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RANGELAND REFERENCE AREAS IN WESTERN NORTH DAKOTA

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INTRODUCTION

Long-term rangeland reference areas are important in understanding the dynamics of rangeland ecosystems. Reference areas are intended to allow natural biological and physical processes to occur unhindered. The primary biological and physical forces affecting rangeland ecosystems are: geologic material, topography, soil parent material, climate (precipitation, temperature, wind, and sunlight), seasonal precipitation patterns, fire, plant competition, and herbivores (mammals, birds, insects, and micro-organisms). These biological and physical forces act together on rangeland ecosystems over the long-term and determine the structure and functions of a stable ecosystem. Long-term reference areas represent the stable rangeland ecosystem for a region with a specific set of biological and physical forces.

Rangeland reference areas can be used to evaluate the effects of mammalian herbivores on the ecosystem if a portion of the reference area is fenced with an exclosure. The exclosures can be designed to exclude all mammals, just large mammals, or just livestock. Reference areas that have a livestock exclosure and a similar area exposed to grazing are categorized as "two-way" reference areas. These "two-way" rangeland reference areas are designed to show the dynamics of a stable rangeland ecosystem with all the biological and physical forces except livestock grazing and also a stable rangeland ecosystem with all the biological and physical forces including livestock grazing.

RANGELAND REFERENCE AREAS

Western North Dakota has four "two-way" rangeland reference areas that are 58 years old. These reference areas

were established by Dr. Warren C. Whitman in the Pyramid Park Region on the eastern edge of the breaks of the Little Missouri River Badlands in 1936-1938. The sites were selected to represent four of the major grassland types of the region (Hanson and Whitman 1938) which would be labeled as range sites in today's terminology. All four sites are located in Billings County, south of the city of Medora.

The Sandy Upland Rangeland Reference Area was classified as the Sandgrass grassland type (Sandy range site) with prairie sandreed (*Calamovilfa longifolia*) as the dominant grass. The reference area is located in Section 15, T138N, R102W, has slopes of 2% east, northeast, and west, an exclosure of 6.3 acres, and was established in 1938.

The Badlands Upland Rangeland Reference Area was classified as the Grama-needlegrass-sedge grassland type (Shallow range site) with blue grama (*Bouteloua gracilis*), needleandthread (*Stipa comata*), and upland sedges (*Carex filifolia* and *C. heliophila*) as the dominant grasses. The reference area is located in Section 5, T138N, R101W, has a slope of 3% north, an exclosure of 6.2 acres in two parts, and was established in 1937.

The Badlands Slope Rangeland Reference Area was classified as the Western wheatgrass-grama-sedge grassland type (Silty range site) with blue grama (*Bouteloua gracilis*), western wheatgrass (*Agropyron smithii*), and upland sedge (*Carex filifolia*) as the dominant grasses. The reference area is located in Section 3, T138N, R101W, has a slope of 3% south, an exclosure of 14 acres, and was established in 1937.

The Sagebrush Flat Range Reference Area was classified as the Sagebrush type (Overflow range site) with silver sage (*Artemisia cana*) as the dominant shrub and western wheatgrass (*Agropyron smithii*), blue grama (*Bouteloua gracilis*), and green needlegrass (*Stipa viridula*) as the dominant grasses. The reference area is located in Section 11, T138N, R101W, has a slope of less than 1%, an exclosure of 4.2 acres, and was established in 1937.

Whitman (1953) reported that these four rangeland reference areas were established by an informal agreement in 1936 with the United States Department of Agriculture Resettlement Administration. When the USDA Soil Conservation Service took over the administration of the Land Utilization Project, a formal lease agreement was signed in 1939 by the North Dakota Agricultural Experiment Station and Soil Conservation Service. The lease agreement was for 50 years and automatically renewable every eight years. When the USDA Forest Service took

over the administration of the Little Missouri National Grassland, they honored the previous lease agreement and issued an Occupancy Permit in 1955 which was a Terminable Permit that was annually renewable as long as the requirements and conditions were met. In 1987, the USDA Forest Service issued a Special Use Permit to North Dakota State University Agricultural Experiment Station for scientific study of the four Grassland Ecosystem Reference Areas. This special use permit is valid until 31 December 2004 and is assumed to be renewable if the requirements and conditions of the permit are met.

