Vegetation of Exclosures in Southwestern North Dakota

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Abstract

A 3-year study of the vegetation in 4 livestock exclosures was begun in 1976 in the mixed grass prairie of southwestern North Dakota. Three of the exclosures were established in 1937 and the fourth in 1938. The exclosures had greater graminoid leaf heights and greater mulch accumulations than the adjacent grazed plots; however, total yield and total belowground biomass were not significantly different between plots in 3 out of the 4 sites. The major difference between the exclosures and the adjacent grazed plots was species composition. The production of blue grama (*Bouteloua gracilis* (H.B.K.) Griffiths) was lower, and the production of thread-leaf sedge (*Carex filifolia* Nutt.) and another sedge (*Carex heliophila* Mack.) was greater in the exclosures than on the adjacent grazed plots. A summary by growth form also showed that the midgrass and tallgrass growth form category was more dominant in only 1 out of 4 exclosures. The interpretation of these data indicates that the potential for changes in growth form dominance and total yield due to management inputs must be evaluated on a site specific basis. Species composition also was a more reliable indicator of successional status than growth form dominance.

The exclusion of domestic livestock from grazed rangeland often initiates secondary succession. If left undisturbed, this succession may culminate in a plant community with a relatively stable composition. Although ungrazed grassland vegetation in the Northern Great Plains may differ from the pristine vegetation which developed under grazing by native herbivores (Larson 1940, and England and DeVos 1969), it is intrinsically valuable as an easily definable reference point for the documentation and interpretation of secondary successional trends. Range managers have often used exclosures, cemeteries, and other areas inaccessible to livestock to determine the potential for improvement on grazed rangeland.

In the northern mixed grass prairie (i.e. mixed grass prairie in the Northern Great Plains), midgrasses generally have been more dominant on ungrazed than on grazed ranges while the shortgrass, blue grama (*Bouteloua gracilis* (H.B.K.) Griffiths), has been less dominant (Sarvis 1941, Larson and Whitman 1942, Smoliak 1965, and Whitman 1974). Other characteristics of ungrazed vegetation have included a greater aboveground herbaceous production (Larson and Whitman 1942, Lodge 1954, Smoliak 1965, and Whitman 1974), and a greater grass height (Smoliak 1965 and Whitman 1974).

Microclimatic changes associated with the exclusion of grazing include a greater percent soil moisture (Lodge 1954, Smoliak et al. 1972, and Whitman 1974), lower soil temperatures, less wind movement, lower average air temperatures at heights of less than 1 m above the canopy, and less severe evaporative conditions (Whitman 1974).

This project was begun in 1976 to study the vegetation in 4 livestock exclosures in the mixed grass prairie and to provide additional insight into secondary succession with the exclusion of grazing.

Materials and Methods

In the late 1930's, 1 cattle exclosure was established on each of 4 sites within 14 km of each other in the Little Missouri Badlands of southwestern North Dakota (Table 1). This area was part of the mixed grass prairie (Weaver and Albertson 1956) and the principal grassland species were blue grama, thread-leaf sedge (*Carex filifolia* Nutt.), western wheatgrass (*Agropyron smithii* Rydb.), and needle-and-thread (*Stipa comata* Trin. and Rupr.) (Whitman 1953).

The climate was semiarid with over 75% of the average annual precipitation falling during the April through September "growing season" (Stewart and Stewart 1973). The mean annual precipitation was about 356 mm. The mean annual temperature was about

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Table 1. Site descriptions of the Sagebrush Flat, East Tracy Mountain, West Tracy Mountain, and Sandy Upland sites.

Site	Date Established	Soil Series[1]	% Slope/ Aspect	Vegetation Type[3]
Sagebrush Flat				
Ungrazed	1937	Havrelon	1	Sagebrush
Grazed		Havrelon	1	Sagebrush
East Tracy Mountain				
Ungrazed	1938	Farland[2]	3/S	Western
Grazed		Farland[2]	3/S	wheatgrass grama-sedge
West Tracy Mountain				
Ungrazed	1937	Telfer	3/N	Grama-needle-
Grazed		Lihen	3/N	grass-sedge
Sandy Upland				
Ungrazed	1937	Blanchard	2/NE, E,W	Sandgrass
Grazed		Blanchard	2/NE, E,W,	Sandgrass

[1]Havrelor [illegible] sandy, mixed [illegible] Blanchard [illegible]
[2]Farland- [illegible] ier textured B horizon and was darker to a deeper depth than a typical Farland series soil.
[3]Vegetation classification was based on Hanson and Whitman (1938).

