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Investigation of the effects of recreationist horse grazing on a subalpine meadow community in the North Cascades

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AN INVESTIGATION OF THE EFFECTS OF RECREATIONIST HORSE GRAZING ON A SUBALPINE MEADOW COMMUNITY IN THE NORTH CASCADES

By

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An Investigation of the Effects of Recreationist Horse Grazing on a Subalpine Meadow Community in the North Cascades (32 pp.)

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The effects of horse grazing on a subalpine meadow community in north central Washington are evaluated by comparing the vegetation of a grazed meadow with that of an ungrazed one. Eighty 0.1 m^2 plots were sampled in each meadow. Species frequency, foliar coverage, bare ground, and a soil profile for the meadows are included. *Festuca viridula* was almost absent in the grazed meadow; it was the dominant plant in the ungrazed one. Unpalatable species were found to be far more prominent in the grazed meadow. The outward appearance of the grazed meadow did not differ significantly from that of the ungrazed one, although some visual differences exist in late summer, early fall, and immediately after grazing.

ACKNOWLEDGMENTS

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INTRODUCTION

The effects of recreational activities upon the surface of the land is of increasing concern to land management agencies. In the past two decades there has been a corresponding interest in the academic community to study these effects. Numerous attempts have been made to qualify and quantify the causes and effects of what has collectively been called impact. Studies have involved topics ranging in diversity from human waste disposal on rivers, to trampling effects in various plant ecotypes, and even the psychological and social effects of crowding in wilderness areas.

An area of recreationist-caused impact that has received considerable attention from management agencies in the form of restrictions, closures, and regulations is horse use. Horses have been excluded from large portions of the Appalachian Trail in the eastern states, eliminated from many high density wilderness areas nationwide, and restricted in some form in virtually every national forest, national park, and wilderness area in the United States. At the same time there have been few studies to quantify or qualify specific horse-caused impacts. There is, apparently, either a preconceived idea as to what these impacts are, or a lack of interest on the part of researchers to study them.

The purpose of this study was not to quantify horse impacts in general. This study deals primarily with grazing in one community type

in the North Cascades. The information contained herein also serves as a base line for determining future changes in the vegetation of two meadows.

DEFINITION OF TERMS

The subalpine zone has been described many different ways in the ecological literature. Earlier, this zone was referred to as the Hudzonian zone by Merriam (Bailey 1936). Arno (1966) and Habeck and Hartley (1968) recognize that there are three types of timber line existing in this zone: forest line, the upper limit of continuously closed forest; tree line, the upper limit of erect trees; and scrub line, the upper limit of krummholz. Franklin and Dyrness (1973) include the upper portion of a closed forest in their discussions of subalpine vegetation. Love (1970) includes the krummholz belt in the subalpine vegetation. Douglas (1971, 1972) considers the subalpine zone to extend only from the forest line to the tree line. In this paper the subalpine zone follows the description of Douglas; this is the most realistic for the North Cascades.

The term community refers to a homogeneous group of plants that exist in a limited area within which there is no marked progressive change toward a different type of vegetation (Whittaker 1967). It is often noted in the ecological literature that subalpine zone vegetation is usually heterogeneous, consisting of a mosaic of separate vegetation units in an often limited area. Topographic, microsite, and snow accumulation differences typically account for this heterogeneity (Douglas and Bliss 1977, Franklin and Dyrness 1973, Henderson

1974); however, transect data from different portions of the two meadows studied for this paper indicate that relatively homogeneous vegetation exists within both of them.

Community type refers to a specific community that recurs throughout a given area. Although composition differences always exist between any separate stands of vegetation, a community type can be recognized as an entity because of its repeated composition similarity. Because vegetation research in the North Cascades subalpine zone has been reported almost exclusively by Douglas, the community types he describes are utilized in this study. Complete community descriptions for this zone are found in Douglas (1971, 1972) and Douglas and Bliss (1977). All species names are from Hitchcock and Cronquist (1973), with the exception of *Bromus polyanthus*. This was described only in Cronquist et al. (1977).

STUDY AREA

The North Cascades National Park complex is located in north central Washington, extending from the head of Lake Chelan to the Canadian border (Fig. 1). The complex contains Lake Chelan and the Ross Lake National Recreation Areas, and North Cascades National Park. The Rainbow Meadows study area is within the Lake Chelan National Recreation Area, approximately five miles from the national park boundary and ten miles from the nearest road. It is on the east side of the crest of the Cascade range, located at an elevation of 1,524 m. The meadow area of the study is in the lower portion of the subalpine zone.

