United States
Department of
Agriculture

Forest Service

**Northeastern Forest
Experiment Station**

Research Paper
NE-555

1985

Hiker Trampling Impacts on Eastern Forests

R. E. Leonard
J. L. McMahon
K. M. Kehoe

The Authors

R. E. Leonard is Project Leader, J. L. McMahon is a forestry technician, and K. M. Kehoe is a biological lab technician, Backcountry Recreation Facilities, Northeastern Forest Experiment Station, Durham, New Hampshire.

Manuscript received for publication 15 June 1984

Abstract

Trampling impact studies were conducted in two eastern forest stands in the White Mountains, New Hampshire. Changes in plant mortality on simulated trails during a trampling period and a recovery period were monitored photographically. The extent of damage and rate of recovery varied among species. For most species, the greatest change in plant mortality occurred between 100 and 300 trampling passes.

Introduction

Before effective management strategies can be designed for backcountry areas, managers need information that either prescribes desired levels of use for a given set of ecological conditions or predicts ecological changes for known levels of use.

Disturbances induced by recreational activities have been well documented. In a pioneer study, Bates (1935) observed that trampling had both direct and indirect effects on the vegetation of an area through mechanical damage to plant parts and changes in soil structure. Other studies (Frissel and Duncan 1965, Cole 1978) correlate trampling pressure to death of vegetation underfoot. Changes in species composition over time have been noted by LaPage (1967) and Bayfield (1971). Watson and coworkers (1970), Speight (1975), and others reported that the lack of vegetation on a site greatly increases the potential for soil erosion, which in turn may affect other areas of vegetation. Much of the work to date, however, is based on observations taken after high levels of use have already occurred on preexisting trails, or is descriptive rather than quantitative in nature.

This trampling study was designed to relate given intensities of use to observed changes in the vegetation and soils of two previously undisturbed forest systems. The survival of certain plant species and the unvegetated ground were photographically monitored through a season of trampling and then for 3 years of trail recovery. Soil compaction was also documented. The greatest increase in plant mortality on simulated trails occurred at a low intensity of trampling, with gradual increases in mortality at higher intensities. This finding concurs with results reported by Frissel and Duncan (1965), LaPage (1967), and Bell and Bliss (1973) who found that loss of cover occurs most rapidly at the onset of trampling, then subsides as trampling continues. When overall percentage of area coverage per species was compared between high- and low-use trails (at the end of the trampling season), the high-use trails showed a noticeably greater reduction in area coverage than did the low-use trails. The width of the impacted zone (trail width) was established during the initial stages of trampling. Similar results were reported by More (1980).

Background Information

Doublehead Mountain is located within the White Mountain National Forest, 2.4 miles northeast of Jackson, New Hampshire. Its 4 miles of hiking and skiing trails were cleared in the 1930's by the Civilian Conservation Corps. Since then, the trails have been maintained by the USDA Forest Service. An estimated 1,500 to 2,000 people use these trails each year.

Glacial till deposited by the most recent episode of glaciation, the Wisconsin Ice Sheet, forms the major soil parent materials of Doublehead and most of the White Mountain region. Soils found on Doublehead belong to the Spodosol order, the Haplorthod subdivision, and the Marlow and Lyman-Berkshire series (Bailey and Pilgrim 1983, USDA, SCS 1977). The bedrock of Doublehead Mountain is composed of Hastingsite granite, which is a greenish-gray, medium- to coarse-grained equigranular rock. Feldspar and quartz are the primary minerals in this rock type (Billings 1980).

