Preface

Knowledge of the growth and development of individual plant species is essential for the establishment of scientific standards for proper management of native rangelands (Dr Warren C. Whitman circa 1950). Range scientists conducting ecological research at the NDSU Dickinson Research Extension Center have strived to collect quantifiable information on individual plant species during 1946 to 2012. This information has been compiled into three reports organized by plant categories: 1) Grasses and Upland Sedges, 2) Forbs, and 3) Shrubs and Subshrubs.

Autecology of Grasses on the Northern Mixed Grass Prairie

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Prairie ecosystems are complex; exceedingly more complex than the most complicated machines ever built by humans. The long-standing standard process to understand complex systems is to initially investigate the separate component parts. The gained knowledge of each part combined with the synergistic effects resulting when the parts work together provide the information needed to develop an understanding of the whole ecosystem. This classical concept of biological systems was developed by the Greek philosopher/scientist Aristotle (384-322 BC) who taught that "the whole is greater than the sum of its parts".

The goals of this study were developed by Dr. Warren C. Whitman (c. 1950) and Dr. Harold Goetz (1963) which were to gain quantitative knowledge of each component species and to provide a pathway essential for the understanding of the whole prairie ecosystem that would result in the development and establishment of scientific standards for proper management of native rangelands of the Northern Plains.

This report is an autecological study of individual grass and upland sedge species living on northern mixed grass prairie ecosystems. The change in growth and development during the annual growing season life history and the changes in abundance through time are quantitatively described from data collected during 67 growing seasons for six ecological studies conducted at the Dickinson Research Extension Center over a time period from 1946 to 2012.

Grasses are herbaceous monocotyledons that have a long-lived, nonwoody, subterranian crown with vegetative buds that produce one to several tillers with 6 to 8 narrow, linear, two-rancked leaves with parallel veins. Each tiller lives for two growing seasons. Each leaf is attached to the hollow stem at a node and has an axillary bud that has the potential to develop into a vegetative secondary tiller.

Upland Sedges are perennial herbaceous monocotyledons that have a short nonwoody rootstock that produce three-angled solid or pithy stems that form three-ranked whorled narrow leaves with parallel veins. Upland sedges grow in well drained soils and do not grow in saturated or subirrigated soils.

Companion autecological studies provide quantitative descriptions of forb species and of shrub and subshrub species on the Northern Mixed Grass Prairie.

Autecology of Blue Grama on the Northern Mixed Grass Prairie

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The autecology of Blue grama, *Bouteloua gracilis*, is one of the prairie plant species included in a long ecological study conducted at the NDSU Dickinson Research Extension Center during 67 growing seasons from 1946 to 2012 that quantitatively describes the changes in growth and development during the annual growing season life history and the changes in abundance through time as affected by management treatments for the intended purpose of the development and establishment of scientific standards for proper management of native rangelands of the Northern Plains. The introduction to this study can be found in report DREC 16-1093 (Manske 2016).

Blue grama, *Bouteloua gracilis* (Kunth) Lag. ex Griffiths, is a member of the grass family, Poaceae, tribe, Cynodonteae, and is a native, long lived perennial, monocot, warm-season, short grass, that is drought tolerant, moderately tolerant of alkaline soils, not tolerant of shading and flooding, and intolerant of acidic and saline soils. The first North Dakota record is Bolley 1891. Early aerial growth consists of basal leaves arising from basal tillers lateral to the crown. Basal leaf blades are 3-10 cm (1.2-3.9 in) long, 1-2 mm wide, tapering to a point. The leaves curl when dry at maturity. The split sheath has translucent margins. The collar is continuous and medium broad with long hairs, at the inside sheath edge. The ligule is a dense fringe of hairs 0.5 mm long. The auricles are absent. The short inconspicuous rhizomes facilitate mat formation. The extensive root system is extremely well developed. The main roots are fine, 0.5-1.0 mm thick, taper to 0.2 mm thick, however having high tensile strength. The great density is attributed to the abundance of branching. The lateral spread is 20-25 cm (8-10 in) outward from the basal of the crown. Most roots grow vertically downward to 91 cm (3 ft) deep with a few main roots extending to 1.8 m (6 ft) deep. Fine lateral roots 1.3-2.5 cm (0.5-1.0 in) long, branched to the 3rd order have a frequency of 1.8 per cm (4.3 per in). The greatest root density occurs in the top 46 cm (4.3 in) of soil permitting rapid response to low precipitation events. Regeneration is primarily asexual propagation by lateral basal tillers. Seedling success is low as a result of competition from established plants. Flower stalks are slender, solid pith filled, 16-50 cm (6-20 in) tall. Inflorescence are 2 (rarely 3) eyebrow shaped spikes 2-5 cm (0.8-2.0 in) long with numerous perfect florets clustered all on one side. Flower period is from early July to August. Aerial parts are highly palatable to livestock. Stevens (1963) claimed that blue grama is our most valuable native pasture grass for drier soil. Fire top kills aerial parts and destoys great proportions of the crown material when soil is dry. Fire halts the processes of the four major defoliation resistance mechanisms and causes great reductions in biomass production and tiller density. This summary information on growth development and regeneration of Blue grama was based on works of Weaver 1954, Stevens 1963, Zaczkowski 1972, Dodds 1979, Great Plains Flora Association 1986, Anderson 2003, Larson and Johnson 2007, Wynia 2007, and Stubbendieck et al. 2011.

