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Leave Only Footprints?

How Backcountry Campsite Use Affects Forest Structure

Photo James Taylor

by James Y. Taylor

Decades ago, Aldo Leopold stated that it would not be logging, mining, or roads that would threaten the wilderness, but the people who came to visit these areas. Although many camping-induced impacts may initially be subtle, campsites receive the greatest impact of any backcountry areas and land managers are concerned that cumulative and accelerated changes may be occurring. If management strategies and practices to conserve wilderness environments are to be developed, measurements of the impacts and environmental changes are essential. One such impact that had not been researched was that of camping-related activities on the forest structure surrounding backcountry campsites.

To determine if such changes are measurable, I studied 30 campsites in Yellowstone National Park (YNP) during 1993 and 1994.

My hypotheses were that:

- The density of tree saplings up to 140 cm (4.6 ft) height would increase as distance from the campsite increased.
- The forest structure around campsites would be measurably different depending on user type, i.e., sites used by backpackers compared to those used by campers arriving by canoes and motorboats.
- More annual campsite users would correlate with a larger area of impact.

This research was conducted as part of a master's degree program within the Department of Earth Science at Montana State University in cooperation with Tom Olliff of the Backcountry Office in Yellowstone, with funding provided by the Yellowstone Center for Mountain Environments (now the Mountain Research Center) at Montana State University. David Cole, of the Aldo Leopold Center for Wilderness Research, Intermountain Research Station, U.S. Forest Service, also provided financial and technical support which proved invaluable.

Previous Research

Research within mountainous environments (Cole 1982, 1989) has shown that forest tree species and other woody vegetation are more susceptible to damage by trampling than are forbs. In the Eagle Cap Wilderness (Cole 1986) and the Bob Marshall Wilderness (Cole 1983), saplings were found to be more susceptible to trampling than were mature trees, and almost all saplings within campsite areas were eliminated because of trampling. The forest regeneration that did occur took place within isolated pockets of campsites where young trees were protected by mature trees.

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Increasing campsite use has been positively correlated with increased impacts. It has been found that even with low use, campsite degradation, reductions in tree density, and changes in the percent of understory vegetation have occurred within mountain environments of the western United States. Studies of human use and campsite impacts have shown that the most influential factors of recreational impact included user behavior and mode of travel.

