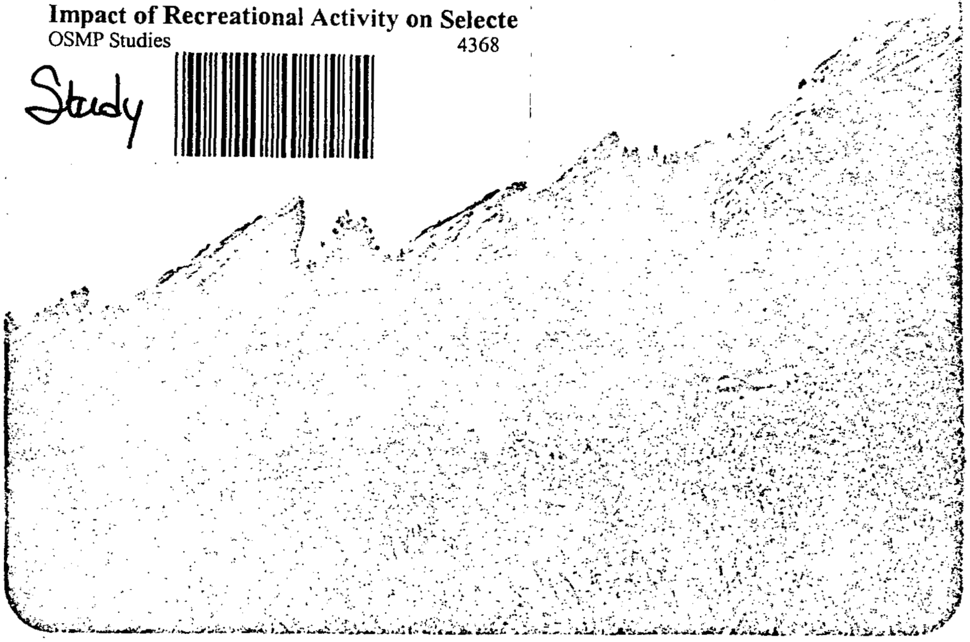

THE IMPACT OF RECREATIONAL ACTIVITY ON SELECTED PLANT COMMUNITIES ALONG MESA TRAIL

Boulder Mountain Park
Boulder, Colorado

Att

Donna Rauhauser
March, 1977
EPOB 521; Dynamics of
Mountain Ecosystems
Dr. John Marr, Professor

ABSTRACT

The intent of this study was to investigate the impact of heavy recreational usage on trailside vegetation. Three sites along the Mesa Trail in Boulder Mountain Park were selected so as to be representative of the vegetation characteristic of: 1) a mesic woodland; 2) a xeric meadow and 3) an intermittently hydric streamside. Each study site had slightly different soils, topographic features, moisture availability, and radiation regimes, but all received aproximately the same amount of visitor use.

At the three locations, a 5 x 5 meter plot was marked off on both sides of the trail. Each 1 x 5 meter strip which paralleled the trail axis was designated a "zone of influence" and the vegetation in that zone sampled with line transects.

These zones were then compared both within and between sites to determine the effect of distance from trail edge on vegetation density, species diversity, and species frequency.

It was found that only the meadow site exhibited the expected increase in vegetation density, diversity and frequency with distance from trail edge. Both the wooded and streamside sites displayed a somewhat irregular decrease in these three vegetative parameters with distance off trail.

LOCATION OF STUDY SITES 1, 2, AND 3

1: 24,370

SOURCE: Boulder Mountain Park Trail Map
Published by Boulder Group, Colorado Mountain Club
1973

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1 INTRODUCTION

The Mesa Trail sections examined in this study (see Fig. 1) are only a small fraction of the 42 miles of named trails maintained within the 6000 acres of Boulder Mountain Park. The area receives heavy and increasing recreational use due to close proximity to Boulder and suitability for day hikes.

Records have not been kept of use levels in the area, although management plans call for the installation of "seeing eye" counters in the near future.[1] Lacking this data, a measure of the increasing intensity of trail use may be gained by reference to air photos taken of the area in 1938, 1956, and 1971. (Exhibits 1, 2, and 3)

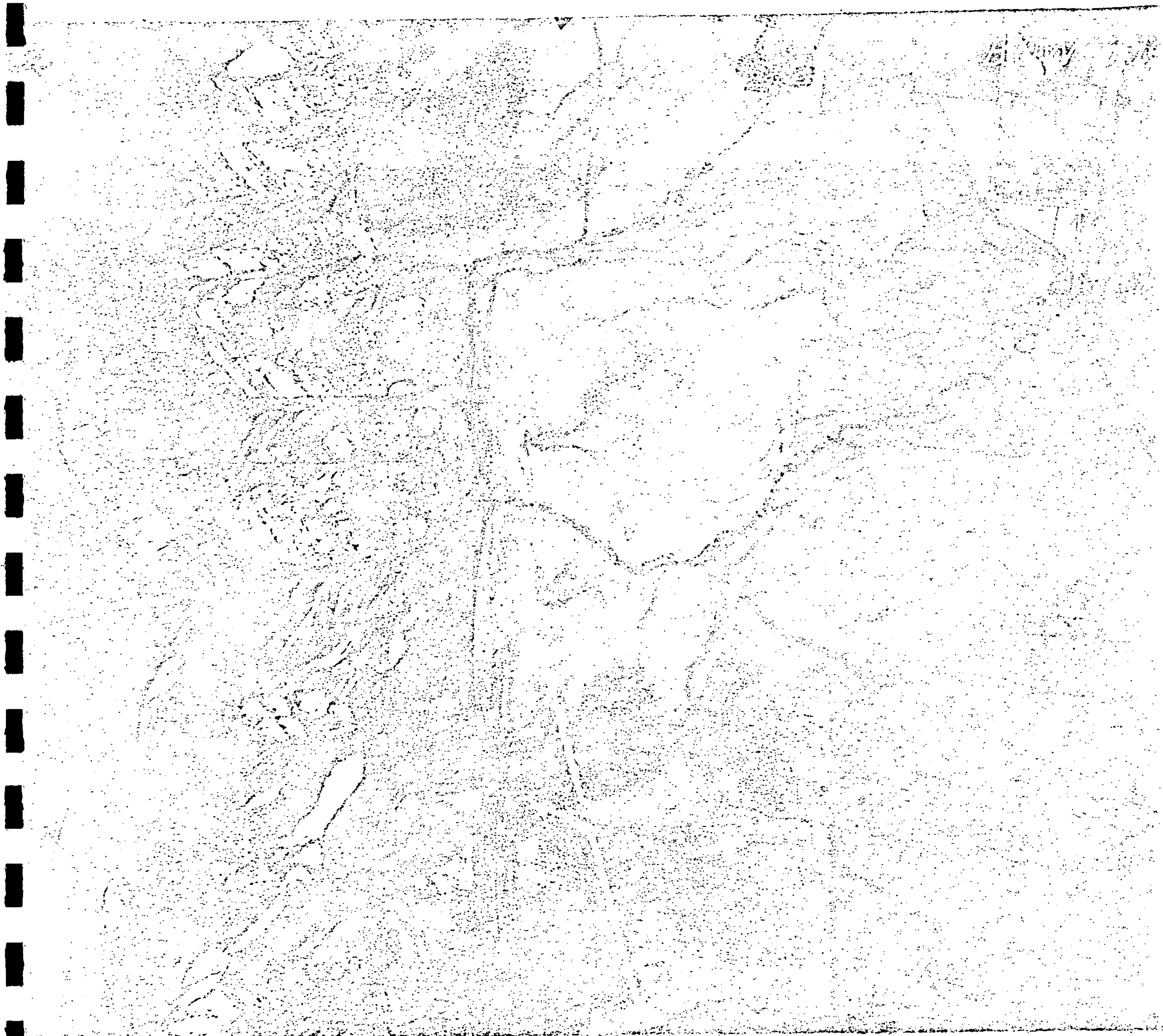
In the 1938 photo, only faint, single-route trail scars can be discerned. By 1956, the trail scars appear to be slightly deeper and wider; new housing units are also in evidence. The 1971 photo clearly illustrates the proliferation of urban development, the advent of trails leading from subdivision boundaries to the Mountain Park, the deepening and widening of existing Park trails, and particularly, the development of multiple routes along the Mesa Trail.

