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Experimental Evaluations of Two Leave-No-Trace Techniques: Removing Boots and Using Geotextile Groundcloths (Scrim)

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Research Summary

Experiments were designed to evaluate the effectiveness of two recommended Leave-No-Trace practices—removing boots and using a geotextile groundcloth, referred to colloquially as "scrim," in camp. One experiment compared trampling impacts on vegetation in four different vegetation types when hikers wore lug-soled boots and when they wore lightweight running shoes. About 6 percent more vegetation cover loss occurred when the tramplers wore lug-soled boots than when they wore running shoes. However, 1 year after trampling, the magnitude of cover loss did not differ. Moreover, footwear had no effect on vegetation height.

In the second experiment, conducted on two different vegetation types, a geotextile groundcloth was placed over the ground cover vegetation before trampling took place. When the groundcloth was in place, trampling caused only about one-half the vegetation cover loss it caused when the groundcloth was not in place. However, 1 year after trampling, magnitude of cover loss did not differ. Footwear had no effect on vegetation height.

These results suggest that these two practices have small short-term benefits but no long-term benefits. Therefore, they are unlikely to contribute to a meaningful reduction in resource impact. However, they are not harmful.

Acknowledgments

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Contents

	Page
Introduction	1
Footwear Experiment	1
Methods	1
Results	2
Discussion	2
Geotextile Groundcloth Experiment	3
Methods	3
Results	4
Discussion	6
Conclusions	6
References	7

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Experimental Evaluations of Two Leave-No-Trace Techniques: Removing Boots and Using Geotextile Groundcloths (Scrim)

David N. Cole

Introduction

Recreational use of wilderness alters natural conditions intended for preservation. The magnitude of recreation impact is highly influenced by the behavior of recreationists. Consequently, considerable effort has gone into development of the "Leave-No-Trace" educational program. Leave-No-Trace is designed to promote responsible use of wildlands by visitors participating in nonmotorized recreational activities (Swain 1996). The program unites four Federal land-managing agencies—the Forest Service, National Park Service, Bureau of Land Management, and Fish and Wildlife Service—with nongovernmental organizations, manufacturers, user groups, and individuals. The program attempts to build awareness, appreciation, and respect for the wildness in places. It teaches visitors how to minimize their impact on wildlands by recommending specific low-impact techniques (Hampton and Cole 1995). One technique that is often suggested is to remove boots when you arrive at camp and put on soft-soled footwear. The rationale for this suggestion is that lug-soled boots have more potential to cause erosion (Harlow 1977) or to impact plants. Another recent trend, particularly with packstock groups, is to lay down geotextile groundcloths (commonly referred to as scrim) in camp (Stoner and others 1993). The rationale for their use is that they shield vegetation and soil from the direct abrasive effects of trampling, and therefore reduce damage. Experiments were undertaken to evaluate these two techniques—removing boots and laying down scrim—as effective means of reducing trampling impacts on vegetation.

Footwear Experiment

The investigation of footwear effects was part of a larger investigation of trampling impacts in four mountainous regions of the country (Cole 1993). It was conducted in one vegetation type in each of four mountainous regions in the United States. The four vegetation types, named for the most abundant ground cover species, were: (1) Sitka valerian (*Valeriana sitchensis*), lush subalpine herb meadows in the Cascade Mountains, WA; (2) grouse whortleberry (*Vaccinium scoparium*), subalpine coniferous forests in the Rocky Mountains, CO; (3) Canada mayflower (*Maianthemum canadensis*), low-elevation hardwood forests with a herbaceous ground cover in the White Mountains, NH; and (4) hog-peanut (*Amphircarpa bracteata*), low-elevation cove hardwood forests with a herbaceous ground cover in the Great Smoky Mountains, NC.

Methods

Details of the exerimental design follow the protocols of Cole and Bayfield (1993). Four replicate sets of experimental trampling lanes were established on level sites in each of the four vegetation types. Each set consisted of nine lanes, each 0.5 m wide and 1.5 m long. Treatments were randomly assigned to lanes. One lane was a control and received no trampling. The other lanes received either 25, 75, 200, or 500 passes, either by a hiker in lug-soled boots or a hiker in running shoes. A pass was a one-way walk down the lane.