Procedures

The 1946-1947 Study

Grass and upland sedge species samples to determine crude protein and phosphorus content were collected weekly during the growing seasons of 1946 and 1947 from two seeded domesticated grasslands and a native rangeland pasture at the Dickinson Research Extension Center located at Dickinson in western North Dakota. Current year's growth of lead tillers of each species was included in the sample; previous year's growth was separated and discarded. Ungrazed samples were collected for each species except for Kentucky bluegrass, which only grew along a watercourse where almost all of the plants had been grazed and remained in an immature vegetative stage, however, a small number of plants escaped grazing and developed normally providing the phenological development data. Crude protein (N X 6.25) content was determined by the procedure outlined in the Official and Tentative Methods of Analysis (A.O.A.C. 1945). Phosphorus content was determined by the method outlined by Bolin and Stamberg (1944). Data were reported as percent of oven-dried weight.

Plant condition by stage of plant development and growth habit was collected for each

species on sample dates. These data are reported as phenological growth stage in the current report. The grass nutritional quality and phenological growth data were published in Whitman et al. 1951.

The 1955-1962 Study

Grass and upland sedge tiller growth in height of leaves and stalks were collected from ungrazed plants during the growing seasons of 1955-1962. Basal leaves were measured from ground level to the tip of the extended leaves. Culm leaves were measured from ground level to the apex of the uppermost leaf. Stalk measurements were from ground levels to the tip of the stalk or to the tip of the inflorescence after it had developed. An average of 10 plants of each species were measured at approximate 7 to 10 day intervals from early May until early September. In addition, phenological growth stages were recorded to include stalk initiation, head emergence, flowering (anthesis), seed development, seed maturity, earliest seed shedding, and an estimation of percent of leaf dry in relation to total leaf area. The grass growth in height and phenological data were reported in Goetz 1963.

The 1964-1969 Study

Phenological data of grass and upland sedge at anthesis stage was determined by recording observation dates. Leaf senescence by date was determined as an estimation of percentage of dry leaf in relation to total leaf area. Grass and upland sedge tiller growth in height of leaves were collected from ungrazed plants during the growing seasons of 1964-1966. Basal leaves were measured from ground level to the tip of the extended leaf. Culm leaves were measured from ground level to the apex of the uppermost leaf. An average of 20 plants at approximately 7 to 10 day intervals during the growing season from mid April to late August from control treatment on sandy, silty, overflow, and thin claypan ecological sites. Phenological data of anthesis stage, leaf senescence, and growth in leaf height were reported in Goetz 1970. Crude protein content of grasses and upland sedges was determined from a composite of 10 samples of each species collected systematically at biweekly intervals from mid May to early September, 1964-1969 on sandy, silty, overflow, and thin claypan ecological sites. Plant material was oven dried at 105°F. Analysis of the samples were made by the Cereal Technology Department, North Dakota State University, using standard crude protein determinations and reported in Goetz 1975.

The 1969-1971 Study

The range of flowering time of grasses and upland sedges was determined by recording daily observations of plants at anthesis on several prairie habitat type collection locations distributed throughout 4,569 square miles of southwestern North Dakota. The daily observed flowering plant data collected during the growing seasons of 1969 to 1971 from April to August were reported as flower sample periods with 7 to 8 day duration in Zaczkowski 1972.

