Growth Pattern and Phenological Development of Major Graminoids on the Northern Plains

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CONTENTS
VOLUME 2

Growth Pattern and Phenological Development of Blue Grama on the Northern Plains

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Intact grassland ecosystems are complex; exceedingly more complex than the most complicated machines ever built by humans. Knowledge and understanding of the growth pattern and phenological development of the major forage grasses are fundamentally essential for generation of biologically effective management strategies with inclusivity of all biotic and abiotic components of grassland ecosystems in the Northern Plains.

The inspirational 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 relationships of ecosystem components that would result in the development and establishment of scientific standards for proper management of grazinglands in the Northern Plains.

This growth pattern and phenological development study of the major forage graminoids was conducted during the growing seasons of 1983-1986 and 1987-1989 with data collected biweekly June-August. The study included 3 cool season, 2 warm season, 1 upland sedge, 1 naturalized, and 2 domesticated grasses. The study sites were located at the NDSU Dickinson Research Extension Center ranch near Manning in western North Dakota and consisted of 143 acres (58 ha) of two seeded domesticated grasslands and 720 acres (291 ha) of native rangeland pastures separated into three management treatments, each with two replications, with data collection sites established on sandy, shallow, and silty ecological sites. Each ecological site of the grazed treatments had matching paired plots, one grazed and the other with an ungrazed exclosure.

Study Area

The physiography of the study area consists of the Unglaciated section of the Missouri Plateau (Fenneman 1931, 1946; Hunt 1974). The landscape surface is highly eroded fluvial sedimentary deposits of material removed from the uplifted Rocky Mountains. Most of the deposition occurred from slow meandering streams during the Laramide Orogeny and during the 20 to 30 million years of the late Cretaceous and early Tertiary Periods following the uplift. Intense widespread erosion of these sediments occurred from about 5 to 3 million years ago during the late Pliocene Epoch (Bluemle 2000). The extensive erosion during this period removed about 500 to 1000 feet of sediments (Fenneman 1931) forming a landscape with well developed integrated drainage systems of broad mature valleys and gently rolling uplands containing widely spaced large hills and buttes with erosion resistant caps raising 500 to 650 feet above the plain (Bluemle 2000).

The soils of western North Dakota developed from eroded Tertiary fluvial sedimentary deposits in the Ustic-Frigid soil moisture-temperature regime. The Ustic soil moisture regime is typical of semi arid climates. The Frigid soil temperature regime has mean annual soil temperatures of less than 47° F (8° C) (Soil Survey Staff 1975). These soils are primarily Typic Borolls (semi arid cool Mollisols) and support vegetation of mid and short grasses of the Mixed Grass Prairie (Manske 2008b).

The current "native" plant species in the Northern Plains did not originate here. All of the plant species have migrated into the region by different mechanisms and at different times and rates. The present plant species have flora affinities to northern, eastern, western, Rocky Mountain, and Great Basin plant communities (Zaczkowski 1972). This wide mix of plant species was formed from remnants of previously existing plant communities. The climate changed about 5,000 years ago to conditions like those of the present, with cycles of wet and dry periods (Bluemle 1977, 1991; Manske 1994). The large diversity of plant species that make up the current mixed grass prairie permits dynamic responses to changes in climatic conditions by increasing the combination of plant species favored by any set of climatic conditions (Manske 2008a).

Long-Term Weather

The NDSU Dickinson Research Extension Center ranch is located in Dunn County in western North Dakota, at 47° 14' north latitude, 102° 50' west longitude. Mean annual temperature is 42.3° F (5.7° C). January is the coldest month, with mean temperature of 14.6° F (-9.7° C). July and August are the warmest months with mean temperatures of 69.7° F (20.9° C) and 68.6° F (20.3° C), respectively. Long-term (1982-2012) mean annual precipitation is 16.91 inches (429.61 mm). The perennial plant growing season precipitation (April to October) is 14.13 inches (358.97 mm) and is 83.6% of annual precipitation. June has the greatest monthly precipitation at 3.27 inches (83.08 mm). The precipitation received during the 3-month period of May, June, and July (8.26 inches, 209.80 mm) accounts for 48.8% of the annual precipitation.

Growing season months with water deficiency disrupt plant growth rates and are identified from monthly temperature and precipitation data by the Emberger ombrothermic diagram technique. Long-term (1983-2012) 30 year reoccurrence rates (table 1) show relatively low rates of water deficiency reoccurring during April (16.7%), May and June (10.0%), moderate rates during July and October (36.7%), and high rates during August (56.7%) and September (60.0%). Long-term occurrence of water deficiency conditions was 33.3% of the growing season months, for a mean of 2.0 water deficient months per each 6.0 month growing season (15 Apr-15 Oct).

Growing Season Precipitation

The growing season precipitation information collected during the grass leaf height study has been grouped into two periods with the first period occurring during 1983 to 1986 and the second period occurring during 1987 to 1989.

Mean growing season precipitation of 1983-1986 (table 2) was 14.11 inches (99.9% of LTM). None of the four 6 month growing seasons received precipitation at less than 80% of LTM. One growing season, 1986, received precipitation at near 130% of LTM. The rate of water deficiency occurrence during the four growing seasons was 29.2%, for a mean of 1.75 water deficient months per growing season (table 3). The growing season of 1984 had 3.0 months in water deficiency. The growing seasons of 1983 and 1986 had 1.5 months in water deficiency each. The growing season of 1985 had 1.0 month in water deficiency.

Mean growing season precipitation of 1987-1989 (table 4) was low at 9.14 inches (64.7% of LTM). The growing season of 1987 received 11.53 inches (81.6% of LTM) precipitation. The growing season of 1989 received 10.60 inches (75.0% of LTM) precipitation. The growing season of 1988 received only 5.30 inches (37.5% of LTM) precipitation and was dry. The rate of water deficiency occurrence during the three growing seasons was 61.1%, for a mean of 3.7 water deficient months per growing season (table 5). The growing seasons of 1987 and 1989 had 3.0 months in water deficiency each. The growing season of 1988 had 5.0 months of its 6 month growing season in water deficiency conditions. That is comparable to 2 other growing seasons with high water deficiency conditions. The growing season of 1934 had 4.5 months in water deficiency and the growing season of 1936 had 5.5 months in water deficiency.

Table 1. Growing season months with water deficiency, DREC ranch, 1983-2012.

	Apr	May	Jun	Jul	Aug	Sep	Oct	# Months	% 6 Months 15 Apr-15 Oct
Total	5	3	3	11	17	18	11	60.0	33.3
% of 30 Years	16.7	10.0	10.0	36.7	56.7	60.0	36.7		

Table 2. Precipitation in inches and percent of long-term mean for perennial plant growing season months, DREC ranch, 1983-1986.

	Apr	May	Jun	Jul	Aug	Sep	Oct	Growing Season	Annual Total
Long-Term Mean 1982-2012	1.44	2.56	3.27	2.43	1.70	1.42	1.31	14.13	16.91
1983	0.21	1.53	3.26	2.56	4.45	0.86	0.72	13.59	15.55
% of LTM	14.58	59.77	99.69	105.35	261.76	60.56	54.96	96.18	91.96
1984	2.87	0.00	5.30	0.11	1.92	0.53	0.96	11.69	12.88
% of LTM	199.31	0.00	162.08	4.53	112.94	37.32	73.28	82.73	76.17
1985	1.24	3.25	1.58	1.07	1.84	1.69	2.13	12.80	15.13
% of LTM	86.11	126.95	48.32	44.03	108.24	119.01	162.60	90.59	89.47
1986	3.13	3.68	2.58	3.04	0.46	5.29	0.18	18.36	22.96
% of LTM	217.36	143.75	78.90	125.10	27.06	372.54	13.74	129.94	135.78
1983-1986	1.86	2.12	3.18	1.70	2.17	2.09	1.00	14.11	16.63
% of LTM	129.34	82.62	97.25	69.75	127.50	147.36	76.15	99.86	98.34

Table 3. Growing season months with water deficiency conditions that caused water stress in perennial plants, DREC ranch, 1983-1986.

	APR	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**# Months**	**% 6 Months 15 Apr-15 Oct**
1983								1.5	25.0
1984								3.0	50.0
1985								1.0	16.7
1986								1.5	25.0
#	**1**	**1**	**0**	**2**	**1**	**2**	**1**	**7.0**	**29.2**
%	**25.0**	**25.0**	**0.0**	**50.0**	**25.0**	**50.0**	**25.0**		

Table 4. Precipitation in inches and percent of long-term mean for perennial plant growing season months, DREC ranch, 1987-1989.

	Apr	May	Jun	Jul	Aug	Sep	Oct	Growing Season	Annual Total
Long-Term Mean 1982-2012	1.44	2.56	3.27	2.43	1.70	1.42	1.31	14.13	16.91
1987	0.10	1.38	1.15	5.39	2.65	0.78	0.08	11.53	14.13
% of LTM	6.94	53.91	35.17	221.81	155.88	54.93	6.11	81.60	83.56
1988	0.00	1.85	1.70	0.88	0.03	0.73	0.11	5.30	9.03
% of LTM	0.00	72.27	51.99	36.21	1.76	51.41	8.40	37.51	53.40
1989	2.92	1.73	1.63	1.30	1.36	0.70	0.96	10.60	13.07
% of LTM	202.78	67.58	49.85	53.50	80.00	49.30	73.28	75.02	77.29
1987-1989	1.01	1.65	1.49	2.52	1.35	0.74	0.38	9.14	12.08
% of LTM	69.91	64.58	45.67	103.84	79.22	51.88	29.26	64.71	71.42

Table 5. Growing season months with water deficiency conditions that caused water stress in perennial plants, DREC ranch, 1987-1989.

	APR	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**# Months**	**% 6 Months 15 Apr-15 Oct**
1987								3.0	50.0
1988								5.0	83.3
1989								3.0	50.0
#	**2**	**0**	**2**	**2**	**2**	**3**	**2**	**11.0**	**61.1**
%	**66.7**	**0.0**	**66.7**	**66.7**	**66.7**	**100.0**	**66.7**		

Procedures

The 1983-1989 Study

Grass tiller leaf heights were determined for reproductive lead tillers, vegetative tillers, and secondary tillers on a biweekly sampling period from June through August. Each leaf of ten ungrazed tillers of each study species was measured with a meter stick to the nearest 0.1 cm from ground level to the tips of the extended leaves. Basal leaf heights were measured for grass species in which the leaves and stalks were distinctly separate. Stalk leaf heights were measured for grass species where leaves are attached to the culm during vegetative stages and fruiting stages.

Degree of leaf senescence was estimated as percent dryness for each leaf. Percent dryness for basal leaves was considered from the apex to ground level. Percent dryness for stalk leaves was considered for the blade only. The categories of dryness were: 0%, 2%, 25%, 50%, 75%, 98% and 100% dry. Start of senescence was considered to be dryness greater than 2%. Leaves with less than 50% senescent tissue were designated to be photosynthetically active.

Grass flower stalk heights were determined by measurements from ground level to the tip of the stalk or the apex of the top floret. The awns, if present, were not included in the height measurements. The phenological stages of flower stalk development were recorded as: flower stalk developing (FSD), head emergence (HE), anthesis (Ant), seeds developing (SD), and seeds being shed (SBS). Recording the flower stalk development stages started when stalk enlargement or swelling was outwardly noticeable; prior development is not detectable without destruction of the tiller. The swelling of the stalk, traditionally called the boot stage, was categorized as the flower stalk developing stage. Head emergence is a short duration stage but easily defined when the flower head emerges from the sheath and rapidly elongates to near full height. Anthesis (flowering) is also a short duration stage but easily defined by the exposure of the anthers and stigmas. Needle and thread is usually cleistogamous that self-fertilizes without opening and exposing the anthers and stigmas. Following fertilization, the seeds develop through milk, dough, and mature stages which are difficult to differentiate on small grass seeds. These seed progression stages have been separated into more easily defined categories of seeds developing for the early seed stages and seeds being shed for the mature seed stages when seeds could be easily removed from the inflorescence by wind, by gentle rubbing, or when it could be observed that some seeds had already been dropped. Sometimes a floret will abort the seed production process resulting in failure of viable seeds to materialize. This condition could be revealed in the data set as earlier than normal recordings of seeds being shed.

During 1983 to 1986, the paired plot sample sites with sandy, shallow, silty and clay soil types were managed by ungrazed and grazed treatments of the twice-over rotation strategy. During 1987 to 1989, the paired plot sample sites with sandy, shallow, and silty soil types were managed by long-term nongrazed treatments, and by ungrazed and grazed treatments of the traditional seasonlong practice and the twice-over rotation strategy.

Designation of Tiller Types

Reproductive lead tillers are second year tillers derived from carryover tillers that were vegetative tillers during the previous growing season. The portions of the carryover leaves that have intact cell walls will regreen with active chlorophyll early in the growing season and provide photosynthate for rapid growth of new current years leaves. New leaf development resumed in the spring a little earlier than other warm season grasses in mid April but growth was slow until early or mid May. The anthesis (flowering) period can occur between early and late July with all first flowers occurring after 21 June. No new leaves are produced after the anthesis stage, during the seed development stages. Flower stalks had 1 or 2 small leaves and usually produce 2 or 7 basal leaves. Reproductive lead tillers are terminal at the end of the growing season; their apical meristem was used up producing a flower head.

Vegetative tillers are first year tillers derived from early spring initiated secondary tillers that have developed from fall produced crown tiller buds and have escaped hormonal control by a lead tiller. Vegetative tillers produced 3.5 new basal leaves around mid June. These tillers are the primary forage tillers with rapid growth rates, usually producing 5 to 7 basal leaves and occasionally producing leaves 8 and 9 during the growing season. The apical meristem remains vegetative, permitting these tillers to overwinter as carryover tillers and becoming reproductive lead tillers during the successive growing season.

Secondary tillers are young current growing season tillers usually with 2 to 4 basal leaves that initiated from axillary buds during May to July and that remain hormonally controlled by a dominant lead tiller that has proprietary access to all resources slowing rates of growth. The secondary tillers can become independent from the hormone control of the lead tiller and transform into vegetative tillers with rapid growth rates during July and August. A large quantity of new leaves develop from crown buds during August.

Results

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 base 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 destroys 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.

During the seven years of this study, the number of blue grama tillers measured was 15,701 with 4549 tillers on sandy soils, 4600 tillers on shallow soils, 4828 tillers on silty soils, and 1724 tillers on clay soils (tables 6, 7, 8, and 9). The collection protocol required measurement on all available flower stalks and ten vegetative tillers on each sample site each collection period, amounting to 360 tillers per year on the twice-over treatment and 120 tillers per year on the seasonlong and nongrazed treatments. During the 3 growing seasons with low precipitation amounts, less than ten tillers were measured each collection period. The reductions in sample numbers would indicate the degree of negative affect from reduced precipitation. This affect is designated as collection efficiency on tables 6, 7, 8, and 9.

Table 6. Number of tillers measured from management treatments on sandy soils.

Tiller Type	Twice-over 1983-1986 Ungrazed	Twice-over 1983-1986 Grazed	Twice-over 1987-1989 Ungrazed	Twice-over 1987-1989 Grazed	Seasonlong 1987-1989 Ungrazed	Seasonlong 1987-1989 Grazed	Nongrazed 1987-1989 Ungrazed
Flower Stalk	38	47	18	37	0	12	6
Vegetative	841	1209	401	281	75	54	142
Secondary	153	365	337	294	21	102	116
Subtotal	1032	1621	756	612	96	168	264
Total	2653		1368		264		264
Sum total	4549						
Collection Efficiency	72%	113%	70%	57%	27%	47%	73%

Table 7. Number of tillers measured from management treatments on shallow soils.

Tiller Type	Twice-over 1983-1986 Ungrazed	Twice-over 1983-1986 Grazed	Twice-over 1987-1989 Ungrazed	Twice-over 1987-1989 Grazed	Seasonlong 1987-1989 Ungrazed	Seasonlong 1987-1989 Grazed	Nongrazed 1987-1989 Ungrazed
Flower Stalk	55	72	45	41	6	8	7
Vegetative	800	1183	425	307	106	42	148
Secondary	177	391	288	276	20	94	109
Subtotal	1032	1646	758	624	132	144	264
Total	2678		1382		276		264
Sum total	4600						
Collection Efficiency	72%	114%	70%	58%	37%	40%	73%

Table 8. Number of tillers measured from management treatments on silty soils.

Tiller Type	Twice-over 1983-1986		Twice-over 1987-1989		Seasonlong 1987-1989		Nongrazed 1987-1989
	Ungrazed	Grazed	Ungrazed	Grazed	Ungrazed	Grazed	Ungrazed
Flower Stalk	55	66	32	40	9	12	6
Vegetative	750	1176	416	250	104	89	173
Secondary	225	435	320	333	137	115	85
Subtotal	1030	1677	768	623	250	216	264
Total	2707		1391		466		264
Sum total				4828			
Collection Efficiency	72%	116%	71%	58%	69%	60%	73%

Table 9. Number of tillers measured from management treatments on clay soils.

Tiller Type	Twice-over 1983-1986		Twice-over 1987-1989		Seasonlong 1987-1989		Nongrazed 1987-1989
	Ungrazed	Grazed	Ungrazed	Grazed	Ungrazed	Grazed	Ungrazed
Flower Stalk	24	32					
Vegetative	480	714					
Secondary	156	318					
Subtotal	660	1064					
Total	1724						
Sum total							
Collection Efficiency	46%	74%					

Reproductive Lead Tillers

The second year reproductive lead tillers had the fastest rate of growth and development until mid to late July. Some early growth tillers reached the boot stage (FSD) after mid June. Flower stalk development occurred very rapidly with the early lead tillers progressing through head emergence (HE) during late June and reaching the flower stage during early July. Most lead tillers reached anthesis (Ant) during July. Late developing lead tillers reached anthesis by late July or early August. No new leaves were produced after the anthesis stage. Seeds developed (SD) through the milk and dough stages during late July and early August with most seeds reaching maturity (SBS) from mid to late August or early September (table 10). The apical meristem of reproductive lead tillers can no longer produce leaf buds after it had produced flower buds and these tillers were terminated at the end of the growing season.

Growth and development data of blue grama reproductive lead tillers on sandy soils managed with the twice-over strategy and the ungrazed treatment during 1983 to 1986 are on table 11.

Reproductive lead tillers with 2 to 7 basal leaves on the twice-over strategy during 1983 to 1986 composed 2.9% of the total population with 47 tillers (table 6) that had a mean flower stalk height of 15.3 cm, during the growing season a mean of 57.8% leaves were photosynthetically active with a mean basal leaf height of 10.4 cm and the tallest leaf averaged 13.9 cm tall (table 11).

Reproductive lead tillers with 2 to 7 basal leaves on the ungrazed treatment during 1983 to 1986 composed 3.7% of the total population with 38 tillers (table 6) that had a mean flower stalk height of 18.5 cm, during the growing season a mean of 46.2% leaves were photosynthetically active with a mean basal leaf height of 12.2 cm and the tallest leaf averaged 16.2 cm tall (table 11).

Growth and development data of blue grama reproductive lead tillers on shallow soils managed with the twice-over strategy and the ungrazed treatment during 1983 to 1986 are on table 12.

Reproductive lead tillers with 2 to 7 basal leaves on the twice-over strategy during 1983 to 1986 composed 4.4% of the total population with 72 tillers (table 7) that had a mean flower stalk height of 15.3 cm, during the growing season a mean of 50.4% leaves were photosynthetically active with a mean basal leaf height of 9.0 cm and the tallest leaf averaged 11.8 cm tall (table 12).

Reproductive lead tillers with 2 to 7 basal leaves on the ungrazed treatment during 1983 to 1986 composed 5.3% of the total population with 55 tillers (table 7) that had a mean flower stalk height of 16.1 cm, during the growing season a mean of 55.2% leaves were photosynthetically active with a mean basal leaf height of 10.4 cm and the tallest leaf averaged 12.6 cm tall (table 12).

Growth and development data of blue grama reproductive lead tillers on silty soils managed with the twice-over strategy and the ungrazed treatment during 1983 to 1986 are on table 13.

Reproductive lead tillers with 2 to 7 basal leaves on the twice-over strategy during 1983 to 1986 composed 3.9% of the total population with 66 tillers (table 8) that had a mean flower stalk height of 17.3 cm, during the growing season a mean of 54.0% leaves were photosynthetically active with a mean basal leaf height of 11.0 cm and the tallest leaf averaged 14.9 cm tall (table 13).

Reproductive lead tillers with 2 to 7 basal leaves on the ungrazed treatment during 1983 to 1986 composed 5.3% of the total population with 55 tillers (table 8) that had a mean flower stalk height of 17.8 cm, during the growing season a mean of 54.1% leaves were photosynthetically active with a mean basal leaf height of 15.2 cm and the tallest leaf averaged 18.0 cm tall (table 13).

Growth and development data of blue grama reproductive lead tillers on clay soils managed with the twice-over strategy and the ungrazed treatment during 1983 to 1986 are on table 14.

Reproductive lead tillers with 2 to 7 basal leaves on the twice-over strategy during 1983 to 1986 composed 3.0% of the total population with 32 tillers (table 9) that had a mean flower stalk height of 19.4 cm, during the growing season a mean of 67.7% leaves were photosynthetically active with a mean basal leaf height of 11.6 cm and the tallest leaf averaged 15.5 cm tall (table 14).

Reproductive lead tillers with 2 to 7 basal leaves on the ungrazed treatment during 1983 to 1986 composed 3.6% of the total population with 24 tillers (table 9) that had a mean flower stalk height of 23.8 cm, during the growing season a mean of 63.1% leaves were photosynthetically active with a mean basal leaf height of 15.7 cm and the tallest leaf averaged 19.7 cm tall (table 14).

Growth and development data of blue grama reproductive lead tillers on sandy soils managed with the twice-over strategy and the ungrazed treatment and the seasonlong and nongrazed treatments during 1987 to 1989 are on table 15.

Reproductive lead tillers with 2 to 7 basal leaves on the twice-over strategy during 1987 to 1989 composed 6.0% of the total population with 37 tillers (table 6) that had a mean flower stalk height of 20.3 cm, during the growing season a mean of 64.7% leaves were photosynthetically active with a mean basal leaf height of 9.9 cm and the tallest leaf averaged 13.7 cm tall (table 15).

Reproductive lead tillers with 2 to 7 basal leaves on the ungrazed treatment during 1987 to 1989 composed 2.4% of the total population with 18 tillers (table 6) that had a mean flower stalk height of 20.0 cm, during the growing season a mean of 50.3% leaves were photosynthetically active with a mean basal leaf height of 12.3 cm and the tallest leaf averaged 13.1 cm tall (table 15).

Reproductive lead tillers with 2 to 7 basal leaves on the seasonlong treatment during 1987 to 1989 composed 7.1% of the total population with 12 tillers (table 6) that had a mean flower stalk height of 15.2 cm, during the growing season a mean of 65.9% leaves were photosynthetically active with a mean basal leaf height of 10.0 cm and the tallest leaf averaged 11.7 cm tall (table 15).

Reproductive lead tillers with 2 to 7 basal leaves on the nongrazed treatment during 1987 to 1989 composed 2.3% of the total population with 6 tillers (table 6) that had a mean flower stalk height of 28.9 cm, during the growing season a mean of 55.6% leaves were photosynthetically active with a mean basal leaf height of 21.0 cm and the tallest leaf averaged 25.6 cm tall (table 15).

Growth and development data of blue grama reproductive lead tillers on shallow soils managed with the twice-over strategy and the ungrazed treatment and the seasonlong and nongrazed treatments during 1987 to 1989 are on table 16.

Reproductive lead tillers with 2 to 7 basal leaves on the twice-over strategy during 1987 to 1989 composed 6.6% of the total population with 41 tillers (table 7) that had a mean flower stalk height of 17.5 cm, during the growing season a mean of 51.0% leaves were photosynthetically active with a mean basal leaf height of 7.0 cm and the tallest leaf averaged 9.3 cm tall (table 16).

Reproductive lead tillers with 2 to 7 basal leaves on the ungrazed treatment during 1987 to 1989 composed 5.9% of the total population with 45 tillers (table 7) that had a mean flower stalk height of 19.8 cm, during the growing season a mean of 58.0% leaves were photosynthetically active with a mean basal leaf height of 10.7 cm and the tallest leaf averaged 13.0 cm tall (table 16).

Reproductive lead tillers with 2 to 7 basal leaves on the seasonlong treatment during 1987 to 1989 composed 5.6% of the total population with 8 tillers (table 7) that had a mean flower stalk height of 17.1 cm, during the growing season a mean of 65.2% leaves were photosynthetically active with a mean basal leaf height of 9.6 cm and the tallest leaf averaged 13.0 cm tall (table 16).

Reproductive lead tillers with 2 to 7 basal leaves on the nongrazed treatment during 1987 to 1989 composed 2.7% of the total population with 7 tillers (table 7) that had a mean flower stalk height of 13.4 cm, during the growing season a mean of 60.0% leaves were photosynthetically active with a mean basal leaf height of 11.2 cm and the tallest leaf averaged 13.2 cm tall (table 16).

Growth and development data of blue grama reproductive lead tillers on silty soils managed with the twice-over strategy and the ungrazed treatment and the seasonlong and nongrazed treatments during 1987 to 1989 are on table 17.

Reproductive lead tillers with 2 to 7 basal leaves on the twice-over strategy during 1987 to 1989 composed 6.4% of the total population with 40 tillers (table 8) that had a mean flower stalk height of 17.2 cm, during the growing season a mean of 47.5% leaves were photosynthetically active with a mean basal leaf height of 9.6 cm and the tallest leaf averaged 10.8 cm tall (table 17).

Reproductive lead tillers with 2 to 7 basal leaves on the ungrazed treatment during 1987 to 1989 composed 4.2% of the total population with 32 tillers (table 8) that had a mean flower stalk height of 18.8 cm, during the growing season a mean of 48.6% leaves were photosynthetically active with a mean basal leaf height of 12.6 cm and the tallest leaf averaged 13.7 cm tall (table 17).

Reproductive lead tillers with 2 to 7 basal leaves on the seasonlong treatment during 1987 to 1989 composed 5.6% of the total population with 12 tillers (table 8) that had a mean flower stalk height of 13.2 cm, during the growing season a mean of 54.6% leaves were photosynthetically active with a mean basal leaf height of 6.4 cm and the tallest leaf averaged 8.2 cm tall (table 17).

Reproductive lead tillers with 2 to 7 basal leaves on the nongrazed treatment during 1987 to 1989 composed 2.3% of the total population with 6 tillers (table 8) that had a mean flower stalk height of 29.3 cm, during the growing season a mean of 61.1% leaves were photosynthetically active with a mean basal leaf height of 15.0 cm and the tallest leaf averaged 19.3 cm tall (table 17).

All of the reproductive lead tillers measured during this study were not grazed including the tillers located on grazed treatments. The not grazed tillers remaining on the grazed treatments tended to have slightly shorter mean flower stalk heights, mean basal leaf heights, and mean tallest leaf heights which were not significantly different than the not grazed tillers on the ungrazed treatments on the sandy, shallow, silty, and clay soils during the 1983-1986 and on the sandy, shallow, and silty soils during the 1987-1989 periods. It is not believed that grazed treatments cause reproductive lead tillers to produce slightly shorter flower stalk and basal leaf heights. It is surmised that grazing cattle have a disproportional rate of selection for taller tillers than for shorter tillers leaving a distorted sample population of not grazed tillers with slightly shorter leaf heights.

Leaves grow and senesce in about the same order of their appearance. This study has designated that leaves with less than 50% senescent tissue to be photosynthetically active. Tillers growing on the twice-over treatment tended to have greater photosynthetically active leaves (56.0%) than the tillers growing on the ungrazed treatment (53.5%). Reproductive lead tillers located on the grazed twice-over treatment had 2.5 more photosynthetically active leaves than the tillers located on the ungrazed treatment.

Reproductive lead tillers composed a low percentage of the total measured tiller population. Reproductive lead tillers located on the twice-over treatment composed 3.6% (217 tillers) and 6.4% (118 tillers) and the reproductive tillers located on the ungrazed treatment composed 4.6% (172 tillers) and 4.2% (95 tillers) of the total tiller population during the 1983-1986 period and the 1987-1989 period, respectively. Reproductive lead tillers located on the seasonlong and nongrazed treatments composed 6.1% (32 tillers) and 2.4% (19 tillers) of the total population during the 1987-1989 period, respectively.

Table 10. Phenological stages of flower stalk development for blue grama, 1983-1986.

6 Jun	22 Jun	6 Jul	22 Jul	6 Aug	22 Aug
	FSD				
	HE	HE			
		Ant	Ant		
			SD	SD	
				SBS	SBS

FSD flower stalk developing
HE head emergence
Ant anthesis (flowering)
SD seeds developing
SBS seeds being shed

Table 11. Growth and development of blue grama reproductive lead tillers on sandy soils managed with twice-over grazing and ungrazed treatments, 1983-1986.

Sandy	6 Jun	22 Jun	6 Jul	22 Jul	6 Aug	22 Aug
Twice-over 1983-1986						
Stalk Height cm			8.4	15.3	19.4	18.1
% Active Leaf			63.6	66.7	56.0	44.8
Leaf Height cm			11.3	10.4	11.9	8.0
Tallest Leaf cm			13.8	13.8	16.8	11.2
Ungrazed 1983-1986						
Stalk Height cm				16.7	20.0	18.9
% Active Leaf				60.0	46.7	32.0
Leaf Height cm				12.2	13.6	10.8
Tallest Leaf cm				15.3	18.7	14.6

Table 12. Growth and development of blue grama reproductive lead tillers on shallow soils managed with twice-over grazing and ungrazed treatments, 1983-1986.

Shallow	6 Jun	22 Jun	6 Jul	22 Jul	6 Aug	22 Aug
Twice-over 1983-1986						
Stalk Height cm			9.0	17.5	17.0	17.6
% Active Leaf			64.7	52.6	44.4	40.0
Leaf Height cm			6.9	10.6	8.8	9.7
Tallest Leaf cm			8.7	14.1	11.4	12.9
Ungrazed 1983-1986						
Stalk Height cm			9.6	16.3	21.8	16.6
% Active Leaf			78.6	50.0	53.3	38.9
Leaf Height cm			9.5	10.3	11.6	10.3
Tallest Leaf cm			12.5	12.2	13.7	11.8

Table 13. Growth and development of blue grama reproductive lead tillers on silty soils managed with twice-over grazing and ungrazed treatments, 1983-1986.

Silty	6 Jun	22 Jun	6 Jul	22 Jul	6 Aug	22 Aug
Twice-over 1983-1986						
Stalk Height cm			9.6	20.3	17.0	22.3
% Active Leaf			60.0	66.7	61.1	28.1
Leaf Height cm			6.9	12.7	10.5	14.0
Tallest Leaf cm			11.9	18.1	12.6	16.8
Ungrazed 1983-1986						
Stalk Height cm		13.5	12.0	20.1	19.1	24.3
% Active Leaf		50.0	66.7	63.6	53.3	37.0
Leaf Height cm		14.8	13.3	15.5	13.9	18.3
Tallest Leaf cm		18.5	15.4	19.2	17.8	19.2

Table 14. Growth and development of blue grama reproductive lead tillers on clay soils managed with twice-over grazing and ungrazed treatments, 1983-1986.

Clay	6 Jun	22 Jun	6 Jul	22 Jul	6 Aug	22 Aug
Twice-over 1983-1986						
Stalk Height cm			14.7	17.0	22.2	23.6
% Active Leaf			72.7	61.1	88.9	48.0
Leaf Height cm			11.4	10.7	11.4	13.0
Tallest Leaf cm			16.4	12.9	16.1	16.5
Ungrazed 1983-1986						
Stalk Height cm				25.3		22.2
% Active Leaf				70.6		55.6
Leaf Height cm				16.2		15.2
Tallest Leaf cm				21.8		17.6

Table 15. Growth and development of blue grama reproductive lead tillers on sandy soils managed with twice-over grazing and ungrazed treatments and the seasonlong and nongrazed treatments, 1987-1989.

Sandy	6 Jun	22 Jun	6 Jul	22 Jul	6 Aug	22 Aug
Twice-over 1987-1989						
Stalk Height cm			15.9	22.7	19.0	23.5
% Active Leaf			60.0	80.0	60.0	58.8
Leaf Height cm			8.6	11.4	8.5	11.1
Tallest Leaf cm			9.1	18.0	13.1	14.6
Ungrazed 1987-1989						
Stalk Height cm					20.7	19.3
% Active Leaf					55.6	45.0
Leaf Height cm					13.0	11.6
Tallest Leaf cm					14.2	12.0
Seasonlong 1987-1989						
Stalk Height cm				9.8	16.5	19.2
% Active Leaf				77.8	60.0	60.0
Leaf Height cm				9.7	10.3	10.1
Tallest Leaf cm				11.0	11.9	12.1
Nongrazed 1987-1989						
Stalk Height cm						28.9
% Active Leaf						55.6
Leaf Height cm						21.0
Tallest Leaf cm						25.6

Table 16. Growth and development of blue grama reproductive lead tillers on shallow soils managed with twice-over grazing and ungrazed treatments and the seasonlong and nongrazed treatments, 1987-1989.

Shallow	6 Jun	22 Jun	6 Jul	22 Jul	6 Aug	22 Aug
Twice-over 1987-1989						
Stalk Height cm		24.3	16.5	9.4	14.7	22.6
% Active Leaf		20.0	71.4	62.5	0.0	50.0
Leaf Height cm		2.5	8.8	6.6	-	10.0
Tallest Leaf cm		2.5	12.5	9.5	-	12.5
Ungrazed 1987-1989						
Stalk Height cm		20.7	20.3	16.5	19.9	21.4
% Active Leaf		100.0	66.7	59.1	20.0	44.4
Leaf Height cm		11.2	10.4	12.5	10.2	9.2
Tallest Leaf cm		14.6	13.5	15.6	10.2	11.1
Seasonlong 1987-1989						
Stalk Height cm					11.6	22.5
% Active Leaf					66.7	63.6
Leaf Height cm					7.8	11.4
Tallest Leaf cm					9.6	16.3
Nongrazed 1987-1989						
Stalk Height cm				8.0		18.8
% Active Leaf				60.0		60.0
Leaf Height cm				10.9		11.4
Tallest Leaf cm				11.5		14.9

Table 17. Growth and development of blue grama reproductive lead tillers on silty soils managed with twice-over grazing and ungrazed treatments and the seasonlong and nongrazed treatments, 1987-1989.

Silty	6 Jun	22 Jun	6 Jul	22 Jul	6 Aug	22 Aug
Twice-over 1987-1989						
Stalk Height cm			19.5	12.1	15.3	22.0
% Active Leaf			50.0	60.0	40.0	40.0
Leaf Height cm			9.4	8.6	10.6	9.6
Tallest Leaf cm			9.4	10.4	10.6	12.7
Ungrazed 1987-1989						
Stalk Height cm			13.7	15.4	19.6	26.5
% Active Leaf			60.0	44.4	40.0	50.0
Leaf Height cm			7.9	16.8	9.8	15.7
Tallest Leaf cm			9.5	16.5	9.8	19.1
Seasonlong 1987-1989						
Stalk Height cm			6.5	13.3		19.8
% Active Leaf			50.0	60.0		53.8
Leaf Height cm			4.7	8.7		5.9
Tallest Leaf cm			4.7	10.9		8.9
Nongrazed 1987-1989						
Stalk Height cm						29.3
% Active Leaf						61.1
Leaf Height cm						15.0
Tallest Leaf cm						19.3

Vegetative Tillers

The vegetative tillers had the second fastest rate of growth and development continuing until mid to late July. Early new leaf development for vegetative tillers arise from fall produced crown tiller buds during mid April. The rate of growth greatly increased during May and early June resulting in tillers with 3.5 leaves during mid June. During mid to late July the rate of growth decreased resulting in tillers with 5 to 7 basal leaves. A few of the vegetative tillers with 5 to 7 basal leaves added leaves 8 and 9 during July and August (figure 1).

Growth and development data of blue grama vegetative tillers on sandy soils managed with the twice-over strategy during 1983 to 1986 are on table 18.

Vegetative tillers with 5 leaves composed 46.8% of the population with 566 tillers, during the growing season a mean of 3.5 leaves (70.0%) were photosynthetically active with a mean leaf height of 6.2 cm and the tallest leaf averaged 9.5 cm tall (table 18).

Vegetative tillers with 6 leaves composed 39.0% of the population with 472 tillers, during the growing season a mean of 4.0 leaves (66.7%) were photosynthetically active with a mean leaf height of 6.0 cm and the tallest leaf averaged 7.3 cm tall (table 18).

Vegetative tillers with 7 leaves composed 11.6% of the population with 140 tillers, during the growing season a mean of 4.3 leaves (61.9%) were photosynthetically active with a mean leaf height of 6.3 cm and the tallest leaf averaged 7.9 cm tall (table 18).

Vegetative tillers with 8 leaves composed 2.5% of the population with 30 tillers, during the growing season a mean of 5.0 leaves (62.5%) were photosynthetically active with a mean leaf height of 6.7 cm and the tallest leaf averaged 8.4 cm tall (table 18).

Vegetative tillers with 9 leaves composed 0.1% of the population with 1 tiller, during the growing season a mean of 3.0 leaves (33.3%) were photosynthetically active with a mean leaf height of 9.7 cm and the tallest leaf averaged 12.9 cm tall (table 18).

Growth and development data of blue grama vegetative tillers on sandy soils managed with the ungrazed treatment during 1983 to 1986 are on table 19.

Vegetative tillers with 5 leaves composed 49.8% of the population with 419 tillers, during the growing season a mean of 3.3 leaves (66.7%) were photosynthetically active with a mean leaf height of 5.9 cm and the tallest leaf averaged 9.8 cm tall (table 19).

Vegetative tillers with 6 leaves composed 36.7% of the population with 309 tillers, during the growing season a mean of 3.9 leaves (65.3%) were photosynthetically active with a mean leaf height of 6.5 cm and the tallest leaf averaged 8.0 cm tall (table 19).

Vegetative tillers with 7 leaves composed 11.4% of the population with 96 tillers, during the growing season a mean of 4.2 leaves (59.5%) were photosynthetically active with a mean leaf height of 7.1 cm and the tallest leaf averaged 9.0 cm tall (table 19).

Vegetative tillers with 8 leaves composed 1.8% of the population with 15 tillers, during the growing season a mean of 5.0 leaves (62.5%) were photosynthetically active with a mean leaf height of 7.3 cm and the tallest leaf averaged 10.7 cm tall (table 19).

Vegetative tillers with 9 leaves composed 0.2% of the population with 2 tillers, during the growing season a mean of 6.0 leaves (66.7%) were photosynthetically active with a mean leaf height of 4.9 cm and the tallest leaf averaged 5.9 cm tall (table 19).

Growth and development data of blue grama vegetative tillers on shallow soils managed with the twice-over strategy during 1983 to 1986 are on table 20.

Vegetative tillers with 5 leaves composed 51.5% of the population with 609 tillers, during the growing season a mean of 3.3 leaves (65.0%) were photosynthetically active with a mean leaf height of 4.0 cm and the tallest leaf averaged 4.7 cm tall (table 20).

Vegetative tillers with 6 leaves composed 35.7% of the population with 422 tillers, during the growing season a mean of 3.9 leaves (65.3%) were photosynthetically active with a mean leaf height of 4.1 cm and the tallest leaf averaged 4.9 cm tall (table 20).

