



Effects of grazing on vegetation in the *Artemisia tridentata*-*Festuca idahoensis* habitat type
by Peter Odd Husby

A thesis submitted in partial fulfillment of the requirement for the degree of Master of Science in
Range Science

Montana State University

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Abstract:

A study was conducted during summer 1981 to determine the effects of grazing on plant composition in the big sagebrush (*Artemisia tridentata*)-Idaho fescue (*Festuca idahoensis*) habitat type in southwestern Montana! Thirty stands ranging from ungrazed to severely grazed were sampled for percent canopy cover and frequency of each species and an index of Idaho fescue vigor was obtained. Computer-generated ordination as well as manual and computer-assisted clustering techniques revealed two distinct vegetation gradients in the stands sampled. An Idaho fescue gradient was inversely related to grazing intensity. A big sagebrush gradient was apparently related to environmental variables not measured during the study but was not related to grazing intensity. The response of most other species to grazing was highly variable. It was concluded that range, condition criteria for the big sagebrush-Idaho fescue habitat type should be based primarily on Idaho fescue cover.

A preliminary range condition classification is presented for the habitat type. Idaho fescue vigor was generally inversely related to grazing intensity but was not a reliable indicator of range condition.

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IDAHOENSIS HABITAT TYPE

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A thesis submitted in partial fulfillment
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December 1982

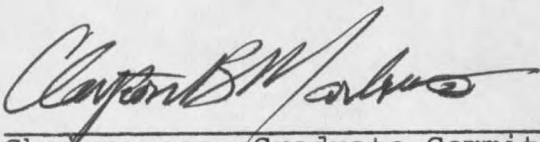
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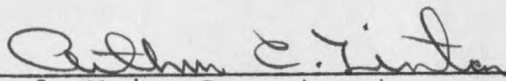
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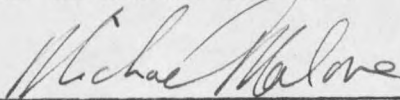
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ABSTRACT

A study was conducted during summer 1981 to determine the effects of grazing on plant composition in the big sagebrush (Artemisia tridentata)-Idaho fescue (Festuca idahoensis) habitat type in southwestern Montana. Thirty stands ranging from ungrazed to severely grazed were sampled for percent canopy cover and frequency of each species and an index of Idaho fescue vigor was obtained. Computer-generated ordination as well as manual and computer-assisted clustering techniques revealed two distinct vegetation gradients in the stands sampled. An Idaho fescue gradient was inversely related to grazing intensity. A big sagebrush gradient was apparently related to environmental variables not measured during the study but was not related to grazing intensity. The response of most other species to grazing was highly variable. It was concluded that range condition criteria for the big sagebrush-Idaho fescue habitat type should be based primarily on Idaho fescue cover. A preliminary range condition classification is presented for the habitat type. Idaho fescue vigor was generally inversely related to grazing intensity but was not a reliable indicator of range condition.

CHAPTER 1

INTRODUCTION

The habitat type concept (Daubenmire 1968) has been widely used as a basis for land classification and management in the western United States (Daubenmire 1968, 1970; Pfister et al. 1977; Pfister 1981; Mueggler and Stewart 1980). Daubenmire (1970) defined a "habitat type" as the aggregate of all environmentally equivalent areas and used as an indicator of their similarity their ability to support the same primary climax vegetation. Since habitat types reflect the inherent productivity of the land as indicated by the climax vegetation, the system provides a framework for intensive land management.

Mueggler and Stewart (1980) recently developed a habitat type classification for the rangelands of western Montana. The USDA Forest Service's Region I now requires that its range allotments be mapped at the habitat type level in all areas where this classification applies (USDA 1977). However, since seral communities cover much of the landscape, they must be described before the system can be fully applied to rangeland management (Arno 1981; Hironaka 1979; Tisdale and Hironaka 1981). Hironaka (1979) noted that combined information on climax communities and

their attendant seral communities permits interpretation of where a particular vegetation is in relation to its potential and also suggests the probable successional pathway of the current vegetation, since all the seral communities are related to a single climax and to each other.

Rangeland habitat type identification is difficult on severely disturbed ranges because several (even rather dissimilar) climax communities may converge to the same seral plant community (Huschle and Hironaka 1980). Also, relatively pristine examples of a climax rangeland community are often not found adjacent to disturbed sites because of the long history of livestock grazing on western ranges. Munn et al. (1978) suggested that soil and climate may be the best guide to the habitat type on severely disturbed ranges. Descriptions of the seral communities associated with each habitat type, when combined with soil and climatic information, will supplement these features in habitat type identification.

"Range condition" is defined by the Forest Service as the deviation of the ecosystem from the climax condition in plant composition, vigor of key species, and soil stability. Range condition classes have long been thought to represent the major successional stages of the range types (Parker 1954). However, the climax plant composition may vary considerably within the fairly broad

range types often used in range condition analysis.

Several climax communities may occur within these broadly defined range types, indicating the variability of site potential within them. Evanko and Peterson (1955) found that the variability in species composition between high condition fescue grasslands in southwestern Montana was often greater than the variability due to different grazing intensities within them. This emphasizes the desirability of using a finer environmental typing system such as provided by Mueggler and Stewart (1980). Evanko and Peterson (1955) also noted that the response of a plant species to grazing depended upon site characteristics and associated species. Similarly, Mueggler and Stewart (1980) documented differential species response to grazing between habitat types, indicating a need for more site-specific range condition evaluations.

This study was conducted during summer 1981 to describe vegetation changes caused by grazing in the big sagebrush-Idaho fescue (Artemisia tridentata-Festuca idahoensis--Artr/Feid) habitat type in southwestern Montana and to evaluate Forest Service range condition criteria used for plant communities in this habitat type.

CHAPTER 2

STUDY AREA

The study was conducted within a 5680 square km area of southwestern Montana including parts of the Gallatin, Madison, Ruby and Beaverhead River drainages (Figure 1).

Geologic parent materials include primarily Tertiary volcanic rocks in the Gallatin and Madison River drainages, early Precambrian gneisses and schists in the Tobacco Root Mountains and mixed conglomerates, shales, sandstones and mudstones of the Kootenai Formation and Montana Group in the Ruby River drainage (Ross et al. 1955; Veseth and Montagne 1980). Based on a sample of three, Munn et al. (1978) described the soils of the Artr/Feid habitat type as Pachic Cryoborolls of the coarse-to-fine loamy families with ustic moisture regimes, although Typic Cryoboralfs may be found near forest margins. Weaver (1978) summarized the physical and chemical characteristics of 11 soil samples from Idaho fescue grasslands. Surface horizons were loam in texture and high in organic matter (about 7%). These characteristics are consistent with those of the Cryoborolls described by Munn et al. (1978).

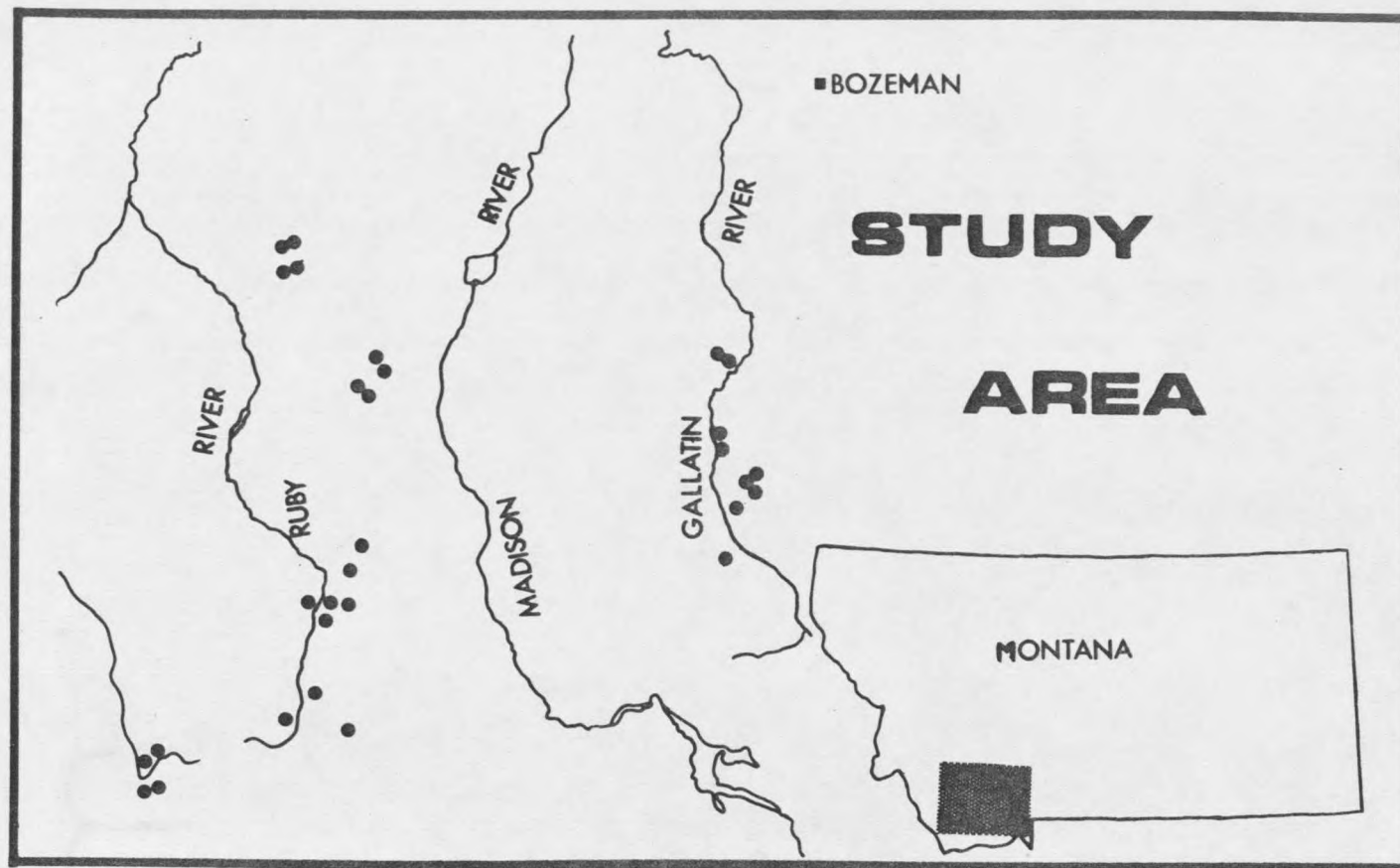


Figure 1. Study area and location of sample sites. The shaded portion of the map shows the location of the study area in southwestern Montana.

The Artr/Feid type falls within the 36- to 75-cm annual precipitation range with about 52% occurring from May through September (U. S. Dept. Commerce 1968-79; Ross and Hunter 1976). Short, cool summers and long winters are characteristic. Weaver (1979) summarized climatic characteristics of Idaho fescue grasslands based on data from 17 stations in Montana, Wyoming, Idaho and Washington. Average annual precipitation was 48 cm. Peak precipitation occurred from late May-June for dry to average sites and in January and June for the wetter sites. There were 4 months with less than 6 frosts. The mean temperature of the coolest and warmest months was -8°C and 17°C , respectively.

Sample stands were located between 1750 and 2400 m elevation on a variety of combinations of slope, aspect and topography. The plant community varied from scattered parkland within forest types to large expanses of uninterrupted sagebrush grassland.

Artemisia tridentata spp. vaseyana was the dominant shrub on all sites, but A. tridentata spp. tridentata occurred in two streambottom stands. Idaho fescue dominated the understory vegetation with prairie Junegrass (Koeleria pyramidata), Sandberg bluegrass (Poa sandbergii)

and bluebunch wheatgrass (Agropyron spicatum) as conspicuous associates. Lupine (Lupinus sericeus) and pussytoes (Antennaria spp.) were common forbs found in the vegetation.

CHAPTER 3

METHODS

Thirty sample stands were chosen to represent the full grazing sere including those grazed little or not at all to sites severely disturbed by grazing and trampling. Whenever possible, fenceline pairs were sampled where relatively undisturbed stands were found adjacent to stands representing various grazing intensities.

Sampling methods were based on those used by Mueggler and Stewart (1980). A 20x20 m macroplot containing two randomly located 15-m line transects was established at each site. Ten 2x5 dm quadrats were evenly spaced along each of the two transects and canopy cover (%) of bare ground, rock, litter, mosses, lichens and all vascular plants was estimated within them using the coverage classes of Daubenmire (1959). Plant nomenclature followed Hitchcock and Cronquist (1973).

An index of vigor for Idaho fescue was obtained by classifying the first 30 fescue plants intercepted by the transect according to basal diameter class (<1", 1-2", 2-4", 4-6", 6-8", >8") and by counting the number of seedstalks per plant.

Fecal counts were conducted within the macroplots to quantify use by livestock and big game.

A 100-hit step-loop transect (Parker 1951) was also conducted along the transects for use in range condition evaluation. Range condition was determined using the Mountain Grassland Scorecard (USDA 1977) and the step-loop data.

Additional information recorded at each site included aspect, percent slope and elevation. Color photographs were also taken at each site.

Data analysis included computer-generated ordination (Swan et al. 1969) and cluster analysis (Sokal and Sneath 1963) of canopy cover data as aids in ordering the sample stands according to their vegetational similarity. Sorenson's (1948) index of similarity was used in these methods. Association table analysis (Mueller-Dombois and Ellenberg 1974) was used in conjunction with these methods to determine the species most responsible for the clustering of stands and to identify patterns of secondary species associated with grazing intensity or environmental variables.

Linear regression analysis was used to determine the relationship between major species encountered in the Artr/Feid habitat type and a t-test was used to identify significant ($p = 0.05$) differences in a given species abundance for the fenceline contrasts sampled.

