: rock, firepit, tree trunk and root, exposed mineral soil, organic litter, and vegetation. The cover of each vascular plant species and that of mosses as a group were also estimated. Coverages were estimated to the nearest percent if under 10 percent and in 10 percent coverage classes where cover exceeded 10 percent. In the latter case, the midpoints of each class were used to estimate mean cover on the campsite.

Soil information was collected at four places on each campsite between 3.28 and 6.56 ft (1 and 2 m) from the central point (fig. 10). In contrast to the ground-cover information, this concentrates the sampling in the most highly disturbed parts of the campsite.

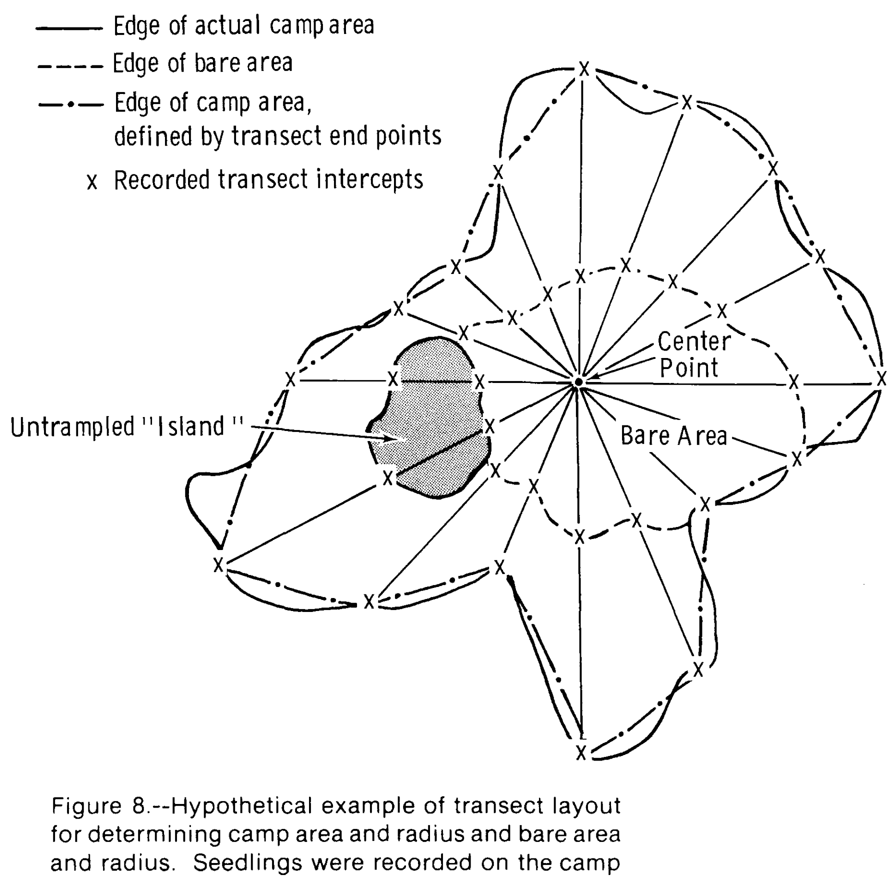

Figure 8.--Hypothetical example of transect layout for determining camp area and radius and bare area and radius. Seedlings were recorded on the camp area defined by transect end points, exclusive of the untrampled "island;" mature trees were recorded on the entire camp area.

Figure 9.--Coverages of rock, firepit, tree trunk and root, exposed mineral soil, organic litter, and vegetation were estimated in approximately 15 quadrats on each campsite.

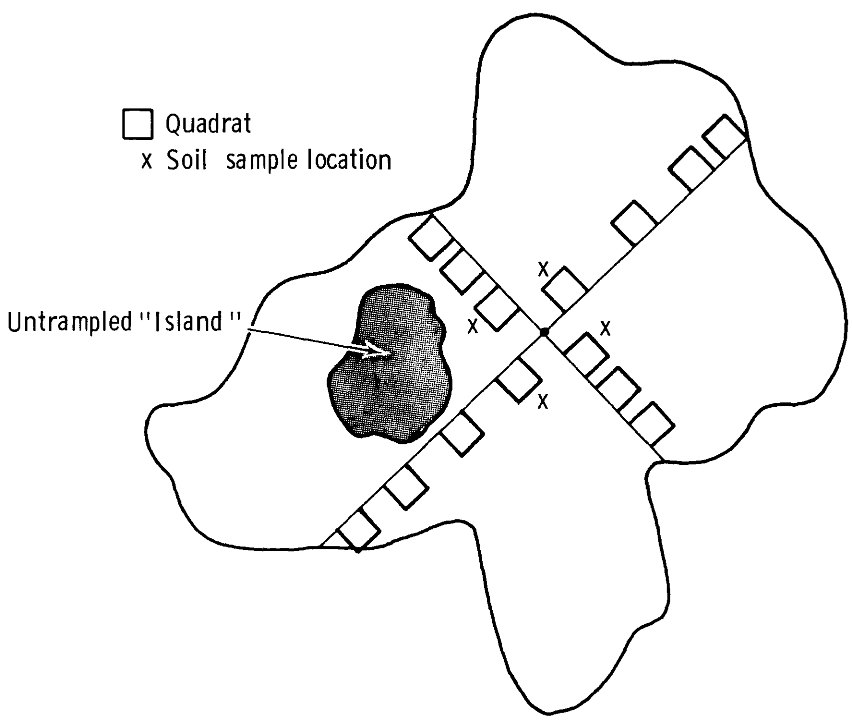

Figure 10.--Quadrat layout and location of soil samples on hypothetical campsite.

At each of the four locations, duff depth, bulk density, pH, and infiltration rates were measured and soil samples collected. Duff depth was a measure of the depth of the organic litter and fermentation (0) horizons. The colorimetric method was used to determine pH in the field. Infiltration rates were measured with a double-ring infiltrometer. The rate at which the first 0.39 inch (1 cm) entered the soil was called the instantaneous infiltration rate, while the rate for the first 2 inches (5 cm) was called the saturated rate. Sample points were not presoaked. Volumes for bulk density calculations were determined by measuring the amount of water required to fill a hand-excavated, cellophane-lined hole, 2 inches (5 cm) deep by about 3.5 inches (9 cm) in diameter. The excavated soil was removed in plastic bags for weight determination (fig. 11). Use of the hand-excavation method made precise volume measurements difficult, but this method was judged to be more accurate than the use of soil corers in these rocky soils. As with pH, bulk density measurements were taken in the uppermost portion of the mineral soil after the organic horizons had been removed.

Finally, each campsite was assigned a condition class rating, a visual estimate of campsite condition developed by Frissell (1978).

Figure 11.--Infiltration rates were measured with a double-ring infiltrometer. Soil samples were collected and the volume of the excavated hole was determined for use in calculating bulk density.

Control plots were located in the vicinity in order to get some measure of undisturbed conditions. The size of controls varied between 980 and 2,164 ft^2 (91 and 201 m^2). Percent coverage was estimated for rock, tree trunk and root, exposed mineral soil, organic litter, vegetation, and plant species for the entire control plot. Seedlings were counted on a 538-ft^2 (50-m^2) circular subplot. Four sets of soil measurements and samples, identical to those taken on campsites, were taken on control plots.

DATA ANALYSIS

Distances to the edges of the campsite and the edges of the bare area were averaged to obtain mean radius of camp and bare area measures. They were also plotted on scaled maps, and a polar planimeter was used to determine the camp and bare area. "Islands" of undisturbed vegetation intercepted by more than one transect were subtracted from the total area.

A single mean value was calculated for duff depth, bulk density, pH, instantaneous infiltration rate, and saturated infiltration rate for each campsite and each control. Infiltration rates were expressed in centimeters-per-minute for both the 1-cm and 5-cm applications. The pH values were converted to H^+ concentrations, averaged, and reconverted to pH values.

Soil samples were analyzed at the Montana Forest and Conservation Experiment Station, Missoula, Mont. Each sample was ovendried and weighed to determine bulk density. Nitrate content was determined before drying, using the Specific Ion Analyzer. The four soil samples from each campsite were then passed through a 2-mm screen and composited. Calcium, potassium, magnesium, and sodium concentrations were determined by extraction in 1N ammonium acetate and analysis with the Atomic Absorption Spectrophotometer. Phosphate was extracted with dilute acid fluoride and its concentration determined by molybdenum blue stannous chloride color reaction; total nitrogen was determined by using the modified micro-Kjeldahl procedure (Hesse 1972). Texture was analyzed by buoyucous hydrometer method and organic matter content was determined by combustion at 525° C.

For statistical analysis, standard parametric tests could not be used because the assumption of a normally distributed population could not be made and the sample size was small. Therefore, nonparametric tests were used and the tabular data presented include medians (probably the best measure of central tendency), as well as means and their 95 percent confidence interval.

The significance of differences between campsites and controls was examined with the Wilcoxon matched-pairs, signed-ranks test (Siegel 1956). Those variables that differed were examined further in order to see if the differences were correlated with difference in amount of use.

The relationship between campsite impact and amount of use can be examined in several ways. Most studies have compared existing conditions on campsites that receive different amounts of use. This approach has the serious drawback of assuming that all sites were originally identical and, therefore, that differences in the existing conditions on lightly and heavily used campsites reflect differences in the amount of change which has occurred, rather than differences in original conditions.

This drawback can be alleviated, to some extent, by establishing campsite-control pairs and comparing the differences between campsites and controls--an estimate of amount of change--on sites which receive different amounts of use. The problem with this approach, which has only been tried by Frissell and Duncan (1965) and Fichtler (1980) is that results will be misleading if control sites are not truly similar to original campsite conditions. Both approaches have opposing strengths and weaknesses. One uses no information about original conditions (control samples), while the other uses so much information that results may be distorted by too much faith in control samples. Both approaches have been taken in this study in order to profit from the unique perspective each provides.

In this second type of analysis, both absolute and relative measures of change are presented. Absolute change is simply the difference between the measure on the control site and the measure on the campsite. For example, if vegetation cover was 10 percent on the control-site and 1 percent on the campsite, the absolute change would be 9 percent. Because absolute change is highly dependent on original conditions (in the example above, 10 percent is the maximum change possible), relative values were also calculated. Relative change is the absolute change expressed as a percentage of the measure on the control site. In the example above, relative change measures show that 90 percent of the vegetation has been lost. Again, both of these change measures are provided to give as complete an interpretation of the data as possible. Negative change values, in both cases, indicate higher values on the campsite.

Change in species composition was measured with the following coefficient of floristic dissimilarity:

$$FD = 0.5\Sigma|p_1 - p_2|$$

where p_1 is the relative cover of a given species on the control plot, and p_2 is the relative cover of the same species on the campsite (Cole 1978). Additional methods of species composition analysis are discussed in the results section.

Finally, a summary impact rating was calculated for each campsite in a manner similar to that employed by Merriam and others (1973). Impact indicators included camp area, relative vegetation loss, absolute increase in bare ground, floristic dissimilarity, relative seedling loss, percent of trees with trunk scars, relative decrease in duff depth, and relative decrease in instantaneous infiltration rate (table 1). For each of these indicators, the range in amount of change was divided into three classes with approximately the same number of campsites in each class. Each campsite was assigned to one of these classes and given an impact value of 1 to 3 (low to high amount of change) for each indicator. The mean of all impact values that apply to each campsite[4] determines the index of impact or impact rating.

[4] When there were no trees on the camp, the trunk scar indicator was not considered; when there were no seedlings on controls, the seedling indicator was not considered.

Table 1.--Values used to calculate the impact rating for each campsite[1]

Impact value	Camp area	Relative vegetation loss	Absolute increase in bare ground	Floristic dissimilarity	Relative seeding loss	Trees with trunk scars	Relative decrease in duff depth	Relative decrease in instantaneous infiltration rate
	Indicators of impact							
	m^2	Percent						
1	<100	< 75	< 10	< 50	< 76	< 15	< 45	< 20
2	100-220	75-95	10-40	50-65	76-95	15-45	45-75	20-70
3	>220	> 95	> 40	> 65	> 95	> 45	> 75	> 70

[1]The impact rating is the mean impact value for all impact indicators used.

All correlations used Kendall's tau as a statistic (Siegel 1956). Kolmogorov-Smirnov tests (Siegel 1956) were used to compare the amount of change which had occurred on heavily used sites located within 200 feet (61 m) of lakeshores to that on heavily used sites more than 200 feet (61 m) from lakeshores.

RESULTS AND DISCUSSION

How Much Change Has Occurred on the Campsites?

Campsite area varied between 387 and 6,060 ft^2 (36 and 563 m^2), with the median site being 2,077 ft^2 (193 m^2) (table 2). The largely barren central core comprised about 45 percent of a "typical" campsite, although this percentage varied between 15 and almost 100 percent.