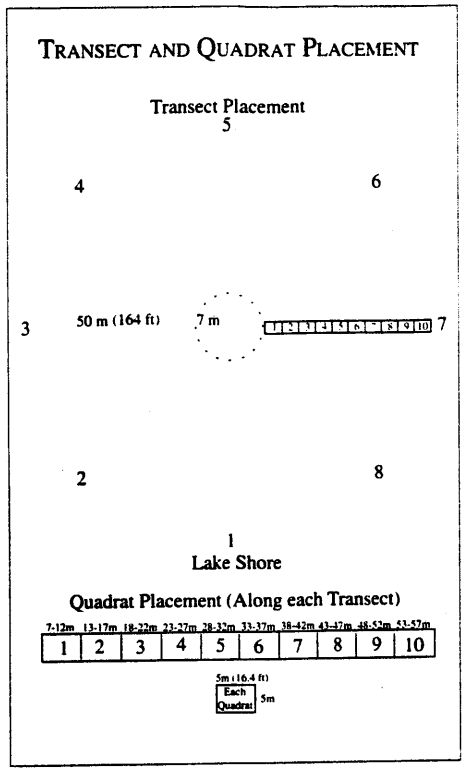
Sampling Method

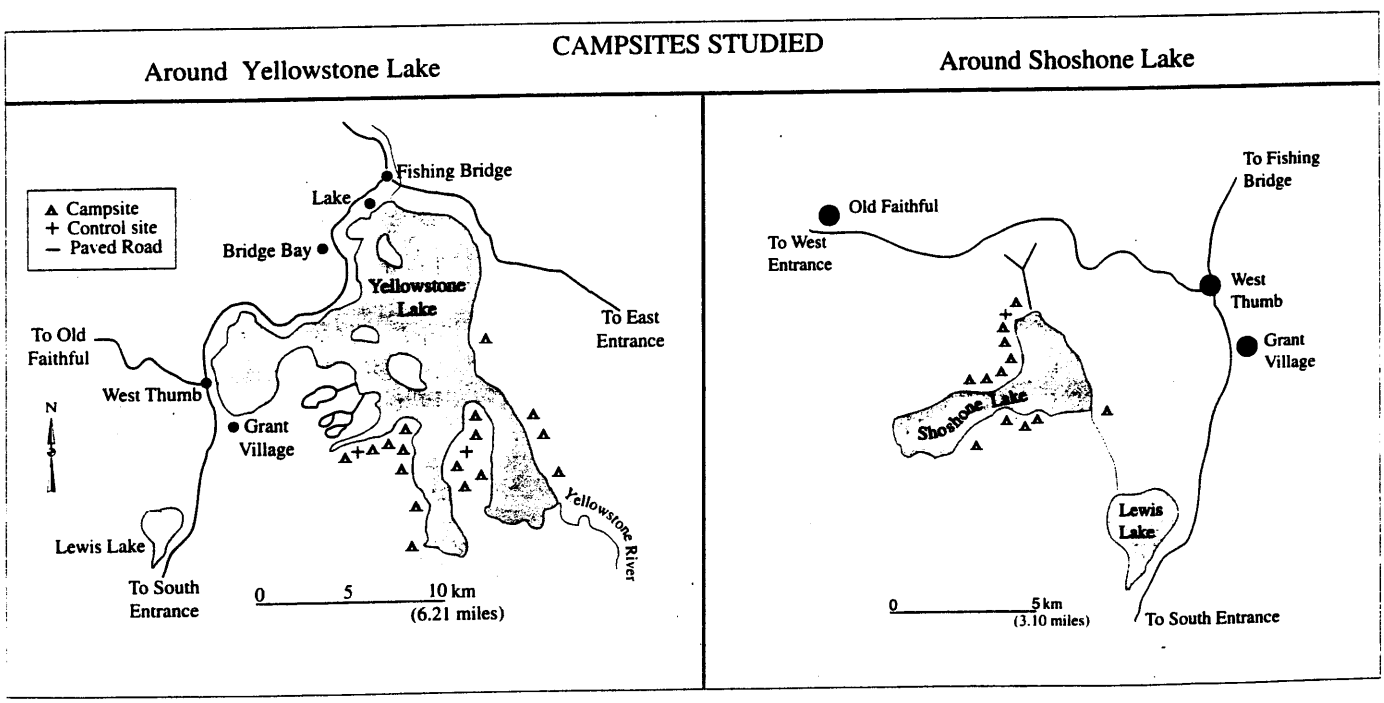
We chose YNP for this study because it has data available on the annual numbers of backcountry users and types of use for each campsite. This type of data is rare, and has been lacking in many previous impact studies. Topographic maps, aerial photographs, backcountry user data, surficial geology maps, habitat maps, cover type maps, and previous campsite inventories were used to select backcountry campsites on both Yellowstone Lake and Shoshone Lake, which had multiple user types and an abundance of campsites at similar elevations with similar microclimatic conditions.

