SUMMARY
RANGE MANAGEMENT
REPORT

Effects on Mixed Grass Prairie
from 75 Years of Nongrazing

North Dakota State University
Dickinson Research Extension Center

Dickinson, North Dakota
September 2017

DREC 1 7-3068

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What are the consequences to grassland ecosystems if cattle grazing were successfully removed from public rangeland?

Traditionally, rangeland ecosystems have been managed from the perspective of the "use" of the grassland. Livestock grazing along with watershed, wildlife, and recreation are considered to be the major uses. Management for a use does not consider rangelands as complex ecosystems and neglects to address the biological requirements of the grass plants and soil microorganisms. The uses of rangeland renewable resources should not be the objective of management. The management should be the means to accomplish the uses.

Rangelands are complex ecosystems consisting of numerous biotic (living) and abiotic (nonliving) components. The biotic components are the grass plants, soil organisms, and grazing graminivores that have biological and physiological requirements. The abiotic components include radiant energy and sunlight, the essential major elements of carbon, hydrogen, nitrogen, and oxygen, with biogeochemical cycles that transform the elements between organic forms and inorganic forms, and the minor essential macro- and microminerals required by living organisms.

Grass plants, soil organisms, and graminivores have developed complex symbiotic relationships. The grazing graminivores depend on grass plants for nutritious forage. Grass plants depend on rhizosphere organisms for mineralization of essential elements, primarily nitrogen, from the soil organic matter. The main sources of soil organic matter are grazing animal waste and dead plant material. Rhizosphere organisms depend on grass plants for energy in the form of short carbon chains. Grass plants exudate short carbon chain energy through the roots into the rhizosphere following partial defoliation of the aboveground leaf material by grazing graminivores. Grass plants produce double the leaf biomass than is required by the plant for normal growth and maintenance in order to provide nutritious leaf forage to the grazing graminivores. Management of rangeland ecosystems must meet the biological and physiological requirements of the biotic components and stimulate the biogeochemical processes that cycle the abiotic components.

Background of Study Area

Ownership of much of the public domain land in the North American Northern Plains was transferred from the U.S. Government through the Homestead Act of 1862 and the Federal Railroad Land Grant Act of 1864. These laws were adjusted several times, but the lawmakers failed to address the requirements of the natural resources in semi-arid regions, causing numerous long-lasting management problems. In addition, the economic depression of 1929, the severe drought conditions of 1934 and 1936, and low agricultural commodity prices during the late 1920's and early 1930's created extreme hardships for these homesteaders. Starting in 1935, the U.S. Government was permitted to repurchase 1,104,789 acres of submarginal homestead land in North Dakota (Hibbard 1965, Carstensen 1968, Manske 1994, 2008). A 1937 law provided for the implementation of follow-up conservation and utilization programs and the development of improved practices of management of the repurchased grasslands. The USDA (U.S. Department of Agriculture) Agriculture Resettlement Administration authorized the establishment of experimental rangeland management laboratory areas by North Dakota Agricultural Experiment Station on the Little Missouri River Badlands (Whitman 1953). In 1936, Dr. Warren C. Whitman established four two-way rangeland reference areas. These included a livestock exclosure and a similar area exposed to livestock grazing on sandy, shallow, silty, and overflow ecological sites (Hanson and Whitman 1938). This ongoing long-term project monitors changes in herbage biomass production, plant species composition and soil characteristics inside the nongrazed exclosure areas and in the grazed areas. During the growing season of 2011, the effects of long-term nongrazing after 75 years were compared to the effects of moderately stocked, seasonlong grazing treatments i.e. 7-to-8 months from 1 May through to 31 December, with the grazing season shortened because of inclement weather conditions during most years.