Essentially all of the trees growing on those sites had been "damaged" by recreationists (fig. 12). Damage to many of these trees was relatively minor--lower branches had been broken or nails had been driven into the trunks. Twenty-seven percent of these trees, however, bore trunk scars from chopping. Of these scars, 22 percent were larger than 1 ft^2 (0.99 m^2) and 67 percent were located below breast height, conditions under which the probability of decay in spruce and true fir is particularly high (Wright and Isaac 1956).

Another 33 percent of the trees on the campsites had been cut down. Observations in the field suggested that, as a damage estimate, this value should have been even higher because more felled trees were found just beyond the campsite periphery than on the campsite itself. Most of these felled trees were less than 2 inches (5 cm) in diameter at breast height, so the loss of saplings available to eventually replace the overstory trees is also more dramatic than these figures suggest.

This frequency of mechanical damage to trees is higher than that reported elsewhere. McCool and others (1969) report that 60 to 65 percent of the sites they studied in the Boundary Waters Canoe Area had damaged trees; in the Eagle Cap essentially all sites with trees had damage. In two Montana backcountry areas, only 68 percent of the trees on all campsites had been damaged (Fichtler 1980).

Despite this damage to the overstory, there was little evidence of recreation-related tree mortality or even loss of vigor except where trees had been felled outright. The fact that more than six decades of recreational use have had little noticeable effect suggests that premature mortality may never by a serious problem. Other studies have also noted a lack of tree mortality despite extensive mechanical damage (for example, James and others 1979) except where the tree species is particularly susceptible to decay (Hinds 1976) or where severe edaphic limitations occur (Settergren and Cole 1970). This has led to the conclusion that mature trees are the growth form least sensitive to recreational impact (Leeson 1979). It is possible, however, that premature windthrow may not be recognized as recreation-caused or that disease may eventually become a problem.

Table 2.--General characteristics of the campsites

Statistic	Camp area (N = 22)	Bare area (N = 22)	Mutilated trees (N = 19)	Trees with exposed roots (N = 19)	Felled trees (N = 19)	Scarred trees (N = 19)	Floristic dissimilarity[1] (N = 22)	Condition class[2] (N = 22)
	m^2		Percent					
Median	193	87	96	32	28	25	59	4.0
Mean[3]	197 ± 57	97 ± 27	91 ± 5	34 ± 12	33 ± 11	27 ± 9	55 ± 8	3.7 ± 0.3

[1]A measure of the percent change in species composition on the campsite.

[2]A visual estimate of impact proposed by Frissell (1978) which varies between 1 (low impact) and 5 (high impact).

[3]Includes a 95 percent confidence interval.

Figure 12.--Over 90 percent of the mature trees on the sample campsites had been scarred, felled, or had limbs cut.

Of the 19 campsites with trees on the site, 17 had trees with exposed roots. On a typical campsite, approximately 30 percent of the trees had exposed roots. Frissell and Duncan (1965) found trees with exposed roots on 60 percent of the campsites they examined, while James and others (1979) found 7 to 14 exposed roots per sample tree on their campsites.

Seedling densities on control sites were almost 10 times higher than on campsites (table 3). This amounts to a 92 percent loss of seedlings on the median campsite, with no campsite having more than 50 percent of the seedlings found on undisturbed sites. The few seedlings that do survive on campsites (four seedlings per site was the median) inevitably occur in protected areas behind

Table 3.--Ground coverages and seedling densities for campsites and controls and estimates of amount of change[1]

Statistic	Seedlings (N = 22)	Vegetation (N = 22)	Bare ground (N = 22)	Litter (N = 22)	Stone (N = 22)	Tree trunk and root (N = 22)
	Stems/ha	----------	----------	*Percent*	----------	----------
Campsite						
Median	329	6	31	59	2.4	
Mean[2]	507 ± 236	8 ± 4	33 ± 10	51 ± 10	4.6 ± 2.4	1.5 ± 0.6
Control						
Median	2,647	61	1	27	5.0	
Mean	5,020 ± 2,362	55 ± 10	6 ± 5	28 ± 7	10.7 ± 5.4	0.8 ± 0.4
Median absolute change	2,266	47	-25	-30	3.0	-0.6
Median relative change (percent)	92	87	-1,598	-116	58	-10
Significance level	[3]<0.001	[3]<0.001	[3]<0.001	0.002	0.005	

[1]Absolute change is the control value minus the campsite value; relative change is the absolute change divided by the control value. Positive values indicate that campsite values are lower than control values; negative values indicate higher campsite values than controls. Significance was tested with the Wilcoxon matched-pairs, signed-ranks test. Differences were considered significant if the level of significance was less than 0.05. Non-significant differences are left blank.

[2]Includes a 95 percent confidence interval.

[3]One-tailed tests were used because the direction of change was predicted prior to testing.

boulders or in dense clumps of saplings. There was no evidence that any of the tree species were particularly resistant to trampling. This near-elimination of seedlings has been reported wherever campsite seedling densities have been studied (Frissell and Duncan 1965; Magill and Nord 1963; Brown and others 1977; Fichtler 1980). Along with the loss of saplings to felling, this forecasts a future lack of trees to replace the overstory trees when they eventually die. Continued recruitment of trees will probably be one of the major challenges to long-term site maintenance.

Ground-cover changes have also been dramatic. As vegetation cover has disappeared, increasing amounts of bare mineral soil and organic litter have been exposed. A small, but statistically significant, decrease in stone cover is also evident. This may result from removal of rocks on campsites to make fire rings or to smooth sleeping areas, but probably also reflects a tendency for campsites to be located on exceptionally stone-free sites.

In comparison to controls, the median campsite had one-tenth the vegetative cover, 30 times as much bare ground, and twice the exposed litter cover. Eighty-seven percent of the original vegetation had been lost, leaving only 6 percent scattered about the site. These results are comparable to those of Frissell and Duncan (1965) in the Boundary Waters Canoe Area, and to Coombs' (1976) measures on heavy-use sites in the Idaho Primitive Area. Cover loss was much less extreme on developed sites in Rhode Island (Brown and others 1977) and Pennsylvania (LaPage 1967), where trampling-resistant species, usually exotic grasses, maintain some vegetative cover.

The median floristic dissimilarity between campsites and controls, 59 percent, indicates that a pronounced shift in species composition of the undergrowth has occurred. Inherent variability in species composition between undisturbed stands of this vegetation type accounts for about 25 percent of this dissimilarity (Cole 1978). Differences in excess of 25 percent can be attributed to changes resulting from recreational use. Previous estimates of floristic dissimilarity on similar campsites in the Eagle Cap Wilderness were about 80 percent (Cole 1981a), but these campsite measurements were concentrated close to the heavily used central core of the site. Apparently, and not unexpectedly, the change in species composition on each campsite decreases from campsite center to campsite periphery.

Every species experiences a decrease in cover on the campsites, with the exception of three introduced species--*Poa annua* (annual bluegrass), *Sagina saginoides* (alpine pearlwort), and *Spergularia rubra* (red sand-spurry), and six natives that are only found in small quantities on one or two of the campsites.[5] Therefore, there is no widespread "invasion" of species that increase in abundance in response to recreational use. This contrasts with lower elevation campsites where weedy invaders such as *Taraxacum officinale* (common dandelion) and *Poa pratensis* (Kentucky bluegrass) are usually the most abundant species on campsites (Cole 1977).

Some species increase in relative importance on campsites, however. Table 4 provides two indexes of change in importance for the most common vascular plant species in the area. The major species that increase in importance on campsites are *Carex microptera* (small-winged sedge), *Carex rossii* (Ross sedge), *Juncus parryi* (Parry's rush), *Muhlenbergia filiformis* (pullup muhly), and *Sibbaldia procumbens* (creeping sibbaldia), four graminoids, and a rhizomatous, mat-forming forb with creeping stems. A number of other studies have also found that *Carex* sp., *Juncus parryi,* and *Sibbaldia procumbens* are resistant to trampling (for example, Landals and Scotter 1973; Holmes and Dobson 1976).

The major species that decrease in importance on campsites are *Antennaria alpina* (alpine pussytoes), *Festuca viridula* (green fescue), *Hieracium gracile* (slender hawkweed), *Phyllodoce empetriformis* (red mountain-heath), *Potentilla flabellifolia* (fan-leaf cinquefoil), *Vaccinium scoparium,* and *Veronica cusickii* (Cusick's speedwell). The sensitivity of the brittle shrubs *Phyllodoce* and *Vaccinium* has been a consistent finding (for example, Dale and Weaver 1974; Hartley 1976), but results for the other species have been inconsistent. For example, *Hieracium gracille* has been judged to be resistant by Coombs (1976) and sensitive by Schreiner (1974), Hartley (1976), and this study. Apparently, the response of many species varies with such factors as season, type of impact, associated plants, and, perhaps, phenotypic variability within the species.

The three most prominent understory species on controls--*Vaccinium scoparium, Phyllodoce empetriformis,* and *Juncus parryi*--undergo pronounced shifts in importance on campsites (table 5). The median, combined, relative cover of *Vaccinium* and *Phyllodoce* drops from 39 percent on controls to 6 percent on campsites, while the median, combined, relative cover of *Juncus* and *Carex rossii* increases from 8 percent on controls to 28 percent on campsites. All differences are statistically significant.

When the response of major growth forms to camping is compared, graminoids increase in importance, while shrubs and bryophytes decrease, and forbs are essentially unaffected (table 5). Shrubs make up 41 percent of the cover on controls, but only 9 percent on the median campsite. Median graminoid values increase from 28 percent on controls to 56 percent on campsites. Similar responses have been noted in other subalpine campsite impact studies (Cole 1979; Leeson 1979; Weaver and others 1979).

As vegetation cover is removed, litter cover values increase. This increase, apparent in table 3, is not a real increase in litter; more litter is exposed because the overlying vegetation cover has been removed. Failure to recognize this has caused confusion about litter response to camping in some studies (for example, Coombs 1976). Increased litter cover values on campsites indicate that vegetation cover is removed more rapidly, exposing the underlying litter, than litter is removed, exposing bare ground. Nevertheless, litter is being removed, as the increases in bare ground indicate. Table 3 shows that on the median campsite, litter cover increases about 50 percent as a result of vegetation destruction, but about 25 to 30 percent of the litter cover is eroded, exposing bare ground.

[5]Appendix 1 contains frequency and cover data for all species encountered on campsites or controls.

Table 4.--Relative importance of the most common vascular plant species[1] on campsites and controls

Species	A[2]	B[2]
Antennaria alpina	0.3	0.9
Antennaria lanata	2.4	.7
Carex microptera	1.5	1.5
Carex rossii	9.0	4.5
Erigeron peregrinus	.6	1.9
Festuca viridula	.2	.9
Hieracium gracile	.1	.4
Juncus parryi	3.2	1.7
Luzula hitchcockii	.8	1.6
Muhlenbergia filiformis	1.5	3.6
Phyllodoce empetriformis	.5	.4
Potentilla flabellifolia	.5	.5
Sibbaldia procumbens	1.3	3.5
Vaccinium scoparium	.2	.5
Veronica cusickii	.6	.7

[1]All species with a mean cover greater than 1 percent or which occur on more than one-third of the control sites.

[2]Column A is the ratio between the number of cases in which relative cover is higher on campsites than controls, and the number of cases in which the reverse is true. Column B is the ratio between mean relative cover on campsites and mean relative cover on controls. A number greater than 1 indicates that the species increases in relative importance on campsites.

Table 5.--Relative cover of growth forms and selected species on campsites and controls

Growth forms and selected species	Control sites (N = 21)		Campsites (N = 21)		Significance level[1]
	Median	Mean	Median	Mean	
Graminoids	28	27 ± 7	56	55 ± 7	0.002
Shrubs	41	42 ± 10	9	19 ± 8	.002
Forbs	18	19 ± 5	21	21 ± 8	
Bryophytes	10	12 ± 4	1	5 ± 3	.005
Carex rossii	2	2 ± 1	8	14 ± 7	.001
Juncus parryi	6	12 ± 5	20	22 ± 7	.005
Vaccinium scoparium	30	28 ± 9	5	13 ± 7	.005
Phyllodoce empetriformis	9	11 ± 4	1	5 ± 3	.004

[1]Significance was tested with the Wilcoxon matched-pairs, signed-ranks test. Differences were considered significant if the significance level was less than 0.05. Nonsignificant differences are left blank.

This increase in bare ground is much more severe than that reported by Young (1978) on developed sites in Illinois, or by Frissell and Duncan (1965) and Fichtler (1980) on backcountry sites in Minnesota and Montana, respectively. It is comparable to the results of Brown and others (1977) for developed sites in Rhode Island and of Coombs (1976) for bare soil and erosion pavement on heavy-use, backcountry sites in Idaho.

