COMPARISON OF LIGHTLY GRAZED AND UNGRAZED RANGE IN THE FESCUE GRASSLAND OF SOUTHWESTERN ALBERTA[1]

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ABSTRACT

The influence of grazing on the vegetative cover of fescue grassland in southwestern Alberta was assessed by studying two adjoining sites, one lightly grazed, the other ungrazed. Percentage basal area, yield, water-intake rate, soil temperature, soil moisture, and amount of root material were compared on a paired plot basis.

The data showed that light grazing resulted in the development of a richer flora dominated by *Danthonia parryi*. Protection from grazing appeared to simplify the flora with a trend toward a cover consisting largely of *Festuca scabrella*. There was little evidence of difference in productivity between the two sites. Cooler and moister conditions prevailed in the upper 12 inches of the soil profile of the ungrazed site as a result of heavy accumulation of mulch. Considerably more root material to a depth of 54 inches was present on the lightly grazed site. The harmful effects of herbage removal, shown by clipping studies, were not apparent in the field study under a light rate of grazing.

INTRODUCTION

Range management literature stresses the harmful effects of grazing, as the tendency is to describe regressive trends from protected to overgrazed sites. Consequently, little is known about grazing pressure as an ecological influence (3).

Light grazing is frequently suggested as a means of range improvement and studies have shown the practice to be feasible (4, 5, 10). This is at variance with much of the experimental evidence which suggests that herbage removal is damaging. Too little is known of the effects of light grazing to permit any very meaningful conclusions (3).

The objectives of the study reported herein were to obtain quantitative data on the differences between lightly grazed and ungrazed range sites and to assess the effects of grazing *per se* on the vegetative cover.

DESCRIPTION OF THE AREA

At the Range Experiment Substation, Stavely, Alberta, an area that had been lightly grazed (average utilization 15 to 25 per cent) for a period of 12 years was available for study. A 2-acre exclosure within this field and an adjoining 2-acre plot from the field itself were selected for comparison (Figure 1).

From 1884 to 1908 the site was grazed by cattle on a moderate use basis (1). From 1908 to 1920, the area carried horses again on a moderate summer use basis. It was used as summer range for cattle from 1920 to 1943 and was heavily grazed during the drought years of the thirties. In 1944 the area became part of a large ranch and was lightly used as winter pasture until 1949. In 1949 the area was lightly stocked with cattle on a summer use basis; the exclosure was fenced and protected from all grazing by livestock. This type of use was maintained until 1960.

[1]Contribution from the Forage Crops Section, Canada Agriculture Research Station, Lethbridge, Alta.

The vegetation of the area has been described by Moss (7) and Moss and Campbell (9). It is considered part of the *Festuca scabrella* association, although it has a richer flora than much of the remainder of the association. *Danthonia parryi* and *Festuca idahoensis* are the chief associated grasses. *D. parryi* is of particular interest since it behaves as an edaphic subclimax species on exposed sites and as a disclimax under heavy utilization (8).

The study site was situated on orthic shallow black soil developed on glacial till. The texture of the soil ranged from loam to clay loam. The climate has been classified as "moist subhumid" with little or no water deficiency at any season (12). Average annual precipitation near the study sites for the period 1950-1959 was 23.91 inches of which 9.21 inches, or approximately 40 per cent, was received as snow.

METHODS

The study was divided into three parts as follows:

1. *Vegetation*

A vegetation analysis was conducted by the vertical point method (6). Three thousand points per study site were examined and the percentage basal area was determined in August, 1960. Basal area data obtained by the same method in August, 1949, were available for comparison.

Yields of the various components of the vegetative cover were determined in late July, 1960, by clipping 30 four-square-foot plots on each study area. The clipped material was divided into green grass, green forbs and shrubs, fresh mulch, and humic mulch according to the method of Dyksterhuis and Schmutz (2). Green grass consisted of all live portions and the dead tips of the growing grasses; *Carex* spp. were included in this group. Green forbs and shrubs consisted of the living, above-ground portion of these plants and included partially dead stems. Fresh mulch consisted of the fresh residuum of herbage and was made up of the upper layer of bulky, coarse, leafy, and largely undecayed natural mulch. Humic mulch consisted of largely decayed, disintegrated, and fragmented organic residuum of fresh mulch. The dry matter contents of these materials were determined.

Plant vigour was rated by measuring the maximum leaf height and average basal diameter of 40 paired plants of *F. scabrella*.

2. *Soil*

Soil moisture samples were taken at 12-inch increments to a depth of 48 inches with a King tube. Thirty cores were obtained in each study area. Soil moisture was determined by oven drying the samples for 24 hours at 220°F. Soil temperatures at an 8-inch depth were recorded daily at ten paired locations from August 1 to October 31, 1960.