Vegetative tillers with 7 leaves composed 11.5% of the population with 136 tillers, during the growing season a mean of 4.7 leaves (67.1%) were photosynthetically active with a mean leaf height of 4.4 cm and the tallest leaf averaged 5.4 cm tall (table 20).

Vegetative tillers with 8 leaves composed 1.3% of the population with 15 tillers, during the growing season a mean of 4.8 leaves (59.4%) were photosynthetically active with a mean leaf height of 4.6 cm and the tallest leaf averaged 5.8 cm tall (table 20).

Vegetative tillers with 9 leaves composed 0.1% of the population with 1 tiller, during the growing season a mean of 3.0 leaves (33.3%) were photosynthetically active with a mean leaf height of 2.2 cm and the tallest leaf averaged 2.9 cm tall (table 20).

Growth and development data of blue grama vegetative tillers on shallow soils managed with the ungrazed treatment during 1983 to 1986 are on table 21.

Vegetative tillers with 5 leaves composed 49.3% of the population with 394 tillers, during the growing season a mean of 3.3 leaves (65.0%) were photosynthetically active with a mean leaf height of 4.4 cm and the tallest leaf averaged 5.3 cm tall (table 21).

Vegetative tillers with 6 leaves composed 40.3% of the population with 322 tillers, during the growing season a mean of 3.9 leaves (65.3%) were photosynthetically active with a mean leaf height of 5.0 cm and the tallest leaf averaged 6.6 cm tall (table 21).

Vegetative tillers with 7 leaves composed 10.1% of the population with 81 tillers, during the growing season a mean of 4.7 leaves (67.8%) were photosynthetically active with a mean leaf height of 4.6 cm and the tallest leaf averaged 5.9 cm tall (table 21).

Vegetative tillers with 8 leaves composed 0.3% of the population with 2 tillers, during the growing season a mean of 6.0 leaves (75.0%) were photosynthetically active with a mean leaf height of 4.7 cm and the tallest leaf averaged 7.4 cm tall (table 21).

Vegetative tillers with 9 leaves composed 0.1% of the population with 1 tiller, during the growing season a mean of 6.0 leaves (66.7%) were photosynthetically active with a mean leaf height of 3.8 cm and the tallest leaf averaged 5.0 cm tall (table 21).

Growth and development data of blue grama vegetative tillers on silty soils managed with the twice-over strategy during 1983 to 1986 are on table 22.

Vegetative tillers with 5 leaves composed 47.3% of the population with 556 tillers, during the growing season a mean of 3.2 leaves (63.3%) were photosynthetically active with a mean leaf height of 6.1 cm and the tallest leaf averaged 7.1 cm tall (table 22).

Vegetative tillers with 6 leaves composed 38.4% of the population with 451 tillers, during the growing season a mean of 3.8 leaves (63.9%) were photosynthetically active with a mean leaf height of 6.1 cm and the tallest leaf averaged 7.5 cm tall (table 22).

Vegetative tillers with 7 leaves composed 12.5% of the population with 147 tillers, during the growing season a mean of 4.5 leaves (64.3%) were photosynthetically active with a mean leaf height of 6.2 cm and the tallest leaf averaged 7.9 cm tall (table 22).

Vegetative tillers with 8 leaves composed 1.6% of the population with 19 tillers, during the growing season a mean of 4.2 leaves (53.1%) were photosynthetically active with a mean leaf height of 7.5 cm and the tallest leaf averaged 9.9 cm tall (table 22).

Vegetative tillers with 9 leaves composed 0.3% of the population with 3 tillers, during the growing season a mean of 3.5 leaves (38.9%) were photosynthetically active with a mean leaf height of 10.5 cm and the tallest leaf averaged 13.7 cm tall (table 22).

Growth and development data of blue grama vegetative tillers on silty soils managed with the ungrazed treatment during 1983 to 1986 are on table 23.

Vegetative tillers with 5 leaves composed 45.1% of the population with 338 tillers, during the growing season a mean of 3.1 leaves (61.7%) were photosynthetically active with a mean leaf height of 7.5 cm and the tallest leaf averaged 9.1 cm tall (table 23).

Vegetative tillers with 6 leaves composed 39.3% of the population with 295 tillers, during the growing season a mean of 3.9 leaves (65.3%) were photosynthetically active with a mean leaf height of 8.7 cm and the tallest leaf averaged 10.9 cm tall (table 23).

Vegetative tillers with 7 leaves composed 13.5% of the population with 101 tillers, during the growing season a mean of 4.1 leaves (59.5%) were photosynthetically active with a mean leaf height of 9.4 cm and the tallest leaf averaged 12.1 cm tall (table 23).

Vegetative tillers with 8 leaves composed 1.7% of the population with 13 tillers, during the growing season a mean of 3.5 leaves (43.8%) were photosynthetically active with a mean leaf height of 11.8 cm and the tallest leaf averaged 15.4 cm tall (table 23).

Vegetative tillers with 9 leaves composed 0.4% of the population with 3 tillers, during the growing season a mean of 3.8 leaves (41.7%) were photosynthetically active with a mean leaf height of 12.0 cm and the tallest leaf averaged 17.2 cm tall (table 23).

Growth and development data of blue grama vegetative tillers on clay soils managed with the twice-over strategy during 1983 to 1986 are on table 24.

Vegetative tillers with 5 leaves composed 60.4% of the population with 431 tillers, during the growing season a mean of 3.2 leaves (63.3%) were photosynthetically active with a mean leaf height of 6.0 cm and the tallest leaf averaged 8.8 cm tall (table 24).

Vegetative tillers with 6 leaves composed 30.0% of the population with 214 tillers, during the growing season a mean of 3.8 leaves (63.9%) were photosynthetically active with a mean leaf height of 5.4 cm and the tallest leaf averaged 6.7 cm tall (table 24).

Vegetative tillers with 7 leaves composed 8.5% of the population with 61 tillers, during the growing season a mean of 4.1 leaves (58.3%) were photosynthetically active with a mean leaf height of 5.5 cm and the tallest leaf averaged 7.6 cm tall (table 24).

Vegetative tillers with 8 leaves composed 1.0% of the population with 7 tillers, during the growing season a mean of 4.3 leaves (54.2%) were photosynthetically active with a mean leaf height of 7.7 cm and the tallest leaf averaged 11.1 cm tall (table 24).

Vegetative tillers with 9 leaves composed 0.1% of the population with 1 tiller, during the growing season a mean of 4.0 leaves (44.4%) were photosynthetically active with a mean leaf height of 10.7 cm and the tallest leaf averaged 18.7 cm tall (table 24).

Growth and development data of blue grama vegetative tillers on clay soils managed with the ungrazed treatment during 1983 to 1986 are on table 25.

Vegetative tillers with 5 leaves composed 52.9% of the population with 254 tillers, during the growing season a mean of 3.1 leaves (61.7%) were photosynthetically active with a mean leaf height of 7.7 cm and the tallest leaf averaged 11.1 cm tall (table 25).

Vegetative tillers with 6 leaves composed 37.7% of the population with 181 tillers, during the growing season a mean of 3.3 leaves (54.2%) were photosynthetically active with a mean leaf height of 7.2 cm and the tallest leaf averaged 8.8 cm tall (table 25).

Vegetative tillers with 7 leaves composed 8.3% of the population with 40 tillers, during the growing season a mean of 4.3 leaves (61.9%) were photosynthetically active with a mean leaf height of 8.6 cm and the tallest leaf averaged 11.0 cm tall (table 25).

Vegetative tillers with 8 leaves composed 1.0% of the population with 5 tillers, during the growing season a mean of 4.2 leaves (53.1%) were photosynthetically active with a mean leaf height of 6.9 cm and the tallest leaf averaged 9.5 cm tall (table 25).

Vegetative tillers with 9 leaves composed 0.0% of the population with 0 tillers (table 25).

Growth and development data of blue grama vegetative tillers on sandy soils managed with the twice-over strategy during 1987 to 1989 are on table 26.

Vegetative tillers with 5 leaves composed 57.7% of the population with 162 tillers, during the growing season a mean of 3.3 leaves (66.7%) were photosynthetically active with a mean leaf height of 5.2 cm and the tallest leaf averaged 6.9 cm tall (table 26).

Vegetative tillers with 6 leaves composed 33.1% of the population with 93 tillers, during the growing season a mean of 4.0 leaves (66.7%) were photosynthetically active with a mean leaf height of 4.1 cm and the tallest leaf averaged 5.0 cm tall (table 26).

Vegetative tillers with 7 leaves composed 8.9% of the population with 25 tillers, during the growing season a mean of 4.5 leaves (64.3%) were photosynthetically active with a mean leaf height of 3.6 cm and the tallest leaf averaged 4.4 cm tall (table 26).

Vegetative tillers with 8 leaves composed 0.4% of the population with 1 tiller, during the growing season a mean of 6.0 leaves (75.0%) were photosynthetically active with a mean leaf height of 4.7 cm and the tallest leaf averaged 6.3 cm tall (table 26).

Vegetative tillers with 9 leaves composed 0.0% of the population with 0 tillers (table 26).

Growth and development data of blue grama vegetative tillers on sandy soils managed with the ungrazed treatment during 1987 to 1989 are on table 27.

Vegetative tillers with 5 leaves composed 57.6% of the population with 231 tillers, during the growing season a mean of 3.2 leaves (63.3%) were photosynthetically active with a mean leaf height of 6.4 cm and the tallest leaf averaged 8.3 cm tall (table 27).

Vegetative tillers with 6 leaves composed 34.9% of the population with 140 tillers, during the growing season a mean of 4.0 leaves (66.7%) were photosynthetically active with a mean leaf height of 6.4 cm and the tallest leaf averaged 7.8 cm tall (table 27).

Vegetative tillers with 7 leaves composed 6.5% of the population with 26 tillers, during the growing season a mean of 4.7 leaves (67.8%) were photosynthetically active with a mean leaf height of 6.1 cm and the tallest leaf averaged 7.8 cm tall (table 27).

Vegetative tillers with 8 leaves composed 0.7% of the population with 3 tillers, during the growing season a mean of 5.5 leaves (68.8%) were photosynthetically active with a mean leaf height of 7.7 cm and the tallest leaf averaged 9.5 cm tall (table 27).

Vegetative tillers with 9 leaves composed 0.2% of the population with 1 tiller, during the growing season a mean of 7.0 leaves (77.8%) were photosynthetically active with a mean leaf height of 5.3 cm and the tallest leaf averaged 7.5 cm tall (table 27).

Growth and development data of blue grama vegetative tillers on sandy soils managed with the traditional seasonlong practice during 1987 to 1989 are on table 28.

Vegetative tillers with 5 leaves composed 57.4% of the population with 31 tillers, during the growing season a mean of 3.6 leaves (71.7%) were photosynthetically active with a mean leaf height of 18.8 cm and the tallest leaf averaged 23.2 cm tall (table 28).

Vegetative tillers with 6 leaves composed 37.0% of the population with 20 tillers, during the growing season a mean of 4.0 leaves (66.7%) were photosynthetically active with a mean leaf height of 22.4 cm and the tallest leaf averaged 29.2 cm tall (table 28).

Vegetative tillers with 7 leaves composed 5.6% of the population with 3 tillers, during the growing season a mean of 4.5 leaves (64.3%) were photosynthetically active with a mean leaf height of 25.5 cm and the tallest leaf averaged 32.7 cm tall (table 28).

Vegetative tillers with 8 and 9 leaves composed 0.0% of the population with 0 tillers (table 28).

Growth and development data of blue grama vegetative tillers on sandy soils managed with the long-term nongrazed treatment during 1987 to 1989 are on table 29.

Vegetative tillers with 5 leaves composed 62.7% of the population with 89 tillers, during the growing season a mean of 3.6 leaves (72.0%) were photosynthetically active with a mean leaf height of 4.6 cm and the tallest leaf averaged 6.2 cm tall (table 29).

Vegetative tillers with 6 leaves composed 29.6% of the population with 42 tillers, during the growing season a mean of 4.0 leaves (66.7%) were photosynthetically active with a mean leaf height of 4.9 cm and the tallest leaf averaged 6.3 cm tall (table 29).

Vegetative tillers with 7 leaves composed 7.0% of the population with 10 tillers, during the growing season a mean of 4.3 leaves (61.9%) were photosynthetically active with a mean leaf height of 5.3 cm and the tallest leaf averaged 7.1 cm tall (table 29).

Vegetative tillers with 8 leaves composed 0.7% of the population with 1 tiller, during the growing season a mean of 3.0 leaves (37.5%) were photosynthetically active with a mean leaf height of 5.6 cm and the tallest leaf averaged 6.3 cm tall (table 29).

Vegetative tillers with 9 leaves composed 0.0% of the population with 0 tillers (table 29).

Growth and development data of blue grama vegetative tillers on shallow soils managed with the twice-over strategy during 1987 to 1989 are on table 30.

Vegetative tillers with 5 leaves composed 66.4% of the population with 204 tillers, during the growing season a mean of 3.3 leaves (66.7%) were photosynthetically active with a mean leaf height of 9.5 cm and the tallest leaf averaged 13.2 cm tall (table 30).

Vegetative tillers with 6 leaves composed 30.0% of the population with 92 tillers, during the growing season a mean of 3.8 leaves (62.5%) were photosynthetically active with a mean leaf height of 9.6 cm and the tallest leaf averaged 11.9 cm tall (table 30).

Vegetative tillers with 7 leaves composed 2.6% of the population with 8 tillers, during the growing season a mean of 4.3 leaves (61.9%) were photosynthetically active with a mean leaf height of 9.4 cm and the tallest leaf averaged 12.0 cm tall (table 30).

Vegetative tillers with 8 leaves composed 1.0% of the population with 3 tillers, during the growing season a mean of 5.0 leaves (62.5%) were photosynthetically active with a mean leaf height of 12.7 cm and the tallest leaf averaged 16.2 cm tall (table 30).

Vegetative tillers with 9 leaves composed 0.0% of the population with 0 tillers (table 30).

Growth and development data of blue grama vegetative tillers on shallow soils managed with the ungrazed treatment during 1987 to 1989 are on table 31.

Vegetative tillers with 5 leaves composed 61.4% of the population with 261 tillers, during the growing season a mean of 3.3 leaves (66.7%) were photosynthetically active with a mean leaf height of 5.5 cm and the tallest leaf averaged 7.0 cm tall (table 31).

Vegetative tillers with 6 leaves composed 33.2% of the population with 141 tillers, during the growing season a mean of 3.8 leaves (62.5%) were photosynthetically active with a mean leaf height of 4.6 cm and the tallest leaf averaged 5.2 cm tall (table 31).

Vegetative tillers with 7 leaves composed 4.9% of the population with 21 tillers, during the growing season a mean of 4.3 leaves (61.9%) were photosynthetically active with a mean leaf height of 4.5 cm and the tallest leaf averaged 5.8 cm tall (table 31).

Vegetative tillers with 8 leaves composed 0.5% of the population with 2 tillers, during the growing season a mean of 5.5 leaves (68.8%) were photosynthetically active with a mean leaf height of 8.6 cm and the tallest leaf averaged 11.0 cm tall (table 31).

Vegetative tillers with 9 leaves composed 0.0% of the population with 0 tillers (table 31).

Growth and development data of blue grama vegetative tillers on shallow soils managed with the traditional seasonlong practice during 1987 to 1989 are on table 32.

Vegetative tillers with 5 leaves composed 78.6% of the population with 33 tillers, during the growing season a mean of 3.7 leaves (73.3%) were photosynthetically active with a mean leaf height of 4.1 cm and the tallest leaf averaged 4.9 cm tall (table 32).

Vegetative tillers with 6 leaves composed 21.4% of the population with 9 tillers, during the growing season a mean of 4.0 leaves (66.7%) were photosynthetically active with a mean leaf height of

4.9 cm and the tallest leaf averaged 7.1 cm tall (table 32).

Vegetative tillers with 7, 8, and 9 leaves composed 0.0% of the population with 0 tillers (table 32).

Growth and development data of blue grama vegetative tillers on shallow soils managed with the long-term nongrazed treatment during 1987 to 1989 are on table 33.

Vegetative tillers with 5 leaves composed 53.4% of the population with 79 tillers, during the growing season a mean of 3.2 leaves (64.0%) were photosynthetically active with a mean leaf height of 6.2 cm and the tallest leaf averaged 8.4 cm tall (table 33).

Vegetative tillers with 6 leaves composed 39.9% of the population with 59 tillers, during the growing season a mean of 3.8 leaves (62.5%) were photosynthetically active with a mean leaf height of 6.8 cm and the tallest leaf averaged 8.5 cm tall (table 33).

Vegetative tillers with 7 leaves composed 6.1% of the population with 9 tillers, during the growing season a mean of 3.5 leaves (50.0%) were photosynthetically active with a mean leaf height of 6.7 cm and the tallest leaf averaged 8.4 cm tall (table 33).

Vegetative tillers with 8 leaves composed 0.7% of the population with 1 tiller, during the growing season a mean of 3.0 leaves (37.5%) were photosynthetically active with a mean leaf height of 7.1 cm and the tallest leaf averaged 10.8 cm tall (table 33).

Vegetative tillers with 9 leaves composed 0.0% of the population with 0 tillers (table 33).

Growth and development data of blue grama vegetative tillers on silty soils managed with the twice-over strategy during 1987 to 1989 are on table 34.

Vegetative tillers with 5 leaves composed 68.0% of the population with 170 tillers, during the growing season a mean of 3.4 leaves (68.0%) were photosynthetically active with a mean leaf height of 4.8 cm and the tallest leaf averaged 5.9 cm tall (table 34).

Vegetative tillers with 6 leaves composed 28.4% of the population with 71 tillers, during the growing season a mean of 3.5 leaves (58.4%) were photosynthetically active with a mean leaf height of 4.5 cm and the tallest leaf averaged 5.6 cm tall (table 34).

Vegetative tillers with 7 leaves composed 3.6% of the population with 9 tillers, during the growing season a mean of 3.2 leaves (46.4%) were photosynthetically active with a mean leaf height of 5.5 cm and the tallest leaf averaged 6.6 cm tall (table 34).

Vegetative tillers with 8 and 9 leaves composed 0.0% of the population with 0 tillers (table 34).

Growth and development data of blue grama vegetative tillers on silty soils managed with the ungrazed treatment during 1987 to 1989 are on table 35.

Vegetative tillers with 5 leaves composed 62.0% of the population with 258 tillers, during the growing season a mean of 3.3 leaves (66.7%) were photosynthetically active with a mean leaf height of 6.1 cm and the tallest leaf averaged 7.4 cm tall (table 35).

Vegetative tillers with 6 leaves composed 31.5% of the population with 131 tillers, during the growing season a mean of 4.2 leaves (70.0%) were photosynthetically active with a mean leaf height of 6.6 cm and the tallest leaf averaged 8.3 cm tall (table 35).

Vegetative tillers with 7 leaves composed 6.3% of the population with 26 tillers, during the growing season a mean of 5.0 leaves (71.4%) were photosynthetically active with a mean leaf height of 8.7 cm and the tallest leaf averaged 11.3 cm tall (table 35).

Vegetative tillers with 8 leaves composed 0.0% of the population with 0 tillers (table 35).

Vegetative tillers with 9 leaves composed 0.2% of the population with 1 tiller, during the growing season a mean of 4.0 leaves (44.4%) were photosynthetically active with a mean leaf height of 10.9 cm and the tallest leaf averaged 13.8 cm tall (table 35).

Growth and development data of blue grama vegetative tillers on silty soils managed with the traditional seasonlong practice during 1987 to 1989 are on table 36.

Vegetative tillers with 5 leaves composed 74.2% of the population with 66 tillers, during the growing season a mean of 3.3 leaves (66.7%) were photosynthetically active with a mean leaf height of 4.6 cm and the tallest leaf averaged 5.5 cm tall (table 36).

Vegetative tillers with 6 leaves composed 24.7% of the population with 22 tillers, during the growing season a mean of 4.0 leaves (66.7%) were photosynthetically active with a mean leaf height of 5.2 cm and the tallest leaf averaged 6.3 cm tall (table 36).

Vegetative tillers with 7 leaves composed 1.1% of the population with 1 tiller, during the growing season a mean of 4.0 leaves (57.1%) were photosynthetically active with a mean leaf height of 7.0 cm and the tallest leaf averaged 8.3 cm tall (table 36).

Vegetative tillers with 8 and 9 leaves composed 0.0% of the population with 0 tillers (table 36).

Growth and development data of blue grama vegetative tillers on silty soils managed with the long-term nongrazed treatment during 1987 to 1989 are on table 37

Vegetative tillers with 5 leaves composed 68.8 the population with 119 tillers, during the growing season a mean of 3.3 leaves (66.7%) were photosynthetically active with a mean leaf height of 7.9 cm and the tallest leaf averaged 9.8 cm tall (table 37).

Vegetative tillers with 6 leaves composed 27.2% of the population with 47 tillers, during the growing season a mean of 3.8 leaves (62.5%) were photosynthetically active with a mean leaf height of 8.3 cm and the tallest leaf averaged 10.4 cm tall (table 37).

Vegetative tillers with 7 leaves composed 4.0% of the population with 7 tillers, during the growing season a mean of 4.0 leaves (57.1%) were photosynthetically active with a mean leaf height of 7.9 cm and the tallest leaf averaged 10.3 cm tall (table 37).

Vegetative tillers with 8 and 9 leaves composed 0.0% of the population with 0 tillers (table 37).

Not all the leaves on a grass tiller are photosynthetically active during the entire growing season. Leaves grow and senesce in the order they appear. The first leaves are usually dry by early June and the second leaves are usually dry by late June. The rate of leaf senescence can be rapid during water deficiency periods and slow during periods with adequate precipitation. During senescence, leaves translocate cell components to other plant parts. The senesced leaf has less weight and has very low nutritional quality. The greater number of leaves not senescent, the greater the tiller nutritional quality.

The rate of leaf senescence of blue grama vegetative tillers on sandy, shallow, silty and clay soils managed with the ungrazed and twice-over treatments during 1983 to 1986 that received adequate precipitation was very similar with the first and second leaves drying during June. Most tillers with 5 to 7 leaves maintained leaf 3 plus all of their younger leaves photosynthetically active through August. The tillers with 8 and 9 leaves maintained 4.6 and 4.2 photosynthetically active leaves, respectively.

The rate of leaf senescence of blue grama vegetative tillers on sandy, shallow, and silty soils managed with the nongrazed, seasonlong, ungrazed, and twice-over treatments during 1987 to 1989 that had water deficiency during most of the growing season months was more severe than during the 1983 to 1986 period. Most tillers failed to produce leaf 9. Tillers on the nongrazed and seasonlong treatments maintained a mean of 3.3 and 3.4 photosynthetically active leaves during the growing season, respectively. Tillers on the twice-over and ungrazed treatment maintained a mean of 3.7 and 3.8 photosynthetically active leaves, respectively.

All of the vegetative tillers of blue grama with 5 to 9 leaves measured during this study were not grazed including the tillers located on grazed treatments. The not grazed tillers remaining on the grazed treatments tended to have slightly shorter mean leaf heights and mean tallest leaf heights which were not significantly different than the not grazed tillers on the ungrazed and nongrazed treatments on the sandy, shallow, silty, and clay soils during the 1983-1986 period and on the sandy, shallow, and silty soils during the 1987-1989 period. It is not believed that grazed treatments cause vegetative tillers to produce slightly shorter leaf heights. It is surmised that grazing cattle have a disproportional rate of selection for taller tillers than for shorter tillers leaving a distorted sample population of not grazed tillers with slightly shorter leaf heights.

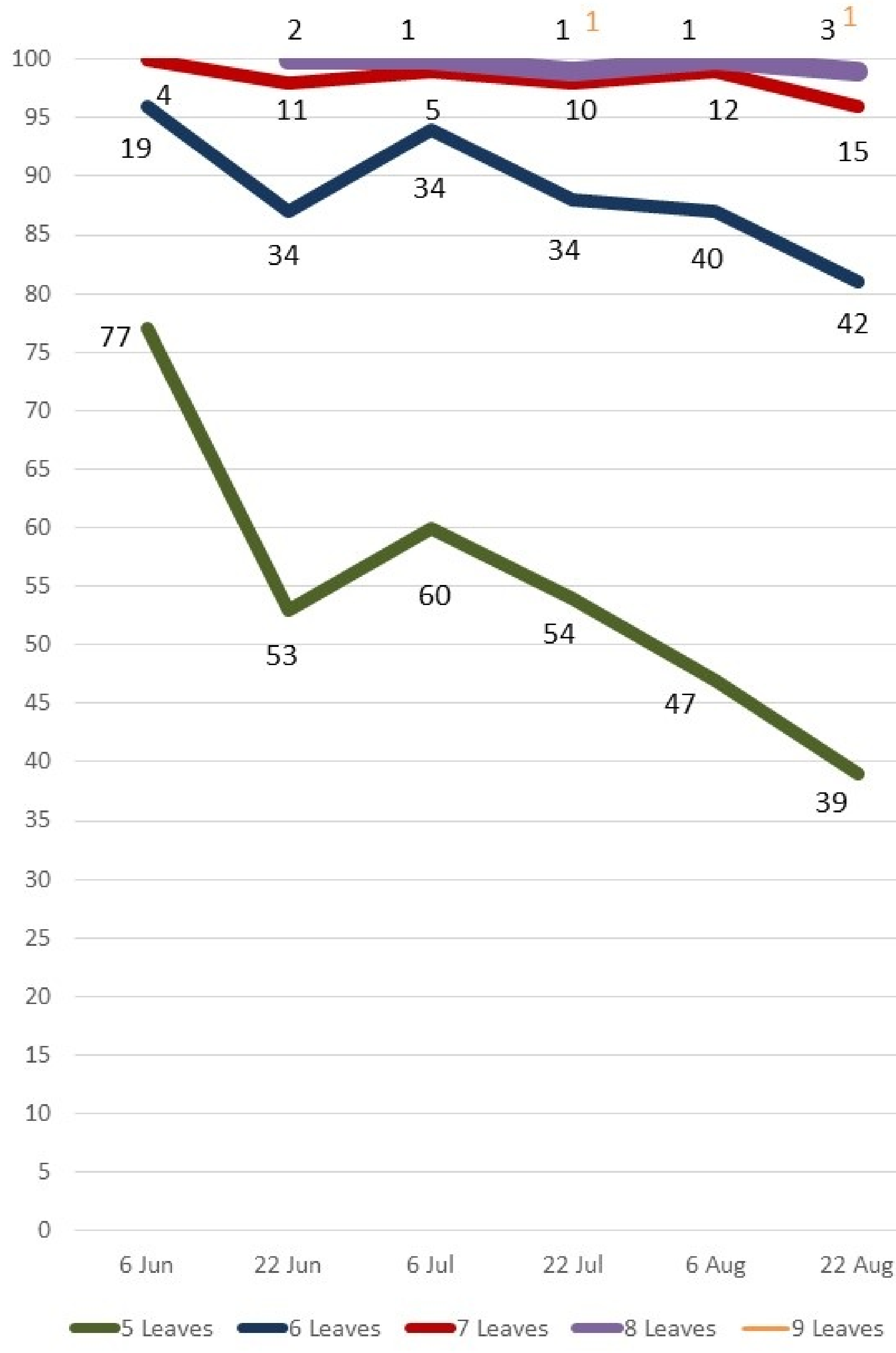

Figure 1. Percent of vegetative tiller population with 5 to 9 leaves.

Table 18. Growth and development of blue grama vegetative tillers with 5 to 9 leaves on sandy soils managed with the twice-over strategy, 1983-1986.

Sandy	6 Jun	22 Jun	6 Jul	22 Jul	6 Aug	22 Aug
5 Leaves						
% Population	72.2	49.8	50.8	55.9	39.3	29.5
% Active Leaf	80.0	80.0	60.0	70.0	60.0	70.0
Leaf Height cm	6.6	5.4	7.1	6.5	6.3	5.5
Tallest Leaf cm	12.1	9.2	10.5	9.7	8.3	7.1
6 Leaves						
% Population	19.0	42.0	38.5	36.7	46.4	42.0
% Active Leaf	66.7	66.7	66.7	66.7	66.7	66.7
Leaf Height cm	6.2	5.3	6.5	6.2	6.1	5.5
Tallest Leaf cm	7.5	6.9	7.9	7.6	7.3	6.6
7 Leaves						
% Population	8.9	6.9	8.2	5.9	13.4	22.4
% Active Leaf	71.4	64.3	57.1	64.3	57.1	57.1
Leaf Height cm	6.2	5.9	6.3	6.1	6.7	6.7
Tallest Leaf cm	8.6	7.7	7.2	7.9	8.3	7.9
8 Leaves						
% Population	0.0	1.2	2.5	1.5	0.9	5.8
% Active Leaf	-	62.5	62.5	62.5	75.0	50.0
Leaf Height cm	-	5.0	7.2	7.7	6.5	7.2
Tallest Leaf cm	-	5.8	8.5	9.7	9.0	8.9
9 leaves						
% Population	0.0	0.0	0.0	0.0	0.0	0.3
% Active Leaf	-	-	-	-	-	33.3
Leaf Height cm	-	-	-	-	-	9.7
Tallest Leaf cm	-	-	-	-	-	12.9
% Population	100.1	99.9	100.0	100.0	100.0	100.0

Table 19. Growth and development of blue grama vegetative tillers with 5 to 9 leaves on sandy soils managed with the ungrazed treatment, 1983-1986.

Sandy	6 Jun	22 Jun	6 Jul	22 Jul	6 Aug	22 Aug
5 Leaves						
% Population	71.4	52.3	55.6	67.2	42.0	27.5
% Active Leaf	80.0	70.0	80.0	60.0	60.0	50.0
Leaf Height cm	6.9	5.9	5.6	3.9	6.5	6.8
Tallest Leaf cm	12.1	9.0	8.9	10.4	10.0	8.1
6 Leaves						
% Population	23.1	33.3	35.5	29.4	42.9	48.2
% Active Leaf	66.7	66.7	66.7	66.7	66.7	58.3
Leaf Height cm	6.7	5.8	7.4	6.0	7.0	6.2
Tallest Leaf cm	8.8	7.4	8.8	7.1	8.6	7.3
7 Leaves						
% Population	4.4	10.8	8.9	3.4	12.6	21.2
% Active Leaf	57.1	64.3	71.4	57.1	57.1	50.0
Leaf Height cm	8.2	6.1	7.9	5.6	7.2	7.4
Tallest Leaf cm	10.3	8.6	10.3	6.7	9.0	8.8
8 Leaves						
% Population	1.1	2.6	0.0	0.0	2.5	3.1
% Active Leaf	62.5	62.5	-	-	62.5	62.5
Leaf Height cm	9.8	4.7	-	-	6.4	8.3
Tallest Leaf cm	14.8	7.1	-	-	8.9	12.1
9 leaves						
% Population	0.0	1.0	0.0	0.0	0.0	0.0
% Active Leaf	-	66.7	-	-	-	-
Leaf Height cm	-	4.9	-	-	-	-
Tallest Leaf cm	-	5.9	-	-	-	-
% Population	100.0	100.0	100.0	100.0	100.0	100.0

Table 20. Growth and development of blue grama vegetative tillers with 5 to 9 leaves on shallow soils managed with the twice-over strategy, 1983-1986.

Shallow	6 Jun	22 Jun	6 Jul	22 Jul	6 Aug	22 Aug
5 Leaves						
% Population	83.5	50.2	67.3	51.5	50.9	39.2
% Active Leaf	80.0	70.0	60.0	60.0	60.0	60.0
Leaf Height cm	4.0	3.9	3.8	4.3	4.2	3.7
Tallest Leaf cm	5.0	4.7	4.4	4.9	4.9	4.2
6 Leaves						
% Population	16.5	34.8	28.0	36.8	33.0	43.7
% Active Leaf	66.7	58.3	66.7	66.7	66.7	66.7
Leaf Height cm	3.5	4.1	4.2	4.3	4.2	4.4
Tallest Leaf cm	4.4	5.1	4.9	5.3	4.9	4.9
7 Leaves						
% Population	0.0	13.1	4.7	11.1	15.2	14.5
% Active Leaf	-	64.3	71.4	64.3	71.4	64.3
Leaf Height cm	-	4.3	4.3	4.5	4.6	4.1
Tallest Leaf cm	-	5.6	5.8	5.4	5.4	4.7
8 Leaves						
% Population	0.0	1.5	0.0	0.7	0.9	2.6
% Active Leaf	-	62.5	-	50.0	75.0	50.0
Leaf Height cm	-	3.6	-	4.2	4.1	6.3
Tallest Leaf cm	-	5.0	-	5.3	5.0	8.0
9 leaves						
% Population	0.0	0.4	0.0	0.0	0.0	0.0
% Active Leaf	-	33.3	-	-	-	-
Leaf Height cm	-	2.2	-	-	-	-
Tallest Leaf cm	-	2.9	-	-	-	-
% Population	100.0	100.0	100.0	100.1	100.0	100.0

Table 21. Growth and development of blue grama vegetative tillers with 5 to 9 leaves on shallow soils managed with the ungrazed treatment, 1983-1986.

Shallow	6 Jun	22 Jun	6 Jul	22 Jul	6 Aug	22 Aug
5 Leaves						
% Population	80.2	50.5	53.8	49.1	41.3	37.6
% Active Leaf	80.0	60.0	80.0	60.0	60.0	50.0
Leaf Height cm	4.0	4.6	4.2	4.7	4.4	4.5
Tallest Leaf cm	5.4	5.3	5.2	5.5	5.2	5.4
6 Leaves						
% Population	13.6	42.5	38.7	33.9	45.2	50.8
% Active Leaf	66.7	66.7	66.7	66.7	66.7	58.3
Leaf Height cm	5.2	4.3	5.0	5.0	4.7	5.6
Tallest Leaf cm	6.4	5.5	6.3	6.0	5.4	6.8
7 Leaves						
% Population	6.2	7.0	7.5	15.2	12.7	11.6
% Active Leaf	71.4	64.3	71.4	71.4	71.4	57.1
Leaf Height cm	4.1	2.8	5.5	5.4	4.3	5.5
Tallest Leaf cm	5.5	4.1	7.1	6.9	4.8	7.2
8 Leaves						
% Population	0.0	0.0	0.0	1.8	0.0	0.0
% Active Leaf	-	-	-	75.0	-	-
Leaf Height cm	-	-	-	4.7	-	-
Tallest Leaf cm	-	-	-	7.4	-	-
9 leaves						
% Population	0.0	0.0	0.0	0.0	0.8	0.0
% Active Leaf	-	-	-	-	66.7	-
Leaf Height cm	-	-	-	-	3.8	-
Tallest Leaf cm	-	-	-	-	5.0	-
% Population	100.0	100.0	100.0	100.0	100.0	100.0

Table 22. Growth and development of blue grama vegetative tillers with 5 to 9 leaves on silty soils managed with the twice-over strategy, 1983-1986.

Silty	6 Jun	22 Jun	6 Jul	22 Jul	6 Aug	22 Aug
5 Leaves						
% Population	68.0	50.0	63.4	48.0	38.8	37.6
% Active Leaf	80.0	60.0	60.0	60.0	60.0	60.0
Leaf Height cm	5.1	5.3	5.9	7.1	6.6	6.3
Tallest Leaf cm	6.9	6.4	6.9	8.1	6.9	7.1
6 Leaves						
% Population	26.9	32.5	29.3	38.0	47.4	46.3
% Active Leaf	66.7	58.3	66.7	66.7	66.7	58.3
Leaf Height cm	5.6	5.2	5.9	6.7	6.1	7.0
Tallest Leaf cm	7.3	6.4	7.7	8.0	7.1	8.4
7 Leaves						
% Population	5.1	13.2	6.1	13.1	13.8	14.1
% Active Leaf	71.4	57.1	71.4	64.3	71.4	50.0
Leaf Height cm	5.5	5.1	5.9	7.7	6.1	6.9
Tallest Leaf cm	7.6	7.1	8.2	8.9	7.1	8.5
8 Leaves						
% Population	0.0	3.6	1.2	0.9	0.0	1.7
% Active Leaf	-	50.0	62.5	50.0	-	50.0
Leaf Height cm	-	6.1	7.2	7.5	-	9.3
Tallest Leaf cm	-	7.8	10.8	9.7	-	11.3
9 leaves						
% Population	0.0	0.7	0.0	0.0	0.0	0.3
% Active Leaf	-	44.1	-	-	-	33.3
Leaf Height cm	-	8.0	-	-	-	12.9
Tallest Leaf cm	0	0	0	0	0	0
% Population	100.0	100.0	100.0	100.0	100.0	100.0

Table 23. Growth and development of blue grama vegetative tillers with 5 to 9 leaves on silty soils managed with the ungrazed treatment, 1983-1986.

Silty	6 Jun	22 Jun	6 Jul	22 Jul	6 Aug	22 Aug
5 Leaves						
% Population	54.3	45.5	58.2	57.9	40.0	31.4
% Active Leaf	80.0	60.0	60.0	60.0	60.0	50.0
Leaf Height cm	6.3	7.0	7.9	8.3	7.6	8.1
Tallest Leaf cm	9.0	8.5	9.0	9.7	9.1	9.1
6 Leaves						
% Population	31.4	37.6	32.9	36.8	49.6	41.8
% Active Leaf	66.7	66.7	66.7	66.7	66.7	58.3
Leaf Height cm	7.6	7.3	9.6	10.5	8.7	8.7
Tallest Leaf cm	10.7	9.0	11.5	13.1	10.6	10.5
7 Leaves						
% Population	14.3	13.5	8.9	5.3	10.4	21.6
% Active Leaf	57.1	64.3	57.1	57.1	57.1	64.3
Leaf Height cm	8.4	7.8	7.9	12.3	10.5	9.2
Tallest Leaf cm	12.0	10.3	9.5	13.9	13.4	13.6
8 Leaves						
% Population	0.0	2.8	0.0	0.0	0.0	4.1
% Active Leaf	-	50.0	-	-	-	37.5
Leaf Height cm	-	9.8	-	-	-	13.8
Tallest Leaf cm	-	13.9	-	-	-	16.8
9 leaves						
% Population	0.0	0.6	0.0	0.0	0.0	1.0
% Active Leaf	-	55.6	-	-	-	27.8
Leaf Height cm	-	10.7	-	-	-	13.2
Tallest Leaf cm	-	16.2	-	-	-	18.2
% Population	100.0	100.0	100.0	100.0	100.0	99.9

Table 24. Growth and development of blue grama vegetative tillers with 5 to 9 leaves on clay soils managed with the twice-over strategy, 1983-1986.