The loss of organic litter is more evident in the decrease in duff depth presented in table 6. The depth of the soil organic horizons on campsites was less than one-half what it was on controls. On the other hand, the organic matter content of the upper A horizon was about 20 percent higher on campsites than on controls, suggesting that, although some of the surface organic litter pulverized by recreational use is probably removed by erosion, some of it moves down into the uppermost mineral horizons where it accumulates. Monti and Mackintosh (1979) present photomicrographs which clearly show bands of "humus" particles which have accumulated in the upper 2.54 to 7.62 inches (1 to 3 cm) of mineral soil on campsites in Ontario. About 55 percent of the O horizon was lost on these campsites, a figure close to the 51 percent lost on Eagle Cap campsites, despite much heavier use in Ontario. Similar measures of reduction in duff depth--60 to 65 percent--have been reported on campsites in the Boundary Waters Canoe Area (Frissell and Duncan 1965; McCool and others 1969).

Measures of the magnitude and even direction of change in soil organic matter content have been less consistent. We found a 20 percent increase on campsites. Monti and Mackintosh (1979) and Legg and Schneider (1977), working in northern forest types in Ontario and Michigan, respectively, also report accumulations of organic matter in the surface mineral horizons on campsites, but they did not compare this to conditions on control sites. Young and Gilmore (1976) found a 28 percent increase in soil organic matter on forested campsites in Illinois. Studies in Colorado, Iowa, and Ontario, however, have found decreases in soil organic matter on campsites (Dotzenko and others 1967; Dawson and others 1978; Rutherford and Scott 1979). At this time, there is no apparent explanation for this difference in results, as the direction of change is not correlated with vegetation type, soil type, climatic regimen, campsite age, amount of use, or measurement technique.

Bulk density increased on campsites, but this increase was not as great as expected (15 percent). Bulk densities were unusually low, both on campsites and controls, reflecting the high organic matter content of the soil and the influence of volcanic ash. These characteristics make the soil less compactible and prevent the more sizable increases of 72 percent, 46 percent, 34 percent, 30 percent, 23 percent, and 21 percent reported on campsites in Rhode Island (Brown and others 1977), Colorado (Dotzenko and others 1967), Ontario (Monti and Mackintosh 1979), Iowa (Dawson and others 1978), Missouri (Settergren and Cole 1970), and Michigan (Legg and Schneider 1977), respectively.

Although the effects of changes in bulk density on vegetative growth are highly variable, most studies have shown no harmful effects until bulk densities exceed 1.3 g/cm^3 or more (Barton and others 1966; Minore and others 1969). In fact, in some sandy soils, low levels of compaction improve the growth of certain species by increasing the water-holding capacity of the soil (Blom 1976). This suggests that, particularly on the Eagle Cap campsites where bulk densities are universally low, increases in bulk density may not be a significant impact. Other manifestations of compaction, such as decreased infiltration rates or loss of microsites suitable for seed germination (Harper and others 1965), may be more significant.

Table 6.--Soil conditions on campsites and controls and estimates of amount of change[1]

Statistic	Duff depth (N = 22)	pH (N = 20)	Instantaneous infiltration rate (N = 20)	Saturated infiltration rate (N = 22)	NO_3 (N = 20)	K (N = 20)	Mg (N = 20)	Ca (N = 20)	Na (N = 20)	PO_4 (N = 20)	Total N (N = 20)	Organic matter (N = 20)	Bulk density (N = 20)
	cm		*cm/min*		*Parts per million*							*Percent*	*g/cm^3*
Campsite													
Median	0.25	5.48	0.33	0.16	7.6	195	61	528	53	14	3,193	18	0.95
Mean[2]	0.32 ± 0.18	5.44 ± 0.16	0.38 ± 0.10	0.16 ± 0.04	7.9 ± 2.5	211 ± 39	80 ± 33	666 ± 222	55 ± 5	20 ± 9	3,493 ± 780	19 ± 4	0.96 ± 0.09
Control													
Median	0.53	5.13	0.59	0.25	3.6	167	39	287	45	11	2,342	15	0.88
Mean	0.74 ± 0.30	5.13 ± 0.09	0.66 ± 0.17	0.26 ± 0.05	7.4 ± 2.9	183 ± 37	42 ± 8	362 ± 89	47 ± 3	21 ± 9	2,868 ± 626	15 ± 2	0.88 ± 0.08
Median Absolute Change	0.30	-0.50	0.19	0.09	-4.1	-40	-23	-300	-6	0.8	-165	-2	-0.11
Median Relative change (percent)	51	-9	29	33	-68	-28	-107	-101	-13	2	-5	-20	-15
Significance	[3]<.001	.003	[3].003	[3]<.001			.001	.002	.014			.027	[3].047

[1]Absolute change is the control value minus the campsite value; relative change is the absolute change divided by the control value. Positive values indicate that campsite values are lower than control values; negative values indicate higher campsite values than controls. Significance was tested with the Wilcoxon matched-pairs, signed-ranks test. Differences were considered significant if the level of significance was less than 0.05. Nonsignificant differences are left blank.

[2]Includes a 95 percent confidence interval.

[3]One-tailed test.

The decreases in infiltration rates on Eagle Cap campsites, while statistically significant, are also much less pronounced than decreases found elsewhere. The rate at which the first 0.39 inch (1 cm) of water percolates into the soil is 28 percent slower on campsites than on controls; the decrease on campsites when 2 inches (5 cm) of water were applied was about the same--33 percent. In contrast, other studies have found infiltration rates on controls to be 20 to 60 times higher than on campsites (Brown and others 1977; James and others 1979; Monti and Mackintosh 1979).

Most of this difference in magnitude of change is a result of extremely low infiltration rates on Eagle Cap controls. Infiltration rates on the campsites are comparable to those on campsites in other studies; rates on controls are an order of magnitude lower. Soils were notably hydrophobic and were not presoaked. Hydrophobicity, which can cause dramatic reductions in infiltration rates, is particularly pronounced in highly organic and sandy soils, like those in this study (Singer and Ugolini 1976). Studies have also found soils under ericaceous shrubs and conifers to be particularly water-repellant (Richardson and Hole 1978).

Finally, several statistically significant changes in soil chemistry were found. From a median value of 5.13 on controls, pH increased to 5.48 on campsites. Concentrations of Mg, Ca, and Na were also significantly higher on campsites; Mg increased 107 percent, and Ca and Na increased 101 percent and 13 percent, respectively. Concentrations of NO_3, K, and total N increased on campsites, but the results were so variable that a significant difference could not be established. Phosphate content, like particle-size distribution,[6] did not differ. These results contrast somewhat with those of Young and Gilmore (1976). They found similar increases in Ca (116 percent) and Na (57 percent) on campsites, in addition to increases in P (50 percent) and N (26 percent), and no change in Mg, the nutrient which increased the most on the Eagle Cap campsites. Rutherford and Scott (1979) found no change in Mg, K, or PO_4, and a decrease in NO_3. Obviously, the effects of camping on soil chemistry are highly variable, depending upon the extent to which campfire ashes are scattered about the site; the nutrient inputs in excess food, soap, and so forth; the degree to which leaching is reduced by decreased infiltration rates (Young and Gilmore 1976); and the innate character of the undisturbed soil.

It is doubtful, however, that any of these changes are significant in an ecological sense. For example, in a Montana study which included *Abies lasiocarpa-Pinus contorta-Carex geyeri-Vaccinium scoparium* (subalpine fir-lodgepole pine-elk sedge-grouse whortleberry) forests, seasonal variations in soil pH and Na content were greater than the differences between campsites and controls found in this study (Weaver and Forcella 1979). Although changes in Mg and Ca concentrations on campsites were greater than their seasonal variability, the differences were not sufficiently dramatic to suggest any basic ecological change.

It is interesting to note that those ions which increased the most on the Eagle Cap campsites are highly mobile ions, particularly susceptible to leaching. Their presence in high concentrations on campsites supports the hypothesis of Young and Gilmore (1976) that campsite increases are a result of reduced leaching.

To What Extent Do Impacts Vary with Differences in Amount of Use?

Despite these sizable differences between campsites and controls, the amount of change that has occurred on campsites is extremely variable. This is reflected in the large confidence intervals around the means in tables 2, 3, 5, and 6. It has often been assumed that most of this variability in campsite conditions and impacts can be attributed to differences in the amount of use the site receives. I (Cole 1981b) have suggested that environmental differences usually contribute more to variability than use differences. In this study, environmental variability was reduced by only examining campsites in *Abies lasiocarpa/Vaccinium scoparium* forests, close to lakes, and between elevations of 7,050 and 7,800 ft (2 150 and 2 400 m). This allowed a clearer view of the relationship between amount of use and campsite impact.

The relationship between amount of use and impact, for parameters which exhibit significant differences between campsites and controls, are presented in tables 7, 8, and 9. Amount of use is compared to existing site conditions (table 7), the absolute amount of change which has occurred on the site (table 8), and the relative amount of change which has occurred on the site (table 9).

From these tables, there is no significant correlation between the amount of use a site receives and the following variables: camp area; mutilated, felled, or scarred trees; litter cover; soil pH; instantaneous or saturated infiltration rates; Mg, Ca, or Na concentrations; soil organic matter; or bulk density.

Although light-use sites are generally smaller than moderate- and heavy-use sites (table 7), campsite area is highly variable and there is substantial overlap in size between use classes. For example, the low-use site at Hidden Lake is 2,906 ft^2 (270 m^2), while a heavy-use site at Minam Lake is only 850 ft^2 (79 m^2). This variability explains the nonsignificant Kendall correlation coefficient and also the nonsignificant Kolmogorov-Smirnov contrast between light- and moderate- use sites, despite the difference in median and mean values. With a larger sample size, it would probably have been possible to conclude that light-use sites are generally smaller than more heavily used sites (significance level was 0.064). There is little difference in the size of moderate- and heavy-use sites, however. Most increases in campsite size can probably be attributed to occasional use by abnormally large parties, or parties with packstock, a process largely independent of frequency of use by more typical, small, backpacking parties.

Tree mutilations also appear to increase in abundance with increasing use, but, again, differences are dwarfed by variability. Differences in the frequency of felled and

[6]Data are not presented because no differences between campsite and control were noted.

scarred trees are not related in any consistent manner to the amount of use a site receives. This is not surprising as most tree damage can probably be ascribed to a few atypically destructive groups, again making the frequency of use by undestructive parties irrelevant. Fichtler (1980) also found no relationship between use and tree injury. James and others (1979), however, did find an increase in the number of trunk scars per stem from 1.9 on recently built, light-use sites to 4.3 on the older, heavy-use sites. This damage, which is cumulative, is probably more strongly related to campsite age than to use frequency.

Litter cover, as noted previously, is dependent on changes in vegetation cover and bare ground. Consequently, interpretation of these values is difficult. Coombs (1976) and Fichtler (1980) reported no difference in litter cover between light- and heavy-use sites, but they failed to note that vegetation loss causes an apparent, but not a real, increase in litter values. Thus, their results, similar to these in showing no significant differences between use levels, probably disguise a real loss in litter cover with increasing use, coincident with an increase in bare ground, which will be discussed. Legg and Schneider (1977) reported a significant decrease in litter cover on more heavily used sites, and Young (1978) reported a reduction in litter with increased use, although differences were not statistically significant.

Soil pH generally increases with increasing use. A large sample size might have allowed a statistically significant relationship to be established, but, again, differences between use levels are minor in comparison to site-to-site variability (table 7). The same conclusion can be drawn from measures of the amount of change in pH on the campsites (tables 8 and 9). Young and Gilmore (1976) found that the pH on sites used 34 to 66 days per year (6.1) was significantly higher than the pH on sites used 0 to 33 days per year (5.7), but that a further increase in use caused no further change. These increases, even if they can be attributed to increased use of the campsites, are so slight that they are not ecologically meaningful.