5.3° C with a maximum mean monthly temperature of 21.7° C in July and a minimum of -10.6° C in January (Jensen 1972).

One grazed plot was established in 1976 adjacent to each of the 4 previously described exclosures. The grazed plots were part of larger grazing units which were grazed by cow-calf pairs. The grazing permits ran from 1 May through 31 December; however, the grazing season was probably shortened in most years due to deteriorating weather conditions in the late fall. Ocular estimates of the grazing intensity on the grazed plots in 1976 and 1977, and sporadic data since 1952 indicated that the average vegetation utilization ranged from 40 to 50% (data before 1976 was provided by Dr. Warren Whitman, North Dakota State Univ., Fargo).

The ungrazed and grazed plots ranged from 0.2 to 1.0 ha. Vegetation was sampled during the summers of 1976 through 1978. Percent cover of cryptogams was measured using a 10-pin point-frame systematically placed 300 times (3,000 points) in each plot each year. In the Sagebrush Flat site only 2,000 points were taken in each plot in 1976 and 3,000 points in 1977 and 1978.

Table 2. Mean foliar cover (%) of shrubs on the Sagebrush Flat site. The means were based on four 50 m line transects in each plot in each of the years 1976 through 1978.

Species	Ungrazed	Grazed
Artemisia cana	24.6	28.0
Symphoricarpos occidentalis	4.2	<0.1
Miscellaneous shrubs	1.7	0.0
Total	30.5	28.1

Herbaceous production was sampled in August each year after the main growth period had ended. Ten 0.5-m² quadrats, randomly located along systematically placed lines, were clipped at ground level in each plot. The quadrats in the grazed plots were protected from grazing during the growing season with cages. The first quadrat in each plot was clipped by species while species composition was estimated in the remaining 9 quadrats, which were then clipped by forbs and graminoids. Mulch (both the standing dead from the previous year and litter) was hand collected. Mulch and herbage samples were oven dried at 66° C to a constant weight.

Heights of the extended vegetative leaves of randomly selected plants were measured in the quadrats before clipping.

The foliar cover of the shrub stratum in the Sagebrush Flat site was measured with four 50-m line transects randomly located in each plot in each year. Foliar cover included only the live intercept to the nearest millimeter and excluded the breaks within the canopy.

Belowground biomass was sampled in early August, 1978. Cores, 2.1 cm in diameter, were taken at 20 systematically chosen points within each plot and systematically combined into 5 composite samples per plot at each depth. The biomass was separated from the soil by flotation, collected on a soil sieve with 0.5-mm openings, and oven dried at 66° C to a constant weight.

Each year's data were analyzed separately using the *t*-test. The resulting probabilities were then combined over the 3 sample years within each site using the method described by Fisher (1970). Site differences could not be statistically separated from treatment

Table 3. Mean aboveground herbaceous production (g/m²) and summary by growth form (%) on the ungrazed (U) and grazed (G) Sagebrush Flat, East Tracy Mountain, West Tracy Mountain, and Sandy Upland plots. The means were based on ten 0.5 m² quadrats in each plot in each of the years 1976 through 1978.

	Sagebrush Flat		East Tracy Mountain		West Tracy Mountain		Sandy Upland	
Growth Form/Species[1]	U	G	U	G	U	G	U	G
Midgrasses and tallgrasses (%)	94.8	92.8	78.6	58.1	15.8	24.0	49.7	55.4
Agropyron smithii	27.0	96.2	94.0	77.8	7.7	5.2	2.0	6.5
Calamagrostis montanensis	101.7	41.6	1.3	0.7	0.1	6.7	<0.1	1.5
Calamovilfa longifolia	18.4	0.0			2.3	0.0	46.7	40.2
Poa pratensis			65.4	0.4	0.0	<0.1	0.4	0.3
Stipa comata	2.0	10.2	7.6	11.2	7.2	5.9	32.1	29.7
Stipa viridula	54.7	41.6	6.8	<0.1	0.4	0.0		
Miscellaneous	11.1	37.1	8.6	14.9	4.2	12.1	0.2	6.4
Shortgrasses and sedges (%)	0.2	5.0	14.6	24.9	73.2	41.6	45.3	38.8
Bouteloua gracilis	0.5	11.7	6.4	38.4	24.5	35.1	0.9	17.2
Carex filifolia			25.6	2.5	41.8	13.0	69.4	41.3
Carex heliophila			1.2	1.4	34.7	2.8	3.5	0.2
Miscellaneous	0.0	0.5	1.0	2.7	0.5	1.0	0.4	0.6
Annual grasses (%)			0.0	0.2	0.0	<0.1	0.1	0.2
Miscellaneous			0.0	0.5	0.0	0.1	0.2	0.3
Total graminoids	215.4	238.9	217.9*	150.5	123.4*	81.9	155.8	144.2
Total forbs	11.5	5.5	15.9	30.3	15.3*	42.8	7.9	8.7
Total yield	226.8	244.3	233.8*	180.8	138.7	124.7	163.7	152.8
Mulch	486.3*	176.9	380.3*	90.2	193.1*	45.4	307.8*	189.9

