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Area of Vegetation Loss: A New Index of Campsite Impact

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ABSTRACT

Expressions of the amount of vegetation lost on campsites should reflect both the proportion of vegetation lost and the areal extent of vegetation loss. A new index-area of vegetation loss—incorporates these two elements by multiplying campsite area by absolute vegetation loss. Guidelines on how to take the measurements needed to calculate this index are provided Results of previous studies-using this new index—reconfirm the importance of concentrating camping both on a small number of sites and in a small area on each site,

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The study of recreational impacts on campsites is still in an early and largely descriptive phase. Measurement techniques are still being developed. Loss of vegetation is one of the most frequently described effects of camping. A variety of techniques have been employed to estimate vegetation loss as a result of camping. This paper reviews alternative techniques and proposes **a** new index of vegetation impact on campsites. Previously reported data on vegetation impact on campsites are reinterpreted using this new index.

MEASURES OF VEGETATION LOSS ON CAMPSITES

Estimates of vegetation cover provide the most common measures of vegetation loss on campsites. In a few cases it has been possible to take cover estimates on campsites before they were camped on; in these studies subsequent estimates on campsites can be directly compared to predisturbance conditions (for example, LaPage 1967). More commonly, existing campsites are the objects of interest. In this case, vegetation cover on campsites is compared with vegetation cover on neighboring control sites-sites judged to have conditions similar to those on the campsite prior to use.

Several means of evaluating vegetation cover loss are possible, regardless of whether the basis of comparison is pre- and postcamping or campsite and control. In some cases, cover values are simply reported for campsites and undisturbed sites, along with a judgment of statistical significance (for example, Stohlgren and Parsons 1986). This allows the reader to evaluate the magnitude of vegetation loss, but it does not provide a quantitative estimate of vegetation loss. Consequently, it is difficult to compare the magnitude of change on different sites.

One simple quantitative estimate of vegetation loss can be derived by subtracting vegetation cover on the campsite from vegetation cover on the undisturbed site. This index has been termed "absolute change" (Cole 1982), or absolute vegetation loss. For example, if vegetation cover on campsite and undisturbed site are 30 percent and 60 percent, respectively, absolute vegetation loss is 30 percent. This provides an estimate of how much vegetation cover has been removed by camping; vegetation capable of covering about 30 percent of the surface of the campsite has been removed.

This index provides a readily interpretable estimate of absolute amounts of vegetation loss on a per unit area basis-in most cases, per campsite. The major drawback to this index is that maximum values of absolute vegetation loss are determined by the vegetation ***cover*** of undisturbed sites. Absolute loss can be as high as 100 percent in places where undisturbed vegetation cover is 100 percent; however, where vegetation is sparse on undisturbed sites, maximum possible values for absolute loss are very low. Consequently, the effect on absolute loss of variation in undisturbed vegetation cover can obscure the influence of factors that may be of more interest. This is particularly true where the factor of interest is the durability of different vegetation types.

For some purposes, therefore, we need an index that standardizes maximum possible values for vegetation loss. An index that does this has been called "percent cover reduction" (Cole 1978), "relative change" (Cole 1982) or, to parallel absolute vegetation loss, relative vegetation loss. This index is simply absolute change as a percentage of the vegetation cover on the undisturbed site. Relative vegetation loss for the previous example, where absolute loss was 30 percent, is 50 percent. While absolute change provides a measure of how much vegetation has been lost, relative change expresses this loss as a

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percentage of how much could possibly be lost. If there had been only 20 percent cover, under undisturbed conditions, absolute loss cannot exceed 20 percent even if all vegetation is lost; however, if all vegetation is lost, relative loss would be 100 percent.

Both of these measures express vegetation loss on a per-unit-area basis. Neither take into account the amount of area over which vegetation loss occurs. Separate measures of campsite area and devegetated area (the area without any vegetation) have often been provided (for example, Cole 1982); however, there has been little explicit recognition that 50 percent vegetation loss on a 100-m^2 campsite represents much more loss than 50 percent loss on a 50-m^2 campsite. Both vegetation loss per unit area and the area over which loss occurs determine the amount of vegetation loss that has occurred.