Measurements were taken on each lane in two adjacent 30 by 50 cm subplots. Visual estimates of cover were recorded, by cover class, for each species of vascular plant and for mosses and lichens. Total vegetation cover was the sum of the coverages for individual species, mosses, and lichens. Mean vegetation height was recorded with a point quadrat frame with five pins. The frame was placed 10 times in each subplot. Pins were dropped to the ground. When pins hit live vegetation, the height of the pin strike was recorded. Mean height was the mean of the pin strikes.

Measurements were taken immediately prior to trampling, 2 weeks after trampling, and 1 year after trampling. The primary measures of vegetation response to trampling were relative vegetation cover and relative vegetation height, 2 weeks and 1 year after trampling. Relative vegetation cover was calculated as:

$$\frac{\text{Surviving cover on trampled subplots}}{\text{Initial cover on trampled subplots}} \times \text{cf} \times 100 \text{ percent}$$

where:

$$\text{cf} = \frac{\text{Initial cover on control subplots}}{\text{Surviving cover on control subplots}}$$

Relative height was calculated in a similar manner, substituting height for cover. Both relative cover and height would be 100 percent in the absence of any trampling effect. Lower relative cover and height measures indicate greater trampling disturbance.

The significance of footwear effects was assessed within a three-way analysis of variance, with footwear, trampling intensity, and vegetation type as main factors. This permitted identification of the effect of footwear, while statistically controlling the effects of trampling intensity and vegetation type. Where interactions between footwear and the other main factors were significant, simple effects were examined in more detail.

Results

Relative cover after trampling varied significantly with all three main factors (table 1). Footwear was the factor with the least effect on relative cover. None of the interactions of other factors with footwear were significant. Although the type of footwear worn had a statistically significant effect, the magnitude of effect was not pronounced (fig. 1). Mean relative cover after trampling was 31 percent when the trampler wore lug-soled boots and 37 percent when the trampler wore running shoes.

One year after trampling, the type of footwear worn had no effect on relative vegetation cover (table 1). The interaction between vegetation type and footwear was significant, however. Lug-soled boots caused more impact than running shoes in two vegetation types and less impact in the other two types (fig. 2). None of these individual differences were statistically significant. Overall, mean relative cover 1 year after trampling was 68 percent when the trampler wore lug-soled boots and 67 percent when the trampler wore running shoes.

Neither relative vegetation height after trampling nor height 1 year after trampling varied significantly with type of footwear ($p > 0.1$). Two weeks after trampling, the effect of footwear interacted with the effect of vegetation type. Lug-soled boots caused more impact than running shoes in three vegetation types and less impact in the fourth type. None of these differences were statistically significant, however. Mean relative height after trampling was 29 percent when the trampler wore lug-soled boots and 34 percent when the trampler wore running shoes. Mean relative height 1 year after trampling was 69 percent when the trampler wore lug-soled boots and 72 percent when the trampler wore running shoes.

Discussion

This experiment shows that the type of footwear worn can affect magnitude of vegetation disturbance but that differences are neither substantial nor long lasting. When the trampler wore boots, short-term vegetation cover loss was greater than when the trampler wore running shoes. However, the mean difference in cover loss was only 6 percent, and differences were nonexistent 1 year after trampling. Footwear had no

Table 1—Analysis of variance for the effect of footwear (boot or running shoe), trampling intensity, and vegetation type on relative vegetation cover 2 weeks and 1 year after trampling.