Clay	6 Jun	22 Jun	6 Jul	22 Jul	6 Aug	22 Aug
5 Leaves						
% Population	85.4	62.4	58.9	61.7	60.6	51.8
% Active Leaf	80.0	60.0	60.0	60.0	60.0	60.0
Leaf Height cm	5.8	6.2	4.7	6.7	6.0	6.5
Tallest Leaf cm	10.1	9.8	6.7	9.7	8.3	8.4
6 Leaves						
% Population	12.5	26.3	39.7	26.9	33.3	35.2
% Active Leaf	66.7	66.7	66.7	66.7	50.0	66.7
Leaf Height cm	5.0	4.3	4.8	5.7	6.4	6.3
Tallest Leaf cm	7.0	5.6	5.6	6.9	7.5	7.6
7 Leaves						
% Population	2.1	11.3	1.4	10.4	4.5	10.4
% Active Leaf	71.4	57.1	28.6	64.3	71.4	57.1
Leaf Height cm	5.8	4.8	4.8	6.1	5.3	6.3
Tallest Leaf cm	10.0	6.5	7.2	7.9	6.6	7.1
8 Leaves						
% Population	0.0	0.0	0.0	0.5	1.5	2.6
% Active Leaf	-	-	-	37.5	75.0	50.0
Leaf Height cm	-	-	-	9.5	7.3	6.3
Tallest Leaf cm	-	-	-	12.0	12.2	9.0
9 leaves						
% Population	0.0	0.0	0.0	0.5	0.0	0.0
% Active Leaf	-	-	-	44.4	-	-
Leaf Height cm	-	-	-	10.7	-	-
Tallest Leaf cm	-	-	-	18.3	-	-
% Population	100.0	100.0	100.0	100.0	99.9	100.0

Table 25. Growth and development of blue grama vegetative tillers with 5 to 9 leaves on clay soils managed with the ungrazed treatment, 1983-1986.

Clay	6 Jun	22 Jun	6 Jul	22 Jul	6 Aug	22 Aug
5 Leaves						
% Population	72.5	56.5	50.0	55.4	48.6	45.7
% Active Leaf	80.0	60.0	60.0	60.0	60.0	50.0
Leaf Height cm	8.1	6.4	7.8	8.3	8.1	7.3
Tallest Leaf cm	14.5	8.8	11.8	12.7	10.4	8.3
6 Leaves						
% Population	15.0	36.1	45.7	36.5	37.5	43.1
% Active Leaf	50.0	66.7	66.7	66.7	50.0	58.3
Leaf Height cm	6.1	6.3	6.8	7.8	7.2	8.8
Tallest Leaf cm	7.8	7.8	8.6	9.1	8.6	10.8
7 Leaves						
% Population	12.5	6.5	4.3	6.8	12.5	9.5
% Active Leaf	42.9	71.4	57.1	71.4	71.4	57.1
Leaf Height cm	9.1	4.9	7.7	13.4	9.4	6.8
Tallest Leaf cm	10.8	7.1	10.0	17.2	11.6	9.3
8 Leaves						
% Population	0.0	0.9	0.0	1.4	1.4	1.7
% Active Leaf	-	62.5	-	62.5	50.0	37.5
Leaf Height cm	-	3.4	-	12.8	6.6	4.7
Tallest Leaf cm	-	4.6	-	17.9	9.2	6.2
9 leaves						
% Population	0.0	0.0	0.0	0.0	0.0	0.0
% Active Leaf	-	-	-	-	-	-
Leaf Height cm	-	-	-	-	-	-
Tallest Leaf cm	-	-	-	-	-	-
% Population	100.0	100.0	100.0	100.1	100.0	100.0

Table 26. Growth and development of blue grama vegetative tillers with 5 to 9 leaves on sandy soils managed with the twice-over strategy, 1987-1989.

Sandy	6 Jun	22 Jun	6 Jul	22 Jul	6 Aug	22 Aug
5 Leaves						
% Population	75.9	64.1	100.0	51.6	100.0	44.8
% Active Leaf	60.0	60.0	80.0	60.0	80.0	60.0
Leaf Height cm	3.4	5.1	4.9	5.3	7.0	5.2
Tallest Leaf cm	3.5	7.1	6.0	7.7	10.0	7.0
6 Leaves						
% Population	20.7	30.8	0.0	37.6	0.0	41.7
% Active Leaf	66.7	66.7	-	66.7	-	66.7
Leaf Height cm	3.0	4.3	-	4.1	-	4.9
Tallest Leaf cm	3.3	5.8	-	4.8	-	6.2
7 Leaves						
% Population	3.4	5.1	0.0	9.7	0.0	13.5
% Active Leaf	57.1	71.4	-	57.1	-	71.4
Leaf Height cm	2.6	4.2	-	3.8	-	3.9
Tallest Leaf cm	3.1	5.0	-	4.7	-	4.9
8 Leaves						
% Population	0.0	0.0	0.0	1.1	0.0	0.0
% Active Leaf	-	-	-	75.0	-	-
Leaf Height cm	-	-	-	4.7	-	-
Tallest Leaf cm	-	-	-	6.3	-	-
9 leaves						
% Population	0.0	0.0	0.0	0.0	0.0	0.0
% Active Leaf	-	-	-	-	-	-
Leaf Height cm	-	-	-	-	-	-
Tallest Leaf cm	-	-	-	-	-	-
% Population	100.0	100.0	100.0	100.0	100.0	100.0

Table 27. Growth and development of blue grama vegetative tillers with 5 to 9 leaves on sandy soils managed with the ungrazed treatment, 1987-1989.

Sandy	6 Jun	22 Jun	6 Jul	22 Jul	6 Aug	22 Aug
5 Leaves						
% Population	65.5	70.5	100.0	37.2	100.0	50.0
% Active Leaf	60.0	60.0	80.0	60.0	80.0	40.0
Leaf Height cm	4.7	6.6	5.1	7.3	6.0	8.8
Tallest Leaf cm	5.4	8.3	6.2	10.7	7.9	11.5
6 Leaves						
% Population	26.7	26.2	0.0	55.3	0.0	38.7
% Active Leaf	66.7	66.7	-	66.7	-	66.7
Leaf Height cm	4.9	7.6	-	5.6	-	7.4
Tallest Leaf cm	5.8	9.6	-	6.9	-	8.7
7 Leaves						
% Population	7.8	3.3	0.0	6.4	0.0	8.5
% Active Leaf	71.4	71.4	-	57.1	-	71.4
Leaf Height cm	4.6	6.5	-	5.9	-	7.5
Tallest Leaf cm	5.8	9.2	-	6.7	-	9.4
8 Leaves						
% Population	0.0	0.0	0.0	1.1	0.0	1.9
% Active Leaf	-	-	-	62.5	-	75.0
Leaf Height cm	-	-	-	7.0	-	8.4
Tallest Leaf cm	-	-	-	8.1	-	10.8
9 leaves						
% Population	0.0	0.0	0.0	0.0	0.0	0.9
% Active Leaf	-	-	-	-	-	77.8
Leaf Height cm	-	-	-	-	-	5.3
Tallest Leaf cm	-	-	-	-	-	7.5
% Population	100.0	100.0	100.0	100.0	100.0	100.0

Table 28. Growth and development of blue grama vegetative tillers with 5 to 9 leaves on sandy soils managed with the seasonlong treatment, 1987-1989.

Sandy	6 Jun	22 Jun	6 Jul	22 Jul	6 Aug	22 Aug
5 Leaves						
% Population	83.8	53.3	100.0	83.3	0.0	46.2
% Active Leaf	80.0	60.0	80.0	80.0	-	60.0
Leaf Height cm	4.6	3.3	4.7	4.4	-	5.9
Tallest Leaf cm	7.2	3.9	5.8	5.0	-	9.3
6 Leaves						
% Population	10.8	26.7	0.0	16.7	0.0	46.2
% Active Leaf	50.0	66.7	-	83.3	-	66.7
Leaf Height cm	5.7	3.5	-	5.7	-	4.6
Tallest Leaf cm	6.3	4.5	-	8.2	-	6.0
7 Leaves						
% Population	5.4	13.3	0.0	0.0	0.0	7.7
% Active Leaf	57.1	57.1	-	-	-	71.4
Leaf Height cm	7.9	3.8	-	-	-	4.3
Tallest Leaf cm	10.1	5.6	-	-	-	5.9
8 Leaves						
% Population	0.0	6.7	0.0	0.0	0.0	0.0
% Active Leaf	-	37.5	-	-	-	-
Leaf Height cm	-	5.6	-	-	-	-
Tallest Leaf cm	-	6.3	-	-	-	-
9 leaves						
% Population	0.0	0.0	0.0	0.0	0.0	0.0
% Active Leaf	-	-	-	-	-	-
Leaf Height cm	-	-	-	-	-	-
Tallest Leaf cm	-	-	-	-	-	-
% Population	100.0	100.0	100.0	100.0	0.0	100.1

Table 29. Growth and development of blue grama vegetative tillers with 5 to 9 leaves on sandy soils managed with the nongrazed treatment, 1987-1989.

Sandy	6 Jun	22 Jun	6 Jul	22 Jul	6 Aug	22 Aug
5 Leaves						
% Population	60.6	66.7	100.0	54.8	100.0	52.4
% Active Leaf	60.0	60.0	80.0	80.0	60.0	60.0
Leaf Height cm	8.6	9.3	5.7	10.8	8.3	14.3
Tallest Leaf cm	10.4	12.5	7.5	16.6	10.0	21.9
6 Leaves						
% Population	36.4	33.3	0.0	25.8	0.0	38.1
% Active Leaf	66.7	50.0	-	66.7	-	66.7
Leaf Height cm	8.7	7.4	-	10.5	-	11.9
Tallest Leaf cm	11.6	8.7	-	11.8	-	15.5
7 Leaves						
% Population	3.0	0.0	0.0	16.1	0.0	9.5
% Active Leaf	71.4	-	-	57.1	-	57.1
Leaf Height cm	7.0	-	-	10.5	-	10.6
Tallest Leaf cm	10.8	-	-	12.3	-	12.8
8 Leaves						
% Population	0.0	0.0	0.0	3.2	0.0	0.0
% Active Leaf	-	-	-	62.5	-	-
Leaf Height cm	-	-	-	12.7	-	-
Tallest Leaf cm	-	-	-	16.2	-	-
9 leaves						
% Population	0.0	0.0	0.0	0.0	0.0	0.0
% Active Leaf	-	-	-	-	-	-
Leaf Height cm	-	-	-	-	-	-
Tallest Leaf cm	-	-	-	-	-	-
% Population	100.0	100.0	100.0	99.9	100.0	100.0

Table 30. Growth and development of blue grama vegetative tillers with 5 to 9 leaves on shallow soils managed with the twice-over strategy, 1987-1989.

Shallow	6 Jun	22 Jun	6 Jul	22 Jul	6 Aug	22 Aug
5 Leaves						
% Population	66.7	64.6	90.0	62.1	100.0	61.3
% Active Leaf	60.0	60.0	80.0	60.0	80.0	60.0
Leaf Height cm	3.3	4.1	4.6	4.9	6.3	6.8
Tallest Leaf cm	3.7	4.8	5.8	7.4	8.8	10.8
6 Leaves						
% Population	27.8	33.3	10.0	35.8	0.0	32.3
% Active Leaf	66.7	66.7	83.3	66.7	-	66.7
Leaf Height cm	2.6	4.7	5.6	3.7	-	5.4
Tallest Leaf cm	3.5	5.5	7.9	4.2	-	6.9
7 Leaves						
% Population	2.8	2.1	0.0	1.1	0.0	5.4
% Active Leaf	42.9	57.1	-	71.4	-	42.9
Leaf Height cm	3.1	8.1	-	4.2	-	5.2
Tallest Leaf cm	4.5	9.5	-	5.6	-	6.6
8 Leaves						
% Population	2.8	0.0	0.0	1.1	0.0	1.1
% Active Leaf	62.5	-	-	75.0	-	50.0
Leaf Height cm	2.5	-	-	2.7	-	5.2
Tallest Leaf cm	3.8	-	-	3.9	-	7.7
9 leaves						
% Population	0.0	0.0	0.0	0.0	0.0	0.0
% Active Leaf	-	-	-	-	-	-
Leaf Height cm	-	-	-	-	-	-
Tallest Leaf cm	-	-	-	-	-	-
% Population	100.1	100.0	100.0	100.1	100.0	100.1

Table 31. Growth and development of blue grama vegetative tillers with 5 to 9 leaves on shallow soils managed with the ungrazed treatment, 1987-1989.

Shallow	6 Jun	22 Jun	6 Jul	22 Jul	6 Aug	22 Aug
5 Leaves						
% Population	51.6	74.4	100.0	62.1	100.0	55.6
% Active Leaf	60.0	60.0	80.0	60.0	80.0	60.0
Leaf Height cm	3.8	4.0	4.3	5.0	9.5	6.1
Tallest Leaf cm	4.3	4.6	5.7	5.4	13.1	9.1
6 Leaves						
% Population	40.2	25.6	0.0	30.5	0.0	38.9
% Active Leaf	66.7	66.7	-	66.7	-	50.0
Leaf Height cm	4.2	4.2	-	4.7	-	5.2
Tallest Leaf cm	4.9	4.7	-	5.5	-	5.7
7 Leaves						
% Population	8.2	0.0	0.0	6.3	0.0	4.6
% Active Leaf	71.4	-	-	71.4	-	42.9
Leaf Height cm	3.6	-	-	4.7	-	5.2
Tallest Leaf cm	4.5	-	-	6.2	-	6.6
8 Leaves						
% Population	0.0	0.0	0.0	1.1	0.0	0.9
% Active Leaf	-	-	-	75.0	-	62.5
Leaf Height cm	-	-	-	5.9	-	11.3
Tallest Leaf cm	-	-	-	7.6	-	14.3
9 leaves						
% Population	0.0	0.0	0.0	0.0	0.0	0.0
% Active Leaf	-	-	-	-	-	-
Leaf Height cm	-	-	-	-	-	-
Tallest Leaf cm	-	-	-	-	-	-
% Population	100.0	100.0	100.0	100.0	100.0	100.0

Table 32. Growth and development of blue grama vegetative tillers with 5 to 9 leaves on shallow soils managed with the seasonlong treatment, 1987-1989.

Shallow	6 Jun	22 Jun	6 Jul	22 Jul	6 Aug	22 Aug
5 Leaves						
% Population	100.0	100.0	100.0	100.0	100.0	50.0
% Active Leaf	60.0	80.0	80.0	80.0	80.0	60.0
Leaf Height cm	3.4	2.0	5.9	4.7	3.9	4.4
Tallest Leaf cm	3.6	2.9	7.0	5.4	5.1	5.5
6 Leaves						
% Population	0.0	0.0	0.0	0.0	0.0	50.0
% Active Leaf	-	-	-	-	-	66.7
Leaf Height cm	-	-	-	-	-	4.9
Tallest Leaf cm	-	-	-	-	-	7.1
7 Leaves						
% Population	0.0	0.0	0.0	0.0	0.0	0.0
% Active Leaf	-	-	-	-	-	-
Leaf Height cm	-	-	-	-	-	-
Tallest Leaf cm	-	-	-	-	-	-
8 Leaves						
% Population	0.0	0.0	0.0	0.0	0.0	0.0
% Active Leaf	-	-	-	-	-	-
Leaf Height cm	-	-	-	-	-	-
Tallest Leaf cm	-	-	-	-	-	-
9 leaves						
% Population	0.0	0.0	0.0	0.0	0.0	0.0
% Active Leaf	-	-	-	-	-	-
Leaf Height cm	-	-	-	-	-	-
Tallest Leaf cm	-	-	-	-	-	-
% Population	100.0	100.0	100.0	100.0	100.0	100.0

Table 33. Growth and development of blue grama vegetative tillers with 5 to 9 leaves on shallow soils managed with the nongrazed treatment, 1987-1989.

Shallow	6 Jun	22 Jun	6 Jul	22 Jul	6 Aug	22 Aug
5 Leaves						
% Population	51.7	56.5	100.0	26.8	0.0	57.1
% Active Leaf	60.0	60.0	80.0	60.0	-	60.0
Leaf Height cm	7.7	6.7	5.1	6.5	-	5.2
Tallest Leaf cm	10.4	8.0	7.2	9.5	-	6.8
6 Leaves						
% Population	31.0	43.5	0.0	61.0	0.0	42.9
% Active Leaf	66.7	66.7	-	66.7	-	50.0
Leaf Height cm	6.7	8.1	-	5.6	-	6.9
Tallest Leaf cm	9.4	10.2	-	6.3	-	8.0
7 Leaves						
% Population	17.2	0.0	0.0	9.8	0.0	0.0
% Active Leaf	57.1	-	-	42.9	-	-
Leaf Height cm	7.2	-	-	6.1	-	-
Tallest Leaf cm	9.4	-	-	7.4	-	-
8 Leaves						
% Population	0.0	0.0	0.0	2.4	0.0	0.0
% Active Leaf	-	-	-	37.5	-	-
Leaf Height cm	-	-	-	7.1	-	-
Tallest Leaf cm	-	-	-	10.8	-	-
9 leaves						
% Population	0.0	0.0	0.0	0.0	0.0	0.0
% Active Leaf	-	-	-	-	-	-
Leaf Height cm	-	-	-	-	-	-
Tallest Leaf cm	-	-	-	-	-	-
% Population	99.9	100.0	100.0	100.0	0.0	100.0

Table 34. Growth and development of blue grama vegetative tillers with 5 to 9 leaves on silty soils managed with the twice-over strategy, 1987-1989.

Silty	6 Jun	22 Jun	6 Jul	22 Jul	6 Aug	22 Aug
5 Leaves						
% Population	72.2	73.3	100.0	57.0	100.0	71.7
% Active Leaf	40.0	60.0	80.0	60.0	80.0	60.0
Leaf Height cm	3.3	4.4	4.5	4.4	6.8	5.1
Tallest Leaf cm	4.1	5.1	5.5	4.9	10.0	5.8
6 Leaves						
% Population	25.0	24.4	0.0	40.0	0.0	20.8
% Active Leaf	50.0	50.0	-	66.7	-	66.7
Leaf Height cm	3.6	4.6	-	3.7	-	6.2
Tallest Leaf cm	4.1	5.5	-	4.3	-	8.4
7 Leaves						
% Population	2.8	2.2	0.0	3.0	0.0	7.5
% Active Leaf	14.3	28.6	-	71.4	-	71.4
Leaf Height cm	3.0	7.5	-	3.6	-	7.8
Tallest Leaf cm	3.0	7.6	-	4.7	-	11.2
8 Leaves						
% Population	0.0	0.0	0.0	0.0	0.0	0.0
% Active Leaf	-	-	-	-	-	-
Leaf Height cm	-	-	-	-	-	-
Tallest Leaf cm	-	-	-	-	-	-
9 leaves						
% Population	0.0	0.0	0.0	0.0	0.0	0.0
% Active Leaf	-	-	-	-	-	-
Leaf Height cm	-	-	-	-	-	-
Tallest Leaf cm	-	-	-	-	-	-
% Population	100.0	99.9	100.0	100.0	100.0	100.0

Table 35. Growth and development of blue grama vegetative tillers with 5 to 9 leaves on silty soils managed with the ungrazed treatment, 1987-1989.

Silty	6 Jun	22 Jun	6 Jul	22 Jul	6 Aug	22 Aug
5 Leaves						
% Population	54.5	65.6	95.7	63.6	100.0	55.7
% Active Leaf	60.0	60.0	80.0	60.0	80.0	60.0
Leaf Height cm	5.1	5.6	7.3	7.8	4.7	6.2
Tallest Leaf cm	6.0	6.5	9.3	8.5	7.0	6.8
6 Leaves						
% Population	37.1	31.3	4.3	28.9	0.0	37.1
% Active Leaf	66.7	66.7	83.3	66.7	-	66.7
Leaf Height cm	5.8	6.6	5.5	7.3	-	7.9
Tallest Leaf cm	6.8	8.3	8.2	8.2	-	9.8
7 Leaves						
% Population	8.3	3.1	0.0	7.4	0.0	5.7
% Active Leaf	71.4	71.4	-	71.4	-	71.4
Leaf Height cm	6.9	8.8	-	9.2	-	9.9
Tallest Leaf cm	8.8	10.6	-	11.3	-	14.3
8 Leaves						
% Population	0.0	0.0	0.0	0.0	0.0	0.0
% Active Leaf	-	-	-	-	-	-
Leaf Height cm	-	-	-	-	-	-
Tallest Leaf cm	-	-	-	-	-	-
9 leaves						
% Population	0.0	0.0	0.0	0.0	0.0	1.4
% Active Leaf	-	-	-	-	-	44.4
Leaf Height cm	-	-	-	-	-	10.9
Tallest Leaf cm	-	-	-	-	-	13.8
% Population	99.9	100.0	100.0	99.9	100.0	99.9

Table 36. Growth and development of blue grama vegetative tillers with 5 to 9 leaves on silty soils managed with the seasonlong treatment, 1987-1989.

Silty	6 Jun	22 Jun	6 Jul	22 Jul	6 Aug	22 Aug
5 Leaves						
% Population	100.0	64.7	100.0	69.2	100.0	73.5
% Active Leaf	60.0	60.0	80.0	60.0	80.0	60.0
Leaf Height cm	4.6	6.0	4.0	4.4	3.6	4.7
Tallest Leaf cm	5.0	7.2	5.2	5.1	5.2	5.5
6 Leaves						
% Population	0.0	35.3	0.0	30.8	0.0	23.5
% Active Leaf	-	66.7	-	66.7	-	66.7
Leaf Height cm	-	5.3	-	4.8	-	5.6
Tallest Leaf cm	-	6.7	-	6.1	-	6.2
7 Leaves						
% Population	0.0	0.0	0.0	0.0	0.0	2.9
% Active Leaf	-	-	-	-	-	57.1
Leaf Height cm	-	-	-	-	-	7.0
Tallest Leaf cm	-	-	-	-	-	8.3
8 Leaves						
% Population	0.0	0.0	0.0	0.0	0.0	0.0
% Active Leaf	-	-	-	-	-	-
Leaf Height cm	-	-	-	-	-	-
Tallest Leaf cm	-	-	-	-	-	-
9 leaves						
% Population	0.0	0.0	0.0	0.0	0.0	0.0
% Active Leaf	-	-	-	-	-	-
Leaf Height cm	-	-	-	-	-	-
Tallest Leaf cm	-	-	-	-	-	-
% Population	100.0	100.0	100.0	100.0	100.0	99.9

Table 37. Growth and development of blue grama vegetative tillers with 5 to 9 leaves on silty soils managed with the nongrazed treatment, 1987-1989.

Silty	6 Jun	22 Jun	6 Jul	22 Jul	6 Aug	22 Aug
5 Leaves						
% Population	56.1	72.2	100.0	73.9	100.0	60.6
% Active Leaf	60.0	60.0	80.0	60.0	80.0	60.0
Leaf Height cm	8.8	7.4	7.7	7.4	7.5	8.4
Tallest Leaf cm	10.6	9.2	10.5	9.4	9.4	9.6
6 Leaves						
% Population	40.4	27.8	0.0	21.7	0.0	27.3
% Active Leaf	66.7	66.7	-	66.7	-	50.0
Leaf Height cm	9.0	7.3	-	7.1	-	9.8
Tallest Leaf cm	11.7	10.2	-	8.1	-	11.7
7 Leaves						
% Population	3.5	0.0	0.0	4.3	0.0	12.1
% Active Leaf	57.1	-	-	57.1	-	57.1
Leaf Height cm	7.9	-	-	7.7	-	8.0
Tallest Leaf cm	10.8	-	-	10.1	-	10.1
8 Leaves						
% Population	0.0	0.0	0.0	0.0	0.0	0.0
% Active Leaf	-	-	-	-	-	-
Leaf Height cm	-	-	-	-	-	-
Tallest Leaf cm	-	-	-	-	-	-
9 leaves						
% Population	0.0	0.0	0.0	0.0	0.0	0.0
% Active Leaf	-	-	-	-	-	-
Leaf Height cm	-	-	-	-	-	-
Tallest Leaf cm	-	-	-	-	-	-
% Population	100.0	100.0	100.0	99.9	100.0	100.0

Secondary Tillers

The secondary tillers had very slow rates of growth and development until they produce their fourth leaf. During growing seasons with normal precipitation conditions (1983-1986), secondary tillers made up about 25.5% of the total tiller population on the grazed twice-over treatment and made up about 19.4% of the ungrazed treatment. During growing seasons with below normal precipitation conditions (1987-1989), secondary tillers made up a greater proportion of the total tiller population, with 48.6% on the grazed twice-over strategy, 41.4% on the ungrazed treatment, 59.7% on the seasonlong, and 39.1% on the nongrazed treatments.

Growth and development data of blue grama secondary tillers on sandy, shallow, silty, and clay soils managed with the twice-over strategy and the ungrazed treatment during 1983 to 1986 are on tables 38, 39, 40, and 41, respectively.

Secondary tillers with 2 to 4 leaves on sandy soils of the twice-over strategy composed 22.5% of the total population with 365 tillers (table 6), during the growing season 84.8% of the leaves were photosynthetically active with a mean leaf height of 4.7 cm and the tallest leaf averaged 5.3 cm tall (table 38).

Secondary tillers with 2 to 4 leaves on sandy soils of the ungrazed treatment composed 14.8% of the total tiller population with 153 tillers (table 6), during the growing season 67.6% of the leaves were photosynthetically active with a mean leaf height of 4.8 cm and the tallest leaf averaged 6.0 cm tall (table 38).

Secondary tillers with 2 to 4 leaves on shallow soils of the twice-over strategy composed 23.8% of the total tiller population with 391 tillers (table 7), during the growing season 80.8% of the leaves were photosynthetically active with a mean leaf height of 3.6 cm and the tallest leaf averaged 4.1 cm tall (table 39).

Secondary tillers with 2 to 4 leaves on shallow soils of the ungrazed treatment composed 17.2% of the total tiller population with 177 tillers (table 7), during the growing season 78.3% of the leaves were photosynthetically active with a mean leaf height of 3.8 cm and the tallest leaf averaged 4.5 cm tall (table 39).

Secondary tillers with 2 to 4 leaves on silty soils of the twice-over strategy composed 25.9% of the total tiller population with 435 tillers (table 8), during the growing season 76.6% of the leaves were photosynthetically active with a mean leaf height of 5.7 cm and the tallest leaf averaged 6.4 cm tall (table 40).

Secondary tillers with 2 to 4 leaves on silty soils of the ungrazed treatment composed 21.8% of the total tiller population with 225 tillers (table 8), during the growing season 67.4% of the leaves were photosynthetically active with a mean leaf height of 6.8 cm and the tallest leaf averaged 7.8 cm tall (table 40).

Secondary tillers with 2 to 4 leaves on clay soils of the twice-over strategy composed 29.9% of the total tiller population with 318 tillers (table 9), during the growing season 73.9% of the leaves were photosynthetically active with a mean leaf height of 5.0 cm and the tallest leaf averaged 5.9 cm tall (table 41).

Secondary tillers with 2 to 4 leaves on clay soils of the ungrazed treatment composed 23.6% of the total tiller population with 156 tillers (table 9), during the growing season 68.5% of the leaves were photosynthetically active with a mean leaf height of 6.4 cm and the tallest leaf averaged 7.3 cm tall (table 41).

Growth and development data of blue grama secondary tillers on sandy, shallow, and silty soils managed with the twice-over strategy and the ungrazed treatment and with the seasonlong and nongrazed treatments during 1987 to 1989 are on tables 42, 43, and 44, respectively.

Secondary tillers with 2 to 4 leaves on sandy soils of the twice-over strategy composed 48.0% of the total tiller population with 294 tillers (table 6), during the growing season 66.5% of the leaves were photosynthetically active with a mean leaf height of 4.5 cm and the tallest leaf averaged 5.0 cm tall (table 42).

Secondary tillers with 2 to 4 leaves on sandy soils of the ungrazed treatment composed 44.6% of the total tiller population with 337 tillers (table 6), during the growing season 68.4% of the leaves were photosynthetically active with a mean leaf height of 6.1 cm and the tallest leaf averaged 7.1 cm tall (table 42).

Secondary tillers with 2 to 4 leaves on sandy soils of the seasonlong treatment composed 60.7% of the total tiller population with 102 tillers (table 6), during the growing season 78.4% of the leaves were photosynthetically active with a mean leaf height of 5.3 cm and the tallest leaf averaged 6.0 cm tall (table 42).

Secondary tillers with 2 to 4 leaves on sandy soils of the nongrazed treatment composed 43.9% of the total tiller population with 116 tillers (table 6), during the growing season 75.7% of the leaves were photosynthetically active with a mean leaf height of 6.6 cm and the tallest leaf averaged 7.6 cm tall (table 42).

Secondary tillers with 2 to 4 leaves on shallow soils of the twice-over strategy composed 44.2% of the total tiller population with 276 tillers (table 7), during the growing season 73.1% of the leaves were photosynthetically active with a mean leaf height of 4.0 cm and the tallest leaf averaged 4.5 cm tall (table 43).

Secondary tillers with 2 to 4 leaves on shallow soils of the ungrazed treatment composed 38.0% of the total tiller population with 288 tillers (table 7), during the growing season 69.4% of the leaves were photosynthetically active with a mean leaf height of 5.3 cm and the tallest leaf averaged 5.9 cm tall (table 43).

Secondary tillers with 2 to 4 leaves on shallow soils of the seasonlong treatment composed 65.3% of the total tiller population with 94 tillers (table 7), during the growing season 77.8% of the leaves were photosynthetically active with a mean leaf height of 4.1 cm and the tallest leaf averaged 4.7 cm tall (table 43).

Secondary tillers with 2 to 4 leaves on shallow soils of the nongrazed treatment composed 41.3% of the total tiller population with 109 tillers (table 7), during the growing season 70.6% of the leaves were photosynthetically active with a mean leaf height of 5.4 cm and the tallest leaf averaged 6.6 cm tall (table 43).

Secondary tillers with 2 to 4 leaves on silty soils of the twice-over strategy composed 53.5% of the total tiller population with 333 tillers (table 8), during the growing season 64.3% of the leaves were photosynthetically active with a mean leaf height of 4.4 cm and the tallest leaf averaged 4.9 cm tall (table 44).

Secondary tillers with 2 to 4 leaves on silty soils of the ungrazed treatment composed 41.7% of the total tiller population with 320 tillers (table 8), during the growing season 69.6% of the leaves were photosynthetically active with a mean leaf height of 6.5 cm and the tallest leaf averaged 7.5 cm tall (table 44).

Secondary tillers with 2 to 4 leaves on silty soils of the seasonlong treatment composed 53.2% of the total tiller population with 115 tillers (table 8), during the growing season 75.6% of the leaves were photosynthetically active with a mean leaf height of 4.1 cm and the tallest leaf averaged 4.8 cm tall (table 44).

Secondary tillers with 2 to 4 leaves on silty soils of the nongrazed treatment composed 32.2% of the total tiller population with 85 tillers (table 8), during the growing season 63.1% of the leaves were photosynthetically active with a mean leaf height of 6.9 cm and the tallest leaf averaged 8.1 cm tall (table 44).

All of the secondary tillers measured during this study were not grazed including the tillers located on grazed treatments. The not grazed tillers remaining on the grazed treatments tended to have slightly shorter mean leaf heights and mean tallest leaf heights which were not significantly different than the not grazed tillers on the ungrazed treatments on sandy, shallow, silty, and clay soils during the 1983-1986 period (tables 38, 39, 40, and 41) and on the sandy, shallow, and silty soils during the 1987-1989 period (tables 42, 43, and 44). It is not believed that grazed treatments cause secondary tillers to produce slightly shorter leaf heights. It is surmised that grazing cattle have a disproportional rate of selection for taller tillers than for shorter tillers leaving a distorted sample population of not grazed tillers with slightly shorter leaf heights.

Leaves grow and senesce in about the same order of their appearance. This study has designated that leaves with less than 50% senescent tissue to be photosynthetically active. Tillers growing on the twice-over treatment tended to have greater photosynthetically active leaves (79.0%) than the tillers growing on the ungrazed treatment (70.5%), during the growing seasons with normal precipitation conditions (1983 to 1986).

Secondary tillers composed a low percentage of the total measured tiller population during the 1983 to 1986 period with normal precipitation conditions with 24.1% on the grazed twice-over strategy and 17.9% on the ungrazed treatment. The quantity of secondary tillers greatly increased during the 1987 to 1989 period with below normal precipitation conditions and composed 48.6% on the grazed twice-over strategy and 41.4% on the ungrazed treatment.

Table 38. Growth and development of blue grama secondary tillers on sandy soils managed with the twice-over grazing and ungrazed treatments, 1983-1986.

Sandy	6 Jun	22 Jun	6 Jul	22 Jul	6 Aug	22 Aug
Twice-over 1983-1986						
% Population	45.1	38.1	13.5	19.3	12.5	8.7
% Active Leaf	100.0	93.8	85.7	81.8	75.0	72.7
Leaf Height cm	4.7	4.6	3.9	5.0	5.7	4.2
Tallest Leaf cm	5.7	5.3	4.4	6.0	5.8	4.4
Ungrazed 1983-1986						
% Population	36.8	18.3	13.9	11.9	7.0	4.9
% Active Leaf	100.0	78.6	57.1	57.1	50.0	62.5
Leaf Height cm	4.3	5.2	5.1	5.2	3.1	5.8
Tallest Leaf cm	5.7	6.0	5.6	6.8	6.1	6.0

Table 39. Growth and development of blue grama secondary tillers on shallow soils managed with the twice-over grazing and ungrazed treatments, 1983-1986.

Shallow	6 Jun	22 Jun	6 Jul	22 Jul	6 Aug	22 Aug
Twice-over 1983-1986						
% Population	45.1	38.2	21.9	22.3	11.1	8.5
% Active Leaf	100.0	87.5	85.7	63.6	75.0	72.7
Leaf Height cm	3.2	3.1	3.3	4.5	3.5	3.7
Tallest Leaf cm	3.9	3.4	3.6	5.3	4.0	4.3
Ungrazed 1983-1986						
% Population	43.8	37.5	24.8	8.2	1.6	6.4
% Active Leaf	100.0	85.7	71.4	75.0	75.0	62.5
Leaf Height cm	2.9	3.1	4.3	4.5	2.9	5.0
Tallest Leaf cm	3.5	3.8	4.8	5.2	3.5	6.0

Table 40. Growth and development of blue grama secondary tillers on silty soils managed with the twice-over grazing and ungrazed treatments, 1983-1986.

Silty	6 Jun	22 Jun	6 Jul	22 Jul	6 Aug	22 Aug
Twice-over 1983-1986						
% Population	45.8	38.6	41.4	21.3	7.9	11.3
% Active Leaf	100.0	87.5	85.7	75.0	50.0	61.5
Leaf Height cm	4.6	5.0	6.3	6.4	6.1	5.7
Tallest Leaf cm	5.6	5.6	7.0	7.3	6.3	6.4
Ungrazed 1983-1986						
% Population	47.0	25.5	46.3	10.9	8.7	4.4
% Active Leaf	85.7	75.0	71.4	75.0	42.9	54.5
Leaf Height cm	5.3	5.3	7.4	8.4	6.3	8.0
Tallest Leaf cm	6.2	5.4	8.0	9.1	8.7	9.6

Table 41. Growth and development of blue grama secondary tillers on clay soils managed with the twice-over grazing and ungrazed treatments, 1983-1986.

Clay	6 Jun	22 Jun	6 Jul	22 Jul	6 Aug	22 Aug
Twice-over 1983-1986						
% Population	50.0	49.6	22.3	17.2	23.3	14.2
% Active Leaf	85.7	87.5	71.4	81.8	71.4	45.5
Leaf Height cm	5.1	4.2	5.0	4.7	5.9	5.3
Tallest Leaf cm	5.9	4.9	5.8	5.4	7.3	6.0
Ungrazed 1983-1986						
% Population	58.3	25.0	27.1	16.9	15.3	7.9
% Active Leaf	88.9	71.4	71.4	50.0	75.0	59.5
Leaf Height cm	5.8	5.9	6.3	7.4	6.7	6.4
Tallest Leaf cm	6.8	6.4	6.8	8.5	8.1	8.4

Table 42. Growth and development of blue grama secondary tillers on sandy soils managed with the twice-over grazing and ungrazed treatments and the seasonlong and nongrazed treatmetns, 1987-1989.

Sandy	6 Jun	22 Jun	6 Jul	22 Jul	6 Aug	22 Aug
Twice-over 1987-1989						
% Population	59.7	67.2	81.0	34.0	81.0	17.9
% Active Leaf	66.7	71.4	75.0	71.4	71.4	42.9
Leaf Height cm	3.9	4.3	4.8	4.3	5.7	3.9
Tallest Leaf cm	4.0	4.7	5.7	4.7	6.1	4.7
Ungrazed 1987-1989						
% Population	38.6	57.6	80.6	36.1	84.8	11.7
% Active Leaf	88.9	71.4	71.4	57.1	71.4	50.0
Leaf Height cm	6.6	5.5	5.2	5.8	7.8	5.9
Tallest Leaf cm	8.7	5.9	6.6	6.2	9.2	6.2
Seasonlong 1987-1989						
% Population	100.0	70.8	91.7	71.4	100.0	7.1
% Active Leaf	100.0	71.4	71.4	85.7	75.0	66.7
Leaf Height cm	5.1	4.2	4.5	7.2	5.3	-
Tallest Leaf cm	5.9	4.6	5.2	8.2	6.0	-
Nongrazed 1987-1989						
% Population	54.2	62.5	29.2	35.4	95.8	0.0
% Active Leaf	85.7	71.4	75.0	75.0	71.4	-
Leaf Height cm	7.6	7.8	5.3	7.3	4.8	-
Tallest Leaf cm	8.9	8.4	6.1	9.0	5.4	-

Table 43. Growth and development of blue grama secondary tillers on shallow soils managed with the twice-over grazing and ungrazed treatments and the seasonlong and nongrazed treatmetns, 1987-1989.

Shallow	6 Jun	22 Jun	6 Jul	22 Jul	6 Aug	22 Aug
Twice-over 1987-1989						
% Population	50.0	59.3	67.7	29.6	78.6	26.2
% Active Leaf	71.4	88.9	71.4	85.7	71.4	50.0
Leaf Height cm	4.1	4.0	3.8	3.7	3.7	4.8
Tallest Leaf cm	4.6	4.4	4.6	4.2	4.1	4.9
Ungrazed 1987-1989						
% Population	36.5	41.8	86.7	29.6	85.1	8.5
% Active Leaf	71.4	66.7	71.4	85.7	71.4	50.0
Leaf Height cm	4.0	5.5	5.3	5.0	6.8	5.4
Tallest Leaf cm	4.2	5.8	6.0	5.6	8.2	5.8
Seasonlong 1987-1989						
% Population	91.7	95.8	62.5	54.2	95.5	0.0
% Active Leaf	100.0	71.4	75.0	71.4	71.4	-
Leaf Height cm	2.9	3.4	4.7	5.2	4.4	-
Tallest Leaf cm	3.6	3.9	5.3	5.4	5.1	-
Nongrazed 1987-1989						
% Population	54.4	52.1	16.7	12.8	100.0	16.7
% Active Leaf	88.9	66.7	75.0	75.0	75.0	42.9
Leaf Height cm	4.7	7.2	5.1	4.5	5.7	5.3
Tallest Leaf cm	6.0	8.2	7.2	4.8	7.0	6.1

Table 44. Growth and development of blue grama secondary tillers on silty soils managed with the twice-over grazing and ungrazed treatments and the seasonlong and nongrazed treatmetns, 1987-1989.