Using these common measures of campsite impact, it is possible to derive a simple estimate of how much vegetation has been lost on campsites. Absolute vegetation loss provides an estimate of how much vegetation has been lost per unit area. Therefore, multiplying absolute loss by campsite area should provide an estimate of how much vegetation has been removed from the campsite. For example, if vegetation cover is 60 percent where undisturbed and 30 percent on campsites, absolute loss is 30-percent. This implies that camping has removed vegetation, on average, from 30 percent of each unit of area on the campsite. Therefore, on a 100-m^2 campsite, about 30-m^2 of vegetation have been removed. This is correct only if estimates of cover are representative of the entire campsite and not biased toward either the more highly devegetated campsite core or the more vegetated periphery.

This index, which might be termed "area of vegetation loss," integrates both area1 and loss per unit area concerns in a single easily interpretable estimate. It varies, as absolute loss does, with the vegetation cover of undisturbed sites. This can be a problem when attempting to isolate the effect of a single factor, such as vegetation durability, if undisturbed vegetation cover is highly variable. Where this is not a concern, however, the index provides a better estimate of vegetation loss than any other single measure.

REPORTED AMOUNTS OF VEGETATION LOSS ON CAMPSITES

Many studies of campsite impact report either percentage of vegetation loss (for example, Frissell and Duncan 1965) or area of the campsite (Bratton and others 1978), but few present both. The most comparable data that consider both the area and percentage of vegetation loss come from a series of studies by Cole and by Marion, conducted on campsites in the Eagle Cap Wilderness, OR (Cole 1982, 1986a), the Bob Marshall Wilderness, MT (Cole 1983), Grand Canyon National Park, AZ (Cole 1986b), the Boundary Waters Canoe Area Wilderness, MN (Marion 1984), and National Park Service areas along the New River, WV, and the Delaware River, NY, NJ, and PA (Cole and Marion 1988).

Various measures of vegetation loss for campsites in each of these areas are presented in table 1. Values are consistently high for all vegetation loss measures on sites at New River Gorge; they are consistently intermediate in value at the Boundary Waters and the Upper Delaware. Other areas are less consistent, however. Absolute vegetation loss is lowest on Eagle Cap sites, but other measures are intermediate in value. Bob Marshall sites have the lowest relative vegetation loss, and Delaware Water Gap sites have the largest devegetated area. The most divergent response is on Grand Canyon sites, which have the smallest area but the most relative vegetation loss. The area of vegetation loss, the proposed new index, clearly shows the high level of vegetation loss on typical New River sites, the low level on Grand Canyon sites, and the intermediate levels elsewhere.

Table I-Mean measures of vegetation change on campsites in seven different areas

Ares	Campslte area	Devege-tated area	Absolute vegetation loss	Relative vegetation loss	Area of vegetation loss
	------m^2------		----Percent----		m^2
New River Gorge	322	144	81	89	261
Delaware Water Gap	269	181	58	82	156
Boundary Waters Canoe Area[1]	220	n.a.	62	68	136
Bob Marshall	258	49	50	59	129
Upper Delaware River	176	85	61	69	107
Eagle Cap	197	97	47	85	93
Grand Canyon'	44	44	58	100	26

Measurement techniques differed from the other areas. Differences are minor; on Grand Canyon sites. campsite area is underestimated and both vegetation loss measures are overestimated: differences on Boundary Waters sites are difficult to predict.

Relationship Between Amount of Use and Vegetation Loss

There has been considerable interest in explaining why impact levels on some campsites are more extreme than those on others. The relationship between amount of use and vegetation loss on campsites has received considerable attention. Table 2 compares vegetation loss on high- and low-use campsites in the Boundary Waters Canoe Area Wilderness, Delaware Water Gap, Eagle Cap Wilderness, and the Grand Canyon. Although the definitions of these two use level classes differed between areas, the difference between classes was always about an order of magnitude. Use levels were estimated to be highest on Grand Canyon sites, followed by Boundary Waters, Delaware Water Gap, and Eagle Cap sites.

When describing the relationship between amount of use and vegetation loss, most attention has been paid to percent vegetation loss. Use of absolute vegetation loss as an index of change is appropriate as long as the vegetation cover of undisturbed sites is approximately the same on both high- and low-use sites; this was the case in all these studies. As the figures for absolute vegetation loss show, high-use sites have values 1.0 to 1.5 times as high as low-use sites, despite the fact that high-use sites receive an order of magnitude more use. This result has led to characterization of the use/impact relationship as highly curvilinear.

Differences in campsite area, related to amount of use, are more substantial, however. High-use sites are usually two to three times as large as low-use sites. The amount of vegetation that is lost increases as campsite area increases, even if percent vegetation loss remains constant. When we multiply camp area and absolute loss values, to obtain an estimate of how much vegetation has been lost, differences increase further (table 2). Using these area of vegetation loss values, high-use sites typically lose about three times as much vegetation as low-use sites, although this differential ranges from two on Grand Canyon sites to five on Boundary Waters sites.

