Vegetation Responses to Grazing Management on a Foothill Sheep Range

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Highlight

Measurements were made of cover, yield, and vigor of plants at five locations in fenced exclosures and on adjacent range moderately grazed by sheep in fall through spring. Under the conditions of this study, four years of either deferment or moderate grazing did not cause major changes in vegetation cover, but there were improvements in the yield composition and vigor of climax-dominant perennial grasses.

It often is suggested that overgrazed ranges can be improved by decreasing livestock numbers or by deferring grazing for a few years. This hypothesis was tested on a central Montana foothill range (Fig. 1) which had been intensively grazed by sheep and cattle prior to 1953. Two management treatments — moderate grazing by sheep and no grazing —were imposed upon the vegetation from 1953 to 1957. Measurements were made of cover, yield, and vigor of individual plant species at five locations in fenced exclosures and on adjacent range moderately grazed in fall, winter, and spring by herded sheep. This paper reports the influence of four years of deferment and moderate grazing on vegetation cover, yield, composition, and vigor.

Experimental Range and Procedures

The study was conducted on the Shaw ranch near White Sulphur Springs in Meagher County, Montana. Lying in gently to sharply rolling foothills on the west slope of the Castle Mountains, the ranch is vegetated by plants from both the Palouse and the mixed prairies. Of the Palouse prairie species, bluebunch wheatgrass *(Agropyron spicatum)* generally dominates the drier sites and Idaho fescue *(Festuca idahoensis)* generally dominates the more mesic sites. Important mixed prairie species include prairie Junegrass *(Koeleria cristata)*, western wheatgrass *(Agropyron smithii)*, plains reedgrass *(Calamogrostis montanensis)*, needle-and-thread grass *(Stipa comata)*, blue grama *(Bouteloua gracilis)*, and needleleaf sedge *(Carex eleocharis)*. Many forbs are present, but Hood's phlox *(Phlox hoodii)* and prairie milkvetch *(Astragalus striatus)* are the most abundant, and fringed sagewort *(Artemisia frigida)* is the most abundant shrubby plant. Small or little clubmoss *(Selaginella densa)*, a heterosporous plant, is common on many sites.

About two-thirds of the 18.5-inch average annual precipitation at nearby White Sulphur Springs falls from April through September. Precipitation from September through August in inches was as follows: 1952-53, 15.1; 1953-54, 15.6; 1954-55, 20.2; 1955-56, 16.1 and 1956-57, 18.0.

Soils in the area are undifferentiated gravelly to sandy loams derived from outwash igneous and metamorphic rocks. Sandy loams predominated on the sites which were studied. Solum depths varied from 8 to 16 inches. Soils, vegetation, and physiographic features of the range are described further by Vogel (1960).

Five sites representing soil and topographic variations typical of the general area were selected for study. Sites 1, 2, and 3 were on west aspects of 2 to 5% slopes, site 4 was on a north aspect of 2% slope, and site 5 was on a southwest aspect of 9% slope. Additional characteristics of these sites are reported by Van Dyne et al. (1963).

Two adjacent areas at each site

FIGURE 1. Sheep grazing on Montana foothill rangeland.

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were selected with similar soils, slope, exposure, and vegetation and a 75 by 75-ft exclosure was constructed on one of the two areas in 1953. Five 50-ft line transects were established in each exclosure and five on the adjacent grazed areas. An index to plant cover and composition was obtained by the point-quadrat method with points read at 1-inch intervals along the transects in 1953 and 1957. A total of 30,000 points were recorded in each year.

A procedure similar to Coupland's (1950) was used in recording point contacts. Basal hits were recorded on the stems of most forbs, rhizomatous grasses and sedges, on the crown of bunchgrasses, and on litter (including mulch, lichens, and feces), bare ground and rocks. First hits on foliage were recorded on shrubs and half-shrubs, on mat-forming forbs (e.g., Hood's phlox, pussytoes, *Antennaria* spp. and three-leaved milkvetch, *Astragalus gilviflorus*), and on small clubmoss. These point contact data are referred to collectively in this paper as "cover" and are expressed as percent of ground covered. Cover composition referred to herein is percent of total herbage cover contributed by individual species.

