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Defoliation Effects on Yield and Bud and Tiller Numbers of Two Sandhills Grasses

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Abstract

Intensive grazing strategies for the Nebraska Sandhills must be based on time and frequency of defoliation of key warm-season grasses. A 3-year field study was conducted in the Nebraska Sandhills to determine the effects of defoliation on yield and bud and tiller number of sand bluestem [*Andropogon gerardii* var. *paucipilus* (Nash) Fern.] and prairie sandreed [*Calamovilfa longifolia* (Hook.) Scribn.]. Defoliation (7 cm) treatments imposed on a 1.5 × 1-m plot were: a single defoliation on 10 June, 10 July, or 10 August; 2 successive defoliations on 10 June and 10 August; or 3 successive defoliations on 10 June, 10 July, and 10 August. All plots were harvested in October to obtain aftermath yield. Control plots were harvested only at the end of the growing season (October). Defoliation treatments were initiated in 1986, 1987, and 1988 on different plots and the effect of year of initiation as well as the effect of 3 successive years of repeated treatment (1986 plots) was evaluated. Annual dry matter (DM) yield, and bud and tiller numbers were measured. Following the initial year of treatment multiple defoliations increased yield of both grasses while bud and tiller numbers were similar to those of the control plants. After 3 years of repeated treatment, annual DM yield of sand bluestem for all defoliation treatments was lower than the control. A single defoliation of sand bluestem in August or a June–July–August defoliation reduced bud number compared to other treatments and the control. A June–August defoliation of prairie sandreed over a 3-year period increased annual DM yield compared to all treatments and the control although defoliation treatments reduced bud number. The optimum time and frequency of defoliation for annual DM yield and bud and tiller number was a single June or July defoliation for sand bluestem and a June–August defoliation for prairie sandreed.

Key Words: clipping frequency, forage yield, sand bluestem [*Andropogon gerardii* var. *paucipilus* (Nash) Fern.], prairie sandreed [*Calamovilfa longifolia* (Hook.) Scribn.].

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Growth and development of range grasses is influenced by time and frequency of defoliation. A single July defoliation of little bluestem [*Schizachyrium scoparium* (Michx.) Nash] in the Nebraska Sandhills was the optimum treatment for total dry matter (DM) yield, tiller weight and number, and bud number (Mullahey et al. 1990). Defoliation at early growth stages of bluebunch wheatgrass [*Pseudoroegneria spicata* subsp. *spicata* (Pursh) A. Love] (Stoddart et al. 1975) and blue grama [*Bouteloua gracilis* (H.B.K.) Lag. ex Steud.] (Turner and Klipple 1952) reduced forage yield less than later defoliations.

Herbage yields of unclipped western wheatgrass [*Pascopyrum smithii* (Rydb.) A. Love] were 60% higher than those of plants receiving multiple defoliations (Buwai and Trlica 1977). Multiple defoliations severely reduced total seasonal yield and tiller numbers of sand lovegrass [*Eragrostis trichodes* (Nutt.) Wood] compared to those of unclipped plants (Moser and Perry 1983). Additional studies have reported reduced herbage yields when clipping frequency was increased (Alberda 1957, Dwyer et al. 1963, Reed and Dwyer 1971). Frequent defoliation of warm-season grasses severely reduced root development, inhibited rhizome development, and reduced herbage yield compared to unclipped plants (Biswell and Weaver 1933). Butler and Briske (1988) reported that grazing large, individual little bluestem plants fragmented the clump into scattered plants with higher tiller density/unit of basal area.

The objectives of this study were to determine the initial effect of time and frequency of close defoliation within a growing season and the cumulative effect of 3 years of repeated defoliations on annual DM yield and bud and tiller numbers of sand bluestem [*Andropogon gerardii* var. *pauciplius* (Nash) Fern.] and prairie sandreed [*Calamovilfa longifolia* Hook.) Scribn.] growing in a community.

Materials and Methods

A field study was conducted at the Gudmundsen Sandhills Laboratory (GSL) near Whitman, Neb., during 1986 to 1988. The study site was on a Valentine fine sand (mixed, mesic Typic Ustipsamments) with a 30% south-facing slope in high-good range condition. The plant community consisted primarily of sand bluestem, prairie sandreed, schweinitzii flatsedge (*Cyperus schweinitzii* Torr.), and a composite of different forbs and other grasses such as sand lovegrass and little bluestem. Prior to this study, the area had not been grazed for 10 years.