*Significantly different from the grazed value at the 0.05 level.
[1]Individual species were not tested because the data did not satisfy the assumptions of the test.

Table 4. Mean leaf heights (cm) of selected species on the ungrazed (U) and grazed (G) Sagebrush Flat, East Tracy Mountain, West Tracy Mountain, and Sandy Upland plots. The means were based on not less than 8 or more than 40 measurements in each plot in each of the years 1976 through 1978.

Species	Sagebrush Flat		East Tracy Mountain		West Tracy Mountain		Sandy Upland	
	U	G	U	G	U	G	U	G
Agropyron smithii	43.1	42.4	40.6*	28.2	32.6*	22.5		
Bouteloua gracilis			19.8*	12.3	17.3*	8.2		
Calamagrostis montanensis	35.5	33.5						
Carex filifolia			28.4*	13.2	21.1*	10.1	21.3*	16.1
Stipa comata							32.3*	25.1
Stipa viridula	63.7*	53.4						

*Significantly different from the grazed value at the 0.05 level.

Table 5. Mean belowground biomass (g/m²) on the ungrazed (U) and grazed (G) Sagebrush Flat, East Tracy Mountain, West Tracy Mountain, and Sandy Upland plots in 1978. The means were based on five composite samples in each plot unless otherwise indicated.

Depth (cm)	Sagebrush Flat		East Tracy Mountain		West Tracy Mountain		Sandy Upland	
	U	G[1]	U	G	U	G	U	G
0–15	1415*	1952	1227*	1725	1955	1784	2135	2421
15–30	489*	870	264	354	589	577	706	749
30–46	400*	598	240[1]	243	462	361	463	329
46–61	352	401	238	185	276	202	349	234
61–76	313	392	101[1]	182	175*	95	154	153
76–91	201	583	178	95	88	85	160	144
91–122	286	468	134	120	66	75	146	231
Total	3456*	5262	2384[1]	2903	3610	3180	4114	4261

*Significantly different from the grazed value at the 0.05 level.
[1]Mean of four composite samples.

effects as a result of the lack of true replication. This is typical of exclosure studies because the early exclosures were rarely replicated when they were established. Therefore, the interpretation of these results assumed that the site differences were small relative to treatment effects as a result of careful plot selection. No assumption could be made about the pre-exclosure vegetation in the sites as a result of the lack of supporting data.

Floristic nomenclature was based on McGregor et al. (1977).

Results

Sagebrush Flat Site

There were no major differences in the live foliar cover of the shrubs between the ungrazed and grazed Sagebrush Flat plots (Table 2) but there was a large number of dwarf sagebrush (*Artemisia cana* Pursh) seedlings on the grazed plot and almost no seedlings on the ungrazed plot (unpublished plant density data). Therefore, the reproduction of dwarf sagebrush was limited in the ungrazed plot. This was an indication that secondary succession may not have been complete in the Sagebrush Flat exclosure 40 years after it was fenced.

There were no significant differences in the yield of forbs or graminoids between plots but there was a major difference in species composition (Table 3). Plains reedgrass (*Calamagrostis montanensis* Scribn.) was the dominant grass on the ungrazed plot while western wheatgrass was dominant on the grazed plot. Both of these grasses are midgrasses so there was not a major difference in growth form dominance between plots. The shortgrass and sedge growth form category was not a major component of the vegetation in either plot in the Sagebrush Flat site.

Mean leaf heights of western wheatgrass and plains reedgrass, the 2 dominant grass species, were not significantly different between plots (Table 4). This may have been an indication that grazing was not physiologically severe for those species in the grazed plot.

Mean belowground biomass to a depth of 46 cm was significantly lower in the ungrazed than in the grazed plot (Table 5).