CHAPTER 4

RESULTS AND DISCUSSION

Cluster Analysis

The cluster analysis (Figure 2) resulted in the five clusters of stands and four outliers as detailed in Appendix A. Clusters A-D were all similar to each other at the 75 percent level or greater, while cluster E showed little similarity to the others. Association table analysis, using vertical alignment of species and horizontal alignment of the clusters of stands, indicated that species presence/absence was of little value in differentiating the clusters. Instead, canopy cover of Idaho fescue proved to be the major differentiating criterion. Quantities of major species in the five clusters are compared in Figure 3. Idaho fescue cover showed a general decrease across the clusters, being greatest in cluster A, intermediate in clusters B-D, and lowest in cluster E. The four outlier stands had intermediate values. Big sagebrush cover was significantly lower in clusters A and D, but showed no consistent pattern across the groups. Lupine cover showed a slight tendency to decrease across the clusters while Sandberg bluegrass cover showed the opposite trend. It was concluded that Idaho fescue cover provided the most ecologically sound basis for

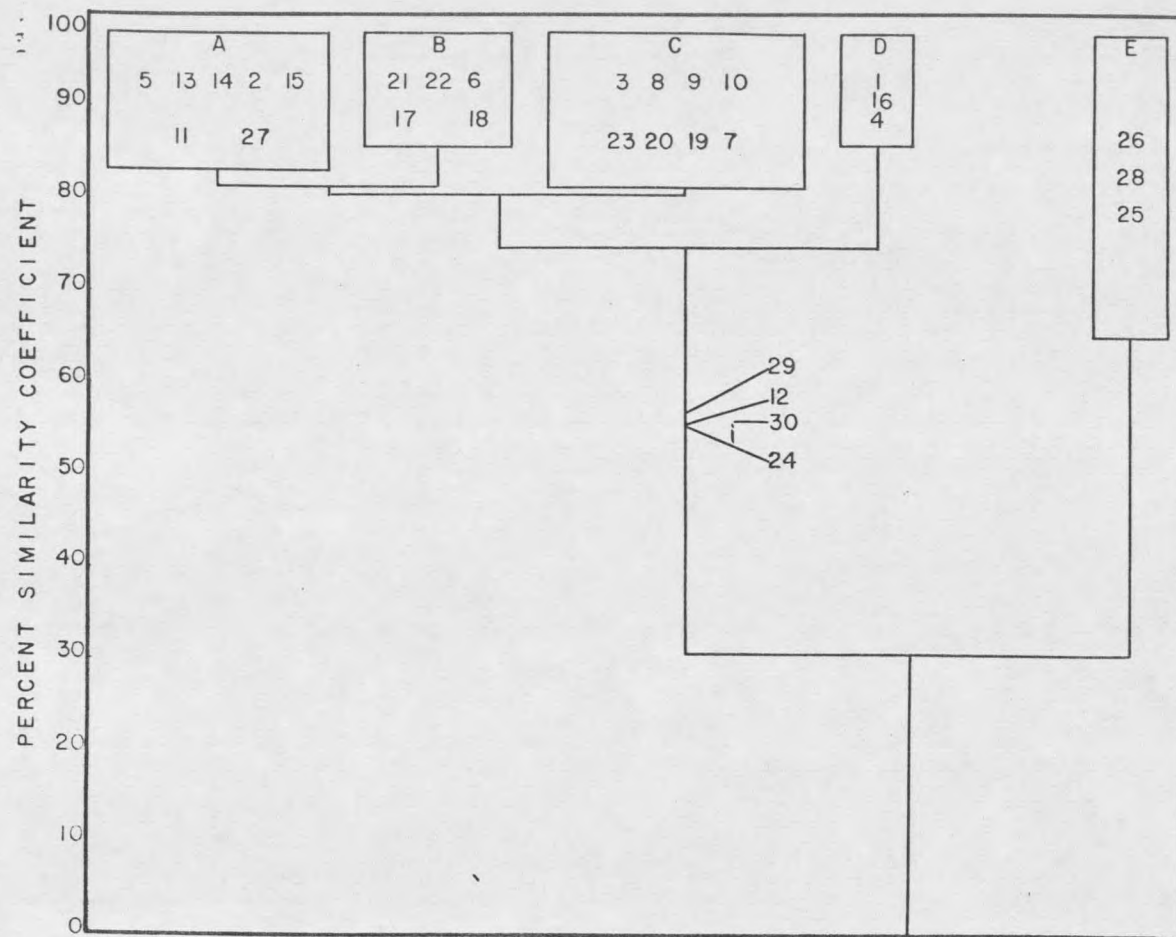


Figure 2. Simplified dendrogram derived from the cluster analysis (Appendix A). Numbers inside the boxes identify sample stands in each cluster. The scale at the left indicates the level of similarity (0=no similarity; 100 = high similarity).

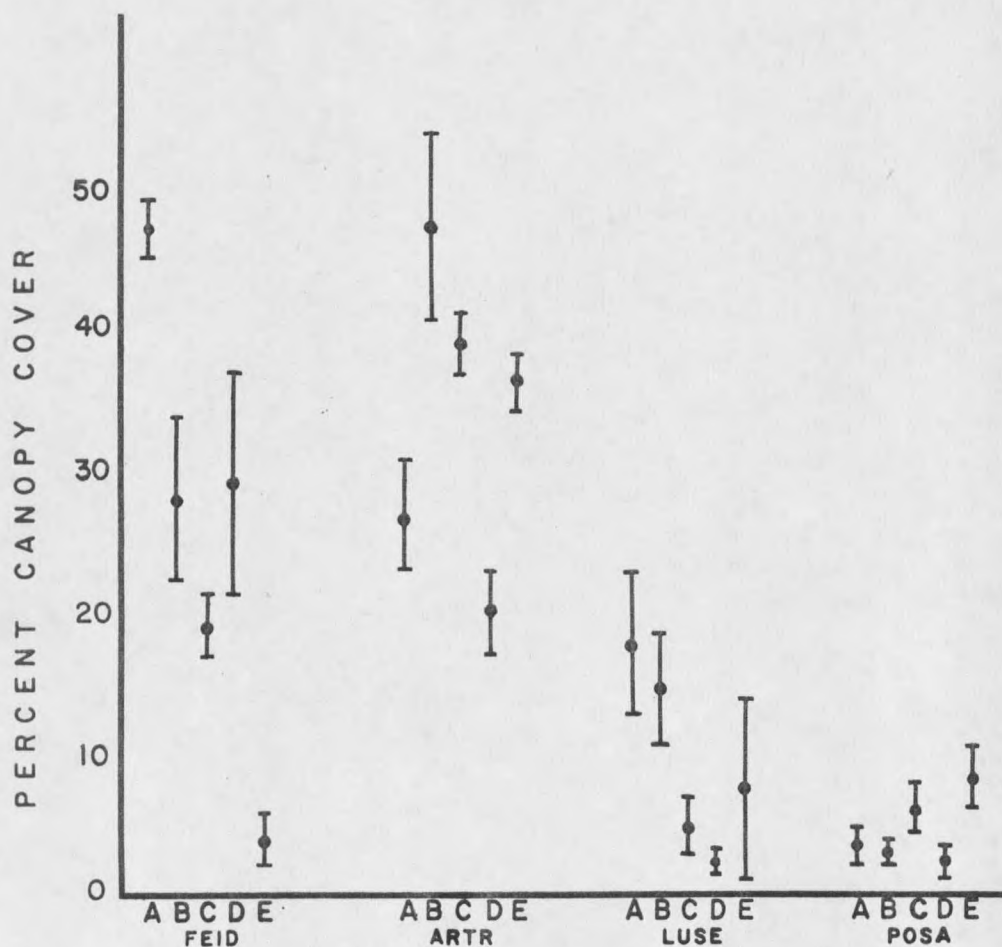


Figure 3. Comparison of major species' mean canopy cover among groups identified by cluster analysis. ABCDE designate the clusters from Figure 2. Feid = Idaho fescue, Artr = big sagebrush; Luse = silky lupine and Posa = Sandberg bluegrass. The brackets around each mean represent the 95% confidence level.

ordering the sample stands into a gradient related to grazing intensity or into supposed successional plant communities within the Artr/Feid habitat type.

Ordination

The results of the ordination (Appendix B) complimented those of the cluster analysis. The x-axis was strongly related to Idaho fescue cover (Figure 4) and the y-axis was related generally to big sagebrush cover (Figure 5). A comparison of the ordination (Appendix B) and the dendrogram (Figure 2) shows that clusters A, C and E specify an Idaho fescue gradient (shown below to be a grazing gradient) and clusters B, C and D along with the four outlier stands specify a cross gradient related to big sagebrush cover.

Huschle and Hironaka (1980) found that secondary successional gradients were represented by the major axes in their ordination of seral sites. The ordination in this study (Figure 4) suggested that arranging the sample stands in order of decreasing Idaho fescue cover (x-axis) generally represents a retrogressive successional gradient caused by increasing intensity of grazing in the Artr/Feid habitat type. Arrangement of the stands according to big sagebrush (y-axis) cover (Figure 5) does not correlate with grazing intensity. This species is generally considered unpalatable to livestock (Daubenmire 1970). The relationship between Idaho fescue and big sagebrush is discussed later.

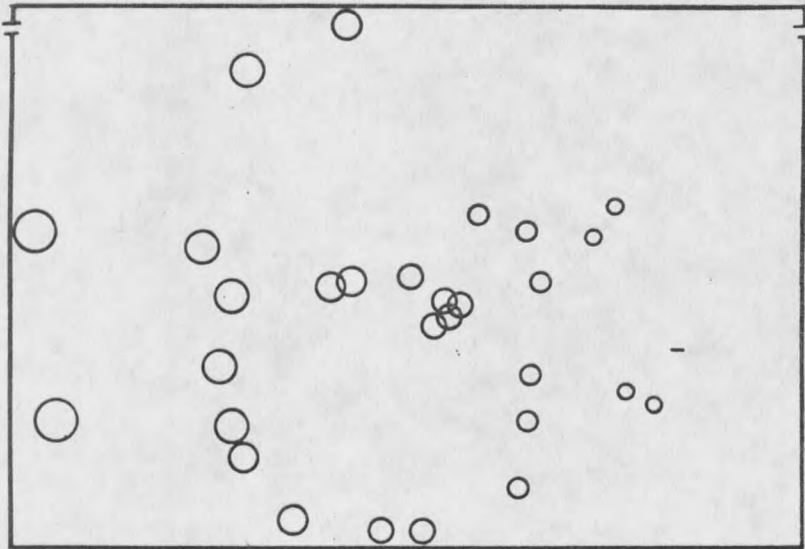


Figure 4. Ordination of Idaho fescue canopy cover. Progressively larger circles represent canopy cover of <10, 10-20, 20-30, 30-40, 40-50 and >50 percent. A dash represents absence.

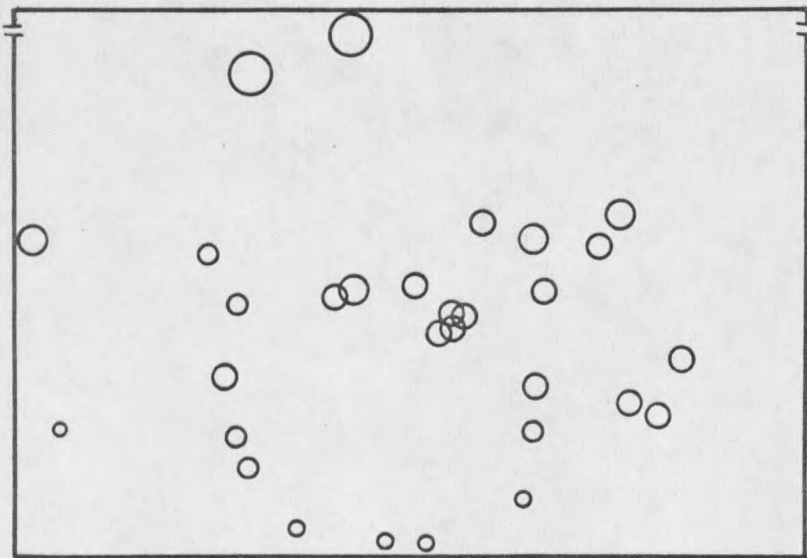


Figure 5. Ordination of big sagebrush canopy cover. Progressively larger circles represent canopy cover of <10, 10-20, 20-30, 30-40, 40-50, 50-60 and 60-70 percent.

Evanko and Peterson (1955) found that Idaho fescue cover decreased with increasing grazing intensity in mountain grasslands within my study area. Several other authors have also shown the detrimental effects of increasingly heavy grazing on Idaho fescue (Hurd 1959; Klemmedsdon 1956; Mueggler and Stewart 1980; Pond 1960; Trillica et al. 1980).

Factors other than grazing could conceivably affect the amount of Idaho fescue cover on a given site. These include slope, elevation, aspect, topographic position and soil characteristics. Munn et al. (1978) found that the depth of the mollic epipedon was highly correlated with the productivity of rangeland habitat types in western Montana. No soils information was collected during this study. However, plotting slope, aspect and elevation on the ordination revealed no patterns associated with the Idaho fescue gradient. Since combinations of these three factors greatly affect the availability of soil moisture for plant growth, it is assumed that they represent an index of potential site productivity. Thus, it is concluded that with few exceptions, the Idaho fescue gradient observed in this study represents a response to grazing. Daubenmire (1940) also arranged a series of stands according to the abundance of the dominant palatable species and concluded that "the decrease of palatable plants and increase of non-palatable ones both point to the validity of my assumptions of proper sequential arrangement of stands."

Stands No. 20 and No. 22 (Appendix B) are likely exceptions to the grazing relationship. Although these stands had intermediate Idaho fescue cover (28 and 24 percent, respectively), they may be producing near their maximum because they occur on dry, rocky ridges which probably represent the lower end of site potential within the Artr/Feid habitat type. The presence of 22 percent needle-and-thread (Stipa comata) cover in stand No. 20, the highest found in this study, indicates relatively coarse soils (Tisdale and Hironaka 1981) and possibly lower site potential. Mueggler and Stewart (1980) found that needle-and-thread habitat types were relatively low in site potential in western Montana.

Figures 6-11 further support the contention that the x-axis of the ordination represents a grazing gradient. Figure 6 shows that the amount of bare ground generally increased along the grazing gradient while Figure 7 shows the opposite trend for litter cover. Exceptions occur in both cases, however. Ellison (1960) reviewed many studies in which bare ground and litter were associated with grazing intensity in this same manner. Evanko and Peterson (1955) found a trend toward less litter cover and more bare ground on heavier grazed grasslands within my study area, but pointed out that many exceptions occur on specific sites in relation to factors such as runoff, slope, exposure and amount and kind of vegetation.