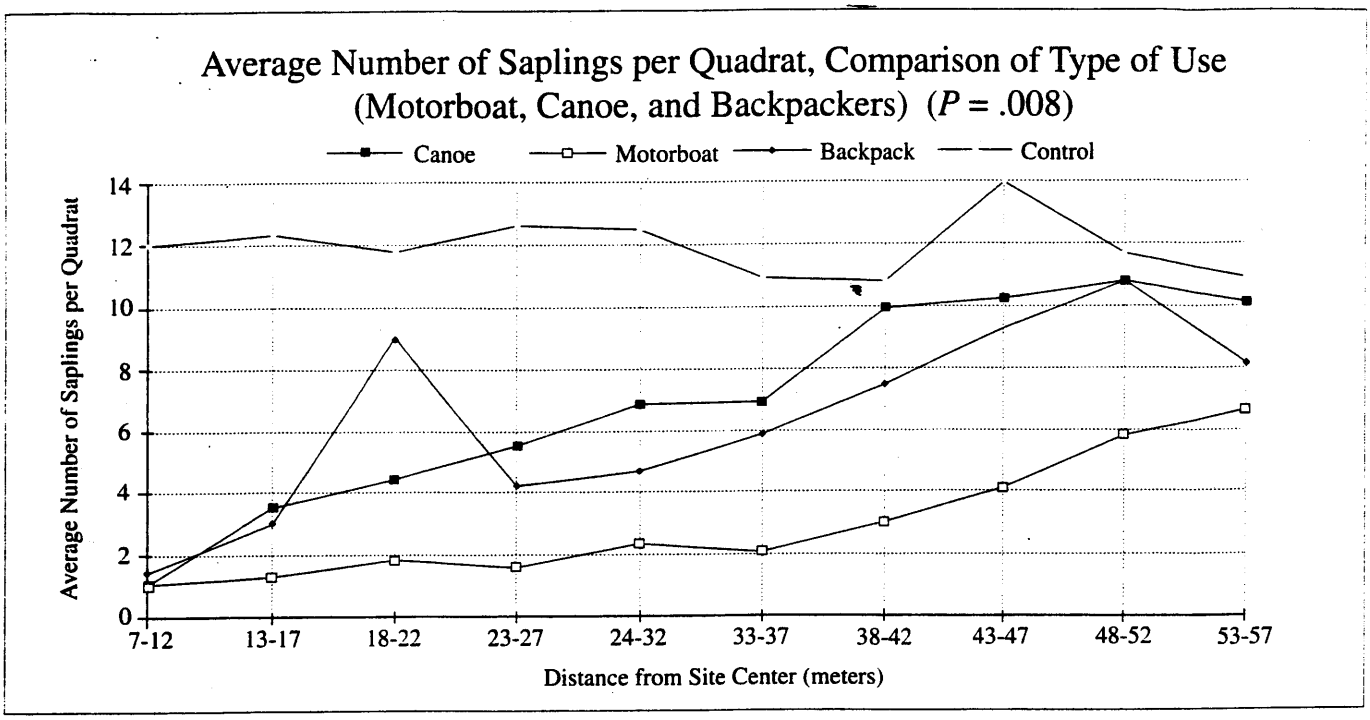
This study included 30 campsites within the lodgepole cover types (LP1 and LP2 as used by Don Despain of the National Biological Service in Yellowstone): 12 were exclusively motorboat sites, 13 were exclusively canoe sites, and 5 were exclusively backpacking sites. (There are no stock sites on Yellowstone or Shoshone lakes.) The average annual number of users at each of the 30 campsites ranged from 37 to 756. To maintain an even rate of regeneration potential, sites in older forests and those recovering from recent fires were not used. Three control sites, which showed no signs of prior use, were measured in the same way as the campsites so that as many natural factors as possible would remain constant. These non-camping control sites were randomly located 1 km along the shoreline from every tenth campsite studied.

Sampling techniques were based on two pilot studies and previous literature. Eight 57-m transects radiated outward from the center of each campsite. The first transect was placed perpendicular from the campsite center to the lake shore, and the other seven transects were placed at 45° angles apart from each other. Along each transect, 10 consecutively placed quadrats 5 x 5-m were sampled, for a total of 2,000 m^2 or 20 percent of the forest surrounding each site. This sampling structure made it possible to collect data on the direction, the intensity, and the spatial extent of camping impacts.

The biotic components sampled included tree size and species, understory vegetation cover, and percent canopy cover. Trees were classified into three classes up to sapling height of 140 cm. For taller trees, trunk diameter at breast height (dbh) measurement allowed classification into two classes of 0-15 and 15+cm. Canopy density was measured by placing a spherical densiometer in the center of each quadrat. Understory vegetation was sampled by type (moss, grass, sedge, forb, shrub) and percent cover.