On that portion of Mesa Trail under study, most recreation use was by hikers, joggers, and horse riders. Generally, most hikers enter the area from the north via the Bluebell Shelter and Chautauqua accesses. An increasing number of people park their cars at the National Center for Atmospheric Research (NCAR) facility and enter the Park via the NCAR access trail, which is consequently becoming heavily impacted and widened.

1 Personal communication from Dick Lyman, Chief Park Ranger

EXHIBIT 1

AIR PHOTOGRAPH OF STUDY AREA IN 1938



SCALE: 1: 20,250
SOURCE: UNITED STATES FOREST SERVICE
DATE: 8-5-1938
CONTRACTOR: B.O.W.
EXPOSURE: 1-16

N ↑

EXHIBIT 2

AIR PHOTOGRAPH OF STUDY SITES IN 1956

1: 22,200

SOURCE: U.S. FOREST SERVICE
DATE: 9-2-56
CONTRACTOR: ECB

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Exhibit 3

AIR PHOTOGRAPH OF STUDY SITES IN 1971

1:29,460
SOURCE: U.S. GEOLOGICAL SURVEY
DATE : 8-3-71
CONTRACTOR: GS. VCCC
EXPOSURE - 1-23

N

Horse riders generally enter the trail system from the Dunn properties to the south. It would be difficult to isolate the individual effect of hikers, joggers, and horse riders; other studies have indicated, however, that the horse hooves and greater weight have a much greater cutting and compacting effect than the Vibram or rubber soles of the hiker or jogger.

II STUDY OBJECTIVES

Previous trail studies (California State College, 1972; Sierra Club Outing Committee, 1972) have found that the degree of physical deterioration of vegetation and soils observed along a recreational route reflects:

a) the type and extent of trail usage

b) time of year when the trail is used

c) geomorphological characteristics of the terrain through which the trail passes

d) resiliency of particular vegetative forms or species to sustain recreational impact

This study was an attempt to focus on the interaction between the last two points by examining the condition of trailside vegetation and soils at three sites which were chosen as representative of xeric, mesic and hydric micro-environments.

The working hypothesis was that:

1) Different microenvironments, receiving similar levels of recreational usage will exhibit different degrees of resilience due to variabilities in site characteristics.

2) The degree of impact would diminish with distance from

trail center. The expected pattern would be greater species diversity and frequency and less soil compaction with distance off trail

III SITE SELECTION

Three study sites were selected within a 1/2 mile segment of the Mesa Trail in that portion of Boulder Mountatin Park located directly west of the NCAR facility at an elevation of about 6000'. (see site map in Fig. 1).

A comprehensive view of the study area with each site identified may be seen in the photo of Fig. 2. All sites received a high level of trail usage and were similar in some physiographic and macroclimatic features such as general soil types and the receipt of 16-24 inches of precipitation annually.[2] Each site had very different microclimatic characteristics and consequently represented different types of plant communities.

Site 1 -- Mesic Wooded was located ~275' south of the Mesa and NCAR trail intersection. Located within a Ponderosa Pine stand, the area was deeply shaded by the tree canopy and had an understory of forbs and grasses with a dense vegetative litter of pine needles, downed trees and branches. A species list occurs in Table 1 and indicates that Deschampsia caespitosa and Aristida longiseta are the dominant grasses and Mahonia repens the dominant forb.

A photograph of the site (Fig. 3) shows that the trail itself is level here, but set into the face of a gently sloping hill which causes runoff from the slope above to accumululate on the downslope edge of the trail.

2 Soil Survey of Boulder County Area, 1975, p. 10.

Figure 2

Comprehensive view of study area

Figure 3

Site 1- Wooded

Soils at the site are identified by the Soil Survey of Boulder County Area as colluvials, underlain by a sandy loam. A fairly well decomposed humus layer occupies the top 1/2-1" of the soil profile.

Site 2-Xeric Meadow, was located ~75' north of the Mesa/NCAR trail intersection where the trail passes through a dry and open grassland complex with little shade. Dominant species (see Table 2) include Koeleria gracilis, Deschampsia caespitosa, Trisetum spicatum and Bouteloua gracilis among the grasses and Chrysothamnus nauseosus and Artemisia glauca as dominant forbs

The study area can be seen in the photograph of Figure 4 as that portion of the trail occupying the crest of the hill and hence fairly level. Evident in the immediate foreground is the severe trail erosion occuring only a slight distance away, where the slope steepens appreciably.