Table 7.--Relationship between campsite conditions and the amount of use the site receives[1]

Impact parameter	Light-use sites (N = 6)		Moderate-use sites (N = 6)		Heavy-use sites (N = 10)		Kendall tau
	Median	Mean	Median	Mean	Median	Mean	
Camp area (m^2)	48	109 ± 99	224	275 ± 196	205	204 ± 51	
Bare area (m^2)	19	51 ± 53	122	112 ± 66	93	116 ± 40	0.30
Mutilated trees (percent)	74	60 ± 49	85	73 ± 40	97	93 ± 7	
Trees with exposed roots (percent)	3	7 ± 8	33	34 ± 26	39	39 ± 22	.41
Felled trees (percent)	43	41 ± 40	12	21 ± 26	34	34 ± 12	
Scarred trees (percent)	3	13 ± 17	37	36 ± 22	11	21 ± 26	
Floristic dissimilarity (percent)	31	42 ± 18	60	59 ± 25	64	61 ± 11	.33
Seedlings (number/ha)	174	314 ± 366	299	404 ± 352	335	686 ± 488	
Vegetation cover (percent)	9	12 ± 11	6	10 ± 12	4	5 ± 2	-.41
Bare ground (percent)	14	30 ± 28	20	26 ± 19	35	40 ± 16	
Litter (percent)	40	50 ± 28	62	56 ± 25	51	49 ± 17	
Duff depth (cm)	0.15	0.22 ± 0.18	0.45	0.67 ± 0.72	0.15	0.18 ± 0.09	-.35
pH	5.25	5.32 ± 0.41	5.25	5.37 ± 0.43	5.55	5.58 ± 0.16	
Instantaneous infiltration rate (cm/min)	0.54	0.60 ± 0.19	0.19	0.28 ± 0.22	0.28	0.32 ± 0.13	
Saturated infiltration rate (cm/min)	0.23	0.24 ± 0.17	0.12	0.15 ± 0.07	0.14	0.13 ± 0.04	
Mg (p/m)	34	50 ± 26	67	132 ± 237	61	77 ± 26	
Ca (p/m)	280	425 ± 265	755	1,070 ± 1,345	528	650 ± 263	
Na (p/m)	54	52 ± 10	53	62 ± 16	51	55 ± 8	
Organic matter (percent)	12	18 ± 11	14	17 ± 13	18	20 ± 5	
Bulk density (g/cm^3)	0.95	1.04 ± 0.29	0.90	0.90 ± 0.19	0.95	0.94 ± 0.11	
Impact rating	1.5	1.6 ± 0.4	2.0	2.0 ± 0.4	2.2	2.1 ± 0.2	.41

[1]Significance level was 0.05. Nonsignificant relationships are left blank.

Table 8.--Relationship between the absolute amount of change which has occurred on a campsite and the amount of use the site receives[1]

Impact parameter	Light-use sites (N = 6)		Moderate-use sites (N = 6)		Heavy-use sites (N = 10)		Kendall tau
	Median	Mean	Median	Mean	Median	Mean	
Seedlings (number/ha)	1,113	1,245 ± 667	1,825	3,742 ± 3,241	3,727	6,936 ± 5,210	0.57
Vegetation cover (percent)	37	38 ± 15	30	40 ± 34	60	56 ± 15	.29
Bare ground (percent)	-5	-15 ± 26	-26	-24 ± 19	-32	-37 ± 17	-.34
Litter (percent)	-26	-22 ± 24	-26	-23 ± 30	-35	-25 ± 20	
Duff depth (cm)	0.06	0.13 ± 0.26	0.15	0.58 ± 1.21	0.35	0.49 ± 0.20	.40
pH	-0.15	-0.15 ± 0.39	-0.25	-0.27 ± 0.40	-0.60	-0.36 ± 0.24	
Instantaneous infiltration rate (cm/min)	0.07	0.21 ± 0.47	0.46	0.41 ± 0.37	0.05	0.20 ± 0.23	
Saturated infiltration rate (cm/min)	0.01	0.03 ± 0.12	0.12	0.16 ± 0.18	0.09	0.08 ± 0.06	
Mg (p/m)	-18	-19 ± 22	-28	-86 ± 136	-35	-30 ± 32	
Ca (p/m)	-216	-221 ± 236	-483	-677 ± 790	-300	-206 ± 176	
Na (p/m)	-8	-4 ± 11	-15	-19 ± 16	-5	-6 ± 10	
Organic matter (percent)	-5	-5 ± 6	-4	0 ± 6	-2	-5 ± 5	
Bulk density (g/cm^3)	-0.13	-0.09 ± 0.15	-0.08	-0.05 ± 0.15	-0.14	-0.09 ± 0.14	

[1]The absolute amount of change is the difference between conditions on the campsite and control. A positive change represents a decrease in that measure on the campsite. Significance level was 0.05. Nonsignificant relationships are left blank.

Table 9.--Relationship between the relative amount of change which has occurred on a campsite and the amount of use the site receives[1]

Impact parameter	Light-use sites (N = 6)		Moderate-use sites (N = 6)		Heavy-use sites (N = 10)		Kendall tau
	Median	Mean	Median	Mean	Median	Mean	
Seedlings (percent)	73	82 ± 17	92	90 ± 11	89	86 ± 11	
Vegetation cover (percent)	71	78 ± 17	71	70 ± 30	94	91 ± 6	0.29
Bare ground (percent)	-529	-504 ± 638	-1,595	-2,110 ± 1,967	-3,293	-3,136 ± 1,726	-.43
Litter (percent)	-118	-91 ± 115	-49	-233 ± 461	-277	-240 ± 207	
Duff depth (percent)	3	2 ± 109	21	34 ± 52	68	72 ± 12	.36
pH (percent)	-3	-3 ± 8	-5	-5 ± 8	-11	-7 ± 5	
Instantaneous infiltration rate (percent)	8	40 ± 147	57	59 ± 20	12	12 ± 53	
Saturated infiltration rate (percent)	-2	0 ± 39	39	43 ± 22	42	30 ± 30	
Mg (percent)	-41	-67 ± 78	-109	-158 ± 213	-108	-78 ± 50	
Ca (percent)	-105	-99 ± 97	-160	-178 ± 176	-30	-69 ± 63	
Na (percent)	-25	-11 ± 23	-33	-45 ± 43	-10	-14 ± 21	
Organic matter (percent)	-19	-43 ± 61	-26	2 ± 32	-20	-35 ± 35	
Bulk density (percent)	-16	-11 ± 14	-11	-8 ± 17	-16	-13 ± 16	

[1]The relative amount of change is the difference between campsite and control conditions expressed as a percentage of control conditions (that is, change as a percentage of original conditions). A positive change represents a decrease in that measure on the campsite. Significance level was 0.05. Nonsignificant relationships are left blank.

Differences in the amount of change in other soil properties are even more erratic and variable. For example, instantaneous infiltration rates are reduced, on the average, 40 percent on light-use sites, 59 percent on moderate-use sites, and 12 percent on heavy-use sites; standard deviations are usually greater than the differences between use categories (table 9). The lack of relationship between amount of use and infiltration rates, Mg concentrations, and soil organic matter supports earlier studies. James and others (1979) found mean infiltration rates of 0.27 cm/min on recently built, light-use sites, and 0.29 cm/min on older, heavy-use sites. As reduced infiltration rates are probably one of the more detrimental consequences of soil compaction, these findings--that rates are reduced as much on light-use sites as on heavy-use sites--seem very important.

Young and Gilmore (1976) found similar Mg concentrations and organic matter content on campsites receiving different amounts of use. Organic matter content on their sites was 3 to 4 percent, in contrast to 17 to 20 percent on Eagle Cap campsites, suggesting that the lack of relationship between use and organic matter content applies to a broad range of soil types.

The lack of relationship between use and bulk density, Ca, and Na concentrations is inconsistent with earlier studies. Young and Gilmore (1976) report significant differences in Ca content between light- and moderate-use sites; concentrations on light- and heavy-use sites, however, were not significantly different, and differences between soil types were more pronounced than differences between use categories. They also report significant differences in Na content between light- and heavy-use sites, but differences between light-and moderate-use sites or moderate- and heavy-use sites were not significant. Apparently, the relationship between soil chemistry change and amount of recreational use can be highly variable. The differences involved, however, appear to almost always be so slight that differences in availability of nutrients to plants should be negligible. This makes the question of statistical significance moot.

The lack of relationship between amount of use and bulk density is more difficult to dismiss, as increased bulk density is commonly considered to be an ecologically significant campsite impact, and both Dotzenko and others (1967) and Legg and Schneider (1977) report increases in bulk density associated with increased use. Perhaps our lack of relationship is a result of measurement error with the hand-excavation technique, or perhaps the relative noncompactibility of the Eagle Cap soils makes differences in amount of use less important. Both Dotzenko and others (1967) and Legg and Schneider (1977) found more pronounced differences between controls and their light-use sites than between light- and heavy-use sites. Increases in soil penetration resistance on campsites, another measure of compaction, were not correlated with amount of use in Fichtler's (1980) study.

For the remaining parameters, there is some evidence that impact may be related to amount of use. These parameters will be analyzed in more detail.

SEEDLINGS

Seedling densities are actually higher on heavy-use sites than on moderate- or light-use sites (table 7). This would suggest that impact has been greater on light-use sites. An opposing interpretation emerges when absolute seedling loss is examined; the difference between the density of seedlings on controls and campsites increases from light- to heavy-use sites (table 8). Relative seedling loss is relatively constant across the use categories.

In order to facilitate interpretation, these results have been graphically portrayed in figure 13. Seedling densities on controls are extremely variable, but always an order of magnitude greater than the less variable campsite densities (fig. 13a). The great variability in seedling densities on control sites makes comparisons of absolute loss (fig. 13b) misleading and favors the use of relative loss (fig. 13c) as a measure of impact. Clearly, seedlings are almost completely eliminated on all campsites, regardless of the amount of use they receive. Being highly susceptible to trampling, any consistent use is sufficient to kill most of the seedlings. The number of seedlings surviving on a campsite is probably more a function of the number of protected suitable germination sites than the amount of use the site receives. Fichtler (1980) also found no difference in relative seedling loss between light- and heavy-use sites.

VEGETATION COVER

In comparison to more lightly used campsites, heavy-use sites have less vegetation (table 7), and the amount of change, whether expressed in absolute values (table 8) or relative values (table 9), has been greater. As shown in figure 14, however, differences between use levels are minor in comparison to the differences between campsites and controls. The median cover on the light-use sites is 9 percent; 71 percent of the original cover has been lost. The median cover on heavy-use sites is 4 percent, a 94-percent loss. In this case, there is a statistically significant increase in vegetation impact associated with increased use, but the differences are not pronounced.

These results are similar to those of Frissell and Duncan (1965), who found 12-percent vegetation cover on light-use sites; 81 percent of the original cover had been lost. Heavy-use sites retained a 5-percent cover, a 91 percent loss. In their case, the difference in existing cover on campsites was statistically significant, but the difference in amount of change was not. Therefore, at these use levels (higher than those found in the Eagle Cap), in the northern Minnesota environment, differences in amount of vegetation change were not related to amount of use. Similarly, Fichtler (1980) found no difference in relative cover loss between light- and heavy-use sites in Montana, Young (1978) found no relationship between vegetation cover and amount of use on Illinois campsites, and LaPage (1967) found no relationship between use and change in cover after campsites in Pennsylvania were more than 1 year old.

The only study to show any sizable difference in cover between light- and heavy-use sites was Coombs' (1976) study in the Idaho Primitive Area, where use was extremely low. She found about 30 percent cover on light-use sites (a relative loss of 30 percent) and 8 percent on heavy-use sites (a relative loss of 81 percent). Apparently, vegetation change is considerably less pronounced at very low use levels, but even a few nights of use per year in the Eagle Cap appears to be enough to eliminate most of the vegetation.

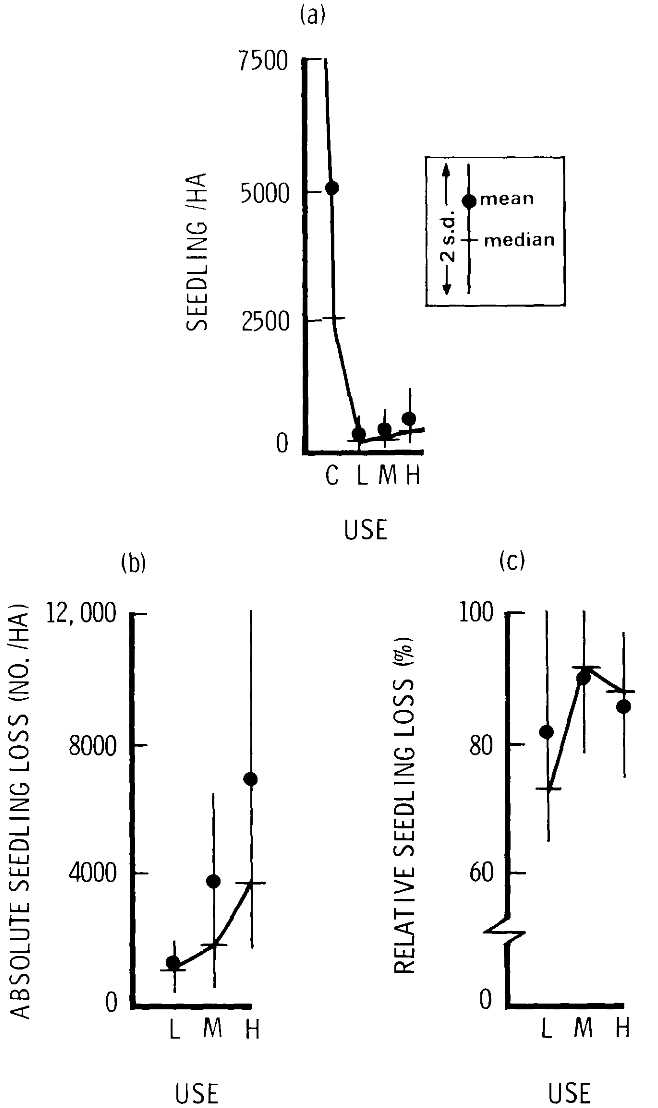

Figure 13.--Seedling loss in relation to amount of use. Median, mean, and two standard deviations for: (a) seedlings per hectare on controls, light-, moderate-, and heavy-use campsites; (b) the absolute reduction in seedling density that has occurred on light-, moderate-, and heavy-use campsites; and (c) the relative reduction in seedling density that has occurred on light-, moderate-, and heavy-use campsites. The medians in each use category have been connected by a line.