These four rangeland reference areas are the oldest and best scientifically documented reference areas in North Dakota and possibly in the northern Great Plains. Dr. Whitman established these rangeland reference areas for the purpose of studying the long-term effects of grazing on four typical grassland ecosystems by monitoring changes in herbage production, plant species composition, and soil characteristics. Eight years of data were collected by Dr. Whitman during the years following establishment on locations within the exclosures and similar areas outside the exclosures that were exposed to grazing. Six years of additional data were collected by Dr. Whitman after 1952, but this data collection was not as intensive as the data collection before World War II.

Dr. Michael Brand continued this project with intensive research data collection at these sites from 1976 through 1978 to document the changes in vegetation and soils of the exclosures and adjacent grazed areas after 40 years. A summary of Dr. Brand's data reported in Brand 1980, and Brand and Goetz 1986 is included in this report.

METHODS AND TREATMENTS

Dr. Brand collected data on aboveground herbaceous production, belowground biomass, and plant species composition. The aboveground herbaceous production was sampled by clipping ten 0.5m^2 quadrants per plot per year to ground level in August, 1976-1978. Species categories were separated on one quadrant and estimated on nine quadrants. Belowground biomass was sampled with 20 soil cores, 2.1 cm in diameter, per plot to a depth of 4 feet in August 1978. Plant species composition was sampled using the 10-pin point frame with 3000 points per plot per year in June and July, 1976-1978 (Brand 1980, Brand and Goetz 1986).

The barbed wire fence on the exclosures has stayed intact fairly well over the years. There have been a few brief periods with broken wire in which cattle have entered the exclosures. These incidents have been so infrequent that it

is assumed that no changes to the range ecosystem have been made as a result of livestock within the exclosures. All exclosure fences had major replacement and repair work done in 1987 and 1988 and are in good condition. The Badlands Slope exclosure was observed to have a patch of leafy spurge (*Euphorbia esula*) in 1982, which was sprayed several times with Tordon 22K until 1987 when the stem density was determined to be 90 to 95% reduced. This patch has again increased in recent years. The portion of the reference areas within the exclosures represents stable rangeland ecosystems for western North Dakota with all the biological and physical forces except large grazing herbivores.

The portions of the reference areas that are outside the exclosures have been annually exposed to seasonlong grazing by livestock, primarily cow-calf pairs. The grazing treatments are part of larger grazing units which are allotments in the Little Missouri National Grassland, administered by USDA Forest Service and managed in cooperation with North Dakota Grazing Associations. Grazing permits for these allotments run from 1 May through 31 December but most years the grazing season has been shortened to seven months because of inclement weather conditions. The average utilization of the vegetation at these reference areas was determined by Dr. Whitman with Ocular Estimates to be 40 to 50% from 1952 through 1978. The portion of the reference areas outside the exclosures represents stable rangeland ecosystems for western North Dakota with all the biological and physical forces including large grazing herbivores and were managed with moderate seven to eight month seasonlong grazing treatments.

DISCUSSION

Dr. Brand's data show that the aboveground herbage biomass was not very different between the exclosure and grazed treatments at each reference area (Table 1) except that the exclosure at the silty range site had greater graminoid herbage production primarily because of an increase in Kentucky bluegrass (*Poa pratensis*), and the exclosure at the shallow range site had a greater graminoid herbage production primarily because of an increase in upland sedges. The mulch biomass on each exclosure was significantly greater than the grazed treatments (Table 1) and was an accumulation of four or five years of herbage production. This mulch ties up some of the nutrients required for new plant growth and reduces the amount of sunlight reaching the soil surface.

The belowground biomass, which can have portions with variable ages from current year to about five years old, was

generally greater on the grazed treatments of each reference area (Table 2) except on the shallow range site which had belowground biomass about the same on each plot. Whitman (1974) found that the belowground biomass was consistently greater on the grazed treatments than on the exclosures during his microclimate studies in western North Dakota.

Shortgrasses made up a greater percentage of the aboveground biomass on all the grazed plots compared to the exclosures (Table 3). Sedges made up a greater percentage of the aboveground biomass on the exclosures than on the grazed plots (Table 3) except on the overflow range site. Mid and tall grasses made up a greater percentage of the aboveground biomass on the grazed plots of the sandy range site and shallow range site than on the exclosures (Table 3). Mid and tall grasses made up a greater percentage of the aboveground biomass on the exclosure of the silty range site than on the grazed plot (Table 3). This increase in biomass in the silty range site exclosure was primarily from Kentucky bluegrass. Aboveground biomass of mid and tall grasses on the overflow range site was about the same on the grazed plot and exclosure (Table 3).