Herbage yield was measured in 9.6 ft^2 plots in 1953 and 6 ft^2 plots in 1957 in the grazed areas and in the protected areas at each site by techniques described by Van Dyne et al. (1963). A total of 20 and 40 plots were clipped in 1953 and 1957 respectively. Temporary exclusion of sheep from the grazed areas in 1953 and in 1957 provided estimates of herbage production unbiased by grazing by large animals. Litter was collected in each plot in 1957.

Maximum seedstalk and leaf lengths and individual plant basal areas were measured for several species. These plants were selected by taking measurements on the appropriate species occurring at every tenth point along the transect lines. Usually 20 to 25 plants of a species were measured for a grazing treatment at each site, and an additional equal number of plants of fringed sagewort were selected at random. Basal area for individual bunchgrasses was calculated as $\pi \cdot a \cdot b$ where a and b are half-axes at right angles across the plant crown.

The range was stocked with sheep in fall, winter, and spring at about 0.26 animal unit months/acre during the experiment. The sheep were herded for uniform distribution, but lower elevations usually were grazed more in the spring, while many of the ridgetops were grazed more in the winter because they were blown free of snow.

The changes from 1953 to 1957 in basal cover and yield were examined by analysis of variance. Vegetation changes in response to the grazing treatments are emphasized in the discussion because site effects and interactions were insignificant for most species. Differences which are discussed are significant ($P < .05$) unless stated otherwise.

Results

Changes in cover. — Neither moderate grazing nor complete protection from grazing caused a significant change in total herbage cover (excluding small clubmoss) during the 4-year study period. Cover on protected areas changed only from 13.1% in 1953 to 12.5% in 1957 and on grazed areas from 12.1% to 12.4% (Table 1). Cover composition changes were similar to cover changes, thus they are not presented but may be calculated from the data in Table 1.

However, cover of several species and groups of species changed significantly from 1953 to 1957. Cover of grasses and sedges as a group was less in 1957 on both grazed and protected areas. Idaho fescue cover did not change on protected areas, but decreased on grazed areas. Cover of bluebunch wheatgrass did not change on either area. The only bunchgrasses that increased in cover on both grazed and protected areas were the bluegrasses (*Poa cusickii* and *P. secunda*). Most rhizomatous grasses and sedges, of which plains reedgrass was the most common, decreased about the same on grazed and protected areas. An exception was needleleaf sedge which showed no change.

Table 1. Average cover of herbage (in percent) on five sites determined by point analysis on protected and grazed areas in 1953 and 1957.[1]

Species or Group	Protected		Grazed	
	1953	1957	1953	1957
Blue grama	0.2	0.1	0.4	0.3
Bluebunch wheatgrass	0.8	0.8	0.9	0.9
Bluegrasses[2]	0.5	1.3	0.3	1.4
Prairie Junegrass	3.6	2.5	3.6	2.5
Idaho fescue[3]	1.7	1.7	1.3	1.0
Needle-and-thread	0.8	0.6	0.4	0.4
All Bunchgrasses	7.6	6.9	6.9	6.5
Needleleaf sedge	0.2	0.2	0.3	0.3
Plains reedgrass	1.5	0.8	0.8	0.4
Wheatgrasses[4]	0.1	0.2	0.6	0.4
All Rhizomatous spp.	1.8	1.2	1.6	1.1
ALL GRASSES AND SEDGES	9.4	8.1	8.5	7.6
Hood's phlox	1.2	1.6	0.7	1.6
Other forbs	0.5	0.5	0.9	0.7
ALL FORBS	1.7	2.1	1.6	2.3
Fringed sagewort	1.5	1.3	1.5	2.1
Other shrubby spp.	0.5	1.0	0.5	0.4
ALL SHRUBS AND HALF-SHRUBS	2.0	2.3	2.0	2.5
TOTAL HERBAGE	13.1	12.5	12.1	12.4
Small clubmoss	21.0	17.6	15.1	7.1
Litter	34.2	52.7	43.2	53.6
TOTAL COVER	68.3	82.8	70.4	73.1

[1] Although protected and grazed were equivalent in 1953 they are reported separately because the same lines were reread in 1957.
[2] *Poa secunda* and *P. cusickii*.
[3] Idaho fescue for site 4 only.
[4] *Agropyron smithii* and *A. dasystachyum*.