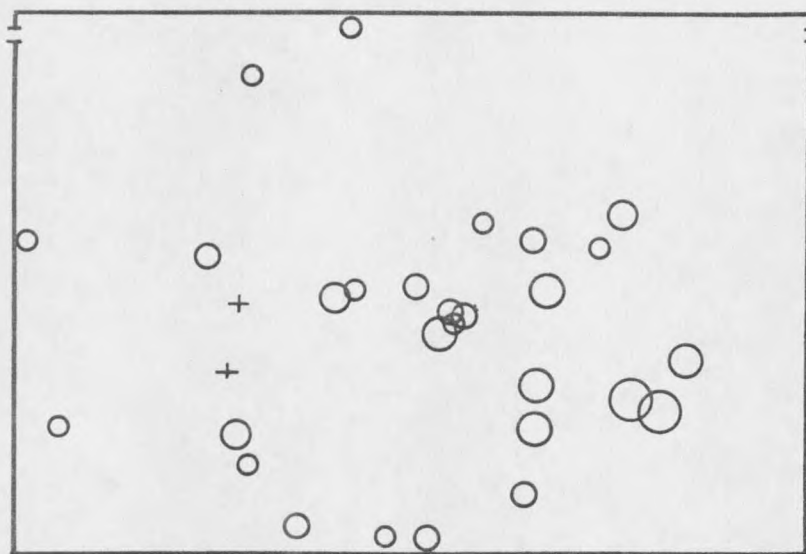


Figure 6. Ordination of percent bare ground. Progressively larger circles represent 1-5, 5-10, 10-20, 20-30 and > 30 percent. A + represents a trace.

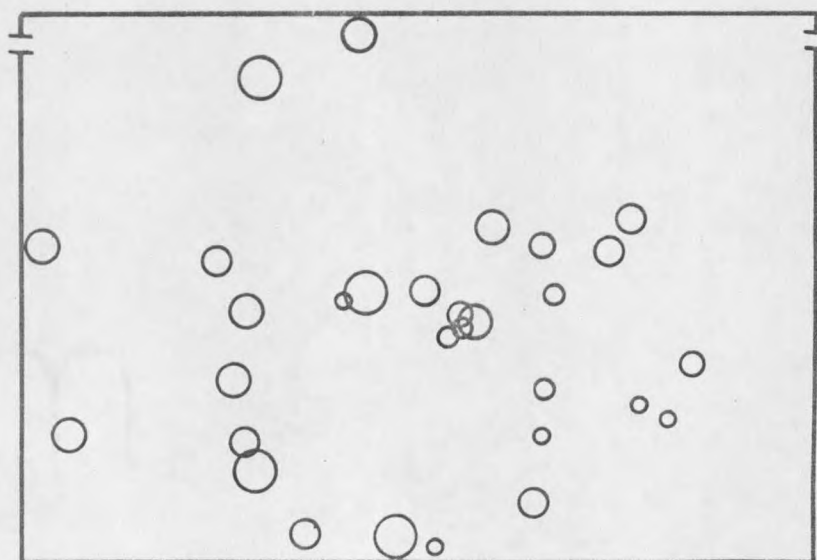


Figure 7. Ordination of percent litter cover. Progressively larger circles represent litter cover of <50, 50-60, 60-70, 70-80, 80-90 and 90-100 percent.

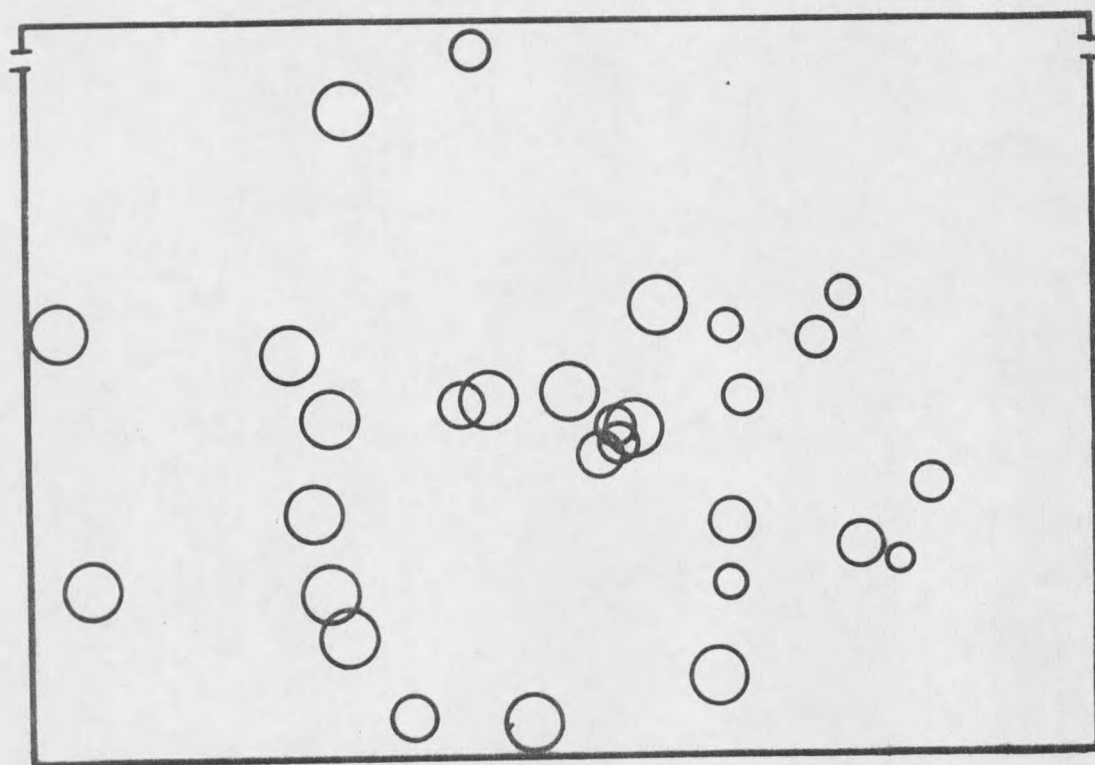


Figure 8. Ordination of total perennial grass cover. Progressively larger circles represent perennial grass cover of <20, 20-35, 35-50, 50-65 and >65 percent.

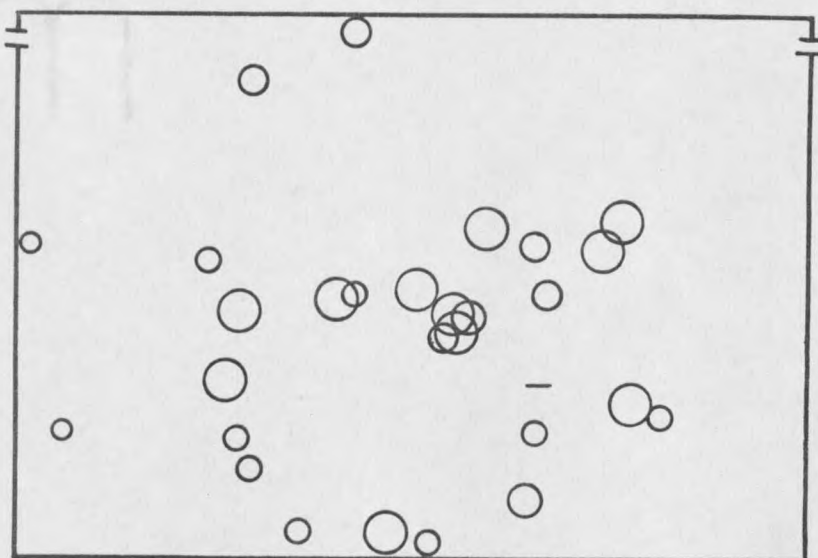


Figure 9. Ordination of the percent of 30 Idaho fescue plants in the <1-inch basal diameter class. Progressively larger circles represent 1-5, 5-20, 20-30, 30-40 and >40 percent.

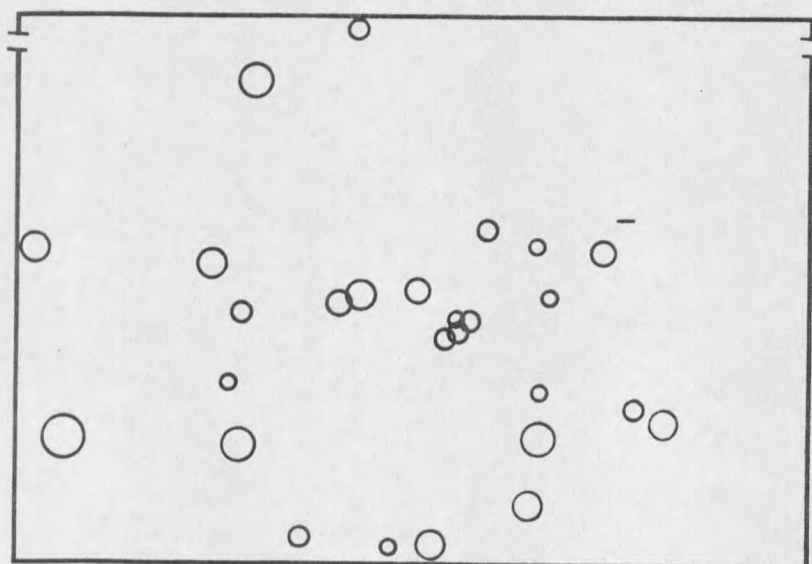


Figure 10. Ordination of the mean number of Idaho fescue seedstalks per plant (for plants >2-inch basal diameter). Progressively larger circles represent 1-5, 5-10, 10-15, 15-20, 20-25 and >25 seedstalks per plant.

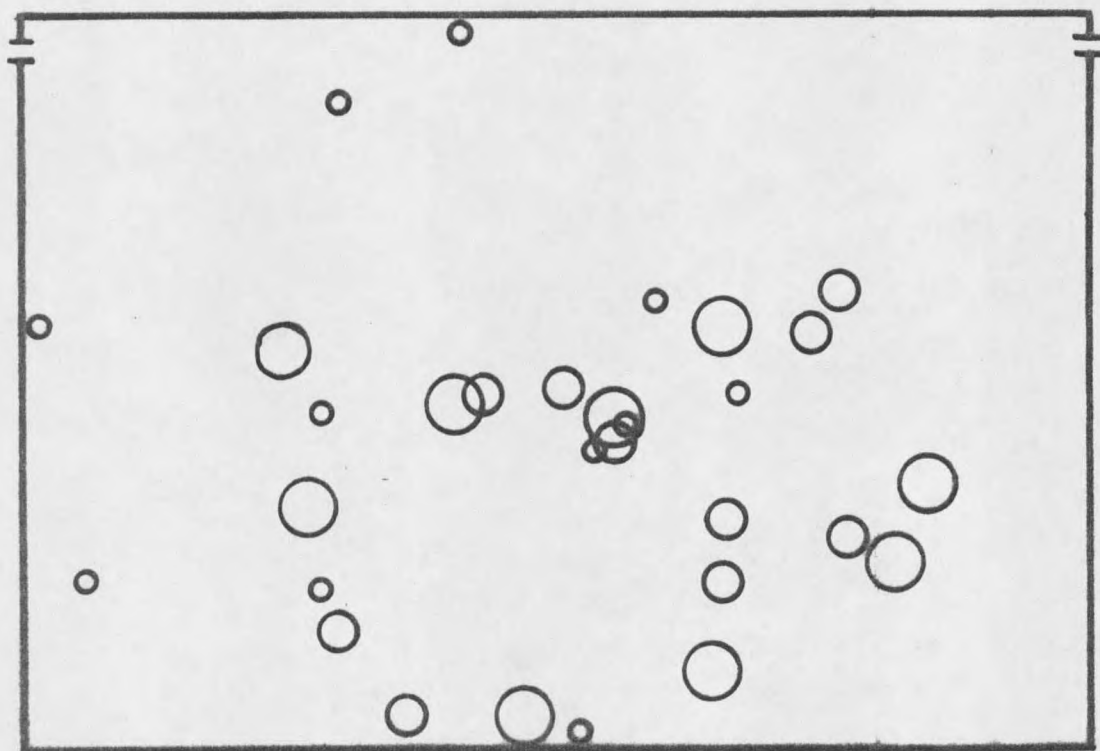


Figure 11. Ordination of the number of cattle, horse or elk fecal piles per 20x20 m macroplot. Progressively larger circles represent low (<10), medium (10-20) and high (>20) values.

The five stands in the upper right of the ordination (Figures 6, 7) had relatively less bare ground and more litter than might be expected considering the trends described above. Leaf fall from abundant big sagebrush (Figure 5) and an increase of secondary perennial grasses and forbs probably explains these apparent exceptions to the effects of grazing.

Total perennial grass cover (Figure 8) generally decreased on the right (heavier grazed) end of the ordination, although the trend was not as clearly defined as that of Idaho fescue cover (Figure 4). A decrease in the perennial grass component as a function of grazing has been documented in the literature (Parker 1951; Evanko and Peterson 1955; Ellison 1960) although exceptions often occur on sites where rhizomatous grasses increase with grazing (Daubenmire 1968). This is the case on site No. 18 (Appendix B) where Idaho fescue cover has been reduced to 18 percent, but Kentucky bluegrass (Poa pratensis), with 14 percent cover, in combination with several small bunchgrasses, has kept the total perennial grass cover relatively high. The heavily grazed site No. 28 (Appendix B) had only 4 percent Idaho fescue cover but also had 14 percent Kentucky bluegrass cover which, together with the other rhizomatous grasses thickspike wheatgrass (Agropyron dasystachyum) and plains reedgrass (Calamograstis montanensis) and relatively high coverage of bluebunch wheatgrass and Cusick's bluegrass

(Poa cusickii), kept total perennial grass cover higher than might be expected. Site No. 29 (Appendix B), although showing signs of heavy livestock use, had a diverse assemblage of perennial grasses and the 15 percent coverage of threadleaf sedge (Carex filifolia), together with contributions from thickspike wheatgrass and Canada bluegrass (Poa compressa), resulted in high perennial grass cover.

Many studies (Evanko and Peterson 1955; Hurd 1959; Mueggler 1967; Mueggler 1975; Ratliff and Reppert 1974; Pond 1960) have shown that vigor of Idaho fescue is markedly reduced as grazing intensity increases. Ellison (1960) stated that heavy grazing of bunchgrasses results in a shift in the population toward a higher proportion of smaller plants. Evanko and Peterson (1955) found this true of Idaho fescue within my study area and indicated that basal area of this grass was a sensitive indicator of response to grazing. Figure 9 shows a trend toward a higher proportion of small Idaho fescue plants (<1" basal diameter) on the right (heavier grazed) side of the ordination. Figure 10 shows some trend toward a decreasing number of seedstalks per plant associated with increasing grazing intensity. Ratliff and Reppert (1974) found that flower stalk production of Idaho fescue was reduced by grazing but was also highly dependent upon spring precipitation. Spring precipitation was very high during this study and seedstalk production was exceptional. The numerous exceptions to these general

trends in Figures 9-10 may result from many factors. Sites which have been severely grazed and then rested for several years may show high vigor. Species composition changes would occur much more slowly. The relationship between class of stock and season of use also may affect the vigor of the plants. Laycock (1967) found that heavy fall grazing by sheep on sagebrush grass ranges favored vigor of the perennial grasses but spring grazing reduced vigor. Pond (1960) found that grazing is much more harmful to Idaho fescue plants growing on granitic soils than on sedimentary soils, both of which occurred in my study area.