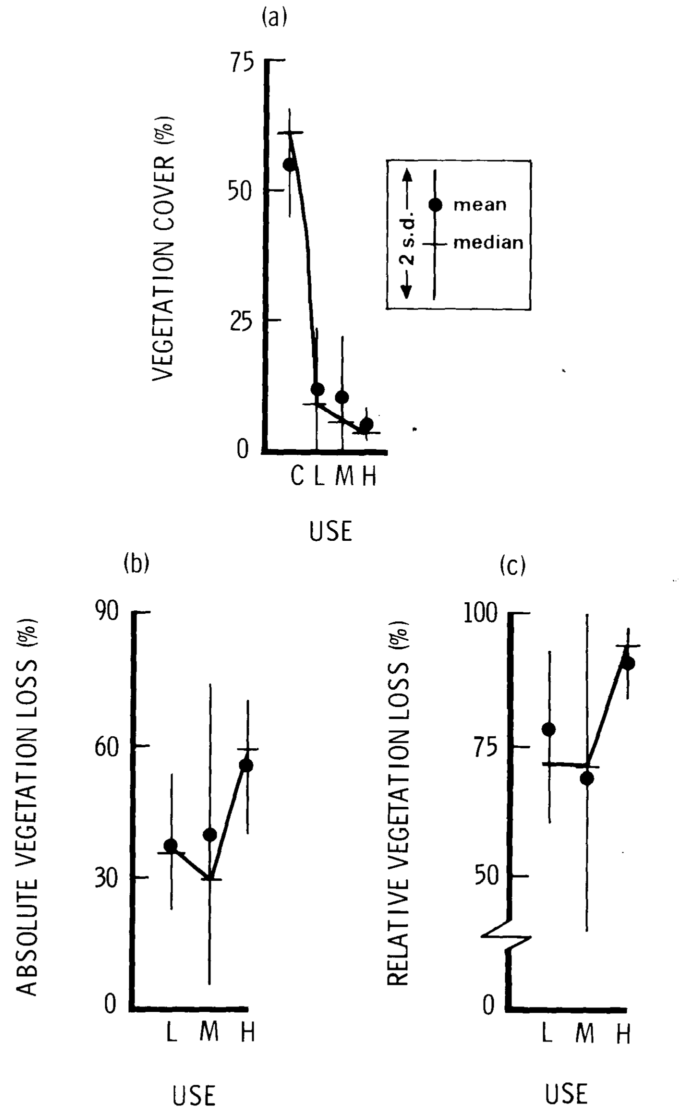

Figure 14.--Loss of vegetation cover in relation to amount of use. Median, mean, and two standard deviations for: (a) vegetation cover on controls, light-, moderate-, and heavy-use campsites; (b) absolute reduction in vegetation cover on light-, moderate-, and heavy-use campsites; and (c) relative reduction in vegetation cover on light-, moderate-, and heavy-use campsites. The medians in each use category have been connected by a line.

Species diversity does not vary substantially with differences in amount of use. The median species richness--the number of species per 161 ft^2 (15 m^2)-- was 12, 10.5, and 11.5, on light-, moderate-, and heavy-use sites, respectively. The reciprocal of Simpson's index, a measure of species heterogeneity which is most sensitive to changes in dominant species (Peet 1974), was 4.76, 4.37, and 4.48, on light-, moderate-, and heavy-use sites, respectively. Young (1978) reported a decrease in species richness at high-use levels, but the short-use season at Eagle Cap precludes such heavy use. At the lower use levels typical of high-elevation wilderness areas, species diversity does not appear to be highly influenced by amount of use. In fact, Coombs (1976) found more species on light-use sites than on controls, a finding that supports the observation that species diversity increases at low levels of trampling stress and decreases at high levels of stress (Slatter 1978).

Change in species composition, reflected in the index of floristic dissimilarity, does appear to increase with increasing use, however, from a median value of 31 percent on light-use sites to 64 percent on heavy-use sites (table 7). This suggests that, although heavy-use sites retain as many species and almost as much cover as light-use sites, heavy-use sites experience a more pronounced shift in species compostion. This contrasts with the results of Fichtler (1980), who found no relationship between floristic dissimilarity and amount of use.

Although species composition has been more highly altered on heavy-use campsites, there are no significant differences in the relative importance of growth forms or major species associated with differences in amount of use (table 10). James and others (1979) also found no relationship between use intensity and understory species composition on campsites in coniferous forests, despite pronounced shifts in species composition on campsites. Apparently, species compositional changes may become more pronounced as use intensity increases, but so many other factors influence the surviving populations that the importance of individual species and growth forms does not vary consistently in relation to amount of use.

The more heavily used sites also have a larger central core devoid of vegetation. This bare area increases from a median value of 205 ft^2 (19 m^2) on light-use sites to 1,313 ft^2 (122 m^2) and 1,001 ft^2 (93 m^2) on moderate- and heavy-use sites, respectively (table 7). The proportion of a site that is denuded, however, is similar on light-, moderate-, and heavy-use sites. The barren central core is 40 percent of the area of the median light-use campsite and 45 percent of the heavy-use campsite area.

This finding contrasts with the results of Moorhead and Schreiner (1979). Working in Olympic National Park, they found no consistent relationship between a similar measure of bare area and amount of use, despite significant differences in bare area between different vegetation types. This is one case where it has been clearly shown that environmental differences influence the amount of impact more highly than differences in amount of use.

BARE GROUND

Although median bare ground increases from light- to heavy-use sites, these differences are not statistically significant (table 7). When campsites and controls are compared to give an estimate of amount of change, differences are significant (tables 8 and 9). The median light-use site has 5 percent more bare soil exposed than its associated control (absolute change); this represents a 529 percent increase (relative change). On moderate-use sites, 26 percent more bare soil is exposed, a 1,595-percent increase; and on heavy-use sites, these measures of change increase to 32 percent and 3,292 percent, respectively (tables 8 and 9). Graphically portrayed in figure 15, this suggests that the increase in bare ground which occurs on a campsite is controlled to a significant extent by the amount of use the site receives.

Similar results have been found by Young (1978) on campsites in Illinois. He found that bare ground increased from negligible amounts on controls to 30 percent on light-use sites (0 to 33 days per year) and 56 percent on moderate-use sites (33 to 66 days per year), but as use exceeded 66 days per year, no significant increase in bare ground occurred. Coombs (1976) found that bare ground and erosion pavement increased from 2 percent on controls to 15 percent on light-use sites and 26 percent on heavy-use sites in the Idaho Primitive Area. Fichtler (1980) found that bare ground increased sevenfold on light-use sites and seventeenfold on heavy-use sites. This was the only impact parameter that increased significantly with increased use. These results suggest strongly that heavy-use sites experience significantly greater increases in bare ground exposure than light-use sites.

Table 10.--Relative cover of growth forms and selected species in relation to amount of use

Growth forms and selected species	Light-use sites (N = 6)		Moderate-use sites (N = 6)		Heavy-use sites (N = 10)		Kendall tau[1]
	Median	Mean	Median	Mean	Median	Mean	
	Percent						
Graminoids	66	65 ± 18	53	51 ± 15	52	51 ± 8	
Shrubs	17	16 ± 11	9	16 ± 15	6	21 ± 14	
Forbs	5	13 ± 12	35	29 ± 21	17	21 ± 12	
Bryophytes	0.3	6 ± 10	1	3 ± 3	2	6 ± 5	
Carex rossii	5	5 ± 3	9	20 ± 20	9	15 ± 9	
Juncus parryi	20	29 ± 17	12	14 ± 8	27	24 ± 10	
Vaccinium scoparium	3	8 ± 10	6	14 ± 15	6	15 ± 12	
Phyllodoce empetriformis	2	6 ± 5	0.5	1 ± 1	0.3	6 ± 7	

[1]None of the relationships were significant at the 0.05 level.

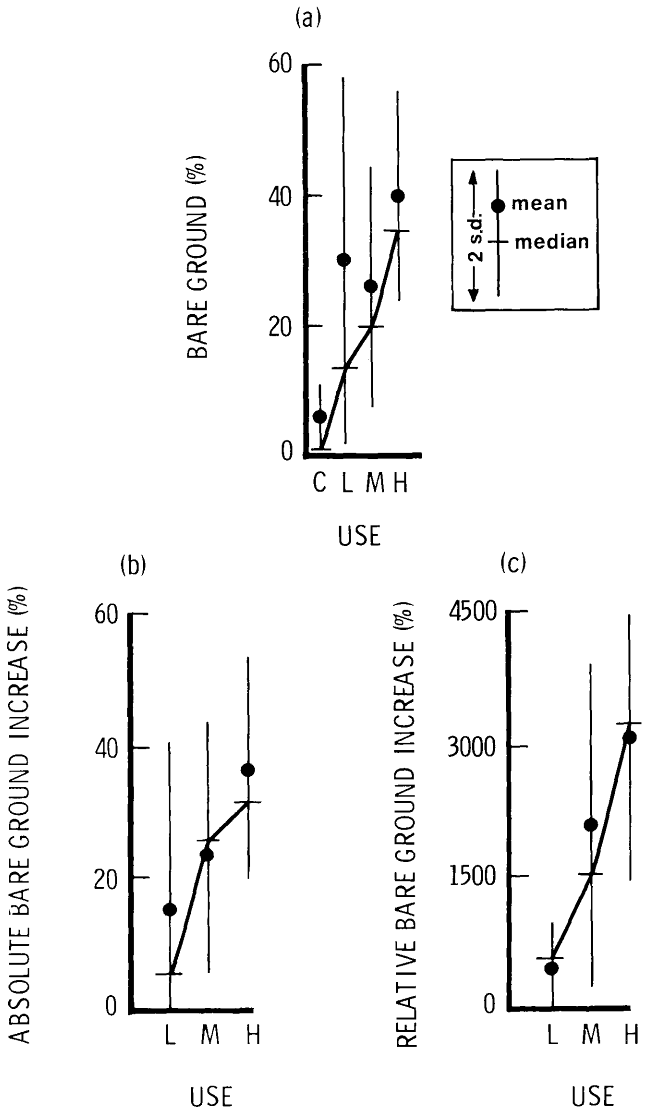

Figure 15.--Increase in bare ground in relation to amount of use. Median, mean, and two standard deviations for: (a) bare ground cover on controls, light-, moderate-, and heavy-use campsites; (b) absolute increase in bare ground cover on light-, moderate-, and heavy-use campsites; and (c) relative increase in bare ground cover on light-, moderate-, and heavy-use campsites. The medians in each use category have been connected by a line.

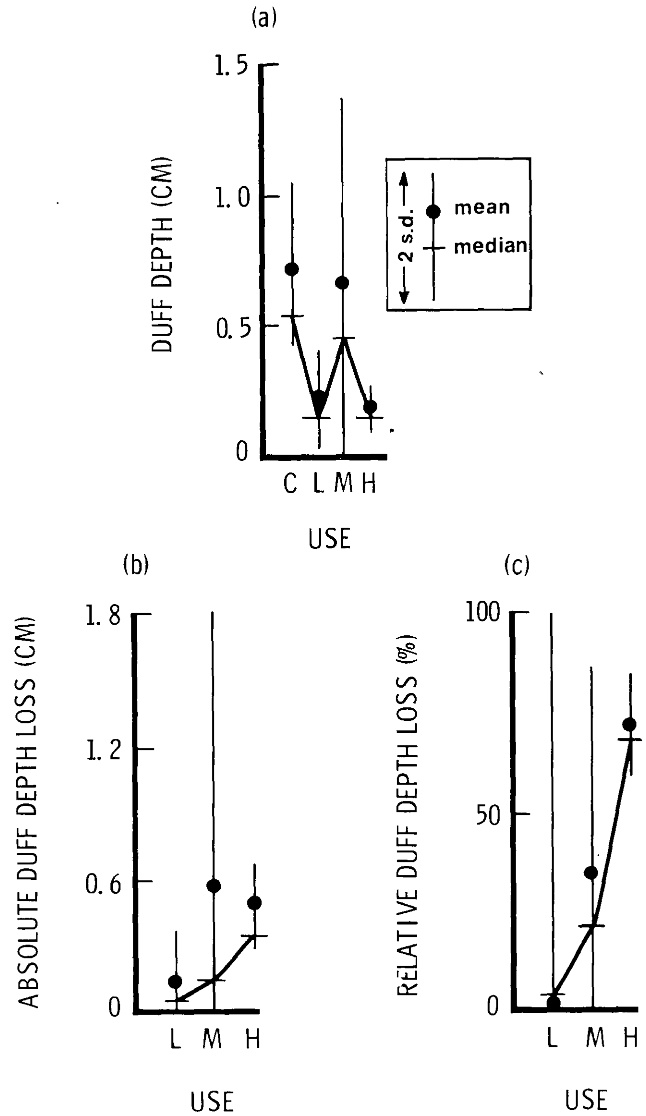

Figure 16.--Decrease in duff depth in relation to amount of use. Median, mean, and two standard deviations for: (a) duff depth on controls, light-, moderate-, and heavy-use campsites; (b) absolute reduction in duff depth on light-, moderate-, and heavy-use campsites; and (c) relative reduction in duff depth on light-, moderate-, and heavy-use campsites. The medians in each use category have been connected by a line.