The 1983-2012 Study

A long-term change in grass and upland sedges species abundance study was conducted during active plant growth of July and August each growing season of 1983 to 2012 (30 years) on native rangeland pastures at the Dickinson Research Extension Center ranch located near Manning, North Dakota. Effects from three management treatments were evaluated: 1) long-term nongrazing, 2) traditional seasonlong grazing, and 3) twice-over rotation grazing. Each treatment had two replications, each with data collection sites on sandy, shallow, and silty ecological sites. Each ecological site of the two grazed treatments had matching paired plots, one grazed and the other with an ungrazed exclosure. The sandy, shallow, and silty ecological sites were each replicated two times on the nongrazed treatment, three times on the seasonlong treatment, and six times on the twice-over treatment.

During the initial phase of this study, 1983 to 1986, the long-term nongrazed and seasonlong treatments were at different locations and moved to the permanent study locations in 1987. The data collected on those two treatments during 1983 to 1986 were not included in this report.

Abundance of each grass and upland sedge species was determined with plant species basal cover by the ten-pin point frame method (Cook and Stubbendieck 1986). The point frame method was used to collect data at 2000 points along permanent transect lines at each sample site both inside (ungrazed) and outside (grazed) each exclosure. Basal cover, relative basal cover, percent frequency, relative percent frequency, and importance value were determined from the ten-pin point frame data. Point frame data collection period was 1983 to 2012 on the twice-over treatment and was 1987 to 2012 on the long-term nongrazed and on the seasonlong treatments. However, point frame data was not collected during 1992 on the sandy ecological sites of all three treatments.

During some growing seasons, the point frame method did not document the presence of a particular plant species which will be reflected in the data summary tables as an 0.00 or as a blank spot.

The 1983-2012 study attempted to quantify the increasing or decreasing changes in individual plant species abundance during 30 growing seasons by comparing differences in the importance values of individual species during multiple year periods. Importance value is an old technique that combines relative basal cover with relative frequency producing a scale of 0 to 200 that ranks individual species abundance within a plant community relative to the individual abundance of the other species in the community during the growing season. Basal cover importance value ranks the grasses, upland sedges, forbs, and shrubs in a community. The quantity of change in the importance value of an individual species across time indicates the magnitude of the increases or decreases in abundance of that species relative to the changes in abundance of the other species.

Results

Blue grama resumes basal leaf growth from basal tillers on short rhizomes. Growth of new Blue grama leaves is visible by 15 April (tables 2). Leaf growth is rapid during May and slows to about half that rate during June. Blue grama produces 3.5 new leaves around mid June, with crude protein content at 14.8%, and a high phosphorus content at 0.329% (table 1). Lead tillers at the 3.5 new leaf stage are physiologically capable of positive response to partial defoliation of 25% to 33% of leaf weight by graminivores. During mid June, leaf height is 69% of maximum at 7.4 cm (3 in) tall (table 2). Early stalk growth is visible by 22 June, develops to the boot stage between 26 June and 2 July, reaches head emergence during 4 to 8 July, produces the first flowers between 16 and 18 July, with a 5 week flower period between early July and the first week of August (tables 3, 4, and 5). The flower stalks are at 68% height in late June, at 80% height in mid July, and at 100.0% maximum height in early August (table 3). The lead tiller contains 13% crude protein in early July and drops below the requirements of lactating cows during the fourth week of July (tables 1 and 6). Leaf growth is at 86% in early July and at 100% growth in height in late July (table 2). Seeds are developing by 30 July, reach the mature stage during 12 to 13 August, and start being shed 21 to 26 August (tables 1 and 5). Leaf dryness starts early August continues through August into late September (tables 1 and 5). Phosphorus content drops below requirements of lactating cows during early August (tables 1 and 6). Leaf dryness during the 1964-1969 study started at the same time on the sandy and silty sites (table 7) as during the 1955-1962 study (table 5) but occurred later after 25% dry (table 7). Leaf dryness started early on the thin claypan site and started later on the overflow site (table 7). Leaf height on the thin claypan was shorter during a growing season and crude protein content was greater after mid July (tables 8 and 9) than on the silty site (tables 1 and 2). Leaf height on the sandy and silty sites during the 1964-1969 study were taller during June and July and crude protein content dropped below a lactating cows requirements earlier (tables 8 and 9) than those on the 1955-1962 study (tables 1 and 2). Blue grama herbage biomass was clipped every two weeks for 5 growing seasons on an ungrazed area that was nearly a pure stand of blue grama. Peak herbage biomass was reached during mid August and blue grama composed between 61% and 71% of the sites total herbage production (table 10).