Fecal counts in the macroplots (Figure 11) also indicate a trend toward heavier use associated with decreasing Idaho fescue cover, further supporting the contention that the x-axis represents a grazing gradient.

Table 1 summarizes available information on the history of use of the sample stands. This information is compatible with the conclusion that the x-axis of the ordination represents a grazing gradient. Note that stand No. 25, which had no Idaho fescue (Appendix B; Figure 4) and was farthest to the right on the ordination, was described as being severely grazed (Table 1). Stand No. 2, with 64 percent Idaho fescue cover and farthest to the left on the ordination, was described as essentially ungrazed in Table 1.

Table 1. History of use of sample stands.¹

Stand Number	Grazing History	Source
1	Last grazed in 1978; fairly heavy cattle use prior to 1978; now a Forest Service horse pasture with light use.	Richard Duncan, Range Conservationist, USDA-Forest Service, Bozeman, MT
2	Light or no use since the 1930s; probably very light use prior to that.	"
5	Classified as deteriorated elk winter range in 1956; present evidence of heavy winter-spring elk use.	"
6	Exclosure constructed by Paul Packer in 1956 on deteriorated elk winter range; range condition has changed from good to fair as sagebrush has increased inside the exclosure.	"
7	Elk winter range.	"
8	Elk winter range.	"
9	Cattle grazing prior to 1920; sheep and horse grazing 1920-1934; heavy horse and mule use since 1934; Forest Service reported overuse in 1934 and currently classifies it as fair condition with a downward trend.	"
10	Horse pasture with very light use.	Marianne Neville, Range Conservationist, USDA-Forest Service, Sheridan, MT
15	No grazing since highway was constructed because the stand is located between the highway and a pasture fence.	Personal observation.

Table 1 - continued

Stand Number	Grazing History	Source
16	Spring-fall cattle range; stocking rate is probably fairly light.	Tom Whitmar, Range Conser- vationist, USDI- BLM, Dillon, MT
17	No grazing since highway con- struction because the stand is located between the highway and a pasture fence.	Personal obser- vation.
18	Heavily grazed sheep range (year- long) from mid 1960s into the 1970s; now a cow/calf pasture with no specific management system.	Tom Whitmar, Range Conser- vationist, USDI- BLM, Dillon, MT
19	Pasture grazed by 275 cow/calf pairs May 20-June 4; then 30 head remain in pasture for the rest of the season; this is a fairly light stocking rate but cattle may con- centrate along the fence in this stand during spring.	Tom Whitmar, Range Conser- vationist, USDI- BLM, Dillon, MT
20	Pasture grazed by 50-60 yearling cattle June 5-October 15 for the last 10-15 years; this is a light stocking rate.	"
22	Range condition has improved during the last 12 years under a rest-rotation grazing system; year-long elk and mule deer range.	"
25	Very heavy cattle use because it is near water and in a pasture corner where cattle concentrate while waiting to be moved to the next pasture.	Marianne Neville, Range Conserva- tionist, USDA- Forest Service, Sheridan, MT
26	Heavy cattle use prior to 1955; series of modified rest-rotation systems since 1955; history of heavy elk use.	"

Table 1 - continued

Stand Number	Grazing History	Source
27	Has been exclosed from grazing for many years..	"
29	Sheep use has been excessive for 25 years; season of use has decreased from 180 days (1919-1961) to 127 days since 1961.	"
30	Primarily sheep range since the late 1800s; changed to cattle use in 1974; now in a 4-pasture rest-rotation system.	"

¹History of use information was not available for all stands. Some stands were located in very large pastures where the grazing history was not site-specific enough to apply to this study. A few stands were located on private land and the owners could not be located. Information was most available for stands located on federal lands (USDA Forest Service and USDI Bureau of Land Management).

Species Response to Grazing Based on the Ordination

Table 2 summarizes the results presented above and shows the decreaser and increaser species associated with the grazing gradient. Species showing no response to grazing are listed in Table 3.

Idaho fescue cover (Table 2) generally exceeded 30 percent on the lightly grazed sites but decreased to less than 10 percent under heavy grazing. The high palatability of this bunchgrass (Mueggler and Stewart 1980), combined with the fact that it was the only abundant forage species, explain this response. Evanko and Peterson (1955) found that Idaho fescue was a decreaser on sites where it was dominant within my study area. As mentioned above, the 28 and 24 percent Idaho fescue cover on sites 20 and 22, respectively, may represent near climax amounts since these stands appeared to be on sites with a relatively low potential.

The indirect effects of grazing may account for the response of the remaining decreasers in Table 2. Onion (Allium sp.) and bluebell (Mertensia viridis) are succulent spring forbs and their decreaser response may be partly due to grazing by all classes of stock early in the year. However, arnica (Arnica sororia), besseya (Besseya wyomingensis), sulfurflower (Eriogonum umbellatum), alumroot (Heuchera sp.) and silky lupine (Lupinus sericeus) are relatively low in palatability (Mueggler and Stewart 1980), and other factors

Table 2. Summary of selected stand characteristics and coverage of decreaser and increaser species.¹

Stand No.	2	14	17	15	11	13	27	1	6	4	5	10	20	12	24
Pair No.	1	13	18	16		14		2	5	3	6		19		23
LOCATION															
R	4E	5W	3W	2W	6W	6W	3W	4E	5E	4E	5E	4W	4W	6W	3W
T	6S	12S	6S	6S	12S	12S	9S	6S	9S	7S	9S	12S	4S	12S	10S
S	1	31	25	16	36	36	14	1	7	16	7	13	34	36	3
DROPPINGS ²															
C	1	5			42	36		10				12	13	55	4
H										19					
E											54				
DEGREE OF GRAZING ³															
L	L	L	L	L	L	M	L	M	L	M	M	L	M	M	M
RANGE CONDITION ⁴															
Comp		9	8	9	8	9	8					8	8	6	9
Vigor		5	4	4	3	4	3					4	3	2	3
RPPD		5	5	5	5	5	5					5	5	5	3
Class		G	G	G	G	G	G					G	G	F	F
FEID VIGOR															
Basal diameter ⁵															
<1"	3	3	23	19	53	16	43	16	23	17	45	16	47	70	20
1-2"	32	37	60	48	43	61	37	32	43	57	48	50	37	27	67
2-4"	58	57	17	32	3	23	20	48	33	27	6	34	16	3	13
4-6"	6	3													
NO. SEED STALKS PER PLANT ⁶								No data							
<1"	3.0	5.0	2.9	2.3	1.9	0.2	1.7		0.1	1.8	1.0	4.8	1.3	1.1	2.3
1-2"	5.6	18.9	4.6	10.3	5.0	6.7	7.7		2.9	1.7	2.9	7.1	5.0	5.8	4.4
2-4"	15.4	37.1	23.0	20.6	1.0	19.0	8.0		5.6	6.1	9.0	16.3	15.4	3.0	18.0
4-6"	35.0	75.0													
SPECIES DIVERSITY ⁷	0.84	0.94	0.90	0.82	1.10	0.90	1.03	0.97	0.56	0.80	0.83	1.0	0.97	1.08	1.0
RICHNESS ⁸	26	26	22	19	30	26	29	29	18	19	27	33	21	30	20
EVENNESS ⁹	0.60	0.66	0.67	0.64	0.74	0.62	0.71	0.66	0.45	0.63	0.58	0.66	0.73	0.73	0.76
% BARE GROUND	1	2	2	14	+	6	+	1	1	9	16	4	10	3	12
% LITTER COVER	85	83	91	72	89	78	86	95	87	74	41	88	71	86	38
DECREASESERS (% CANOPY COVER)															
<u>Festuca idahoensis</u>	64	58	47	44	44	43	42	38	37	36	34	33	28	27	25
<u>Allium</u> sp.	4		1	+			4	2							
<u>Arnica sororia</u>	5		6				+			4					
<u>Besseyia wyomingensis</u>					1		+					+		1	
<u>Eriogonum umbellatum</u>	+	+				1	3	1	+	1	+	4		2	
<u>Heuchera</u> sp.		1					+				+				
<u>Lupinus sericeus</u>	9	27	9	7		39	21	+	16		19	+	10		
<u>Mertensia viridis</u>	+	+			+	+					+	+			
INCREASESERS (% CANOPY COVER)															
<u>Bromus carinatus</u>															
<u>Calamagrostis montenensis</u>	7				1						+				
<u>Danthonia intermedia</u>					3									39	+
<u>Poa sandbergii</u>		9	+	1		3	7		2	4	5	1	15	1	17
<u>Stipa richardsonii</u>										+					
<u>Antennaria parvifolia</u>			6				12								5
<u>Aster campestris</u>							2								2
<u>Phlox hoodii</u>				1						1				7	+
<u>Sedum</u> sp.				1			2								5
<u>Chrysothamnus nauseosus</u>													1		2
<u>C. viscidiflorus</u>		+			1	+									1

Table 2 - continued

Stand No.	22	3	30	9	8	18	23	21	16	29	19	26	28	7	25
Pair No.	21	4				17	24	22	15		20				
LOCATION															
R	4W	4E	3W	4E	5E	3W	3W	4W	2W	3W	4W	3W	3W	5E	3W
T	4S	7S	12S	9S	9S	6S	10S	5S	12S	11S	5S	9S	10S	9S	10S
S	35	16	14	11	7	25	3	2	16	29	3	14	21	7	4
DROPPINGS ²															
C	3		5			3	17	2	18	47	18	9	19		42
H		29		10											
E					42							8		58	
DEGREE OF GRAZING ³	L	H	M	M	M	M	H	M	H	M	H	M	H	H	H
RANGE CONDITION ⁴															
Comp	7		7			6	9	7	8	7	5	5	6		4
Vigor	3		3			3	2	2	3	2	1	3	1		1
RPPD	4		5			5	3	3	3	5	4	5	4		4
Class	F		F			F	F	F	F	F	P	F	F		P
FEED VIGOR															
Basal diameter ⁵															
<1"	20	47	33	47	20	42	0	25	13	33	50	43	50	10	--
1-2"	63	47	53	40	43	45	53	63	67	43	50	37	40	58	--
2-4"	17	6	13	13	37	13	47	13	20	20		20	10	32	--
4-6"										3					
NO. SEED STALKS PER PLANT ⁶															
<1"	0.7	0.5	1.4	1.3	0.7	1.7	0	0.9	1.3	1.2	0.1	1.5	0.5	0.7	--
1-2"	8.2	1.0	5.6	3.9	0.5	3.6	2.0	3.9	9.6	6.2	0.3	3.0	1.6	6.1	--
2-4"	10.2	3.5	9.3	7.3	1.5	9.3	2.8	3.0	21.2	17.2		10.7	1.7	16.4	--
4-6"										15.0					
SPECIES DIVERSITY ⁷	0.94	0.85	1.15	1.02	0.69	1.05	0.97	0.93	1.02	1.34	1.00	0.98	1.05	0.91	0.94
RICHNESS ⁸	19	21	29	22	14	29	24	20	25	33	26	27	23	27	25
EVENNESS ⁹	0.74	0.64	0.79	0.76	0.60	0.72	0.70	0.71	0.73	0.88	0.71	0.69	0.77	0.64	0.67
% BARE GROUND	22	10	7	4	6	3	20	22	27	7	13	3	42	43	26
% LITTER COVER	59	62	84	57	66	90	56	60	38	78	76	77	44	34	62
DECREASERS (% CANOPY COVER)															
<i>Festuca idahoensis</i>		23	23	20	18	18	16	15	14	12	8	7	4	3	0
<i>Allium</i> sp.	+							+						+	+
<i>Arnica sororia</i>		+				+									
<i>Besseyia wyomingensis</i>															
<i>Eriogonum umbellatum</i>		3								3					
<i>Heuchera</i> sp.							+								
<i>Lupinus sericeus</i>	10			13	4	28		8	4	7	11	23		+	
<i>Mertensia viridis</i>															
INCREASERS (% CANOPY COVER)															
<i>Bromus carinatus</i>			3			+				2		+	+		
<i>Calamagrostis montenensis</i>					1		1			5		5	3	1	5
<i>Danthonia intermedia</i>			1			1	1			4		+			
<i>Poa sandbergii</i>	3	9	2	6	3	2	6	2	3	+	7	13	4	1	6
<i>Stipa richardsonii</i>						1				2				1	
<i>Antennaria parvifolia</i>			2			6	11		+	11		24	17		1
<i>Aster campestris</i>												5	6		1
<i>Phlox hoodii</i>		3					1		2			3			1
<i>Sedum</i> sp.	+						+	3	3			2			
<i>Chrysothamnus nauseosus</i>							2				5				2
<i>C. viscidiflorus</i>					+		6	1	+	2				1	+

¹Stands arranged in order of decreasing Idaho fescue cover.

²No. of fecal piles per 20 m² macroplot. C = cattle, H = horse, E = elk.

³Estimated from history of use information and the relative abundance of palatable forage species.
L = light or none, M = moderate, H = heavy.

⁴Range condition calculated using the Mountain Grassland Scorecard (USDA For. Serv. 1979) and the step-loop data. Comp = % composition of desirables, intermediates, least desirables; 60% of condition score; Vigor = rating based on vigor data in this table; 15% of condition score; RPPD = relative perennial plant density = perennial plant density + litter: 25% of total score. Range condition was not calculated for stands 1-9 because of an error in the step-loop procedure.

⁵Percent of 30 Idaho fescue plants within the basal diameter size classes listed.

⁶Mean no. of seedstalks per plant by basal diameter size class.

⁷Species diversity = $\bar{H} = -\frac{\sum (n_i)}{N} \log \left(\frac{n_i}{N} \right) = -\sum P_i \log P_i$. n_i = importance value for each species; N = total of importance values; P_i = importance probability for each species.

⁸Richness = no. of species per stand.

⁹Evenness = $e = \frac{\bar{H}}{\log S}$. $\bar{H}$ = Shannon Index.