A measure of water-intake was obtained with a mobile infiltrometer according to the procedure outlined by Rauzi (11). A simulated rainfall intensity of 3.60 inches per hour was applied to three 4-square-foot plots in each study area. Yields of herbage and mulch and soil loss were determined on the same plots.

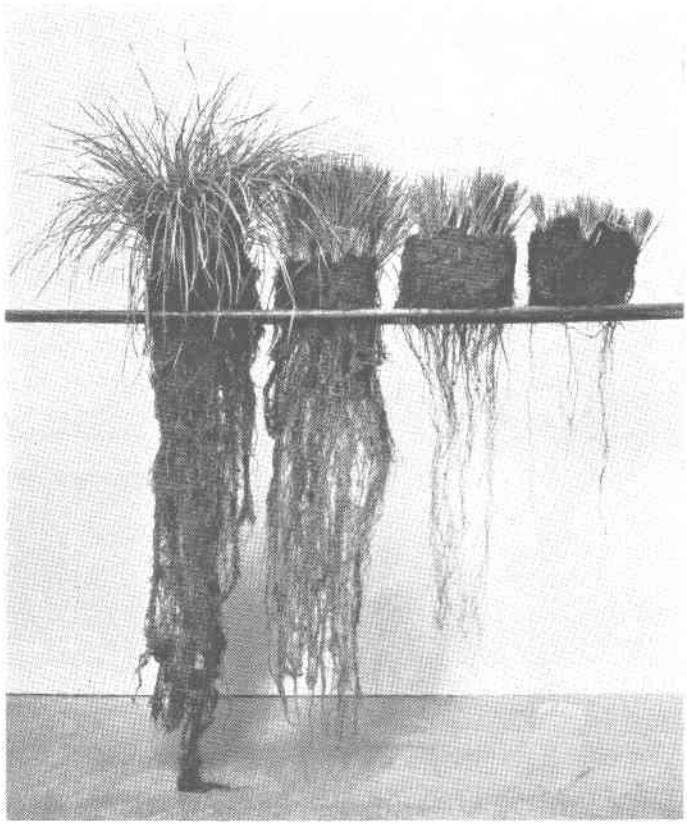

FIGURE 2. Plants of *Festuca scabrella* unclipped and clipped to stubble heights of 5 inches, 3 inches, and 1½ inches at 4-week intervals.

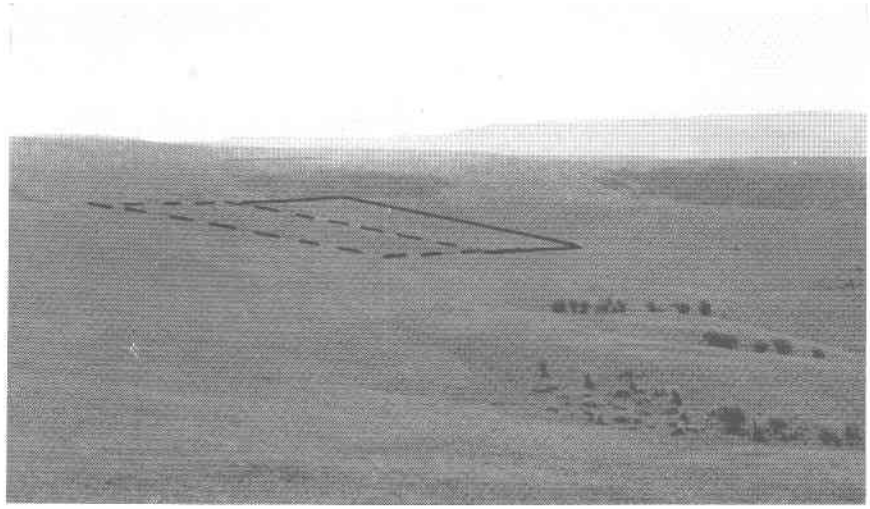

FIGURE 1. General view of the study sites showing the ungrazed exclosure (*broken line*) and lightly grazed area (*solid line*). The study sites were located on a moderate west-facing slope.

Thirty 2½-inch cores were obtained by 6-inch increments to a depth of 54 inches within each study area. Since the samples were found to be too small for effective root washing, the separate increments for each treatment were bulked, washed, and a single weight of roots recorded.

Student's Pairing Method was used in the analysis of part of the data obtained in (*1*) and (*2*) above.