Simulated trails and study plots were established on two sites. Site No. 1 was in a mixed hardwood-softwood stand at approximately 1,950 feet (590 m) elevation. Sugar maple (*Acer saccharum* Marsh.), red spruce (*Picea rubens* Sarg.), white ash (*Fraxinus americana* L.), and balsam fir (*Abies balsamea* L.) formed the canopy of this stand. The canopy had a 70 to 75 percent enclosure. Beneath this layer, the dominant understory plants included maple spp. (*Acer saccharum* Marsh., *A. rubrum* L., *A. pensylvanicum* L.), hobblebush (*Viburnum alnifolium* Marsh.), red spruce and balsam fir. Ground cover species included starflower (*Trientalis borealis* Raf.), Indian cucumber root (*Medeola virginiana* L.), wood aster (*Aster acuminatus* Michx.), rose twisted-stalk (*Streptopus roseus* Michx.), and other forbs, ferns, and tree seedlings. The bouldery soil at this site consisted of a 7- to 9-inch (17.5 to 22.5 cm) organic layer of partly to fully decayed leaves, needles, and roots (the 01 and 02 soil horizons), over a 0.5- to 2-inch (1.3 to 5 cm) leached, grayish-brown layer (A2 horizon), over a 10-inch (25 cm) dark brown, sandy layer (the B horizon). Below this we intercepted a layer of gravel and rocks of unknown depth. Depth of bedrock was not measured.

Site No. 2 was in a coniferous forest at approximately 3,000 feet (909 m) elevation. The canopy layer was composed primarily of balsam fir, with some red spruce and paper birch (*Betula papyrifera* Marsh.). Fir dominated the understory; fir seedlings, Canada mayflower (*Maianthemum canadense* Desf.), blue-bead lily (*Clintonia borealis* (Ait.) Raf.) and mosses covered the forest floor. Blowdowns were plentiful. A representative soil profile at this site consisted of a 1.5- to 2-inch (3 to 4 cm) thick surface organic layer, over a dark reddish-brown and yellowish-red fairly compact sandy/pebbly layer of unknown depth. Slopes were less than 5 percent at both sites. Plant identification was done in the field using Gray's Manual of Botany (Fernald 1950).

Methods

Three 30-meter-long, 1-meter-wide trails were set up at each site; two were trampled a given number of times, one remained a control. Trampling was done once a week over a 10-week period from June to August, 1978. High-use trails (trail A at the hardwood site, trail X at the conifer site) received 150 one-way passes per week for a season total of 1,500 passes. Low-use trails (C at the hardwood site, Z at the conifer site) received 25 passes per week for a total of 250 passes.

Four field assistants, weighing from 125 to 160 pounds, walked down the center of the simulated trails. They wore lug-soled boots because this type of sole seemed to be the most commonly encountered type of hiking boot in the 1970's. Backpacks were not worn by the tramplers.

Percentage of Plant Survival

To document ground cover changes over time, ten 1-meter by 0.5-meter study plots were established randomly on each trail. Each plot was photographed a total of nine times. In 1978, photographs were taken before trampling began and at five 2-week intervals as trampling progressed throughout the summer. After trampling had ended and trails were recovering, each plot was photographed in June of 1979, 1980, and 1981.

The quadropod technique developed by McBride and Leonard (1982) was used for photographing the study plots. The photographs were analyzed in the lab in the following manner.

The slide of the study plot was projected onto an audioviewer projector screen. An acetate overlay with a scaled-down outline of the quadrat frame was placed over the quadrat image, and boundaries of plant types and the unvegetated areas were marked. The area of each cover type was determined with a planimeter. Individual plants (such as fir seedlings) were counted by species if the area could not be accurately measured. These absolute numbers were converted to relative percentages by assigning the greatest number of plants or area coverage of a species on any given date in 1978 a value of 100 percent. The dominant ground cover species at each site were selected for study. Site No. 1 species included rose twisted-stalk and sugar maple seedlings. Site No. 2 species included balsam fir seedlings and Canada mayflower.

The major objectives of photoplot analysis were:

1. to monitor the survival and eventual recovery of certain species;
2. to determine what level of trampling caused plant mortality; and
3. to determine trail width and soil compaction.

Trail Width and Soil Compaction

Trail width—the area of visible trampling damage—was measured in the same way as plant survival to determine whether an increase in trampling caused a corresponding increase in the disturbed area.