Effects on Sapling Occurrence

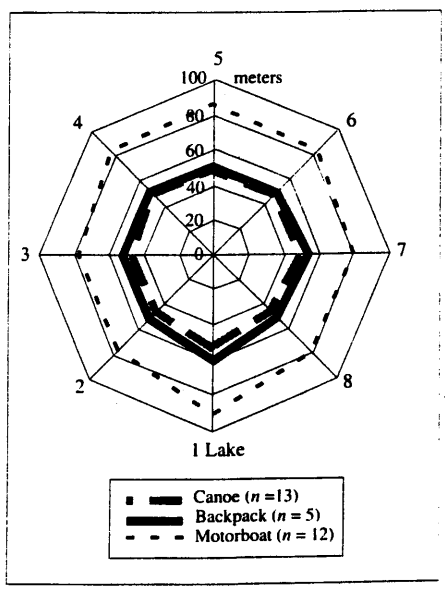
The campsites had an average of 5.22 conifer saplings per quadrat; the control sites had an average of 11.96 saplings per quadrat. This difference in density was significant ($P = 0.00002$), and an important impact that we investigated further. The intercept point where the average number of saplings per quadrat at the campsites equalled the average density at the control sites was graphed. This provides a visual assessment of the change in sapling density showing the spatial extent and possible impact of backcountry use at the campsites.

Density of saplings. The spatial impact and density of saplings around the campsites are best understood by looking at each transect separately. All transects within the campsites were significantly different from those in the control sites. Within the campsites, the average density increased from 1.09 saplings in quadrat 1 to 8.35 saplings in quadrat 10 (farthest from the campsite center), indicating a strong positive correlation ($r = 0.97$) between distance from the center of the site and the density of saplings. The average number of saplings per quadrat increased outward along all campsite transects except in the transect from the center of the site to the lakeshore.

A comparison of the average density of saplings at the three types of campsites shows the different effect each user type had on forest structure. Campsites used by canoe and backpack groups had an average of 6.9 and 6.4 saplings per quadrat, respectively, while sites used by those traveling by motorboat had an average of 2.9 saplings.

Spatial extent. At all campsite types, sapling density increased with distance away from the center of the site; the positive correlations between density and increasing distance for canoe, motorboat, and backpacking use were 0.96, 0.92, and 0.77 respectively. The difference in the average density of saplings at the three campsite types was significant ($P = 0.00000002$). A radar graph compares their spatial impact, i.e., the distance from the center of each campsite type where the average density of saplings equaled the average density at the control sites. The motorboat sites had the largest spatial impact, with an average intercept point that was 82 m from the campsite center.

Number of users. The negative correlation ($r = -0.70$) between the number of backpackers and the number of saplings shows that as use increases, the density of saplings around the campsite decreases. The number of motorboat users and the number of saplings also had a negative correlation ($r = -0.40$). The lack of any substantial correlation ($r = 0.16$) between the number canoe users and saplings indicates uniform density of saplings even as canoe site users increase.

