Modeling Wilderness Campsites: Factors That Influence Amount of Impact

DAVID N. COLE
Intermountain Research Station
US Department of Agriculture, Forest Service
PO Box 8089
Missoula, Montana 59807, USA

ABSTRACT / A standard campsite model is proposed and then manipulated to examine the influence of individual variables on amount of vegetation loss. Amount of impact is influenced by amount of use, vegetation fragility, vegetation density, and the degree to which activities are concentrated spatially on the site. Degree of concentration also influences the importance of the other explanatory variables. Amount of use and vegetation fragility are equally important determinants of impact and are most influential where activity concentration is low. The curvilinear relationship between amount of use and amount of impact can be explained by the tendency for activities to become increasingly concentrated as amount of use increases. This relationship should not vary with regional or environmental characteristics except where these influence degree of activity concentration.

Wilderness areas have been established “to ensure that an increasing population … does not occupy and modify all areas within the United States” (Wilderness Act, PL 88-577). Management objectives stress preserving and protecting wilderness lands in their natural condition and minimizing the evidence of human use. Wilderness also is intended to provide outstanding opportunities for primitive recreation. The goals of recreation use and nature preservation invariably conflict, particularly at campsites where recreational users spend much of their time. Managers generally deal with this dilemma by allowing overnight camping in wilderness, while instituting management programs to keep impacts within acceptable limits.

Numerous management actions have been taken to limit campsite impacts. Strategies range from use restrictions, such as limits on amount of use, party size, and length of stay, to controls on the location of campsites and programs that encourage low-impact camping behavior. Research has attempted to build a stronger knowledge base on which to build campsite management programs. Empirical studies have explored the functional relationships between independent variables, such as amount of use, and various dependent measures of campsite impact (Cole 1987a). This approach attempts to identify factors that strongly influence amount of impact—factors that could be controlled to minimize impacts.

Although these empirical studies have helped identify the factors that determine amount of campsite impact, they have been less successful than hoped. It has proven difficult to isolate the influence of individual variables because the influence of any single variable, such as amount of use, is always confounded by that of another variable, such as type of use. For example, sites that are used frequently often are used by different types of groups than infrequently used sites. In addition, the lack of a theoretical framework for these studies has made it difficult to provide explanations for observed relationships, some of which have been counter-intuitive.

This article utilizes hypothetical campsite models to overcome these difficulties. A standard model is proposed and then manipulated to examine the influence of individual variables on amount of impact. Objectives are to (1) understand how each independent variable influences amount of impact, (2) understand the relative importance of each independent variable, (3) understand the nature of interaction between variables, and (4) provide an explanation for observed relationships between independent variables and amount of impact.

Factors that Influence Amount of Impact

As such phrases as “overused campsite” suggest, the amount of use a site receives influences amount of impact. In one of the earliest studies of wilderness campsites, Frissell and Duncan (1965) compared the amount of vegetation loss on low-, moderate-, and high-use campsites in the Boundary Waters Canoe Area Wilderness, Minnesota, USA. They found more vegetation loss on the high-use sites than on the low-use sites, but substantial vegetation loss occurred even on the low-use
sites. Numerous studies have shown that at relatively low use levels, the amount of use a campsite receives has a profound influence on amount of impact; however, at higher use levels, amount of use frequently has little effect on amount of impact (Cole 1987a). Although this has been a consistent finding, an adequate explanation for this relationship has never been provided.

While most attention has been focused on the relationship between campsite impact and amount of use, other variables also influence amount of impact. Characteristics of both the camping group and the behavior of individuals can influence impact levels profoundly. For example, in the Bob Marshall Wilderness, Montana, USA, sites used by groups with stock were six times the size of sites used only by backpackers (Cole 1983). Stock sites had 11 times the number of damaged trees, had more severely compacted soils, had lost more of their organic horizons, and had been invaded more extensively by exotic plants. Although empirical data are lacking, one could hypothesize about other group characteristics likely to influence amount of impact. Large groups have more potential to cause impact: so do groups that travel without a gas stove and cook over wood fires every night. Individual behavior is also important. Some campers chop on trees; others tie horses to trees, build bough beds, and dig ditches around their tents. These and many other behaviors cause much more impact than that caused by campers proficient in low-impact practices.

For many behavioral influences, cause-and-effect relationships are quite obvious, as are the solutions. Individual behavior needs to be changed and educational programs have been developed in an attempt to elicit change. The impacts associated with such behaviors as chopping trees, ditching tents, and tying horses to trees are unnecessary and can potentially be eliminated. In contrast, the campsite impacts caused by trampling—loss of groundcover vegetation, disruption of organic soil horizons, and compaction of mineral soils—are inevitable with use and are the ones most in need of study.

The characteristics of a site that relate to vulnerability also influence amount of impact. Certain plants, particularly those that are low-growing, tufted, and with wiry leaves and stems, are better able to survive trampling than others (Cole 1987a). Coarse soils are less prone to compaction problems than fine-textured soils (Lull 1959). Likewise, the extent to which certain features are present affects amount of impact. For example, sites with little or no vegetation cannot suffer much vegetation loss. A substrate without any coherent structure, such as a sand beach, cannot be compacted. Sites without trees cannot suffer tree damage. Thus, both extent and vulnerability are relevant.

The Modeling Approach

In the subsequent analysis, a model campsite is established, with standard user and environmental characteristics. Amount of impact is calculated for this standard model and for alternative models in which one of several factors is permitted to vary from the standard model. The explanatory variables to be examined are (1) amount of use, (2) vegetation fragility, (3) vegetation density, and (4) the degree to which onsite traffic is concentrated.

The primary response variable used to evaluate amount of impact will be the area of vegetation loss (Cole 1989). Vegetation loss is among the most obvious changes to occur on campsites and, therefore, is a primary indicator of amount of impact. Area of vegetation loss is the best single index for comparing loss across a variety of situations because it incorporates both the proportion of vegetation lost on the campsite and the area of the campsite. It is calculated as follows:

1. Subtract mean vegetation cover on the entire campsite from mean cover on a comparable undisturbed place offsite. This difference, referred to as absolute vegetation loss, is a measure of the per-unit-area vegetation loss. It has a maximum possible value equal to the undisturbed percent vegetation cover (when all onsite vegetation has been eliminated) and a minimum value of zero (when there has been no vegetation loss).
2. Multiply absolute vegetation loss by campsite area.

This index provides a two-dimensional estimate of the amount of vegetation removed by recreational use of a campsite.

Standard Campsite Model

For the standard model, assume a circular campsite with a center point. Assume the following characteristics of use distribution on the campsite: (1) all trampling occurs with walking back and forth between the center and the perimeter of the site, (2) all directions from the center are trampled equally, and (3) no more time is spent close to the center than at any other distance from the center. Given these assumptions, a gradient of trampling intensity exists in which the number of “tramples” (trampling intensity) decreases 50% with each doubling of distance from the center point. This follows because the circumference of any circle doubles as the radius doubles. The same number of tramples spread across twice the circumference represents half the trampling intensity. For example, if we assume a use level that