Silty	6 Jun	22 Jun	6 Jul	22 Jul	6 Aug	22 Aug
Twice-over 1987-1989						
% Population	50.0	62.2	91.3	24.8	84.4	57.9
% Active Leaf	57.1	71.4	71.4	71.4	71.4	42.9
Leaf Height cm	4.1	4.3	4.2	5.5	3.6	4.4
Tallest Leaf cm	4.8	4.5	5.0	6.3	4.1	4.7
Ungrazed 1987-1989						
% Population	31.3	55.6	65.2	12.9	90.9	45.7
% Active Leaf	71.4	85.7	75.0	71.4	71.4	42.9
Leaf Height cm	6.0	5.6	8.5	6.9	6.2	5.7
Tallest Leaf cm	6.9	6.5	10.3	7.7	7.4	6.4
Seasonlong 1987-1989						
% Population	83.3	64.6	66.7	42.2	95.8	19.0
% Active Leaf	85.7	71.4	75.0	71.4	75.0	75.0
Leaf Height cm	3.5	4.1	4.3	4.2	4.6	4.1
Tallest Leaf cm	4.1	4.8	5.0	4.7	5.4	4.6
Nongrazed 1987-1989						
% Population	20.8	25.0	8.3	52.1	91.7	21.4
% Active Leaf	42.9	71.4	75.0	85.7	75.0	28.6
Leaf Height cm	5.1	7.8	6.3	6.3	5.6	10.0
Tallest Leaf cm	6.3	10.0	7.8	7.4	6.9	10.4

Discussion

Blue grama, *Bouteloua gracilis,* is a native, long lived perennial, warm-season, short grass, monocot, of the grass family that is abundant on heathy mixed grass prairie plant communities. Blue grama can grow on sandy, shallow, silty, clay, and thin claypan ecological sites. It is drought tolerant, moderately tolerant of alkaline soils, however, it is not tolerant of shading and flooding, and intolerant of acidic and saline soils. Early aerial growth of lead tillers arises from carryover tillers, and basal leaves of vegetative tillers arise from fall produced crown tiller buds. New leaves are visible during mid April, which is a little earlier than other warm season grasses. Leaf growth is slow until early or mid May. Rapid growth produces 3.5 new leaves by mid June. Early flower stalk growth reaches the boot stage after mid June, progressing through head emergence during late June to early July. Anthesis occurs during a 5 week period from early July through the first week of August. Seeds develop through the milk and dough stages during late July and early August, mature and are being shed during mid to late August or early September.

Vegetative tillers produce 5 to 7 basal leaves by mid to late July when the rate of growth decreases. A few vegetative tillers continue growth and produce leaf 8 or 9 during late July and August. Tillers with 5 to 7 leaves lose leaves 1 and 2 to senescence but maintain all the other leaves as photosynthetically active. Tillers with 8 or 9 leaves usually maintain 4 or 5 photosynthetically active leaves.

Secondary tillers develop during the growing season in May or June and grow slowly until they produce their fourth leaf, when they develop into vegetative tillers usually during July or August. Blue grama is an unusual warm season grass and produce a relatively large quantity of new leaf growth during August.

Blue grama's short stature belies the importance of its contribution to the mixed grass prairie. The mat forming aboveground parts cover the soil protecting it from heat and erosion. The high density of tillers prevents undesirable species from invading. The deep roots descend to 1.8 m (6 ft) helping soil formation and the dense shallow roots stabilize the soil from moving and permit rapid plant response to low precipitation events. The huge quantity of nutritious forage produces a large portion of the livestock's weight performance. Blue grama holds the prairie plant communities together and is a most valuable asset to the Northern Plains.

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Literature Cited

Anderson, M.C. 2003. Boutelona gracilis. Fire Effects Information System. USDA. Forest Service. http://www.fs.fed.us/database/feis/

Bluemle, J.P. 1977. The face of North Dakota: the geologic story. North Dakota Geological Survey. Ed. Series 11. 73p.

Bluemle, J.P. 1991. The face of North Dakota. Revised edition. North Dakota Geological Survey. Ed. Series 21. 177p.

Bluemle, J.P. 2000. The face of North Dakota. 3rd edition. North Dakota Geological Survey. Ed. Series 26. 206p. 1pl.

Dodds, D.L. 1979. Common grasses and sedges in North Dakota. NDSU Extension Service R-658. Fargo, ND.

Fenneman, N.M. 1931. Physiography of western United States. McGraw-Hill Book Company, New York, NY. 534p.

Fenneman, N.M. 1946. Physical divisions of the United States. USDI Geological Survey. Map.

Goetz, H. 1963. Growth and development of native range plants in the mixed prairie of western North Dakota. M. S. Thesis, North Dakota State University, Fargo, ND. 165p.

Great Plains Flora Association. 1986. Flora of the Great Plains. University of Kansas, Lawrence, KS.

Hunt, C.B. 1974. Natural regions of the United States and Canada. W.H. Freeman and Company, San Francisco, CA. 725p.

Larson, G.E., and J.R. Johnson. 2007. Plants of the Black Hills and Bear Lodge Mountains. 2nd Edition. South Dakota State University, Brookings, SD. 608p.

Manske, L.L. 1994. History and land use practices in the Little Missouri Badlands and western North Dakota. Proceedings-Leafy Spurge Strategic Planning Workshop. USDI National Park Service, Dickinson, ND. p. 3-16.

Manske, L.L. 2008a. Prehistorical conditions of rangelands in the Northern Plains. NDSU Dickinson Research Extension Center. Summary Range Management Report DREC 08-3015b. Dickinson, ND. 5p.

Manske, L.L. 2008b. Physiography, soil, and native vegetation of the Northern Plains. NDSU Dickinson Research Extension Center. Summary Range Management Report DREC 08-3048. Dickinson, ND. 28p.

Soil Survey Staff. 1975. Soil Taxonomy. Agriculture Handbook No. 436. USDA Soil Conservation Service. U.S. Government Printing Office, Washington, D.C. 754p.

Stevens, O.A. 1963. Handbook of North Dakota plants. North Dakota Institute for Regional Studies. Fargo, ND.

Stubbendieck, J., S.L. Hatch, and N.M. Bryan. 2011. North American wildland plants. 2nd Ed. University of Nebraska Press. Lincoln, NE.

Weaver, J.E. 1954. North American Prairie. Johnson Publishing Co. Lincoln, NE.

Whitman, W.C. c. 1950. Native range plants–their growth and development in relation to the establishment of standards for their proper utilization. Hatch Project 9-5.

Wynia, R. 2007. Boutelona gracilis (Kunth) Lag. Ex Griffiths. Plant Database. USDA. Natural Resources Conservation Service. Manhattan, KS. http://plants.usda.gov/

Zaczkowski, N.K. 1972. Vascular flora of Billings, Bowman, Golden Valley, and Slope Counties, North Dakota. PhD. Thesis. North Dakota State University, Fargo, ND. 219 p.

Growth Pattern and Phenological Development of Prairie Sandreed on the Northern Plains

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Intact grassland ecosystems are complex; exceedingly more complex than the most complicated machines ever built by humans. Knowledge and understanding of the growth pattern and phenological development of the major forage grasses are fundamentally essential for generation of biologically effective management strategies with inclusivity of all biotic and abiotic components of grassland ecosystems in the Northern Plains.

The inspirational 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 relationships of ecosystem components that would result in the development and establishment of scientific standards for proper management of grazinglands in the Northern Plains.

This growth pattern and phenological development study of the major forage graminoids was conducted during the growing seasons of 1983-1986 and 1987-1989 with data collected biweekly June-August. The study included 3 cool season, 2 warm season, 1 upland sedge, 1 naturalized, and 2 domesticated grasses. The study sites were located at the NDSU Dickinson Research Extension Center ranch near Manning in western North Dakota and consisted of 143 acres (58 ha) of two seeded domesticated grasslands and 720 acres (291 ha) of native rangeland pastures separated into three management treatments, each with two replications, with data collection sites established on sandy, shallow, and silty ecological sites. Each ecological site of the grazed treatments had matching paired plots, one grazed and the other with an ungrazed exclosure.

Study Area

The physiography of the study area consists of the Unglaciated section of the Missouri Plateau (Fenneman 1931, 1946; Hunt 1974). The landscape surface is highly eroded fluvial sedimentary deposits of material removed from the uplifted Rocky Mountains. Most of the deposition occurred from slow meandering streams during the Laramide Orogeny and during the 20 to 30 million years of the late Cretaceous and early Tertiary Periods following the uplift. Intense widespread erosion of these sediments occurred from about 5 to 3 million years ago during the late Pliocene Epoch (Bluemle 2000). The extensive erosion during this period removed about 500 to 1000 feet of sediments (Fenneman 1931) forming a landscape with well developed integrated drainage systems of broad mature valleys and gently rolling uplands containing widely spaced large hills and buttes with erosion resistant caps raising 500 to 650 feet above the plain (Bluemle 2000).

The soils of western North Dakota developed from eroded Tertiary fluvial sedimentary deposits in the Ustic-Frigid soil moisture-temperature regime. The Ustic soil moisture regime is typical of semi arid climates. The Frigid soil temperature regime has mean annual soil temperatures of less than 47° F (8° C) (Soil Survey Staff 1975). These soils are primarily Typic Borolls (semi arid cool Mollisols) and support vegetation of mid and short grasses of the Mixed Grass Prairie (Manske 2008b).

The current "native" plant species in the Northern Plains did not originate here. All of the plant species have migrated into the region by different mechanisms and at different times and rates. The present plant species have flora affinities to northern, eastern, western, Rocky Mountain, and Great Basin plant communities (Zaczkowski 1972). This wide mix of plant species was formed from remnants of previously existing plant communities. The climate changed about 5,000 years ago to conditions like those of the present, with cycles of wet and dry periods (Bluemle 1977, 1991; Manske 1994). The large diversity of plant species that make up the current mixed grass prairie permits dynamic responses to changes in climatic conditions by increasing the combination of plant species favored by any set of climatic conditions (Manske 2008a).

Long-Term Weather

The NDSU Dickinson Research Extension Center ranch is located in Dunn County in western North Dakota, at 47° 14' north latitude, 102° 50' west longitude. Mean annual temperature is 42.3° F (5.7° C). January is the coldest month, with mean temperature of 14.6° F (-9.7° C). July and August are the warmest months with mean temperatures of 69.7° F (20.9° C) and 68.6° F (20.3° C), respectively. Long-term (1982-2012) mean annual precipitation is 16.91 inches (429.61 mm). The perennial plant growing season precipitation (April to October) is 14.13 inches (358.97 mm) and is 83.6% of annual precipitation. June has the greatest monthly precipitation at 3.27 inches (83.08 mm). The precipitation received during the 3-month period of May, June, and July (8.26 inches, 209.80 mm) accounts for 48.8% of the annual precipitation.

Growing season months with water deficiency disrupt plant growth rates and are identified from monthly temperature and precipitation data by the Emberger ombrothermic diagram technique. Long-term (1983-2012) 30 year reoccurrence rates (table 1) show relatively low rates of water deficiency reoccurring during April (16.7%), May and June (10.0%), moderate rates during July and October (36.7%), and high rates during August (56.7%) and September (60.0%). Long-term occurrence of water deficiency conditions was 33.3% of the growing season months, for a mean of 2.0 water deficient months per each 6.0 month growing season (15 Apr-15 Oct).

Growing Season Precipitation

The growing season precipitation information collected during the grass leaf height study has been grouped into two periods with the first period occurring during 1983 to 1986 and the second period occurring during 1987 to 1989.

Mean growing season precipitation of 1983-1986 (table 2) was 14.11 inches (99.9% of LTM). None of the four 6 month growing seasons received precipitation at less than 80% of LTM. One growing season, 1986, received precipitation at near 130% of LTM. The rate of water deficiency occurrence during the four growing seasons was 29.2%, for a mean of 1.75 water deficient months per growing season (table 3). The growing season of 1984 had 3.0 months in water deficiency. The growing seasons of 1983 and 1986 had 1.5 months in water deficiency each. The growing season of 1985 had 1.0 month in water deficiency.

Mean growing season precipitation of 1987-1989 (table 4) was low at 9.14 inches (64.7% of LTM). The growing season of 1987 received 11.53 inches (81.6% of LTM) precipitation. The growing season of 1989 received 10.60 inches (75.0% of LTM) precipitation. The growing season of 1988 received only 5.30 inches (37.5% of LTM) precipitation and was dry. The rate of water deficiency occurrence during the three growing seasons was 61.1%, for a mean of 3.7 water deficient months per growing season (table 5). The growing seasons of 1987 and 1989 had 3.0 months in water deficiency each. The growing season of 1988 had 5.0 months of its 6 month growing season in water deficiency conditions. That is comparable to 2 other growing seasons with high water deficiency conditions. The growing season of 1934 had 4.5 months in water deficiency and the growing season of 1936 had 5.5 months in water deficiency.

Table 1. Growing season months with water deficiency, DREC ranch, 1983-2012.

	Apr	May	Jun	Jul	Aug	Sep	Oct	# Months	% 6 Months 15 Apr-15 Oct
Total	5	3	3	11	17	18	11	60.0	33.3
% of 30 Years	16.7	10.0	10.0	36.7	56.7	60.0	36.7		

Table 2. Precipitation in inches and percent of long-term mean for perennial plant growing season months, DREC ranch, 1983-1986.

	Apr	May	Jun	Jul	Aug	Sep	Oct	Growing Season	Annual Total
Long-Term Mean 1982-2012	1.44	2.56	3.27	2.43	1.70	1.42	1.31	14.13	16.91
1983	0.21	1.53	3.26	2.56	4.45	0.86	0.72	13.59	15.55
% of LTM	14.58	59.77	99.69	105.35	261.76	60.56	54.96	96.18	91.96
1984	2.87	0.00	5.30	0.11	1.92	0.53	0.96	11.69	12.88
% of LTM	199.31	0.00	162.08	4.53	112.94	37.32	73.28	82.73	76.17
1985	1.24	3.25	1.58	1.07	1.84	1.69	2.13	12.80	15.13
% of LTM	86.11	126.95	48.32	44.03	108.24	119.01	162.60	90.59	89.47
1986	3.13	3.68	2.58	3.04	0.46	5.29	0.18	18.36	22.96
% of LTM	217.36	143.75	78.90	125.10	27.06	372.54	13.74	129.94	135.78
1983-1986	1.86	2.12	3.18	1.70	2.17	2.09	1.00	14.11	16.63
% of LTM	129.34	82.62	97.25	69.75	127.50	147.36	76.15	99.86	98.34

Table 3. Growing season months with water deficiency conditions that caused water stress in perennial plants, DREC ranch, 1983-1986.

	APR	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**# Months**	**% 6 Months 15 Apr-15 Oct**
1983								1.5	25.0
1984								3.0	50.0
1985								1.0	16.7
1986								1.5	25.0
#	**1**	**1**	**0**	**2**	**1**	**2**	**1**	**7.0**	**29.2**
%	**25.0**	**25.0**	**0.0**	**50.0**	**25.0**	**50.0**	**25.0**		

Table 4. Precipitation in inches and percent of long-term mean for perennial plant growing season months, DREC ranch, 1987-1989.

	Apr	May	Jun	Jul	Aug	Sep	Oct	Growing Season	Annual Total
Long-Term Mean 1982-2012	1.44	2.56	3.27	2.43	1.70	1.42	1.31	14.13	16.91
1987	0.10	1.38	1.15	5.39	2.65	0.78	0.08	11.53	14.13
% of LTM	6.94	53.91	35.17	221.81	155.88	54.93	6.11	81.60	83.56
1988	0.00	1.85	1.70	0.88	0.03	0.73	0.11	5.30	9.03
% of LTM	0.00	72.27	51.99	36.21	1.76	51.41	8.40	37.51	53.40
1989	2.92	1.73	1.63	1.30	1.36	0.70	0.96	10.60	13.07
% of LTM	202.78	67.58	49.85	53.50	80.00	49.30	73.28	75.02	77.29
1987-1989	1.01	1.65	1.49	2.52	1.35	0.74	0.38	9.14	12.08
% of LTM	69.91	64.58	45.67	103.84	79.22	51.88	29.26	64.71	71.42

Table 5. Growing season months with water deficiency conditions that caused water stress in perennial plants, DREC ranch, 1987-1989.

	APR	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**# Months**	**% 6 Months 15 Apr-15 Oct**
1987								3.0	50.0
1988								5.0	83.3
1989								3.0	50.0
#	**2**	**0**	**2**	**2**	**2**	**3**	**2**	**11.0**	**61.1**
%	**66.7**	**0.0**	**66.7**	**66.7**	**66.7**	**100.0**	**66.7**		

Procedures

The 1983-1989 Study

Grass tiller leaf heights were determined for reproductive lead tillers, vegetative tillers, and secondary tillers on a biweekly sampling period from June through August. Each leaf of ten ungrazed tillers of each study species was measured with a meter stick to the nearest 0.1 cm from ground level to the tips of the extended leaves. Basal leaf heights were measured for grass species in which the leaves and stalks were distinctly separate. Stalk leaf heights were measured for grass species where leaves are attached to the culm during vegetative stages and fruiting stages.

Degree of leaf senescence was estimated as percent dryness for each leaf. Percent dryness for basal leaves was considered from the apex to ground level. Percent dryness for stalk leaves was considered for the blade only. The categories of dryness were: 0%, 2%, 25%, 50%, 75%, 98% and 100% dry. Start of senescence was considered to be dryness greater than 2%. Leaves with less than 50% senescent tissue were designated to be photosynthetically active.

Grass flower stalk heights were determined by measurements from ground level to the tip of the stalk or the apex of the top floret. The awns, if present, were not included in the height measurements. The phenological stages of flower stalk development were recorded as: flower stalk developing (FSD), head emergence (HE), anthesis (Ant), seeds developing (SD), and seeds being shed (SBS). Recording the flower stalk development stages started when stalk enlargement or swelling was outwardly noticeable; prior development is not detectable without destruction of the tiller. The swelling of the stalk, traditionally called the boot stage, was categorized as the flower stalk developing stage. Head emergence is a short duration stage but easily defined when the flower head emerges from the sheath and rapidly elongates to near full height. Anthesis (flowering) is also a short duration stage but easily defined by the exposure of the anthers and stigmas. Needle and thread is usually cleistogamous that self-fertilizes without opening and exposing the anthers and stigmas. Following fertilization, the seeds develop through milk, dough, and mature stages which are difficult to differentiate on small grass seeds. These seed progression stages have been separated into more easily defined categories of seeds developing for the early seed stages and seeds being shed for the mature seed stages when seeds could be easily removed from the inflorescence by wind, by gentle rubbing, or when it could be observed that some seeds had already been dropped. Sometimes a floret will abort the seed production process resulting in failure of viable seeds to materialize. This condition could be revealed in the data set as earlier than normal recordings of seeds being shed.

During 1983 to 1986, the paired plot sample sites with sandy soil type were managed by ungrazed and grazed treatments of the twice-over rotation strategy. During 1987 to 1989, the paired plot sample sites with sandy soil type were managed by long-term nongrazed treatments, and by ungrazed and grazed treatments of the traditional seasonlong practice and the twice-over rotation strategy.

Designation of Tiller Types

Reproductive lead tillers are second year tillers derived from carryover tillers that were vegetative tillers during the previous growing season. The portions of the carryover leaves that have intact cell walls will regreen with active chlorophyll early in the growing season and provide photosynthate for rapid growth of new current years leaves. Two and three new leaves are produced during May, the fourth full leaf is produced before early June, and tillers with 8 full leaves were produced during the first week of June. The anthesis (flowering) period can occur between mid July to early August with all early first flowers occurring after 21 June. No new leaves are produced after the anthesis stage, during the seed development stages. Tillers that flower early usually produce 5 or 6 stalk leaves and tillers that flower later usually produce 7 or 10 stalk leaves. Reproductive lead tillers are terminal at the end of the growing season; their apical meristem was used up producing a flower head.

Vegetative tillers are first year tillers derived from early spring initiated secondary tillers that have developed from fall produced terminal rhizome tiller buds and have escaped hormonal control by a lead tiller. These tillers are the primary forage tillers with rapid growth rates, usually producing 5 to 10 stalk leaves during the growing season. The apical meristem remains vegetative, permitting these tillers to overwinter as carryover tillers and becoming reproductive lead tillers during the successive growing season.

Secondary tillers are young current growing season tillers usually initiated from terminal rhizome axillary buds during May to July. Lead tillers of prairie sandreed have little hormone control over secondary tillers because of the rhizome distance.

The longer the rhizome, the lower the hormone control. Some secondary tillers with short rhizomes can remain at the 2 or 3 leaf stage for longer than a month or two. The secondary tillers that produce 4 leaves become totally independent from all hormone control of the lead tiller and transform into vegetative tillers with rapid growth rates.

Results

Prairie sandreed, *Calamovilfa longifolia* (Hook.) Hack. Ex Scribn. & Southw., is a member of the grass family, Poaceae, tribe, Cynodonteae, and is a native, long lived perennial, monocot, warm-season, tall grass, that is drought resistant, tolerant of alkaline soils, not tolerant of salt and susceptible to trampling. The first North Dakota record is Bergman 1911. Early aerial growth consists of basal leaves arising from fall produced tiller buds, that have very sharp tips located at the terminal ends of rhizome branches. Basal leaf blades are 20-30 cm (8-12 in) long, 4-8 mm wide, coarse, firm, leathery, and tapering to a point. The split sheath has overlapping margins with a pinkish base. The distinct inflated collar is broad and continuous with tufts of long fine hairs on the inner margins. The ligule is a dense ring of hairs 1-3 mm long. The auricles are absent. The extensive rhizomes are more than 30 cm (12 in) long, stout, scaly, have a shiny pale whitish color and are terminal with one tiller. The dense fibrous root system has numerous wiry main roots, 2-3 mm thick, arising from stem crowns and rhizome nodes growing vertically and obliquely downward, mostly in the top 46 cm (18 in) of soil, with lateral branches up to 15 cm (6 in) long developing along the full length of the roots, and has a few long main roots that extend down to 1.5 m (60 in) deep, effectively stabilizing deep sandy soils. Regeneration is primarily asexual propagation by large quantities of rhizome tillers. Seedling vigor is only fair and mortality, caused by low soil water in the upper layers, is high. Flower stalks are robust, 1-2 m (39-79 in) tall, solitary, forming large colonies. Inflorescence is a panicle 10-40 cm (4-16 in) long with whorled ascending branches, that are semi open. Spikelets are 4-7 mm long, and have one floret with a dense basal ring of white hairs. Flower period is from mid July to early August. Seed production is low. The leaves are highly palatable and readily eaten by livestock, however, the coarse stems are not eaten, giving the false impression that this grass is undesirable as forage. Fire top kills aerial parts halting the processes of the four major defoliation resistance mechanisms and causing great reductions in biomass production and tiller density. This summary information on growth development and regeneration of Prairie sandreed was based on works of Stevens 1963, Zaczkowski 1972, Dodds 1979, Great Plains Flora Association 1986, Hauser 2005, Duckwitz and Wynia 2006, Johnson and Larson 2007, and Stubbendieck et al. 2011.

During the seven years of this study, the number of prairie sandreed tillers measured were 4386 on sandy soils (table 6). The collection protocol required measurement on all available flower stalks and ten vegetative tillers on each sample site each collection period, amounting to 360 tillers per year on the twice-over treatment and 120 tillers per year on the seasonlong and nongrazed treatments. During the 3 growing seasons with low precipitation amounts, less than ten tillers were measured each collection period. The reductions in sample numbers would indicate the degree of negative affect from reduced precipitation. This affect is designated as collection efficiency on table 6.

Table 6. Number of tillers measured from management treatments on sandy soils.

Tiller Type	Twice-over 1983-1986		Twice-over 1987-1989		Seasonlong 1987-1989	Nongrazed 1987-1989
	Ungrazed	Grazed	Ungrazed	Grazed	Grazed	Ungrazed
Flower Stalk	133	124	27	25	5	7
Vegetative	989	1144	479	513	181	186
Secondary	21	23	196	178	90	65
Subtotal	1143	1291	702	716	276	258
Total	2434		1418			
Sum total				4386		
Collection Efficiency	79%	90%	65%	66%	38%	72%

Reproductive Lead Tillers

The second year reproductive lead tillers had the fastest rate of growth and development until mid or late July. Some early growth tillers reached the boot stage (FSD) shortly after mid June. Flower stalk development progressed through head emergence (HE) with some early lead tillers reaching first flower shortly after mid July. After the flower stage (Ant), 50% of the ungrazed treatment flower stalks had 9 or 10 stalk leaves and 42% of the grazed treatment flower stalks had 9 or 10 stalk leaves. No new leaves were produced after the anthesis stage. Seeds developed (SD) through the milk and dough stages reaching maturity (SBS) during August and into early September (table 7). The apical meristem of reproductive lead tillers can no longer produce leaf buds after it had produced flower buds and these tillers were terminated at the end of the growing season.

Growth and development data of prairie sandreed reproductive lead tillers on sandy soils managed with the twice-over strategy and the ungrazed treatment during 1983 to 1986 and 1987 to 1989 are on table 8.

Reproductive lead tillers with 5 to 10 stalk leaves on the twice-over strategy during 1983 to 1986 composed 9.6% of the total population with 124 tillers (table 6) that had a mean flower stalk height of 44.4 cm, during the growing season a mean of 59.8% of the leaves were photosynthetically active with a mean leaf height of 32.3 cm and the tallest leaf averaged 40.5 cm tall (table 8).

Reproductive lead tillers with 5 to 10 stalk leaves on the ungrazed treatment during 1983 to 1986 composed 11.6% of the total population with 133 tillers (table 6) that had a mean flower stalk height of 51.7 cm, during the growing season a mean of 61.3% of the leaves were photosynthetically active with a mean leaf height of 40.7 cm and the tallest leaf averaged 47.9 cm tall (table 8).

Reproductive lead tillers with 5 to 10 stalk leaves on the twice-over strategy during 1987 to 1989 composed 3.5% of the total population with 25 tillers (table 6) that had a mean flower stalk height of 35.5 cm, during the growing season a mean of 65.0% of the leaves were photosynthetically active with a mean leaf height of 22.8 cm and the tallest leaf averaged 31.3 cm tall (table 8).

Reproductive lead tillers with 5 to 10 stalk leaves on the ungrazed treatment during 1987 to 1989 composed 3.8% of the total population with 27 tillers (table 6) that had a mean flower stalk height of 49.0 cm, during the growing season a mean of 59.4% of the leaves were photosynthetically active with a mean leaf height of 35.2 cm and the tallest leaf averaged 39.7 cm tall (table 8).

The quality of reproductive lead tillers on the seasonlong and nongrazed treatments during 1987 to 1989 were too low to develop meaningful analysis (table 6).

All of the reproductive lead tillers measured during this study were not grazed including the tillers located on grazed treatments. The not grazed tillers remaining on the grazed treatments tended to have slightly shorter mean leaf heights and mean tallest leaf heights which were not significantly different than the not grazed tillers on the ungrazed treatments on the sandy soils during the 1983-1986 and 1987-1989 periods (table 8). It is not believed that grazed treatments cause reproductive lead tillers to produce slightly shorter leaf heights. It is surmised that grazing cattle have a disproportional rate of selection for taller tillers than for shorter tillers leaving a distorted sample population of not grazed tillers with slightly shorter leaf heights.

Leaves grow and senesce in about the same order of their appearance. This study has designated that leaves with less than 50% senescent tissue to be photosynthetically active. Tillers growing on the twice-over treatment tended to have greater photosynthetically active leaves (62.4%) than the tillers growing on the ungrazed treatment (60.4%). Reproductive lead tillers located on the grazed twice-over treatment had 2.0% more photosynthetically active leaves than the tillers located on the ungrazed treatment (table 8).

Reproductive lead tillers composed a low percentage of the total measured tiller population. Reproductive lead tillers located on the twice-over treatment composed 9.6% and 3.5% and the reproductive tillers located on the ungrazed treatment composed 11.6% and 3.8% of the total tiller population during the 1983-1986 period and the 1987-1989 period, respectively. Reproductive lead tillers located on the seasonlong and nongrazed treatments composed 2.5% (5 tillers) and 2.7% (7 tillers) of the total population during the 1987-1989 period, respectively (table 6).

Table 7. Phenological stages of flower stalk development for prairie sandreed, 1983-1986.

6 Jun	22 Jun	6 Jul	22 Jul	6 Aug	22 Aug
	FSD	FSD			
		HE	HE		
			Ant	Ant	
				SD	SD
				SBS	SBS

FSD flower stalk developing
HE head emergence
Ant anthesis (flowering)
SD seeds developing
SBS seeds being shed

Table 8. Growth and development of prairie sandreed reproductive lead tillers on sandy soils managed with twice-over grazing and ungrazed treatments, 1983-1986, 1987-1989.

	6 Jun	22 Jun	6 Jul	22 Jul	6 Aug	22 Aug
Twice-over 1983-1986						
Stalk Height cm	-	-	40.9	46.2	44.6	46.0
% Active Leaf	-	-	73.3	60.8	52.5	52.5
Leaf Height cm	-	-	32.0	33.4	30.9	32.8
Tallest Leaf cm	-	-	44.9	43.9	34.6	38.7
Ungrazed 1983-1986						
Stalk Height cm	-	-	40.5	51.7	58.1	56.3
% Active Leaf	-	-	70.6	63.8	64.7	45.9
Leaf Height cm	-	-	39.8	40.2	42.3	40.3
Tallest Leaf cm	-	-	51.4	46.3	48.6	45.3
Twice-over 1987-1989						
Stalk Height cm	-	-	-	28.8	40.8	37.0
% Active Leaf	-	-	-	72.5	66.7	55.9
Leaf Height cm	-	-	-	21.6	24.0	22.9
Tallest Leaf cm	-	-	-	33.7	28.8	31.4
Ungrazed 1987-1989						
Stalk Height cm	-	-	-	50.2	51.2	45.6
% Active Leaf	-	-	-	66.7	60.0	51.4
Leaf Height cm	-	-	-	37.8	34.6	33.1
Tallest Leaf cm	-	-	-	45.5	36.7	37.0

Vegetative Tillers

The vegetative tillers had the second fastest rate of growth and development continuing until mid to late July. Early new leaf development for vegetative tillers arise from fall produced terminal rhizome tiller buds during early May. The rate of growth greatly increased during late May and early June resulting in 84% of the tillers with 5 or 6 leaves and 16% of the tillers with 7 or 8 leaves during early June. During mid to late July the rate of growth decreased resulting in 20% of the tillers with 5 or 6 leaves, 57% of the tillers with 7 or 8 leaves, and 23% of the tillers with 9 or 10 leaves. Most of the vegetative tillers with 8, 9, or 10 leaves stop adding leaves after late July. A very low number of vegetative tillers with 4, 5, 6, or 7 leaves added additional leaves after late July (figure 1).

Growth and development data of prairie sandreed vegetative tillers on sandy soils managed with the twice-over strategy during 1983 to 1986 are on table 9.

Vegetative tillers with 5 leaves composed 11.6% of the population with 133 tillers, during the growing season a mean of 3.5 leaves (70.0%) were photosynthetically active with a mean leaf height of 19.2 cm and the tallest leaf averaged 23.4 cm tall (table 9).

Vegetative tillers with 6 leaves composed 25.0% of the population with 286 tillers, during the growing season a mean of 4.3 leaves (72.2%) were photosynthetically active with a mean leaf height of 19.6 cm and the tallest leaf averaged 24.3 cm tall (table 9).

Vegetative tillers with 7 leaves composed 28.1% of the population with 321 tillers, during the growing season a mean of 4.6 leaves (65.5%) were photosynthetically active with a mean leaf height of 21.9 cm and the tallest leaf averaged 27.0 cm tall (table 9).

Vegetative tillers with 8 leaves composed 19.2% of the population with 220 tillers, during the growing season a mean of 5.2 leaves (64.6%) were photosynthetically active with a mean leaf height of 25.2 cm and the tallest leaf averaged 30.2 cm tall (table 9).

Vegetative tillers with 9 leaves composed 10.2% of the population with 117 tillers, during the growing season a mean of 6.0 leaves (66.7%) were photosynthetically active with a mean leaf height of 24.7 cm and the tallest leaf averaged 29.1 cm tall (table 9).

Vegetative tillers with 10 leaves composed 5.9% of the population with 67 tillers, during the growing season a mean of 7.0 leaves (70.0%) were photosynthetically active with a mean leaf height of 24.6 cm and the tallest leaf averaged 30.7 cm tall (table 9).

Growth and development data of prairie sandreed vegetative tillers on sandy soils managed with the ungrazed treatment during 1983 to 1986 are on table 10.

Vegetative tillers with 5 leaves composed 9.7% of the population with 96 tillers, during the growing season a mean of 3.6 leaves (71.7%) were photosynthetically active with a mean leaf height of 24.0 cm and the tallest leaf averaged 30.2 cm tall (table 10).

Vegetative tillers with 6 leaves composed 21.1% of the population with 209 tillers, during the growing season a mean of 4.1 leaves (68.1%) were photosynthetically active with a mean leaf height of 23.6 cm and the tallest leaf averaged 28.8 cm tall (table 10).

Vegetative tillers with 7 leaves composed 25.2% of the population with 249 tillers, during the growing season a mean of 4.6 leaves (65.5%) were photosynthetically active with a mean leaf height of 26.5 cm and the tallest leaf averaged 31.2 cm tall (table 10).

Vegetative tillers with 8 leaves composed 21.9% of the population with 217 tillers, during the growing season a mean of 5.2 leaves (65.6%) were photosynthetically active with a mean leaf height of 28.4 cm and the tallest leaf averaged 34.0 cm tall (table 10).

Vegetative tillers with 9 leaves composed 14.0% of the population with 138 tillers, during the growing season a mean of 5.9 leaves (65.6%) were photosynthetically active with a mean leaf height of 29.4 cm and the tallest leaf averaged 35.2 cm tall (table 10).

Vegetative tillers with 10 leaves composed 8.1% of the population with 80 tillers, during the growing season a mean of 6.7 leaves (67.0%) were photosynthetically active with a mean leaf height of 33.5 cm and the tallest leaf averaged 41.8 cm tall (table 10).

Growth and development data of prairie sandreed vegetative tillers on sandy soils managed with the twice-over strategy during 1987 to 1989 are on table 11.

Vegetative tillers with 5 leaves composed 44.6% of the population with 229 tillers, during the growing season a mean of 3.8 leaves (76.7%) were photosynthetically active with a mean leaf height of 16.9 cm and the tallest leaf averaged 20.7cm tall (table 11).

Vegetative tillers with 6 leaves composed 28.1% of the population with 144 tillers, during the growing season a mean of 4.2 leaves (70.0%) were photosynthetically active with a mean leaf height of 19.2 cm and the tallest leaf averaged 22.7 cm tall (table 11).

Vegetative tillers with 7 leaves composed 13.3% of the population with 68 tillers, during the growing season a mean of 5.0 leaves (71.4%) were photosynthetically active with a mean leaf height of 17.1 cm and the tallest leaf averaged 22.9 cm tall (table 11).

Vegetative tillers with 8 leaves composed 9.6% of the population with 49 tillers, during the growing season a mean of 5.7 leaves (70.8%) were photosynthetically active with a mean leaf height of 19.8 cm and the tallest leaf averaged 24.1 cm tall (table 11).

Vegetative tillers with 9 leaves composed 3.5% of the population with 18 tillers, during the growing season a mean of 6.3 leaves (70.4%) were photosynthetically active with a mean leaf height of 20.4 cm and the tallest leaf averaged 26.5 cm tall (table 11).

Vegetative tillers with 10 leaves composed 1.0% of the population with 5 tillers, during the growing season a mean of 7.5 leaves (75.0%) were photosynthetically active with a mean leaf height of 17.9 cm and the tallest leaf averaged 26.9 cm tall (table 11).

Growth and development data of prairie sandreed vegetative tillers on sandy soils managed with the traditional seasonlong practice during 1987 to 1989 are on table 12.

Vegetative tillers with 5 leaves composed 48.1% of the population with 87 tillers, during the growing season a mean of 3.6 leaves (71.7%) were photosynthetically active with a mean leaf height of 18.8 cm and the tallest leaf averaged 23.2 cm tall (table 12).

Vegetative tillers with 6 leaves composed 23.2% of the population with 42 tillers, during the growing season a mean of 4.0 leaves (66.7%) were photosynthetically active with a mean leaf height of 22.4 cm and the tallest leaf averaged 29.2 cm tall (table 12).

Vegetative tillers with 7 leaves composed 18.2% of the population with 33 tillers, during the growing season a mean of 4.5 leaves (64.3%) were photosynthetically active with a mean leaf height of 25.5 cm and the tallest leaf averaged 32.7 cm tall (table 12).

Vegetative tillers with 8 leaves composed 4.4% of the population with 8 tillers, during the growing season a mean of 4.0 leaves (50.0%) were photosynthetically active with a mean leaf height of 22.0 cm and the tallest leaf averaged 26.9 cm tall (table 12).

Vegetative tillers with 9 leaves composed 5.0% of the population with 9 tillers, during the growing season a mean of 5.0 leaves (55.6%) were photosynthetically active with a mean leaf height of 22.6 cm and the tallest leaf averaged 26.8 cm tall (table 12).

Vegetative tillers with 10 leaves composed 1.1% of the population with 2 tillers, during the growing season a mean of 6.5 leaves (65.0%) were photosynthetically active with a mean leaf height of 28.9 cm and the tallest leaf averaged 39.5 cm tall (table 12).

Growth and development data of prairie sandreed vegetative tillers on sandy soils managed with the long-term nongrazed treatment during 1987 to 1989 are on table 13.

Vegetative tillers with 5 leaves composed 48.4% of the population with 90 tillers, during the growing season a mean of 3.8 leaves (76.7%) were photosynthetically active with a mean leaf height of 25.5 cm and the tallest leaf averaged 31.8 cm tall (table 13).

Vegetative tillers with 6 leaves composed 29.6% of the population with 55 tillers, during the growing season a mean of 4.2 leaves (69.5%) were photosynthetically active with a mean leaf height of 26.2 cm and the tallest leaf averaged 33.1 cm tall (table 13).

Vegetative tillers with 7 leaves composed 17.2% of the population with 32 tillers, during the growing season a mean of 4.6 leaves (65.7%) were photosynthetically active with a mean leaf height of 26.8 cm and the tallest leaf averaged 32.5 cm tall (table 13).

Vegetative tillers with 8 leaves composed 4.8% of the population with 9 tillers, during the growing season a mean of 5.0 leaves (62.5%) were photosynthetically active with a mean leaf height of 30.8 cm and the tallest leaf averaged 40.9 cm tall (table 13).

Vegetative tillers with 9 and 10 leaves composed 0.0% of the population with 0.0 tillers each (table 13).

Not all the leaves on a grass tiller are photosynthetically active during the entire growing season. Leaves grow and senesce in the order they appear. The first leaves are usually dry by early June and the second leaves are usually dry by late June. The rate of leaf senescence can be rapid during water deficiency periods and slow during periods with adequate precipitation. During senescence, leaves translocate cell components to other plant parts. The senesced leaf has less weight and has very low nutritional quality. The greater number of leaves not senescent, the greater the tiller nutritional quality.

The rate of leaf senescence of prairie sandreed vegetative tillers on sandy soils managed with the ungrazed and twice-over treatments during 1983 to 1986 that received adequate precipitation was very similar with the first and second leaves drying during June and one or two other leaves drying after late July. Most tillers maintained 3 to 6 photosynthetically active leaves through August (table 14).