Soils at this site are derived from weathered shale and show in profile a surface layer of a reddish-brown stony loam, underlain by a reddish-gray light clay loam.

Site 3 - Intermittent Streamside was located~500' north of the Mesa/NCAR trail intersection where the trail dips down to cross Skunk Creek. Water flow in the creek was low during the time of the study (fall) but water stains on the surrounding rocks as well as vegetation distribution would indicate a much higher water level is possible, probably during spring runoff.

The site was moderately well shaded by shrub and tree forms of Acer negundo and Salix exigua. Reference to the species list in Table 3 indicates that Dactylis glomerata and Sitanion longifolium were the dominant grasses and Taraxacum officinale and Viola adunca the dominant forbs.

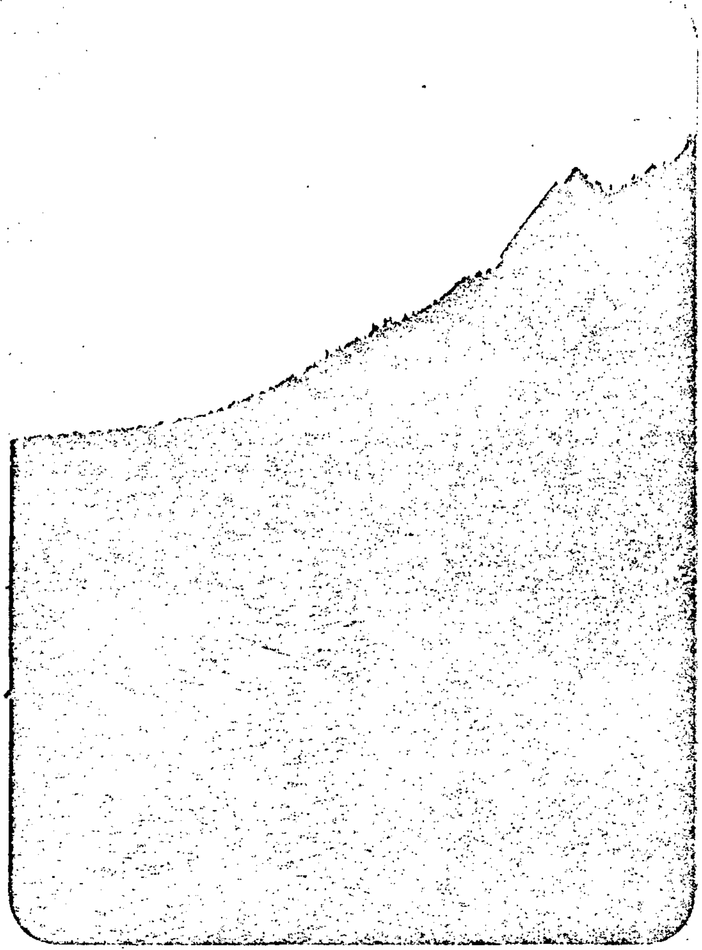


Figure 4
Site 2- Meadow

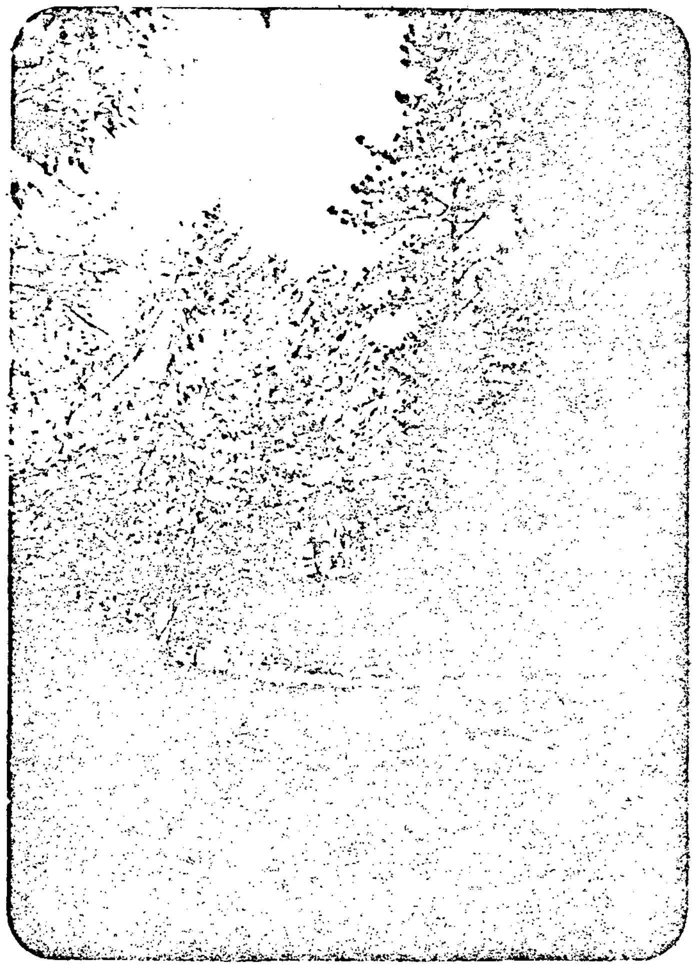


Figure 5
Site 3- Streamside

Due to limitations of time, labor and expertise, it was not possible to make a thorough investigation of the local microclimatic factors characteristic of each site, such as soil moisture and temperature, air temperature, humidity, local precipitation or wind. Since so many of these interdependent variables were uncontrolled and unmeasured, results found in this study are of limited generalization and may be characteristic of only the specific site studied.

IV METHODOLOGY

Data collected at each site centered around vegetation analysis as supplemented by soil erosion and compaction rates.

Vegetation analysis

At each of the sites described above, a pair of 5 x 5 meter plots were laid out which bordered the trail on either side. The objective was to sample vetetation at an increasingly greater distance from the trail bed. Each of the five, one-meter intervals was considered a subplot or zone of influence as labeled in Figure 7.

Line transects were placed at 1 meter intervals along the trail, and at 10 cm. intervals a "hit" was recorded as either a particular plant species, vegetative litter, mineral soil or rock.