3. Greenhouse Study

Sods containing single plants of *F. scabrella* were removed from an ungrazed stand, trimmed to 6 x 6 x 4 inches, and transplanted into metal containers filled with a 60:40 mixture of loam and sand. The containers measured 10 x 10 x 28 inches deep and had one removable side. Top-growth was removed when the sods were placed in the greenhouse. Tiller numbers of all plants were made approximately equal at the beginning of the clipping experiment and were determined at the end of the 16-week growing period. Four clipping intensities were used; clipped at the end of 16 weeks and at 4-week intervals to stubble heights of 1½, 3, and 5 inches. Yields of top-growth and root-growth were determined at the end of the growing period.

RESULTS

The percentage basal area of vegetation on the lightly grazed and ungrazed sites in 1960 and the percentage basal area in 1949 are presented in Table 1. *D. parryi* decreased under protection while *F. scabrella* increased. This would seem to support Moss (8), who stated that the former grass behaves as a disclimax under grazing pressure. The basal area of *D. parryi* was maintained under light grazing even with the increase in basal area of *F. scabrella*. *F. idahoensis*, which has reacted as an increaser under heavy grazing, showed a slight reduction in percentage basal area under light grazing. Percentage basal area of *Bromus pumpellianus* increased considerably from 1949 to 1960 on the ungrazed site and to a lesser extent under light grazing. The increased growth occurred between the tussocks of *F. scabrella* and in the presence of natural mulch. The increased percentage basal area of "Forbs and shrubs" shown for both the ungrazed and lightly grazed sites was due to an increase in size of plants of *Potentilla fruticosa*.

TABLE 1.—AVERAGE PERCENTAGE BASAL AREA OF VEGETATION OF TWO STUDY SITES AT STAVELY IN 1949 AND 1960

Species[1]	Study sites in 1949	Ungrazed 1960	Lightly grazed 1960
Danthonia parryi	8.25	5.57	8.80
Festuca scabrella	3.75	6.03	4.97
Festuca idahoensis	1.35	1.53	1.10
Agropyron subsecundum	0.35	0.13	0.40
Bromus pumpellianus	0.01	1.40	0.60
Other grasses	0.69	0.07	0.40
Carex spp.	1.80	1.50	2.77
Forbs and shrubs	3.30	4.29	4.74
Total	19.50	20.52	23.78

[1]Nomenclature follows that of Moss, E. H. Flora of Alberta. Univ. Toronto Press. 1959.

TABLE 2.—HEIGHT AND DIAMETER OF FESTUCA SCABRELLA PLANTS AND YIELDS OF SOME COMPONENTS OF THE VEGETATIVE COVER, STAVELY, 1960

	Ungrazed	Lightly grazed	D.F.	"t"
Festuca scabrella:				
Average plant height (inches)	19.8	19.0	39	1.11
Average plant diameter (inches)	4.39	3.38	39	2.46*
Yield (pounds dry matter per acre):				
Green grass	1,464	1,252	29	2.09*
Green forbs and shrubs	762	936	29	1.24
Total green herbage	2,226	2,188	29	0.28
Fresh mulch	3,889	2,881	29	4.00**
Humic mulch	7.154	4,850	29	4.94**
Total mulch	11,043	7,731	29	5.70**
Total organic matter	13,299	9,919		

*Significant at P 0.05
**Significant at P 0.01

Total number of species detected by the point method, including *Carex* spp., was considerably greater under light grazing (31 species) than on the protected area (19 species) or on the study sites in 1949 (23 species). Nine grass species were detected in 1949, while in 1960 eight species were noted on the lightly grazed area and six species on the ungrazed site. Thirteen species of forbs and shrubs were detected in 1949, while twenty-two were noted under light grazing and twelve under protection in 1960. The additional forbs detected under light grazing included *Thalictrum venulosum*, *Heuchera richardsonii*, *Zizia aptera*, *Anemone patens* var. *wolfgangiania*, *Taraxacum officinale*, *Agoseris glauca*, *Lupinus argenteus*, *Geum triflorum*, *Fragaria virginiana*, and *Thermopsis rhombifolia*. *Stipa spartea* var. *curtiseta* and *Agropyron dasystachyum* were detected in 1949 but were not recorded on the protected site in 1960.

Comparisons of several constituents of the vegetative cover are shown in Table 2. Plant vigour, as reflected by the height of *F. scabrella*, did not differ between treatments. Diameter of plants was significantly different (P 0.05), smaller plants being characteristic of the lightly grazed area. This is in agreement with Moss and Campbell (9), who pointed out that a decrease in diameter of tussocks occurs when fescue prairie is utilized.