Source of variation	df	Two weeks after trampling: Mean square	Two weeks after trampling: F	One year after trampling: Mean square	One year after trampling: F
Model	34	2,643	18.10[a]	2,787	8.50[a]
Error	93	146		328	
Main effects					
Footwear	1	1,249	8.55[a]	3	0.01
Trampling intensity	3	18,988	130.05[a]	11,033	33.64[a]
Vegetation type	3	7,186	49.22[a]	8,995	27.42[a]
Blocks	3	1,050	7.19[a]	5,013	15.28[a]
Interactions					
Footwear x intensity	3	138	0.95	237	0.72
Footwear x vegetation	3	333	2.28	929	2.83[b]
Intensity x vegetation	9	532	3.64[a]	1,408	4.29[a]
Footwear x intensity x vegetation	9	81	0.55	384	1.17

[a]Significance: <0.01.
[b]Significance: <0.05.

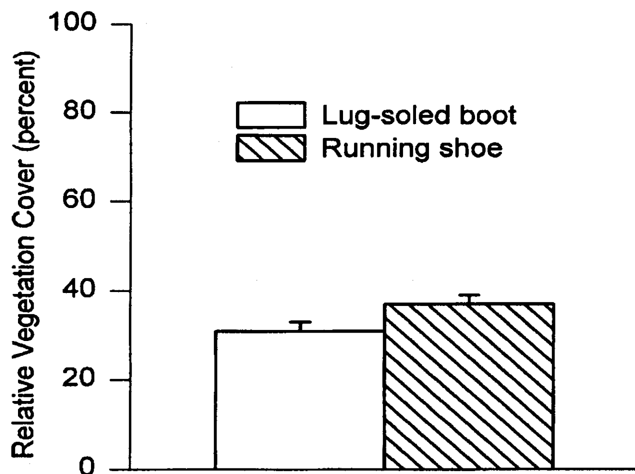

Figure 1—Mean relative vegetation cover 2 weeks after trampling by hikers in lug-soled boots and in lightweight running shoes. Bars indicate 1 standard error.

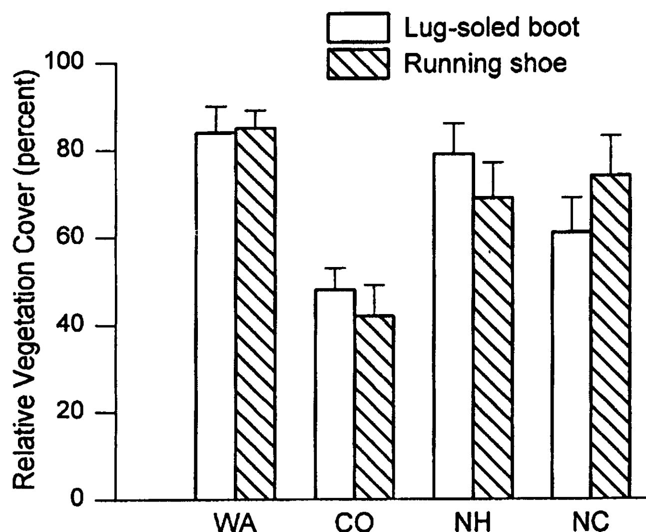

Figure 2—Mean relative vegetation cover 1 year after trampling by hikers in lug-soled boots and lightweight running shoes in Washington (WA), Colorado (CO), New Hampshire (NH), and North Carolina (NC). Bars indicate 1 standard error.

effect on vegetation height. In a study conducted in Great Smoky Mountains National Park, Whittaker (1978) also reported no difference in magnitude of vegetation height reduction, depending on whether the trampler wore lug-soled boots or lightweight shoes with soft soles.

Type of footwear appears to have even less effect on the magnitude of soil impacts. Two studies assessed the effect of footwear on variables related to erosion potential, sediment yield, and amount of soil adhered to soles (Kuss 1983; Saunders and others 1980). In both studies, no significant differences between boots with lug soles and boots without lug soles were found. Kuss (1983) conducted his studies at several soil moisture levels and in several soil types, suggesting his findings may be representative of a range of trail conditions. Saunders and others (1980) reported that a lug-sole boot collected more soil during trampling than a tennis shoe, but since they did not report their data, the magnitude of difference cannot be determined.