This data was later used to calculate the vegetation density, species diversity and species frequency for each subplot.

Trail Erosion and Soil Compaction Analysis

Trail erosion was defined as the total amount of soil eroded from the trail bed. A rough estimate of soil loss was obtained by measuring the average depth and width of the trail bed at each site.

Figure 6
Trail section showing development of parallel routes

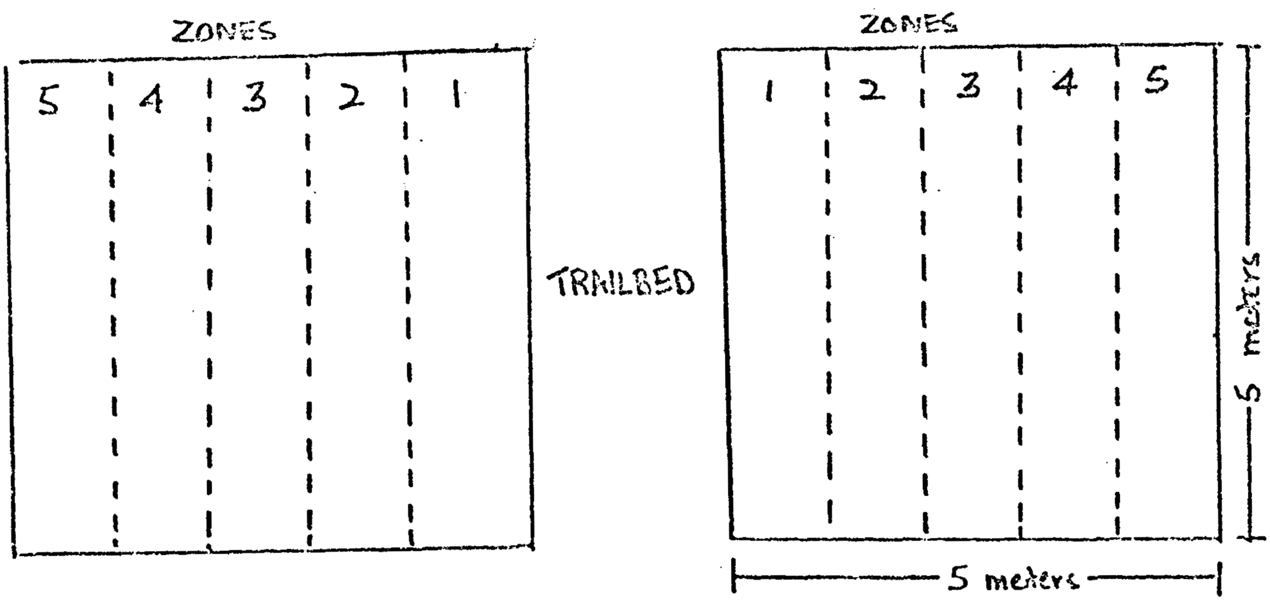


Figure 7
Diagram of study plot layout

These figures were then used to calculate the total volume of earth displaced per linear meter of trail.

A Soiltest TVA penetrometer was used to measure soil compaction. Readings were taken at 1 meter intervals within and between zones and these results combined to obtain an average compaction reading for each zone.

The reliability and replicability of this method is highly dependent on both human and physical variabilities in taking the measurement. While the instrument worked well enough on the off-trail, uncompacted soils, it was often impossible to penetrate the hardpacked trail surface. In addition, grass turf mats, dense plant roots, rocks and gravel were often encountered in taking readings and often resulted in what were probably erroneously high compaction readings.

Due to these difficulties with the penetrometer and the insensitive or inaccurate readings obtained, the soil compaction data was considered as only supplemental to the main study findings.

V RESULTS

Samples taken within the subplots on both sides of the trail were combined to obtain a profile of 5 zones of influence, ranging from 1 to 5 meters off the trail. This division into zones of influence was maintained throughout all tabulations of results.

Vegetation density relations within each site are depicted in the combined graph and table of Figure 8 in which the total ground cover is divided into that percentage which is:

1) Vegetation - the total count of individual plants encountered regardless of species.

2) Litter - a hit where partially or fully decomposed organic matter (e.g. decomposed grass mats, leaves, fine twigs) was encountered which could not be identified as living plant material.

3) Mineral Soil - the occurence of a bare soil or rock surface totally lacking vegetative litter.

Species diversity is the numerical total of those species present within each zone of influence. A graphical and tabular representation occurs in Figure 9.

Species frequency was defined as the frequency with which a given species was encountered within the vegetative cover of each zone. This measurement was computed by dividing the number of hits of a given species by the total number of vegetation hits, resulting in the percentage of total vegetation cover occupied by a given species. Tables 1, 2, and 3 present this data for each site.

Soil erosion and compaction rates are summarized in Table 4. A rough cross-section sketch of the trail bed profile is included; by measuring these dimensions it was possible to obtain an approximation of the amount of soil displaced per linear meter of trail.

The soil compaction rates derived from the TVA penetrometer readings are, as explained above, not wholly reliable, and can only indicate trends within each site. The off-trail/on-trail ratio was obtained by dividing the rate of the densely compacted soil of the trail center by the theoretically normal compaction rate of Zone 5, to derive an estimate of how greatly the center trail was compacted above normal.