Grass species composition in rangeland ecosystems is variable during a growing season and dynamic among growing seasons. Patterns in the changes of individual grass species abundance was followed for 30 growing seasons during the 1983-2012 study on the sandy, shallow, and silty ecological sites of the long-term nongrazed, traditional seasonlong, and twice-over rotation management treatments (tables 11 and 12).

On the sandy site of the nongrazed treatment, Blue grama was present during 96.0% of the years that basal cover data were collected with a mean 2.33% basal cover during the total 30 year period. During the early period (1983-1992), Blue grama was present during 100.0% of the years with a mean 0.95% basal cover. During the later period (1998-2012), Blue grama was present during 100.0% of the years with a mean 2.95% basal cover. The percent present remained at 100.0% and basal cover increased on the sandy site of the nongrazed treatment over time (tables 11 and 12).

On the sandy site of the ungrazed seasonlong treatment, Blue grama was present during 40.0% of the years that basal cover data were collected with a mean 1.37% basal cover during the total 30 year period. During the early period (1983-1992), Blue grama was not present. During the later period (1998-2012), Blue grama was present during 66.7% of the years with a mean 2.29% basal cover. Blue grama was not present during the early period and all

basal cover observations were made during the later period indicating a low abundance (tables 11 and 12).

On the sandy site of the grazed seasonlong treatment, Blue grama was present during 100.0% of the years that basal cover data were collected with a mean 5.93% basal cover during the total 30 year period. During the early period (1983-1992), Blue grama was present during 100.0% of the years with a mean 2.44% basal cover. During the later period (1998-2012), Blue grama was present during 100.0% of the years with a mean 6.90% basal cover. The percent present remained at 100.0% and the basal cover increased greatly on the sandy site of the grazed seasonlong treatment over time (tables 11 and 12). The percent present and basal cover were greater on the sandy site of the grazed seasonlong treatment than those on the sandy site of the ungrazed seasonlong treatment.

On the sandy site of the ungrazed twice-over treatment, Blue grama was present during 96.4% of the years that basal cover data were collected with a mean 1.12% basal cover during the total 30 year period. During the early period (1983-1992), Blue grama was present during 100.0% of the years with a mean 4.61% basal cover. During the later period (1998-2012), Blue grama was present during 93.3% of the years with a mean 0.53% basal cover. The percent present decreased and basal cover greatly decreased on the sandy site of the ungrazed twice-over treatment over time (tables 11 and 12).

On the sandy site of the grazed twice-over treatment, Blue grama was present during 100.0% of the years that basal cover data were collected with a mean 4.15% basal cover during the total 30 year period. During the early period (1983-1992), Blue grama was present during 100.0% of the years with a mean 4.17% basal cover. During the later period (1998-2012), Blue grama was present during 100.0% of the years with a mean 3.50% basal cover. The percent present remained at 100.0% and basal cover decreased on the sandy site of the grazed twice-over treatment over time (tables 11 and 12). The percent present and basal cover were greater on the sandy site of the grazed twice-over treatment than those on the sandy site of the ungrazed twice-over treatment.

On the shallow site of the nongrazed treatment, Blue grama was present during 100.0% of the years that basal cover data were collected with a mean 3.63% basal cover during the total 30 year period. During the early period (1983-1992), Blue grama was present during 100.0% of the years with a mean 1.74% basal cover. During the later period (1998-2012), Blue grama was present during 100.0% of the years with a mean 3.90% basal cover. The percent present remained at 100.0% and basal cover greatly increased on the shallow site of the nongrazed treatment over time (tables 11 and 12).

On the shallow site of the ungrazed seasonlong treatment, Blue grama was present during 38.5% of the years that basal cover data were collected with a mean 2.22% basal cover during the total 30 year period. During the early period (1983-1992), Blue grama was not present. During the later period (1998-2012), Blue grama was present during 66.7% of the years with a mean 3.84% basal cover. Blue grama was not present during the early period and all basal cover observations were made during the later period indicated abundant plants (tables 11 and 12).

On the shallow site of the grazed seasonlong treatment, Blue grama was present during 100.0% of the years that basal cover data were collected with a mean 10.33% basal cover during the total 30 year period. During the early period (1983-1992), Blue grama was present during 100.0% of the years with a mean 6.49% basal cover. During the later period (1998-2012), Blue grama was present during 100.0% of the years with a mean 10.98% basal cover. The percent present remained at 100.0% and basal cover greatly increased on the shallow site of the grazed seasonlong treatment over time (tables 11 and 12). The percent present and basal cover were greater on the shallow site of the grazed seasonlong treatment than those on the shallow site of the ungrazed seasonlong treatment.