Although changing footwear is unlikely to contribute to meaningful reductions in resource impacts, there appear to be no negative consequences of this behavior. Many campers change to lighter shoes simply because they are more comfortable. There may be benefits from this practice that could not be evaluated in our experiments. For example, an effective way to minimize trampling damage to campsite vegetation is to avoid stepping on plants. Campers in light shoes may be more likely to watch where they place their feet than campers in heavy boots. If so, they will cause less vegetation damage.

Geotextile Groundcloth Experiment

The investigation of the effects of a geotextile groundcloth (commonly referred to as scrim) was part of a larger investigation of trampling impacts by hikers, llamas, and horses (Cole and Spildie, submitted). It was conducted in two montane coniferous forest vegetation types in western Montana. One type (denoted the *Equisetum* type) had an understory dominated by forbs, particularly horsetail (*Equisetum arvense*) and queencup beadlily (*Clintonia uniflora*). The other type (denoted the *Vaccinium* type) had an understory dominated by the low shrub grouse whortleberry (*Vaccinium scoparium*).

Methods

Four replicate sets of experimental trampling lanes were established in each of the two vegetation types. Each set consisted of five lanes 0.5 m wide and 3.0 m long. Treatments were randomly assigned to lanes. One lane was a control lane and received no trampling. The other lanes received either 25 or 150 passes by a hiker in boots, with or without a geotextile groundcloth covering the vegetation. The groundcloth was removed immediately after trampling ceased. A pass was a one-way walk down the lane.

Measurements and the calculation of response variables were identical to those for the footwear experiment, with three exceptions. First, subplots were located 1 m apart, instead of adjacent to each other. Second, vegetation cover was calculated as the proportion of the 100 pins (50 in each subplot) that hit live vegetation. Field observations suggested that the responses of vascular plants might differ from those of mosses and lichens. Relative cover of vascular plants was calculated in addition to relative cover of all vegetation.

The significance of the groundcloth's effects was assessed within a three-way analysis of variance, with groundcloth (presence or absence), trampling intensity, and vegetation type as main factors. This permitted identification of the effect of the groundcloth, while statistically controlling the effects of trampling intensity and vegetation type. Where interactions between the groundcloth and the other main factors were significant, simple effects were examined in more detail.

Results

The three main factors (groundcloth, trampling intensity, and vegetation type) and their interactions did not explain much of the variation in relative cover of all vegetation after trampling ($F = 1.38, p = 0.26$). Nevertheless, the effect of groundcloth was significant ($F = 5.64, p = 0.03$). Without the groundcloth, mean relative cover after trampling was 73 percent. With the groundcloth in place, mean relative cover after trampling was 85 percent.

The model was much more effective in explaining variation in the relative cover of vascular plants (table 2). Relative cover of vascular plants 2 weeks after trampling varied significantly with presence or absence of the groundcloth, as well as trampling intensity. Overall, relative cover of vascular plants was 66 percent after trampling without the groundcloth and 85 percent after trampling with the groundcloth in place. The interaction between groundcloth and vegetation type was moderately strong ($p = 0.07$). The positive effects of the groundcloth were more pronounced in the *Vaccinium* vegetation type (fig. 3).

The low shrub understory of the *Vaccinium* vegetation type is generally more resistant to trampling than the erect forbs of the *Equisetum* type (Cole and Spildie, submitted). Most cover loss in the *Vaccinium* type resulted from breakage of the woody stems and branches of *Vaccinium scoparium*. Flattening of *Vaccinium* plants was insufficient to kill them. Field observations suggested that the groundcloth was effective in reducing breakage of woody stems and branches. However, the trampling experiments were conducted in midsummer before the woody stems and branches of *Vaccinium* were highly brittle. Later in the season, when woody parts are brittle, the effect of the groundcloth may be different. The fragile forbs of the *Equisetum* type were usually killed if they were flattened; consequently, the groundcloth offered them relatively little protection.