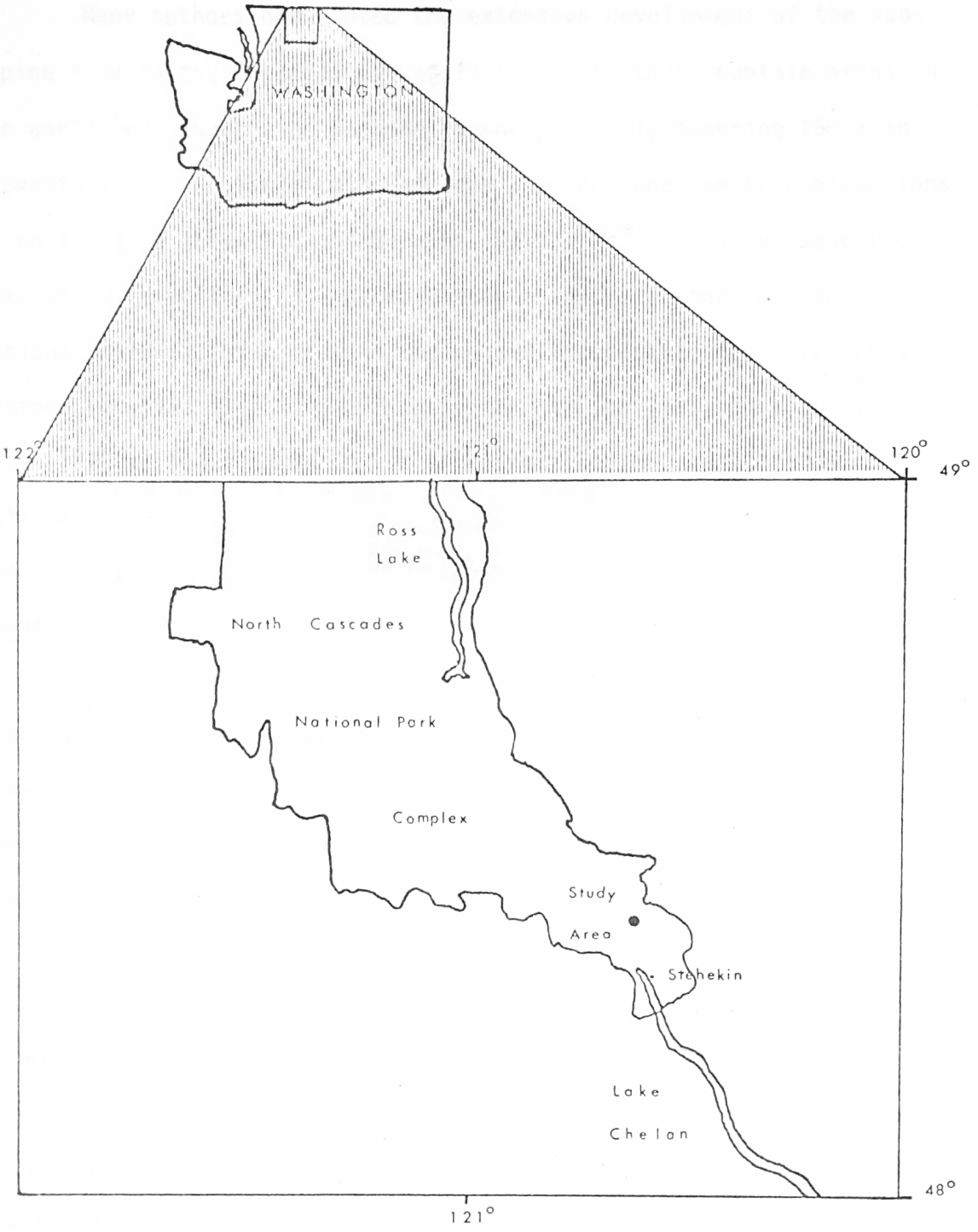

Figure 1

LOCATION OF STUDY AREA

Many authors have noted the extensive development of the subalpine zone in the Cascades of Washington. In other mountain areas in the world the timber line ecotone is sharp, rarely spanning 150 m in elevation. In the Washington Cascades this ecotone can span elevations of up to 500 m (Franklin and Dyrness 1973). It is usually suggested that the late-melting snow packs caused by heavy winter snow accumulations characteristic of this region are responsible for this broad ecotone (Douglas 1971, 1972, Franklin and Trappe 1963, Kuramota and Bliss 1970). These authors have concluded that the vegetation in this zone responds more to these snow accumulations than to mean temperatures, growing season temperatures, or temperature fluctuations.

The area is also characterized by warm spring temperatures with varying amounts of precipitation; hot, dry summers that often extend well into September; and cool, wet autumns with snow accumulations beginning in early to mid-November. The annual precipitation at Stehekin, Washington, approximately six miles away, is 86 cm. Because of the higher elevation of the study area, the precitipation there is probably much greater. Snow melt from the meadows can occur as early as mid-June (as in 1977) or as late as August 20 (as in 1972).

Weather data at these elevations is quite limited in the Cascades. Douglas and Bliss (1977) established some high elevation weather stations in the area in the mid-1970s. The extreme variability of the region's weather, caused by the meeting of continental and maritime weather patterns, allowed even relatively short distances between weather stations to create great differences in weather data.

During the summer the meadows can suffer from moisture stress. Although some researchers have stated that moisture stress and high growing season temperatures are often the major factors controlling the distributions of high elevation plants (Billings et al. 1966, Thilenius 1975), this does not appear to be the case in Rainbow Meadows or in any of the lower subalpine meadows of the North Cascades. Several summers will often pass with virtually no moisture stress in evidence. Douglas and Bliss (1977), in their work with meadow community ordination, correlated distribution most strongly with the time of snow melt.