A soil test penetrometer was used to measure soil compaction. Measurements were taken at the tread centers of each trail and at random intervals across the trails. A total of 50 samples were taken at the conclusion of the trampling period. Sixty samples were taken the following spring to measure changes after a recovery period.

The relative compaction or penetration resistance of the forest soils was measured in an effort to determine:

1. the levels of compaction in relation to the number of passes;
2. the levels of compaction across the width of the trail; and
3. the recovery of soils by the following spring (recovery period was 9 months).

Results and Discussion

Percentage of Plant Survival

Survival data (recorded in relative percentages) for selected species are presented in Table 1. Results are separated into high-use, low-use, and control categories for both the trampling and recovery phases of the study. High-use data (up to 1,500 passes) during the trampling and recovery phases are shown in Figure 1. Percentage of survival of all four species dropped significantly between 0 and 300 passes. This change is analyzed further in Figure 2, which depicts percentage of survival of plant species on trails subjected to lower levels of use (up to 250 passes).

Two major trends are apparent from the results:

1. All species seem to be significantly affected by initial trampling stress. The greatest reduction in percentage of survival for each species occurred at 300 passes on high-use trails. However, the highest plant mortality does not necessarily occur at the onset of trampling. In general, the largest change in percentage of survival occurred between 100 and 300 passes. Figure 1 indicates that after 300 passes, reductions in percentage of survival become less pronounced.
2. Revegetation of the trails was rapid and, for most species, percentage of survival during the recovery phase rose to near or above 100 percent. Recovery times varied with species. Other factors such as natural senescence, high seed years, and plant growth characteristics may have influenced percentage of survival and regeneration. Some of these factors are explained in the following discussion of individual species.

Table 1.—Percentage of plant survival during trampling and recovery phases, by species and level of use.

Trail	Trampling Phase					Recovery Phase		
	0/0[a] 6/26/78	100/300 7/19/78	150/600 7/24/78	200/900 8/10/78	250/1,500 9/4/78	6/4/79	6/5/80	6/3/81
				S. roseus				
Control—B	97	100	89	93	79	83	131	113
Low use—C	100	68	51	47	41	53	91	70
High use—A	100	45	35	26	9	55	125	83
				A. saccharum				
Control—B	80	97	96	86	94	109	128	95
Low use—C	93	84	63	66	64	230	202	178
High use—A	100	48	47	40	41	75	72	138
				A. balsamea				
Control—Y	86	97	92	95	87	80	56	93
Low use—Z	83	90	82	88	61	57	22	272
High use—Z	100	40	30	28	22	35	14	126
				M. canadense				
Control—Y	100	66	61	58	20	91	126	171
Low use—Z	100	64	53	43	5	55	66	132
High use—X	100	25	15	19	4	51	69	86

[a]Number of passes for low use/high use.