The rate of leaf senescence of prairie sandreed vegetative tillers on sandy soils managed with the nongrazed, seasonlong, and twice-over treatments during 1987 to 1989 that had water deficiency during most of the growing season months was more severe than during the 1983 to 1986 period. Most tillers failed to produce leaves 8, 9, or 10. Tillers on the nongrazed and seasonlong treatments maintained a mean of 2.5 and 2.4 photosynthetically active leaves during the growing season, respectively. Tillers on the twice-over treatment maintained a mean of 3.4 photosynthetically active leaves (table 15).

All of the vegetative tillers of prairie sandreed with 5 to 10 leaves measured during this study were not grazed including the tillers located on grazed treatments. The not grazed tillers remaining on the grazed treatments tended to have slightly shorter mean leaf heights and mean tallest leaf heights which were not significantly different than the not grazed tillers on the ungrazed and nongrazed treatments on the sandy soils during the 1983-1986 and 1987-1989 periods (tables 9 to 13). It is not believed that grazed treatments cause vegetative tillers to produce slightly shorter leaf heights. It is surmised that grazing cattle have a disproportional rate of selection for taller tillers than for shorter tillers leaving a distorted sample population of not grazed tillers with slightly shorter leaf heights.

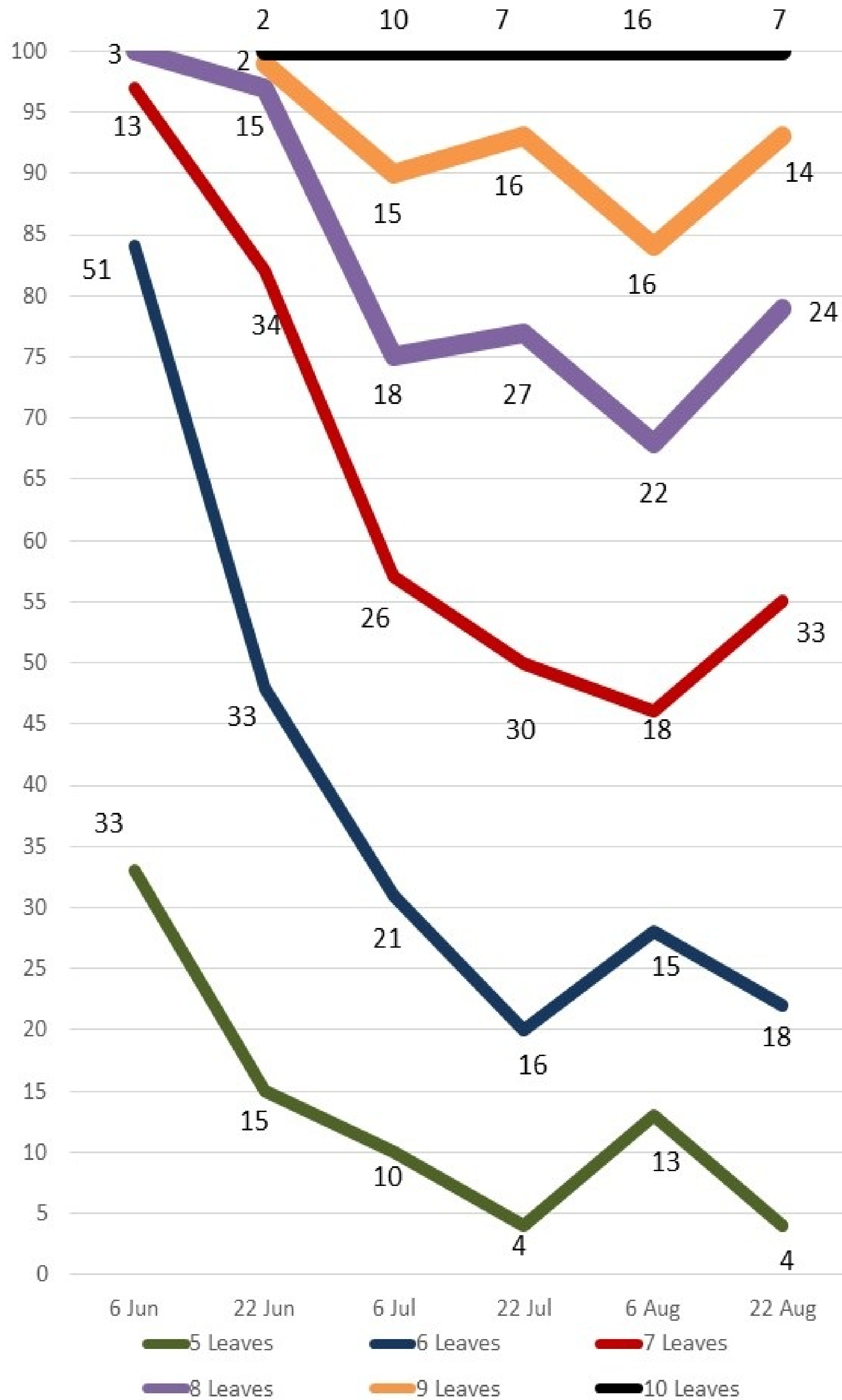

Figure 1. Percent of vegetative tiller population with 5 to 10 leaves.

Table 9. Growth and development of Prairie sandreed vegetative tillers with 5 to 10 leaves on sandy soils managed with the twice-over strategy, 1983-1986.

	6 Jun	22 Jun	6 Jul	22 Jul	6 Aug	22 Aug
5 Leaves						
% Population	33.0	14.9	10.2	4.1	12.6	4.2
% Active Leaf	80.0	70.0	100.0	60.0	60.0	50.0
Leaf Height cm	18.4	22.4	5.7	29.1	19.2	20.3
Tallest Leaf cm	25.6	26.5	8.0	35.0	23.4	22.1
6 Leaves						
% Population	51.2	33.1	21.2	15.7	15.1	18.1
% Active Leaf	83.3	66.7	100.0	66.7	66.7	50.0
Leaf Height cm	22.2	24.0	6.8	24.7	17.4	22.7
Tallest Leaf cm	31.1	29.0	10.6	30.4	19.6	24.8
7 Leaves						
% Population	13.4	33.8	26.3	30.2	18.5	32.8
% Active Leaf	85.7	71.4	71.4	57.1	57.1	50.0
Leaf Height cm	23.1	25.5	13.3	25.7	21.5	22.0
Tallest Leaf cm	34.2	32.3	16.6	28.3	26.0	24.7
8 Leaves						
% Population	2.4	15.3	18.2	27.3	21.8	23.9
% Active Leaf	75.0	68.8	62.5	62.5	62.5	56.3
Leaf Height cm	30.3	26.5	22.8	27.0	22.5	22.1
Tallest Leaf cm	42.8	33.1	24.9	30.2	24.8	25.2
9 Leaves						
% Population	0.0	2.5	14.6	15.7	16.0	13.9
% Active Leaf	-	77.8	66.7	61.1	66.7	61.1
Leaf Height cm	-	25.7	25.4	26.7	24.2	21.3
Tallest Leaf cm	-	31.4	30.2	29.5	28.6	25.6
10 Leaves						
% Population	0.0	0.4	9.5	7.0	16.0	7.1
% Active Leaf	-	80.0	70.0	70.0	70.0	60.0
Leaf Height cm	-	12.7	28.1	28.6	28.0	25.8
Tallest Leaf cm	-	21.2	32.8	35.8	34.2	29.7
% Population	100.0	100.0	100.0	100.0	100.0	100.0

Table 10. Growth and development of Prairie sandreed vegetative tillers with 5 to 10 leaves on sandy soils managed with the ungrazed treatment, 1983-1986.

	6 Jun	22 Jun	6 Jul	22 Jul	6 Aug	22 Aug
5 Leaves						
% Population	34.1	5.6	2.3	10.0	4.2	5.5
% Active Leaf	80.0	80.0	80.0	70.0	60.0	60.0
Leaf Height cm	21.3	24.6	15.5	28.2	25.6	28.7
Tallest Leaf cm	28.8	31.5	21.9	35.1	29.6	34.4
6 Leaves						
% Population	40.3	28.2	15.2	21.3	8.5	16.0
% Active Leaf	83.3	66.7	100.0	58.3	50.0	50.0
Leaf Height cm	23.2	28.5	7.2	30.8	26.2	25.4
Tallest Leaf cm	32.6	33.4	11.0	35.1	32.0	28.4
7 Leaves						
% Population	22.5	35.9	20.5	22.6	16.1	29.8
% Active Leaf	71.4	71.4	71.4	57.1	57.1	64.3
Leaf Height cm	25.9	31.1	17.6	31.7	31.7	20.9
Tallest Leaf cm	32.6	38.2	21.7	35.2	35.7	23.9
8 Leaves						
% Population	3.1	21.8	32.6	22.6	29.7	21.8
% Active Leaf	75.0	62.5	75.0	62.5	62.5	56.3
Leaf Height cm	26.7	32.9	22.2	31.7	33.4	23.3
Tallest Leaf cm	37.2	39.2	27.2	34.3	39.5	26.8
9 Leaves						
% Population	0.0	7.7	17.4	14.3	23.7	18.1
% Active Leaf	-	66.7	77.8	72.2	55.6	55.6
Leaf Height cm	-	34.3	24.2	31.1	32.0	25.5
Tallest Leaf cm	-	41.7	30.2	36.2	37.3	30.7
10 Leaves						
% Population	0.0	0.7	12.1	9.1	17.8	8.8
% Active Leaf	-	70.0	70.0	65.0	70.0	60.0
Leaf Height cm	-	38.1	38.0	30.3	33.4	27.8
Tallest Leaf cm	-	54.0	43.4	37.3	40.0	34.4
% Population	100.0	99.9	100.1	99.9	100.0	100.0

Table 11. Growth and development of Prairie sandreed vegetative tillers with 5 to 10 leaves on sandy soils managed with the twice-over strategy, 1987-1989.

	6 Jun	22 Jun	6 Jul	22 Jul	6 Aug	22 Aug
5 Leaves						
% Population	78.6	36.1	76.3	19.3	100.0	16.3
% Active Leaf	80.0	80.0	80.0	80.0	80.0	60.0
Leaf Height cm	19.2	17.4	19.1	15.9	18.0	11.9
Tallest Leaf cm	23.5	19.7	23.4	20.8	22.8	13.7
6 Leaves						
% Population	20.6	34.4	20.3	30.3	0.0	38.0
% Active Leaf	66.7	66.7	83.3	66.7	-	66.7
Leaf Height cm	20.9	20.1	21.6	17.5	-	15.9
Tallest Leaf cm	23.3	22.7	28.2	20.7	-	18.8
7 Leaves						
% Population	0.8	14.8	3.4	22.7	0.0	22.5
% Active Leaf	71.4	71.4	85.7	71.4	-	57.1
Leaf Height cm	12.3	25.0	13.2	16.9	-	18.0
Tallest Leaf cm	19.1	29.7	24.3	21.9	-	19.4
8 Leaves						
% Population	0.0	13.1	0.0	19.3	0.0	14.0
% Active Leaf	-	75.0	-	75.0	-	62.5
Leaf Height cm	-	23.9	-	17.4	-	18.2
Tallest Leaf cm	-	28.5	-	23.6	-	20.3
9 Leaves						
% Population	0.0	1.6	0.0	7.6	0.0	6.2
% Active Leaf	-	77.8	-	77.8	-	55.6
Leaf Height cm	-	23.5	-	19.9	-	17.7
Tallest Leaf cm	-	31.2	-	26.8	-	21.5
10 Leaves						
% Population	0.0	0.0	0.0	0.8	0.0	3.1
% Active Leaf	-	-	-	80.0	-	70.0
Leaf Height cm	-	-	-	15.1	-	20.6
Tallest Leaf cm	-	-	-	29.3	-	24.5
% Population	100.0	100.0	100.0	100.0	100.0	100.1

Table 12. Growth and development of Prairie sandreed vegetative tillers with 5 to 10 leaves on sandy soils managed with the traditional seasonlong practice, 1987-1989.

	6 Jun	22 Jun	6 Jul	22 Jul	6 Aug	22 Aug
5 Leaves						
% Population	69.6	37.0	100.0	41.5	100.0	17.0
% Active Leaf	90.0	60.0	80.0	80.0	80.0	40.0
Leaf Height cm	24.1	23.8	15.9	20.3	14.4	14.0
Tallest Leaf cm	31.7	30.0	20.9	23.6	17.2	15.5
6 Leaves						
% Population	28.3	25.9	0.0	24.4	0.0	25.5
% Active Leaf	83.3	66.7	-	66.7	-	50.0
Leaf Height cm	22.3	24.5	-	22.3	-	20.6
Tallest Leaf cm	31.4	34.4	-	27.2	-	23.8
7 Leaves						
% Population	2.2	37.0	0.0	17.1	0.0	31.9
% Active Leaf	85.7	57.1	-	57.1	-	57.1
Leaf Height cm	23.2	32.0	-	25.7	-	20.9
Tallest Leaf cm	37.5	36.8	-	32.6	-	24.0
8 Leaves						
% Population	0.0	0.0	0.0	7.3	0.0	10.6
% Active Leaf	-	-	-	50.0	-	50.0
Leaf Height cm	-	-	-	22.2	-	21.8
Tallest Leaf cm	-	-	-	28.2	-	25.6
9 Leaves						
% Population	0.0	0.0	0.0	7.3	0.0	12.8
% Active Leaf	-	-	-	55.6	-	55.6
Leaf Height cm	-	-	-	23.4	-	21.7
Tallest Leaf cm	-	-	-	25.7	-	27.8
10 Leaves						
% Population	0.0	0.0	0.0	2.4	0.0	2.1
% Active Leaf	-	-	-	60.0	-	70.0
Leaf Height cm	-	-	-	31.5	-	26.3
Tallest Leaf cm	-	-	-	37.7	-	41.2
% Population	100.1	99.9	100.0	100.0	100.0	99.9

Table 13. Growth and development of Prairie sandreed vegetative tillers with 5 to 10 leaves on sandy soils managed with the long-term nongrazed treatment, 1987-1989.

	6 Jun	22 Jun	6 Jul	22 Jul	6 Aug	22 Aug
5 Leaves						
% Population	56.1	48.6	63.6	34.4	87.5	26.3
% Active Leaf	80.0	80.0	80.0	80.0	80.0	60.0
Leaf Height cm	25.2	25.0	18.6	26.0	33.4	25.0
Tallest Leaf cm	34.2	30.6	23.8	32.0	40.1	30.3
6 Leaves						
% Population	36.6	35.1	31.8	21.9	12.5	28.9
% Active Leaf	83.3	66.7	83.3	66.7	66.7	50.0
Leaf Height cm	20.6	29.4	27.0	27.7	30.1	22.6
Tallest Leaf cm	32.5	35.8	36.5	31.3	36.6	25.9
7 Leaves						
% Population	4.9	8.1	4.5	37.5	0.0	36.8
% Active Leaf	57.1	71.4	85.7	57.1	-	57.1
Leaf Height cm	29.1	32.1	25.4	27.6	-	19.8
Tallest Leaf cm	33.7	41.0	30.4	32.7	-	24.7
8 Leaves						
% Population	2.4	8.1	0.0	6.3	0.0	7.9
% Active Leaf	75.0	62.5	-	62.5	-	50.0
Leaf Height cm	27.2	37.0	-	30.9	-	27.9
Tallest Leaf cm	42.1	48.0	-	38.7	-	34.9
9 Leaves						
% Population	0.0	0.0	0.0	0.0	0.0	0.0
% Active Leaf	-	-	-	-	-	-
Leaf Height cm	-	-	-	-	-	-
Tallest Leaf cm	-	-	-	-	-	-
10 Leaves						
% Population	0.0	0.0	0.0	0.0	0.0	0.0
% Active Leaf	-	-	-	-	-	-
Leaf Height cm	-	-	-	-	-	-
Tallest Leaf cm	-	-	-	-	-	-
% Population	100.0	99.9	99.9	100.1	100.0	99.9

Table 14. Number of photosynthetically active leaves for Prairie sandreed vegetative tillers with 5 to 10 leaves on sandy soils managed with ungrazed and twice-over treatments, 1983-1986.

Leaves/Tiller	6 Jun	22 Jun	6 Jul	22 Jul	6 Aug	22 Aug	Mean
Ungrazed							
5 Leaves	4	4	4	3.5	3	3	3.6
6 Leaves	5	4	6	3.5	3	3	4.1
7 Leaves	5	5	5	4	4	4.5	4.6
8 Leaves	6	5	6	5	5	4.5	5.3
9 Leaves	0	6	7	6.5	5	5	4.9
10 Leaves	0	7	7	6.5	7	6	5.6
	3.3	5.2	5.8	4.8	4.5	4.3	4.7
Twice-over							
5 Leaves	4	3.5	5	3	3	2.5	3.5
6 Leaves	5	4	6	4	4	3	4.3
7 Leaves	6	5	5	4	4	3.5	4.6
8 Leaves	6	5.5	5	5	5	4.5	5.2
9 Leaves	0	7	6	5.5	6	5.5	5.0
10 Leaves	0	8	7	7	7	6	5.8
	3.5	5.5	5.7	4.8	4.8	4.2	4.8

Table 15. Number of photosynthetically active leaves for Prairie sandreed vegetative tillers with 5 to 10 leaves on sandy soils managed with nongrazed, seasonlong, and twice-over treatments, 1987-1989.

Leaves/Tiller	6 Jun	22 Jun	6 Jul	22 Jul	6 Aug	22 Aug	Mean
Nongrazed							
5 Leaves	4	4	4	4	4	3	3.8
6 Leaves	5	4	5	4	4	3	4.2
7 Leaves	4	5	6	4	0	4	3.8
8 Leaves	6	5	0	5	0	4	3.3
9 Leaves	0	0	0	0	0	0	0.0
10 Leaves	0	0	0	0	0	0	0.0
	3.2	3.0	2.5	2.8	1.3	2.3	2.5
Seasonlong							
5 Leaves	4.5	3	4	4	4	2	3.6
6 Leaves	5	4	0	4	0	3	2.7
7 Leaves	6	4	0	4	0	4	3.0
8 Leaves	0	0	0	4	0	4	1.3
9 Leaves	0	0	0	5	0	5	1.7
10 Leaves	0	0	0	6	0	7	2.2
	2.6	1.8	0.7	4.5	0.7	4.2	2.4
Twice-over							
5 Leaves	4	4	4	4	4	3	3.8
6 Leaves	4	4	5	4	0	4	3.5
7 Leaves	5	5	6	5	0	4	4.2
8 Leaves	0	6	0	6	0	5	2.8
9 Leaves	0	7	0	7	0	5	3.2
10 Leaves	0	0	0	8	0	7	2.5
	2.2	4.3	2.5	5.7	0.7	4.7	3.4

Secondary Tillers

The secondary tillers had very slow rates of growth and development until they produce their fourth leaf. During growing seasons with normal precipitation conditions (1983 to 1986), secondary tillers made up only 1.8% of the total tiller population on the grazed twice-over treatment and made up about 1.8% of the ungrazed treatment. During growing seasons with below normal precipitation conditions (1987 to 1989), secondary tillers made up a greater proportion of the total tiller population, with 24.9% on the twice-over strategy, 32.6% on the seasonlong, and 25.2% on the nongrazed treatments.

Growth and development prairie sandreed secondary tillers on sandy soils managed with the ungrazed and twice-over treatments during 1983 to 1986 and managed with the nongrazed, seasonlong, and twice-over treatments during 1987 to 1989 are on table 16.

Secondary tillers with 2 to 4 leaves on the ungrazed treatment during 1983 to 1986 composed 1.8% of the total tiller population with 21 tillers, during the growing season 64.3% of the leaves were photosynthetically active with a mean leaf height of 22.9 cm and the tallest leaf averaged 27.9 cm tall (table 16).

Secondary tillers with 2 to 4 leaves on the twice-over strategy during 1983 to 1986 composed 1.8% of the total tiller population with 23 tillers, during the growing season 65.5% of the leaves were photosynthetically active with a mean leaf height of 15.0 cm and the tallest leaf averaged 17.0 cm tall (table 16).

Secondary tillers with 2 to 4 leaves on the nongrazed treatment during 1987to 1989 composed 25.2% of the total tiller population with 65 tillers, during the growing season 75.5% of the leaves were photosynthetically active with a mean leaf height of 22.7 cm and the tallest leaf averaged 28.6 cm tall (table 16).

Secondary tillers with 2 to 4 leaves on the seasonlong treatment during 1987 to 1989 composed 32.6% of the total tiller population with 90 tillers, during the growing season 76.2% of the leaves were photosynthetically active with a mean leaf height of 19.2 cm and the tallest leaf averaged 22.3 cm tall (table 16).

Secondary tillers with 2 to 4 leaves on the twice-over strategy during 1987 to 1989 composed 24.9% of the total tiller population with 178 tillers, during the growing season 78.0% of the leaves were photosynthetically active with a mean leaf height of 15.7 cm and the tallest leaf averaged 17.8 cm tall (table 16).

All of the secondary tillers measured during this study were not grazed including the tillers located on grazed treatments. The not grazed tillers remaining on the grazed treatments tended to have slightly shorter mean leaf heights and mean tallest leaf heights which were not significantly different than the not grazed tillers on the ungrazed and nongrazed treatments on the sandy soils during the 1983-1986 and 1987-1989 periods (tables 16). It is not believed that grazed treatments cause secondary tillers to produce slightly shorter leaf heights. It is surmised that grazing cattle have a disproportional rate of selection for taller tillers than for shorter tillers leaving a distorted sample population of not grazed tillers with slightly shorter leaf heights.

Leaves grow and senesce in about the same order of their appearance. This study has designated that leaves with less than 50% senescent tissue to be photosynthetically active. The rate of senescence of the secondary tiller leaves was about the same on the ungrazed and twice-over treatments during 1983 to 1098. The rate of senescence of the secondary tiller leaves was about the same on the nongrazed, seasonlong, and twice-over treatments during 1987 to 1989.

Secondary tillers composed a low percentage of the total measured tiller population during the 1983 to 1986 period with normal precipitation conditions. The quantity of secondary tillers greatly increased during the 1987 to 1989 period with below normal precipitation conditions. The below normal precipitation conditions caused greater restrictions on leaf development of the younger secondary tillers on all treatments.

Table 16. Growth and development of Prairie sandreed secondary tillers on sandy soils managed with the ungrazed and twice-over treatments, 1983-1986, and with the nongrazed, seasonlong, and twice-over treatments, 1987-1989.

	6 Jun	22 Jun	6 Jul	22 Jul	6 Aug	22 Aug
Ungrazed 1983-1986						
% Population	7.9	1.4	0.8	2.5	0.0	0.4
% Active Leaf	75.0	75.0	75.0	71.4	-	25.0
Leaf Height cm	17.3	20.3	19.9	18.6	-	38.2
Tallest Leaf cm	20.0	31.6	28.6	20.9	-	38.2
Twice-over 1983-1986						
% Population	11.2	2.1	0.0	0.0	0.0	0.4
% Active Leaf	71.4	75.0	-	-	-	50.0
Leaf Height cm	10.5	20.8	-	-	-	13.8
Tallest Leaf cm	11.9	25.2	-	-	-	13.9
Nongrazed 1987-1989						
% Population	43.1	22.9	8.3	30.4	23.8	5.0
% Active Leaf	100.0	71.4	75.0	71.4	60.0	75.0
Leaf Height cm	23.0	18.2	14.2	32.0	26.0	-
Tallest Leaf cm	27.4	23.5	24.4	39.3	28.5	-
Seasonlong 1987-1989						
% Population	36.9	43.8	79.2	12.8	54.5	0.0
% Active Leaf	92.3	63.6	75.0	75.0	75.0	-
Leaf Height cm	18.6	22.1	17.6	20.1	17.6	-
Tallest Leaf cm	23.9	23.8	21.2	22.3	20.5	-
Twice-over 1987-1989						
% Population	32.6	48.3	18.1	4.0	66.7	3.0
% Active Leaf	100.0	71.4	75.0	75.0	71.4	75.0
Leaf Height cm	16.4	17.4	18.1	18.2	12.3	11.7
Tallest Leaf cm	20.6	18.4	20.6	21.1	13.3	12.5

Discussion

Prairie sandreed, *Calamorilfa longifolia,* is a native, long-lived perennial, warm season, tall grass, monocot, of the grass family that is abundant on healthy mixed grass prairie plant communities. Prairie sandreed forms large colonies on sandy soils with sand that is 28 to 36 cm (11 to 14 in) deep. Prairie sandreed can grow at an impoverished condition on sandy soils less than 28 cm (11 in) of depth and on shallow and silty sites. It is drought resistant, tolerant of alkaline soils, not tolerant of salt, and susceptible of trampling. Prairie sandreed is one of the two native grasses in the mixed grass prairie that can be reduced and removed from the prairie by heavy or poor grazing management practices. The leaves are highly palatable to grazing animals, however, the coarse stems are rarely grazed, which leaves 15 to 30 cm (6 to 12 in) stems standing, giving the false appearance that this grass is undesired by livestock.

Prairie sandreed tillers live for two growing seasons; the first growing season as a vegetative tiller and the second as a reproductive lead tiller. Early season activity starts by regreening with active chlorophyll the portions of the carryover leaves that have intact cell walls from the previous growing season vegetative tillers. The green portion of the carryover leaves provides large quantities of carbohydrates and energy for the production of new current year leaves. New leaf growth of reproductive lead tillers is visible during early May. Leaf growth is rapid during May and June and then becomes much slower after July. Flower stalks reached the boot stage shortly after mid June, progressed through head emergence during early and mid July, and reaching the flower stage shortly after mid July. The flower stage usually occurred during a 3 week period from mid July through the first week of August. By the time that flower stalks produce flowers, about half of the stalks have 9 or 10 leaves. Maximum stalk height was reached during late August. No new leaves are produced after the anthesis stage. Seeds developed and reached maturity during August and were being shed during mid August to early September. Some of the seeds remained in the stalks through winter and into the early portion of the next growing season.

Early new leaf development for vegetative tillers arise from fall produced terminal rhizome tiller buds during early May. Leaves develop rapidly resulting in 84% of the tillers with 5 or 6 leaves and 16% of the tillers with 7 or 8 leaves during early June. By late July, 20% of the tillers have 5 or 6 leaves, 57% have 7 or 8 leaves, and 23% have 9 or 10 leaves. Most of the vegetative tillers with 8, 9, or 10 leaves do not add additional leaves after late July. A very low percentage of the vegetative tillers have 4, 5, 6, or 7 leaves during late July and most of these will add one leaf after late July.

Secondary tillers are not much different from vegetative tillers other than the time of early new leaf development occurs later and leaf accumulation occurs much slower. During normal precipitation growing seasons, most of the "late" developing secondary tillers produce their fifth leaf during late June to late July and move into the vegetative tiller category with slightly fewer leaves than the older vegetative tillers. During August, a low number of secondary tillers initiate new development, with most producing 4 leaves before frost. During growing seasons with below normal precipitation, a high percentage of the vegetative tillers and secondary tiller only produce 3 or 4 leaves during June to mid July with additional leaves produced during late July and August.

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Literature Cited

Bluemle, J.P. 1977. The face of North Dakota: the geologic story. North Dakota Geological Survey. Ed. Series 11. 73p.

Bluemle, J.P. 1991. The face of North Dakota. Revised edition. North Dakota Geological Survey. Ed. Series 21. 177p.

Bluemle, J.P. 2000. The face of North Dakota. 3rd edition. North Dakota Geological Survey. Ed. Series 26. 206p. 1pl.

Dodds, D.L. 1979. Common grasses and sedges in North Dakota. NDSU Extension Service R-658. Fargo, ND.

Duckwitz, W. And R. Wynia. 2006. Calamovilfa longifolia. Scribn. Plant Database. USDA. Natural Resources Conservation Service. Bismarck, ND. and Manhattan, KS. http://plants.usda.gov/

Fenneman, N.M. 1931. Physiography of western United States. McGraw-Hill Book Company, New York, NY. 534p.

Fenneman, N.M. 1946. Physical divisions of the United States. USDI Geological Survey. Map.

Goetz, H. 1963. Growth and development of native range plants in the mixed prairie of western North Dakota. M. S. Thesis, North Dakota State University, Fargo, ND. 165p.

Great Plains Flora Association. 1986. Flora of the Great Plains. University of Kansas, Lawrence, KS.

Hauser A.S. 2005. Calamovilfa longifolia. Fire Effects Information System. USDA. Forest Service. http://www.fs.fed.us/database/feis/

Hunt, C.B. 1974. Natural regions of the United States and Canada. W.H. Freeman and Company, San Francisco, CA. 725p.

Johnson, J.R., and G.E. Larson. 2007. Grassland plants of South Dakota and the Northern Great Plains. South Dakota University. B 566 (rev.). Brookings, SD.

Manske, L.L. 1994. History and land use practices in the Little Missouri Badlands and western North Dakota. Proceedings-Leafy Spurge Strategic Planning Workshop. USDI National Park Service, Dickinson, ND. p. 3-16.

Manske, L.L. 2008a. Prehistorical conditions of rangelands in the Northern Plains. NDSU Dickinson Research Extension Center. Summary Range Management Report DREC 08-3015b. Dickinson, ND. 5p.

Manske, L.L. 2008b. Physiography, soil, and native vegetation of the Northern Plains. NDSU Dickinson Research Extension Center. Summary Range Management Report DREC 08-3048. Dickinson, ND. 28p.

Soil Survey Staff. 1975. Soil Taxonomy. Agriculture Handbook No. 436. USDA Soil Conservation Service. U.S. Government Printing Office, Washington, D.C. 754p.

Stevens, O.A. 1963. Handbook of North Dakota plants. North Dakota Institute for Regional Studies. Fargo, ND.

Stubbendieck, J., S.L. Hatch, and N.M. Bryan. 2011. North American wildland plants. 2nd Ed. University of Nebraska Press. Lincoln, NE.

Whitman, W.C. c. 1950. Native range plants–their growth and development in relation to the establishment of standards for their proper utilization. Hatch Project 9-5.

Zaczkowski, N.K. 1972. Vascular flora of Billings, Bowman, Golden Valley, and Slope Counties, North Dakota. PhD. Thesis. North Dakota State University, Fargo, ND. 219 p.

Growth Pattern and Phenological Development of Threadleaf Sedge on the Northern Plains

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Intact grassland ecosystems are complex; exceedingly more complex than the most complicated machines ever built by humans. Knowledge and understanding of the growth pattern and phenological development of the major forage grasses are fundamentally essential for generation of biologically effective management strategies with inclusivity of all biotic and abiotic components of grassland ecosystems in the Northern Plains.

The inspirational 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 relationships of ecosystem components that would result in the development and establishment of scientific standards for proper management of grazinglands in the Northern Plains.

This growth pattern and phenological development study of the major forage graminoids was conducted during the growing seasons of 1983-1986 and 1987-1989 with data collected biweekly June-August. The study included 3 cool season, 2 warm season, 1 upland sedge, 1 naturalized, and 2 domesticated grasses. The study sites were located at the NDSU Dickinson Research Extension Center ranch near Manning in western North Dakota and consisted of 143 acres (58 ha) of two seeded domesticated grasslands and 720 acres (291 ha) of native rangeland pastures separated into three management treatments, each with two replications, with data collection sites established on sandy, shallow, and silty ecological sites. Each ecological site of the grazed treatments had matching paired plots, one grazed and the other with an ungrazed exclosure.

Study Area

The physiography of the study area consists of the Unglaciated section of the Missouri Plateau (Fenneman 1931, 1946; Hunt 1974). The landscape surface is highly eroded fluvial sedimentary deposits of material removed from the uplifted Rocky Mountains. Most of the deposition occurred from slow meandering streams during the Laramide Orogeny and during the 20 to 30 million years of the late Cretaceous and early Tertiary Periods following the uplift. Intense widespread erosion of these sediments occurred from about 5 to 3 million years ago during the late Pliocene Epoch (Bluemle 2000). The extensive erosion during this period removed about 500 to 1000 feet of sediments (Fenneman 1931) forming a landscape with well developed integrated drainage systems of broad mature valleys and gently rolling uplands containing widely spaced large hills and buttes with erosion resistant caps raising 500 to 650 feet above the plain (Bluemle 2000).

The soils of western North Dakota developed from eroded Tertiary fluvial sedimentary deposits in the Ustic-Frigid soil moisture-temperature regime. The Ustic soil moisture regime is typical of semi arid climates. The Frigid soil temperature regime has mean annual soil temperatures of less than 47° F (8° C) (Soil Survey Staff 1975). These soils are primarily Typic Borolls (semi arid cool Mollisols) and support vegetation of mid and short grasses of the Mixed Grass Prairie (Manske 2008b).

The current “native” plant species in the Northern Plains did not originate here. All of the plant species have migrated into the region by different mechanisms and at different times and rates. The present plant species have flora affinities to northern, eastern, western, Rocky Mountain, and Great Basin plant communities (Zaczkowski 1972). This wide mix of plant species was formed from remnants of previously existing plant communities. The climate changed about 5,000 years ago to conditions like those of the present, with cycles of wet and dry periods (Bluemle 1977, 1991; Manske 1994). The large diversity of plant species that make up the current mixed grass prairie permits dynamic responses to changes in climatic conditions by increasing the combination of plant species favored by any set of climatic conditions (Manske 2008a).

Long-Term Weather

The NDSU Dickinson Research Extension Center ranch is located in Dunn County in western North Dakota, at 47° 14' north latitude, 102° 50' west longitude. Mean annual temperature is 42.3° F (5.7° C). January is the coldest month, with mean temperature of 14.6° F (-9.7° C). July and August are the warmest months with mean temperatures of 69.7° F (20.9° C) and 68.6° F (20.3° C), respectively. Long-term (1982-2012) mean annual precipitation is 16.91 inches (429.61 mm). The perennial plant growing season precipitation (April to October) is 14.13 inches (358.97 mm) and is 83.6% of annual precipitation. June has the greatest monthly precipitation at 3.27 inches (83.08 mm). The precipitation received during the 3-month period of May, June, and July (8.26 inches, 209.80 mm) accounts for 48.8% of the annual precipitation.

Growing season months with water deficiency disrupt plant growth rates and are identified from monthly temperature and precipitation data by the Emberger ombrothermic diagram technique. Long-term (1983-2012) 30 year reoccurrence rates (table 1) show relatively low rates of water deficiency reoccurring during April (16.7%), May and June (10.0%), moderate rates during July and October (36.7%), and high rates during August (56.7%) and September (60.0%). Long-term occurrence of water deficiency conditions was 33.3% of the growing season months, for a mean of 2.0 water deficient months per each 6.0 month growing season (15 Apr-15 Oct).

Growing Season Precipitation

The growing season precipitation information collected during the grass leaf height study has been grouped into two periods with the first period occurring during 1983 to 1986 and the second period occurring during 1987 to 1989.

Mean growing season precipitation of 1983-1986 (table 2) was 14.11 inches (99.9% of LTM). None of the four 6 month growing seasons received precipitation at less than 80% of LTM. One growing season, 1986, received precipitation at near 130% of LTM. The rate of water deficiency occurrence during the four growing seasons was 29.2%, for a mean of 1.75 water deficient months per growing season (table 3). The growing season of 1984 had 3.0 months in water deficiency. The growing seasons of 1983 and 1986 had 1.5 months in water deficiency each. The growing season of 1985 had 1.0 month in water deficiency.

Mean growing season precipitation of 1987-1989 (table 4) was low at 9.14 inches (64.7% of LTM). The growing season of 1987 received 11.53 inches (81.6% of LTM) precipitation. The growing season of 1989 received 10.60 inches (75.0% of LTM) precipitation. The growing season of 1988 received only 5.30 inches (37.5% of LTM) precipitation and was dry. The rate of water deficiency occurrence during the three growing seasons was 61.1%, for a mean of 3.7 water deficient months per growing season (table 5). The growing seasons of 1987 and 1989 had 3.0 months in water deficiency each. The growing season of 1988 had 5.0 months of its 6 month growing season in water deficiency conditions. That is comparable to 2 other growing seasons with high water deficiency conditions. The growing season of 1934 had 4.5 months in water deficiency and the growing season of 1936 had 5.5 months in water deficiency.

Table 1. Growing season months with water deficiency, DREC ranch, 1983-2012.

	Apr	May	Jun	Jul	Aug	Sep	Oct	# Months	% 6 Months 15 Apr-15 Oct
Total	5	3	3	11	17	18	11	60.0	33.3
% of 30 Years	16.7	10.0	10.0	36.7	56.7	60.0	36.7		

Table 2. Precipitation in inches and percent of long-term mean for perennial plant growing season months, DREC ranch, 1983-1986.

	Apr	May	Jun	Jul	Aug	Sep	Oct	Growing Season	Annual Total
Long-Term Mean 1982-2012	1.44	2.56	3.27	2.43	1.70	1.42	1.31	14.13	16.91
1983	0.21	1.53	3.26	2.56	4.45	0.86	0.72	13.59	15.55
% of LTM	14.58	59.77	99.69	105.35	261.76	60.56	54.96	96.18	91.96
1984	2.87	0.00	5.30	0.11	1.92	0.53	0.96	11.69	12.88
% of LTM	199.31	0.00	162.08	4.53	112.94	37.32	73.28	82.73	76.17
1985	1.24	3.25	1.58	1.07	1.84	1.69	2.13	12.80	15.13
% of LTM	86.11	126.95	48.32	44.03	108.24	119.01	162.60	90.59	89.47
1986	3.13	3.68	2.58	3.04	0.46	5.29	0.18	18.36	22.96
% of LTM	217.36	143.75	78.90	125.10	27.06	372.54	13.74	129.94	135.78
1983-1986	1.86	2.12	3.18	1.70	2.17	2.09	1.00	14.11	16.63
% of LTM	129.34	82.62	97.25	69.75	127.50	147.36	76.15	99.86	98.34

Table 3. Growing season months with water deficiency conditions that caused water stress in perennial plants, DREC ranch, 1983-1986.

	APR	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**# Months**	**% 6 Months 15 Apr-15 Oct**
1983								1.5	25.0
1984								3.0	50.0
1985								1.0	16.7
1986								1.5	25.0
#	**1**	**1**	**0**	**2**	**1**	**2**	**1**	**7.0**	**29.2**
%	**25.0**	**25.0**	**0.0**	**50.0**	**25.0**	**50.0**	**25.0**		

Table 4. Precipitation in inches and percent of long-term mean for perennial plant growing season months, DREC ranch, 1987-1989.

	Apr	May	Jun	Jul	Aug	Sep	Oct	Growing Season	Annual Total
Long-Term Mean 1982-2012	1.44	2.56	3.27	2.43	1.70	1.42	1.31	14.13	16.91
1987	0.10	1.38	1.15	5.39	2.65	0.78	0.08	11.53	14.13
% of LTM	6.94	53.91	35.17	221.81	155.88	54.93	6.11	81.60	83.56
1988	0.00	1.85	1.70	0.88	0.03	0.73	0.11	5.30	9.03
% of LTM	0.00	72.27	51.99	36.21	1.76	51.41	8.40	37.51	53.40
1989	2.92	1.73	1.63	1.30	1.36	0.70	0.96	10.60	13.07
% of LTM	202.78	67.58	49.85	53.50	80.00	49.30	73.28	75.02	77.29
1987-1989	1.01	1.65	1.49	2.52	1.35	0.74	0.38	9.14	12.08
% of LTM	69.91	64.58	45.67	103.84	79.22	51.88	29.26	64.71	71.42

Table 5. Growing season months with water deficiency conditions that caused water stress in perennial plants, DREC ranch, 1987-1989.