On the shallow site of the ungrazed twice-over treatment, Blue grama was present during 100.0% of the years that basal cover data were collected with a mean 7.78% basal cover during the total 30 year period. During the early period (1983-1992), Blue grama was present during 100.0% of the years with a mean 9.49% basal cover. During the later period (1998-2012), Blue grama was present during 100.0% of the years with a mean 6.20% basal cover. The percent present remained at 100.0% and basal cover greatly decreased on the shallow site of the ungrazed twice-over treatment over time (tables 11 and 12).

On the shallow site of the grazed twice-over treatment, Blue grama was present during 100.0% of the years that basal cover data were collected with a mean 13.62% basal cover during the total 30 year period. During the early period (1983-1992), Blue grama was present during 100.0% of the years with a

mean 11.61% basal cover. During the later period (1998-2012), Blue grama was present during 100.0% of the years with a mean 14.62% basal cover. The percent present remained at 100.0% and basal cover increased on the shallow site of the grazed twice-over treatment over time (tables 11 and 12). The percent present was the same at 100.0% and basal cover was greater on the shallow site of the grazed twice-over treatment than that on the shallow site of the ungrazed twice-over treatment.

On the silty site of the nongrazed treatment, Blue grama was present during 100.0% of the years that basal cover data were collected with a mean 2.80% basal cover during the total 30 year period. During the early period (1983-1992), Blue grama was present during 100.0% of the years with a mean 2.78% basal cover. During the later period (1998-2012), Blue grama was present during 100.0% of the years with a mean 2.47% basal cover. The percent present remained at 100.0% and basal cover decreased on the silty site of the nongrazed treatment over time (tables 11 and 12).

On the silty site of the ungrazed seasonlong treatment, Blue grama was present during 100.0% of the years that basal cover data were collected with a mean 6.05% basal cover during the total 30 year period. During the early period (1983-1992), Blue grama was present during 100.0% of the years with a mean 7.79% basal cover. During the later period (1998-2012), Blue grama was present during 100.0% of the years with a mean 4.68% basal cover. The percent present remained at 100.0% and basal cover decreased greatly on the silty site of the ungrazed seasonlong treatment over time (tables 11 and 12).

On the silty site of the grazed seasonlong treatment, Blue grama was present during 100.0% of the years that basal cover data were collected with a mean 8.77% basal cover during the total 30 year period. During the early period (1983-1992), Blue grama was present during 100.0% of the years with a mean 9.46% basal cover. During the later period (1998-2012), Blue grama was present during 100.0% of the years with a mean 7.74% basal cover. The percent present remained at 100.0% and basal cover decreased on the silty site of the grazed seasonlong treatment over time (tables 11 and 12). The percent present was the same at 100.0% and basal cover was greater on the silty site of the grazed seasonlong treatment than that on the silty site of the ungrazed seasonlong treatment.

On the silty site of the ungrazed twice-over treatment, Blue grama was present during 100.0% of the years that basal cover data were collected with a mean 4.85% basal cover during the total 30 year period. During the early period (1983-1992), Blue grama was present during 100.0% of the years with a mean 9.32% basal cover. During the later period (1998-2012), Blue grama was present during 100.0% of the years with a mean 1.79% basal cover. The percent present remained at 100.0% and basal cover decreased greatly on the silty site of the ungrazed twice-over treatment over time (tables 11 and 12).

On the silty site of the grazed twice-over treatment, Blue grama was present during 100.0% of the years that basal cover data were collected with a mean 15.96% basal cover during the total 30 year period. During the early period (1983-1992), Blue grama was present during 100.0% of the years with a mean 13.20% basal cover. During the later period (1998-2012), Blue grama was present during 100.0% of the years with a mean 17.37% basal cover. The percent present remained at 100.0% and basal cover increased on the silty site of the grazed twice-over treatment over time (tables 11 and 12). The percent present was the same at 100.0% and basal cover was greater on the silty site of the grazed twice-over treatment than that on the silty site of the ungrazed twice-over treatment.

On the sandy site, Blue grama was present during 86.5% of the years with a mean 2.98% basal cover. On the shallow site, Blue grama was present during 87.7% of the years with a mean 7.52% basal cover. On the silty site, Blue grama was present during 100.0% of the years with a mean 7.68% basal cover. The percent present and basal cover were greater on the silty site.