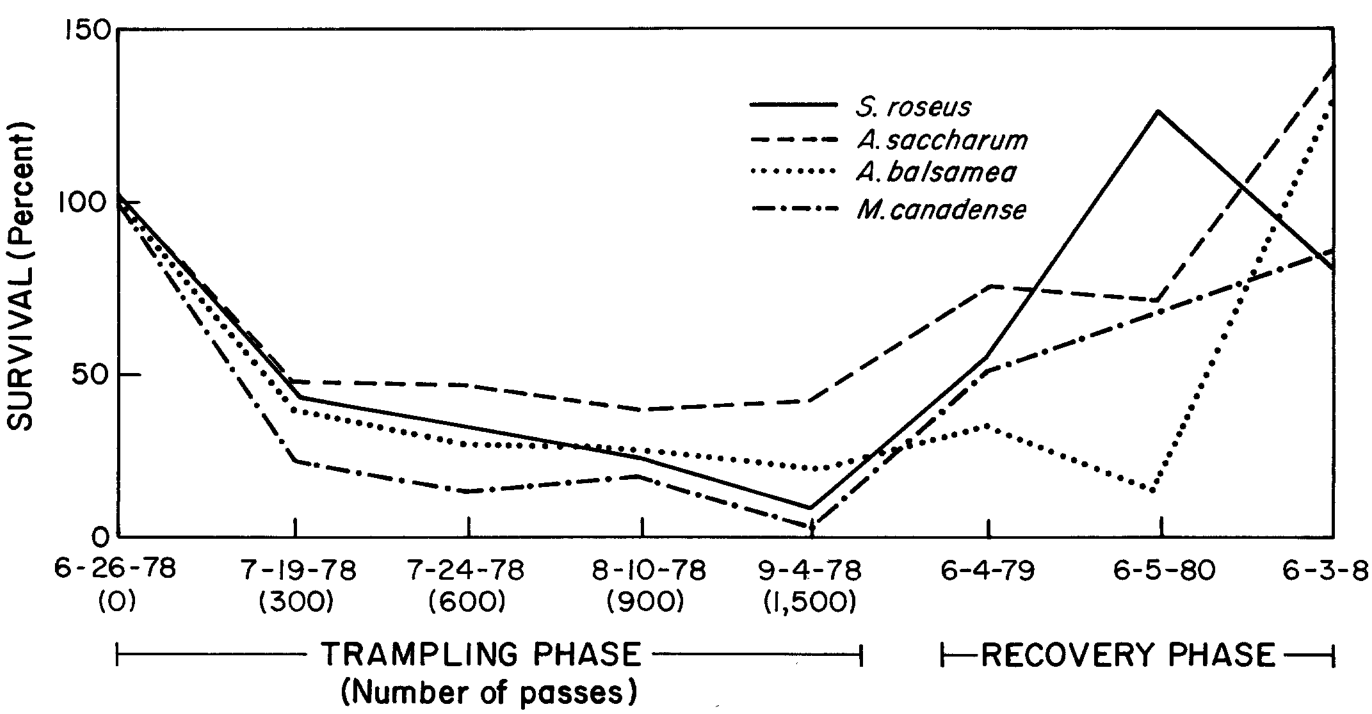

Figure 1.—High-use data during trampling and recovery phases.

Canada mayflower had the greatest decline in percentage of survival during the trampling period. This decline was paralleled in the control trail, indicating that the low survival by the end of the summer was partially due to the natural senescence. By the third year, recovery was complete (132 percent) on trails that had received 250 passes. On trails that had received 1,500 passes, recovery was only 86 percent by the third year. The decline in percentage of survival of rose twisted-stalk is very similar to that of Canada mayflower during the trampling phase. Both species are rhizomatous perennials with broad, delicate leaves. Regrowth probably occurred from underground rhizomes that were not damaged by trampling.

Sugar maple and balsam fir seedlings showed more than 100 percent recovery after 3 years in both high- and low-use trails. Sugar maple seems to be the most resilient of the species studied. Figure 2 suggests that low levels of trampling stress (up to 250 passes) did not cause significant plant mortality and for sugar maple may actually have been beneficial. The percentage of survival of sugar maple rose to 230 percent in 1979. Low levels of trampling may have scarified the soil surface, creating a more favorable seedbed. Balsam fir showed a large percentage of survival increase between 1980 (22 percent) and 1981 (272 percent), which might be attributed to the occurrence of a high-seed year for fir.

Trail Width and Soil Compaction

After measuring the area of visible trampling stress and the change in percentage of unvegetated area in the plots, we observed the following:

1. The initial 2 weeks of trampling established the width of the trail. Hiking pressure, whether 250 or 1,500 passes, resulted in nearly the same area of disturbance.
2. Soils at the spruce-fir site were compacted nearly twice as much at 1,500 tramples as at 250 tramples. By contrast, soil compaction changed only slightly between 250 and 1,500 tramples at the hardwood-softwood site.
3. Even though most visible disturbance occurred in the center portion of the study area, adjacent areas were indirectly affected by trampling stress. As was expected, peak compaction occurred at the center of the trails where the most footsteps landed. We were unable to obtain consistent results of changes in soil compaction after the recovery period. In general, high-use trails showed more compaction after a 9-month recovery period than during the trampling phase, and low-use trails showed less compaction. It is recommended that soil compaction be measured over a larger recovery period to obtain more conclusive results.