The geology of the area is relatively complex. The Cascade uplift occurred in the Pliocene. The oldest rocks are crystaline basement material, primarily gneisses. Intermixed with the gneisses are scattered limestone formations and granitic intrusions. The severe glaciation which characterizes the region has combined with volcanic ash deposits from Mount Rainier, Glacier Peak, Mount Baker, and other nearby volcanoes to produce a very heterogeneous and complex soil pattern (Misch 1952, 1966). Plant communities of the region basically respond to topographic gradients, although there is probably some vegetation variation attributable to soil parent material, particularly in those areas of the isolated limestone formations.

The soils of the Cascades, particularly in the inaccessible areas of the national park and recreation areas, have not been mapped or extensively studied. Soils of the subalpine region are generally thin, often rocky, and quite young. A soil profile of the two meadows studied is included in the Results section (see Table 3, p. 16). The

study area soils were classified as Inceptisols.

The vegetation of the eastern slopes of the Cascades is an interesting combination of maritime and continental species. Lower elevations contain maritime species such as *Cornus nutallii, Alnus rubra,* and *Acer macrophyllum*. These exist alongside stands of *Pinus ponderosa* and *Pseudotsuga menziesii* var. *glauca*. These unusual combinations exist throughout the region. Because of more rigorous growing conditions, it is doubtful that the high elevation areas contain as many maritime plants as the lowlands.

Until recently, little has been written about the subalpine meadows of the Washington Cascades. Henderson's (1974) work at Mount Rainier and Douglas' (1971) work in the North Cascades have done much to fill the void. Although Douglas suggested that the western North Cascades is a "relatively homogeneous ecological province" (Douglas 1972, p. 147), after working with plant communities from the central and eastern North Cascades, he concluded that these plant communities are quite variable because of rapid shifts in environmental gradients. He did, however, describe some community types that seem to hold for the area (Douglas and Bliss 1977).

Sheep grazing, between 1920 and 1960, played an an important part in the economy of north central Washington. Abundant lowland grasslands were available for winter range, and the extensive subalpine meadow communities provided forage during the summer and early fall months. The U.S. National Park Service took over the management of the area from the U.S.D.A. Forest Service in 1968. Grazing activities were probably not well-documented before that time. I have been unable to

locate any U.S.D.A. Forest Service grazing records that pertain to the area. Discussions with early residents indicate that sheep herds, as typical in the west, were large and they gazed extensively throughout the subalpine zone.

Along with sheep, the grazing of recreationists' horses has been continual since the late 1940s. Due to the isolation of the area, most horse use came from several outfitters operating therein. In the 1950s and 1960s, the outfitting expeditions often contained 30 or more horses in one group. Since 1968, outfitter operations have sharply decreased. There is presently only one outfitter operating in the south district of the park complex on a regular basis. Since 1968, the enforcement of new regulations by the U.S. National Park Service has closed several area trails to stock use and has limited the size of horse parties. Horse grazing in the south unit of the park complex is, at present, almost entirely confined to four areas: McAlester Pass, Rainbow Meadows, Lake Juanita, and the north fork of Bridge Creek. Grazing occurs in each area with varying frequency and intensity each summer. This usually occurs before plant species in the meadows reach maturity. A second period of use often occurs again during the hunting season in September and October.

Rainbow Meadows was chosen as a study area because of the existence of a small, ungrazed meadow 800 m away. This small (three hectare) lower meadow is removed from the established horse camps of an upper meadow also selected for my study. My observation indicates that this meadow is in a pristine condition. Slope, soils, aspect, surrounding forest vegetation, period of insolation, and time

of snow melt of the two meadows appear similar. There is an elevation difference between the two of approximately 20 m.

Evidence of past fires is extensive in the eastern North Cascades. Although fire is often an important factor in the creation and maintenance of subalpine meadows (Bockheim 1972, Henderson 1974, Kuramoto and Bliss 1970), there was no evidence of fire found on the surface or in the soil of the selected meadows.

Both sample meadows are surrounded by closed forests of *Abies amabilis* and *Abies lasiocarpa*. The invasion of the meadows is indicated in a contiguous larger meadow. It contains an island of *Abies lasiocarpa* in which the oldest trees are approximately 40 years of age. The center trees are the older, indicating an outward spread. The trees of the surrounding closed forests show little indication of encroaching on this meadow. Boundaries between the meadow and forest communities are quite sharp in the study meadows. Two meadow-bordering *Picea engelmannii* were aged, using an increment bore.[1] Both were approximately 260 years old.

The study meadows had a south aspect and slopes ranging from three to eight per cent; both are at the base of rather broad avalanche paths which run yearly. These avalanches play an important role in maintaining the meadows, and they add substantially to the accumulated winter snow cover. Thornburgh (1969) suggested that, although the herb-grass meadow types may be seral to shrub and closed forests, they are often maintained by the action of avalanching snow because

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[1]A total of eight cores were taken at breast height.

the tree and shrub types are more susceptible to injury from moving snow.

Because of its small size and isolation, the lower meadow of this study probably received less attention from sheep and sheepherders. Since sheep grazing was terminated, the lower meadow has been virtually undisturbed. Because of the distance from established horse camps and the limited amount of forage, it is doubtful that this meadow has received any intentional horse grazing.