	APR	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**# Months**	**% 6 Months 15 Apr-15 Oct**
1987								3.0	50.0
1988								5.0	83.3
1989								3.0	50.0
#	**2**	**0**	**2**	**2**	**2**	**3**	**2**	**11.0**	**61.1**
%	**66.7**	**0.0**	**66.7**	**66.7**	**66.7**	**100.0**	**66.7**		

Procedures

The 1983-1989 Study

Sedge tiller leaf heights were determined for reproductive lead tillers, vegetative tillers, and secondary tillers on a biweekly sampling period from June through August. Each leaf of ten ungrazed tillers of each study species was measured with a meter stick to the nearest 0.1 cm from ground level to the tips of the extended leaves. Basal leaf heights were measured for sedge species in which the leaves and stalks were distinctly separate.

Degree of leaf senescence was estimated as percent dryness for each leaf. Percent dryness for basal leaves was considered from the apex to ground level. Percent dryness for stalk leaves was considered for the blade only. The categories of dryness were: 0%, 2%, 25%, 50%, 75%, 98% and 100% dry. Start of senescence was considered to be dryness greater than 2%. Leaves with less than 50% senescent tissue were designated to be photosynthetically active.

Sedge flower stalk heights were determined by measurements from ground level to the tip of the stalk or the apex of the top floret. The awns, if present, were not included in the height measurements. The phenological stages of flower stalk development were recorded as: flower stalk developing (FSD), head emergence (HE), anthesis (Ant), seeds developing (SD), and seeds being shed (SBS). Recording the flower stalk development stages started when stalk enlargement or swelling was outwardly noticeable; prior development is not detectable without destruction of the tiller. The swelling of the stalk, traditionally called the boot stage, was categorized as the flower stalk developing stage. Head emergence is a short duration stage but easily defined when the flower head emerges from the sheath and rapidly elongates to near full height. Anthesis (flowering) is also a short duration stage but easily defined by the exposure of the anthers and stigmas. Following fertilization, the seeds develop through milk, dough, and mature stages which are difficult to differentiate on small sedge seeds. These seed progression stages have been separated into more easily defined categories of seeds developing for the early seed stages and seeds being shed for the mature seed stages when seeds could be easily removed from the inflorescence by wind, by gentle rubbing, or when it could be observed that some seeds had already been dropped. Sometimes a floret will abort the seed production process resulting in failure of viable seeds to materialize. This condition could be revealed in the data set as earlier than normal recordings of seeds being shed.

During 1983 to 1986, the paired plot sample sites with sandy, shallow, silty and clay soil types were managed by ungrazed and grazed treatments of the twice-over rotation strategy. During 1987 to 1989, the paired plot sample sites with sandy, shallow, and silty soil types were managed by long-term nongrazed treatments, and by ungrazed and grazed treatments of the traditional seasonlong practice and the twice-over rotation strategy.

Designation of Tiller Types

Reproductive lead tillers are second year tillers derived from carryover tillers that were vegetative tillers during the previous growing season. The portions of the carryover leaves that have intact cell walls will regreen with active chlorophyll early in the growing season and provide photosynthate for rapid growth of new current years leaves. New leaf development resumed early spring in early April with rapid growth during May. The anthesis (flowering) period can occur between late April and early June with first flowers usually occurring during early May. No new leaves are produced after the anthesis stage, during the seed development stages. Flower stalks produce no leaves and develop from tillers that produce 2 basal whorls of 3 new leaves. The chestnut brown bases of previous years leaves are persistent during the following growing season that lead tillers produce flower stalks. Reproductive lead tillers are terminal during the growing season following seed development; their apical meristem was used up producing a flower head.

Vegetative tillers are first year tillers derived from previous growing season initiated fall tillers and from early spring initiated secondary tillers that have escaped hormonal control by a lead tiller. Vegetative tillers produce 2 basal whorls of 3 leaves before early June. These tillers are the primary forage tillers with rapid growth rates, usually producing 2 whorls with a total of 6 new leaves and occasionally produce a third whorl of 3 leaves during the growing season. The apical meristem remains vegetative, permitting these tillers to overwinter as carryover tillers and becoming reproductive lead tillers during the successive growing season.

Secondary tillers are young current growing season tillers usually with 1 whorl of 3 new leaves that develop at slow rates of growth. The secondary tillers can transform into vegetative tillers with rapid growth rates.

Results

Threadleaf sedge, *Carex filifolia* Nutt., is a member of the sedge family, Cyperaceae, and is a native, long lived perennial, monocot, cool-season, short graminoid, that is shade tolerant. The first North Dakota record is Bolley 1891. Early aerial growth consists of basal leaves arising from rootstock buds. Basal leaf blades are very fine, thread like, wiry, densely clustered at base with 3 per stem, 7.6-15.2 cm (3-6 in) long, 0.25 mm wide, tapering to a point, usually with edges rolled in, and dark green. Previous years stem and leaf bases are persistent during the following growing season and are chestnut brown. The sheath is papery and squared off at top. The ligule is very a short. The rhizomes are short and black. The extensive fibrous root system has numerous tough, wiry main roots 0.8 mm or less thick, that are resistant to decay as a result of the increased strength from the black pigment, melanin. The lateral spread is from 38 cm (15 in) to 76 cm (30 in) with roots growing obliquely downward, branching profusely, with numerous roots 5 cm (2 in) long. Most main roots descending to 61 cm (24 in) deep and a few long main roots reaching 76 cm (30 in) deep. The terminal ends of the roots are densely appearing broom like (genista). The densest concentration of root mat occurs in the upper 30.5 cm (12 in) of soil. Regeneration is primarily asexual propagation by tiller buds. Flower stalks are erect, triangular in cross section, 10-20 cm (4-8 in) tall. Inflorescence is a solitary terminal narrow spike, 10-25 mm long with male flowers above and a few female flowers below (monoecious). Flower period is from late April to mid June. Aerial parts are highly palatable to livestock. Fire top kills aerial parts and consumes entire crown when soil is dry. This summary information on growth development and regeneration of Threadleaf sedge was based on works of Stevens 1963, Zaczkowski 1972, Dodds 1979, Great Plains Flora Association 1986, Hauser 2006, and Johnson and Larson 2007.

During the seven years of this study, the number of threadleaf sedge tillers measured was 14,604 with 4530 tillers on sandy soils, 4445 tillers on shallow soils, 4472 tillers on silty soils, and 1157 tillers on clay soils (tables 6, 7, 8, and 9). The collection protocol required measurement on all available flower stalks and ten vegetative tillers on each sample site each collection period, amounting to 360 tillers per year on the twice-over treatment and 120 tillers per year on the seasonlong and nongrazed treatments. During the 3 growing seasons with low precipitation amounts, less than ten tillers were measured each collection period. The reductions in sample numbers would indicate the degree of negative affect from reduced precipitation. This affect is designated as collection efficiency on tables 6, 7, 8, and 9.

Table 6. Number of tillers measured from management treatments on sandy soils.

Tiller Type	Twice-over 1983-1986		Twice-over 1987-1989			Seasonlong 1987-1989	Nongrazed 1987-1989
	Ungrazed	Grazed	Ungrazed	Grazed		Grazed	Ungrazed
Flower Stalk	167	119	68	58		26	26
Vegetative	1101	726	278	202		87	105
Secondary	411	251	359	304		121	121
Subtotal	1679	1096	705	564		234	252
Total	2775		1269				
Sum total					4530		
Collection Efficiency	117%	76%	65%	52%		33%	70%

Table 7. Number of tillers measured from management treatments on shallow soils.

Tiller Type	Twice-over 1983-1986		Twice-over 1987-1989			Seasonlong 1987-1989	Nongrazed 1987-1989
	Ungrazed	Grazed	Ungrazed	Grazed		Grazed	Ungrazed
Flower Stalk	175	117	80	55		32	41
Vegetative	884	678	323	245		98	124
Secondary	484	267	312	285		146	99
Subtotal	1543	1062	715	585		276	264
Total	2605		1300				
Sum total					4445		
Collection Efficiency	107%	74%	66%	54%		38%	73%

Table 8. Number of tillers measured from management treatments on silty soils.

Tiller Type	Twice-over 1983-1986		Twice-over 1987-1989			Seasonlong 1987-1989	Nongrazed 1987-1989
	Ungrazed	Grazed	Ungrazed	Grazed		Grazed	Ungrazed
Flower Stalk	166	116	100	70		51	31
Vegetative	956	600	258	131		156	151
Secondary	425	220	345	351		285	60
Subtotal	1547	936	703	552		492	242
Total	2483		1255				
Sum total					4472		
Collection Efficiency	107%	65%	65%	51%		68%	67%

Table 9. Number of tillers measured from management treatments on clay soils.

Tiller Type	Twice-over 1983-1986		Twice-over 1987-1989		Seasonlong 1987-1989		Nongrazed 1987-1989
	Ungrazed	Grazed	Ungrazed	Grazed	Ungrazed	Grazed	Ungrazed
Flower Stalk	75	42					
Vegetative	412	224					
Secondary	249	155					
Subtotal	736	421					
Total	1157						
Sum total							
Collection Efficiency	51%	29%					

Reproductive Lead Tillers

The second year reproductive lead tillers had the fastest rate of growth and development during late April and May with slow development in mid July. Reproductive lead tillers reach the boot stage (FSD) during early to late April. Flower stalk development occurred very rapidly with the lead tillers progressing through head emergence (HE) during mid April to early June and reaching the flower stage during the 5 week period of early May to the first week of June. No new leaves were produced after the anthesis stage. Seeds developed (SD) through the milk and dough stages during early May to mid June with most seeds reaching maturity (SBS) after mid June to early July (table 10). The apical meristem of reproductive lead tillers can no longer produce leaf buds after it had produced flower buds. The basal leaves of the lead tillers rapidly dried during June and were completely senescent by mid July.

Growth and development data of threadleaf sedge reproductive lead tillers on sandy soils managed with the twice-over strategy and the ungrazed treatment during 1983 to 1986 are on table 11.

Reproductive lead tillers with 2 to 7 basal leaves on the twice-over strategy during 1983 to 1986 composed 10.9% of the total population with 119 tillers (table 6) that had a mean flower stalk height of 11.1 cm, during the growing season a mean of 9.7% leaves were photosynthetically active with a mean basal leaf height of 5.2 cm and the tallest leaf averaged 5.5 cm tall (table 11).

Reproductive lead tillers with 2 to 7 basal leaves on the ungrazed treatment during 1983 to 1986 composed 9.9% of the total population with 167 tillers (table 6) that had a mean flower stalk height of 13.4 cm, during the growing season a mean of 11.7% leaves were photosynthetically active with a mean basal leaf height of 7.8 cm and the tallest leaf averaged 9.3 cm tall (table 11).

Growth and development data of threadleaf sedge reproductive lead tillers on shallow soils managed with the twice-over strategy and the ungrazed treatment during 1983 to 1986 are on table 12.

Reproductive lead tillers with 2 to 7 basal leaves on the twice-over strategy during 1983 to 1986 composed 11.0% the total population with 117 tillers (table 7) that had a mean flower stalk height of 9.1 cm, during the growing season a mean of 14.6% leaves were photosynthetically active with a mean basal leaf height of 4.7 cm and the tallest leaf averaged 5.2 cm tall (table 12).

Reproductive lead tillers with 2 to 7 basal leaves on the ungrazed treatment during 1983 to 1986 composed 11.3% the total population with 175 tillers (table 7) that had a mean flower stalk height of 10.2 cm, during the growing season a mean of 18.0% leaves were photosynthetically active with a mean basal leaf height of 5.1 cm and the tallest leaf averaged 5.8 cm tall (table 12).

Growth and development data of threadleaf sedge reproductive lead tillers on silty soils managed with the twice-over strategy and the ungrazed treatment during 1983 to 1986 are on table 13.

Reproductive lead tillers with 2 to 7 basal leaves on the twice-over strategy during 1983 to 1986 composed 12.4% of the total population with 116 tillers (table 8) that had a mean flower stalk height of 12.7 cm, during the growing season a mean of 16.0% leaves were photosynthetically active with a mean basal leaf height of 6.8 cm and the tallest leaf averaged 7.4 cm tall (table 13).

Reproductive lead tillers with 2 to 7 basal leaves on the ungrazed treatment during 1983 to 1986 composed 10.7% of the total population with 166 tillers (table 8) that had a mean flower stalk height of 15.7 cm, during the growing season a mean of 9.5% leaves were photosynthetically active with a mean basal leaf height of 8.4 cm and the tallest leaf averaged 8.5 cm tall (table 13).

Growth and development data of threadleaf sedge reproductive lead tillers on clay soils managed with the twice-over strategy and the ungrazed treatment during 1983 to 1986 are on table 14.

Reproductive lead tillers with 2 to 7 basal leaves on the twice-over strategy during 1983 to 1986 composed 10.0% of the total population with 42 tillers (table 9) that had a mean flower stalk height of 11.6 cm, during the growing season a mean of 16.1% leaves were photosynthetically active with a mean basal leaf height of 4.1 cm and the tallest leaf averaged 5.1 cm tall (table 14).

Reproductive lead tillers with 2 to 7 basal leaves on the ungrazed treatment during 1983 to 1986 composed 10.2% of the total population with 75 tillers (table 9) that had a mean flower stalk height of 14.9 cm, during the growing season a mean of 18.2% leaves were photosynthetically active with a mean basal leaf height of 6.8 cm and the tallest leaf averaged 7.2 cm tall (table 14).

Growth and development data of threadleaf sedge reproductive lead tillers on sandy soils managed with the twice-over strategy and the ungrazed treatment and the seasonlong and nongrazed treatments during 1987 to 1989 are on table 15.

Reproductive lead tillers with 2 to 7 basal leaves on the twice-over strategy during 1987 to 1989 composed 10.3% of the total population with 58 tillers (table 6) that had a mean flower stalk height of 9.5 cm, during the growing season a mean of 10.0% leaves were photosynthetically active with a mean basal leaf height of 5.1 cm and the tallest leaf averaged 6.9 cm tall (table 15).

Reproductive lead tillers with 2 to 7 basal leaves on the ungrazed treatment during 1987 to 1989 composed 9.6% of the total population with 68 tillers (table 6) that had a mean flower stalk height of 11.2 cm, during the growing season a mean of 19.5% leaves were photosynthetically active with a mean basal leaf height of 9.2 cm and the tallest leaf averaged 10.2 cm tall (table 15).

Reproductive lead tillers with 2 to 7 basal leaves on the seasonlong treatment during 1987 to 1989 composed 11.1% of the total population with 26 tillers (table 6) that had a mean flower stalk height of 10.8 cm, during the growing season a mean of 7.2% leaves were photosynthetically active with a mean basal leaf height of 6.4 cm and the tallest leaf averaged 8.6 cm tall (table 15).

Reproductive lead tillers with 2 to 7 basal leaves on the nongrazed treatment during 1987 to 1989 composed 10.3% of the total population with 26 tillers (table 6) that had a mean flower stalk height of 14.2 cm, during the growing season a mean of 7.2% leaves were photosynthetically active with a mean basal leaf height of 5.9 cm and the tallest leaf averaged 6.5 cm tall (table 15).

Growth and development data of threadleaf sedge reproductive lead tillers on shallow soils managed with the twice-over strategy and the ungrazed treatment and the seasonlong and nongrazed treatments during 1987 to 1989 are on table 16.

Reproductive lead tillers with 2 to 7 basal leaves on the twice-over strategy during 1987 to 1989 composed 9.4% of the total population with 55 tillers (table 7) that had a mean flower stalk height of 8.1 cm, during the growing season a mean of 13.3% leaves were photosynthetically active with a mean basal leaf height of 4.1 cm and the tallest leaf averaged 5.1 cm tall (table 16).

Reproductive lead tillers with 2 to 7 basal leaves on the ungrazed treatment during 1987 to 1989 composed 11.2% of the total population with 80 tillers (table 7) that had a mean flower stalk height of 10.8 cm, during the growing season a mean of 24.7% leaves were photosynthetically active with a mean basal leaf height of 6.9 cm and the tallest leaf averaged 7.3 cm tall (table 16).

Reproductive lead tillers with 2 to 7 basal leaves on the seasonlong treatment during 1987 to 1989 composed 11.6% of the total population with 32 tillers (table 7) that had a mean flower stalk height of 12.1 cm, during the growing season a mean of 10.7% leaves were photosynthetically active with a mean basal leaf height of 6.4 cm and the tallest leaf averaged 7.3 cm tall (table 16).

Reproductive lead tillers with 2 to 7 basal leaves on the nongrazed treatment during 1987 to 1989 composed 15.5% of the total population with 41 tillers (table 7) that had a mean flower stalk height of 15.7 cm, during the growing season a mean of 15.9% leaves were photosynthetically active with a mean basal leaf height of 10.0 cm and the tallest leaf averaged 11.0 cm tall (table 16).

Growth and development data of threadleaf sedge reproductive lead tillers on silty soils managed with the twice-over strategy and the ungrazed treatment and the seasonlong and nongrazed treatments during 1987 to 1989 are on table 17.

Reproductive lead tillers with 2 to 7 basal leaves on the twice-over strategy during 1987 to 1989 composed 12.7% of the total population with 70 tillers (table 8) that had a mean flower stalk height of 10.3 cm, during the growing season a mean of 21.4% leaves were photosynthetically active with a mean basal leaf height of 6.9 cm and the tallest leaf averaged 7.8 cm tall (table 17).

Reproductive lead tillers with 2 to 7 basal leaves on the ungrazed treatment during 1987 to 1989 composed 14.2% of the total population with 100 tillers (table 8) that had a mean flower stalk height of 15.1 cm, during the growing season a mean of 17.5% leaves were photosynthetically active with a mean basal leaf height of 11.5 cm and the tallest leaf averaged 13.2 cm tall (table 17).

Reproductive lead tillers with 2 to 7 basal leaves on the seasonlong treatment during 1987 to 1989 composed 10.4% of the total population with 51 tillers (table 8) that had a mean flower stalk height of 10.3 cm, during the growing season a mean of 14.7% leaves were photosynthetically active with a mean basal leaf height of 7.6 cm and the tallest leaf averaged 9.1 cm tall (table 17).

Reproductive lead tillers with 2 to 7 basal leaves on the nongrazed treatment during 1987 to 1989 composed 12.8% of the total population with 31 tillers (table 8) that had a mean flower stalk height of 14.7 cm, during the growing season a mean of 9.7% leaves were photosynthetically active with a mean basal leaf height of 11.5 cm and the tallest leaf averaged 13.8 cm tall (table 17).

All of the reproductive lead tillers measured during this study were not grazed including the tillers located on grazed treatments. The not grazed tillers remaining on the grazed treatments tended to have slightly shorter mean flower stalk heights, mean basal leaf heights, and mean tallest leaf heights which were not significantly different than the not grazed tillers on the ungrazed treatments on the sandy, shallow, silty, and clay soils during the 1983-1986 period. The mean flower stalk heights were slightly lower on the grazed treatments than on the ungrazed treatments on the sandy, shallow, and silty soils during the 1987-1989 period. It is not believed that grazed treatments cause reproductive lead tillers to produce slightly shorter flower stalk and basal leaf heights. It is surmised that grazing cattle have a disproportional rate of selection for taller tillers than for shorter tillers leaving a distorted sample population of not grazed tillers with slightly shorter leaf heights.

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Leaves grow and senesce in about the same order of their appearance. This study has designated that leaves with less than 50% senescent tissue to be photosynthetically active. The reproductive lead tillers had 2 basal whorls of 3 new leaves. All of the basal leaves dried very rapidly during June and were completely senescent by mid July. Flower stalks senesce rapidly following the seed development stage.

Reproductive lead tillers composed a relatively low percentage of the total measured tiller population. Reproductive lead tillers located on the twice-over treatment composed 11.2% (394 tillers) and 10.8% (183 tillers) and the reproductive tillers located on the ungrazed treatment composed 10.6% (583 tillers) and 11.7% (248 tillers) of the total tiller population during the 1983-1986 period and the 1987-1989 period, respectively. Reproductive lead tillers located on the seasonlong and nongrazed treatments composed 10.9% (109 tillers) and 12.9% (98 tillers) of the total population during the 1987-1989 period, respectively.

Table 10. Phenological stages of flower stalk development for threadleaf sedge, 1983-1986.

6 Apr	22 Apr	6 May	22 May	6 Jun	22 Jun
FSD	FSD				
	HE	HE			
	Ant	Ant	Ant	Ant	
		SD	SD	SD	
			SBS	SBS	SBS

FSD flower stalk developing
HE head emergence
Ant anthesis (flowering)
SD seeds developing
SBS seeds being shed

Table 11. Growth and development of threadleaf sedge reproductive lead tillers on sandy soils managed with twice-over grazing and ungrazed treatments, 1983-1986.

Sandy	6 Jun	22 Jun	6 Jul	22 Jul	6 Aug	22 Aug
Twice-over 1983-1986						
Stalk Height cm	13.5	10.4	12.0	9.2	11.4	10.1
% Active Leaf	42.9	15.4	0.0	0.0	0.0	0.0
Leaf Height cm	6.2	4.1	-	-	-	-
Tallest Leaf cm	6.3	4.6	-	-	-	-
Ungrazed 1983-1986						
Stalk Height cm	12.6	14.8	13.2	13.7	13.3	12.9
% Active Leaf	21.4	13.8	0.0	12.5	0.0	9.5
Leaf Height cm	6.3	7.3	-	7.9	-	9.6
Tallest Leaf cm	6.3	9.6	-	9.7	-	11.4

Table 12. Growth and development of threadleaf sedge reproductive lead tillers on shallow soils managed with twice-over grazing and ungrazed treatments, 1983-1986.

Shallow	6 Jun	22 Jun	6 Jul	22 Jul	6 Aug	22 Aug
Twice-over 1983-1986						
Stalk Height cm	8.3	9.5	8.8	8.4	8.8	10.5
% Active Leaf	50.0	37.5	0.0	0.0	0.0	0.0
Leaf Height cm	3.8	5.5	-	-	-	-
Tallest Leaf cm	4.3	6.1	-	-	-	-
Ungrazed 1983-1986						
Stalk Height cm	10.8	10.3	9.9	10.2	9.4	10.7
% Active Leaf	57.1	10.3	0.0	20.7	0.0	20.0
Leaf Height cm	5.6	4.2	-	6.6	-	3.9
Tallest Leaf cm	6.3	5.1	-	7.3	-	4.3

Table 13. Growth and development of threadleaf sedge reproductive lead tillers on silty soils managed with twice-over grazing and ungrazed treatments, 1983-1986.

Silty	6 Jun	22 Jun	6 Jul	22 Jul	6 Aug	22 Aug
Twice-over 1983-1986						
Stalk Height cm	13.3	11.3	13.5	11.9	12.9	13.5
% Active Leaf	55.6	31.6	0.0	8.7	0.0	0.0
Leaf Height cm	5.1	8.1	-	7.2	-	-
Tallest Leaf cm	5.8	8.3	-	8.1	-	-
Ungrazed 1983-1986						
Stalk Height cm	16.9	14.6	15.8	15.0	15.2	16.8
% Active Leaf	35.7	21.1	0.0	0.0	0.0	0.0
Leaf Height cm	6.9	9.8	-	-	-	-
Tallest Leaf cm	7.1	9.8	-	-	-	-

Table 14. Growth and development of threadleaf sedge reproductive lead tillers on clay soils managed with twice-over grazing and ungrazed treatments, 1983-1986.

Clay	6 Jun	22 Jun	6 Jul	22 Jul	6 Aug	22 Aug
Twice-over 1983-1986						
Stalk Height cm	14.8	11.4	11.3	8.2	10.7	13.0
% Active Leaf	66.7	30.0	0.0	0.0	0.0	0.0
Leaf Height cm	4.9	3.2	-	-	-	-
Tallest Leaf cm	6.2	4.0	-	-	-	-
Ungrazed 1983-1986						
Stalk Height cm	17.9	13.2	14.2	12.6	17.0	14.7
% Active Leaf	42.9	44.1	0.0	0.0	0.0	22.2
Leaf Height cm	5.7	6.5	-	-	-	8.3
Tallest Leaf cm	5.9	6.8	-	-	-	8.8

Table 15. Growth and development of threadleaf sedge reproductive lead tillers on sandy soils managed with twice-over grazing and ungrazed treatments and the seasonlong and nongrazed treatments, 1987-1989.

Sandy	6 Jun	22 Jun	6 Jul	22 Jul	6 Aug	22 Aug
Twice-over 1987-1989						
Stalk Height cm	6.8	10.4	11.9	8.5	-	9.8
% Active Leaf	60.0	0.0	0.0	0.0	0.0	0.0
Leaf Height cm	5.1	-	-	-	-	-
Tallest Leaf cm	6.9	-	-	-	-	-
Ungrazed 1987-1989						
Stalk Height cm	9.8	10.9	13.5	10.8	-	11.2
% Active Leaf	66.7	0.0	50.0	0.0	0.0	0.0
Leaf Height cm	7.1	-	11.3	-	-	-
Tallest Leaf cm	9.0	-	11.3	-	-	-
Seasonlong 1987-1989						
Stalk Height cm	9.5	10.0	-	9.6	-	14.0
% Active Leaf	14.3	28.6	0.0	0.0	0.0	0.0
Leaf Height cm	10.1	2.7	-	-	-	-
Tallest Leaf cm	14.2	3.0	-	-	-	-
Nongrazed 1987-1989						
Stalk Height cm	16.3	11.3	-	16.7	-	12.6
% Active Leaf	33.3	10.0	0.0	0.0	0.0	0.0
Leaf Height cm	8.2	3.5	-	-	-	-
Tallest Leaf cm	9.4	3.5	-	-	-	-

Table 16. Growth and development of threadleaf sedge reproductive lead tillers on shallow soils managed with twice-over grazing and ungrazed treatments and the seasonlong and nongrazed treatments, 1987-1989.

Shallow	6 Jun	22 Jun	6 Jul	22 Jul	6 Aug	22 Aug
Twice-over 1987-1989						
Stalk Height cm	4.1	9.0	-	9.2	-	10.1
% Active Leaf	40.0	40.0	0.0	0.0	0.0	0.0
Leaf Height cm	4.4	3.8	-	-	-	-
Tallest Leaf cm	5.0	5.1	-	-	-	-
Ungrazed 1987-1989						
Stalk Height cm	9.9	9.7	13.4	10.4	-	10.8
% Active Leaf	55.0	11.1	60.0	22.2	0.0	0.0
Leaf Height cm	6.0	3.5	11.2	6.7	-	-
Tallest Leaf cm	7.2	3.5	11.8	6.8	-	-
Seasonlong 1987-1989						
Stalk Height cm	11.7	8.5	14.9	14.8	-	10.6
% Active Leaf	44.4	20.0	0.0	0.0	0.0	0.0
Leaf Height cm	6.0	6.7	-	-	-	-
Tallest Leaf cm	7.8	6.8	-	-	-	-
Nongrazed 1987-1989						
Stalk Height cm	13.1	13.7	21.1	14.3	-	16.5
% Active Leaf	28.6	0.0	66.7	0.0	0.0	0.0
Leaf Height cm	6.8	-	13.2	-	-	-
Tallest Leaf cm	6.8	-	15.1	-	-	-

Table 17. Growth and development of threadleaf sedge reproductive lead tillers on silty soils managed with twice-over grazing and ungrazed treatments and the seasonlong and nongrazed treatments, 1987-1989.

Silty	6 Jun	22 Jun	6 Jul	22 Jul	6 Aug	22 Aug
Twice-over 1987-1989						
Stalk Height cm	8.2	8.2	15.3	9.0	-	10.8
% Active Leaf	57.1	11.1	60.0	0.0	0.0	0.0
Leaf Height cm	4.8	7.7	8.1	-	-	-
Tallest Leaf cm	6.1	7.7	9.6	-	-	-
Ungrazed 1987-1989						
Stalk Height cm	12.7	11.0	22.3	10.9	18.4	15.1
% Active Leaf	45.0	0.0	60.0	0.0	0.0	0.0
Leaf Height cm	10.0	-	13.0	-	-	-
Tallest Leaf cm	11.6	-	14.8	-	-	-
Seasonlong 1987-1989						
Stalk Height cm	9.3	10.0	12.5	11.4	-	8.5
% Active Leaf	43.8	0.0	44.4	0.0	0.0	0.0
Leaf Height cm	4.4	-	10.8	-	-	-
Tallest Leaf cm	5.1	-	13.0	-	-	-
Nongrazed 1987-1989						
Stalk Height cm	17.7	15.2	-	14.8	10.7	15.3
% Active Leaf	58.3	0.0	0.0	0.0	0.0	0.0
Leaf Height cm	11.5	-	-	-	-	-
Tallest Leaf cm	13.8	-	-	-	-	-

Vegetative Tillers

The vegetative tillers had the second fastest rate of growth and development continuing until mid to late July. Early new leaf development for vegetative tillers arise from fall tillers produced from crown tiller buds during August of the previous growing season and from early spring initiated tiller buds. The rate of growth greatly increased during early or mid May resulting in tillers with 2 basal whorls with 6 new leaves during late May. During July the rate of growth decreased. A few of the vegetative tillers added a third whorl of 3 leaves during July and August (figure 1).

Growth and development data of threadleaf sedge vegetative tillers on sandy soils managed with the twice-over strategy during 1983 to 1986 are on table 18.

Vegetative tillers with 5 leaves composed 58.8% of the population with 427 tillers, during the growing season a mean of 2.8 leaves (56.7%) were photosynthetically active with a mean leaf height of 6.4 cm and the tallest leaf averaged 7.9 cm tall (table 18).

Vegetative tillers with 6 leaves composed 33.6% of the population with 244 tillers, during the growing season a mean of 3.3 leaves (54.2%) were photosynthetically active with a mean leaf height of 7.0 cm and the tallest leaf averaged 8.8 cm tall (table 18).

Vegetative tillers with 7 leaves composed 7.0% of the population with 51 tillers, during the growing season a mean of 3.7 leaves (52.4%) were photosynthetically active with a mean leaf height of 6.5 cm and the tallest leaf averaged 8.6 cm tall (table 18).

Vegetative tillers with 8 leaves composed 0.4% of the population with 3 tillers, during the growing season a mean of 3.0 leaves (37.5%) were photosynthetically active with a mean leaf height of 15.5 cm and the tallest leaf averaged 16.5 cm tall (table 18).

Vegetative tillers with 9 leaves composed 0.1% of the population with 1 tiller, during the growing season a mean of 4.5 leaves (50.0%) were photosynthetically active with a mean leaf height of 12.3 cm and the tallest leaf averaged 16.3 cm tall (table 18).

Growth and development data of threadleaf sedge vegetative tillers on sandy soils managed with the ungrazed treatment during 1983 to 1986 are on table 19.

Vegetative tillers with 5 leaves composed 56.6% of the population with 623 tillers, during the growing season a mean of 2.8 leaves (55.0%) were photosynthetically active with a mean leaf height of 7.5 cm and the tallest leaf averaged 9.1 cm tall (table 19).

Vegetative tillers with 6 leaves composed 33.4% of the population with 368 tillers, during the growing season a mean of 3.2 leaves (52.8%) were photosynthetically active with a mean leaf height of 7.6 cm and the tallest leaf averaged 9.8 cm tall (table 19).

Vegetative tillers with 7 leaves composed 7.7% of the population with 85 tillers, during the growing season a mean of 4.1 leaves (58.3%) were photosynthetically active with a mean leaf height of 7.7 cm and the tallest leaf averaged 10.3 cm tall (table 19).

Vegetative tillers with 8 leaves composed 1.5% of the population with 17 tillers, during the growing season a mean of 4.9 leaves (61.0%) were photosynthetically active with a mean leaf height of 8.1 cm and the tallest leaf averaged 11.4 cm tall (table 19).

Vegetative tillers with 9 leaves composed 0.7% of the population with 8 tillers, during the growing season a mean of 5.4 leaves (60.0%) were photosynthetically active with a mean leaf height of 7.4 cm and the tallest leaf averaged 12.0 cm tall (table 19).

Growth and development data of threadleaf sedge vegetative tillers on shallow soils managed with the twice-over strategy during 1983 to 1986 are on table 20.

Vegetative tillers with 5 leaves composed 65.9% of the population with 447 tillers, during the growing season a mean of 2.9 leaves (58.3%) were photosynthetically active with a mean leaf height of 4.8 cm and the tallest leaf averaged 5.9 cm tall (table 20).

Vegetative tillers with 6 leaves composed 30.8% of the population with 209 tillers, during the growing season a mean of 3.3 leaves (54.2%) were photosynthetically active with a mean leaf height of 5.1 cm and the tallest leaf averaged 6.5 cm tall (table 20).

Vegetative tillers with 7 leaves composed 3.1% of the population with 21 tillers, during the growing season a mean of 3.7 leaves (52.8%) were photosynthetically active with a mean leaf height of 4.7 cm and the tallest leaf averaged 6.5 cm tall (table 20).

Vegetative tillers with 8 leaves composed 0.2% of the population with 1 tiller, during the growing season a mean of 4.0 leaves (50.0%) were photosynthetically active with a mean leaf height of 4.5 cm and the tallest leaf averaged 6.3 cm tall (table 20).

Vegetative tillers with 9 leaves composed 0.0% of the population with 0 tillers (table 20).

Growth and development data of threadleaf sedge vegetative tillers on shallow soils managed with the ungrazed treatment during 1983 to 1986 are on table 21.

Vegetative tillers with 5 leaves composed 63.8% of the population with 564 tillers, during the growing season a mean of 2.8 leaves (56.7%) were photosynthetically active with a mean leaf height of 5.7 cm and the tallest leaf averaged 7.0 cm tall (table 21).

Vegetative tillers with 6 leaves composed 29.1% of the population with 257 tillers, during the growing season a mean of 3.2 leaves (52.8%) were photosynthetically active with a mean leaf height of 5.9 cm and the tallest leaf averaged 7.7 cm tall (table 21).

Vegetative tillers with 7 leaves composed 5.7% of the population with 50 tillers, during the growing season a mean of 3.5 leaves (50.0%) were photosynthetically active with a mean leaf height of 5.7 cm and the tallest leaf averaged 7.4 cm tall (table 21).

Vegetative tillers with 8 leaves composed 1.5% of the population with 13 tillers, during the growing season a mean of 4.8 leaves (59.8%) were photosynthetically active with a mean leaf height of 5.8 cm and the tallest leaf averaged 8.1 cm tall (table 21).

Vegetative tillers with 9 leaves composed 0.0% of the population with 0 tillers (table 21).

Growth and development data of threadleaf sedge vegetative tillers on silty soils managed with the twice-over strategy during 1983 to 1986 are on table 22.

Vegetative tillers with 5 leaves composed 58.2% of the population with 349 tillers, during the growing season a mean of 3.1 leaves (61.7%) were photosynthetically active with a mean leaf height of 6.8 cm and the tallest leaf averaged 8.1 cm tall (table 22).

Vegetative tillers with 6 leaves composed 33.8% of the population with 203 tillers, during the growing season a mean of 3.5 leaves (58.3%) were photosynthetically active with a mean leaf height of 6.3 cm and the tallest leaf averaged 7.9 cm tall (table 22).

Vegetative tillers with 7 leaves composed 7.2% of the population with 43 tillers, during the growing season a mean of 3.7 leaves (52.9%) were photosynthetically active with a mean leaf height of 7.0 cm and the tallest leaf averaged 9.0 cm tall (table 22).

Vegetative tillers with 8 leaves composed 0.7% of the population with 4 tillers, during the growing season a mean of 4.7 leaves (58.3%) were photosynthetically active with a mean leaf height of 7.8 cm and the tallest leaf averaged 11.8 cm tall (table 22).

Vegetative tillers with 9 leaves composed 0.2% of the population with 1 tiller, during the growing season a mean of 5.0 leaves (55.6%) were photosynthetically active with a mean leaf height of 9.7 cm and the tallest leaf averaged 13.8 cm tall (table 22).

Growth and development data of threadleaf sedge vegetative tillers on silty soils managed with the ungrazed treatment during 1983 to 1986 are on table 23.

Vegetative tillers with 5 leaves composed 59.4% of the population with 568 tillers, during the growing season a mean of 2.9 leaves (58.3%) were photosynthetically active with a mean leaf height of 8.7 cm and the tallest leaf averaged 10.6 cm tall (table 23).

Vegetative tillers with 6 leaves composed 31.5% of the population with 301 tillers, during the growing season a mean of 3.2 leaves (52.8%) were photosynthetically active with a mean leaf height of

8.8 cm and the tallest leaf averaged 11.1 cm tall (table 23).

Vegetative tillers with 7 leaves composed 7.1% of the population with 68 tillers, during the growing season a mean of 4.5 leaves (64.3%) were photosynthetically active with a mean leaf height of 8.1 cm and the tallest leaf averaged 10.9 cm tall (table 23).

Vegetative tillers with 8 leaves composed 1.6% of the population with 15 tillers, during the growing season a mean of 4.6 leaves (57.5%) were photosynthetically active with a mean leaf height of 9.8 cm and the tallest leaf averaged 14.8 cm tall (table 23).

Vegetative tillers with 9 leaves composed 0.4% of the population with 4 tillers, during the growing season a mean of 6.2 leaves (68.4%) were photosynthetically active with a mean leaf height of 6.2 cm and the tallest leaf averaged 8.1 cm tall (table 23).

Growth and development data of threadleaf sedge vegetative tillers on clay soils managed with the twice-over strategy during 1983 to 1986 are on table 24.

Vegetative tillers with 5 leaves composed 74.1% of the population with 166 tillers, during the growing season a mean of 2.9 leaves (58.3%) were photosynthetically active with a mean leaf height of 5.7 cm and the tallest leaf averaged 7.1 cm tall (table 24).

Vegetative tillers with 6 leaves composed 18.3% of the population with 41 tillers, during the growing season a mean of 3.5 leaves (58.3%) were photosynthetically active with a mean leaf height of 5.7 cm and the tallest leaf averaged 7.0 cm tall (table 24).

Vegetative tillers with 7 leaves composed 6.7% of the population with 15 tillers, during the growing season a mean of 4.0 leaves (57.1%) were photosynthetically active with a mean leaf height of 5.3 cm and the tallest leaf averaged 7.7 cm tall (table 24).

Vegetative tillers with 8 leaves composed 0.9% of the population with 2 tillers, during the growing season a mean of 4.5 leaves (56.3%) were photosynthetically active with a mean leaf height of 3.7 cm and the tallest leaf averaged 5.4 cm tall (table 24).

Vegetative tillers with 9 leaves composed 0.0% of the population with 0 tillers (table 24).

Growth and development data of threadleaf sedge vegetative tillers on clay soils managed with the ungrazed treatment during 1983 to 1986 are on table 25.

Vegetative tillers with 5 leaves composed 61.9% of the population with 255 tillers, during the growing season a mean of 2.9 leaves (58.3%) were photosynthetically active with a mean leaf height of 7.7 cm and the tallest leaf averaged 9.5 cm tall (table 25).

Vegetative tillers with 6 leaves composed 30.3% of the population with 125 tillers, during the growing season a mean of 3.5 leaves (58.3%) were photosynthetically active with a mean leaf height of 8.5 cm and the tallest leaf averaged 10.9 cm tall (table 25).

Vegetative tillers with 7 leaves composed 5.8% of the population with 24 tillers, during the growing season a mean of 3.3 leaves (47.6%) were photosynthetically active with a mean leaf height of 5.6 cm and the tallest leaf averaged 7.1 cm tall (table 25).