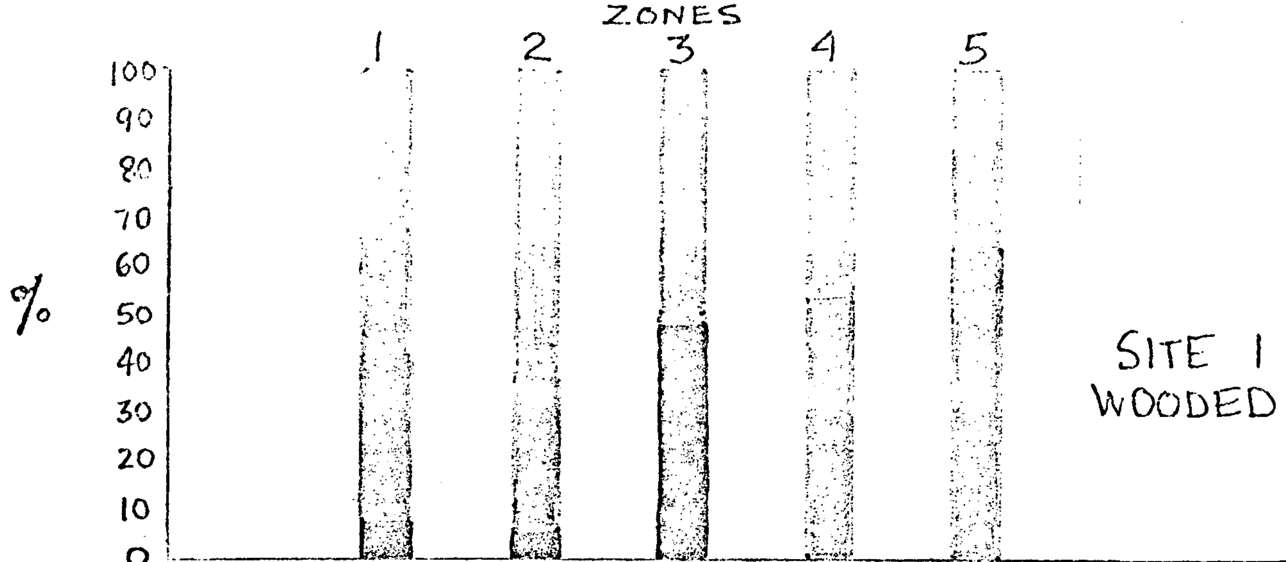
VI DISCUSSION OF RESULTS

Looking first at vegetation density (Fig. 8), Site 1 - Wooded exhibits an overall decrease in total vegetative cover with an irregular progression of 59.5% - 63.5% - 51.5% - 46.5% - 37% through the 5 zones. The percentage of ground covered with litter and mineral soil increases proportionately, with a very high reading of 47% mineral soil in zone 3 due to encountering rocks and downed branches in the area.

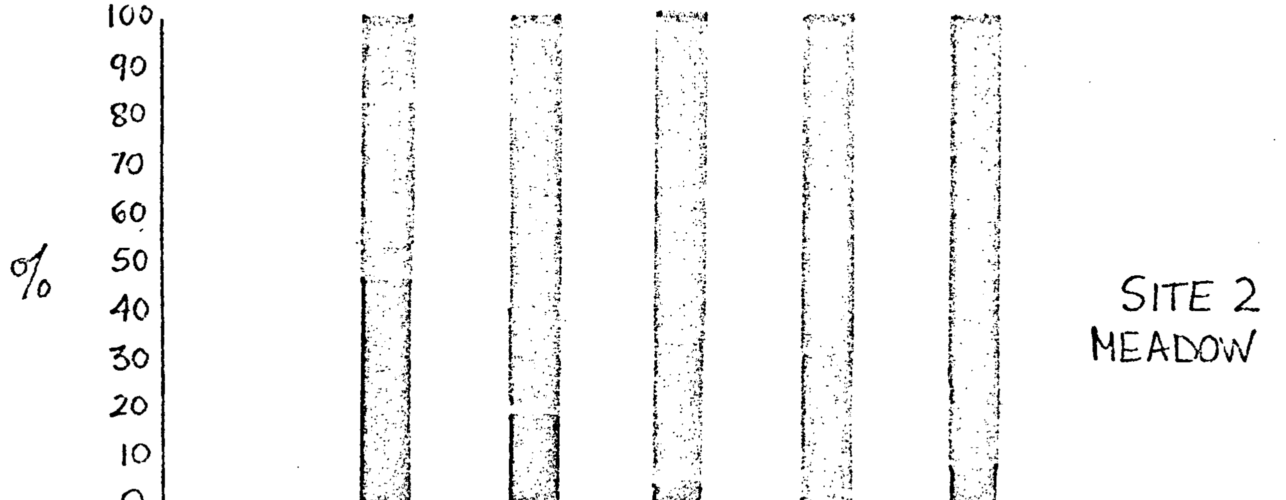
Site 2 - Meadow displays an orderly progression of greater vegetation density, greater litter cover and less exposed soil with distance from trail edge....

Site 3 - Streamside exhibits an irregular pattern of 61% - 48% - 55% - 35% - 51.5% in vegetation density for zones 1-5. Litter and mineral soil reflect a similar variability. This pattern may be due to the very irregular topography of the stream site, with rocks frequently encountered.

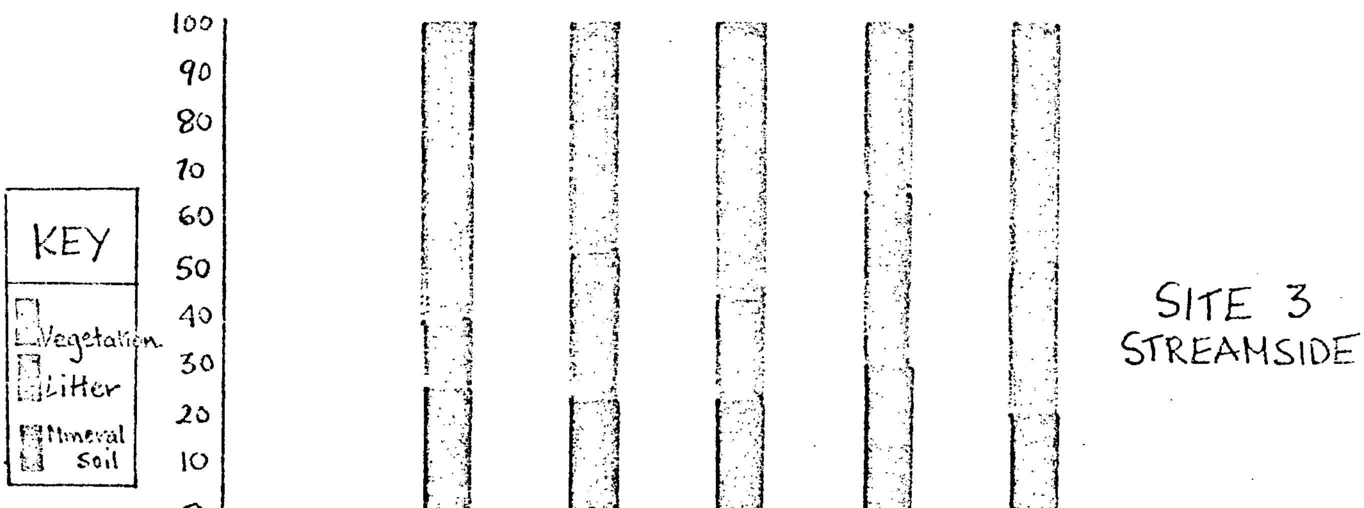
Comparing all three sites, one is struck by the rather low totals in overall vegetative cover. The Meadow plot had the highest total percentage in vegetative cover with 64%. Both of the other two sites had about 50% vegetation cover. If zone 5 is taken as the control or undisturbed zone, then the progression in the Wooded and Streamside plots from greater to less percentage vegetation with distance off trail may be evidence that the trailside habitat at these sites actually provides certain species with some advantages, such as greater surface runoff or nutrient availability.