The grazed meadow of the study is closely adjoined by two others of similar form and vegetation. The particular meadow chosen is contiguous to Rainbow Meadows camp. This is an old, designated horse camp located along a popular trail which connects the Stehekin valley with the Pacific Crest Trail; it is used mainly by through-hikers and horsemen in the North Cascades National Park complex.

All horse traffic utilizing the Rainbow Lake trail presently terminates at Rainbow Meadows camp, the only designated horse camp in the drainage. Although the single outfitter operation in the area accounts for most of the horse use, private parties with varying numbers[2] of horses sometimes make use of the territory. Some undoubtedly pack in horse feed, but the meadows continue to be grazed each season. Photographs of the camp and meadow are shown in Figure 2 (p. 11).

In the fall of 1976, a hunting party with approximately 15 horses remained in Rainbow Meadows camp for ten days. The meadows were

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[2]The U.S. National Park Service has a maximum limit of 12 horses per party.

Rainbow Meadows camp with grazed meadow in foreground

Ungrazed meadow below Rainbow Meadows camp

Figure 2

Photographs of Rainbow Meadows area

heavily grazed and trampled during that time. The disturbance occurred after all meadow species had matured and started dormancy. The primary disturbance was probably caused by trampling. Such intensive grazing is a rare occurrence.

METHODS

A reconnaissance of the meadows was conducted in the summer of 1978. Plant specimens were collected, pressed, and taken to the University of Montana herbarium for identification. Most species were collected between July 15-18 during the peak flowering of that year. Some of the Graminae and *Carex* specimens were collected in August after their seed heads reached maturity.

In the summer of 1979, the meadows were sampled in mid-July. One-tenth square meter plots were established along a 25 meter transect subjectively placed in each of four quadrants in the meadows. Twenty plots were sampled along each of the four transects in each meadow. Canopy coverage and frequency were recorded for each species. This sampling method is detailed in Daubenmire (1959). Although he suggested that 40 plots are sufficient for most meadows, 80 were sampled in each of the study meadows so as to determine whether substantial differences existed in the vegetation within each meadow.

Sampling was conducted over a period of three days during the peak period of flowering.[3] Sampling during earlier or later periods of development would result in slightly different coverage values, and

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[3]July 6-10 in 1979.

early maturing species such as *Erythronium grandiflorum* could easily be missed. Some difficulty existed in determining *Carex* species. They are grouped together and reported as *Carex* spp. in the Results section (see Table 1, p. 14).

Tree ages were determined by taking a core with an increment bore at breast height. Soil profiles were obtained by driving a two-inch aluminum thin-wall electrical conduit into the soil to a depth of two feet, then removing the resulting core. Soil pits were not dug because of the visible impact.

Permission to graze the ungrazed meadow was obtained from the U.S. National Park Service. This was accomplished in accordance with a predetermined intensity. The value of this experiment is limited, however, and the primary results are not reported. After the grazing, many of the plants were damaged by trampling. It was impossible to determine living and dead vegetation during the limited duration of the study. Some broad generalizations derived from this portion of the study are discussed later.

Bare ground for each meadow was determined using the line intersect method. Twelve 25 m transects were scattered randomly in both meadows. Bare ground exceeding 5 cm was recorded whenever it was encountered along the transect.

RESULTS

Results are reported in Tables 1, 2, and 3 (pp. 14, 15, and 16, respectively).

Table 1 shows the composition and per cent bare ground in

Table 1

Data from 160 1/10 Meter^2 Plots Along Eight Transects in Two Meadows

Species	Grazed			Ungrazed		
	fr*	cov† (%)	pv‡	fr*	cov† (%)	pv‡
Ligusticum grayii	28	27	143	35	19	112
Melica spectabilis	32	25	141	16	9	36
Thalictrum occidentale	25	21	105	5	1.2	2.7
Achillea millefolium	34	19	111	27	3.6	19
Carex spp.	8	14	40	31	12	67
Arnica rydbergii	17	8	33	22	21	97
Potentilla flabellifolia	14	6	22	10	4.5	14
Senecio integerrimus	16	5.5	22	--	--	--
Valeriana sitchensis	7	7.5	20	30	12	67
Lupinus latifolius	12	4.8	17	8	2.6	7.4
Phleum spp.	13	4.7	17	11	5	17
Erigeron peregrinus	16	4	16	16	7.6	30
Erythronium grandiflorum	15	4	15	2	0.1	0.1
Castilleja miniata	6	3.8	9.3	--	--	--
Aster engelmannii	9	1.6	4.8	4	0.2	0.4
Erigeron aureus	5	0.9	2	--	--	--
Festuca viridula	3	0.5	0.9	40	51	320
Arenaria capillaris	7	0.5	0.7	--	--	--
Viola glabella	2	0.3	0.4	1	0.1	0.1
Arnica diversifolia	3	0.1	0.2	--	--	--
Montia sibirica	--	--	--	4	0.6	1.2
Polemonium pulcherrimum	--	--	--	3	0.8	1.4
Total cover		158.1			150	
Bare ground		9.8			2.1	

*fr = average frequency in 40 plots.

†cov = average foliar coverage expressed as a percentage of the total sampled area.