Hood's phlox increased in cover on both grazed and protected areas, but other forbs decreased on the grazed locations.

Most of the shrubby plants, except fringed sagewort, increased in cover under protection and decreased slightly on moderately grazed areas. Fringed sagewort, however, increased significantly on the grazed areas but decreased on the protected areas when averaged over all sites. Yet there was a significant treatment by site interaction for the change in cover of this species. At most sites, cover of fringed sagewort increased on both grazed and protected areas, but the increase was much greater on the grazed areas. But, at site 5 with shallow soils overlying bedrock, fringed sagewort decreased on the protected area. The roots of fringed sagewort probably could not grow to their normal depth (Weaver and Albertson, 1956; Schuster, 1964) at site 5 because of the underlying bedrock. However, Schuster (1964) found the lateral spread of fringed sagewort roots to be greater under moderate grazing than under protection. Before 1953, the root system of bluebunch wheatgrass (the dominant species at this site) was weakened as a result of intensive grazing and could not compete with the shallow but more laterally spread root system of fringed sagewort. But when grazing was excluded, bluebunch wheatgrass recovered its vigor and became more competitive with fringed sagewort, causing the latter to decrease in vigor.

Because of its low stature and limited forage value, small clubmoss was not considered as herbage in this study. Yet, it covered more ground area than all other vegetation combined. Although small clubmoss decreased in cover on both grazing treatments, it decreased more on grazed than on protected areas. The relations of small clubmoss to site, climatic, and grazing influences on this and another foothill range are discussed elsewhere (Van Dyne and Vogel, 1966).

Litter cover increased on both protected and grazed areas, but it increased significantly more on the protected areas when averaged over all sites. At site 4, however, litter cover increased more on the grazed than the protected area. Much of the small clubmoss had died (or appeared dead) on the grazed location of this site. Dead clubmoss was included in the litter category and accounted for much of the increase in litter cover.

The increase in plant litter on the protected areas was probably even greater than the data show because most of the fecal material recorded as litter in the exclosures in 1953 would have decayed by 1957; whereas, litter cover on the moderately grazed areas still included accumulated feces in 1957.

Lichens, which are included with litter cover (Table 1) occurred at every site and made up 3.9 and 3.2% of total ground cover on protected and grazed areas, respectively.

Herbage yield and composition. — Total herbage yield in 1957 on moderately grazed areas was 590 lb/acre or about the same as the 1953 total yield of 570 lb/acre (Table 2). Areas protected from grazing yielded about 16% more total herbage in 1957 than in 1953. September to August precipitation was nearly 3 inches greater in 1956-57 than in 1952-53; therefore, changes in total yields cannot be attributed only to grazing practices.

Because weather can mask effects of grazing practices on total herbage yield, change in yield composition is a better criterion than total yield for evaluating the influence of the presence or lack of grazing on range vegetation. Grasses and sedges yielded more pounds of herbage and

Table 2. Average herbage yield (lb/acre) and composition (percent) on five sites in 1953 and on protected and grazed areas in 1957.

	Yield			Yield Composition		
	1953	1957		1953	1957	
Species or Group	Both[1,2]	Prot.	Grazed	Both	Prot.	Grazed
Blue grama	—	<10	10	—	<1	2
Bluebunch wheatgrass	60	120	100	11	18	17
Bluegrasses	—	40	40	—	6	7
Prairie Junegrass	—	90	110	—	14	19
Idaho fescue	—	100	40	—	15	7
Needle-and-thread	—	30	10	—	5	2
All Bunchgrasses	—	380	310	—	58	53
Needleleaf sedge	—	<10	10	—	<1	2
Plains reedgrass	—	70	50	—	11	8
Wheatgrasses	—	20	60	—	3	10
All Rhizomatous spp.	—	90	120	—	14	20
ALL GRASSES AND SEDGES	340	470	430	60	71	73
Hood's phlox	—	60	40	—	9	7
Other forbs	—	70	30	—	11	5
ALL FORBS	120	130	70	21	20	12
Fringed sagewort	80	20	70	14	3	12
Other shrubby spp.	30	40	20	5	6	3
ALL SHRUBS AND HALF-SHRUBS	110	60	90	19	9	15
TOTAL HERBAGE	570	660	590			

[1] Both areas are averaged for 1953 because prior to that time they received similar treatment, but 1953 plot locations differed from those in 1957.