This new way of looking at the relationship between amount of use and vegetation loss on campsites changes conclusions somewhat. This perspective makes it clear that there are substantial differences in vegetation loss between sites receiving different amounts of use. It is still correct, however, to state that even low-use sites lose substantial quantities of vegetation and that the relationship between amount of campsite use and amount of vegetation loss is curvilinear. The degree of curvilinearity is simply less pronounced than when either percent vegetation loss or campsite area was examined separately.

Relationship Between Party Type and Vegetation Loss

Characteristics of users is another factor that can influence amount of impact. Table 3 shows vegetation change measures (1) comparing sites along the New River that are used primarily by large commercially outfitted rafting parties and sites used primarily by smaller groups of local anglers, and (2) comparing sites in the Bob Marshall Wilderness that are used primarily by backpacking parties and sites used primarily by parties that travel with stock. In both cases, differences in absolute vegetation loss are minor; the substantial difference is in area of the site and, therefore, area of vegetation loss. The ability to concentrate use and impact obviously declines as party size increases. In addition, the many small groups of family and friends that make up a typical outfitted party will tend to disperse more widely than a more unified private party. These party characteristics inhibit onsite concentration on outfitter sites at New River. The combination of frequent use, low concentration, and a dense and fragile vegetation cover on outfitter sites along New River results in an area of vegetation loss that probably approaches maximum levels for sites used by individual parties.

Table P-Mean measures of vegetation loss on high- and low-use campsites in four different areas

Area	Campsite area	Absolute vegetation loss	Area of vegetation loss
	m^2	*Percent*	m^2
Boundary Waters Canoe Area			
high-use sites	**347**	**74**	**257**
low-use sites	**104**	**48**	**50**
Delaware Water Gap			
high-use sites	**283**	**71**	**201**
low-use sites	125	55	69
Eagle Cap			
high-use sites	**204**	**56**	**114**
low-use sites	109	**38**	**41**
Grand Canyon			
high-use sites	59	**58**	**34**
low-use sites	**30**	**58**	**17**

Table 3-Mean measures of vegetation loss on campsites used by different party types at New River Gorge and the Bob Marshall Wilderness

Area	Campsite area	Absolute vegetation loss	Area of vegetation loss
	m^2	*Percent*	m^2
New River Gorge			
commercial rafting	**428**	**85**	**364**
local anglers	215	**78**	**168**
gob Marshall			
stock parties	297	**54**	**160**
backpacker	105	**55**	**57**

The greater vegetation loss on stock sites in the Bob Marshall, compared to backpacker sites, probably reflects both more frequent use and less concentration of onsite activities. Degree of concentration is influenced by both party size and style of use. Stock parties tend to be larger than backpacker parties (Lucas 1985). Many of them also utilize a camping style (large wall tents and large stoves) that requires large campsites. Finally, stock impact on the site also expands zones of impact, although the figures reported here do not include stock impacts away from the central camp area. The greater impact associated with use by stock parties could be reduced with more attention to concentrating the impacts of camping activities.

Relationship Between Environment and Vegetation Loss

Environmental characteristics are also likely to influence amount of impact. A variety of characteristics, such as durability and density of the vegetation and the availability of level ground, can influence vegetation loss. Table 4 shows vegetation loss measures for different ecosystem types at Delaware Water Gap and Grand Canyon. At Delaware Water Gap, upland sites are large, but vegetation loss is not severe. Lowland sites, in contrast, are smaller, but vegetation loss is more pronounced. The area of vegetation loss is similar between the two locations. Indeed, part of the reason that lowland sites are smaller is that the dense vegetation inhibits the spread of camping activities and impact.

At Grand Canyon, a similar pattern exists when comparing pinyon-juniper sites with catclaw sites. Ground cover vegetation is sparse in pinyon-juniper, so absolute vegetation loss is low. Ground surface roughness is unusually low in these environments, however; consequently, campsite area is not as constrained as in the catclaw and desert scrub environments, which are extremely rocky and where the vegetation is thorny. Vegetation loss is lowest in desert scrub, where vegetation cover is sparse and rough topography and tough vegetation make campsite expansion difficult.