DUFF DEPTH

Table 7 shows a statistically significant decrease in duff depth associated with increased use, although light-use sites actually have thinner organic horizons than moderate-use sites. Measures of reduction in duff depth, whether absolute (table 8) or relative (table 9) show sizable increases in impact associated with increased use. All of these measures indicate that removal of organic horizons increases as use intensity increases, despite highly variable campsite measurements (fig. 16). The median relative loss of duff increases from 3 percent on light-use sites to 21 percent and 68 percent on moderate- and heavy-use sites, respectively. James and others (1979) found no relationship between use intensity and duff depth, despite pronounced reductions on campsites in general. They did not attempt to pair campsites and controls, however; so site-to-site variability may have disguised any relationship. A second paper on the same study area (Monti and Mackintosh 1979) showed more pronounced reductions in duff depth on high-use sites than on medium- or low-use sites.

TREE ROOT EXPOSURE

The percentage of trees with exposed roots is also significantly lower on light-use sites--3 percent compared to median values of 33 percent and 39 percent on moderate- and heavy-use sites (table 7). Along with the relatively small decrease in duff depth on light-use sites, this suggests that loss of the surface horizons usually does not occur until campsites are used more than about five times per year. Conditions are highly variable, however; some light-use campsites have numerous trees with exposed roots and have lost most of their organic horizons. James and others (1979) found that the mean number of exposed roots within 3.28 ft (1 m) of each sample tree increased from 7.1 on recently built, light-use sites to 13.8 on older, heavy-use sites. Fichtler (1980), however, found no relationship between use and linear feet of exposed roots.

IMPACT RATING

The overall summary measure of impact, which could vary between 1 and 3, had median values of 1.5, 2.0, and 2.2 for light-, moderate-, and heavy-use sites, respectively (table 7). This general increase in impact in response to increased use is statistically significant; however, there is a considerable amount of overlap between use classes. For example, 90 percent of the heavy-use sites have ratings as low or lower than the rating of the most highly impacted low-use site. In other words, heavy-use sites are usually more highly impacted than light-use sites, but differences are slight, and light-use sites can be more highly impacted than heavy-use sites. Moreover, differences between light- and moderate-use sites are much more pronounced than differences between moderate- and heavy-use sites.

How Much Change Occurs in Other Environmental Situations?

It has been suggested that campsite impacts could be reduced by locating campsites on durable sites (Cole 1981b). Trails illustrate the importance of location where poorly located trail segments are badly eroded, while adjacent segments, receiving the same amount of use, are often in good shape.

Experimental trampling studies have found that trampling impact usually varies more between vegetation types than between use levels. For example, in a study at Waterton Lakes National Park, 800 tramples reduced the vegetation of a lodgepole pine stand to 1.1 percent of its original cover. A similar number of tramples in a prairie grassland only reduced cover to 22.1 percent. To maintain this percentage of original cover in the lodgepole stands would require a reduction in the number of tramples to 40 (Nagy and Scotter 1974). In other words, shifting the trampling from lodgepole to grassland sites would accomplish as much, in terms of maintaining original cover, as a twentyfold reduction in use of the lodgepole sites. Moorhead and Schreiner (1979) arrived at similar conclusions in a study of the bare area on campsites in Olympic National Park.

In order to examine the effects of differences in environment, campsite data are presented for four additional sites not located close to subalpine lakes (table 11). Two are located in timberline meadows close to 8,200 ft (2 500 m) in elevation. Campsite 15 at Pocket Lake is a light-use site, while campsite 20 at Glacier Lake is probably a moderate-use site. The two other campsites are located in forested valley bottoms below 6,500 ft (2 000 m). Campsite 21 along the West Fork of the Wallowa River is a heavy-use site, while campsite 22 on the West Fork of the Lostine River is a moderate-use site.

The two campsites in timberline meadows had lost only 10 percent of their vegetation cover, the change in species composition had been negligible, and there was only 3 to 4 percent more bare ground on campsites than on controls. These measures are dramatically lower than any of the other campsites studied. Visual impact is also less (fig. 17), as is reflected in the low condition class ratings of 1.0 and the impact ratings of 1.20 and 1.17.

Although there is a popular belief that timberline meadows are unusually fragile, studies have consistently shown the relative resistance of *Carex nigricans* (black alpine sedge) meadows, the vegetation type in which these sites are located (Campbell and Scotter 1975; Hartley 1976). These meadows are susceptible to impact during early summer snowmelt, but by the time they dry enough to be usable, they are extremely durable sites.

The lower elevation campsites, in contrast, have been as highly altered as the most heavily impacted subalpine forest sites (fig. 18). Only two other sites have higher overall impact ratings, and the reduction in duff depth on these sites is particularly severe. This supports the results of an earlier study in the Eagle Cap Wilderness which found that more vegetation change had occurred on forested sites, regardless of elevation, than on open grassland or meadow sites (Cole 1981a).

Table 11.--Selected conditions and amount of change on campsites located in alpine *Carex nigricans* meadows (15 and 20) and forests below 2 000 m (21 and 22)

Impact parameter	Campsites			
	15	20	21	22
Bare area (m^2)	1	2	101	68
Mutilated trees (percent)	--	--	100	100
Camp seedlings (number/ha)	--	--	0	0
Control seedlings (number/ha)	--	--	0	3,980
Absolute change (number/ha)	--	--	0	3,980
Relative change (percent)	--	--	0	100
Camp vegetation (percent)	88	80	3	5
Control vegetation (percent)	98	90	60	40
Absolute change (percent)	10	10	57	35
Relative change (percent)	10	11	95	88
Camp bare ground (percent)	5	4	20	35
Control bare ground (percent)	1	1	1	1
Absolute change (percent)	-4	-3	-19	-34
Relative change (percent)	-400	-300	-1,900	-3,400
Camp duff depth (cm)	--	0.3	0.6	0.1
Control duff depth (cm)	--	.9	3.4	1.0
Absolute change (cm)	--	.6	2.8	.9
Relative change (percent)	--	67	82	90
Floristic dissimilarity (percent)	25	37	53	84
Condition class	1.0	1.0	4.0	3.5
Impact rating	1.20	1.17	2.43	2.38

Figure 17.--Campsite 20 is located in a timberline meadow at Glacier Lake. Impacts were considerably less pronounced than on forested campsites.

Figure 18.--Campsite 21 is located in lower elevation forests along the West Fork of the Wallowa River. Impacts were as pronounced as on campsites located in subalpine forests.

Are Lakeshore Sites Particularly Fragile?

Lakeshore setbacks are becoming increasingly common in wilderness. Eagle Cap Wilderness regulations prohibit camping within 200 ft (61 m) of any lake. A common justification for this practice is that lakeshores are more fragile than sites set back from the lake. This supposition was tested by comparing conditions on five heavy-use sites located within 200 ft (61 m) of lakes and five heavy-use sites located more than 200 ft (61 m) from lakes.

For the last few years, camping has been prohibited on the lakeshore sites, but enforcement has been difficult. We observed approximately the same numbers of parties still camping on illegal sites as on legal sites. Moreover, lakeshore sites were almost always the longest established sites and the sites that traditionally have received the most use. Therefore, in generalizing about the use history of these two sets of sites, one can safely assume that most lakeshore sites have been more heavily used for a longer period of time, but that in recent years, both sets have received relatively similar amounts of use.

In comparison to setback sites, lakeshore sites tend to be somewhat larger, but less of the site is devoid of vegetation (table 12). They have fewer seedlings, but more vegetation cover, with a species composition that has been less highly altered than that on setback sites. Bare ground is less extensive, but the organic horizons are thinner. Soil pH, Ca concentration, and bulk density are all lower on lakeshore sites. Most of these differences are minor, however, in comparison to highly variable site conditions. Consequently, none of these differences were statistically significant at the 0.05 significance level using the Kolmogorov-Smirnov two-sample test (Siegel 1956).

Table 12.--Campsite conditions on lakeshore sites and sites located more than 200 feet from the lakeshore

Impact parameter	Lakeshore sites (N = 5)		Setback sites (N = 5)	
	Median	Mean	Median	Mean
Camp area (m^2)	219	233 ± 37	190	175 ± 76
Bare area (m^2)	92	108 ± 32	139	123 ± 66
Seedlings (number/ha)	274	377 ± 301	637	994 ± 728
Mutilated trees (percent)	96	90 ± 11	99	95 ± 6
Trees with exposed roots (percent)	40	38 ± 25	38	41 ± 32
Felled trees (percent)	34	29 ± 13	33	38 ± 17
Scarred trees (percent)	17	21 ± 28	5	22 ± 24
Floristic dissimilarity (percent)	50	58 ± 18	66	64 ± 11
Vegetation cover (percent)	8	7 ± 3	3	3 ± 2
Bare ground (percent)	24	37 ± 25	41	43 ± 15
Litter (percent)	59	50 ± 24	50	48 ± 20
Duff depth (cm)	0.13	0.16 ± 0.08	0.20	0.20 ± 0.14
pH	5.40	5.48 ± 0.19	5.65	5.68 ± 0.13
Instantaneous infiltration rate (cm/min)	0.26	0.35 ± 0.25	0.28	0.29 ± 0.03
Saturated infiltration rate (cm/min)	0.09	0.12 ± 0.08	0.14	0.13 ± 0.03
Mg (p/m)	63	72 ± 29	60	81 ± 39
Ca (p/m)	475	538 ± 195	587	762 ± 301
Na (p/m)	56	60 ± 13	50	49 ± 4
Organic matter (percent)	19	23 ± 8	17	16 ± 4
Bulk density (g/cm^3)	0.79	0.86 ± 0.20	0.95	0.98 ± 0.07
Impact rating	2.2	2.2 ± 0.1	2.1	2.1 ± 0.3

When relative and absolute amounts of change were compared, differences in the amount of change in seedling density and pH were the only statistically significant differences. Lakeshore sites had lost 97 percent of their seedlings, compared to 75 percent on sites set back from the lakes. Soil pH increased 9 percent on lakeshore campsites, compared to 13 percent on setback sites. For all of the other parameters measured, the amount of change was essentially the same on the two sets of sites.

Given that seedling loss is the only impact which is more extreme on lakeshore sites, the contention that lakeshores are more fragile appears to be unfounded. In trampling experiments conducted in Waterton Lakes National Park, Nagy and Scotter (1974) found less vegetation change in a subalpine lakeshore meadow community than in the coniferous forests away from lakes. This is not to say, however, that there are no justifiable reasons for prohibiting camping close to lakeshores.

Although water quality studies show little evidence of human health hazards associated with heavy use of backcountry lakes (McDowell 1979), there is some evidence that ionic concentrations and benthic plant populations can be altered by heavy use (Taylor and Erman 1979). Where lakes are uncommon and attract abnormally large numbers of visitors, there may be some danger that all of the lakes will be altered by human use. In this case, the justification for setbacks is not that lakeshores are more fragile, but that the lake ecosystem is rare and should receive special protection.

Another justification for setbacks is that more trails tend to develop between campsites and the lakeshore when the site is located close to the lake. This causes more esthetic and ecological impact--not because the lakeshore site is more fragile, but because the flow of traffic between campsite and lakeshore is more destructive.

There are also a number of sociological justifications. Lakes are commonly primary scenic attractions in wilderness areas and should, therefore, be left as pristine as possible. Moreover, parties camping on the lakeshore effectively claim that territory as their own, prohibiting other parties from having free access to the lakeshore (Hendee and others 1977). Finally, the perception of solitude is increased by moving people back from lakeshores because their visibility is decreased and noise does not carry as readily.