The amount of surficial organic matter found on the study sites (Table 2) was comparable to that reported for tall-grass prairie by Dyksterhuis and Schmutz (2). The differences between the two sites were principally in the amounts of fresh and humic mulch which were higher (P 0.01) on the ungrazed site. Differences in yield of green herbage on the two sites were not significant and the apparent difference in grass yields was probably caused by grazing. The lightly grazed study site was accessible to cattle from May 15 to July 20, 1960.

Cooler and moister conditions prevailed in the upper 12 inches of the soil profile under protection than on the lightly grazed site (Table 3). Soil temperature differences were small and tended to become equal as the season advanced. Percentage soil moisture was higher (P 0.05) in the

TABLE 3.—MEAN MONTHLY SOIL TEMPERATURES AT AN 8-INCH DEPTH ON TWO STUDY SITES

Month	Ungrazed	Lightly grazed
August, 1960	52°F.	54°F.
September, 1960	48°F.	49°F.
October, 1960	43°F.	43°F.

TABLE 4.—PERCENTAGE SOIL MOISTURE AT VARIOUS DEPTHS ON TWO STUDY SITES

Soil depth	Ungrazed	Lightly grazed
0-12 inches	22.19	19.38*
12-24 inches	14.49	14.35
24-36 inches	13.34	13.52
36-48 inches	12.75	14.00

*Significant at P 0.05

TABLE 5.—WEIGHT OF UNDERGROUND PLANT MATERIAL IN POUNDS PER ACRE AT VARIOUS DEPTHS ON TWO STUDY SITES

Soil depth	Ungrazed	Lightly grazed
0- 6 inches	11,193	20,067
6-12 inches	1,109	3,297
12-18 inches	1,797	2,293
18-24 inches	884	1,520
24-30 inches	333	688
30-36 inches	370	470
36-42 inches	351	407
42-48 inches	170	281
48-54 inches	218	242
Total	16,425	29,265

upper 12 inches on the ungrazed site but did not differ between sites at depths of from 12 to 48 inches (Table 4).

Dry weights of root material at various depths from the two sites are shown in Table 5. It is apparent that more root growth occurred on the lightly grazed area than on the protected site at all depths.

Water-intake rate and soil loss are shown in Table 6. Average values for the second 30-minute period and the fourth 15-minute period of a 1-hour run indicate that increasing amounts of natural mulch on the protected site (Table 2) resulted in greater water-intake rates and in lower soil loss per acre. The water application intensity of 3.60 inches per hour used in this test was probably well in excess of natural rainfall intensity for the area.

Results of the greenhouse clipping experiment indicated that herbage removal was damaging to the individual range plant. Four plants of *F. scabrella*, one unclipped, the others clipped to stubble heights of 5, 3, and

TABLE 6.—WATER-INTAKE RATE AND SOIL LOSS FROM TWO STUDY SITES

	Ungrazed	Lightly grazed
Water-intake rate during 1-hour run of:		
Second 30-minutes (inches/hour)	2.24	1.65
Fourth 15 minutes (inches/hour)	2.20	1.59
Soil loss (pounds per acre)	65	133

1½ inches at 4-week intervals, are shown in Figure 2. The 5-inch clipping treatment, comparable to 20 per cent utilization, resulted in a considerable reduction in weight of roots as compared to the unclipped control (Table 7). Tiller production was vigorous when plants were clipped to a 5-inch stubble height but was reduced when plants were clipped to 3 inches. Comparable results have been obtained in greenhouse clipping studies with *F. idahoensis* and *D. parryi**.

DISCUSSION

The character of the vegetation on the study sites was changed as a result of the treatments imposed during the 12-year period. Light grazing tended to favour dominance by *D. parryi* while protection from all grazing favoured dominance by *F. scabrella*. Light grazing resulted in the development of a more varied flora with a greater total percentage basal area while protection from grazing appeared to simplify the flora with a trend toward a cover consisting largely of *F. scabrella*. A varied cover could conceivably be of value to the ecosystem especially during times of climatic stress. The change in character of the vegetation was not accompanied by a change in production. In terms of percentage basal area, there was little doubt that an improvement in range condition had occurred during the 12 years of light grazing.

Large amounts of natural mulch had accumulated on the ungrazed site and seemed to be partially responsible for the simplification in plant composition that had taken place under this treatment. The importance of

**Unpublished data*

TABLE 7.—EFFECT OF VARIOUS CLIPPING TREATMENTS ON FESTUCA SCABRELLA PLANTS IN THE GREENHOUSE

Treatment	Yield of dry matters in grams		Number of tillers		Estimated percentage utilization
	Top-growth	Root-growth	Initial	Final	
Unclipped	20.16	15.03	87	431	0
Clipped every 4 weeks to 1½ inches	1.84	0.68	73	53	90
Clipped every 4 weeks to 3 inches	5.91	2.98	81	192	70
Clipped every 4 weeks to 5 inches	15.96	7.83	77	427	20

natural mulch in conditioning the soil surface for infiltration and resistance to erosion was shown.