The experimental area was divided into 4 replications. A criss-

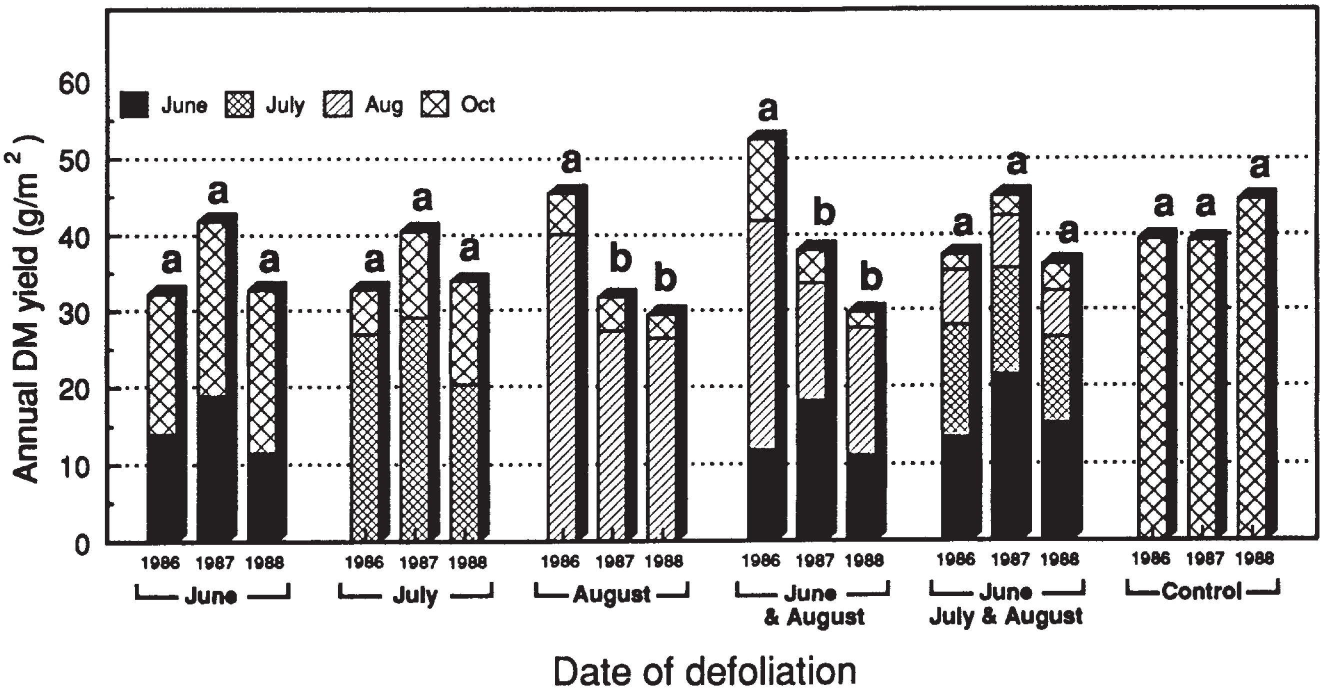

Fig. 1. Annual dry matter (DM) yield of sand bluestem for different defoliation dates for 3 successive years (1986–1988) of repeated defoliations at the Gudmundsen Sandhills Laboratory, Whitman, Nebraska. Bars within a defoliation scheme having the same letter are not significantly different (p>0.10) as determined by Fisher's F-protected L.S.D.

cross pattern was used for treatment delineation with appropriate alleys. Each replication was divided into thirds (1.5-m wide) parallel to the slope and year of initiation (1986, 1987, or 1988) was randomly assigned. The replication was also divided into sixths perpendicular to the slope. Six defoliation treatments were randomly assigned for each replication and were continuous strips across the year-of-initiation treatments (strip split block treatment arrangement) resulting in experimental units that were 1.5 × 1 m. Defoliation treatments were repeated on the 1986 plots in 1987 and 1988 to evaluate cumulative effect. Areas that did not receive a treatment in 1986 and/or 1987 were clipped at dormancy to remove aftermath. Defoliation treatments were: a single defoliation on either 10 June, 10 July, or 10 August; 2 successive defoliations on 10 June and 10 August; or 3 successive defoliations on 10 June, 10 July, and 10 August. Control plots were defoliated only at the end of the growing season (October). All plots were harvested for aftermath yield in October when plants were dormant. Annual DM yield within the defoliation treatments was the sum of growing season harvest(s) plus the October aftermath yield.

All grasses were clipped to 7 cm, schweinitzii flatsedge to 2 cm. Level of forb defoliation varied by species and both leaves and stems were clipped. Criteria for degree of defoliation were based on observations in intensively grazed pastures in May 1986. Plants were classified into 5 categories: sand bluestem, prairie sandreed, other grasses, schweinitzii flatsedge, or forbs. Clipped material was sorted and current year's growth was dried at 60° C for 48 hours to determine DM yield.