On the sandy site of the nongrazed treatment, Blue grama was present during 96.0% of the years with a mean 2.33% basal cover. On the sandy site of the seasonlong treatment, Blue grama was present during 70.0% of the years with a mean 3.65% basal cover. On the sandy site of the twice-over treatment, Blue grama was present during 98.2% of the years with a mean 2.64% basal cover. The percent present was greater on the twice-over treatment and basal cover was greater on the seasonlong treatment.

On the shallow site of the nongrazed treatment, Blue grama was present during 100.0% of the years with a mean 3.63% basal cover. On the shallow site of the seasonlong treatment, Blue grama was present during 69.2% of the years with a mean 6.25% basal cover. On the shallow site of the twice-over treatment, Blue grama was present during

100.0% of the years with a mean 10.70% basal cover. The percent present was at 100.0% on the nongrazed and twice-over treatments and basal cover was greater on the twice-over treatment.

On the silty site of the nongrazed treatment, Blue grama was present during 100.0% of the years with a mean 2.80% basal cover. On the silty site of the seasonlong treatment, Blue grama was present during 100.0% of the years with a mean 7.41% basal cover. On the silty site of the twice-over treatment, Blue grama was present during 100.0% of the years with a mean 10.40% basal cover. The percent present was 100.0% on the nongrazed, seasonlong, and twice-over treatments and basal cover was greater on the twice-over treatment.

On the not grazed treatments, Blue grama was present during 85.7% of the years with a mean 3.57% basal cover. On the grazed treatments, Blue grama was present during 100.0% of the years with a mean 9.79% basal cover. The percent present was greater on the grazed treatments and basal cover was 274% greater on the grazed treatments. On the grazed seasonlong treatment, Blue grama was present during 100.0% of the years with a mean 8.34% basal cover. On the grazed twice-over treatment, Blue grama was present during 100.0% of the years with a mean 11.24% basal cover. The percent present were the same at 100.0% of the years and basal cover was greater on the grazed twice-over treatment.

Discussion

Blue grama, *Bouteloua gracilis*, is a native, long-lived perennial, warm season, short grass, monocot, of the grass family that is abundant on healthy mixed grass prairie plant communities. Blue grama can grow on sandy, shallow, silty, overflow, and thin claypan ecological sites. It grows better on silty sites and grows best on the grazed silty sites managed with the twice-over treatment. Blue grama resumes basal leaf growth from the basal tillers on short rhizomes. New leaves of Blue grama are visible by 15 April. Leaf growth is rapid during May. Leaf growth is at 19% height during late April, 34% height on mid May, 69% height on mid June, 97% height on mid July, and at 100% maximum height on 29 July. Early stalk growth is visible by 22 June. Stalk growth is at 68% height during late June, 80% height on mid July, and at 100% maximum height during early August. The stalk is at boot stage between 26 June and 21 July, at head emergence during 4 to 8 July, early first flowers appear 16 July, mean first flowers occur on 18 July, with a 5 week flower period from early July through the first week of August. Seeds are developing from 30 July, reach mature stage on 12 to 13 August, start being shed during 21 to 26 August. Crude protein content of lead tillers is at 15.9% during early June, is at 14.8% during mid June when the 3.5 new leaf stage is reached, is at 13.1% during early July, and drops below the requirements of lactating cows during the fourth week of July. Lead tillers drop below the phosphorus requirements of lactating cows during early August.

Blue grama is our most valuable native pasture grass for drier soil (Stevens 1963). Blue grama produces great herbage quantity with nutritious quality. The deep roots descend to 1.8 m (6 ft) and the dense shallow roots permit rapid plant response to low precipitation events. The aboveground parts cover the soil protecting it from heat and erosion. The high density prevents undesirable species from invading. Blue grama holds the prairie plant communities together. Blue grama is the most valuable asset on the Northern Mixed Grass Prairie.

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Table 1. Bouteloua gracilis, Blue grama, weekly percent crude protein, percent phosphorus, and phenological growth stages of ungrazed lead tillers in western North Dakota, 1946-1947.

Sample Date	Crude Protein %	Phosphorus %	Phenological Growth Stages
Apr 1			
13			
19			
25			
May 4			
10	16.5	0.251	Early leaf greenup
16	14.6	0.198	
23	15.4	0.207	
28	15.9	0.234	
Jun 6	13.9	0.253	Active leaf growth
13	14.8	0.329	
19	13.2	0.278	
26	14.1	0.283	
Jul 2	13.1	0.277	Flower stalk developing
8	10.7	0.234	Flower stalk emerging
16	9.3	0.219	Flowering (Anthesis)
24	9.7	0.208	
30	7.9	0.235	Seed developing
Aug 6	7.5	0.144	
13	7.8	0.163	Seed maturing
20	7.8	0.185	
26	7.7	0.131	Seed shedding
Sep 3	7.6	0.193	Drying
12	6.7	-	
21	-	-	
29	6.9	0.108	
Oct			
Nov 5	7.3	0.113	Drying

Data from Whitman et al. 1951.