Table 3. Percent canopy cover of species showing no apparent response to grazing.¹

Stand No.	2	14	17	15	11	13	27	1	6	4	5	10	20	12	24	22	3	30	9	8	18	23	21	16	29	19	26	28	7	25	
GRASSES																															
<u>Agropyron</u> <u>dasytach-</u> <u>yum</u>		10			8	+			+		1	3		+	14		+					12			12		+	6	1	3	
<u>A. spicatum</u>		6	7	13		7	3			1	+		6			11	+		1	+	3		9	8		2	3	7	1		
<u>Koeleria</u> <u>pyramidata</u>	3	5	4	7		4	2	2	+	3	7	+	+	6	3	3	3		3	7	3	6	4	2	+	3	3	+	8	5	
<u>Poa cusickii</u>		3				+					1														5			6		15	
<u>P. pratensis</u>	4		+					29				2							3		14	1			+	2	1	14			
<u>Stipa comata</u>		+			+	+		7					22	+		8	+						6			2					
<u>S. occiden-</u> <u>talis</u>	1	+			6			+				10	+	+				6			5	3			6	1					
SEDGES																															
<u>Carex</u> <u>obtusata</u>		1			15	+								12																	
<u>C. pennsyl-</u> <u>vanica</u>	+							+	+	1	+							6	2	3	1										
<u>C. steno-</u> <u>phylla</u>							1					15												2	2		+	2			
FORBS																															
<u>Achillea</u> <u>mille-</u> <u>folium</u>	1	4	4		7	2	+	4	+		1	6	5	7	5	3		16	2		1	2			2	7	1	4	2	3	
<u>Androsace</u> <u>septen-</u> <u>trionalis</u>	+	1	+		+	+		+		+	+			+	1	+					1			+	5			+		1	
<u>Antennaria</u> <u>micro-</u> <u>phylla</u>		3		2	4					2	+			6			1		1				1			6					
<u>Antennaria</u> <u>umbrinella</u>	3				5	7		4		16	+		1			13		22													

Table 3 - continued

Stand No.	2	14	17	15	11	13	27	1	6	4	5	10	20	12	24	22	3	30	9	8	18	23	21	16	29	19	26	28	7	25
<u>Arenaria congesta</u>	4				6		9	5		4		5	3	10			9	6	10		2					4	2			
<u>Arabis nuttallii</u>	+				1		+				+	+			+			+	1								+		+	
<u>A. sp.</u>					+	1	1	+				+				1	+					+	+		+	+	+			
<u>Astragalus aggrestitis</u>			5				+														4						+			1
<u>A. drumondii</u>			13	1					1		4									3	4								2	+
<u>A. miser</u>		6		3		5	3									3							5	1			+	1		
<u>Castilleja sp.</u>	1		2					+										2						+		+				
<u>Cerastium sp.</u>			1	+			+						3			5							1	2					+	
<u>Collinsia parviflora</u>	1	+						1			+	+				2														
<u>Comandra umbellatum</u>				+			8				+		1		2								4			1				
<u>Crepis sp.</u>					1	+								+					4							+				
<u>Draba nemorosa</u>	+							+		+							+			+										
<u>D. sp.</u>						+							+			1							+							
<u>Erysimum asperum</u>		+	+			+						1							+			+				+				+
<u>Geum triflorum</u>			3		2				+			+			1		1	6				1			4					
<u>Penstemon procerus</u>					3									3									+		5					
<u>Phlox multiflora</u>					19						+								1										2	
<u>P. sp.</u>	2					5	3																		3			6		
<u>Rumex paucifolius</u>								1				1		1				+												

Table 3 - continued

Stand No.	2	14	17	15	11	13	27	1	6	4	5	10	20	12	24	22	3	30	9	8	18	23	21	16	29	19	26	28	7	25
<u>Senecio</u> <u>streptanthi-</u> <u>folius</u>									+					+											2				+	
<u>Solidago</u> <u>missouri-</u> <u>ensis</u>										1		4																1		10
<u>Taraxicum</u> <u>officinale</u>	2	3	1		12	1	3	7		+	+		+	7	3		3	+	6		2	+			+	2	3	1	+	19
<u>Viola</u> <u>nuttallii</u>	3	+	3		2			2	1	2	1	4					3		2	1	1	+						+		1
SHRUBS																														
<u>Artemisia</u> <u>frigida</u>					1																		+		1					
<u>A. triden-</u> <u>tata</u>	41	9	61	21	30	25	28	22	66	15	31	40	37	15	13	32	40	39	34	47	38	33	39	24	16	47	38	32	31	38
<u>Tetradymia</u> <u>canescens</u>						+	2				+		5				1		1				1			6				

¹Stands arranged according to decreasing Idaho fescue cover.

must explain the observed decreaser response. Daubenmire (1940) indicated that the removal of the larger, perennial forage species by grazing makes the environment less hospitable for certain smaller plants which depend upon them for protection from wind and intense solar radiation. Ellison (1960) noted that heavy grazing changes the microclimate because the removal of vegetation and litter results in warmer soil surface temperatures and increased evaporation. The net result is a drier, warmer environment which induces drought and invasion by weedy species. Excessive grazing has also been found to alter the biotic component of the ecosystem. Fewer earthworm casts and beetles and more grasshoppers were associated with heavily grazed ranges while rodent and lagomorph populations showed variable response depending on the specific circumstances (Ellison 1960). Reduced earthworm and beetle activity may decrease soil fertility by slowing rates of organic matter decomposition. A combination of the above factors plus direct damage from trampling may be responsible for the decreaser response of the species shown in Table 2. Mueggler and Stewart (1981) found that sulfurflower was the fourth most abundant species on a highly productive site within the Artr/Feid habitat type but was absent or a minor component on less productive sites. Lowered site productivity caused by the indirect effects of heavy grazing may account for the decrease in sulfurflower observed in this study. Mueggler and Stewart

(1980) found that the variable grazing response of Lupinus spp. made a general categorization of its response to grazing impossible, although it appeared to be a decreaser based on my data.

Species showing an increase in cover and/or constancy with increasing grazing intensity are shown in Table 2. Sandberg bluegrass has also been described as an increaser in other studies within and near my study area (Mueggler and Stewart 1980; Evanko and Peterson 1955; Vogl and Van Dyne 1974). Mueggler and Stewart (1980) also categorized timber oatgrass (Danthonia intermedia), Hood's phlox (Phlox hoodii) and rubber rabbitbrush (Chrysothamnus nauseosus) as increasers but did not classify pussytoes (Antennaria spp.) because of variable response to grazing. However, Mueggler and Stewart (1981) found that Antennaria parviflora was an abundant species on Artr/Feid sites of low productivity and less abundant on better sites. The increaser response of pussytoes in this study may reflect the lowering of site quality caused by the indirect effect of grazing as well as a release from competition from decreaser species. The limited occurrence of the remaining increasers in Table 2 makes their classification less reliable. Mueggler and Stewart (1980) described Bromus marginatus (treated as a variety of California brome [B. carinatus] by Hitchcock et al. [1973]) as a decreaser

which contrasts with the apparent increaser response in this study. I have often observed this grass on disturbed areas, however, and it may have increased on disturbed soil resulting from livestock trampling or rodent activity. Evanko and Peterson (1955) and Vogl and Van Dyne (1974) found plains reedgrass to be unaffected by grazing in contrast to the increaser response shown in Table 2. The many species showing no apparent response to grazing (Table 3), including big sagebrush, emphasize the difficulty of generalizing species response based on these data.

The lack of alien invader species was characteristic of even the most heavily grazed sites encountered during this study. This is in contrast to the sagebrush grass region as a whole where the annual cheatgrass (Bromus tectorum) may permanently replace native species under abusive grazing (Daubenmire 1970; Tisdale and Hironaka 1981; Young and Evans 1978). The competitive advantage of cheatgrass is greatest in habitats similar to those of its Mediterranean origin, where aridic and xeric moisture regimes prevail. The rapid early development of this grass and an extensive root system permit depletion of available soil moisture prior to extended summer drought, to the detriment of native species. Daubenmire (1970) indicated that the Bromus community seems to leave no

unused surplus of the crucial soil moisture resource that might permit reinvasion by native species. Where the ustic moisture regimen occurs, as in this study, the lack of an extended summer drought may limit the competitive ability of cheatgrass because more soil moisture is available for native plant reinvasion and growth following abusive grazing. Cryic temperature conditions may further limit the competitiveness of cheatgrass in these areas by limiting early growth.

Species richness, measured as the total number of species encountered per stand, seemed to vary randomly along the Idaho fescue gradient (Table 2). Grime (1979) presented a model showing species diversity to be greatest under moderate levels of disturbance and lower in severe and no disturbance situations. In this study, it was expected that species diversity would be greatest in stands having medium coverage of Idaho fescue because this grass dominates the ground cover in undisturbed stands and heavy grazing and trampling make severely disturbed sites very inhospitable for many species. Variability in potential site productivity, management, availability of propagules and many other factors probably account for the lack of pattern in species diversity across the ordination.

Appendix C summarizes the canopy cover data for species which occurred in less than 10 percent of the sample stands.

Species Response to Grazing Based on
Fenceline Comparisons

Table 4 summarizes the response of plant species and life forms to grazing based on nine fenceline comparisons. This permits an evaluation of species behavior on a site-specific basis. Environmental characteristics were equal on either side of the fence.

Shrub response was variable, reflecting the unpredictable behavior of big sagebrush, the major species in this category. Sagebrush cover was significantly greater ($p = 0.05$) in the ungrazed (or most lightly grazed) stand in two cases (Pairs C and F). In fact, the greatest sagebrush cover encountered during the study occurred on sites 6 and 17 (66 and 61 percent, respectively), both of which have been protected from grazing for many years. Big sagebrush showed an increaser response in three cases (Pairs B, D, I) and was not significantly affected by grazing in four cases.

The dense sagebrush cover in stands no. 6 and 17 was interesting. Stand no. 6 was in an exclosure constructed in 1956 on depleted elk winter range, and stand no. 17 occupied the area between a highway and a pasture fence, effectively an exclosure for many years (Table 1). Sagebrush cover was about twice as great on these ungrazed areas as on the adjacent grazed sites. This increase in sagebrush cover following protection from grazing may have

Table 4. Percent canopy cover of species sampled in nine fenceline pairs.

Stand No.	1 vs 2		3 vs 4		5 vs 6		13 vs 14		15 vs 16		17 vs 18		19 vs 20		21 vs 22		23 vs 24	
Pair	A		B		C		D		E		F		G		H		I	
Level of Grazing	None Mod.		Mod. Heavy		None Mod. Heavy		Light Mod.		None Heavy		None Mod.		Mod. Heavy		Light Mod.		Mod. Heavy	
Est. Site Potential	H		M		M		M		M		M+		L		L		M	
COVER CLASS																		
Shrubs	41	22	15	40	67	32	9	25	21	24	61	38	43	52	32	40	16	41
Perennial Grass	79	76	44	35	39	49	90	59	65	26	58	51	71	24	49	37	60	45
Sedges	1	+	1	--	5	+	1	1	--	2	1	3	5	7	2	2	--	2
Annual Forb	1	3	1	1	--	+	1	+	--	1	+	1	1	1	4	+	1	--
Biennial Forb	+	+	1	+	--	+	1	1	--	--	+	--	--	--	1	+	+	+
Perennial Forb	33	33	25	34	22	30	47	63	20	22	54	49	24	32	21	24	23	15
Bryophytes ¹	22	2*	4	--	3	15*	1	1	1	--	6	4	1	--	16	6 ⁺	17	17
Bare Ground	1	1	9	10	1	16*	2	6	14 ⁺	27	2	3	10	13	22	22	12	20
Litter	85	95*	74	65	87	41*	83	78	72*	38	91	90	79	76	59	60	38	56 ⁺
Rock	2	+	--	1	2	6*	3	2	8*	21	--	+	--	+	3	4	11	6
Lichen	1	--	1	3	2	4	1	+	3	2	4 ⁺	+	+	+	+	2	14	3*
Richness	26	29	19	21	18	27	26	26	19	25	22	29	21	26	19	20	20	24
SHRUBS																		
<u>Artemisia</u>																		
<u> tridentata</u>	41	22	15	40*	66	31*	9	25*	21	24	61	38*	37	47	32	39	13	33 ⁺
<u>A. frigida</u>									1	1								
<u>Chrysothamnus</u>																		
<u> nauseosus</u>													1	5			2	2
<u>C. viscidiflorus</u>							+	+								1	1	6
<u>Tetradymia</u>																		
<u> canescens</u>						+		+										
GRAMINOIDS																		
<u>Agropyron</u>																		
<u> dasystachyum</u>					+	1	10	+									14	12
<u>A. spicatum</u>			1	+		+	6	7	13	8	7	3	6	2	11	9		
<u>Bromus carinatus</u>												1						
<u>Calamagrostis</u>																		
<u> montenensis</u>	7					+												1

Table 4 - continued

Stand No.	1 vs 2		3 vs 4		5 vs 6		13 vs 14		15 vs 16		17 vs 18		19 vs 20		21 vs 22		23 vs 24	
<u>Carex rossii</u>	1	+	1		+	+					1							
<u>C. stenophylla</u>					5				2									
<u>Danthonia</u>																		
<u>intermedia</u>											1						+	1
<u>Festuca</u>																		
<u>idahoensis</u>	64	38*	36	23*	37	34	58	43*	44	14*	47	18*	28	8*	24	15	25	16
<u>Koeleria</u>																		
<u>pyramidata</u>	3	2	3	3	1	7*	5	4	7	2*	4	3	+	3+	3	4	3	6
<u>Poa cusickii</u>						1	3	+										
<u>P. pratensis</u>	4	29*									1	14*		2				1
<u>P. sandbergii</u>			4	9*	2	5+	9	3*	1	3	+	2	15	7*	3	2	17	6*
<u>Stipa comata</u>		7		+			+	+					22	2*	8	6		
<u>S. occidentalis</u>	1	+					+					5	+	1				3
<u>S. richardsonii</u>			+									1						
ANNUAL FORBS																		
<u>Androsace</u>																		
<u>occidentalis</u>			+	1											+			
<u>A. septentrionalis</u>	+	+	+		+		1	+	+		+	1						
<u>Collinsia parviflora</u>	1	1			+		+								2			
<u>Draba nemorosa</u>	+	+	+	+														
<u>D. sp.</u>								+					+		1	+		
BIENNIAL FORBS																		
<u>Arabis drummondii</u>	+																	
<u>A. hoelbollii</u>	+		1															
<u>A. nuttallii</u>					+		+										+	
<u>A. sp.</u>		+		+				1					+		1	+		+
<u>Erysimum asperum</u>							1	+			+							+
PERENNIAL FORBS																		
<u>Achillea</u>																		
<u>millefolium</u>	1	4*			+	1+	4	2			4	1+	5	7	3		5	2+
<u>Agoseris glauca</u>												+						
<u>Allium sp.</u>	4	2							+		1				+	+		
<u>Antennaria</u>																		
<u>microphylla</u>			2	1		+	3		2				6			1		
<u>A. parvifolia</u>										1	6	6					5	11
<u>A. sp.</u>					2													
<u>A. umbrinella</u>	3	4	16	13		+		7					1					