‡pv = prominence value

Table 2

Floristic List of Species Encountered in Rainbow Meadows

Achillea millefolium
*Agropyron spicatum**
*Agroseris glauca**
*Aquilegia formosa**
*Arabis furcata**
Arenaria capillaris
Arnica diversifolia
*Arnica mollis**
Arnica rydbergii
Aster engelmannii
*Bromus polyanthus**
*Bromus sitchensis**
Carex albonigra
Carex hoodii
Carex nigracans
Carex spectabilis
Carex stylosa
Castilleja miniata
*Cirsium edule**
*Dodecatheon pauciflorum**
Erigeron aureus
*Erigeron liebergii**
Erigeron peregrinus
Erythronium grandiflorum
*Festuca subulata**
Festuca viridula
*Habenaria dilatata**
Ligusticum grayii
Lupinus Latifolius
*Lupinus polyphyllus**
Melica spectabilis
Montia sibirica
*Pedicularis bracteosa**
*Pedicularis groenlandica**
Phleum spp.
Polemonium pulcherrimum
Potentilla flabellifolia
Senecio integerrimus
*Senecio macounii**
Thalictrum occidentale
*Trisetum spicatum**
*Vaccinium delicosum**
Valeriana sitchensis
*Veratrum viride**
*Veronica wormkjokdii**
Viola glabella

*Present, but not found in sample plots.

the grazed and ungrazed meadows. Frequency shown is the average number of plots containing a given species. A typical 40-plot sample was used as the basis for this index. Coverage values indicate the total percentage of the sample area covered by foliage from a given species. A prominence value was determined for each species. Included for comparison, it is determined by multiplying the square root of the frequency by the coverage value (Douglas 1972). Species of the grazed meadow are ranked according to this prominence value, which was used by Douglas in all his work on North Cascade vegetation.

A list of species collected in both meadows comprises Table 2. Table 3 shows a typical soil profile for the meadows.

Table 3

A Representative Soil Profile in Rainbow Meadows

O1	Trace; grass, sedge, litter
O2	2-0 cm, partially decomposed litter
A1	0-12 cm, very dark brown, loamy, many roots, pH 4.5
B	12-15 cm, weak boundaries, pH 5, lots of roots
C	15+ cm, gray brown, gravelly, sandy pockets, few roots, pH 5

DISCUSSION

There are at least three ways to study and evaluate animal grazing influences on grasslands and meadows. The first, and probably the most effective, is to study vegetation changes over time with varying grazing pressure. This seems to be the approach utilized by most investigators. The second is to graze a previously ungrazed meadow and record the species consumed and damaged. The third approach is to compare a meadow that has been grazed previously to an undisturbed one.

Several problems and advantages exist with each method. The first depends on either preexisting vegetation data or a considerable length of time being available for the study. The second depends on the use of fistulated animals, the sacrifice of grazed animals, or determining the effects of grazing on the condition of each plant grazed. Unless plants have been ripped out by the roots, it is difficult to detect damage to plants. Species respond differently to mechanical damage and defoliation; some species cease growth immediately, others may be stimulated (Crider 1955, Schuster 1963). The evaluation of each plant grazed was attempted in this study, but was discontinued because of the difficulty involved in interpreting the damage of grazing on that plant. The third method depends upon two areas composed of similar vegetation before disturbance occurred to one of them.

As previously mentioned, the only important difference between the two meadows was 20 m in elevation. Within an ecotone, any gradient is likely to produce substantially different vegetation. The elevation

difference between the grazed and ungrazed meadows is important to note, particularly since the timber line ecotone is considered to be elevation-dependent. If this study were designed to point out subtle differences in vegetation, the elevation difference could make any description attempts difficult and perhaps meaningless.