[2] Only bluebunch wheatgrass and fringed sagewort were measured individually in 1953.

composed more of the total yield in 1957 than in 1953. The increase in yield of grasses and sedges was about 40 lb/acre more on protected areas than on grazed areas, but their percent composition was similar on protected areas (Table 2). Bluebunch wheatgrass contributed one-half or more of the increase in yield composition of grasses and sedges. Idaho fescue and needle-and-thread grass yielded more on protected than grazed areas in 1957, and contributed to the increased composition of bunchgrasses on protected areas. In 1953 these two species had slightly greater cover on the protected areas than on the grazed areas which may account in part for their greater yield in 1957 on the protected areas. However, as will be discussed below, their yield per unit cover in 1957 also was greater on the protected areas than on the grazed areas. Yield and composition of prairie Junegrass and of the rhizomatous wheatgrasses were greater on grazed areas in 1957.

Forbs and shrubby plants composed less of the total yield of herbage in 1957 than in 1953 when averaged over both locations (Table 2). The yield and composition of forbs and shrubby plants, other than fringed sagewort, were about one-half as much on grazed as on protected areas in 1957. Fringed sagewort decreased greatly on protected areas but only slightly on grazed areas.

Yield of litter, other than feces, averaged about 420 lb/acre on protected areas and 270 lb/acre on grazed areas. Litter composed 39% of the total herbage biomass, excluding small clubmoss, on protected areas and 31% on grazed areas.

Plant vigor.—Measurements of leaf length, seedstalk height, and average basal area of individual clumps showed that several of the important grass species were less vigorous on the grazed areas than on adjacent protected areas (Table 3). One exception was bluebunch wheatgrass whose average basal area was greater on grazed areas. However, this was caused by differences at site 5 where average basal area of grazed clumps was 102 cm^2 *vs.* 57 cm^2 for protected clumps. Basal area at the other 4 sites averaged 3.3 cm^2 for grazed clumps and 8.7 cm^2 for protected clumps.

Table 3. Measures of vigor of important grasses on protected and grazed areas in 1957.

Species	Longest Leaf(cm)		Tallest Seedstalk(cm)		Basal Area(cm^2)	
	Prot.	Grazed	Prot.	Grazed	Prot.	Grazed
Bluebunch wheatgrass	24	20	50	48	18	23
Prairie Junegrass	7	5	31	26	2	1
Plains reedgrass[1]	15	12	24	21	—	—
Needle-and-thread[2]	13	10	37	27	5	3
Idaho fescue[3]	19	8	42	36	18	10

[1] Basal area was not measured for rhizomatous species.
[2] Site 5 only
[3] Site 4 only

Forbs and shrubs, except fringed sagewort, generally appeared less vigorous on grazed areas than on protected areas. Fringed sagewort appeared more vigorous on grazed areas. Protected and grazed plants of this species, respectively, averaged 0.27 and 0.91 seedstalks per plant.

Herbage yield per unit cover.—Another index for comparing vigor of grazed plants with protected plants (Table 4) was computed by dividing herbage yield (Table 2) by percent cover (Table 1). Bluebunch wheatgrass, Idaho fescue, and needle-and-thread had higher vigor indices on protected areas than on grazed areas. Prairie Junegrass, the rhizomatous wheatgrasses, plains reedgrass, and fringed sagewort had higher indices on grazed areas. With the possible exception for needle-and-thread data, these results are consistent with the expected reaction of these species to grazing at our study sites. Bluebunch wheatgrass and Idaho fescue are considered decreasers and the other species increasers on most sites in our study area (Soil Conservation Service, 1956). The calculated yield per unit cover indicates that needle-and-thread grass reacted as a decreaser although it is considered to be an increaser in the Soil Conservation Service guides. Because of the deteriorated condition of this range, needle-and-thread grass was able to increase under protection. Eventually it probably will begin to decrease as range condition continues to improve.