Procedures

Changes in vegetation composition over time were described using the 'range condition index'. Range condition index is the percent similarity of the percent composition of the dry weights of major plant species and categories of minor species on a current ecological site compared to the hypothetically determined standards of the percent composition of the dry weights of the major and minor species for that same plant community at its best biological potential. Aboveground herbage biomass was collected by the standard clipping method (Cook and Stubbendieck 1986) sorted in the field into domesticated grasses, cool season grasses, warm season grasses, sedges, forbs, standing dead, litter, and oven dried. Plant species' basal cover was determined by the ten-pin point frame method (Cook and Stubbendieck 1986) and sorted into domesticated grasses, cool season grasses, warm season grasses, sedges, forbs, and litter. The density of forbs was determined by counting individual stems of each forb species rooted inside twenty-five 0.1 m^2 quadrats. The density of shrubs was measured by counting the individual plants of each shrub species rooted inside twenty-five 1.0 m^2 quadrats. A list of the shrubs, cacti, and trees present was also compiled. These procedures adequately represented the shrub component of the grazed plant communities. However, because of the great extent and quantity of woody species growing inside the exclosures, these methods greatly under-sampled the woody plants within each exclosure. The surface areas of the woody shrub and tree map units and the nonwoody grass map units were measured in area as digital data in ArcGIS by visual assessment of USDA National Agriculture Imagery Program 2009 orthoimages as displayed by Google Earth. This was conducted by the Dickinson State University, Department of Agriculture and Technical Studies. Belowground plant root biomass was collected on the nongrazed and grazed treatments of each ecological site by two replicated soil cores 3 in. in diameter and 4 in. in depth. Rhizosphere biomass was collected by three replicated soil cores, using a humane soil beastie catcher (Manske and Urban 2012a). The fresh rhizosphere material, which included the rhizosphere organisms, the active plant roots, and the adhered soil particles, was separated from matrix soil by meticulous excavation with fine hand tools. Soil mineral nitrogen, nitrate and ammonium, were also measured in both treatments.

Results

The traditional seasonlong management practice, i.e. grazed at moderate stocking rates from early May until inclement weather or to late December, was found to be severely antagonistic to sandy ecological sites of mixed grass prairie grasslands. After 75 years, the plant communities had been degraded to a range condition index of 59.8 (low good). The aboveground vegetation consisted of 15.5% standing dead and 84.5% live biomass. The peak growing season live herbage biomass was 1925.29 lbs/ac, comprising 0.0% domesticated grasses, 41.7% native cool season grasses, 24.4% native warm season grasses, 26.2% upland sedges and 7.7% forbs (Table 1). The basal cover consisted of 69.8% litter and 30.2% live herbage. The live basal cover was 0.5% domesticated grasses, 10.8% native cool season grasses, 47.3% native warm season grasses, 38.5% upland sedges, and 2.8% forbs (Table 2). The total forb density was 5.9 stems/0.1 m^2, comprising 89.8% late succession, 3.4% mid succession, and 6.1% early succession forbs. The 'woody species present' list identified three shrub species on the grazed area. The belowground root biomass was 32.5 kg/m^3 and the rhizosphere biomass was 171.0 kg/m^3 (just 42.1% of its potential weight, 406.4 kg/m^3) (Manske 2015) and the available mineral nitrogen was deficient at 31.5 lbs/ac (Manske 2013) (Tables 3 and 4).

The long-term nondefoliation management practice of complete rest from grazing for several decades was also extremely antagonistic to mixed grass prairie grasslands. After 75 years of nondefoliation, the plant communities had been degraded to a range condition index of 36.8 (low fair). The aboveground vegetation comprised 11.0% standing dead and 89.0% live biomass. The peak growing season live herbage biomass was 1861.07 lbs/ac, made up of 62.3% domesticated grasses, 12.9% native cool season grasses, 5.5% native warm season grasses, 10.9% upland sedges, and 8.4% forbs (Table 1). The basal cover consisted of 83.0% litter and 17.0% live herbage. The live basal cover was 33.6% domesticated grasses, 22.7% cool and warm season grasses, 41.6% upland sedges, and 2.1% forbs (Table 2). The total forb density was 3.5 stems/0.1 m^2, with 36.8% late succession, 62.1% mid succession, and 1.1% early succession forbs. The problem of shading greatly reduced the early succession forbs. The 'woody species present' list identified five shrubs, two cactus, and one tree on the nongrazed area. The area infested with woody shrubs and trees was 53.3% of the nongrazed exclosure (Table 5). The belowground root biomass was 14.4 kg/m^3, the rhizosphere biomass was 103.7 kg/m^3 (only 25.5% of its potential weight) (Manske 2015) and the available mineral nitrogen was deficient at 23.5 lbs/ac (Manske 2013) (Tables 3 and 4).