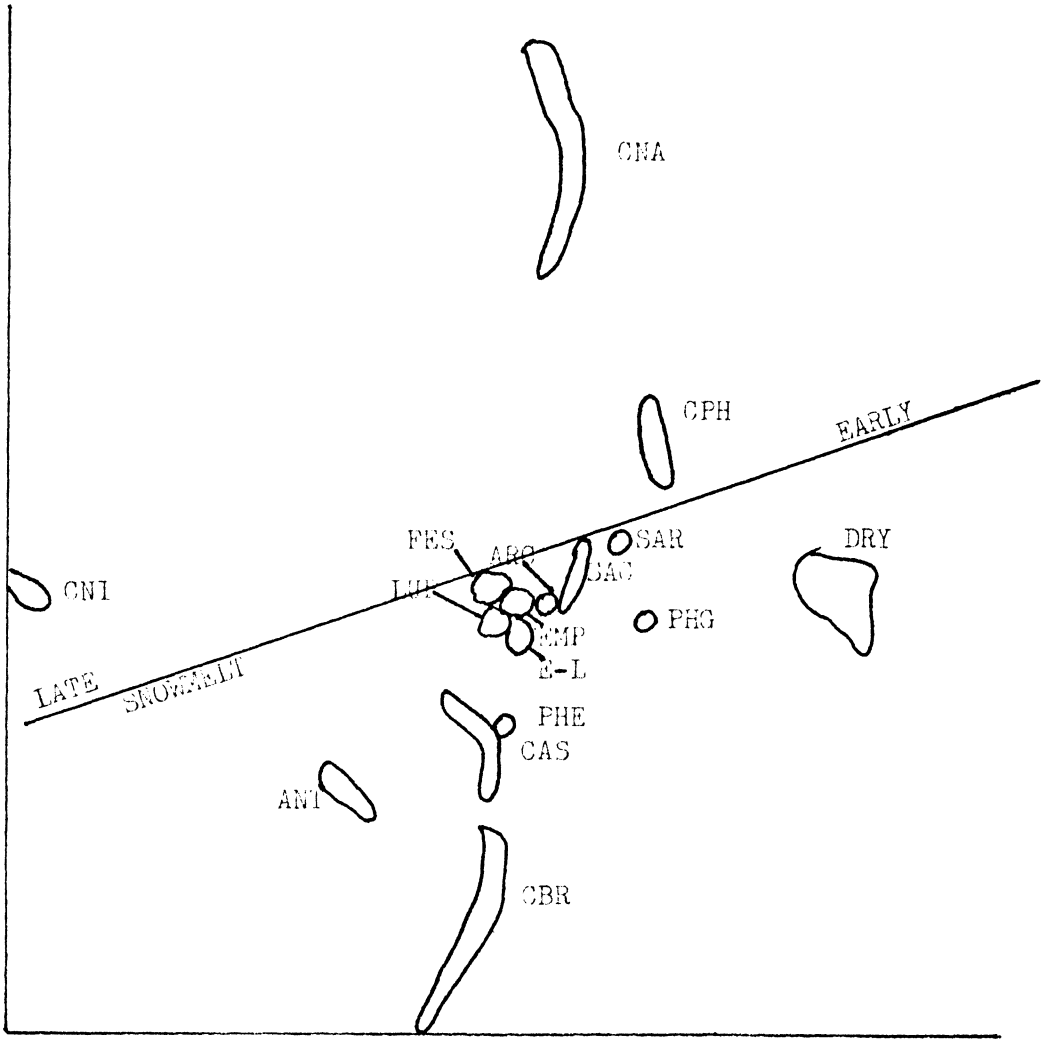
The results of this study do not, however, indicate subtle differences. The principal difference between the meadows is in the amount of *Festuca viridula* present. This species makes up less than one per cent of the coverage of the grazed meadow, compared to 51 per cent of the coverage of the ungrazed meadow.

Douglas (Douglas and Bliss 1977) describes a *Festuca viridula* community type for an area which closely corresponds to the composition of this study's ungrazed meadow. Although most of his sampled stands were approximately 300 m higher than Rainbow Meadows, the species reported in his *Festuca viridula* community type included *Potentilla flabellifolia, Lupinus latifolius, Arnica rydbergii,* and other species found in Rainbow Meadows. Also described are some closely related community types found in the area: a *Lupinus latifolius* type, an *Empetrum nigrum* type, and an *Erigonum pyrolaefolium* type. An ordination of these and other high elevation meadow communities is reproduced in Figure 3 (p. 19). In none of Douglas' stands, does he report *Ligusticum grayii* as a major constituent.

In Henderson's (1974) work on Mount Rainier, a description of lower subalpine communities is presented. Although further removed geographically, his stands were often placed in the lower portion of the subalpine zone, unlike Douglas' (Douglas and Bliss 1977) recent

Figure 2

Ordination of Alpine and High Subalpine Plant Communities
in the Central North Cascades



ANT = *Antennaria lanata*
ARC = *Arctostaphylos uva-ursi*
CAS = *Cassiope mertensiana*
CBR = *Carex breweri*
CNA = *Carex nardina*
CNI = *Carex nigracans*
DRY = *Dryas octopetala*
E-L = *Eriogonum pyrolaefolium*
EMP = *Empetrum nigrum*
FES = *Festuca viridula*
LUP = *Lupinus latifolius*
PHE = *Phyllodoce empetriformis*
PHG = *Phyllodoce glandulifloria*
SAC = *Salix cascadensis*
SAR = *Salix nivalis*

Source:

George W. Douglas and L. C. Bliss, 1977, Alpine and high subalpine plant communities of the North Cascade Range, Washington and British Columbia, Ecological Monographs, 47:119.

work which was almost entirely concentrated in the alpine and the highest communities of the subalpine. In Henderson's *Festuca viridula* community type, *Ligusticum grayii* was a codominant. *Ligusticum grayii* evidently drops out rapidly in the upper portions of the subalpine zone.

By combining Henderson's (1974) and Douglas and Bliss' (1977) studies, the lower subalpine meadow vegetation is predictable. Using the predicted vegetation and comparing it with the vegetation of the ungrazed meadow, I can conclude that the combining of the studies for prediction is valid. Logically, the grazed meadow in its original condition should have been similar to the ungrazed meadow and the findings of Henderson (1974) and Douglas and Bliss (1977). No described community types even remotely resemble the present vegetation occurring in the grazed meadow. It is, however, predictable when one theorizes from the following five points and, thus, one would expect a plant community closely resembling that which presently exists in Rainbow Meadows.

1. The vegetation of this meadow originally existed in a composition closely resembling the *Festuca viridula* community type described by Douglas and Bliss (1977) and the present condition of the ungrazed meadow.

2. Grazing has occurred from sheep and horses in the past 50 years.

3. *Festuca viridula* is sensitive to defoliation; it often is lost when meadow communities are grazed.