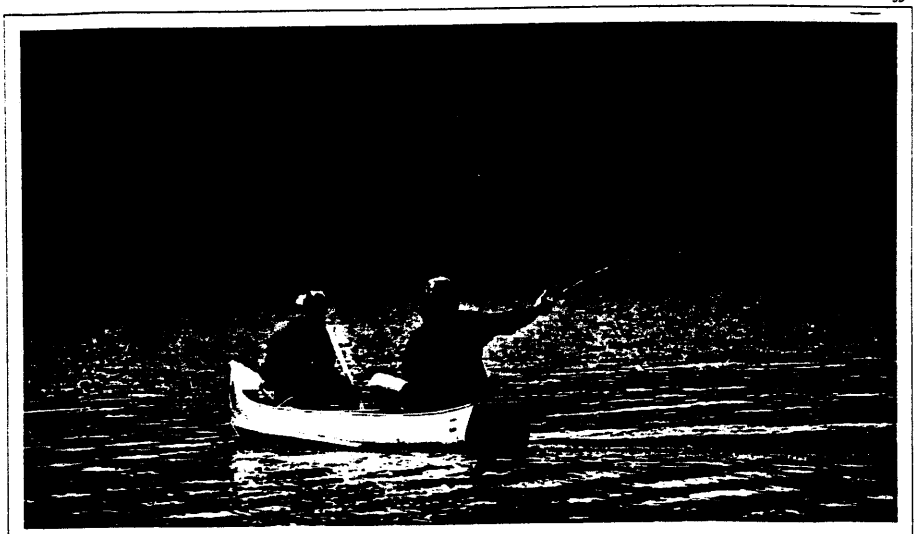


Spatial representation of the distances from the center of campsites in which tree saplings are affected by canoe, backpacking, and motorboat users.

Other Effects on Forest Structure

Forest Canopy. The percent canopy cover in the campsites is an important component of forest structure because

Photo Renee Evanoff



A young couple canoeing from their campsite on Peale Island, Yellowstone Lake.

canopy influences microclimates. A decrease in canopy cover may result in increased amounts of precipitation reaching the forest floor, stronger local forest winds, and increased radiation, which can affect tree survival. According to my research, this aspect of forest structure has also been affected by campsite use. The average percent forest canopy cover differed significantly ($P = 0.00003$) between the campsites and the control sites. A positive correlation ($r = 0.31$) between distance and canopy cover at all campsite types showed that percent canopy cover increased as distance from the campsite centers increased.

Bare Area. The percent bare area also differed significantly ($P = 0.0005$) between the campsites and the control sites. There was a negative correlation ($r = -0.95$) between the distance from the center of a campsite and the percent bare area: as one might expect, the percent bare area decreased as distance from the campsite increased.

Understory Vegetation. For this study we measured moss, grasses, sedges, forbs, and shrubs. The average percent understory vegetation differed significantly ($P = 0.01$) between the campsites and the control sites for all understory components except forbs.

Total Potential Effect

As expected, the forest structure surrounding the campsites at Yellowstone Lake and Shoshone Lake has been affected by campsite use. As measured by the percent of bare area and the occurrence of trees, the changes are focused near the center of the campsites but also extend into the periphery forest. This is similar to the effects seen in other popular backcountry areas (Cole 1983, 1986).

In measuring the spatial extent of change, we found that the average number of saplings per quadrat at the campsites did not equal that at the control sites until a distance of 45 m from the center of the campsite was reached. This means that average affected area was 6,362 m^2 per campsite, or a total affected area of 190,860 m^2 for the 30 backcountry campsites studied. Extrapolating to all 302 backcountry campsites that existed in YNP in 1994, that could equal a potential impact of 1,921,324 m^2.

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My finding that the density of saplings increases as distance from the campsite center increases implies that campsite-related activities have an impact on the regeneration and survival of forest saplings. A better understanding of the attributes of this important relationship is needed in order for managers to develop management strategies and conservation practices to preserve the forested ecosystem. Campsite use could result in the near elimination of forest regeneration, which in turn could lead to reductions in tree density and the unwanted creation or expansion of nonforested areas.

Implications for Wilderness Management

There has been rapid growth during the last century in recreational uses of wild lands. These are the lands that have been protected by agencies such as the NPS, and laws such as the Wilderness Act of 1964, which states that we are to manage designated wilderness areas so that "natural conditions are preserved and the imprint of man's work remains substantially unnoticeable." But Leopold appears to have been correct when he stated that people have a substantial impact on the wilderness areas they visit. The use of backcountry areas for camping is not entirely benign and has a spatial attribute that should be better understood if a management goal for YNP is to balance sustainable recreational use while maintaining environmental integrity. It is important that we understand that a continual increase in recreational use might lead to greater effects on the forests. Educating recreational users in backcountry ethics to reduce trampling, group size, and social trails, and encouraging use of canoes or backpacking over motorboat use may reduce the impact to conifer saplings surrounding backcountry campsites in YNP.

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