Prohibitions on camping close to lakes keep visitors from camping where they most like to camp. The old, traditional campsites were inevitably located close to lakeshores. Managers will need good, justifiable rationales if they are going to convince visitors to camp away from the preferred lakeshores. The argument that mountain lakeshores are more fragile than adjacent areas is generally not tenable. Managers should carefully consider other justifications for setbacks and avoid basing policy on what is often an erroneous argument.

EVALUATION OF IMPACT INDICATORS

Wilderness managers have recognized a need to monitor campsite impacts so they have some objective measure of the changes occurring on a site. Moreover, this is now a requirement under the National Forest Management Act. Most monitoring programs will not be able to measure change in the detail achieved in this study. More often, simple, rapid techniques which can be utilized by personnel with little training will be needed.

One simple system, developed by Frissell (1978), uses condition classes based on visual criteria as follows:

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

We gave each campsite a condition class rating and then correlated these ratings and other possible impact indicators with campsite condition and change to see how well they predicted impact (table 13).

Frissell's condition class rating was the indicator which correlated most highly with the overall impact ratings. It was also significantly correlated with more measures of impact than any of the other indicators. It is not surprising that condition class is correlated with trees with exposed roots, vegetation cover, or bare ground because these are characteristics used in the derivation of the rating. The rating, however, also predicted the amount of change in vegetation and bare ground that has occurred, as well as the change in duff depth, floristic dissimilarity, camp area, and bare area. These include most of the impacts which could be noticed by visitors, as well as all of the impacts which are related to amount of use. Soil impacts are notably unrelated to condition class.

Camp radius and bare radius are impact indicators originally used in Olympic National Park by Schreiner and Moorhead (1976). Both of these indicators are significantly correlated with the overall impact ratings, although not as highly as condition class. Neither of these indicators are consistently correlated with any of the measures of impact intensity. They do, however, provide good estimates of the areal extent of impacts.

Table 13.--Kendall tau correlation coefficients relating campsite impact parameters and impact indicators which might potentially be utilized in a monitoring program. Nonsignificant and redundant relationships have been left blank

	Potential indicators of impact						
Impact parameter	Condition class	Camp radius	Bare radius	Vegetation cover	Bare ground	Trees with exposed roots	Impact class
Camp area	0.38		0.50				0.35
Bare area	.43	0.52		-0.37			.34
Mutilated trees			.36	-.27		0.41	
Trees with exposed roots	.40						
Floristic dissimilarity	.46	.36	.26				.59
Seedlings							
Seedling change (absolute)	.31	.40	.24				.49
Seedling change (relative)							
Vegetation cover	-.48		-.35				
Vegetation change (absolute)	.39					.44	.37
Vegetation change (relative)	.50				0.26		
Bare ground	.36						.32
Bare ground change (absolute)	-.34						-.37
Bare ground change (relative)	-.33					-.32	-.39
Duff depth			.33		-.50		
Duff depth change (absolute)	.31				.37		.48
Duff depth change (relative)	.32				.47		.54
pH							
pH change (absolute)			-.33	.30			
pH change (relative)			-.32	.32			
Instantaneous infiltration			-.30				
Infiltration change (absolute)				.35			.28
Infiltration change (relative)				.35			.34
Bulk density				-.36	.36		
Density change (absolute)	-.33			.44	-.33	-.29	
Density change (relative)				.39		-.33	
Impact rating	.50	.38	.32		.32		

Vegetation cover, bare ground, and trees with exposed roots are generally poor indicators of impact, although, surprisingly, vegetation cover is the best indicator of soil changes. Impact rating was included because it should have been highly correlated with the impact measures. It did not, however, predict amount of impact any better than condition class, despite the time and effort required to obtain the impact rating.

At least, for the campsites studied, it appears that Frissell's condition class rating is the best single indicator of campsite condition. Although it does not identify soil changes very well, it does provide a good indication of overall impact, as well as those changes that use management can influence--bare ground and duff depth, in particular. It also is correlated with the areal extent of impacts, although a supplemental measure of camp radius or bare radius could provide valuable additional information.

There were a number of problems with the condition class ratings, however. The biggest problem was the breadth of some of the categories. Despite variability in site conditions, amount of change, and amount of use, 71 percent of the campsites received a condition class rating of 4. In fact, much of the success of this system as an indicator of impact may simply be its ability to separate a few less heavily impacted sites from this majority of sites. To be useful, Condition Class 4 will need to be subdivided so that the concentration of consistently used campsites in this one class is not so high.

Another major problem is that this rating does not describe the condition of individual measurable parameters. For example, it provides no baseline measure of vegetation cover that could be referred to at a later date to see if cover has changed. In other words, the rating provides a good measure of overall campsite condition, but little information about specific conditions. Managers desiring more specific quantitative information will need to use some other measure, such as percent bare ground or vegetation cover.

Finally, many campsites could be given different ratings depending upon the evaluative criteria chosen. For example, some campsites had exposed tree roots (Condition Class 4), but little bare mineral soil (Condition Class 3). We gave these sites a rating of 3.5. Perhaps a system of separate subjective ratings of ground vegetation, bare mineral soil, tree root exposure, and soil erosion, the main criteria in Frissell's system, along with a measure of areal extent, could avoid most of these problems and still remain highly correlated with overall impact. More research is obviously needed.

CONCLUSIONS AND MANAGEMENT IMPLICATIONS

The median campsite in this study has changed in the following ways:

1. From 85 to 90 percent of the undergrowth vegetation has been removed from the 2,150-ft^2 (200-m^2) camp area, leaving a sparse vegetation cover quite dissimilar in composition to undisturbed sites;
2. About 30 percent of the organic litter layer has been worn away, exposing patches of mineral soil;
3. This loss of vegetation and litter has been most pronounced toward the center of the site where essentially no vegetation persists and 50 percent of the organic horizons have been removed;
4. Essentially all of the trees on the site have been damaged, at least slightly, by recreational use; one-fourth of the trees have been felled and another one-fourth exhibit substantial trunk scarring;
5. Soil erosion has exposed roots on about one-third of the trees;
6. Over 90 percent of the seedlings have been eliminated; the few remaining seedlings are confined to sites protected from human trampling;
7. The soil has been compacted, although even on the most highly disturbed parts of the campsites, bulk density has increased only 15 percent and infiltration rates have decreased only about 30 percent; and
8. The organic content of the surface soil has increased slightly, as have the pH and the concentration of exchangeable Mg, Ca, and Na ions.

In order to utilize this information, the significance of these changes must be questioned. In terms of an ideal wilderness, all of these changes are significant because they represent deviations from natural conditions. This definition of significance cannot be practically applied to campsites, however, because some impact is necessary just to make the campsite functional. For example, the shrubby understory on most of these campsites must be removed before the site makes a comfortable sleeping area.

Given that a certain amount of impact is inevitable whenever a campsite receives consistent and prolonged use, a significant impact might best be defined as any change which reduces the future utility and desirability of the campsite. In other words, a significant impact would be any change that threatens to make the site either nonfunctional or undesirable.

Most site impacts do not appear to sharply reduce site desirability. Although more definitive research is needed, most evidence suggests that visitors seldom notice or are bothered by impacts on campsites (Lucas 1979). In a study in Yosemite National Park, for example, Lee (1975) found that "the use of wood for fires, destruction of ground cover, damage to trees, and other ecological changes in a pristine environment had less influence on the visitor than the presence of 'unnatural' objects," such as litter, horse manure, or constructed facilities.

Of the changes found on campsites, the impact most likely to decrease the future desirability of the campsites is the loss of seedlings and saplings which may forecast the eventual deforestation of campsites. A number of studies have shown that most campers prefer campsites that are shaded to those in the open (for example, Cordell and James 1972). Another study has shown that, contrary to their stated preferences, visitors to a developed campsite usually chose largely devegetated sites (Hancock 1973). This suggests that maintenance of the overstory is probably more important than maintenance of the understory. It is also more feasible. Maintenance of native understory populations, except on protected sites, is realistically impossible because trampling cannot be eliminated. The overstory could be maintained by establishing tree seedlings on protected sites, behind logs or rocks where they will not be trampled, and then ensuring, through an educational program, that they are not cut down as they mature.

The impact most likely to reduce the functional ability of a campsite is long-term erosion. While erosion was not directly measured in this study, tree-root exposure should provide some indication of the amount of erosion which has occurred on a site. When these sites are reexamined in 1984, we will have a better idea of the magnitude of long-term erosion. Informal observations suggest that severe erosion is rare because campsites are usually flat and because compaction reduces the detachability of soil particles, inhibiting erosion by surface runoff. Managers should, however, consider closing sites on which severe erosion is obvious. Those sites will eventually become unusable and, at that point, will be essentially impossible to rehabilitate.

The common assumption that deteriorated campsites are a result of overuse is true by definition; their deteriorated conditions are a result of "too much" use. This study shows, however, that on the campsites studied, even a few nights of use per year are usually "too much," because this use causes most of the change which is likely to occur on a campsite.

Of the 27 impact measurements taken, only seven increase significantly in magnitude when campsite use increases over the range of use included in this study (that is, about a fiftyfold increase from less than one night per year to perhaps as much as 50 nights per year). Reductions in seedling density, vegetation cover, and duff depth, and increases in bare ground, bare area, trees with exposed roots, and floristic dissimilarity of the undergrowth become more pronounced as use increases. For loss of seedlings and vegetation cover, more than 75 percent of the change occurs, however, on light-use sites (fig. 19). In both cases, essentially any consistent annual use eliminates almost all of the seedlings and undergrowth. Thus, the statistically significant correlation with use does not seem to be very meaningful in either a biological or a managerial sense.

The variables which do show meaningful differences related to amount of use are bare ground, bare area, duff depth, floristic dissimilarity, and trees with exposed roots. As use increases from light to moderate amounts, organic litter continues to be removed, creating more bare ground and reducing duff depth; more tree roots are exposed; the central area devoid of vegetation increases in size; and the composition of the undergrowth continues to change. The size of the site also appears to increase, although this difference was not statistically significant.

As use surpasses moderate amounts--probably 10 to 20 nights per year--further increases in use cause little additional change in any of the variables other than duff depth, which continues to decrease dramatically with increased use.

The two major implications of these results are:

1. **Any** annually repeated use of campsites in this environmental situation will cause major onsite ecological changes;

2. Even fiftyfold use reductions will do relatively little to reduce campsite impacts.

These results only apply strictly to campsites near lakeshores, in *Abies lasiocarpa/Vaccinium scoparium* forests of the Eagle Cap Wilderness, between 7,050 and 7,800 ft (2 150 and 2 400 m), on soils derived from granite bedrock. Similar results, however, were also reported by Fichtler (1980) in two Montana areas. Working in *Abies lasiocarpa* forests, with an undergrowth different from that in Eagle Cap on volcanic soils between 5,600 and 7,250 ft (1 700 and 2 200 m), he found that the only significant difference between light- and heavy-use sites was more exposed mineral soil on heavy-use sites.

Less fragile sites, such as low-elevation grasslands, could probably support more use before near-maximum levels of impact were achieved, but even on a low-elevation campground in Pennsylvania in "abandoned field" vegetation on deep, well-drained and productive silt loam flood plain soils, LaPage (1967) found that "the relationship between barren ground and cumulative man-days of use weakened and disappeared entirely" after the campground was 3 years old. More research is needed, but it appears clear that low levels of annual use are sufficient to cause most of the change which is likely to occur on a site. In relatively fragile high-elevation forests where a large proportion of wilderness campsites are located, this threshold appears to be no higher than a few nights of use per year.

In deciding how best to manage impacts, it is important to distinguish between impact intensity and the total aggregate area of impact. The conclusion of this study is that increasing or reducing use has very litle effect

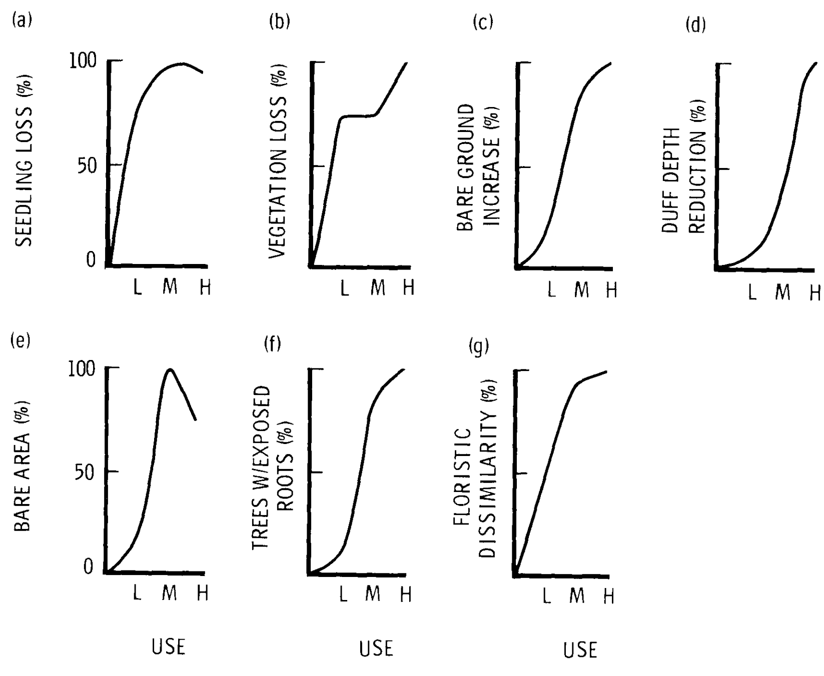

Figure 19.--The relationship between amount of use and amount of impact for those variables with a statistically significant relationship: (a) percent reduction in seedling density; (b) percent reduction in vegetative cover; (c) absolute increase in bare ground; (d) percent reduction in duff depth; (e) bare area; (f) percent of trees with exposed roots; and (g) floristic dissimilarity. For each use category, the median change is expressed as a percentage of the highest median value for any use category.

on impact intensity, such as the magnitude of vegetation loss. Impact intensity can be more effectively minimized through improved campsite location and changes in visitor behavior.