4. *Festuca viridula* is a preferred species of sheep and horses.

5. *Achillea millefolium*, *Ligusticum grayii*, and *Thalictrum occidentale* are known unpalatable species; they existed in the meadow before grazing occurred.

Many studies are found in the literature concerning forage preferences of domestic livestock (Stoddart and Smith, 1955). Quantitative studies involving horses are lacking although Archer (1977) stated that horses show marked preferences for some species. He further noted that horses are extremely selective. Strand (1972, Stanley et al. 1979) correlated the degree of hunger of a horse to its selectivity. He stated that a hungry horse will eat *Pinus contorta* needles if nothing else is available. Personal observation certainly indicates a great degree of preference and selectivity in horses. Certain grazing horses go out of their way, by as much as 50 m, to consume single *Cirsium edule* specimens. During the experimental grazing of the undisturbed meadow, *Festuca viridula* was the most preferred species. *Ligusticum grayii*, *Potentilla flabellifolia*, and *Valeriana sitchensis* were strictly avoided.

Although horse grazing preferences are not well-documented, sheep preferences are often reported. Bedell (1968) and Strickler (1961) have indicated that green fescue is preferred by sheep to the virtual exclusion of other species. On high elevation ranges lacking fescue, the general consensus is that sheep prefer forbs to grasses. Stevens (1966) estimated that, on ranges in Montana, sheep utilize forbs for as much as 89 per cent of their diets.

In the Wallowa mountains in eastern Oregon, where fescue is a primary constitutent, severe overgrazing created serious range damage in

the 1930s. Strickler (1961) estimated the soil loss there at 521 tons per acre. Although horse grazing might cause less of an effect on fescue ranges than sheep grazing, this certainly indicates the sensitivity of *Festuca* communities to grazing.

Based on the predicted vegetation for the grazed meadow, horses have virtually eliminated *Festuca viridula*. Coverage values have decreased from the 50 per cent range to less than one per cent. Frequency values have also drastically decreased. In the ungrazed meadow, *Festuca viridula* was the dominant in every plot sampled. In the grazed meadow it was found in only six plots out of 80. In these six plots it was never rated the dominant species.

The total cover values for each meadow (158 per cent "grazed," 150 per cent "ungrazed") indicate that other species responded to the decreased competition from *Festuca viridula* and became more prominent. The total foliar coverage is actually greater in the grazed meadow. This reflects the increased presence of taller, spreading plant types such as *Thalictrum occidentale*. Also contributing to a greater total foliar coverage is the increased size exhibited by *Achillea millefolium*. Frequency differences for *Achillea millefolium* in the plots of the two meadows are insignificant; however, foliar coverage of this species was nearly five times greater in the grazed meadow than in the ungrazed. Definitely there is a change in competition levels. In the ungrazed meadow, *Achillea millefolium* was rarely found with flowers; this species was almost always less than 15 cm tall and found in shade under taller, more dominant species. In the grazed meadow, *Achillea millefolium* often was greater than 50 cm tall. Individual specimens frequently reached a

height of one meter; these larger plants nearly always had flowers.

The transects utilized to quantify bare ground indicate that there is a greater amount of bare ground in the grazed meadow. The bare ground did not occur in large blocks. Most instances of bare ground had transect measurements of less than 40 cm. When looking across the meadow from an oblique angle, no apparent bare ground exists. No abnormal erosion was detected away from the Rainbow Lake trail and consequently no apparent soil loss.

During the reconnaissance of the meadow in 1978, scattered specimens of *Erigeron liebergii* were found. Since this species is on the working list of threatened, endangered and rare species for Washington (Washington Natural Heritage 1978), special attention was given this species during the summer of 1979. At least 30 individual plants of this species were found in the grazed meadow. They typically occurred in groups in rocky microsites. No individuals of this species were found during the extensive coverage of the ungrazed meadow. It is difficult to postulate whether continual grazing has sufficiently reduced competition in order for this species to invade the grazed meadow or spread from some existing microsite to other points within the meadow. Coverage values for this species are insignificant. No individuals appeared in any of the sample plots. Little else can be said concerning this species except that it is present and that existing levels of grazing seem to have little adverse effect upon it.

Although hay is sometimes packed into Rainbow Meadows, extensive searching in the area of the campsite failed to produce any species that could be considered introduced. Although undetected in the sample

plots, *Bromus polyanthus* was found scattered throughout the grazed meadow. This grass species is a short-lived perennial and is often an indicator of surface disturbances. While it usually occurs on damaged range lands, it can also occur where pocket gophers, ground squirrels, and similar species are present and active. Its absence in the ungrazed meadow might indicate that it exists in the grazed meadow because of horse-caused surface disturbances.

As mentioned previously, past grazing intensities have been difficult to determine for the area of Rainbow Meadows; however, it is fair to assume that grazing intensities are less now than they were in the period from 1920 until 1968. The present grazing intensities of about 12 horses grazing overnight two or three times a year would certainly not be considered extreme grazing pressure. Regardless of when the majority of the grazing occurred, Rainbow Meadows cannot be considered a natural, undisturbed plant community; it is far from it. Continued grazing will inhibit recovery. As long as any grazing exists in Rainbow Meadows, substantial vegetation differences will exist between these meadows and undisturbed ones.