It can be concluded that 75 years of nongrazing caused greater degradation to the site than traditional seasonlong management practice. The range condition index of the plant community on the nongrazed area degraded 38.4% more than that on the grazed area. On the nongazed area, the herbage biomass of native cool season grasses, warm season grasses, and upland sedges decreased by 70.2%, 78.2%, and 59.8%, respectively, and basal cover decreased 49.2%, 84.6%, and 39.2%, respectively (Tables 1 and 2). The basal cover of native grasses with long shoots and stem leaves was 1.0% on the grazed area and 2.9% on the nongrazed area (a 200.0% increase). The basal cover of native grasses with short shoots and basal leaves was 28.2% on the grazed area and 8.1% on the nongrazed area, a 71.4% decrease in the nongrazed area. Grasses with short shoots and basal leaves protect the soil and restrict invasion of unwanted plants. Thus, the higher losses of grasses with short shoots and basal leaves provided open spaces for a greater increase of domesticated grasses in the nongrazed area. The herbage biomass of domesticated grasses increased by 100.0%, and basal cover increased by 3700.0% in the nongrazed area (Tables 1 and 2). The herbage biomass of forbs increased by 6.3%, basal cover decreased by 58.8%, forb stem density decreased by 40.8%, and the number of forb species present decreased by 53.9% in the nongrazed area (Tables 1 and 2). The number of woody shrub and tree species present increased 166.7%. Analysis of black and white aerial photographs estimated shrub cover at 5% during the mid-1930s (Smith 1988). After 75 years, the area covered by the woody plant infestation in the nongrazed exclosure had increased by 967% (Table 5). Standing dead herbage biomass decreased by 34.8% and litter increased by 654.4% in the nongrazed area (Table 1). The belowground root biomass decreased by 55.8% in the nongrazed area and coincided with the 43.8% decrease in total live plant basal cover. The rhizosphere biomass decreased greatly in both the grazed and nongrazed areas but decreased 39.3% more in the nongrazed area (Table 3). The decrease in rhizosphere microbe biomass preceded the decrease in native grass plant composition, which was followed by the increase in domesticated grass composition. Available mineral nitrogen decreased by 25.4% more on the nongrazed area (Manske 2013) (Table 4).

Degradation of grasslands occurs from three primary causes: when management of graminivore grazing fails to adequately activate the ecosystem's biogeochemical processes and the internal grass plant mechanisms; when partial defoliation by grazing graminivores is removed from the grassland; and when greater than 50% of the grass herbage biomass is consumed by heavy or late-season grazing, or fire (Manske 2012b).

In conclusion, nondefoliation management by completely resting mixed grass prairie grasslands is not a revitalizing strategy. Removing graminivores from grasslands to provide rest from grazing results in decreased rhizosphere organism biomass, which in turn leads to deficiencies in mineral nitrogen and other essential elements, degradation of grassland ecosystems, and the encroachment of woody shrubs, trees and domesticated grasses. From these results it is clear that grazing graminivores form an essential annual component of grassland management.

Acknowledgment

I am grateful to Sheri Schneider for assistance in the production of this manuscript and development of the tables.

Table 1. Herbage biomass (lbs/ac) on nongrazed compared to grazed treatment on the sandy ecological site after 75 years, 1936-2011.

Plant Biotype	Grazed	Nongrazed	% Difference
Domesticated	0.00	1158.89	100.00
Cool Season	803.51	239.77	-70.16
Warm Season	468.84	102.04	-78.24
Upland Sedge	505.23	203.38	-59.75
Forbs	147.72	156.99	6.28
Total Live	1925.29	1861.07	-3.34
Standing Dead	353.23	230.49	-34.75
Litter	104.90	791.38	654.41

Table 2. Basal cover (%) on nongrazed compared to grazed treatment on the sandy ecological site after 75 years, 1936-2011.

Plant Biotype	Grazed	Nongrazed	% Difference
Domesticated	0.15	5.70	3700.00
Cool Season	3.25	1.65	-49.23
Warm Season	14.25	2.20	-84.56
Upland Sedge	11.60	7.05	-39.22
Forbs	0.85	0.35	-58.82
Total Live	30.15	16.95	-43.78
Litter	69.85	83.05	18.90

Table 3. Root and rhizosphere biomass (kg/m^3) on nongrazed compared to grazed treatment on the sandy ecological site after 75 years, 1936-2011.

Biomass	Grazed	Nongrazed	% Difference
Root	32.48	14.35	-55.82
Rhizosphere	171.01	103.74	-39.34

Table 4. Soil available mineral nitrogen, nitrate, and ammonium (lbs/ac) on nongrazed compared to grazed treatment on the sandy ecological site after 75 years, 1936-2011.

Mineral Nitrogen	Grazed	Nongrazed	% Difference
Nitrate NO_3	6.33	7.33	15.80
Ammonium NH_4	25.19	16.19	-35.73
$NO_3 + NH_4$	31.52	23.52	-25.38

Table 5. Woody infested shrub and tree plant communities and nonwoody grass plant communities on the sandy ecological site after 75 years, 1936-2011.

Biomass	Total Exclosure Area	Nonwoody Grass	Woody Infected Shrub and Tree
Acres	6.27	2.93	3.34
Percentage		46.67	53.33

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