	1	2	3	4	5		
% Vegetation	59.5	63.5	51.5	46.5	37		51.6
% Litter	33	31.5	1.5	53.5	63	TOTALS:	36.5
% Mineral Soil	7.5	5	47	0	0		11.9



	1	2	3	4	5		
% VEG'T	48	60	68	69.5	76		64.3
% LITTER	6	23	29	30.5	17	TOTALS:	21.1
% MIN. SOIL	46	17	3	0	7		14.6

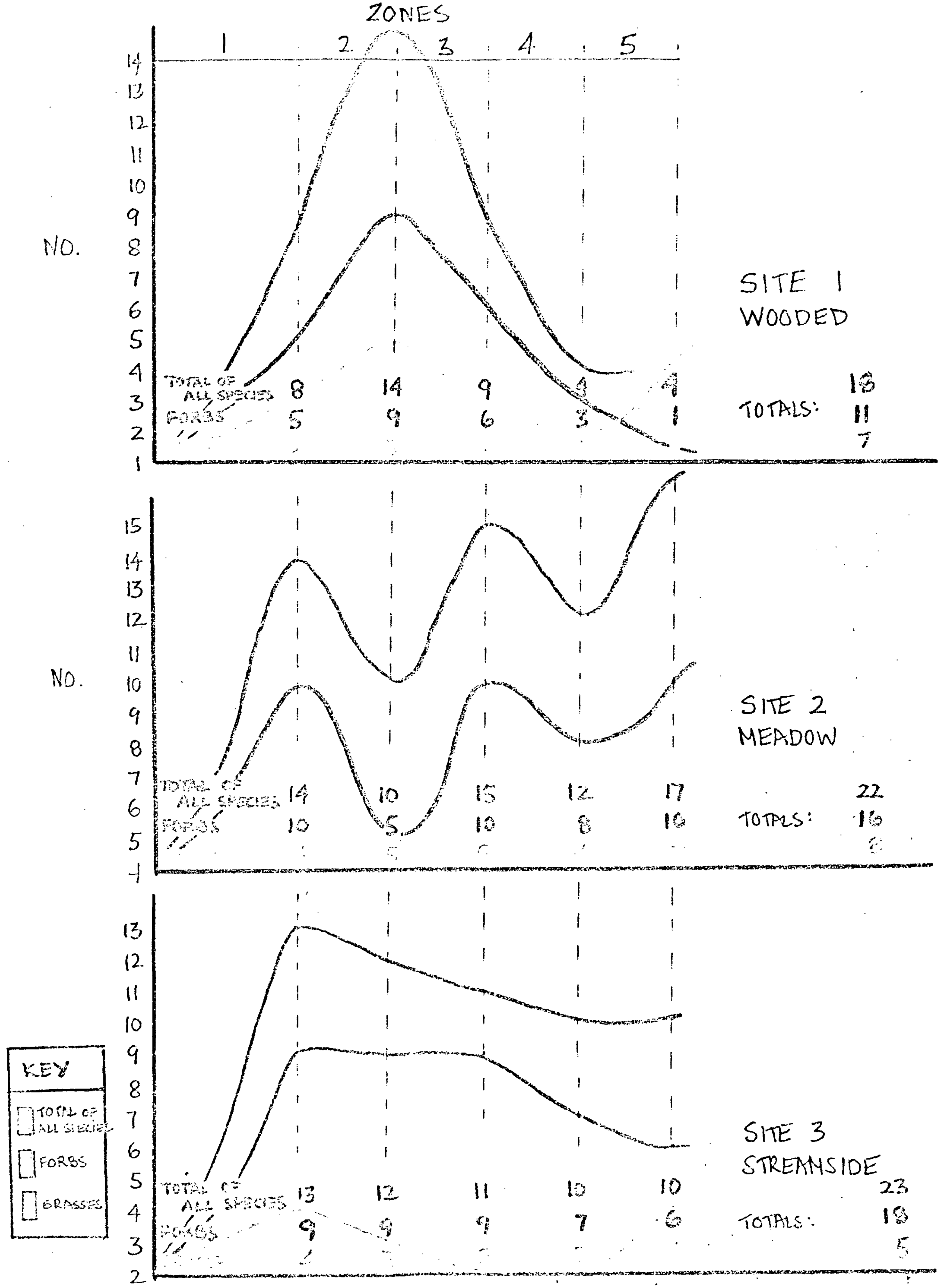


	1	2	3	4	5		
% VEG'T	61	48	55	35	51.5		50.1
% LITTER	12	28.5	22	35	28	TOTALS:	25.1
% MIN. SOIL	27	23.5	23	30	20.5		24.8

In terms of species diversity, the three sites were nearly equal in the total number of species each contained. (See Fig. 9) The meadow and streamside sites, with respectively, 23 and 22 total species, exhibited a slightly greater variability than the wooded site, which had 18 species represented.

The three sites exhibited distinctly different patterns, however, in species diversity throughout the five zones. At Site 1 - Wooded, the specie counts were 8 - 14 - 9 - 4 - 4 in zones 1 - 5, which was an unexpected overall decrease in variability with distance off trail. The abrupt increase to a total of 14 species in Zone 2 of this site is of particular note. Since the trail at Site 1 was cut into the face of a gently sloping hillside, the bare trail surface acts as a collector of the runoff from the slope above. Zone 2 may therefore, reflect that area on the lower side of the trail where the advantages of increased runoff outweigh the damages inflicted on trailside vegetation by hiker or horse contact.