Table 4 - continued

Stand No.	1 vs 2		3 vs 4		5 vs 6		13 vs 14		15 vs 16		17 vs 18		19 vs 20		21 vs 22		23 vs 24	
<i>Arenaria congesta</i>	4	5	4	9							6	2	3	4				
<i>Arnica sororia</i>	5	4		+								+						
<i>Astragalus</i>																		
<i>agrestis</i>											5	3						
<i>A. drummondii</i>					1	4			1		13	4						
<i>A. miser</i>									5	6	3	1			3	5		2
<i>Aster campestris</i>																		
<i>Castilleja</i> sp.	1	+						+			2		+					
<i>Cerastium arvense</i>		+																
<i>C. sp.</i>									+	2	1		3		5	1		2
<i>Comandra umbellatum</i>					+				+				1	1		4		2
<i>Crepis acuminata</i>													+					
<i>C. sp.</i>							+							+				
<i>Cymopterus</i>																		
<i>bipinnatus</i>									+	+								
<i>Delphinium bicolor</i>												+						
<i>Erigeron compositus</i>										2							+	
<i>Eriogonum umbellatum</i>	+	1	1		+	+	+	1										
<i>Frasera speciosa</i>								+										
<i>Fragaria virginiana</i>																		+
<i>Geum triflorum</i>			1		+						3						1	1
<i>Geranium viscos-</i>																		
<i>sissimum</i>		1					2	1										
<i>Heuchera</i> sp.					+		1											+
<i>Lithophragma</i>																		
<i>parviflora</i>	+	+	+															
<i>Lupinus sericeus</i>	9	3*			16	19	27	39 ⁺	7	4	9	28*	10	11	10	8		
<i>Mertensia viridis</i>	1						+	1										
<i>Penstemon aridus</i>									2	2						2		
<i>P. procerus</i>																+		
<i>Phlox hoodii</i>			1	3					1	2							+	1
<i>P. multiflora</i>					+													
<i>P. sp.</i>							2	5										
<i>Rumex paucifolius</i>		1																
<i>Sedum</i> sp.															+	3	5	+
<i>Senecio streptan-</i>																		
<i>thifolius</i>					+				1	3								
<i>Solidago missouriensis</i>					1	4												
<i>Taraxicum officinale</i>	2	7*	+	+	+		3	1			1	2	+	2			3	+
<i>Trifolium</i> sp.		+																
<i>U.I. forb</i>		+																
<i>Viola nuttallii</i>	3	2	2	3	1	1	+											+

¹From here on in this table a "t" test was used to determine significant differences for common forage species, species which occurred in both stands of a pair in more than half of the pairs, and for bare ground, litter, and rock.

*Differences between means are statistically significant at the 5% level.

⁺Differences between means are statistically significant at the 10% level.

resulted from rapid seedling establishment from residual seed in the soil (Mueggler 1956) on heavily grazed and/or trampled sites soon after protection from herbivore use. These seedlings would then have been free from trampling and browsing by herbivores and able to develop a dense canopy before competition from herbaceous species became significant.

Bartolome and Heady (1978) found that most sagebrush reestablishment occurred in the first several years after various treatments in southeastern Oregon. Harniss and McDonough (1975, 1976) found that sufficient sagebrush seed is able to germinate in any given year to contribute to reinvasion of this shrub. Stewart (1982) noted that sagebrush can reestablish itself into a dense stand of Idaho fescue within the Artr/Feid habitat type 14 years after herbicide treatment. However, sagebrush canopy cover is generally less than 30 percent on high condition sites (Mueggler and Stewart 1980), possibly reflecting competition from perennial grasses, notably Idaho fescue.

In summary, the inconsistent response of big sagebrush to grazing noted during this study combined with high coverage of this shrub in some exclosures indicates that big sagebrush is not a reliable indicator of range condition in the Artr/Feid habitat type.

The response of the perennial grasses to grazing varied with the site sampled (Table 4). Perennial grass cover was little affected by grazing on the more productive sites (Pairs A and F) largely due to an increase of the rhizomatous Kentucky bluegrass. This is consistent with the idea that grazing-resistant, competitive species may form a proclimax vegetation on productive sites when the more stress-tolerant climax species are weakened by disturbance (Grime 1979). Daubenmire (1970) indicated that Kentucky bluegrass forms a zootic climax on sites with no lime accumulation in the soil profile. Perennial grass cover appeared to decrease with grazing on the other fenceline pairs sampled. Idaho fescue was the only perennial grass showing a consistent, significant ($p = 0.05$) decreaser response, except for Pair C, where competition from big sagebrush may have limited the increase of this species after protection from elk use, and for Pairs H and I in which the differences were not significant ($p = 0.1$), although fescue cover appeared to decrease with grazing. It may also be possible in the case of Pair C that Idaho fescue cover has not been significantly decreased by elk use on the grazed stand and that Idaho fescue cover on both sides of the fence is close to the climax amount. The response of the other perennial grasses to grazing was variable on the sites sampled.

The response of the remaining life forms to grazing was highly variable (Table 4). The response of all annuals is probably variable regardless of grazing history, and the biennial forbs were too scarce to show any trends. As a group, perennial forbs increased with grazing on 4 of the 9 pairs sampled, decreased in 2 cases, and showed no apparent response in 3 of the pairs. Individual species within this group varied greatly in response to grazing except for sandwort (Arenaria congesta), which appeared to be an increaser in all 4 pairs in which it occurred.

Percent cover of bryophytes, rock and lichens seemed to vary independent of grazing intensity.

Bare ground and litter cover (Table 4) was also highly variable in response to grazing intensity among the pairs sampled. On the more productive sites, bare ground cover was kept low and litter cover high by the increase of Kentucky bluegrass in the more heavily grazed stands. The cover of big sagebrush also explains some of the variability in the response of bare ground and litter cover to grazing. Where sagebrush cover was quite high (i.e., Pair G, stand 19), bare ground cover was relatively low and litter cover fairly high (even on very heavily grazed stands) because of leaf litter produced by this shrub.

Table 4 shows that species diversity (total number of species per stand) was greater on the more heavily grazed sites in 8 of the 9 fenceline pairs sampled. Diversity was the same in stands 13 and 14 (Pair D) where Idaho fescue cover was very similar. This increased diversity on more heavily grazed sites probably results from the reduction of dominance by Idaho fescue which results in increased space, nutrients and soil moisture for a greater variety of species.

Conclusions regarding the response of the plant community to grazing based on the fenceline comparisons are similar to those based on the ordination, but even fewer generalizations can be made. Comparison of fence-line contrasts eliminates other variables, such as site differences, and gives a clearer picture of grazing response. Idaho fescue, a decreaser, was the only species showing a consistent response to grazing. The response of other species was more variable and seemed to be very site-specific. Perennial grasses, as a group, tended to decrease with heavier grazing intensity except on the more productive sites, where Kentucky bluegrass increased in cover. The increase in percent bare ground with heavier grazing was limited on productive sites by Kentucky bluegrass and, on some other sites, by big sagebrush litter. Litter cover showed the opposite relationship to

grazing. These results are similar to those of Evanko and Peterson (1955) who found that species response to grazing was highly variable in mountain grasslands within my study area.

Relationship of Idaho Fescue and Big Sagebrush to Grazing Intensity

Figures 12 and 13 show that big sagebrush cover did not significantly increase as Idaho fescue cover was reduced by grazing in this study. Cover of these two species was poorly correlated ($r^2 = 0.009$). This contrasts with many studies in which big sagebrush was described as an increaser (Bartolome and Heady 1978; Daubenmire 1970; Johnson and Payne 1968; Morris et al. 1976; Mueggler and Stewart 1980; Tueller and Blackburn 1974; and others). The variable response of sagebrush to grazing in this study probably results from a combination of factors. Tisdale and Hironaka (1981) noted that intensity and season of use, kind of livestock and type of vegetation contribute to the varying reaction of any particular area of sagebrush range to grazing. Daubenmire (1970) described wide variation in big sagebrush cover in eastern Washington and felt this was related to changes in subsoil depth across the landscape. Daubenmire (1970) noted that sagebrush generally increases under abusive grazing, but may decrease if heavy concentrations of livestock result

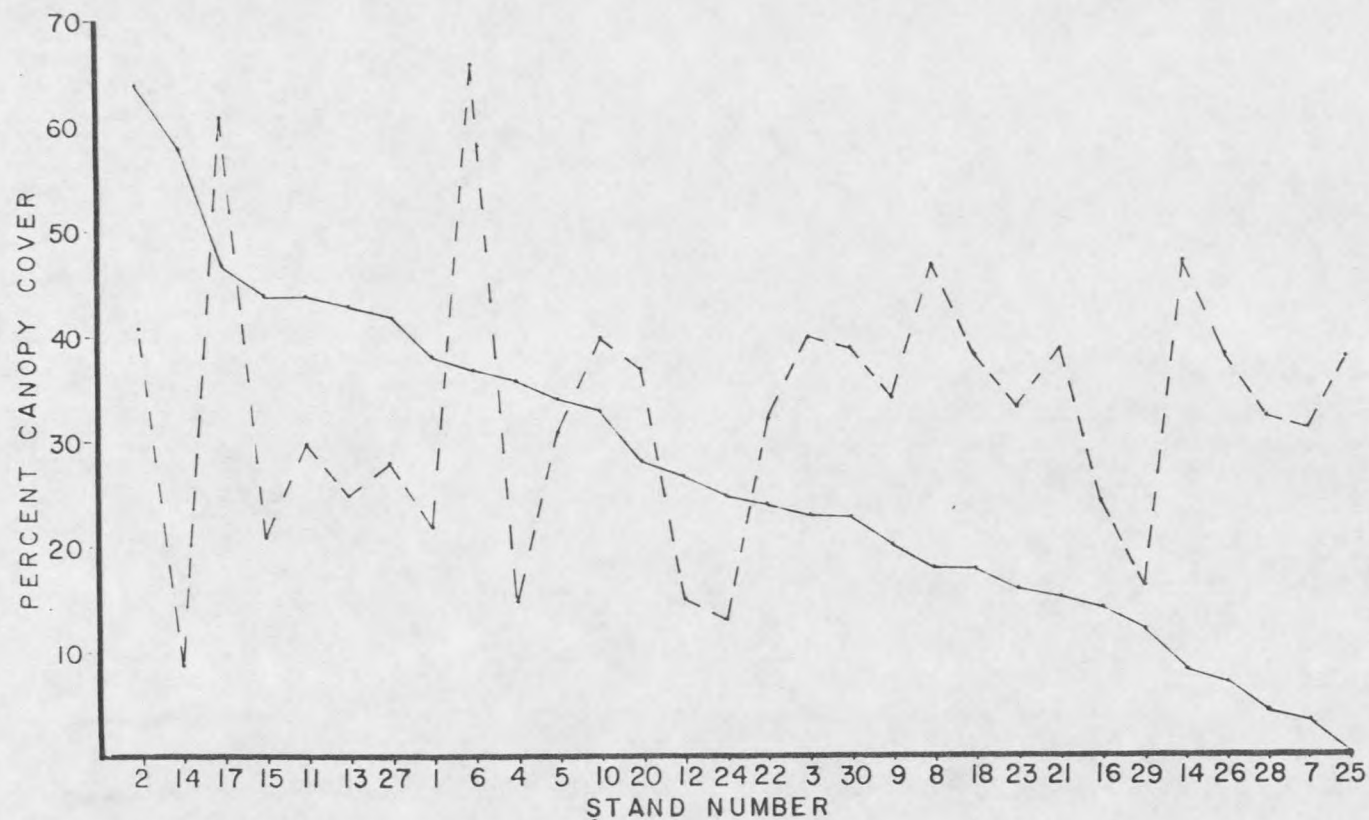


Figure 12. Relationship between Idaho fescue (solid line) and big sagebrush (dotted line) canopy cover (stands arranged in order of decreasing Idaho fescue cover).

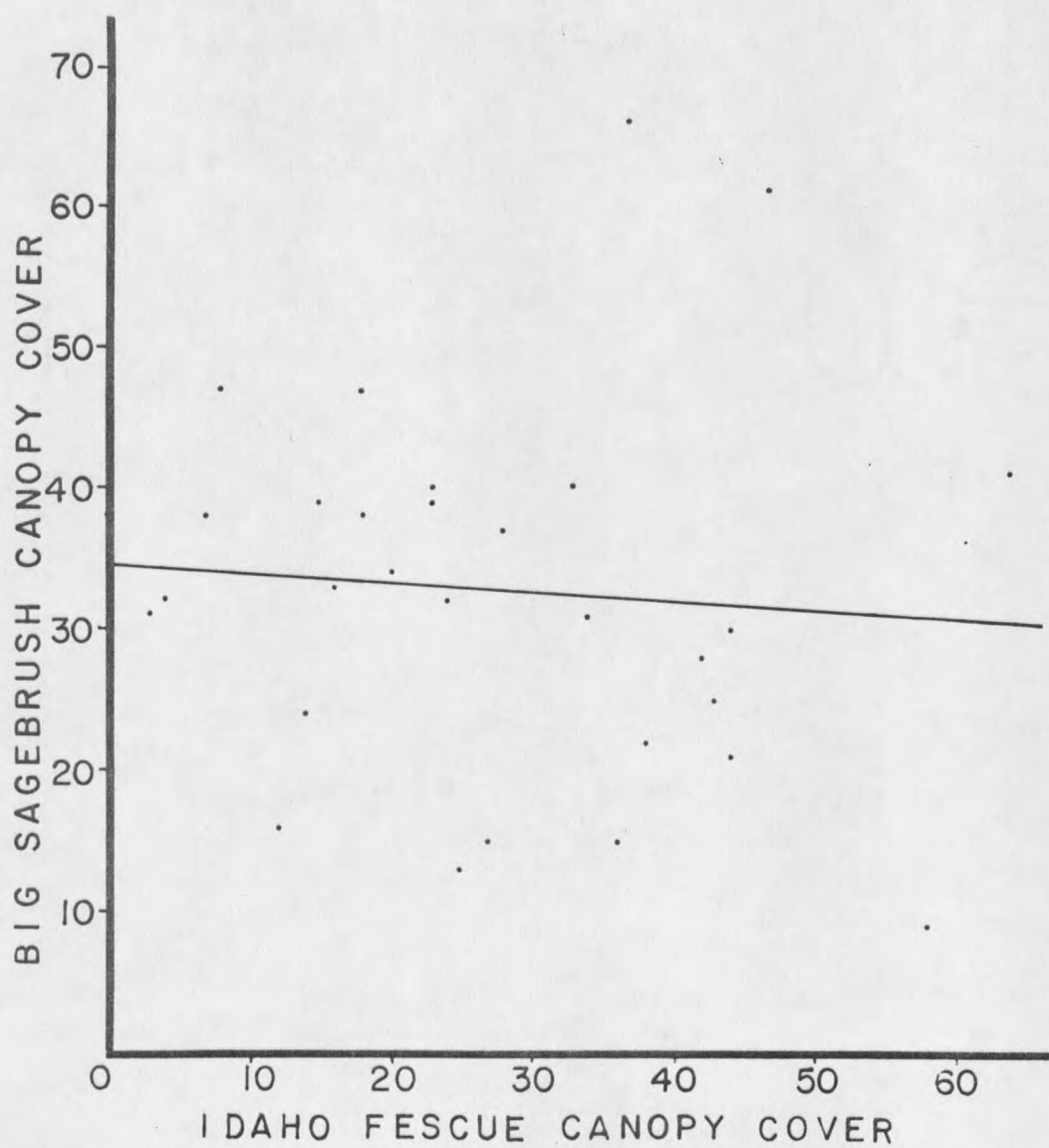


Figure 13. Regression of big sagebrush canopy cover on Idaho fescue canopy cover ($a = 34.78$, $b = -0.076$, $r^2 = 0.009$).

in trampling and subsequent breakage of the shrubs. In this study, heavy browsing by elk and mule deer on winter ranges and trampling by cattle in concentration areas may account for the greater sagebrush cover on the more lightly grazed sites in some cases. Idaho fescue is highly palatable to all classes of livestock and big game using the Artr/Feid habitat type. This explains its consistent decreaser response. Big sagebrush is generally low in palatability but may be used heavily in some cases, which provides a partial explanation of its variable response to grazing. Tisdale and Hironaka (1981) summarized several studies which indicated that sagebrush recovers slowly from severe defoliation and can withstand only about 35 percent use during late spring. Heavy use on winter/spring range may explain some of the cases in this study in which sagebrush appeared to decrease on the more heavily grazed sites.