One year after trampling, the model (groundcloth, trampling intensity, and vegetation type and their interactions) explained much more of the variation in vascular plant cover ($F = 10.00, p < 0.001$) than in total vegetation cover ($F = 2.24, p = 0.07$). For both dependent variables, trampling intensity and vegetation type had the most pronounced effect, while presence or absence of the groundcloth did not explain much variation in vegetation response (table 2). Overall, mean relative cover of vascular plants 1 year after trampling was 78 percent without the groundcloth

Table 2—Analysis of variance for the effect of a geotextile groundcloth "scrim," trampling intensity, and vegetation type on relative cover of vascular plants 2 weeks and 1 year after trampling.

Source of variation	df	Two weeks after trampling		One year after trampling	
		Mean square	F	Mean square	F
Model	7	782	4.68[a]	2,521	10.00[a]
Error	24	167		764	
Main effects					
Groundcloth	1	2,810	16.80[a]	20	0.08
Trampling intensity	1	1,810	10.83[a]	5,022	20.00[a]
Vegetation type	1	32	0.19	5,863	23.25[a]
Interactions					
Groundcloth x intensity	1	144	0.86	64	0.25
Groundcloth x vegetation	1	626	3.75	1,014	4.02
Intensity x vegetation	1	49	0.29	5,629	22.32[a]
Groundcloth x intensity x vegetation	1	5	0.03	35	0.14

[a]Significance: <0.01.

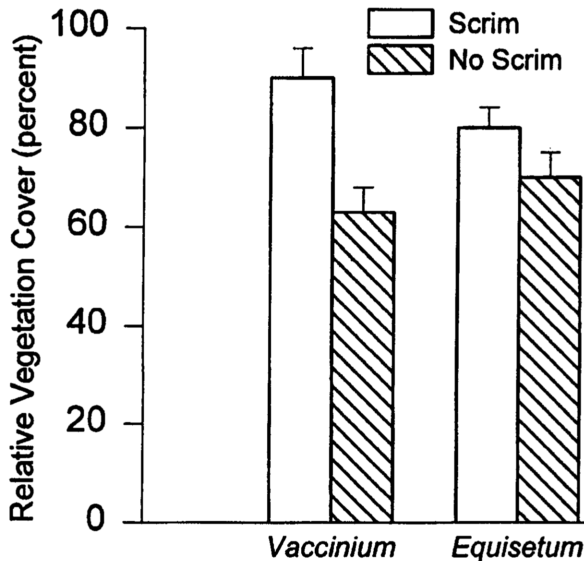

Figure 3—Mean relative cover of vascular plants in two vegetation types—grouse whortleberry (*Vaccinium*) and horsetail (*Equisetum*)—2 weeks after trampling by hikers, with and without a geotextile groundcloth (scrim) to shield the vegetation. Bars indicate1 standard error.

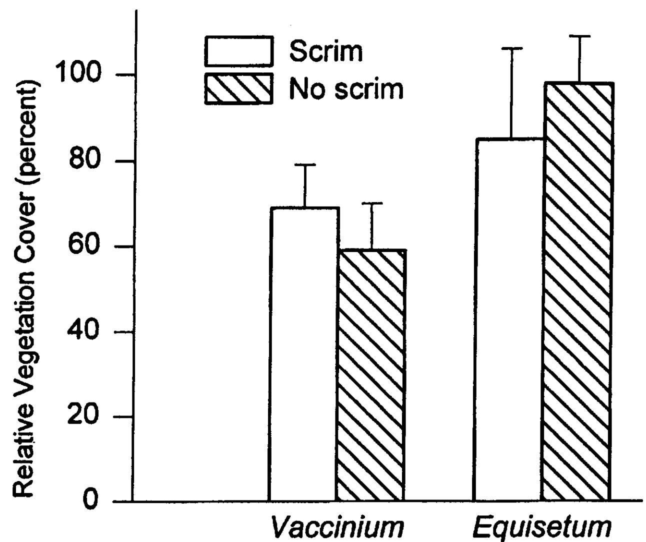

Figure 4—Mean relative cover of vascular plants in two vegetation types—grouse whortleberry (*Vaccinium*) and horsetail (*Equisetum*)—1 year after trampling by hikers, with and without a geotextile groundcloth (scrim) to shield the vegetation. Bars indicate 1 standard error.

and 77 percent with the groundcloth in place. The interaction between groundcloth and vegetation type was moderately strong ($p = 0.06$). In the *Vaccinium* type, more vascular cover survived when the groundcloth was in place; in the *Equisetum* type, less cover survived when the groundcloth was in place (fig. 4). Neither of these differences was statistically significant, suggesting that the effect of the groundcloth on vegetation cover is negligible 1 year after trampling.