The weight of the root mass was greater under light grazing than under protection. Similar results have been noted elsewhere (14). Troughton (14) states that results from a clipping experiment with *Lolium perenne* showed that the weight of roots per plant decreased with increasing intensity of defoliation but that the root weight per unit area of sward increased. This was attributed to an increase in plant density as a result of defoliation. Stevenson and White (13) have also reported a greater weight of roots under grazed than under ungrazed prairie. Thus the increased percentage basal area found under light grazing accounts in part for the difference. Another reason for this difference may be related to a factor that was not assessed in this study. Troughton (14) reports that a number of investigators have noted reduced root growth as a result of partial shading. Shading was a greater factor on the ungrazed site as a result of dominance by a tall-growing species and large amounts of mulch than on the lightly grazed area.

Results obtained from clipping studies in the greenhouse appeared to contradict those obtained in the field. In the greenhouse, a considerable reduction was noted in amount of top- and root-growth when 20 per cent of the herbage was removed. The field study, after 12 years of comparable utilization, showed an increase in amount of root-growth and a slight reduction in amount of top-growth, the latter being attributed to prior utilization by cattle. Wilson (15) reported similar contradictory results between greenhouse and field clipping tests with *F. rubra* and *Dactylis glomerata*. In the greenhouse, yields of both top- and root-growth declined as the severity of clipping increased while, in the field, higher yields were obtained by clipping to a lower stubble height. In a subsequent greenhouse experiment, Wilson (15) used larger sods, harvested the centre portion only, and duplicated field results. He considered that a high light intensity near the base of the plant was important to regrowth and concluded that this was available to potted plants in the greenhouse under all stubble heights but only to closely clipped plants in the field because of self-shading. A similar explanation may apply to the study reported herein. The data suggest that greenhouse clipping tests should be used with caution when applied to actual grazing studies.

CONCLUSIONS

A light rate of grazing on the study site resulted in some diversification in plant composition, a greater total percentage basal area, a lesser accumulation of natural mulch, and in a greater amount of underground plant material per unit area. The harmful effects of herbage removal shown by a clipping experiment were not apparent under a light rate of grazing. This suggests that any beneficial effects of grazing accrue to the ecosystem.

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REFERENCES

1. Craig, John R. Ranching with Lords and Commons. Walter Briggs, Toronto. 1903.
2. Dyksterhuis, E. J., and E. M. Schmutz. Natural mulches or "litter" of grasslands: with kinds and amounts on a southern prairie. Ecology 28:163-179. 1947.
3. Ellison, Lincoln. Influence of grazing on plant succession. Botan. Rev. 26:1-78. 1960.
4. Johnson, W. M. The effects of grazing intensity on plant composition, vigor, and growth of pine-bunchgrass ranges of central Colorado. Ecology 37:790-798. 1956.
5. Kipple, C. E., and R. E. Bement. Light grazing – is it economically feasible as a range improvement practice. Proc. Amer. Soc. Range Management. 1959.
6. Levy, E. B., and E. A. Madden. The point method of pasture analysis. New Zealand J. Agr. 46:267-279. 1933.
7. Moss, E. H. The prairie and associated vegetation of southwestern Alberta. Can. J. Research, C 22:218-229. 1944.
8. Moss, E. H. The vegetation of Alberta. Botan. Rev. 21:493-567. 1955.
9. Moss, E. H., and J. A. Campbell. The fescue grassland of Alberta. Can. J. Research, C 25:209-227. 1947.
10. Nelson, E. W. The influence of precipitation and grazing upon black grama grass ranges. U.S.D.A. Tech. Bull. 409. 1934.
11. Rauzi, Frank. Water-intake studies on range soils at three locations in the Northern Plains. J. Range Management 13:179-184. 1960.
12. Sanderson, Marie. The climates of Canada according to the new Thornwaite classification. Sci. Agr. 28:501-517. 1948.
13. Stevenson, T. M., and W. J. White. Root fibre production of some perennial grasses. Sci. Agr. 22:108-118. 1941.
14. Troughton, Arthur. The underground organs of herbage grasses. Commonwealth Agr. Bur. Bull. 44. 1957.
15. Wilson, D. B. Competition among three pasture species under different levels of soil nitrogen and light intensity. Ph.D. thesis, Oregon State Coll. 1960.