Table 4. Vigor index (lb/acre/% cover) of important species and groups of species on protected and grazed areas in 1957.

Species or Group	Vigor Index		Ratio
	Prot.	Gr.	Prot.: Gr.
Bluebunch w.	150	110	1.4
Idaho fescue	60	40	1.5
Needle-&-thr.	50	25	2.0
Prair. Junegr.	35	45	0.8
All Bunchgrasses	55	45	1.2
Wheatgrasses	100	150	0.7
Plains reedgr.	85	125	0.7
All Rhizom. spp.	75	110	0.7
ALL GRASSES	60	55	1.1
ALL FORBS	60	30	2.0
Fringed sagew.	15	35	0.4
ALL SHRUBBY PLANTS	25	35	0.7
TOTAL HERBAGE	55	50	1.1

Sheep preference for forbs is reflected by the lower vigor index for these plants on grazed areas. Shrubby plants had greater yield per unit cover on grazed areas because of fringed sagewort.

Density and yield per plant.—Other characteristics reflecting species vigor and trend are number of plants per unit area and yield per plant (Table 5). These values were calculated from data on cover, yield, and individual plant basal area.

The population structure of bluebunch wheatgrass on grazed areas was being shifted towards fewer, shorter, and lower yielding plants having larger basal area per plant. Bluebunch wheatgrass plants in protected areas in 1957 produced 3.1 g/plant as compared to 2.9 g/plant in the grazed areas (Table 5).

The other important bunchgrasses reacted differently in that there were slightly more plants/m^2 in the grazed than in the protected locations. However, there were twice as many prairie Junegrass plants on grazed as on protected areas. Although the yield on grazed areas was about one-fifth more than on protected areas, the protected plants were taller, had larger basal areas, and yielded about 0.08 g/plant vs. 0.05 g/plant in the grazed areas. This suggests there were fewer Junegrass seedlings but more mature plants on protected areas than on grazed areas. This conclusion is acceptable because this species is an increaser.

Range condition.—Neither total cover nor total herbage yield differed greatly on areas subjected to moderate grazing by sheep as compared to those deferred from grazing for four years. But, as discussed above, there were important changes in cover and yield composition and vigor of individual plants. This suggests that range condition percentage might differ on the two treatments.

Range condition percentages calculated from 1957 yield data using Soil Conservation Service (1956) guides, respectively on the protected and grazed areas, were as follows: site 1, 40 and 45; site 2, 30 and 25; site 3, 50 and 40; site 4, 40 and 60; site 5, 75 and 75; and the average for all sites, 47 and 49.

These data show that deferment from grazing for four years had no advantage over moderate grazing if measured by range condition percentages. Because there were important differences in yield and cover composition and in vigor suggests that this system of range condition analysis is not a sensitive measure of the differences between grazed and protected areas in our study.

Discussion

It is important to be able to detect and describe vegetation changes that may result from changes in grazing management. Basal area or cover has been considered a better criterion than total productivity for determining vegetation changes over a short period of time because, in contrast to production, cover does not fluctuate greatly with climatic changes (Robinson, 1954). Others have found that plant vigor may reflect trends in range condition sooner than does basal cover or total production (Parker, 1954; Short and Woolfolk, 1956). Hurd (1959) found leaf length to be a reliable index of plant vigor when weight was accepted as the combined vigor expression.

Our results agree in general with those of Hurd (1961) who found total basal cover of grasses, sedges, forbs, litter and bare soil essentially was the same on grazed areas as on protected areas in the Big Horn Mountains. However, basal cover of individual species varied considerably between protected and grazed areas.