Neither vegetation height 2 weeks after trampling nor height 1 year after trampling varied significantly with presence or absence of the groundcloth (table 3).

Table 3—Analysis of variance for the effect of a geotextile groundcloth "scrim," trampling intensity, and vegetation type on relative vegetation height, 2 weeks and 1 year after trampling.

		Two weeks after trampling		One year after trampling	
Source of variation	df	Mean square	F	Mean square	F
Model	7	5,182	13.74[a]	2,588	3.81[a]
Error	24	377		679	
Main effects					
Groundcloth	1	168	0.45	106	0.16
Trampling intensity	1	7,503	19.90[a]	3,051	4.49[b]
Vegetation type	1	25,153	66.70[a]	3,948	5.81[a]
Interactions					
Groundcloth x intensity	1	1,490	3.95	3,661	5.39[b]
Groundcloth x vegetation	1	1,581	4.19[b]	95	0.14
Intensity x vegetation	1	77	0.20	7,171	10.56[a]
Groundcloth x intensity x vegetation	1	298	0.79	85	0.12

[a]Significance: <0.01.
[b]Significance: <0.05.

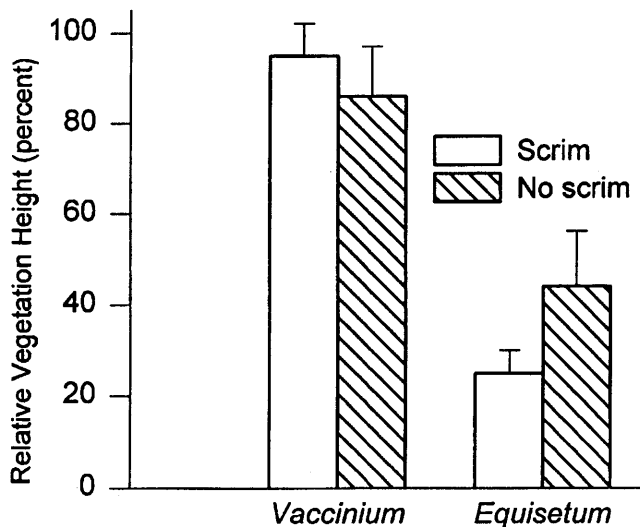

Figure 5—Mean relative vegetation height in two vegetation types 2 weeks after trampling by hikers, with and without a geotextile groundcloth (scrim) to shield the vegetation. Bars indicate 1 standard error.

Two weeks after trampling, mean relative height was slightly lower on the groundcloth plots (60 percent) than on the plots that were trampled without the groundcloth (65 percent). One year after trampling, mean relative height was slightly higher on the lanes that had been covered with the groundcloth (79 percent) than on the lanes that had not been covered (75 percent). Again, these differences are not statistically significant.

Interactions complicate the picture slightly. For vegetation height 2 weeks after trampling, the interactions between groundcloth and both trampling intensity ($p = 0.06$) and vegetation type ($p = 0.05$) are moderately strong. Mean relative height after trampling was higher when the groundcloth was in place in the *Vaccinium* type and lower when the groundcloth was in place in the *Equisetum* type (fig. 5). Mean relative height after trampling was higher when the groundcloth was in place at the higher trampling intensity but lower when the ground cover was in place at the lower trampling intensity. This latter response pattern was repeated for relative vegetation height 1 year after trampling.