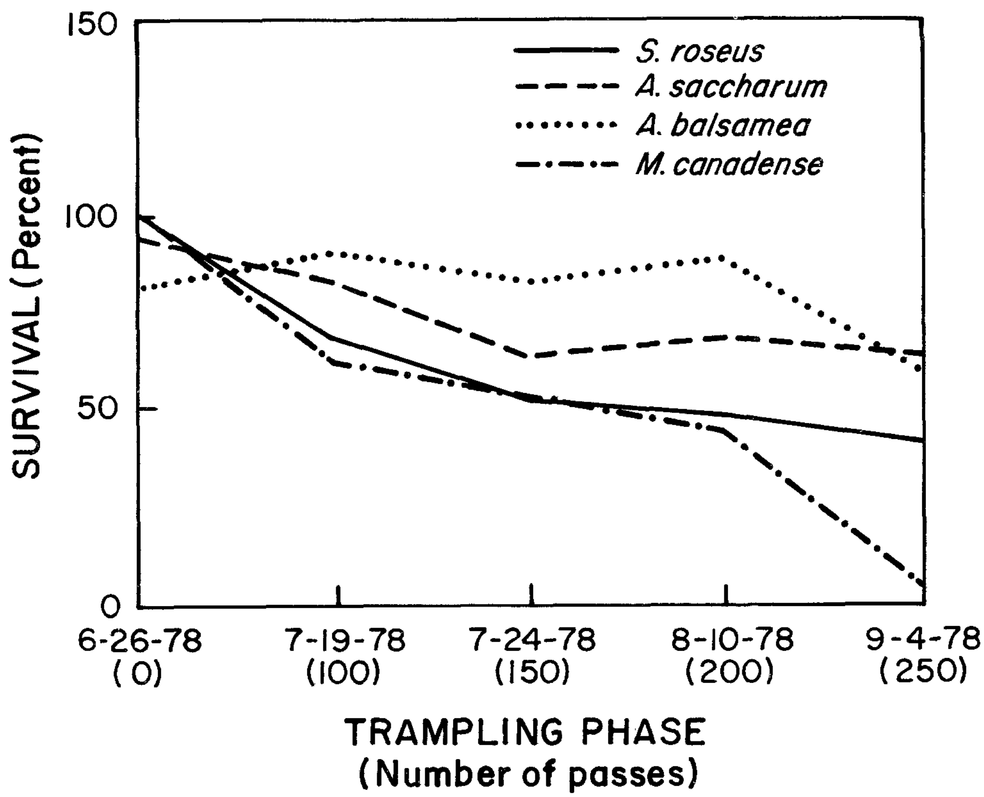

Figure 2.—Low-use data during trampling phase.

Conclusion

In summary, the plant species studied reacted similarly to trampling pressure. All four showed the greatest reduction in percentage of survival at the first 300 passes. More specifically, 100 to 300 passes can be considered a threshold level at which most initial trampling damage occurs. Before 100 passes, damage is relatively low. After 300 passes, damage increases but at a more gradual rate.

Plant species with steady rates of change during both trampling and recovery periods, such as Canada mayflower and sugar maple, should be used in further studies to ascertain their value as indicators of hiking pressure on ground cover.

Recovery periods may be substantial at the use level of 1,500 passes per season. It is likely that if this use level recurred each year, recovery rates would decline.

Literature Cited

Bates, G. H. **The vegetation of footpaths, sidewalks, cart-tracks, and gateways.** Journal of Ecology. 23: 470-487; 1935.