Vegetative tillers with 8 leaves composed 1.7% of the population with 7 tillers, during the growing season a mean of 4.0 leaves (50.0%) were photosynthetically active with a mean leaf height of 8.0 cm and the tallest leaf averaged 10.0 cm tall (table 25).

Vegetative tillers with 9 leaves composed 0.2% of the population with 1 tiller, during the growing season a mean of 7.0 leaves (77.8%) were photosynthetically active with a mean leaf height of 6.9 cm and the tallest leaf averaged 10.5 cm tall (table 25).

Growth and development data of threadleaf sedge vegetative tillers on sandy soils managed with the twice-over strategy during 1987 to 1989 are on table 26.

Vegetative tillers with 5 leaves composed 68.3% of the population with 138 tillers, during the growing season a mean of 3.3 leaves (66.7%) were photosynthetically active with a mean leaf height of 6.4 cm and the tallest leaf averaged 7.7 cm tall (table 26).

Vegetative tillers with 6 leaves composed 22.3% of the population with 45 tillers, during the growing season a mean of 3.3 leaves (54.2%) were photosynthetically active with a mean leaf height of 6.5 cm and the tallest leaf averaged 7.5 cm tall (table 26).

Vegetative tillers with 7 leaves composed 7.9% of the population with 16 tillers, during the growing season a mean of 4.3 leaves (61.9%) were photosynthetically active with a mean leaf height of 4.9 cm and the tallest leaf averaged 6.3 cm tall (table 26).

Vegetative tillers with 8 leaves composed 1.5% of the population with 3 tillers, during the growing season a mean of 1.0 leaves (12.5%) were photosynthetically active with a mean leaf height of 3.0 cm and the tallest leaf averaged 3.0 cm tall (table 26).

Vegetative tillers with 9 leaves composed 0.0% of the population with 0 tillers (table 26).

Growth and development data of threadleaf sedge vegetative tillers on sandy soils managed with the ungrazed treatment during 1987 to 1989 are on table 27.

Vegetative tillers with 5 leaves composed 77.0% of the population with 214 tillers, during the growing season a mean of 3.2 leaves (63.3%) were photosynthetically active with a mean leaf height of 7.2 cm and the tallest leaf averaged 9.0 cm tall (table 27).

Vegetative tillers with 6 leaves composed 21.6% of the population with 60 tillers, during the growing season a mean of 3.3 leaves (54.2%) were photosynthetically active with a mean leaf height of 7.0 cm and the tallest leaf averaged 9.2 cm tall (table 27).

Vegetative tillers with 7 leaves composed 1.4% of the population with 4 tillers, during the growing season a mean of 4.3 leaves (61.9%) were photosynthetically active with a mean leaf height of 8.4 cm and the tallest leaf averaged 11.5 cm tall (table 27).

Vegetative tillers with 8 and 9 leaves composed 0.0% of the population with 0 tillers (table 27).

Growth and development data of threadleaf sedge vegetative tillers on sandy soils managed with the traditional seasonlong practice during 1987 to 1989 are on table 28.

Vegetative tillers with 5 leaves composed 70.1% of the population with 61 tillers, during the growing season a mean of 3.3 leaves (66.0%) were photosynthetically active with a mean leaf height of 7.2 cm and the tallest leaf averaged 8.6 cm tall (table 28).

Vegetative tillers with 6 leaves composed 26.4% of the population with 23 tillers, during the growing season a mean of 3.7 leaves (61.1%) were photosynthetically active with a mean leaf height of 6.8 cm and the tallest leaf averaged 8.5 cm tall (table 28).

Vegetative tillers with 7 leaves composed 3.4% of the population with 3 tillers, during the growing season a mean of 4.0 leaves (57.1%) were photosynthetically active with a mean leaf height of 7.8 cm and the tallest leaf averaged 9.9 cm tall (table 28).

Vegetative tillers with 8 and 9 leaves composed 0.0% of the population with 0 tillers (table 28).

Growth and development data of threadleaf sedge vegetative tillers on sandy soils managed with the long-term nongrazed treatment during 1987 to 1989 are on table 29.

Vegetative tillers with 5 leaves composed 77.1% of the population with 81 tillers, during the growing season a mean of 3.3 leaves (66.7%) were photosynthetically active with a mean leaf height of 16.7 cm and the tallest leaf averaged 22.3 cm tall (table 29).

Vegetative tillers with 6 leaves composed 19.0% of the population with 20 tillers, during the growing season a mean of 4.0 leaves (66.7%) were photosynthetically active with a mean leaf height of 9.3 cm and the tallest leaf averaged 13.6 cm tall (table 29).

Vegetative tillers with 7 leaves composed 2.9% of the population with 3 tillers, during the growing season a mean of 4.3 leaves (61.9%) were photosynthetically active with a mean leaf height of 9.2 cm and the tallest leaf averaged 12.5 cm tall (table 29).

Vegetative tillers with 8 leaves composed 1.0% of the population with 1 tiller, during the growing season a mean of 5.0 leaves (62.5%) were photosynthetically active with a mean leaf height of 8.6 cm and the tallest leaf averaged 12.5 cm tall (table 29).

Vegetative tillers with 9 leaves composed 0.0% of the population with 0 tillers (table 29).

Growth and development data of threadleaf sedge vegetative tillers on shallow soils managed with the twice-over strategy during 1987 to 1989 are on table 30.

Vegetative tillers with 5 leaves composed 78.0% of the population with 191 tillers, during the growing season a mean of 3.2 leaves (63.3%) were photosynthetically active with a mean leaf height of 5.1 cm and the tallest leaf averaged 6.3 cm tall (table 30).

Vegetative tillers with 6 leaves composed 21.6% of the population with 53 tillers, during the growing season a mean of 3.6 leaves (60.0%) were photosynthetically active with a mean leaf height of 5.0 cm and the tallest leaf averaged 6.5 cm tall (table 30).

Vegetative tillers with 7 leaves composed 0.4% of the population with 1 tiller, during the growing season a mean of 4.0 leaves (57.1%) were photosynthetically active with a mean leaf height of 4.3 cm and the tallest leaf averaged 7.0 cm tall (table 30).

Vegetative tillers with 8 and 9 leaves composed 0.0% of the population with 0 tillers (table 30).

Growth and development data of threadleaf sedge vegetative tillers on shallow soils managed with the ungrazed treatment during 1987 to 1989 are on table 31.

Vegetative tillers with 5 leaves composed 72.1% of the population with 233 tillers, during the growing season a mean of 3.2 leaves (63.3%) were photosynthetically active with a mean leaf height of 6.4 cm and the tallest leaf averaged 7.8 cm tall (table 31).

Vegetative tillers with 6 leaves composed 25.1% of the population with 81 tillers, during the growing season a mean of 3.3 leaves (54.2%) were photosynthetically active with a mean leaf height of 5.8 cm and the tallest leaf averaged 7.3 cm tall (table 31).

Vegetative tillers with 7 leaves composed 2.2% of the population with 7 tillers, during the growing season a mean of 4.7 leaves (66.6%) were photosynthetically active with a mean leaf height of 6.7 cm and the tallest leaf averaged 8.6 cm tall (table 31).

Vegetative tillers with 8 leaves composed 0.6% of the population with 2 tillers, during the growing season a mean of 5.5 leaves (68.8%) were photosynthetically active with a mean leaf height of 5.7 cm and the tallest leaf averaged 7.5 cm tall (table 31).

Vegetative tillers with 9 leaves composed 0.0% of the population with 0 tillers (table 31).

Growth and development data of threadleaf sedge vegetative tillers on shallow soils managed with the traditional seasonlong practice during 1987 to 1989 are on table 32.

Vegetative tillers with 5 leaves composed 63.3% of the population with 62 tillers, during the growing season a mean of 3.2 leaves (63.3%) photosynthetically active with a mean leaf height of 6.9 cm and the tallest leaf averaged 8.7 cm tall (table 32).

Vegetative tillers with 6 leaves composed 34.7% of the population with 34 tillers, during the growing season a mean of 3.2 leaves (52.8%) were photosynthetically active with a mean leaf height of 7.2 cm and the tallest leaf averaged 9.7 cm tall (table 32).

Vegetative tillers with 7 leaves composed 2.0% of the population with 2 tillers, during the growing season a mean of 5.0 leaves (71.4%) were photosynthetically active with a mean leaf height of 6.2 cm and the tallest leaf averaged 9.2 cm tall (table 32).

Vegetative tillers with 8, and 9 leaves composed 0.0% of the population with 0 tillers (table 32).

Growth and development data of threadleaf sedge vegetative tillers on shallow soils managed with the long-term nongrazed treatment during 1987 to 1989 are on table 33.

Vegetative tillers with 5 leaves composed 71.0% of the population with 88 tillers, during the growing season a mean of 3.0 leaves (60.0%) were photosynthetically active with a mean leaf height of

8.8 cm and the tallest leaf averaged 12.2 cm tall (table 33).

Vegetative tillers with 6 leaves composed 26.6% of the population with 33 tillers, during the growing season a mean of 3.3 leaves (54.2%) were photosynthetically active with a mean leaf height of 9.9 cm and the tallest leaf averaged 12.6 cm tall (table 33).

Vegetative tillers with 7 leaves composed 2.4% of the population with 3 tillers, during the growing season a mean of 4.0 leaves (57.1%) were photosynthetically active with a mean leaf height of 7.1 cm and the tallest leaf averaged 11.3 cm tall (table 33).

Vegetative tillers with 8 and 9 leaves composed 0.0% of the population with 0 tillers (table 33).

Growth and development data of threadleaf sedge vegetative tillers on silty soils managed with the twice-over strategy during 1987 to 1989 are on table 34.

Vegetative tillers with 5 leaves composed 78.6% of the population with 103 tillers, during the growing season a mean of 3.0 leaves (60.0%) were photosynthetically active with a mean leaf height of 5.9 cm and the tallest leaf averaged 7.5 cm tall (table 34).

Vegetative tillers with 6 leaves composed 18.3% of the population with 24 tillers, during the growing season a mean of 3.3 leaves (54.2%) were photosynthetically active with a mean leaf height of 5.4 cm and the tallest leaf averaged 6.4 cm tall (table 34).

Vegetative tillers with 7 leaves composed 2.3% of the population with 3 tillers, during the growing season a mean of 4.0 leaves (57.1%) were photosynthetically active with a mean leaf height of 5.9 cm and the tallest leaf averaged 8.2 cm tall (table 34).

Vegetative tillers with 8 leaves composed 0.8% of the population with 1 tiller, during the growing season a mean of 5.0 leaves (62.5%) were photosynthetically active with a mean leaf height of 5.9 cm and the tallest leaf averaged 8.9 cm tall (table 34).

Vegetative tillers with 9 leaves composed 0.0% of the population with 0 tillers (table 34).

Growth and development data of threadleaf sedge vegetative tillers on silty soils managed with the ungrazed treatment during 1987 to 1989 are on table 35.

Vegetative tillers with 5 leaves composed 68.6% of the population with 177 tillers, during the growing season a mean of 3.3 leaves (66.7%) were photosynthetically active with a mean leaf height of 8.8 cm and the tallest leaf averaged 10.7 cm tall (table 35).

Vegetative tillers with 6 leaves composed 27.5% of the population with 71 tillers, during the growing season a mean of 3.0 leaves (50.0%) were photosynthetically active with a mean leaf height of 8.4 cm and the tallest leaf averaged 10.6 cm tall (table 35).

Vegetative tillers with 7 leaves composed 3.5% of the population with 9 tillers, during the growing season a mean of 4.3 leaves (61.7%) were photosynthetically active with a mean leaf height of 8.6 cm and the tallest leaf averaged 10.5 cm tall (table 35).

Vegetative tillers with 8 leaves composed 0.4% of the population with 1 tiller, during the growing season a mean of 5.0 leaves (62.5%) were photosynthetically active with a mean leaf height of 12.7 cm and the tallest leaf averaged 16.9 cm tall (table 35).

Vegetative tillers with 9 leaves composed 0.0% of the population with 0 tillers (table 35).

Growth and development data of threadleaf sedge vegetative tillers on silty soils managed with the traditional seasonlong practice during 1987 to 1989 are on table 36.

Vegetative tillers with 5 leaves composed 88.5% of the population with 138 tillers, during the growing season a mean of 3.1 leaves (61.7%) were photosynthetically active with a mean leaf height of 6.3 cm and the tallest leaf averaged 7.6 cm tall (table 36).

Vegetative tillers with 6 leaves composed 10.3% of the population with 16 tillers, during the growing season a mean of 3.4 leaves (56.3%) were photosynthetically active with a mean leaf height of 5.5 cm and the tallest leaf averaged 7.4 cm tall (table 36).

Vegetative tillers with 7 leaves composed 1.3% of the population with 2 tillers, during the growing season a mean of 3.0 leaves (42.9%) were photosynthetically active with a mean leaf height of 8.1 cm and the tallest leaf averaged 10.4 cm tall (table 36).

Vegetative tillers with 8, and 9 leaves composed 0.0% of the population with 0 tillers (table 36).

Growth and development data of threadleaf sedge vegetative tillers on silty soils managed with the long-term nongrazed treatment during 1987 to 1989 are on table 37

Vegetative tillers with 5 leaves composed 69.5% the population with 105 tillers, during the growing season a mean of 3.0 leaves (60.0%) were photosynthetically active with a mean leaf height of 8.4 cm and the tallest leaf averaged 10.4 cm tall (table 37).

Vegetative tillers with 6 leaves composed 25.2% of the population with 38 tillers, during the growing season a mean of 3.8 leaves (62.5%) were photosynthetically active with a mean leaf height of 9.7 cm and the tallest leaf averaged 12.3 cm tall (table 37).

Vegetative tillers with 7 leaves composed 5.3% of the population with 8 tillers, during the growing season a mean of 4.0 leaves (57.1%) were photosynthetically active with a mean leaf height of 7.6 cm and the tallest leaf averaged 10.7 cm tall (table 37).

Vegetative tillers with 8 and 9 leaves composed 0.0% of the population with 0 tillers (table 37).

Not all the leaves on a sedge tiller are photosynthetically active during the entire growing season. Leaves grow and senesce in the order they appear. The rate of leaf senescence can be rapid during water deficiency periods and slow during periods with adequate precipitation. During senescence, leaves translocate cell components to other plant parts. The senesced leaf has less weight and has very low nutritional quality. The greater number of leaves not senescent, the greater the tiller nutritional quality. This study has designated that leaves with less than 50% senescent tissue to be photosynthetically active.

The rate of leaf senescence of threadleaf sedge vegetative tillers on sandy, shallow, silty and clay soils managed with the ungrazed and twice-over treatments during 1983 to 1986 that received adequate precipitation was similar maintaining photosynthetically active leaves at 56.0% on the twice-over and at 57.5% on the ungrazed treatments during June through August. Vegetative tillers maintained 3.7 and 3.8 photosynthetically active leaves on the twice-over and ungrazed treatments through August, respectively. Most tillers produced 8 leaves on sandy, shallow, and clay soils and produced 9 leaves on silty soils.

The rate of leaf senescence of threadleaf sedge vegetative tillers on sandy, shallow, and silty soils managed with the nongrazed, seasonlong, ungrazed, and twice-over treatments during 1987 to 1989 that had water deficiency during most of the growing season months was not very different than that during the 1983 to 1986 period. However, most tillers failed to produce leaf 8 and 9. Tillers on the nongrazed and seasonlong treatments maintained 60.7% and 57.7% photosynthetically active leaves during the growing season, respectively. Tillers on the twice-over and ungrazed treatment maintained 59.7% and 60.2% photosynthetically active leaves, respectively. Vegetative tillers maintained 3.7 and 3.6 photosynthetically active leaves on the twice-over and ungrazed treatments, respectively, and maintained 3.5 and 3.6 photosynthetically active leaves on the seasonlong and nongrazed treatments, respectively.

All of the vegetative tillers of threadleaf sedge measured during this study were not grazed including the tillers located on grazed treatments. The not grazed tillers remaining on the grazed treatments tended to have slightly shorter mean leaf heights and mean tallest leaf heights which were not significantly different than the not grazed tillers on the ungrazed and nongrazed treatments on the sandy, shallow, silty, and clay soils during the 1983-1986 period and on the sandy, shallow, and silty soils during the 1987-1989 period. It is not believed that grazed treatments cause vegetative tillers to produce slightly shorter leaf heights. It is surmised that grazing cattle have a disproportional rate of selection for taller tillers than for shorter tillers leaving a distorted sample population of not grazed tillers with slightly shorter leaf heights.

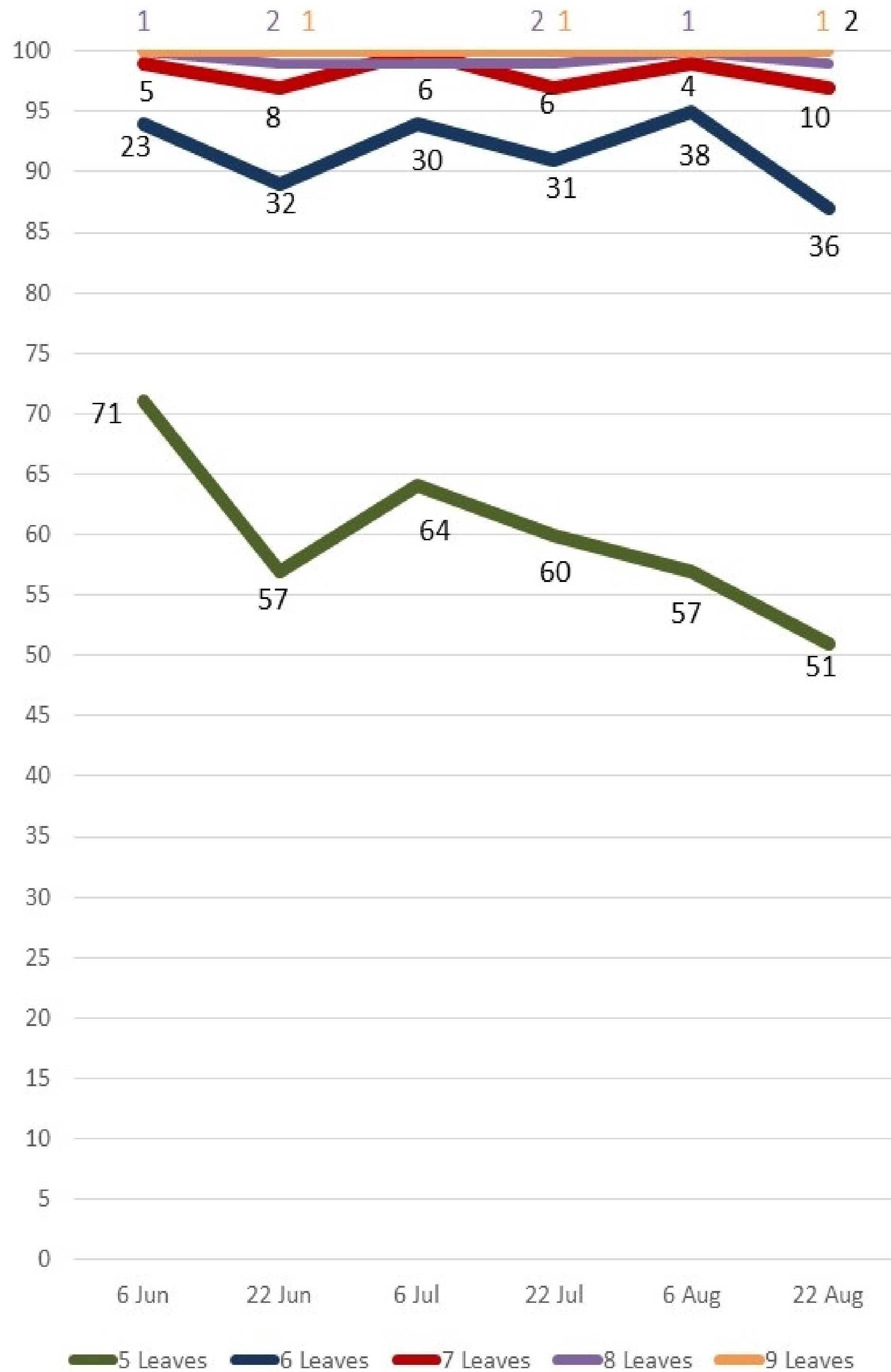

Figure 1. Percent of vegetative tiller population with 5 to 9 leaves.

Table 18. Growth and development of threadleaf sedge vegetative tillers with 5 to 9 leaves on sandy soils managed with the twice-over strategy, 1983-1986.

Sandy	6 Jun	22 Jun	6 Jul	22 Jul	6 Aug	22 Aug
5 Leaves						
% Population	75.8	55.9	62.5	61.3	65.2	48.0
% Active Leaf	80.0	60.0	60.0	50.0	40.0	50.0
Leaf Height cm	7.0	7.1	7.1	6.1	6.1	4.9
Tallest Leaf cm	8.6	8.4	8.5	7.7	8.1	6.1
6 Leaves						
% Population	21.2	29.2	32.5	35.5	30.3	42.9
% Active Leaf	66.7	58.3	50.0	50.0	50.0	50.0
Leaf Height cm	7.4	7.8	8.0	7.6	6.1	5.2
Tallest Leaf cm	9.7	9.2	9.7	9.6	7.8	6.9
7 Leaves						
% Population	3.0	12.4	5.0	3.2	4.5	9.1
% Active Leaf	57.1	57.1	57.1	57.1	42.9	42.9
Leaf Height cm	5.7	8.9	8.0	7.0	4.5	4.9
Tallest Leaf cm	8.2	10.5	10.2	10.3	5.9	6.4
8 Leaves						
% Population	0.0	1.9	0.0	0.0	0.0	0.0
% Active Leaf	-	37.5	-	-	-	-
Leaf Height cm	-	7.3	-	-	-	-
Tallest Leaf cm	-	7.8	-	-	-	-
9 leaves						
% Population	0.0	0.6	0.0	0.0	0.0	0.0
% Active Leaf	-	50.0	-	-	-	-
Leaf Height cm	-	12.3	-	-	-	-
Tallest Leaf cm	-	16.3	-	-	-	-
% Population	100.0	100.0	100.0	100.0	100.0	100.0

Table 19. Growth and development of threadleaf sedge vegetative tillers with 5 to 9 leaves on sandy soils managed with the ungrazed treatment, 1983-1986.

Sandy	6 Jun	22 Jun	6 Jul	22 Jul	6 Aug	22 Aug
5 Leaves						
% Population	72.7	52.8	55.1	63.8	52.7	50.6
% Active Leaf	60.0	60.0	60.0	50.0	60.0	40.0
Leaf Height cm	7.7	8.1	7.7	7.4	7.5	6.5
Tallest Leaf cm	9.1	9.6	9.3	9.1	9.2	8.5
6 Leaves						
% Population	23.9	36.2	34.8	27.5	42.9	35.7
% Active Leaf	66.7	50.0	50.0	58.3	50.0	41.7
Leaf Height cm	8.7	8.5	7.8	7.0	7.2	6.3
Tallest Leaf cm	10.4	10.1	10.3	9.0	10.3	8.5
7 Leaves						
% Population	2.3	7.9	10.1	6.4	4.4	10.5
% Active Leaf	57.1	64.3	71.4	57.1	57.1	42.9
Leaf Height cm	8.1	7.9	6.9	8.0	8.4	6.8
Tallest Leaf cm	12.7	9.9	8.6	10.8	11.5	8.5
8 Leaves						
% Population	1.1	2.0	0.0	1.1	0.0	2.5
% Active Leaf	62.5	62.5	-	62.5	-	56.3
Leaf Height cm	10.9	7.8	-	7.2	-	6.4
Tallest Leaf cm	16.6	10.6	-	8.8	-	9.4
9 leaves						
% Population	0.0	1.2	0.0	1.1	0.0	0.6
% Active Leaf	-	63.2	-	66.7	-	50.0
Leaf Height cm	-	10.0	-	6.7	-	5.7
Tallest Leaf cm	-	15.0	-	10.8	-	10.3
% Population	100.0	100.1	100.0	99.9	100.0	99.9

Table 20. Growth and development of threadleaf sedge vegetative tillers with 5 to 9 leaves on shallow soils managed with the twice-over strategy, 1983-1986.

Shallow	6 Jun	22 Jun	6 Jul	22 Jul	6 Aug	22 Aug
5 Leaves						
% Population	78.3	66.7	74.0	68.4	62.0	57.5
% Active Leaf	80.0	60.0	60.0	50.0	60.0	40.0
Leaf Height cm	5.2	5.2	5.1	5.0	4.1	4.3
Tallest Leaf cm	6.3	6.3	6.0	6.1	4.8	5.8
6 Leaves						
% Population	21.7	30.7	20.5	29.9	31.0	38.7
% Active Leaf	66.7	58.3	50.0	58.3	50.0	41.7
Leaf Height cm	6.2	5.1	5.1	5.4	4.7	4.1
Tallest Leaf cm	7.8	6.7	6.4	6.5	5.9	5.4
7 Leaves						
% Population	0.0	2.6	5.5	1.7	5.6	3.8
% Active Leaf	-	50.0	57.1	50.0	57.1	50.0
Leaf Height cm	-	4.4	4.8	5.8	4.9	3.4
Tallest Leaf cm	-	6.6	6.4	8.3	6.2	4.9
8 Leaves						
% Population	0.0	0.0	0.0	0.0	1.4	0.0
% Active Leaf	-	-	-	-	50.0	-
Leaf Height cm	-	-	-	-	4.5	-
Tallest Leaf cm	-	-	-	-	6.3	-
9 leaves						
% Population	0.0	0.0	0.0	0.0	0.0	0.0
% Active Leaf	-	-	-	-	-	-
Leaf Height cm	-	-	-	-	-	-
Tallest Leaf cm	-	-	-	-	-	-
% Population	100.0	100.0	100.0	100.0	100.0	100.0

Table 21. Growth and development of threadleaf sedge vegetative tillers with 5 to 9 leaves on shallow soils managed with the ungrazed treatment, 1983-1986.

Shallow	6 Jun	22 Jun	6 Jul	22 Jul	6 Aug	22 Aug
5 Leaves						
% Population	80.4	63.3	60.8	61.2	65.5	63.3
% Active Leaf	60.0	60.0	60.0	60.0	60.0	40.0
Leaf Height cm	6.2	6.0	5.9	6.5	5.2	4.9
Tallest Leaf cm	7.1	7.0	6.7	7.7	7.0	6.3
6 Leaves						
% Population	19.6	28.0	29.4	31.2	27.4	30.5
% Active Leaf	66.7	58.3	50.0	50.0	50.0	41.7
Leaf Height cm	5.2	6.1	6.1	6.4	6.7	4.8
Tallest Leaf cm	7.1	7.3	7.8	8.2	9.1	6.5
7 Leaves						
% Population	0.0	5.8	7.8	5.8	7.1	5.8
% Active Leaf	-	42.9	57.1	57.1	42.9	50.0
Leaf Height cm	-	6.0	5.2	6.7	6.4	4.1
Tallest Leaf cm	-	6.9	6.7	9.1	9.1	5.2
8 Leaves						
% Population	0.0	2.9	2.0	1.9	0.0	0.4
% Active Leaf	-	62.5	62.5	62.5	-	50.0
Leaf Height cm	-	5.6	4.1	7.2	-	6.4
Tallest Leaf cm	-	7.1	6.5	10.7	-	8.2
9 leaves						
% Population	0.0	0.0	0.0	0.0	0.0	0.0
% Active Leaf	-	-	-	-	-	-
Leaf Height cm	-	-	-	-	-	-
Tallest Leaf cm	-	-	-	-	-	-
% Population	100.0	100.0	100.0	100.1	100.0	100.0

Table 22. Growth and development of threadleaf sedge vegetative tillers with 5 to 9 leaves on silty soils managed with the twice-over strategy, 1983-1986.

Silty	6 Jun	22 Jun	6 Jul	22 Jul	6 Aug	22 Aug
5 Leaves						
% Population	75.9	59.1	72.9	56.5	48.8	51.8
% Active Leaf	80.0	60.0	60.0	60.0	60.0	50.0
Leaf Height cm	6.6	7.3	8.2	6.6	6.1	5.9
Tallest Leaf cm	8.3	8.5	9.3	7.6	7.3	7.8
6 Leaves						
% Population	16.7	32.7	27.1	35.1	43.9	36.9
% Active Leaf	66.7	58.3	66.7	58.3	50.0	50.0
Leaf Height cm	5.0	7.5	7.0	7.4	5.7	5.4
Tallest Leaf cm	5.9	9.6	8.8	9.0	6.9	6.9
7 Leaves						
% Population	5.6	7.3	0.0	8.4	7.3	9.2
% Active Leaf	71.4	50.0	-	42.9	57.1	42.9
Leaf Height cm	6.9	8.6	-	7.9	5.9	5.6
Tallest Leaf cm	7.7	11.1	-	10.6	7.5	8.1
8 Leaves						
% Population	1.9	0.9	0.0	0.0	0.0	1.4
% Active Leaf	87.5	50.0	-	-	-	37.5
Leaf Height cm	8.3	8.3	-	-	-	6.8
Tallest Leaf cm	12.5	13.2	-	-	-	9.8
9 leaves						
% Population	0.0	0.0	0.0	0.0	0.0	0.7
% Active Leaf	-	-	-	-	-	55.6
Leaf Height cm	-	-	-	-	-	9.7
Tallest Leaf cm	-	-	-	-	-	13.8
% Population	100.1	100.0	100.0	100.0	100.0	100.0

Table 23. Growth and development of threadleaf sedge vegetative tillers with 5 to 9 leaves on silty soils managed with the ungrazed treatment, 1983-1986.

Silty	6 Jun	22 Jun	6 Jul	22 Jul	6 Aug	22 Aug
5 Leaves						
% Population	59.7	59.8	72.6	60.8	63.1	53.3
% Active Leaf	60.0	60.0	60.0	60.0	60.0	50.0
Leaf Height cm	9.3	8.7	8.9	8.7	8.5	8.0
Tallest Leaf cm	11.1	10.6	10.6	10.7	10.5	9.8
6 Leaves						
% Population	30.6	32.4	22.6	30.8	34.5	32.7
% Active Leaf	66.7	58.3	50.0	50.0	50.0	41.7
Leaf Height cm	9.2	8.8	9.7	8.7	9.1	7.1
Tallest Leaf cm	11.4	11.0	12.1	11.0	11.6	9.4
7 Leaves						
% Population	8.1	7.1	4.8	5.2	1.2	11.3
% Active Leaf	71.4	71.4	57.1	57.1	71.4	57.1
Leaf Height cm	9.0	6.5	8.9	7.7	8.8	7.5
Tallest Leaf cm	10.6	9.1	12.3	10.2	14.0	9.2
8 Leaves						
% Population	1.6	0.8	0.0	2.4	1.2	1.9
% Active Leaf	75.0	50.0	-	50.0	62.5	50.0
Leaf Height cm	10.6	14.3	-	6.8	9.4	7.9
Tallest Leaf cm	17.2	17.8	-	9.2	17.9	11.7
9 leaves						
% Population	0.0	0.0	0.0	0.8	0.0	0.8
% Active Leaf	-	-	-	84.2	-	52.6
Leaf Height cm	-	-	-	6.5	-	5.9
Tallest Leaf cm	-	0.0	0.0	0.0	0.0	0.0
% Population	100.0	100.1	100.0	100.0	100.0	100.0

Table 24. Growth and development of threadleaf sedge vegetative tillers with 5 to 9 leaves on clay soils managed with the twice-over strategy, 1983-1986.

Clay	6 Jun	22 Jun	6 Jul	22 Jul	6 Aug	22 Aug
5 Leaves						
% Population	87.0	60.0	86.4	63.0	71.4	86.9
% Active Leaf	80.0	50.0	60.0	60.0	60.0	40.0
Leaf Height cm	7.0	6.6	6.2	6.3	4.5	3.6
Tallest Leaf cm	8.7	7.7	7.7	7.6	6.2	4.6
6 Leaves						
% Population	13.0	24.0	13.6	24.1	28.6	9.8
% Active Leaf	83.3	58.3	66.7	58.3	33.3	50.0
Leaf Height cm	6.0	6.9	6.4	5.9	4.9	4.0
Tallest Leaf cm	7.5	8.2	8.6	7.2	5.1	5.2
7 Leaves						
% Population	0.0	16.0	0.0	9.3	0.0	3.3
% Active Leaf	-	57.1	-	57.1	-	57.1
Leaf Height cm	-	5.9	-	7.5	-	2.6
Tallest Leaf cm	-	8.1	-	11.0	-	4.0
8 Leaves						
% Population	0.0	0.0	0.0	3.7	0.0	0.0
% Active Leaf	-	-	-	56.3	-	-
Leaf Height cm	-	-	-	3.7	-	-
Tallest Leaf cm	-	-	-	5.4	-	-
9 leaves						
% Population	0.0	0.0	0.0	0.0	0.0	0.0
% Active Leaf	-	-	-	-	-	-
Leaf Height cm	-	-	-	-	-	-
Tallest Leaf cm	-	-	-	-	-	-
% Population	100.0	100.0	100.0	100.1	100.0	100.0

Table 25. Growth and development of threadleaf sedge vegetative tillers with 5 to 9 leaves on clay soils managed with the ungrazed treatment, 1983-1986.

Clay	6 Jun	22 Jun	6 Jul	22 Jul	6 Aug	22 Aug
5 Leaves						
% Population	76.2	58.1	56.3	63.6	80.0	60.0
% Active Leaf	60.0	60.0	60.0	60.0	60.0	50.0
Leaf Height cm	8.3	7.9	8.6	7.3	7.3	6.7
Tallest Leaf cm	9.8	9.3	10.1	8.7	10.7	8.2
6 Leaves						
% Population	23.8	32.6	43.8	31.4	20.0	27.3
% Active Leaf	50.0	58.3	66.7	50.0	66.7	58.3
Leaf Height cm	12.6	8.8	8.1	7.3	6.5	7.5
Tallest Leaf cm	15.6	10.3	10.7	9.3	9.8	9.6
7 Leaves						
% Population	0.0	7.8	0.0	2.5	0.0	10.0
% Active Leaf	-	71.4	-	42.9	-	28.6
Leaf Height cm	-	6.5	-	5.2	-	5.0
Tallest Leaf cm	-	7.3	-	8.0	-	6.1
8 Leaves						
% Population	0.0	1.6	0.0	2.5	0.0	1.8
% Active Leaf	-	62.5	-	50.0	-	37.5
Leaf Height cm	-	8.5	-	7.5	-	8.0
Tallest Leaf cm	-	9.5	-	9.6	-	11.0
9 leaves						
% Population	0.0	0.0	0.0	0.0	0.0	0.9
% Active Leaf	-	-	-	-	-	77.8
Leaf Height cm	-	-	-	-	-	6.9
Tallest Leaf cm	-	-	-	-	-	10.5
% Population	100.0	100.1	100.1	100.0	100.0	100.0

Table 26. Growth and development of threadleaf sedge vegetative tillers with 5 to 9 leaves on sandy soils managed with the twice-over strategy, 1987-1989.

Sandy	6 Jun	22 Jun	6 Jul	22 Jul	6 Aug	22 Aug
5 Leaves						
% Population	65.6	73.7	100.0	76.5	100.0	52.6
% Active Leaf	60.0	60.0	80.0	60.0	80.0	60.0
Leaf Height cm	5.9	6.6	7.9	5.9	6.6	5.3
Tallest Leaf cm	6.0	7.9	10.3	7.3	8.6	6.1
6 Leaves						
% Population	25.0	26.3	0.0	17.6	0.0	30.3
% Active Leaf	66.7	50.0	-	33.3	-	66.7
Leaf Height cm	6.4	7.1	-	6.6	-	6.0
Tallest Leaf cm	7.1	8.6	-	7.6	-	6.8
7 Leaves						
% Population	9.4	0.0	0.0	5.9	0.0	13.2
% Active Leaf	71.4	-	-	71.4	-	42.9
Leaf Height cm	5.2	-	-	4.5	-	5.1
Tallest Leaf cm	6.6	-	-	6.0	-	6.4
8 Leaves						
% Population	0.0	0.0	0.0	0.0	0.0	3.9
% Active Leaf	-	-	-	-	-	12.5
Leaf Height cm	-	-	-	-	-	3.0
Tallest Leaf cm	-	-	-	-	-	3.0
9 leaves						
% Population	0.0	0.0	0.0	0.0	0.0	0.0
% Active Leaf	-	-	-	-	-	-
Leaf Height cm	-	-	-	-	-	-
Tallest Leaf cm	-	-	-	-	-	-
% Population	100.0	100.0	100.0	100.0	100.0	100.0

Table 27. Growth and development of threadleaf sedge vegetative tillers with 5 to 9 leaves on sandy soils managed with the ungrazed treatment, 1987-1989.

Sandy	6 Jun	22 Jun	6 Jul	22 Jul	6 Aug	22 Aug
5 Leaves						
% Population	78.3	86.4	100.0	67.9	100.0	70.0
% Active Leaf	60.0	60.0	80.0	60.0	80.0	40.0
Leaf Height cm	7.3	7.3	9.1	6.9	6.2	6.5
Tallest Leaf cm	8.4	9.2	11.2	8.9	8.8	7.5
6 Leaves						
% Population	19.6	13.6	0.0	30.2	0.0	28.6
% Active Leaf	66.7	66.7	-	33.3	-	50.0
Leaf Height cm	6.3	9.0	-	6.0	-	6.7
Tallest Leaf cm	7.6	11.8	-	8.6	-	8.7
7 Leaves						
% Population	2.2	0.0	0.0	1.9	0.0	1.4
% Active Leaf	71.4	-	-	57.1	-	57.1
Leaf Height cm	5.9	-	-	8.5	-	10.9
Tallest Leaf cm	7.5	-	-	12.1	-	14.9
8 Leaves						
% Population	0.0	0.0	0.0	0.0	0.0	0.0
% Active Leaf	-	-	-	-	-	-
Leaf Height cm	-	-	-	-	-	-
Tallest Leaf cm	-	-	-	-	-	-
9 leaves						
% Population	0.0	0.0	0.0	0.0	0.0	0.0
% Active Leaf	-	-	-	-	-	-
Leaf Height cm	-	-	-	-	-	-
Tallest Leaf cm	-	-	-	-	-	-
% Population	100.1	100.0	100.0	100.0	100.0	100.0

Table 28. Growth and development of threadleaf sedge vegetative tillers with 5 to 9 leaves on sandy soils managed with the seasonlong treatment, 1987-1989.