Although some visual impact exists in the meadows immediately after grazing, three to five days later most damaged plants return to an upright state. Most visitors to the area are unfamiliar with plant communities. Few recognize that grazing has had a substantial impact on species composition. At least two management level national park employees have, in the past, commented on the "pristine" condition of Rainbow Meadows when the subject of grazing was introduced.

One of the most interesting aspects of the study was the

discovery that grazing may increase the plant diversity of these subalpine meadows. Species such as *Castillega miniata, Aquilegia formosa, Dodecatheon pauciflorum* and many species of the compositae family are present in the grazed meadow, while being absent or nearly so in the ungrazed meadow. For the average backcountry visitor, the presence of the flowering plants on the grazed meadow may be more pleasing than the appearance of the less colorful ungrazed meadow. Cole (1980) supports this opinion.

Other visual differences do occur. In the fall the herb component of the meadows is usually dry, brown, and dormant although the grasses remain green until very hard frosts occur. Usually, from about mid-August through the fall, the grazed meadows appear substantially less attractive because of the smaller component of grasses in their compositions.

IMPLICATIONS FOR MANAGEMENT

Impacts occur regularly in every wilderness-based recreation area. Human use and impacts always go together. The average horse and rider cause more impact than the average hiker or backpacker. Also, without proper trails, camps, and instruction, hikers can severely impact an area in a very short time. A question must be asked by land managers: when do impacts become unacceptable?

In the 12 years since the U.S. National Park Service took over the management of what is now the North Cascades National Park complex, grazing has been either prohibited or strictly controlled. In the early 1970s, written regulations prohibited grazing. Horse users were

required by regulation to pack their horse feed into the area. Although grazing is still generally prohibited, special provisions are now made (with written permission from the superintendent) which allows grazing in specified areas (Allen 1980).

As mentioned earlier, recreational horse grazing has been continual and a regular occurrence since the 1940s. No citations have been issued in the south unit of the park complex for horse-related violations. Among the managers of the park complex it is, however, well known that horse grazing occurs. In King's Canyon National Park, Strand (1972) also reported that grazing prohibitions did little to stop the grazing there. Some grazing is apparently considered acceptable in North Cascades National Park by current managers.

This paper is presented to provide field information for decisions which have, in the past, been made on the basis of preconceived ideas or subjective judgments. Continued grazing in Rainbow Meadows, at present intensities, will not produce substantial visual impacts to the average visitor. Continued grazing will also not allow natural meadow communities to exist in the area of Rainbow Meadows.

Of the four areas regularly grazed in the south unit of the park complex, Rainbow Meadows is probably the least sensitive to disturbance. McAlester Pass and Lake Juanita are both above 1,900 m, located in the *Larix lyallii* zone. Bare ground is prominent at McAlester Pass and recovery seems quite slow. McAlester Pass is a wet meadow type which Strand (1972) reported as the most susceptible to trampling damage by horses. Willard and Marr (1971) reported that

recovery of damaged alpine areas may take up to one thousand years. While McAlester Pass is not quite in the alpine zone, recovery times in this area can certainly be inferred as being long.

Lake Juanita also exists in the *Larix lyallii* zone. It has experienced considerable impacts in past years from sheep, motorbikes, hikers, and horses. Bare ground exists in scattered spots, usually reflecting choice camping spots. Away from the lake, the area is well-drained and less sensitive to grazing and trampling than McAlester Pass. Side slopes in the area are steep and grass pedestals of up to ten cm indicate that considerable erosion and soil loss has occurred on many of these slopes. This area was very heavily utilized in the past by sheep; the erosion probably results from that impact. Horse grazing typically takes place away from the steeper slopes in areas not exhibiting grass pedestals. In both McAlester Pass and the Lake Juanita area, horse grazing must be carefully monitored and controlled so as to avoid substantial additional impacts.

THE CONTINUATION OF HORSE USE IN WILD AREAS

Horse use in wilderness and national park areas is frequently the subject of heated debate. There are few outdoor users that do not have a strong opinion concerning horse use. Hikers, especially those who have no experience with horses, are almost always adamantly opposed to any horse use in parks and wild areas. Horse owners, users, and outfitters naturally feel as strongly that horses have a place in these wild areas.

Arguments such as these are not unique to the question of horse

use, neither are they completely meritless. It is, however, disappointing to see so many decisions concerning horse use originating from the subjective judgment of individual land managers or groups of managers. It seems obvious that horse regulations in an area fundamentally reflect individual philosophies of the land managers in charge of and responsible for regulations in the area.

In most wild areas of the west nearly every backcountry trail that exists was originally constructed for horse use. Since the influx of hikers that occurred during the 1960s and 1970s, many of these trails have been closed to horse use. The main reason cited for these closures, and for many of the restrictions placed on horse use, seems to be horse-caused impacts.

Since these impacts (resulting in closures and restrictions) are seldom quantified or studied, other alternative measures are rarely considered. It is undoubtedly true that many areas cannot continue to accommodate horse use without an unacceptable amount of impact, it is also true that in many of these areas horse use could continue if impacts were better understood and other positive actions were taken to correct specific problems associated with the mechanisms of the impact.

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