The fact that big sagebrush and Idaho fescue both had relatively high coverage on some sites (Figure 12) indicates that they are adapted to coexist in the climax vegetation of this habitat type. Daubenmire (1970) noted that big sagebrush and perennial grasses have complimentary ecologies because sagebrush can rely on subsoil moisture supplies when the grasses have become dormant in summer. Sagebrush activity at this time maintains nutrient cycling

and litter accumulation and prevents a waste of solar energy when other species are inactive. Tisdale and Hironaka (1981) summarized many studies which substantiate Daubenmire's (1970) claim that sagebrush is adapted to draw on deep as well as shallow moisture supplies. Idaho fescue begins to senesce in this study area during early August (Mueggler 1972). At this time, sagebrush remains active by utilizing deeper moisture supplies unavailable to the shallow-rooted fescue. Bartolome and Heady (1978) noted that sagebrush-grass ranges may contain a high proportion of sagebrush before grass production is adversely affected, which substantiates the above evidence that sagebrush and perennial grasses are adapted to coexist in the climax vegetation.

Table 5 shows that canopy cover of major species on the good condition stands in this study was not significantly different ($p = 0.05$) than that recorded by Mueggler and Stewart (1980). However, big sagebrush cover averaged 32 percent in this study and only 19 percent in Mueggler and Stewart's (1980) study. This may indicate that sagebrush generally increases with grazing in the Artr/Feid habitat type since my stands were probably used more heavily. However, sagebrush cover also varied greatly in Mueggler and Stewart's (1980) relatively pristine stands ranging from 3 to 44 percent, further indicating the

difficulty in generalizing the behavior of this shrub. Shrub cover from the two studies may not be comparable without bias since stands with sagebrush cover as low as 3 percent were not sampled in this study because they did not appear to have a distinctly shrubland aspect. The two studies do indicate, however, that big sagebrush may be abundant in the climax composition of the Artr/Feid habitat type.

Table 5. Comparison of average percent canopy cover of dominant species between Mueggler and Stewart's (1980) stands and the high condition stands in this study.¹

Species	Average Canopy Cover (range)	
	Mueggler and Stewart (1980), 7 stands ²	This Study, 12 stands
<u>Agropyron spicatum</u>	5.3 (2-10)	3.1 (0-13)
<u>Festuca idahoensis</u>	42.7 (17-59)	43.0 (33-64)
<u>Koeleria pyramidata</u>	3.6 (0-8)	3.2 (0-7)
<u>Poa sandbergii</u>	1.4 (0-4)	2.0 (0-9)
<u>Artemisia tridentata</u>	19.4 (3-44)	32.4 (9-66)

¹No significant differences were found in these comparisons using a t-test ($p = 0.05$).

²Mueggler and Stewart (1980) defined the Artr/Feid habitat type - Feid phase on the basis of 8 stands. One of these 8 stands was described as severely disturbed and was therefore omitted from this analysis.

Range Condition

As shown in the above discussion, Idaho fescue was the only species having a consistent, predictable response to grazing in this study. It was concluded that range condition classes should be based primarily on the deviation of Idaho fescue cover from the climax amount. Trilica et al. (1980) also concluded that more emphasis should be placed on the desirable forage species for range condition analysis of Idaho fescue grasslands in the Bighorn Mountains of Wyoming.

Figure 14 shows proposed condition classes based on Idaho fescue cover for the sites sampled during this study. Excellent condition stands have greater than 50 percent fescue cover, good condition sites 30-50 percent, fair condition sites 10-30 percent, and poor condition range has less than 10 percent cover of this grass. Range condition classes based on the Mountain Grassland scorecard currently used by the U. S. Forest Service have been plotted on the ordination in Figure 14 for 21 of the sites. The first 9 sites were excluded because of an error in the step-loop procedure. The two methods of determining range condition gave very similar results. The major differences occurred in the excellent and poor condition classes. The Forest Service method yielded no excellent condition stands and only half as many poor

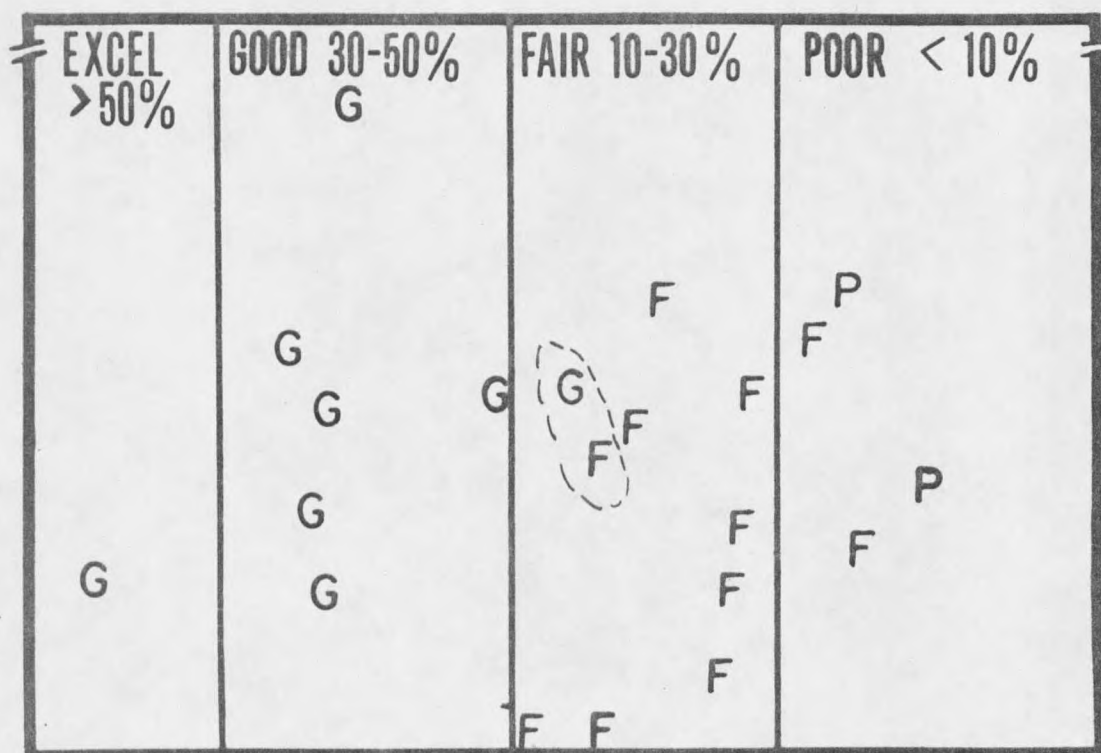


Figure 14. Proposed range condition classes based on percent Idaho fescue cover superimposed on ordination of range condition scores based on the Mountain Grassland scorecard (USDA 1977). Circled stands are discussed in the text. G = good, F = fair, and P = poor.

condition sites as did the method based on Idaho fescue cover. This substantiates comments by range conservationists heard during this study indicating that sites must be either exceptionally good or extremely abused to be classified in the excellent or poor condition classes, respectively, using the Mountain Grassland scorecard. The only other difference between the two methods of range condition determination involved stand no. 20 (circled in Figure 14), rated in good condition using the Mountain Grassland scorecard and in fair condition based on Idaho fescue cover. As discussed above, stands 20 and 22 (both circled in Figure 14) occurred on dry, rocky ridges of relatively low site potential. These stands are probably both in good condition relative to site potential and represent exceptions to the condition classes based on Idaho fescue cover.

The agreement between these two methods of range condition determination is somewhat surprising because the Forest Service method is not based solely on plant composition (60 percent of total score) but also includes plant vigor (15 percent of total score) and "relative perennial plant density," a measure of ground cover (25 percent of total score). Table 2 shows that the plant composition scores overlapped considerably between Forest Service condition ratings. Since plant vigor and relative

perennial plant density both decreased with intensity of grazing (Table 2, Figures 6, 7, 9, 10), these factors apparently compensated for the overlap in plant composition scores and resulted in close agreement between the two methods used to determine range condition. The use of a vigor rating within the range condition score may be questionable since two sites could have different vigor ratings, but identical plant composition. The scattered desirable plants on very poor condition range could have excellent vigor if protected from grazing for a relatively short time since competition from neighboring plants would be reduced. Vigor is thus very useful as an indicator of trend in range condition, but may be misleading as an indicator of condition itself. Evanko and Peterson (1955) and Trilica et al. (1980) pointed out the need for accurate criteria for assessing vigor so that management can be adjusted before species composition is adversely affected by grazing. The use of relative perennial plant density values in the range condition rating must be tied closely to site potential since drier sites may have more bare ground than more productive sites and still be in good ecological range condition.

The classifications desirable, intermediate, and least desirable, used by the Forest Service, do not correspond directly with the terms decreaser, increaser and

invader, used by Dyksterhuis (1949) to indicate a relationship to the climax vegetation. Instead, the Forest Service categories are a compromise between the relationship of a species to the climax, its forage value and value in soil stabilization (Parker 1954). Big sagebrush cover, for example, averages about 20 percent of the climax plant cover in the Artr/Feid habitat type (Mueggler and Stewart 1980). In situations where sagebrush will increase with abusive livestock grazing, an amount equivalent to 20 percent sagebrush cover should be allowed in the increaser category for range condition determination, if such a determination is based on deviation from the climax condition. However, the Mountain Grassland scorecard requires that all sagebrush encountered be classified least desirable (plants that are normally not present in the climax, are poor forage, or have little value in soil stabilization). Sagebrush is present in the climax, is good winter forage for some browsers and is valuable as a soil stabilizer. Conversely, Agropyron spp. are all classified as desirables in the Mountain Grassland scorecard. The results of this study indicate that Agropyron spp. exhibited no definable response to grazing (Tables 3 and 4), and should therefore be classified as intermediates. If the above changes in the classification of big sagebrush and the wheatgrasses were made in the Mountain

Grassland scorecard, little change in condition scores would be expected since a number of hits on sagebrush equivalent to 20 percent cover would be moved from the least desirable to the intermediate category and all wheatgrass hits would be moved from the desirable to the intermediate category. Although this would result in a condition rating more reflective of the deviation from climax plant composition, it would place even more emphasis on the intermediate grouping, which has been discouraged by Trillica et al. (1980). The best solution may be to place more emphasis on the abundance of Idaho fescue as an indicator of range condition because it was found to be a consistent decreaser within the Artr/Feid habitat type. If this is done, a larger sample size for step-loop transects will be necessary. The correlation between percent composition of Idaho fescue based on the Daubenmire transects and the step-loop transects was low ($r^2 = 0.08$). Since the Daubenmire cover data represents a much larger sample than the step-loop transects, data from the latter is probably inadequate. Table 6 summarizes the relationship between range condition classes based on Idaho fescue canopy cover and the step-loop transect data.

Table 6. Average number of hits and near-hits on Idaho fescue by condition class based on 21 step-loop transects.¹

	Exc.	Good	Fair	Poor
Hits (range)	21	18 (7-29)	11 (4-17)	2 (0-5)
Near-hits (range) ²	10	13 (4-22)	9 (1-20)	3 (0-6)
Hits + Near-hits (range)	31	31 (25-40)	20 (7-37)	6 (0-11)
No. of sites	1	8	8	4

¹Condition classes based on coverage of Idaho fescue.

²A near-hit was recorded when no live vegetation occurred in the loop. In such a case, the nearest plant to the left rear quadrant from the loop was recorded.

Neither method of range condition assessment was completely sensitive to the range in site potential which exists within the Artr/Feid habitat type. Judgment must be used with either method so that the range condition rating can be adjusted to reflect site potential. A more objective alternative would involve the development of one scorecard for each site potential unit within the habitat type. Site potential units could be defined on the basis of soil characteristics such as the depth of the A horizon (Munn et al. 1978; Trilica et al. 1980) or on a combination of soils, climate and topography as used by the USDA Soil Conservation Service (SCS). Hann (1982) defined site potential units in forest and rangeland

habitat types which were similar to SCS range sites.

Range condition scorecards based on site potential units within specific habitat types should yield accurate and objective range condition ratings.

CHAPTER 5

SUMMARY AND CONCLUSIONS

Climax plant associations can be considered to be integrators of environmental variables and are useful in identifying areas of the landscape (habitat types) with similar resource potentials and management needs. In this study, the effects of grazing on vegetation in the Artr/Feid habitat type were examined to determine the best field indicators of grazing intensity.

Variation in the community abstract was investigated using ordination and both mechanized and hand-clustering techniques. These procedures produced parallel pictures of vegetation pattern within the stands sampled. Two vegetation gradients were discovered using these techniques.