The good condition of campsites in *Carex nigricans* meadows, in relation to forested sites, suggests the value of improved campsite location. Schreiner and Moorhead (1976), for example, have shown that the bare area of a campsite varies primarily with differences in vegetation. Many studies have shown that sites dominated by graminoids will usually suffer less vegetation loss than sites dominated by shrubs, such as those in this study. Managers might consider closing badly deteriorated sites, particularly those experiencing severe erosion, and opening new sites in more durable locations if necessary.

Visitor behavior can be changed through either minimum-impact camping education or regulations on type of use. A change in visitor behavior could eliminate the scarring and felling of trees and reduce some of the impact on soil chemistry through more careful use of fire and reduced pollution. On the other hand, it can do little to reduce vegetation and litter loss, the increase in bare ground, and soil compaction. These are inevitable consequences of use that are probably acceptable to most visitors, and, in most cases, pose no threat to the long-term usefulness or desirability of the campsite. It might be worth informing people of the problem with tree reproduction, however, in the hope that they might be careful to avoid trampling established seedlings.

Regulations on type of use could also be useful. If effective, a campfire prohibition could at least reduce damage to live trees and changes in soil chemistry. Keeping horses out of camp areas could reduce damage to trees, trampling of seedlings and other undergrowth, soil erosion and tree root exposure, and the size of campsites. Managers must decide if the potential for improvement in site conditions is worth the imposition of regulations.

In contrast to its limited effect on the intensity of impacts on existing campsites, use redistribution could have a pronounced effect on the total aggregate area of impacts. In areas where the amount of use is high enough that annually repeated use of campsites--even once a year in many places--is likely to occur, the area of impact could be reduced by encouraging repetitive use of fewer campsites. Use dispersal, in this situation, will usually increase the number of deteriorated campsites, with little compensatory improvement in conditions on former heavy-use sites. In the Eagle Cap Wilderness, for example, we heard complaints that many areas that were pristine a few years ago now have impacted campsites.

In areas that receive at least moderate amounts of use, such as all the lakes in this study reached by trail, repetitive use of few sites could probably be achieved by merely asking people to camp on previously used sites. In most areas, it should not be necessary to officially designate "legal" campsites, as many areas in the National Park Service and Parks Canada do. Impacts could then be further reduced by closing some campsites in areas having more campsites than necessary. Some lakes in the Eagle Cap Wilderness, for example, are encircled by more than 100 campsites.

In areas where use is very low, dispersal could minimize impacts. This policy requires extreme caution, however, to insure that repeat use of sites does not occur before the site can recover. If it does, campsites will deteriorate over time and the number and total aggregate area of campsite impacts will increase greatly.

A program of education in minimum-impact camping techniques is a prerequisite for a dispersal policy. Visitors must be well educated **before** dispersal will work. Many National Park Service and Parks Canada areas also prohibit fires in areas of dispersed camping to reduce the potential for campsite change. A final necessity is a monitoring program capable of evaluating how well the program is working.

Many types of monitoring programs could be suggested. In highly dispersed-use settings, an inventory of sites showing signs of human use may be adequate. In areas which receive more consistent use, more information on site conditions would be desirable. If a manager does not need quantitative baseline data on specific campsite conditions, such as amount of vegetation cover, some modified[7] version of Frissell's condition classes would provide a good measure of overall site condition. When combined with a measure of campsite or bare area, an inventory of campsites utilizing these two measures should enable the manager to identify trends both in the intensity of impact on individual sites and the areal spread of impacts, either through the enlargement of sites or the proliferation of new campsites.

In many cases, however, managers may need more detailed information on site conditions. Measurements of this type are much more costly because they require precise replication of previous measurements. Our research suggests that percent bare ground measurements are probably the most valuable because, unlike most impact parameters, bare ground varies in response to amount of use. Managers could attempt to manage use in such a manner that bare ground does not increase. Once the cost of precise replication is accepted, however, additional measurements are relatively cheap and should be given serious consideration. In particular, some measure of the campsite or bare area should be taken to supplement measures of impact intensity.

[7] In addition to modifying some of the overly broad categories, managers may also need to redefine categories to more accurately reflect their environmental situation. As suggested previously, a system of separate subjective ratings of ground vegetation, bare mineral soil, tree root exposure, and soil erosion, the main criteria of Frissell's system, along with any additional parameters of concern, might be particularly useful

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APPENDIX

THE DISTRIBUTION OF VASCULAR PLANT SPECIES ENCOUNTERED ON CAMPSITES OR CONTROL PLOTS.

	Frequency of occurrence[1]		Mean cover[2]		Mean relative cover[2]	
Species	Camps	Controls	Camps	Controls	Camps	Controls
Achillea millefolium	0	3	0	+	0	0.4
Agrostis thurberiana	1	0	+	0	0	+
Agrostis variabilis	4	4	+	.4	0.4	.3
Allium validum	0	2	0	+	0	+
Antennaria alpina	4	16	0.2	1.0	1.5	1.6
Antennaria lanata	9	14	.3	2.1	2.5	3.4
Antennaria microphylla	0	1	0	+	0	.1
Arabis lyallii	1	0	+	0	.7	0
Arabis sp.	0	1	0	+	0	.1
Arenaria aculeata	0	5	0	.1	0	.4
Arnica cordifolia	1	3	0	.1	0	.3
Arnica mollis	1	5	.1	.5	.1	.5
Arnica parryi	0	1	0	+	0	+
Aster alpigenus	5	4	.1	.3	1.4	.4
Carex geyeri	1	2	.1	.1	.8	.2
Carex luzulina	0	1	0	+	0	+
Carex microptera	4	5	.2	1.7	2.6	1.7
Carex nigricans	1	2	+	.5	.1	.8
Carex rossii	19	20	.6	1.2	13.4	3.0
Carex scopulorum	0	2	0	0.5	0	0.5
Carex spectabilis[3]	5	6	0.3	.3	2.6	.7
Cassiope mertensiana	2	3	+	.3	+	.2
Castilleja chrysantha	1	6	+	.2	+	.2
Danthonia intermedia	3	6	+	.4	.4	.4
Deschampsia caespitosa	0	2	0	.6	0	.5
Dodecatheon alpinum	1	1	+	+	+	+
Epilobium alpinum	2	2	+	+	+	+
Epilobium angustifolium	1	6	+.1	+	.1	
Epilobium sp.	0	1	0	+	0	+
Erigeron peregrinus	9	16	.1	1.2	2.9	1.5
Eriogonum flavum piperi	0	1	0	+	0	.3
Eriogonum ovalifolium	3	1	+	+	.3	+
Festuca viridula	4	14	.3	1.6	2.1	2.4
Gaultheria humifusa	1	5	+	.6	.1	.6
Gayophytum humile	2	1	+	+	+	+
Gentiana calycosa	0	2	0	.2	0	+
Hieracium albertinum	1	2	0	+	0	.3
Hieracium gracile	4	14	+	.3	.3	.6
Holodiscus discolor	0	1	0	+	0	.1
Hypericum anagalloides	1	0	+	0	+	0
Hypericum formosum	0	6	0	0.4	0	0.4
Juncus drummondii	1	3	+	+	.2	+
Juncus mertensianus	0	1	0	+	0	+
Juncus parryi	20	21	1.7	6.2	21.2	12.4
Ledum glandulosum	1	4	+	.7	+	.6
Lewisia pygmaea	1	0	+	0	+	0
Ligusticum tenuifolium	4	5	+	.1	+	.1
Linanthastrum nuttallii	0	1	0	+	0	+
Lonicera utahensis	0	1	0	+	0	+
Luzula campestris	0	1	0	+	0	+
Luzula hitchcockii	7	9	.4	1.8	4.7	2.9
Muhlenbergia filiformis	9	10	.2	.9	2.5	.7

Continued

APPENDIX (Con.)

THE DISTRIBUTION OF VASCULAR PLANT SPECIES ENCOUNTERED ON CAMPSITES OR CONTROL PLOTS.

	Frequency of occurrence[1]		Mean cover[2]		Mean relative cover[2]	
Species	Camps	Controls	Camps	Controls	Camps	Controls
Oryzopsis exigua	1	6	+	.1	.8	.5
Osmorhiza chilensis	0	1	0	+	0	+
Parnassia fimbriata	0	1	0	+	0	+
Pedicularis contorta	0	1	0	+	0	+
Penstemon fruticosus	0	2	0	+	0	.2
Penstemon rydbergii	1	4	0	.3	.4	.6
Phleum alpinum	4	4	+	.3	.2	.2
Phyllodoce empetriformis	12	18	.3	8.8	4.5	10.6
Poa annua	1	0	+	0	.1	0
Poa gracillima	0	1	0	+	0	+
Poa leibergii	0	1	0	+	0	.1
Poa sandbergii	0	1	0	+	0	+
Poa sp.	0	2	0	+	0	+
Polemonium pulcherrimum	1	4	+	0.1	+	0.4
Polygonum phytolaccaefolium	1	4	+	.2	1.2	.4
Potentilla diversifolia	0	1	0	+	0	+
Potentilla flabellifolia	5	6	.1	2.1	.9	1.8
Potentilla glandulosa	0	1	0	+	0	.1
Potentilla gracilis glabrata	0	1	0	+	0	+
Ranunculus eschscholtzii	0	2	0	+	0	+
Ranunculus populago	1	1	+	+	+	+
Sagina saginoides	2	0	.1	0	.9	0
Senecio cymbalarioides	0	2	0	.5	0	.3
Spergularia rubra	1	0	+	0	+	0
Trisetum spicatum	0	6	0	.4	0	.7
Trisetum wolfii	0	1	0	.2	0	.1
Vaccinium caespitosum	1	4	.1	.7	.5	1.5
Vaccinium scoparium	19	21	.6	19.1	12.6	26.4
Veratrum viride	1	2	+	+	.2	+
Veronica cusickii	9	14	.2	1.9	1.9	2.6
Veronica serpyllifolia	1	0	+	0	+	0
Veronica wormskjoldii	1	0	+	0	+	0
Viola adunca	3	5	+	.3	.1	.3

[1]Number of sites out of a maximum of 22 on which the species was found.

[2]Mean cover is the actual canopy coverage of the species, while relative cover expresses actual cover as a percentage of the total cover on the site. A plus (+) indicates less than 0.1 percent cover.

[3]This species was determined by Charles Feddema to be *C. tolmei* Boott, which Hitchcock and Cronquist (1973) consider to be synonymous with *C. spectabilis*. Some authorities equate *C. tolmei* with *C. paysonis* Clokey (Hermann 1970).

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Cole, David N.

1982. Wilderness campsite impacts: effect of amount of use. USDA For. Serv. Res. Pap. INT-284, 34 p. Intermt. For. and Range Exp. Stn., Ogden, Utah 84401.

Subalpine lakeshore campsites were studied in the Eagle Cap Wilderness, Oreg. Light-use campsites had experienced almost as much alteration as moderate- and heavy-use sites. Sites set back from lakeshores had changed as much as lakeshore sites. Selected indicators of ecological change were evaluated. Implications of this research to management of wilderness campsites are discussed.

KEYWORDS: ecological impact, campsites, wilderness management

The Intermountain Station, headquartered in Ogden, Utah, is one of eight regional experiment stations charged with providing scientific knowledge to help resource managers meet human needs and protect forest and range ecosystems.

The Intermountain Station includes the States of Montana, Idaho, Utah, Nevada, and western Wyoming. About 231 million acres, or 85 percent, of the land area in the Station territory are classified as forest and rangeland. These lands include grasslands, deserts, shrublands, alpine areas, and well-stocked forests. They supply fiber for forest industries; minerals for energy and industrial development; and water for domestic and industrial consumption. They also provide recreation opportunities for millions of visitors each year.

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