Site 2-Meadow, with a pattern of 14-10-15-11-17 in species diversity for zones 1-5, was the only one of the three sites which indicated the expected overall increase in species diversity with distance off trail. Here again, Zone 2 (and to a lesser extent Zone 4) is of particular interest in that species diversity shows a decrease. This anomaly may be explained by reference to Figure 6, which shows how Site 2 might appear in a more advanced state of erosion. Note especially, the emergence of a secondary trail running closely parallel to the first. When the main trail is particularly muddy and affords insecure footing for horse and foot traffic, trail users shift to the higher and drier rim of the main trail bed and in doing so, create these



ZONES
1 2 3 4 5
NO.
TOTAL OF ALL SPECIES 8 14 9 4 4
FORBS 5 9 6 3 1
SITE 1
WOODED
TOTALS: 18 11 7
NO.
TOTAL OF ALL SPECIES 14 10 15 12 17
FORBS 10 5 10 8 10
SITE 2
MEADOW
TOTALS: 22 16
TOTAL OF ALL SPECIES 13 12 11 10 10
FORBS 9 9 9 7 6
SITE 3
STREAMSIDE
TOTALS: 23 18 5
KEY
TOTAL OF ALL SPECIES
FORBS
GRASSES

secondary routes. The depression in species diversity in Zone 2 of Site 2 possibly reflects the development of a secondary route through the site; on-site inspection supports this hypothesis.

The pattern through the five zones of Site 3-Streamside exhibits no particular irregularities other than the unexpected general tendency toward less species diversity with distance from trail.

Turning next to a comparison of species frequency data for the three sites, (Tables 1, 2, & 3) some contrasts may be made regarding the relative distribution of grasses and forbs within each site. Most of the grasses occur in all sites, an indicator of their ability to adapt to a variety of microenvironments... In contrast, few of the forbs found dominant at one site even occured in another, indicating the requirements of these particular forbs for a specialized habitat.

Site 1-Wooded had a nearly equal ratio of grass and rush species (50.5%) to forbs (49.5%). Deschampsia spp was the single most dominant grass, occupying fully 30% of the vegetative cover. Aristida longiseta was the second most dominant grass, contributing 11% of the total. The species composition within Zone 2 may warrant a closer examination since it has been noted earlier that both vegetation density and especially species diversity showed a distinct increase in this zone. The sole appearance in Zone 2 of Juncus compressus as well as the occurrence of Harbouria trachypleura and Galium boreale, all moisture indicator species, lends support to the argument that this zone may benefit from increased surface runoff from the slope above the trail.

TABLE 1

SPECIES FREQUENCY – SITE 1 – WOODED

	% of vegetation within each zone					% of total vegetation in plot
	1	2	3	4	5	
GRASSES & RUSHES						
Deschampsia caespitosa	3	29	46	32	40	30
Aristida longiseta	32	8	10		5	11
Koeleria gracilis	8	5				3
Elymus canadensis	8	2				2
Juncus compressus		10				2
Sitanion longifolium		3			5	1.5
Agropyron trichophorum			3			.5
Bromus tectorum		3				.5
SUBTOTAL	51	60	59	32	50	50.5
FORBS						
Mahonia repens	18	14	17	43	50	28
Galium boreale		6	9	10		5
Artemisia ludoviciana		3	6	15		5
Grindelia squarrosa	15					3.5
Artemisia canadensis	10	3				3
Harbouria trachypleura		5	3			1.5
Campanula rotundifolia		3	3			1
Potentilla fissa Nutt.	3	3				1
Ribes cereum		3				.5
Rosa woodsii	3					.5
Vicia americana Muhl.			3			.5
SUBTOTAL	49	40	41	68	50	49.5
TOTAL	100	100	100	100	100	100

TABLE 2

SPECIES FREQUENCY — SITE 2- MEADOW

GRASSES	PERCENTAGE OF VEGETATION WITHIN EACH ZONE					PERCENTAGE OF TOTAL VEGETATION
	1	2	3	4	5	
Koeleria gracilis	6	19	27	21	13	17
Deschampsia caespitosa	6	19	12	15	11	13
Trisetum spicatum	16	11	10	19	7	13
Bouteloua gracilis	19	28	5		7	12
Agropyron trichophorum					13	3
Bromus tectorum		5			7	2
Sitanion longifolium			2			.5
Stipa comata					2	.5
SUBTOTAL	47	82	56	55	60	61
FORBS						
Chrysothamnus nauseousus	22		7	7	2	8
Artemisia glauca	3	3	10	13	7	7
Alyssum alyssoides	3		5	7	7	4
Heterotheca villosa			5	2	11	3.5
Rosa woodsii	3	6	5			3
Opuntia compressa	3		3	5	2	3
Liatris punctata Hook.	10				2	2
Artemisia frigida	3		3	5		2
Aster fendleri	3			3	3	1.5
Artemisia canadensis		3		3	2	1.5
Artemisia ludoviciana		3	3			1
Astragalus lentiginosus		3				.5
Eriogonum umbellatum	3					.5
Symphoricarpos occidentalis			3			.5
Arabis glabra					2	.5
Solidago missouriensis					2	.5
SUBTOTAL	53	18	44	45	40	39
TOTAL	100	100	100	100	100	100

TABLE 5

SPECIES FREQUENCY – SITE 3 – STREAMSIDE

GRASSES

	PERCENTAGE OF VEGETATION WITHIN EACH ZONE					PERCENTAGE OF TOTAL VEGETATION
	1	2	3	4	5	
Dactylis glomerata	5	21	15	24	3	12
Sitanion longifolium	21	3			19	9
Bromus tectorum	10	7	3			4
Deschampsia caespitosa	8			5	3	3
Koeleria gracilis					3	.5
SUBTOTAL	44	31	18	29	28	28.5

FORBS

	1	2	3	4	5	
Taraxacum officinale	3	11	18	28	26	17
Viola adunca		14	12	9	13	10
Rosa woodsii	23	7		9	3	8
Symphoricarpos occidentalis	10	14	3	5	10	8
Echinocystis lobata			31			7
Aster fendleri	2.5		3	5	17	6.5
Hydrophyllum fendleri	2.5	7		5		3
Rubus idaeus	5	7				2.5
Ribes cereum	2.5		6			2
Lactuca scariola			3	5		2
Salix interior		3		5		2
Verbascum thapsus	5					1.5
Acer negundo		3				.5
Heracleum lanatum			3			.5
Ligusticum porteri					3	.5
Nepeta cateria		3				.5
Viola canadensis			3			.5
Achillea lanulosa	2.5					.5
SUBTOTAL	56	69	82	71	72	71.5
TOTAL	100	100	100	100	100	100

The other forbs and shrubs represented in Site 1 are those characteristic of shaded, well-drained sites. *Mahonia repens*, with 28% of the total cover, is clearly the dominant forb.