First, an Idaho fescue gradient was represented by the x-axis of the ordination and by association clusters A-C-E (also see Figure 3). Idaho fescue cover decreased to the right on the ordination and decreased significantly from clusters A to C to E. Supplementary data suggested that this gradient was directly related to grazing intensity. The number of fecal piles per 20x20 m macroplot decreased to the right on the ordination. Percent bare

ground increased to the right on the ordination, while percent litter cover showed the opposite trend. The number of Idaho fescue seedstalks per plant decreased and the number of small Idaho fescue plants increased to the right on the ordination. Finally, total perennial grass cover decreased to the right on the ordination. This grazing gradient was further substantiated by data from fenceline contrasts (Table 4) which showed that Idaho fescue is a decreaser.

Secondly, a big sagebrush gradient was represented by the y-axis of the ordination and by association clusters B-C-D and four outlier stands (see also Figure 3). This gradient appeared to be unrelated to grazing intensity and probably resulted from environmental factors that were not measured in this study. These may include soil characteristics as well as class of stock and season of use. At two fenceline comparisons, big sagebrush cover was considerably greater within grazing exclosures than in the adjacent grazed pastures.

The behavior of other species in response to grazing was highly variable. Onion, bluebell, arnica, besseya, sulfurflower, alumroot and silky lupine appeared to be decreasers but data from the fenceline pairs indicated that few statistically significant decreases occurred. Species appearing to increase with grazing included California

brome, plains reedgrass, timber oatgrass, Sandberg bluegrass, Richardson's needlegrass (Stipa richardsonii), pussytoes, meadow aster (Aster campestris), Hood's phlox, stonecrop (Sedum sp.), rubber rabbitbrush and green rabbitbrush (Chrysothamnus viscidiflorus).

Idaho fescue cover appeared to be the most reliable indicator of range condition within the Artr/Feid habitat type. Even so, range condition determinations based on Idaho fescue cover and on the Mountain Grassland scorecard used by the Forest Service were remarkably similar.

Judgment must be used when determining range condition within this habitat type to account for the variation in site potential caused by soils, topography and climate. Refined range condition scorecards could be developed by subdividing the Artr/Feid habitat type into site potential units.

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APPENDICES

APPENDIX A

DENDROGRAM OF SAMPLE STANDS

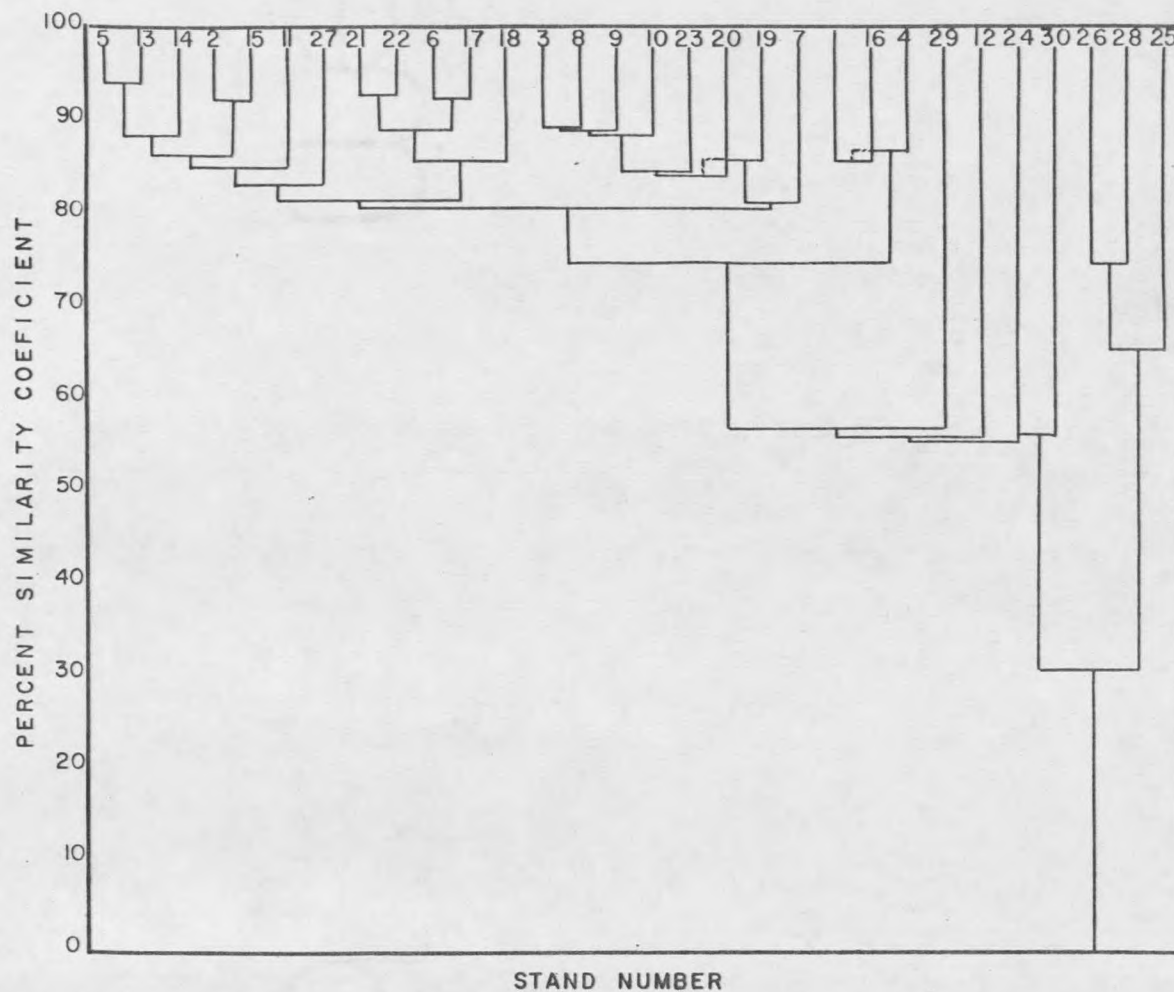


Figure 15. Dendrogram of sample stands. The scale at the left denotes the percent similarity (0 = no similarity; 100 = complete similarity).

APPENDIX B

TWO-DIMENSIONAL ORDINATION OF SAMPLE STANDS

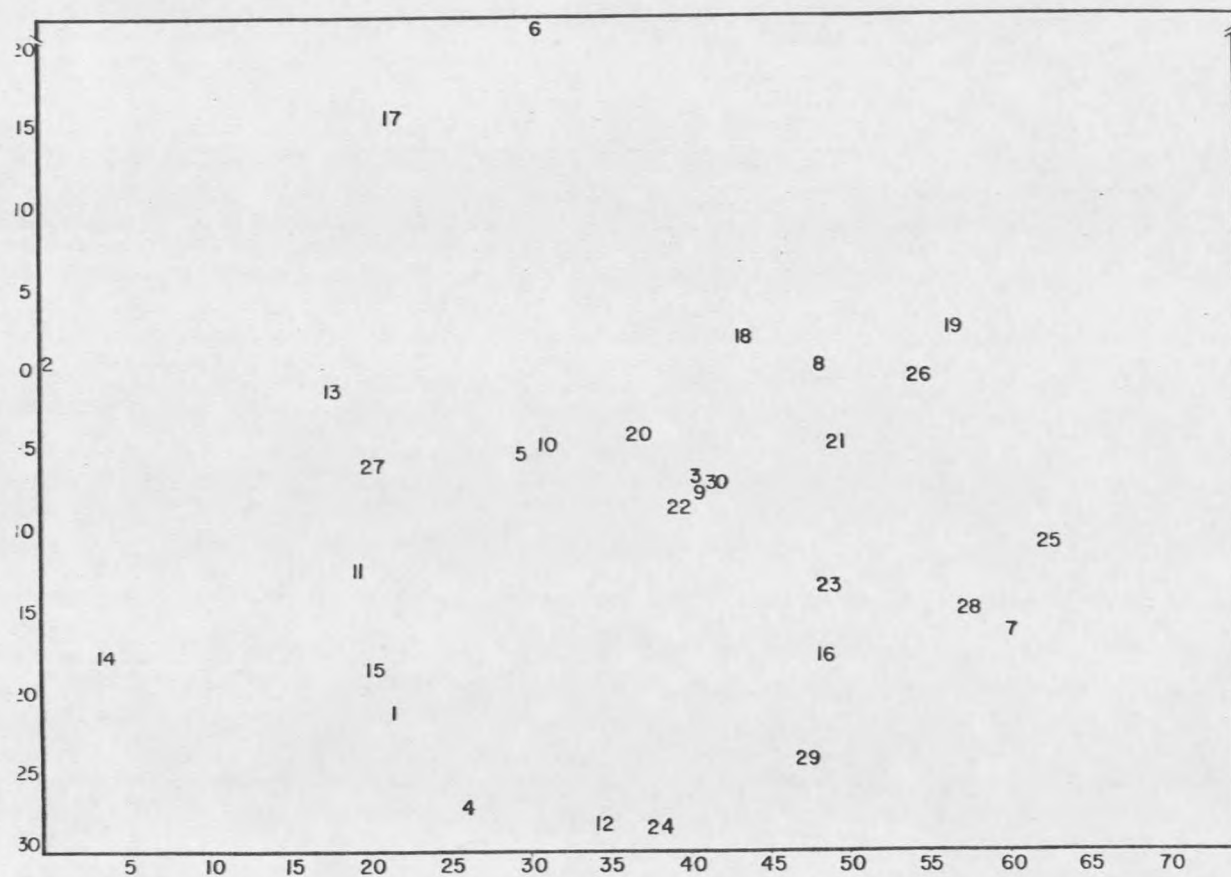


Figure 16. Two-dimensional ordination of sample stands.

APPENDIX C

PERCENT CANOPY COVER OF SPECIES OCCURRING IN
LESS THAN TEN PERCENT OF THE SAMPLE STANDS

Table 7. Percent canopy cover of species occurring in less than ten percent of the sample stands.

Stand No.	2	14	17	15	11	13	27	1	6	4	5	10	20	12	24	22	3	30	9	8	18	23	21	16	29	19	26	28	7	25	
GRASSES																															
<u>Agropyron caninum</u>								1													+										
<u>A. trachycaulum</u>																24															
<u>Agrostis scabra</u>														1	1																
<u>Bromus tectorum</u>																											5				
<u>Muhlenbergia richardsonis</u>																												2			
<u>Phleum pratense</u>											+																				
<u>Poa compressa</u>																											8				
<u>P. sp. #1</u>																					2	1									
<u>P. sp. #2</u>													1							2							+				
Unidentified grass																														+	
SEDGES/RUSHES																															
<u>Carex petasata</u>									5																						
<u>C. sp. #4</u>								1														2									
<u>C. sp. #5</u>														5													7				
<u>C. sp. #6</u>																														1	
<u>C. sp. #7</u>																	2							2							
<u>C. sp. #8</u>																										2					
<u>Juncus effusus</u>															3																
FORBS																															
<u>Agoseris glauca</u>																		3			+									+	
<u>Androsace occidentalis</u>										+							1														
<u>Antennaria sp.</u>																															
<u>Arabis drummondii</u>	+																														
<u>Arabis holboellii</u>	+																														

Table 7 - continued

Stand No.	2	14	17	15	11	13	27	1	6	4	5	10	20	12	24	22	3	30	9	8	18	23	21	16	29	19	26	28	7	25
<u>Artemisia ludoviciana</u>												1																		
<u>Astragalus purshii</u>																								+						
<u>A. adsurgens</u>				2																			4							
<u>Cirsium scariosum</u>																		1							10				+	
<u>Clematis hirsutissima</u>												3																		
<u>Colomia liniaris</u>												1																		
<u>Crepis acuminata</u>													+																	
<u>Cymopterus bipinnatus</u>				+																				+					+	
<u>Cynoglossum officinalis</u>								2																+					+	
<u>Delphinium bicolor</u>												+										+								
<u>Draba verna</u>								+																						
<u>Erigeron compositus</u>														+										2					+	
<u>E. sp. #1</u>													1					4	8											
<u>E. sp. #2</u>				2								2																		
<u>Fragaria virginiana</u>																						+							+	
<u>Frasera speciosa</u>							+													+										
<u>Geranium viscosissimum</u>				2			1	1																						
<u>Hackelia sp.</u>																		1												
<u>Haplopappus acaulis</u>					1																									
<u>Heterotheca villosa</u>																							+		1					
<u>Lesquerella alpina</u>							+																							
<u>Linanthus septentrionalis</u>																				+										
<u>Lithophragma parviflora</u>									+											+										
<u>Lithospermum ruderales</u>																										+				
<u>Lomatium triternatum</u>												1																		
<u>Lupinus lepidus</u>														1																

Table 7 - continued

Stand No.	2	14	17	15	11	13	27	1	6	4	5	10	20	12	24	22	3	30	9	8	18	23	21	16	29	19	26	28	7	25
<u>Melilotus officinalis</u>																								1						
<u>Microseris cuspidata</u>																		4												
<u>Myosotis</u> sp.																	1													
<u>Oxytropis</u> sp.																													+	
<u>Penstemon aridus</u>				2																			2	2						
<u>P.</u> sp.																								1						
<u>Phacelia liniaris</u>															1															
<u>Polygonum douglasii</u>															1	+														
<u>Potentilla gracilis</u>														+				2												
<u>P.</u> sp. #1											1						6													
<u>P.</u> sp. #2											+																			
<u>Ranunculus</u> sp.											+		1																	
<u>Saxifraga integrifolius</u>				5		+								+																
<u>Senecio canus</u>																								+						
<u>S. integrifolius</u>											1							1												
<u>Sisymbrium loesellii</u>																										+				
<u>Smilacena stellata</u>																												5		
<u>Thlaspi parvifolia</u>				+																										
<u>Trifolium</u> sp.								+						+				9												
<u>U. I. forb 1</u>								+																						
<u>U. I. forb 2</u>								+	+																					
<u>U. I. forb 3</u>					+																				2					
<u>U. I. forb 4</u>					+													2							+					
<u>Zygadenus venosus</u>											2																			
SHRUBS/SUBSHRUBS/TREES																														
<u>Artemisia</u> sp.					1																				2			+		
<u>Juniperus scopulorum</u>																													3	
<u>Mahonia repens</u>									1																					
<u>Pinus flexilis</u>																												2		
<u>Potentilla fruticosa</u>														2																
<u>Rosa</u> sp.									+																				+	
<u>Xanthocephalum sarothrae</u>																														+

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