Basal cover of shortgrasses was greater on the grazed plots of all four reference areas compared to the exclosures (Table 4). Basal cover of upland sedges was greater on the exclosures compared to the grazed plots on all reference areas except the overflow range site which did not have upland sedge (Table 4). Basal cover of mid and tall grasses was about the same on the grazed plots and exclosures of the sandy range site and overflow range site (Table 4). Basal cover of mid and tall grasses was greater on the grazed plot on the shallow range site and greater on the exclosure on the silty range site (Table 4).

Basal cover of total graminoids and total herbaceous plants was greater on the grazed plots of all the reference areas compared to the exclosures (Table 5). Blue grama basal cover was greater on the grazed plots of all the reference areas and upland sedge basal cover was greater on the exclosures of all the reference areas (Table 5) except the overflow range site which did not have upland sedge. Kentucky bluegrass basal cover was greater on the exclosure of the silty range site and prairie sandreed basal cover was greater on the exclosure of the sandy range site (Table 5). Western wheatgrass showed a tendency to have greater basal cover on the grazed plots of all the reference areas (Table 5). Plains reedgrass showed a tendency to have greater basal cover on the grazed plots (Table 5) except on the overflow range site. Needleandthread showed a tendency to have greater basal cover on the grazed treatments of the shallow and overflow range sites (Table 5) and a tendency to have greater herbage

production on the grazed treatments of the silty and overflow range sites (Brand and Goetz 1986). The basal cover and herbage production for needleandthread was about the same on each plot of the sandy range site (Table 5, Brand and Goetz 1986).

SUMMARY

These four reference areas show the differences in rangeland ecosystems on sandy, shallow, silty, and overflow range sites after 40 years without livestock grazing and 40 years of 7 to 8 months of moderate seasonlong grazing. Generally, the aboveground herbage production was about the same for most categories on the grazed plots and exclosures except Kentucky bluegrass and upland sedge production which were great enough on the exclosures of the silty range site and shallow range site, respectively, to show an increase in total graminoid production on the respective exclosures. Mulch biomass was greater on all exclosures than on grazed plots. Belowground biomass was greater on grazed plots except the shallow range site which was about the same as the exclosure. Graminoid and total herbaceous plant basal cover was greater on all grazed plots of the reference areas. Blue grama basal cover was greater on the grazed plots. Upland sedge basal cover was greater on the exclosures. Kentucky bluegrass and prairie sandreed basal cover were greater on the exclosures of the silty and sandy range sites, respectively.

Moderate seven to eight month seasonlong grazing management is generally considered by most range managers not to be beneficial to the rangeland ecosystem, and several other grazing management practices have been found to be improvements over this type of seasonlong grazing practice (Sarvis 1941, Manske *et al* 1988, Manske 1994). Forty years of seven to eight months of moderate seasonlong grazing at these reference areas has not reduced the aboveground herbage production as would be expected. This grazing treatment has greater belowground biomass and graminoid basal cover compared to the ecosystems inside the exclosures. The exclosures at the reference areas have eliminated one important biological force from the rangeland ecosystem which is the large grazing herbivore. Most rangeland plants have evolved mechanisms that permit the plants to coexist and thrive with grazing herbivores (Manske 1994). Large grazing herbivores have been an intricate part of the rangeland ecosystem for 20 million years, and need to continue to be a part of the rangeland ecosystem.

CONCLUSIONS

The seven to eight month seasonlong grazing management treatment is generally considered to be inferior to many other grazing management practices, but Dr. Brand's data points out that even with this type of grazing treatment, the rangeland ecosystems with large grazing herbivores showed ecological benefits over ecosystems that have eliminated the large grazing herbivores. When improved grazing management practices are used to manage the grazing herbivores, the ecological benefits to the rangeland ecosystems are even greater than with the eight month seasonlong grazing treatment. Management practices and recommendations that eliminate the large grazing herbivores will develop ecosystems that are not as ecologically healthy over the long-term as rangeland ecosystems that included large grazing herbivores. Rangeland management practices must be ecologically beneficial to the ecosystem or the practice will not be sustainable for the long-term.

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Table 1. Mean aboveground herbage biomass in lbs/acre, 1976-1978.