Table 2. Mean leaf height in cm and percent of maximum leaf height attained by Bouteloua gracilis, Blue grama, 1955-1962.

	April				
	1	8	15	22	29
cm			1.0	1.5	2.0
%			9.0	14.0	19.0
	May				
	1	8	15	22	29
cm	2.0	2.1	3.6	4.8	5.1
%	19.0	20.0	34.0	45.0	48.0
	June				
	1	8	15	22	29
cm	7.3	7.4	7.4	8.1	8.8
%	68.0	69.0	69.0	76.0	82.0
	July				
	1	8	15	22	29
cm	9.4	9.8	10.4	10.5	10.7
%	88.0	92.0	97.0	99.0	100.0
	August				
	1	8	15	22	29
cm					
%					

Data from Goetz 1963.

Table 3. Mean stalk height in cm and percent of maximum stalk height attained by Bouteloua gracilis, Blue grama, 1955-1962.

	April				
	1	8	15	22	29
cm					
%					
	May				
	1	8	15	22	29
cm					
%					
	June				
	1	8	15	22	29
cm				16.0	16.0
%				68.1	68.1
	July				
	1	8	15	22	29
cm	16.5	17.0	18.8	21.0	22.0
%	70.2	72.3	80.0	89.4	93.6
	August				
	1	8	15	22	29
cm	23.5				
%	100.0				

Data from Goetz 1963.

Table 4. First flower and flower period of Bouteloua gracilis, Blue grama.

	Apr	May	Jun	Jul	Aug	Sep
First Flower						
1955-1962						
Earliest				16		
Mean				18		
Flower Period						
1969-1971				XX XX	X	

First Flower Data from Goetz 1963 and Whitman et al. 1951.
Flower Period Data from Zaczkowski 1972.

Table 5. Flower stalk seed development and percent leaf dryness of Bouteloua gracilis, Blue grama.

	Flower Stalk Development			Seed Development	
Data Period	Boot	Emerge	Flower	Mature	Shed
1955-1962	26 Jun	4 Jul	18 Jul	12 Aug	21 Aug
			Percent Leaf Dryness		
Data Period	Leaf Tip	0-25	25-50	50-75	75-100
	Dry	%	%	%	%
1955-1962	25 Jun	5 Aug	21 Aug	27 Aug	21 Sep

Data from Goetz 1963.

Table 6. Intake nutrient requirements as percent of dry matter for range cows with average milk production.

	Dry Gestation	3rd Trimester	Early Lactation	Lactation (Spring, Summer, Fall)
1000 lb cows				
Dry matter (lbs)	21	21	24	24
Crude protein (%)	6.2	7.8	10.5	9.6
Phosphorus (%)	0.11	0.15	0.20	0.18
1200 lb cows				
Dry matter (lbs)	24	24	27	27
Crude protein (%)	6.2	7.8	10.1	9.3
Phosphorus (%)	0.12	0.16	0.19	0.18
1400 lb cows				
Dry matter (lbs)	27	27	30	30
Crude protein (%)	6.2	7.9	9.8	9.0
Phosphorus (%)	0.12	0.17	0.19	0.18

Data from NRC 1996.

Table 7. Mean date of first flower and date of percentage categories of leaf senescence for Blue grama, 1964-1966.

Ecological Site	Anthesis	Leaf Tip Dry	Leaf 0-25% Dry	Leaf 25%-50% Dry	Leaf 50%-75% Dry
Sandy	16 Jul	19 Jun	4 Aug	29 Aug	10 Oct
Silty	20 Jul	22 Jun	6 Aug	6 Sep	9 Sep
Overflow	23 Jul	10 Jul	14 Aug	-	-
Thin claypan	18 Jul	16 Jun	31 Jul	20 Aug	9 Sep

Data from Goetz 1970.

Table 8. Mean leaf height in cm for Blue grama, 1964-1966.