At Site 2-Meadow, grasses occupied 61% of the vegetative cover and forbs only 39% of the total. Grasses,(especially *Bouteloua gracilis*) reached a high of 82% in Zone 2, perhaps indicating a greater resilience to trampling as the secondary route referred to above is cut through this zone. *Koeleria gracilis*, with 17% of total vegetative cover was most frequently encountered, followed closely by *Deschampsia* spp. (13%), *Trisetum spicatum* (13%), and *Bouteloua* spp. (12%). It is interesting that although forbs at the meadow site were low in total abundance, the species diversity was high. Most of the forb species represented were those tolerant of dry, sunny habitats.

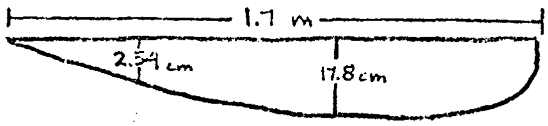
At Site-3-Streamside, forbs were the more efficient competitors, occupying 71.5% of the vegetative cover versus the 28.5% contributed by grasses. The few grasses present, such as Dactylis glomerata and Sitanion longifolia, were those tolerant of more hydric environments. Most of the forbs at this site were of species particularly adapted to shaded, moist conditions; *Taraxacum officinale*, *Viola adunca*, *Rosa woodsii*, *Symphoricarpos occidentalis* and *Echinocystis lobata* together accounted for 50% of the total cover.

The final measurement used to characterize each site is that of soil erosion and compaction rates as summarized in Table 4. The wide variation in trail bed profiles of each site indicates the impact of even slight differences in the slopes on which

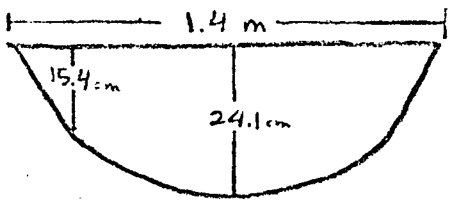
SOIL EROSION AND COMPACTION RATES AT SITES 1,2,&3

SITE	SOIL EROSION				SOIL COMPACTION lbs/sq"							ON-TRAIL / OFF-TRAIL COMPACTION RATIO
	TRAIL WIDTH at study plot midpoint	TRAIL DEPTH		SOIL DISPLACED in cubic meters per meter of trail	ON TRAIL		OFF TRAIL ZONES					
		center	3 cm from trail edge		center	edge	1	2	3	4	5	
1 - WOODED	1.7 m	17.8 cm	2.54 cm	.17	375	125	75	50	25	25	25	15
2 - MEADOW	1.4 m	24.1 cm	15.2 cm	.38	350	200	150	100	100	100	100	3.5
3 - STREAMSIDE	1.9 m	2.54 cm	2.54 cm	.048	500	301.25	100	79	56	46.3	112.5	4.4

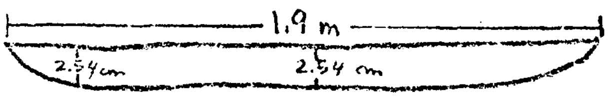
1 - WOODED



2 - MEADOW



3 - STREAMSIDE



the trail section occurs. The lopsided profile of Site 1-Wooded reflects its placement perpendicular to the slope above. Soil erosion at this site is a moderate .17 $m.^3$/meter. Site 2-Meadow has a much narrower and deeper trailbed, reflecting the gullying that results when a trail is located parallel to the slope fall-line; erosion here is much more severe with a rate of .38 $m.^3$/meter The trail at Site 3-Streamside was shallow, wide, and very level and consequently displayed the lowest amount of soil loss - only .05 $m.^3$/meter

An inter-site comparison of soil compaction rates may be misleading due to variability in soil and vegetation types found at the sites. Site 1-Wooded displayed a steady decrease in compaction with distance off trail. The exceedingly high on-trail/off-trail ratio recorded for this site indicates that if accurately measured, the center trail is 15X more compacted than soils 5 meters off the trail.

Site 2-Meadow showed a similar decrease in compaction with distance off trail; the on-trail/off-trail ratio here indicated that the center trailbed was 3.5X more compacted than that of Zone 5.

Site 3-Streamside, despite a general decrease in compaction in Zones 1-4, abruptly increased in Zone 5, perhaps due to encountering stream-carried gravel. Compaction was high in the trail center and, not surprising in light of the wide and shallow trail profile, also high at the trailbed margin. The relatively high on-trail/off-trail ratio of 4,4 would have been even greater with a lower compaction reading in Zone 5.

VII CONCLUSIONS

Based on the results found in this study, only the meadow site seems to suffer an overall diminishment of species diversity and frequency in zones immediately adjacent to the trailbed. The wooded and streamside sites actually indicate a more vigorous and diverse vegetation population in zones bordering the trail. This may be due to the increased reception of sunlight following trail cut through these shaded sites, more abundant water received from trail runoff, or the retention at these sites of nutrients from horse manure..

A more carefully designed and controlled study is required to determine the exact relationship between such environmental factors characterizing a particular habitat, and levels of trail use. Ideally, such an impact study should monitor the exact level of trail use and response of vegetation over time and encompass a more precise identification of soil type, soil compaction, wind and temperature variations and radiation regimes characterizing the study site. A plot much further removed from the trail should be designated as control and so provide a more reliable basis for comparison than a zone only five meters off trail.

Despite the limitations inherent in this study, and perhaps because of them, I feel I have learned a great deal from the project. I realize that the applicability and reliability of any research effort is dependent upon the particular study design chosen and the accuracy with which the field sampling is subsequently carried out. I am much more skilled at keying out plant species and have a new appreciation of the tedium involved in vegetation analysis by line transect. Perhaps most meaningful of all is my increased comprehension of the role played by environmental factors such as sunlight, water, and nutrients in maintaining the vitality of an ecosystem despite disturbance by human activity.