Bailey, G. D.; Pilgrim, S. A. L. **Soils of the White Mountains of New Hampshire and their suitability for recreational development.** Mountain Research and Development. 3(1): 53-60; 1983.

Bayfield, N. G. **Some effects of walking and skiing on vegetation at Cairngorm.** Scientific Management of Animal and Plant Communities for Conservation. Norwich, England: University of East Anglia; 1971.

Bell, K. L.; Bliss, L. C. **Alpine disturbance studies: Olympic National Park.** Biological Conservation. 5(1): 25; 1973.

Billings, M. P. **The geology of New Hampshire.** Part II: Bedrock geology. Concord, NH: New Hampshire State Planning and Development Commission; 1980. 203 p.

Cole, D. N. **Estimating the susceptibility of wildland vegetation to trailside alteration.** Journal of Applied Ecology. 15:281-286; 1978.

Fernald, Merritt Lyndon. **Gray's manual of botany, 8th ed.** Boston, MA: American Book Company; 1950. 1,632 p.

Frissel, S. S., Jr.; Duncan, D. P. **Campsite preference and deterioration in the Quetico-Superior canoe country.** Journal of Forestry. 63:256-260; 1965.

LaPage, W. F. **Some observations on campground trampling and groundcover response.** Res. Pap. NE-68. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station; 1967. 11 p.

McBride, J. C.; Leonard, R. E. **A system for measuring groundcover changes.** Parks. 7(1):20; 1982.

More, T. A. **Trail deterioration as an indicator of trail use in an urban forest recreation area.** Res. Note NE-292. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station; 1980. 4 p.

Speight, M. C. D. **Discussion papers in conservation: Outdoor recreation and its ecological effects.** A bibliography and review. London: University College; 1975.

U.S. Department of Agriculture, Soil Conservation Service and Forest Service. **Soil survey of Carroll County, New Hampshire.** Washington, DC: U.S. Government Printing Office; 1977-202-865/50. 161 p. In cooperation with: New Hampshire Agricultural Experiment Station.

Watson, A.; Bayfield, N.; Moyes, S. M. **Research on human pressures on Scottish mountain tundra, soils and animals.** In: Fuller, W. A.; Kevan, P. G., eds. Proceedings, conference on productivity and conservation in northern circumpolar lands; (dates unknown); Switzerland. New Series No. 16. (Place of publication unknown): IUCN Publications; 1970:256-266.

Leonard, R. E.; McMahon, J. L.; Kehoe, K. M. **Hiker trampling impacts on Eastern forests.** Res. Pap. NE-555. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station; 1985. 5 p.

Trampling impact studies were conducted in two eastern forest stands in the White Mountains, New Hampshire. Changes in plant mortality on simulated trails during a trampling period and a recovery period were monitored photographically. The extent of damage and rate of recovery varied among species. For most species, the greatest change in plant mortality occurred between 100 and 300 trampling passes.

Keywords: Trampling, plant mortality, hiker impact

☆ U.S. GOVERNMENT PRINTING OFFICE: 1985—505-028/538

Headquarters of the Northeastern Forest Experiment Station are in Broomall, Pa. Field laboratories are maintained at:

- Amherst, Massachusetts, in cooperation with the University of Massachusetts.
- Berea, Kentucky, in cooperation with Berea College.
- Burlington, Vermont, in cooperation with the University of Vermont.
- Delaware, Ohio.
- Durham, New Hampshire, in cooperation with the University of New Hampshire.
- Hamden, Connecticut, in cooperation with Yale University.
- Morgantown, West Virginia, in cooperation with West Virginia University, Morgantown.
- Orono, Maine, in cooperation with the University of Maine, Orono.
- Parsons, West Virginia.
- Princeton, West Virginia.
- Syracuse, New York, in cooperation with the State University of New York College of Environmental Sciences and Forestry at Syracuse University, Syracuse.
- University Park, Pennsylvania, in cooperation with the Pennsylvania State University.
- Warren, Pennsylvania.