The findings that (1) none of these differences are statistically significant and (2) the direction of response differs between vegetation types and trampling intensities support a general conclusion that the use of the groundcloth has no consistent or substantial effect on resultant vegetation height. The results suggest that the groundcloth may be more effective in avoiding height reduction in vegetation that is not readily flattened and at relatively high trampling intensities. At low trampling intensities, particularly in vegetation that is readily flattened, the groundcloth can accentuate the flattening effect of trampling. Plants that are not stepped on can be flattened by the weight of the groundcloth as it is trampled.

Discussion

This experiment shows that the use of a geotextile groundcloth in camp can reduce the magnitude of vegetation disturbance, but that differences are not long lasting. When the groundcloth was in place, short-term vegetation cover loss and vascular plant cover loss were 12 percent and 19 percent lower than when the groundcloth was not in place. However, differences were nonexistent 1 year after trampling. Use of the groundcloth had no consistent effect on vegetation height.

This suggests that use of a geotextile groundcloth is unlikely to reduce impact to any meaningful degree. However, it is not likely to aggravate impact either. Anecdotal evidence gathered from outfitters suggests that the primary benefits of using a groundcloth in camp are to avoid dust and mud problems and to facilitate camp cleanup.

Conclusions

Neither changing footwear nor laying down a geotextile groundcloth (commonly referred to as scrim) is likely to contribute to a meaningful reduction in resource impact. Both recommended behaviors have small short-term positive effects but no long-term benefits. Conversely, neither behavior appears likely to aggravate impact problems. Therefore, they are behaviors that can be recommended.

The primary management implication of these findings concerns the prominence these recommendations should be given in "Leave-No-Trace" messages. Wilderness visitors, like all humans, have limits to the attention and cognitive capacity they are willing and able to devote to information. For example, a recent study found that typical wilderness visitors will only allocate enough attention to low-impact messages posted on bulletin boards to comprehend two of the behaviors recommended in the messages (Cole and others 1997).

Because these two recommended behaviors are not likely to have substantial benefits, they should not be high priorities in educational campaigns. The use of

geotextile groundcloths is seldom mentioned in "Leave-No-Trace" literature. However, changing footwear in camp is a relatively common recommendation. These recommendations should not be included in messages designed for educational situations where visitor attention is likely to be severely limited. This probably applies to most situations when messages are delivered on bulletin boards, in visitor centers, and on brochures. Given the need to direct visitor attention to a few important recommendations, the limited space available should be allocated to more important behaviors.

In educational situations where attention is not severely limited, it is more appropriate to include these recommended behaviors. Books and "Leave-No-Trace" training courses are examples of situations where visitor attention is not such a limiting factor. Even in these situations these behaviors will do little, in the long run, to reduce trampling impacts.

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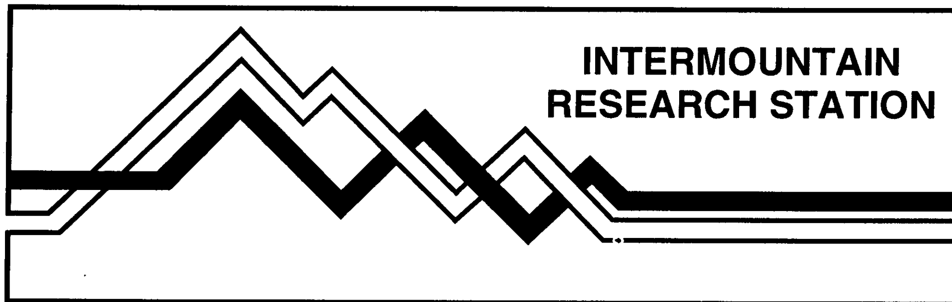
One experiment was designed to compare vegetation impacts when hikers wear lug-soled boots and when they wear lightweight running shoes. A second experiment compared vegetation impacts following trampling with and without a geotextile groundcloth (scrim) in place. Vegetation impacts were greater when hikers wore boots and when the groundcloth was not in place. Differences were small, however, and persisted for less than a year.

Keywords: ecological impacts, trampling, minimum impact education, outdoor recreation management



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