Range managers generally strive to increase forage production, particularly of the desirable forage plants. They may find that yield composition of desirable species will change before does range condition, as measured by our methods, as it did in this study. Yield and composition of bluebunch wheatgrass showed a greater rate of increase on protected areas than on grazed areas. This is expected in our study area where bluebunch wheatgrass decreases with increased grazing intensity (Soil Conservation Service, 1956). The increased yield composition of dominant species such as bluebunch wheatgrass indicated that the range was improving. The greater vigor of grasses in the protected areas would further indicate that the rate of improvement was greater on protected areas than on grazed areas.

Forbs increased in cover but decreased in yield composition on both grazed and protected areas. Most of the increase in forb cover was due to an increase in Hood's phlox. Coupland (1950) stated Hood's phlox is a relatively unpalatable forb, but Clark et al. (1947) and Evanko and Peterson (1955) found it decreased due to intensive grazing by cattle. Other forbs decreased in cover in our grazed areas but did not change on protected areas. Total forb yield decreased in four years on the grazed areas which would be expected due to sheep preference for forbs.

Shrubby plants except fringed sagewort increased both in cover and yield composition on protected areas but decreased on grazed areas. Sheep utilized shrubby plants on this range,

Table 5. Density (plants/m^2) and yield (grams) per plant of four grasses on protected and grazed areas in 1957.

	Density		Yield/plant	
	Protected	Grazed	Protected	Grazed
Bluebunch wheatgrass	4.4	3.9	3.1	2.9
Prairie Junegrass	125	250	.08	.05
Idaho fescue	46	48	1.2	.47
Needle-and-thread	34	36	.29	.13

especially during the winters (Spang, 1954). Fringed sagewort, however, decreased in cover and yield composition on protected areas, but on grazed areas it increased in cover while remaining about the same in yield composition. Fringed sagewort seemed to respond as a sensitive increaser species primarily because it decreased significantly under protection rather than increasing under grazing. Other researchers, however, conclude that increase of fringed sagewort in mixed prairie ranges may be due to an interrelation of climatic conditions and grazing intensity (Reed and Peterson, 1961; Coupland, 1961). They have shown that in a given area the relative abundance of fringed sagewort is directly related to the amount of rainfall and is inversely related to intensity of grazing. Because weather conditions were near normal during this study, fringed sagewort appears to be a useful indicator species for evaluating range trend.

Summary

Vegetation changes on a central Montana foothill range grazed moderately by sheep were compared with those in areas in which grazing was excluded from 1953 to 1957. The range was intensively grazed by sheep and cattle prior to 1953. Precipitation was about normal during the study period.

Total cover of herbaceous vegetation did not change due to moderate grazing or due to complete deferment. The cover of most grasses and sedges decreased slightly from 1953 to 1957 on grazed and protected areas, but bluebunch wheatgrass showed no change. Bluegrasses were the only grasses that increased in basal area. Hood's phlox, the most common forb, increased in cover on grazed and protected areas, but other forbs decreased in cover on grazed areas. Fringed sagewort, a common shrubby plant, decreased in cover under protection and increased on grazed areas.

Total herbage production on moderately grazed areas in 1957 was similar to that in 1953 indicating no major change in yield. Yield of bluebunch wheatgrass, however, increased and that of fringed sagewort decreased from 1953 to 1957. Protected areas yielded 12% more total herbage than moderately grazed areas in 1957. Species yielding more in 1957 in protected than grazed areas included Idaho fescue, needle-and-thread, bluebunch wheatgrass, plains reedgrass, and Hood's phlox. Species yielding more in the grazed areas included fringed sagewort, prairie Junegrass, and western and thickspike wheatgrasses. There was more litter on the protected areas.

Leaf and seedstalk heights indicated greater vigor in protected areas than on grazed areas for most grasses and forbs. Fringed sagewort plants, however, had more seedstalks on grazed than protected areas. As compared to protected areas, there were fewer, shorter and lower yielding bluebunch wheatgrass plants on the grazed areas, but they had larger basal area per plant. Prairie Junegrass plants occurred at a greater density and yielded more per unit area of grazed range than protected range, but the protected plants had larger basal areas and yields per plant.

Four years was too short a time for dramatic changes in cover or yield to occur under the conditions of this study. However, upward trend in the condition of the range, especially on protected areas, was indicated by increased yield composition and vigor of climax dominants.

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