	Sandy Upland Sandy Range Site		Badlands Upland Shallow Range Site		Badlands Slope Silty Range Site		Sagebrush Flat Overflow Range Site	
	Grazed 8.0M	Not Grazed 40Y	Grazed 8.0M	Not Grazed 40Y	Grazed 8.0M	Not Grazed 40Y	Grazed 8.0M	Not Grazed 40Y
GRASSES								
Mid and Tall	775	726	267	195	937	1639	2022	1917
Short	161	13	323	223	371	66	109	5
Sedges	370	650	141	682	35	239	0	0
TOTALS								
Graminoids	1286	1390	731	1101*	1342	1944*	2131	1921
Forbs	78	70	382*	136	270	142	49	103
Herbage	1363	1460	1112	1237	1613	2085*	2179	2023
Mulch	1694	2746*	405	1722*	805	3392*	1578	4338*

* Significantly different from comparable treatment (P<0.05)Brand 1980, Brand and Goetz 1986

Table 2. Mean belowground biomass in lbs/acre, 1978.

	Sandy Upland Sandy Range Site		Badlands Upland Shallow Range Site		Badlands Slope Silty Range Site		Sagebrush Flat Overflow Range_Site	
	Grazed 8.0M	Not Grazed 40Y	Grazed 8.0M	Not Grazed 40Y	Grazed 8.0M	Not Grazed 40Y	Grazed 8.0M	Not Grazed 40Y
0" - 12"	28,276	25,342	21,060	22,692	18,545*	13,300	25,172*	16,984

* Significantly different from comparable treatment (P<0.05)Brand 1980, Brand and Goetz 1986

Table 3. Percent composition of aboveground biomass by growth form, 1976-1978.

	Sandy Upland Sandy Range Site		Badlands Upland Shallow Range Site		Badlands Slope Silty Range Site		Sagebrush Flat Overflow Range Site	
	Grazed 8.0M	Not Grazed 40Y	Grazed 8.0M	Not Grazed 40Y	Grazed 8.0M	Not Grazed 40Y	Grazed 8.0M	Not Grazed 40Y
GRASSES								
Mid and Tall	55.4	49.7	24.0	15.8	58.1	78.6	92.8	94.8
Short	11.8	0.9	29.0	18.0	23.0	3.2	5.0	0.2
Sedges	27.2	44.5	12.7	55.2	2.2	11.5	0.0	0.0

Forbs	5.6	4.8	34.3	11.0	16.8	6.8	2.3	5.1
Brand 1980, Brand and Goetz 1986								

Table 4. Mean percent basal cover by growth form, 1976-1978.

	Sandy Upland Sandy Range Site		Badlands Upland Shallow Range Site		Badlands Slope Silty Range Site		Sagebrush Flat Overflow Range Site	
	Grazed 8.0M	Not Grazed 40Y	Grazed 8.0M	Not Grazed 40Y	Grazed 8.0M	Not Grazed 40Y	Grazed 8.0M	Not Grazed 40Y
GRASSES								
Mid and Tall	1.2	1.2	1.0	0.2	1.3	1.5	2.0	1.9
Short	2.3	0.0	3.6	0.8	2.3	0.4	0.5	0.0
Sedges	3.3	4.6	0.8	2.7	0.3	0.5	0.0	0.0
Forbs	0.1	0.2	0.4	0.1	0.3	0.1	0.1	0.1
Brand 1980								

Table 5. Mean percent basal cover by species, 1976-1978.

	Sandy Upland Sandy Range Site	Badlands Upland Shallow Range	Badlands Slope Silty Range Site	Sagebrush Flat Overflow Range

			Site				Site	
	Grazed 8.0M	Not Grazed 40Y	Grazed 8.0M	Not Grazed 40Y	Grazed 8.0M	Not Grazed 40Y	Grazed 8.0M	Not Grazed 40Y
Grasses								
Western Wheatgrass	0.2	0.1	0.1	<0.1	0.7	0.5	0.9	0.3
Blue Grama	2.3	0.1	3.3	0.8	2.2	0.4	0.5	0.0
Plains Reedgrass	0.1	0.0	0.3	<0.1	0.1	0.0	0.4	1.0
Prairie Sandreed	0.2	0.5	-	-	-	-	-	-
Kentucky Bluegrass	<0.1	<0.1	-	-	<0.1	0.7	<0.1	0.0
Needleand Thread	0.6	0.6	0.2	0.1	0.1	0.1	0.1	0.0
Green Needle	-	-	<0.1	0.0	0.0	0.1	0.3	0.4
Other Grasses	0.2	0.1	0.7	0.2	0.5	0.2	0.2	0.2
Upland Sedge	3.3	4.6	0.8	2.7	0.3	0.5	-	-
TOTALS								
Graminoids	6.8	5.8	5.4	3.7	3.9	2.4	2.4	1.9
Forbs	0.1	0.2	0.4	0.1	0.3	0.1	0.1	0.1

Herbaceous	6.9	5.9	5.8	3.8	4.2	2.5	2.5	2.0

Brand 1980

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