Table 4—Mean measures of vegetation loss on campsites located in different ecosystem types at Grand Canyon and Delaware Water Gap

Area	Campsite area	Absolute vegetation loss	Area of vegetation loss
	m^2	*Percent*	m^2
Delaware Water Gap			
upland	462	41	189
lowland	252	76	192
Grand Canyon			
pinyon-juniper	68	37	25
catclaw	32	83	27
desert scrub	33	50	17

DISCUSSION AND CONCLUSIONS

Measures of Vegetation Loss

A number of different measures of vegetation change have been used to describe and compare levels of vegetation loss on campsites. Each has certain advantages and disadvantages. Because the magnitude of vegetation loss is affected by both the amount of loss per unit area and the area over which this loss occurs, both an area1 and a percentage cover component must be considered. The area of vegetation loss, calculated by multiplying absolute vegetation loss by campsite area, provides such a measure. It provides an area1 estimate of how much vegetation has been removed by camping.

To calculate area of vegetation loss:

1. Measure campsite area. This is best done by establishing a center point and measuring the distance from this point to the edge of obviously disturbed vegetation along a number of radial transects (Cole 1982, 1989).
2. Measure vegetation cover on the campsite. Here it is important to get a measure of vegetation cover that is representative of the entire campsite. It is important not to bias this measure by oversampling one portion of the gradient of diminishing vegetation loss that generally extends from the center of the site to the periphery. This can be accomplished either by making a single estimate of cover for the entire campsite (for example, Marion 1984) or by developing a sampling design in which sampling intensity remains constant with distance from the center of the campsite. For example, Cole (1982) located sample quadrats along transects that extended from campsite center to periphery. The distance between quadrats decreased with distance from the center in order to maintain a constant sampling intensity.
3. Measure vegetation cover on a neighboring undisturbed control site. The site should be similar environmentally to the control-a site judged to be what the campsite would have looked like prior to camping.
4. Subtract vegetation cover on the campsite from vegetation cover on the control; multiply this value (absolute vegetation loss) by campsite area to obtain area of vegetation loss.

While the area of vegetation loss is clearly the most easily interpretable measure of how much vegetation has been lost on campsites, it has one limitation; it is influenced by the vegetation cover of undisturbed sites. Areas that are naturally bare of vegetation (for example, beaches or dry washes) cannot have high absolute vegetation loss values or, therefore, area of vegetation loss values. Usually this is not a problem. Such places simply have little potential for vegetation loss. They are often good places to practice low-impact camping.

Where there is interest in examining the ability of the vegetation to withstand camping, differences in vegetation density make comparisons difficult. Relative vegetation loss is an index that "factors out" differences in

amount of undisturbed vegetation cover. When relative vegetation cover is multiplied by campsite area, however, the resulting index no longer has a straightforward interpretation. Consequently, it appears better to utilize experimental trampling to study vegetation durability. With experiments, area can be kept constant, making it possible to simply compare relative vegetation loss-an index that can be readily interpreted.

Management Implications

Use of this new index of vegetation impact reconfirms the importance of two types of use concentration on campsites. Wherever regular use of campsites occurs, vegetation loss will be minimized by concentrating use on a small number of sites, rather than spreading it over a larger number of sites. This can be illustrated with data from table 2. If high-use sites are used about 10 times as frequently as low-use sites, a given amount of use can be accommodated with either a small number of high-use sites or 10 times as many low-use sites. The aggregate amount of vegetation loss on many low-use sites in the Boundary Waters would be about twice the loss on far fewer high-use sites. This differential is greater in the other areas. In Grand Canyon, spreading use across low-use sites would cause five times the aggregate vegetation loss as concentrating it on high-use sites. Concentration of use on a small number of sites is not as advantageous as results based solely on percent vegetation loss or campsite area suggested; however, it still minimizes aggregate impacts.

This new index emphasizes the importance of concentrating camping activities on as small a part of the campsite as possible-usually the area that has already been denuded. Perhaps the most striking values in tables 1 and 2 are the low levels of vegetation loss on sites in the Grand Canyon. Despite use levels on Grand Canyon sites that exceed levels in most other areas, high-use Grand Canyon sites have lost less vegetation than low-use sites in the other areas. The primary reason for this is that rough topography, rocks, and spiny vegetation force campers to confine their activities to the small areas that have already been cleared and flattened. Although these small areas are completely devegetated by heavy use, the small area of impact more than compensates for the severe vegetation loss. These results suggest that concentrating activities on as small a portion of the campsite as possible is the most effective means of minimizing vegetation loss wherever regular use of vegetated sites occurs.

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