Sandy	6 Jun	22 Jun	6 Jul	22 Jul	6 Aug	22 Aug
5 Leaves						
% Population	72.7	100.0	100.0	72.2	0.0	50.0
% Active Leaf	80.0	50.0	80.0	60.0	-	60.0
Leaf Height cm	8.5	5.6	8.3	7.1	-	6.5
Tallest Leaf cm	10.7	6.6	10.3	8.2	-	7.4
6 Leaves						
% Population	27.3	0.0	0.0	22.2	0.0	43.3
% Active Leaf	66.7	-	-	66.7	-	50.0
Leaf Height cm	6.4	-	-	7.7	-	6.3
Tallest Leaf cm	8.2	-	-	9.7	-	7.7
7 Leaves						
% Population	0.0	0.0	0.0	5.6	0.0	6.7
% Active Leaf	-	-	-	57.1	-	57.1
Leaf Height cm	-	-	-	7.7	-	7.8
Tallest Leaf cm	-	-	-	11.1	-	8.7
8 Leaves						
% Population	0.0	0.0	0.0	0.0	0.0	0.0
% Active Leaf	-	-	-	-	-	-
Leaf Height cm	-	-	-	-	-	-
Tallest Leaf cm	-	-	-	-	-	-
9 leaves						
% Population	0.0	0.0	0.0	0.0	0.0	0.0
% Active Leaf	-	-	-	-	-	-
Leaf Height cm	-	-	-	-	-	-
Tallest Leaf cm	-	-	-	-	-	-
% Population	100.0	100.0	100.0	100.0	0.0	100.0

Table 29. Growth and development of threadleaf sedge vegetative tillers with 5 to 9 leaves on sandy soils managed with the nongrazed treatment, 1987-1989.

Sandy	6 Jun	22 Jun	6 Jul	22 Jul	6 Aug	22 Aug
5 Leaves						
% Population	81.5	53.8	100.0	88.2	100.0	60.7
% Active Leaf	60.0	60.0	80.0	60.0	80.0	60.0
Leaf Height cm	9.7	8.2	9.4	8.9	10.2	7.8
Tallest Leaf cm	11.0	9.1	12.6	10.6	14.0	9.4
6 Leaves						
% Population	14.8	38.5	0.0	11.8	0.0	32.1
% Active Leaf	83.3	66.7	-	66.7	-	50.0
Leaf Height cm	8.3	10.2	-	9.4	-	9.1
Tallest Leaf cm	12.4	13.5	-	16.5	-	12.0
7 Leaves						
% Population	3.7	7.7	0.0	0.0	0.0	3.6
% Active Leaf	71.4	57.1	-	-	-	57.1
Leaf Height cm	9.8	12.5	-	-	-	5.2
Tallest Leaf cm	14.2	15.8	-	-	-	7.5
8 Leaves						
% Population	0.0	0.0	0.0	0.0	0.0	3.6
% Active Leaf	-	-	-	-	-	62.5
Leaf Height cm	-	-	-	-	-	8.6
Tallest Leaf cm	-	-	-	-	-	12.5
9 leaves						
% Population	0.0	0.0	0.0	0.0	0.0	0.0
% Active Leaf	-	-	-	-	-	-
Leaf Height cm	-	-	-	-	-	-
Tallest Leaf cm	-	-	-	-	-	-
% Population	100.0	100.0	100.0	100.0	100.0	100.0

Table 30. Growth and development of threadleaf sedge vegetative tillers with 5 to 9 leaves on shallow soils managed with the twice-over strategy, 1987-1989.

Shallow	6 Jun	22 Jun	6 Jul	22 Jul	6 Aug	22 Aug
5 Leaves						
% Population	84.8	92.9	100.0	81.6	73.5	68.2
% Active Leaf	60.0	60.0	80.0	60.0	60.0	60.0
Leaf Height cm	4.4	4.5	6.6	4.9	5.7	4.2
Tallest Leaf cm	5.0	5.7	8.6	6.6	7.0	5.0
6 Leaves						
% Population	15.2	7.1	0.0	16.3	26.5	31.8
% Active Leaf	66.7	66.7	-	66.7	66.7	33.3
Leaf Height cm	3.5	5.2	-	6.2	6.7	3.6
Tallest Leaf cm	4.7	6.1	-	7.4	9.7	4.7
7 Leaves						
% Population	0.0	0.0	0.0	2.0	0.0	0.0
% Active Leaf	-	-	-	57.1	-	-
Leaf Height cm	-	-	-	4.3	-	-
Tallest Leaf cm	-	-	-	7.0	-	-
8 Leaves						
% Population	0.0	0.0	0.0	0.0	0.0	0.0
% Active Leaf	-	-	-	-	-	-
Leaf Height cm	-	-	-	-	-	-
Tallest Leaf cm	-	-	-	-	-	-
9 leaves						
% Population	0.0	0.0	0.0	0.0	0.0	0.0
% Active Leaf	-	-	-	-	-	-
Leaf Height cm	-	-	-	-	-	-
Tallest Leaf cm	-	-	-	-	-	-
% Population	100.0	100.0	100.0	99.9	100.0	100.0

Table 31. Growth and development of threadleaf sedge vegetative tillers with 5 to 9 leaves on shallow soils managed with the ungrazed treatment, 1987-1989.

Shallow	6 Jun	22 Jun	6 Jul	22 Jul	6 Aug	22 Aug
5 Leaves						
% Population	59.4	83.3	100.0	81.5	100.0	69.1
% Active Leaf	60.0	60.0	80.0	60.0	80.0	40.0
Leaf Height cm	6.5	5.6	6.5	6.7	8.3	5.0
Tallest Leaf cm	7.7	6.4	8.1	7.4	10.9	6.5
6 Leaves						
% Population	35.6	16.7	0.0	16.7	0.0	27.8
% Active Leaf	66.7	50.0	-	50.0	-	50.0
Leaf Height cm	6.2	6.7	-	5.3	-	5.1
Tallest Leaf cm	7.6	8.8	-	6.8	-	5.8
7 Leaves						
% Population	4.0	0.0	0.0	1.9	0.0	2.1
% Active Leaf	57.1	-	-	71.4	-	71.4
Leaf Height cm	7.0	-	-	6.9	-	6.3
Tallest Leaf cm	9.1	-	-	9.8	-	7.0
8 Leaves						
% Population	1.0	0.0	0.0	0.0	0.0	1.0
% Active Leaf	87.5	-	-	-	-	50.0
Leaf Height cm	8.0	-	-	-	-	3.3
Tallest Leaf cm	10.9	-	-	-	-	4.1
9 leaves						
% Population	0.0	0.0	0.0	0.0	0.0	0.0
% Active Leaf	-	-	-	-	-	-
Leaf Height cm	-	-	-	-	-	-
Tallest Leaf cm	-	-	-	-	-	-
% Population	100.0	100.0	100.0	100.1	100.0	100.0

Table 32. Growth and development of threadleaf sedge vegetative tillers with 5 to 9 leaves on shallow soils managed with the seasonlong treatment, 1987-1989.

Shallow	6 Jun	22 Jun	6 Jul	22 Jul	6 Aug	22 Aug
5 Leaves						
% Population	40.0	100.0	100.0	54.2	100.0	78.1
% Active Leaf	60.0	50.0	80.0	60.0	80.0	50.0
Leaf Height cm	8.1	8.9	6.7	7.0	6.0	4.9
Tallest Leaf cm	10.1	10.5	8.5	8.3	8.3	6.1
6 Leaves						
% Population	56.7	0.0	0.0	45.8	0.0	18.8
% Active Leaf	66.7	-	-	50.0	-	41.7
Leaf Height cm	8.6	-	-	7.1	-	5.8
Tallest Leaf cm	11.9	-	-	9.6	-	7.6
7 Leaves						
% Population	3.3	0.0	0.0	0.0	0.0	3.1
% Active Leaf	71.4	-	-	-	-	71.4
Leaf Height cm	9.1	-	-	-	-	3.2
Tallest Leaf cm	12.0	-	-	-	-	6.3
8 Leaves						
% Population	0.0	0.0	0.0	0.0	0.0	0.0
% Active Leaf	-	-	-	-	-	-
Leaf Height cm	-	-	-	-	-	-
Tallest Leaf cm	-	-	-	-	-	-
9 leaves						
% Population	0.0	0.0	0.0	0.0	0.0	0.0
% Active Leaf	-	-	-	-	-	-
Leaf Height cm	-	-	-	-	-	-
Tallest Leaf cm	-	-	-	-	-	-
% Population	100.0	100.0	100.0	100.0	100.0	100.0

Table 33. Growth and development of threadleaf sedge vegetative tillers with 5 to 9 leaves on shallow soils managed with the nongrazed treatment, 1987-1989.

Shallow	6 Jun	22 Jun	6 Jul	22 Jul	6 Aug	22 Aug
5 Leaves						
% Population	73.9	70.6	100.0	67.6	100.0	54.8
% Active Leaf	60.0	40.0	80.0	60.0	80.0	40.0
Leaf Height cm	8.8	10.7	7.5	9.5	8.3	8.1
Tallest Leaf cm	10.6	13.3	13.0	11.0	14.7	10.5
6 Leaves						
% Population	21.7	29.4	0.0	29.4	0.0	41.9
% Active Leaf	66.7	50.0	-	50.0	-	50.0
Leaf Height cm	10.6	10.1	-	8.6	-	10.2
Tallest Leaf cm	13.9	12.4	-	11.0	-	13.0
7 Leaves						
% Population	4.3	0.0	0.0	2.9	0.0	3.2
% Active Leaf	42.9	-	-	57.1	-	71.4
Leaf Height cm	3.7	-	-	7.9	-	9.8
Tallest Leaf cm	6.4	-	-	14.4	-	13.0
8 Leaves						
% Population	0.0	0.0	0.0	0.0	0.0	0.0
% Active Leaf	-	-	-	-	-	-
Leaf Height cm	-	-	-	-	-	-
Tallest Leaf cm	-	-	-	-	-	-
9 leaves						
% Population	0.0	0.0	0.0	0.0	0.0	0.0
% Active Leaf	-	-	-	-	-	-
Leaf Height cm	-	-	-	-	-	-
Tallest Leaf cm	-	-	-	-	-	-
% Population	99.9	100.0	100.0	99.9	100.0	99.9

Table 34. Growth and development of threadleaf sedge vegetative tillers with 5 to 9 leaves on silty soils managed with the twice-over strategy, 1987-1989.

Silty	6 Jun	22 Jun	6 Jul	22 Jul	6 Aug	22 Aug
5 Leaves						
% Population	93.8	91.7	100.0	77.3	100.0	63.4
% Active Leaf	60.0	60.0	60.0	60.0	60.0	60.0
Leaf Height cm	4.4	5.8	9.2	4.4	6.8	4.8
Tallest Leaf cm	5.2	6.6	12.2	5.5	9.6	5.8
6 Leaves						
% Population	6.3	8.3	0.0	20.5	0.0	29.3
% Active Leaf	50.0	50.0	-	50.0	-	66.7
Leaf Height cm	4.7	6.4	-	4.5	-	5.8
Tallest Leaf cm	5.2	7.4	-	5.1	-	7.7
7 Leaves						
% Population	0.0	0.0	0.0	0.0	0.0	7.3
% Active Leaf	-	-	-	-	-	57.1
Leaf Height cm	-	-	-	-	-	5.9
Tallest Leaf cm	-	-	-	-	-	8.2
8 Leaves						
% Population	0.0	0.0	0.0	2.3	0.0	0.0
% Active Leaf	-	-	-	62.5	-	-
Leaf Height cm	-	-	-	5.9	-	-
Tallest Leaf cm	-	-	-	8.9	-	-
9 leaves						
% Population	0.0	0.0	0.0	0.0	0.0	0.0
% Active Leaf	-	-	-	-	-	-
Leaf Height cm	-	-	-	-	-	-
Tallest Leaf cm	-	-	-	-	-	-
% Population	100.1	100.0	100.0	100.1	100.0	100.0

Table 35. Growth and development of threadleaf sedge vegetative tillers with 5 to 9 leaves on silty soils managed with the ungrazed treatment, 1987-1989.

Silty	6 Jun	22 Jun	6 Jul	22 Jul	6 Aug	22 Aug
5 Leaves						
% Population	56.0	56.3	100.0	82.4	100.0	75.0
% Active Leaf	60.0	60.0	80.0	60.0	80.0	60.0
Leaf Height cm	8.1	8.8	13.1	9.2	5.8	7.6
Tallest Leaf cm	9.1	10.5	15.9	10.9	8.5	8.9
6 Leaves						
% Population	37.0	40.6	0.0	14.7	0.0	25.0
% Active Leaf	66.7	50.0	-	33.3	-	50.0
Leaf Height cm	9.7	7.6	-	8.8	-	7.6
Tallest Leaf cm	12.3	9.0	-	10.7	-	10.3
7 Leaves						
% Population	6.0	3.1	0.0	2.9	0.0	0.0
% Active Leaf	83.3	42.9	-	57.1	-	-
Leaf Height cm	9.9	6.7	-	9.1	-	-
Tallest Leaf cm	12.9	7.5	-	11.0	-	-
8 Leaves						
% Population	1.0	0.0	0.0	0.0	0.0	0.0
% Active Leaf	62.5	-	-	-	-	-
Leaf Height cm	12.7	-	-	-	-	-
Tallest Leaf cm	16.9	-	-	-	-	-
9 leaves						
% Population	0.0	0.0	0.0	0.0	0.0	0.0
% Active Leaf	-	-	-	-	-	-
Leaf Height cm	-	-	-	-	-	-
Tallest Leaf cm	-	-	-	-	-	-
% Population	100.0	100.0	100.0	100.0	100.0	100.0

Table 36. Growth and development of threadleaf sedge vegetative tillers with 5 to 9 leaves on silty soils managed with the seasonlong treatment, 1987-1989.

Silty	6 Jun	22 Jun	6 Jul	22 Jul	6 Aug	22 Aug
5 Leaves						
% Population	88.0	87.5	100.0	82.9	100.0	92.2
% Active Leaf	60.0	60.0	70.0	60.0	80.0	40.0
Leaf Height cm	6.1	6.8	7.9	5.5	7.0	4.3
Tallest Leaf cm	6.9	8.5	9.5	7.0	9.3	4.6
6 Leaves						
% Population	8.0	12.5	0.0	17.1	0.0	5.9
% Active Leaf	66.7	50.0	-	58.3	-	50.0
Leaf Height cm	6.0	6.4	-	5.3	-	4.3
Tallest Leaf cm	7.7	9.6	-	7.0	-	5.1
7 Leaves						
% Population	4.0	0.0	0.0	0.0	0.0	2.0
% Active Leaf	71.4	-	-	-	-	14.3
Leaf Height cm	9.6	-	-	-	-	6.5
Tallest Leaf cm	14.2	-	-	-	-	6.5
8 Leaves						
% Population	0.0	0.0	0.0	0.0	0.0	0.0
% Active Leaf	-	-	-	-	-	-
Leaf Height cm	-	-	-	-	-	-
Tallest Leaf cm	-	-	-	-	-	-
9 leaves						
% Population	0.0	0.0	0.0	0.0	0.0	0.0
% Active Leaf	-	-	-	-	-	-
Leaf Height cm	-	-	-	-	-	-
Tallest Leaf cm	-	-	-	-	-	-
% Population	100.0	100.0	100.0	100.0	100.0	100.1

Table 37. Growth and development of threadleaf sedge vegetative tillers with 5 to 9 leaves on silty soils managed with the nongrazed treatment, 1987-1989.

Silty	6 Jun	22 Jun	6 Jul	22 Jul	6 Aug	22 Aug
5 Leaves						
% Population	67.9	44.4	100.0	88.9	100.0	62.5
% Active Leaf	60.0	60.0	80.0	40.0	80.0	40.0
Leaf Height cm	9.3	10.2	11.7	7.1	5.9	6.3
Tallest Leaf cm	10.6	13.3	15.4	7.5	7.7	7.7
6 Leaves						
% Population	30.4	37.0	0.0	11.1	0.0	31.3
% Active Leaf	66.7	66.7	-	66.7	-	50.0
Leaf Height cm	8.6	12.5	-	7.9	-	9.8
Tallest Leaf cm	10.5	16.5	-	10.1	-	12.2
7 Leaves						
% Population	1.8	18.5	0.0	0.0	0.0	6.3
% Active Leaf	71.4	57.1	-	-	-	42.9
Leaf Height cm	6.5	8.0	-	-	-	8.2
Tallest Leaf cm	9.4	11.0	-	-	-	11.8
8 Leaves						
% Population	0.0	0.0	0.0	0.0	0.0	0.0
% Active Leaf	-	-	-	-	-	-
Leaf Height cm	-	-	-	-	-	-
Tallest Leaf cm	-	-	-	-	-	-
9 leaves						
% Population	0.0	0.0	0.0	0.0	0.0	0.0
% Active Leaf	-	-	-	-	-	-
Leaf Height cm	-	-	-	-	-	-
Tallest Leaf cm	-	-	-	-	-	-
% Population	100.1	99.9	100.0	100.0	100.0	100.1

Secondary Tillers

The secondary tillers had very slow rates of growth and development until they produce their fourth leaf that starts the second whorl. During growing seasons with normal precipitation conditions (1983-1986), secondary tillers made up about 27.1% of the total tiller population on the grazed twice-over treatment and made up about 29.3% of the ungrazed treatment. During growing seasons with below normal precipitation conditions (1987-1989), secondary tillers made up a greater proportion of the total tiller population, with 55.4% on the grazed twice-over strategy, 47.7% on the ungrazed treatment, 54.2% on the seasonlong, and 36.8% on the nongrazed treatments.

Growth and development data of threadleaf sedge secondary tillers on sandy, shallow, silty, and clay soils managed with the twice-over strategy and the ungrazed treatment during 1983 to 1986 are on tables 38, 39, 40, and 41, respectively.

Secondary tillers with 2 to 4 leaves on sandy soils of the twice-over strategy composed 22.9% of the total population with 251 tillers (table 6), during the growing season 66.7% of the leaves were photosynthetically active with a mean leaf height of 6.6 cm and the tallest leaf averaged 8.2 cm tall (table 38).

Secondary tillers with 2 to 4 leaves on sandy soils of the ungrazed treatment composed 24.5% of the total tiller population with 411 tillers (table 6), during the growing season 61.6% of the leaves were photosynthetically active with a mean leaf height of 7.8 cm and the tallest leaf averaged 9.2 cm tall (table 38).

Secondary tillers with 2 to 4 leaves on shallow soils of the twice-over strategy composed 25.1% of the total tiller population with 267 tillers (table 7), during the growing season 63.4% of the leaves were photosynthetically active with a mean leaf height of 4.7 cm and the tallest leaf averaged 5.5 cm tall (table 39).

Secondary tillers with 2 to 4 leaves on shallow soils of the ungrazed treatment composed 31.4% of the total tiller population with 484 tillers (table 7), during the growing season 67.6% of the leaves were photosynthetically active with a mean leaf height of 5.4 cm and the tallest leaf averaged 6.4 cm tall (table 39).

Secondary tillers with 2 to 4 leaves on silty soils of the twice-over strategy composed 23.5% of the total tiller population with 220 tillers (table 8), during the growing season 64.3% of the leaves were photosynthetically active with a mean leaf height of 6.8 cm and the tallest leaf averaged 8.2 cm tall (table 40).

Secondary tillers with 2 to 4 leaves on silty soils of the ungrazed treatment composed 27.5% of the total tiller population with 425 tillers (table 8), during the growing season 67.5% of the leaves were photosynthetically active with a mean leaf height of 8.2 cm and the tallest leaf averaged 9.8 cm tall (table 40).

Secondary tillers with 2 to 4 leaves on clay soils of the twice-over strategy composed 36.8% of the total tiller population with 155 tillers (table 9), during the growing season 58.8% of the leaves were photosynthetically active with a mean leaf height of 5.5 cm and the tallest leaf averaged 6.4 cm tall (table 41).

Secondary tillers with 2 to 4 leaves on clay soils of the ungrazed treatment composed 33.8% of the total tiller population with 249 tillers (table 9), during the growing season 60.0% of the leaves were photosynthetically active with a mean leaf height of 6.9 cm and the tallest leaf averaged 8.1 cm tall (table 41).

Growth and development data of threadleaf sedge secondary tillers on sandy, shallow, and silty soils managed with the twice-over strategy and the ungrazed treatment and with the seasonlong and nongrazed treatments during 1987 to 1989 are on tables 42, 43, and 44, respectively.

Secondary tillers with 2 to 4 leaves on sandy soils of the twice-over strategy composed 53.9% of the total tiller population with 304 tillers (table 6), during the growing season 70.1% of the leaves were photosynthetically active with a mean leaf height of 6.5 cm and the tallest leaf averaged 7.8 cm tall (table 42).

Secondary tillers with 2 to 4 leaves on sandy soils of the ungrazed treatment composed 50.4% of the total tiller population with 359 tillers (table 6), during the growing season 61.1% of the leaves were photosynthetically active with a mean leaf height of 7.8 cm and the tallest leaf averaged 9.1 cm tall (table 42).

Secondary tillers with 2 to 4 leaves on sandy soils of the seasonlong treatment composed 51.7% of the total tiller population with 121 tillers (table 6), during the growing season 64.6% of the leaves were photosynthetically active with a mean leaf height of 6.7 cm and the tallest leaf averaged 7.9 cm tall (table 42).

Secondary tillers with 2 to 4 leaves on sandy soils of the nongrazed treatment composed 48.0% of the total tiller population with 121 tillers (table 6), during the growing season 57.7% of the leaves were photosynthetically active with a mean leaf height of 9.1 cm and the tallest leaf averaged 10.7 cm tall (table 42).

Secondary tillers with 2 to 4 leaves on shallow soils of the twice-over strategy composed 48.7% of the total tiller population with 285 tillers (table 7), during the growing season 52.8% of the leaves were photosynthetically active with a mean leaf height of 5.2 cm and the tallest leaf averaged 5.9 cm tall (table 43).

Secondary tillers with 2 to 4 leaves on shallow soils of the ungrazed treatment composed 43.6% of the total tiller population with 312 tillers (table 7), during the growing season 67.1% of the leaves were photosynthetically active with a mean leaf height of 6.5 cm and the tallest leaf averaged 7.5 cm tall (table 43).

Secondary tillers with 2 to 4 leaves on shallow soils of the seasonlong treatment composed 52.9% of the total tiller population with 146 tillers (table 7), during the growing season 62.8% of the leaves were photosynthetically active with a mean leaf height of 5.5 cm and the tallest leaf averaged 6.6 cm tall (table 43).

Secondary tillers with 2 to 4 leaves on shallow soils of the nongrazed treatment composed 37.5% of the total tiller population with 99 tillers (table 7), during the growing season 60.7% of the leaves were photosynthetically active with a mean leaf height of 7.5 cm and the tallest leaf averaged 8.6 cm tall (table 43).

Secondary tillers with 2 to 4 leaves on silty soils of the twice-over strategy composed 63.6% of the total tiller population with 351 tillers (table 8), during the growing season 62.0% of the leaves were photosynthetically active with a mean leaf height of 4.9 cm and the tallest leaf averaged 5.8 cm tall (table 44).

Secondary tillers with 2 to 4 leaves on silty soils of the ungrazed treatment composed 49.1% of the total tiller population with 345 tillers (table 8), during the growing season 66.7% of the leaves were photosynthetically active with a mean leaf height of 8.1 cm and the tallest leaf averaged 9.2 cm tall (table 44).

Secondary tillers with 2 to 4 leaves on silty soils of the seasonlong treatment composed 57.9% of the total tiller population with 285 tillers (table 8), during the growing season 67.9% of the leaves were photosynthetically active with a mean leaf height of 6.1 cm and the tallest leaf averaged 7.2 cm tall (table 44).

Secondary tillers with 2 to 4 leaves on silty soils of the nongrazed treatment composed 24.8% of the total tiller population with 60 tillers (table 8), during the growing season 60.0% of the leaves were photosynthetically active with a mean leaf height of 7.7 cm and the tallest leaf averaged 9.0 cm tall (table 44).

All of the secondary tillers measured during this study were not grazed including the tillers located on grazed treatments. The not grazed tillers remaining on the grazed treatments tended to have slightly shorter mean leaf heights and mean tallest leaf heights which were not significantly different than the not grazed tillers on the ungrazed treatments on sandy, shallow, silty, and clay soils during the 1983-1986 period (tables 38, 39, 40, and 41) and on the sandy, shallow, and silty soils during the 1987-1989 period (tables 42, 43, and 44). It is not believed that grazed treatments cause secondary tillers to produce slightly shorter leaf heights. It is surmised that grazing cattle have a disproportional rate of selection for taller tillers than for shorter tillers leaving a distorted sample population of not grazed tillers with slightly shorter leaf heights.

Leaves grow and senesce in about the same order of their appearance. This study has designated that leaves with less than 50% senescent tissue to be photosynthetically active. Tillers growing on the twice-over treatment tended to have slightly lower photosynthetically active leaves (64.8%) than the tillers growing on the ungrazed treatment (65.6%), during the growing seasons with normal precipitation conditions (1983 to 1986). During the growing seasons with below normal precipitation conditions (1987 to 1989), secondary tillers had lower levels of photosynthetically active leaves with 61.6% on the twice-over strategy, 65.0% on the ungrazed treatment, 65.1% on the traditional seasonlong practice, and 59.5% on the long-term nongrazed treatment.

Secondary tillers composed a high percentage of the total measured tiller population during the 1983 to 1986 period with normal precipitation conditions with 27.1% on the grazed twice-over strategy and 29.3% on the ungrazed treatment. The quantity of secondary tillers greatly increased during the 1987 to 1989 period with below normal precipitation conditions and composed 55.4% on the grazed twice-over strategy, 47.7% on the ungrazed treatment, 54.2% on the traditional seasonlong practice, and 36.8% on the long-term nongrazed treatment.

Table 38. Growth and development of threadleaf sedge secondary tillers on sandy soils managed with the twice-over grazing and ungrazed treatments, 1983-1986.

Sandy	6 Jun	22 Jun	6 Jul	22 Jul	6 Aug	22 Aug
Twice-over 1983-1986						
% Population	42.6	19.9	23.8	29.2	14.4	24.9
% Active Leaf	85.7	71.4	85.7	54.5	57.1	45.5
Leaf Height cm	7.4	6.6	6.5	7.1	7.6	4.3
Tallest Leaf cm	8.7	8.2	8.1	8.9	10.3	4.8
Ungrazed 1983-1986						
% Population	28.5	28.5	21.9	31.2	27.2	23.4
% Active Leaf	71.4	71.4	57.1	62.5	57.1	50.0
Leaf Height cm	10.1	8.1	9.1	7.2	5.7	6.8
Tallest Leaf cm	12.2	9.2	9.9	8.2	7.2	8.5

Table 39. Growth and development of threadleaf sedge secondary tillers on shallow soils managed with the twice-over grazing and ungrazed treatments, 1983-1986.

Shallow	6 Jun	22 Jun	6 Jul	22 Jul	6 Aug	22 Aug
Twice-over 1983-1986						
% Population	42.9	39.4	30.5	22.3	29.7	16.2
% Active Leaf	85.4	78.6	57.1	63.6	50.0	45.5
Leaf Height cm	4.8	5.1	4.1	5.2	4.7	4.4
Tallest Leaf cm	5.4	6.2	4.2	6.3	6.1	4.9
Ungrazed 1983-1986						
% Population	50.9	38.9	51.0	26.8	16.8	36.3
% Active Leaf	85.7	78.6	71.4	56.3	57.1	56.3
Leaf Height cm	5.4	5.1	5.6	6.7	4.1	5.2
Tallest Leaf cm	6.5	5.9	6.9	7.6	5.4	6.2

Table 40. Growth and development of threadleaf sedge secondary tillers on silty soils managed with the twice-over grazing and ungrazed treatments, 1983-1986.

Silty	6 Jun	22 Jun	6 Jul	22 Jul	6 Aug	22 Aug
Twice-over 1983-1986						
% Population	43.2	34.5	26.3	18.1	19.6	24.6
% Active Leaf	85.7	85.7	71.4	50.0	50.0	42.9
Leaf Height cm	8.2	7.5	7.3	6.8	5.4	5.4
Tallest Leaf cm	10.1	9.2	8.1	8.1	6.8	6.7
Ungrazed 1983-1986						
% Population	38.6	29.9	37.4	28.8	25.7	31.1
% Active Leaf	85.7	78.6	71.4	69.2	50.0	50.0
Leaf Height cm	8.2	8.1	9.7	7.8	8.0	7.5
Tallest Leaf cm	9.8	9.9	11.9	9.3	9.5	8.5

Table 41. Growth and development of threadleaf sedge secondary tillers on clay soils managed with the twice-over grazing and ungrazed treatments, 1983-1986.

Clay	6 Jun	22 Jun	6 Jul	22 Jul	6 Aug	22 Aug
Twice-over 1983-1986						
% Population	48.9	39.0	43.6	39.3	57.6	33.0
% Active Leaf	75.0	64.3	57.1	63.6	57.1	35.7
Leaf Height cm	6.7	6.6	5.5	6.6	4.3	3.1
Tallest Leaf cm	7.5	7.7	7.2	7.6	4.7	3.4
Ungrazed 1983-1986						
% Population	47.5	39.7	42.9	29.7	50.0	37.9
% Active Leaf	88.9	71.4	57.1	57.1	57.1	28.6
Leaf Height cm	6.5	7.6	6.7	7.1	6.0	7.5
Tallest Leaf cm	7.5	8.2	8.0	8.3	7.5	9.2

Table 42. Growth and development of threadleaf sedge secondary tillers on sandy soils managed with the twice-over grazing and ungrazed treatments and the seasonlong and nongrazed treatmetns, 1987-1989.

Sandy	6 Jun	22 Jun	6 Jul	22 Jul	6 Aug	22 Aug
Twice-over 1987-1989						
% Population	52.2	79.3	84.1	55.3	78.3	26.9
% Active Leaf	100.0	77.8	71.4	42.9	71.4	57.1
Leaf Height cm	6.4	5.5	6.6	5.9	7.5	6.8
Tallest Leaf cm	7.7	6.4	8.1	6.4	10.3	8.0
Ungrazed 1987-1989						
% Population	39.1	63.0	87.0	55.5	83.3	41.2
% Active Leaf	71.4	66.7	71.4	57.1	75.0	25.0
Leaf Height cm	7.4	7.5	11.2	7.7	7.5	5.2
Tallest Leaf cm	8.3	8.8	13.8	8.7	10.0	5.2
Seasonlong 1987-1989						
% Population	64.5	63.3	75.0	59.1	100.0	16.7
% Active Leaf	87.5	64.3	75.0	57.1	75.0	28.6
Leaf Height cm	7.0	7.7	8.2	5.4	6.7	4.9
Tallest Leaf cm	8.6	8.9	10.2	6.9	7.2	5.5
Nongrazed 1987-1989						
% Population	56.5	66.7	29.2	61.4	87.5	15.2
% Active Leaf	71.4	71.4	75.0	57.1	71.4	0.0
Leaf Height cm	8.9	8.0	9.8	8.2	10.6	-
Tallest Leaf cm	10.2	8.7	12.5	9.9	12.0	-

Table 43. Growth and development of threadleaf sedge secondary tillers on shallow soils managed with the twice-over grazing and ungrazed treatments and the seasonlong and nongrazed treatmetns, 1987-1989.

Shallow	6 Jun	22 Jun	6 Jul	22 Jul	6 Aug	22 Aug
Twice-over 1987-1989						
% Population	48.4	84.4	79.2	57.4	5.6	43.6
% Active Leaf	57.1	66.7	71.4	57.1	50.0	14.3
Leaf Height cm	5.4	5.3	5.7	4.9	6.7	3.4
Tallest Leaf cm	6.5	5.8	7.0	5.4	7.1	3.4
Ungrazed 1987-1989						
% Population	36.1	53.8	95.5	52.2	80.6	11.0
% Active Leaf	71.4	77.8	71.4	57.1	75.0	50.0
Leaf Height cm	6.5	6.4	5.9	6.0	9.0	5.1
Tallest Leaf cm	7.7	7.1	7.3	6.4	10.8	5.9
Seasonlong 1987-1989						
% Population	52.4	82.5	90.5	42.9	91.7	23.8
% Active Leaf	81.3	64.3	71.4	60.0	71.4	28.6
Leaf Height cm	6.3	6.1	7.6	5.4	5.4	2.0
Tallest Leaf cm	7.4	7.4	8.9	7.3	6.5	2.0
Nongrazed 1987-1989						
% Population	60.3	59.5	14.3	8.1	95.8	24.4
% Active Leaf	85.7	71.4	71.4	50.0	71.4	14.3
Leaf Height cm	6.6	8.3	10.7	7.1	10.2	1.9
Tallest Leaf cm	7.6	9.4	12.7	8.0	12.1	1.9

Table 44. Growth and development of threadleaf sedge secondary tillers on silty soils managed with the twice-over grazing and ungrazed treatments and the seasonlong and nongrazed treatmetns, 1987-1989.

Silty	6 Jun	22 Jun	6 Jul	22 Jul	6 Aug	22 Aug
Twice-over 1987-1989						
% Population	71.9	74.7	95.8	42.9	94.4	69.2
% Active Leaf	57.1	88.9	75.0	57.1	71.4	22.2
Leaf Height cm	4.5	4.9	6.7	4.9	4.4	4.2
Tallest Leaf cm	5.5	5.6	8.2	5.8	5.2	4.3
Ungrazed 1987-1989						
% Population	30.1	68.9	84.3	37.6	91.3	65.6
% Active Leaf	71.4	85.7	71.4	57.1	71.4	42.9
Leaf Height cm	7.0	8.6	10.8	6.9	9.0	6.0
Tallest Leaf cm	8.6	9.9	12.2	7.9	10.5	6.3
Seasonlong 1987-1989						
% Population	69.9	62.8	85.0	51.8	98.3	41.4
% Active Leaf	81.3	64.3	75.0	64.3	72.7	50.0
Leaf Height cm	5.7	5.6	7.6	5.4	6.6	5.4
Tallest Leaf cm	6.5	6.7	9.0	5.8	8.1	6.9
Nongrazed 1987-1989						
% Population	8.2	10.0	0.0	72.7	86.4	22.0
% Active Leaf	50.0	50.0	-	71.4	71.4	57.1
Leaf Height cm	7.8	7.7	-	8.3	5.5	9.0
Tallest Leaf cm	9.0	8.5	-	8.8	7.5	11.0

Discussion

Threadleaf sedge*, Carex filifolia,* is a native, long-lived perennial, cool season, short graminoid, monocot, of the sedge family that is abundant on healthy mixed grass prairie plant communities. Threadleaf sedge can grow on sandy, shallow, silty, and clay ecological sites and is drought resistant. Threadleaf sedge tillers live for two growing seasons; the first growing season as a vegetative tiller and the second season as a reproductive lead tiller. Early season activity starts by regreening with active chlorophyll the portions of the carryover leaves that have intact cell walls from the previous growing season vegetative tillers. The green portion of the carryover leaves provides large quantities of carbohydrates and energy for the production of new leaves. The chestnut brown bases of the carryover leaves persist on the reproductive lead tillers during the following growing season.

New leaf growth of threadleaf sedge started in early to mid April, leaf growth rate increased during May and June, and then become much slower during July. The tillers derived from carryover tillers that developed into reproductive lead tillers produced 2 basal whorls with 6 new leaves during May. Early flower stalk growth and development (FSD) began to swell around early to mid April. Early lead tillers progressed rapidly through head emergence (HE) during mid April to early June. Most lead tillers reached anthesis (Ant) during the 5 week flower period of early May to the first week of June. Flower culms produced no stalk leaves. No new basal leaves were produced after the anthesis stage. Seeds developed (SD) through the milk and dough stages during early May to mid June with most seeds reaching maturity (SBS) after mid June to early July. The basal whorls of leaves and the flower stalks of lead tillers dry rapidly during June and are completely senescent by mid July.

The vegetative tillers derived from the previous seasons fall tillers and the current seasons early spring initiated tillers produce 2 basal whorls with 6 new leaves rapidly. Vegetative tillers maintain 56.0% photosynthetically active leaves during June through August portion of the growing season. The basal whorls of vegetative tillers do not senesce during the growing season like the lead tillers.

Secondary tillers are derived from vegetative growth of rhizome tiller buds. The tillers that were initiated during the growing season were hormonally controlled by a dominated lead tiller that has proprietary access to all essential nutrients available to the secondary tillers. This arrangement had positive and negative affects. Most of the time, the secondary tillers have access to greater quantities of essential nutrients than a seedling would have, which ensures secondary tillers with superior survivability. Thus, a high percentage of secondary tillers live and grow for two growing seasons, and almost no seedlings develop into mature plants. However, during periods of water stress or other problematic conditions, lead tillers restrict nutrient flow to secondary tillers resulting in very slow rates of growth or tiller termination. During high water deficiency conditions growing seasons, secondary tillers can remain at the 2 or 3 leaf stage for a month or two. The quantity of secondary tillers increased 131.2% on the twice-over and increased 74.3% on the ungrazed treatment during the growing seasons with high water deficiency conditions (1987-1989). When secondary tillers produce their fourth leaf and start the second whorl, they have adequate leaf area to photosynthesize their own carbon energy and develop a large enough root system for self sustaining nutrient resource uptake.

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Literature Cited

Bluemle, J.P. 1977. The face of North Dakota: the geologic story. North Dakota Geological Survey. Ed. Series 11. 73p.

Bluemle, J.P. 1991. The face of North Dakota. Revised edition. North Dakota Geological Survey. Ed. Series 21. 177p.

Bluemle, J.P. 2000. The face of North Dakota. 3rd edition. North Dakota Geological Survey. Ed. Series 26. 206p. 1pl.

Dodds, D.L. 1979. Common grasses and sedges in North Dakota. NDSU Extension Service R-658. Fargo, ND.

Fenneman, N.M. 1931. Physiography of western United States. McGraw-Hill Book Company, New York, NY. 534p.

Fenneman, N.M. 1946. Physical divisions of the United States. USDI Geological Survey. Map.

Goetz, H. 1963. Growth and development of native range plants in the mixed prairie of western North Dakota. M. S. Thesis, North Dakota State University, Fargo, ND. 165p.

Great Plains Flora Association. 1986. Flora of the Great Plains. University of Kansas, Lawrence, KS.

Hauser A.S. 2006. Carex filifolia. Fire Effects Information System. USDA. Forest Service. http://www.fs.fed.us/database/feis/

Hunt, C.B. 1974. Natural regions of the United States and Canada. W.H. Freeman and Company, San Francisco, CA. 725p.

Johnson, J.R., and G.E. Larson. 2007. Grassland plants of South Dakota and the Northern Great Plains. South Dakota University. B 566 (rev.). Brookings, SD.

Manske, L.L. 1994. History and land use practices in the Little Missouri Badlands and western North Dakota. Proceedings-Leafy Spurge Strategic Planning Workshop. USDI National Park Service, Dickinson, ND. p. 3-16.

Manske, L.L. 2008a. Prehistorical conditions of rangelands in the Northern Plains. NDSU Dickinson Research Extension Center. Summary Range Management Report DREC 08-3015b. Dickinson, ND. 5p.

Manske, L.L. 2008b. Physiography, soil, and native vegetation of the Northern Plains. NDSU Dickinson Research Extension Center. Summary Range Management Report DREC 08-3048. Dickinson, ND. 28p.

Soil Survey Staff. 1975. Soil Taxonomy. Agriculture Handbook No. 436. USDA Soil Conservation Service. U.S. Government Printing Office, Washington, D.C. 754p.

Stevens, O.A. 1963. Handbook of North Dakota plants. North Dakota Institute for Regional Studies. Fargo, ND.

Whitman, W.C. c. 1950. Native range plants–their growth and development in relation to the establishment of standards for their proper utilization. Hatch Project 9-5.

Zaczkowski, N.K. 1972. Vascular flora of Billings, Bowman, Golden Valley, and Slope Counties, North Dakota. PhD. Thesis. North Dakota State University, Fargo, ND. 219 p.