Ecological Site	15 Apr	30 Apr	15 May	31 May	15 Jun	30 Jun	15 Jul	31 Jul	15 Aug	31 Aug	Maximum Height
Sandy	0.51	1.50	2.50	4.50	8.00	10.11	11.30	11.61	11.61	11.51	11.61
Silty	0.99	1.19	2.01	6.20	7.49	8.71	11.91	12.09	11.91	11.91	12.09
Overflow	No Data										
Thin claypan	0.30	0.61	2.01	3.51	5.69	7.29	8.79	9.09	9.09	9.09	9.09

Data from Goetz 1970.

Table 9. Percent crude protein for Blue grama, 1964-1966.

Ecological Site	1 Jun	15 Jun	1 Jul	15 Jul	1 Aug	15 Aug	1 Sep	Mean
Sandy	11.5	11.2	10.0	9.2	8.2	7.6	7.2	9.3
Silty	12.0	10.9	8.8	8.9	9.2	6.7	7.1	9.1
Overflow	No Data							
Thin claypan	11.7	14.1	11.6	11.1	10.0	10.3	9.2	11.1

Data from Goetz 1975.

Table 10. Herbage biomass (lbs/ac) and percent of total weight of Blue grama from an ungrazed area of nearly a pure stand, 1958-1962.

		15 May	1 Jun	15 Jun	1 Jul	15 Jul	1 Aug	15 Aug	1 Sep	Mean
Blue grama	lbs/ac	249.73	384.20	545.56	643.53	788.57	839.48	983.55	842.36	718.18
	%	60.5	70.2	66.8	60.9	63.6	68.8	70.1	70.7	67.3

Data from Goetz 1963.

Table 11. Autecology of Bouteloua gracilis, Blue grama, with growing season changes in basal cover, 1983-2012.					
Eological Site Year Period	Nongrazed	Seasonlong		Twice-over	
		Ungrazed	Grazed	Ungrazed	Grazed
Sandy					
1983-1987	0.85	0.00	1.27	2.68	4.64
1988-1992	0.98	0.00	3.09	1.95	3.57
1993-1998	1.70	0.00	6.32	0.87	5.39
1999-2003	1.23	3.73	5.49	0.60	3.61
2004-2009	3.23	3.30	7.29	0.55	3.20
2010-2012	5.88	3.61	8.94	0.42	4.46
Shallow					
1983-1987	1.50	0.00	7.23	12.35	13.94
1988-1992	1.79	0.00	6.34	7.20	9.28
1993-1998	4.64	0.00	11.17	8.96	13.43
1999-2003	3.42	8.10	8.48	8.19	14.53
2004-2009	3.89	5.55	11.25	4.98	13.67
2010-2012	5.25	5.40	14.92	5.23	19.10
Silty					
1983-1987	3.05	8.00	10.37	13.78	16.91
1988-1992	2.72	7.75	9.28	5.75	9.48
1993-1998	3.58	7.50	10.06	5.56	16.48
1999-2003	2.81	3.88	7.47	2.96	19.61
2004-2009	2.25	4.56	6.86	0.83	14.61
2010-2012	2.39	6.22	10.76	1.15	20.72

Table 12. Autecology of Bouteloua gracilis, Blue grama, with growing season changes in basal cover importance value, 1983-2012.					
Ecological Site Year Period	Nongrazed	Seasonlong		Twice-over	
		Ungrazed	Grazed	Ungrazed	Grazed
Sandy					
1983-1987	7.14	0.00	9.54	20.51	26.82
1988-1992	8.00	0.00	27.68	15.62	27.87
1993-1998	14.79	0.00	44.23	7.67	35.46
1999-2003	10.73	5.77	35.40	6.48	24.47
2004-2009	28.05	28.75	49.70	6.54	23.24
2010-2012	45.06	30.86	55.95	5.06	32.04
Shallow					
1983-1987	11.24	0.00	45.72	68.89	70.37
1988-1992	15.28	0.00	48.18	55.16	70.96
1993-1998	36.51	0.00	69.47	60.21	80.99
1999-2003	26.49	9.61	53.00	52.59	74.58
2004-2009	29.17	40.19	65.06	40.35	73.92
2010-2012	36.08	39.90	72.92	41.52	88.82
Silty					
1983-1987	22.95	57.10	63.53	65.89	69.66
1988-1992	20.91	59.78	60.62	38.46	68.42
1993-1998	29.86	46.11	60.77	40.06	86.50
1999-2003	22.89	23.92	47.32	26.86	88.79
2004-2009	20.32	33.65	45.57	9.09	78.75
2010-2012	23.69	45.97	57.16	11.46	89.05

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