East Tracy Mountain Site

Graminoid production and total yield were significantly greater on the ungrazed than the grazed East Tracy Mountain plot (Table 3). This was a result of the greater production of the 2 midgrasses, Kentucky bluegrass (*Poa pratensis* L.) and western wheatgrass. The production of blue grama also was lower and the production of thread-leaf sedge was greater on the ungrazed plot. These species composition differences were reflected in a greater dominance of the midgrass and tallgrass growth form category on the ungrazed plot. In addition, the mean leaf heights of western wheatgrass, blue grama, and thread-leaf sedge were significantly greater on the ungrazed than on the grazed plot (Table 4).

The East Tracy Mountain site was one of only 2 sites with a cover of small clubmoss (*Selaginella densa* Rydb.). The cover of small clubmoss was 11.4 and 17.9% on the ungrazed and grazed plots, respectively. The total cover of other cryptogams was relatively unimportant in this study and ranged from a high of 6.6% on the grazed Sagebrush Flat plot (entirely bryophytes) to a low of 0.3% on the ungrazed East Tracy Mountain plot. The cover of cryptogams was probably too low to adversely affect infiltration.

There was less belowground biomass at the 0 to 15 cm depth in the ungrazed than in the grazed East Tracy Mountain plot (Table 5). This was similar to the Sagebrush Flat site, which also had a lower belowground biomass at some of the shallower depths.

West Tracy Mountain Site

Brand and Goetz (1978) estimated that secondary succession was complete within the West Tracy Mountain exclosure 22 years after it was fenced (1959). In the current study there was no significant difference in total yield between plots but graminoid production was significantly greater and forb production was significantly lower on the ungrazed plot (Table 3). The production of blue grama also was lower on the ungrazed plot while the production of both thread-leaf sedge and another sedge (*Carex heliophila* Mack.) was greater. These species composition differences were reflected in a greater dominance of the shortgrass and sedge growth form category on the ungrazed than on the grazed West Tracy Mountain plots. Mean leaf heights of western wheatgrass, blue grama, and thread-leaf sedge also were greater on the ungrazed plot (Table 4).

The cover of small clubmoss was 14.4 and 14.0% on the ungrazed and grazed West Tracy Mountain plots, respectively.

Sandy Upland Site

There were no significant differences in the production of forbs or graminoids between the ungrazed and grazed Sandy Upland plots (Table 3). Species composition differences included a lower production of blue grama and a greater production of thread-leaf sedge on the ungrazed plot. There was no major difference in growth form dominance between plots. The mean leaf heights of thread-leaf sedge and needle-and-thread also were greater on the ungrazed plot (Table 4).

Discussion and Conclusions

Mean belowground biomass was significantly lower at some of the shallower depths in the ungrazed than in the grazed Sagebrush Flat and East Tracy Mountain plots. Less belowground biomass generally has been found on ungrazed than on grazed ranges in the northern mixed grass prairie (Smoliak et al. 1972, Whitman 1974, and Sims et al. 1978) although Smoliak (1965) reported a greater

belowground biomass in 2 exclosures. The importance of these differences in belowground biomass was not apparent in this study.

Only the East Tracy Mountain exclosure had a greater dominance of the midgrass and tallgrass growth form category or a greater total yield on the ungrazed than on the grazed plot. In the West Tracy Mountain site, both plots were dominated by the shortgrass and sedge growth form category. In the grazed Sagebrush Flat plot, a decrease in the shortgrass, blue grama, from 26.4% of the total herbaceous yield in the early 1950's (Whitman 1953) to 5% of the total herbaceous yield in 1976 through 1978, reduced the magnitude of the difference in growth form dominance between the ungrazed and grazed plots. This reduction in the dominance of the shortgrass and sedge growth form category on the grazed plot was a result of a decrease in the grazing pressure from "heavy" in the early 1950's (Whitman 1953) to "light" in the current study. Therefore, a greater dominance of the midgrass and tallgrass growth form category was a positive indicator of progressive secondary succession.

Species composition was a more reliable key than growth form dominance to understanding the successional status of a plant community and the potential for improvement. The most consistent results were the lower production of blue grama and the greater production of sedges on the ungrazed plots. The lower dominance of blue grama on ungrazed rangeland has been well documented in the literature as previously reviewed; however, upland sedges are considered by range managers to be "increaser" species. The reaction of upland sedges to grazing should be reevaluated based on these data and similar results by Larson and Whitman (1942), Whitman (1953), and Rauzi (1963).

In this study, site characteristics apparently limited the development of the potential vegetation with the exclusion of grazing. Therefore, range managers should carefully evaluate the site potential before assuming that a reduction in grazing pressure will increase the dominance of the midgrass and tallgrass growth form category or total yield.

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