In October of each year the down-slope one-third of each plot (0.5 × 1 m) was excavated (40 cm depth) to remove roots, rhizomes, and tillers. Soil was replaced and sod removal had no visible impact on vegetation development of adjacent areas in subsequent years. Prairie sandreed and sand bluestem were separated, washed to remove soil, and buds and tillers were counted. Buds occurred either at rhizome nodes or at nodes on the base of a current year's tiller. Tillers of more than 2.5 cm in height (usually green) were defined as current year's growth. Buds comprised meristematic tissue less than 1 cm which had not differentiated into a rhizome or tiller.

Data were analyzed as a split block using the General Linear Models Procedure (SAS 1982) with treatments means separated using Fisher's F-protected L.S.D. Treatment means for year of initiation (1986, 1987, or 1988) were pooled over years if the year of initiation × defoliation treatment interaction was not significant. If the year of initiation × defoliation treatment interaction was significant, the effect of defoliation treatment was analyzed by year. The cumulative effect of defoliation treatments applied in 3 successive years (1986–1988 on 1986-initiated plots only) was analyzed in a similar manner. Differences among treatment means were declared significant at p<0.10.

Results and Discussion

Initial Year of Treatment

Sand Bluestem

A year of initiation × defoliation treatment interaction occurred for annual DM yield (Table 1). In 1986 and 1988 only the 2-defoliation treatment was higher in annual DM yield than the control. In 1987 the single June or July defoliation produced higher annual DM yields than the control although precipitation was generally below normal during June and July. The 1988 precipitation (530 mm) was above normal (480 mm) and mean annual DM yields from all defoliated plots generally were higher than those in control plots. However, only yields of the 2-defoliation treatment were significantly greater from those of the control. These results differed from Moser and Perry (1983), who reported total yield of grazing-sensitive sand lovegrass following 1 year of clipping was greatest for unclipped plants although plants clipped once were higher in yield than plants clipped 2 or 3 times. Vogel and Bjugstad (1968) found yield of little bluestem, big bluestem (*Andropogon gerardii* Vitman), and indiangrass [*Sorghastrum nutans* (L.) Nash] was highest for unclipped plants following 1 year compared to clipping at different times during the growing season. Our study area had not been grazed for 10 years before this study. Initial plant vigor may have allowed greater yield of defoliated plants in the first year of treatments than has been reported in the literature.

No significant year of initiation × defoliation treatment interac-

Table 1. Annual dry matter (DM) yield of sand bluestem and prairie sandreed for each year of defoliation initiation (1986, 1987, or 1988) at the Gudmundsen Sandhills Laboratory, Whitman, Nebraska.

Date of defoliation	Annual DM yield (g/m²) 1986	1987	1988
	Sand bluestem[1]		
Control	39.4b[2]	40.0b	55.1b
June	32.4b	60.3a	66.9ab
July	32.7b	57.9a	54.3b
Aug.	45.5ab	50.3ab	61.0ab
June, Aug.	52.2a	46.2ab	71.8a
June, July, Aug.	37.4ab	47.6ab	65.9ab
	Prairie sandreed[3]		
Control	34.7b	32.4b	26.1a
June	27.8b	32.7b	29.4a
July	38.0ab	47.2b	36.4a
Aug.	34.2b	43.2b	38.4a
June, Aug.	53.0a	71.0a	37.4a
June, July, Aug.	36.7ab	65.9a	31.0a

[1]Year of initiation × defoliation treatment interaction significant ($p<0.10$).
[2]Numbers in a column with the same letter are not significantly different at the 0.10 level as determined by Fisher's F-protected L.S.D.
[3]Year of initiation × defoliation treatment interaction not significant ($p>0.10$).

tion occurred for bud and tiller number. There was no treatment effect on bud numbers during the first year. Bud number averaged over treatments in 1986 (256/m²) was lower than in 1987 (537/m²) or 1988 (520/m²) with no difference between 1987 and 1988. Precipitation during the growing season was higher in 1987 (313 mm) and 1988 (530 mm), which could explain the large number of buds compared to 1986 (202 mm). Additionally, lower precipitation in June and July of 1986 (61.0 and 14.7 mm, respectively), when sand bluestem initiated buds (Brejda et al. 1989), may have reduced bud numbers in 1986. Tiller number was not different among treatments. Tiller number for all treatments in 1986 (57/m²) was significantly lower than in 1987 (96/m²) or 1988 (102/m²), which followed the same trend as bud number and precipitation pattern.

Prairie Sandreed

Annual DM yield of prairie sandreed was generally higher for multiple defoliations (Table 1). Annual DM yield for 1986, 1987 and 1988, averaged over all treatments, was variable (37.3, 48.7, and 33.1 g/m², respectively) with 1987 being different from 1988. Differences among years were partially related to increasing precipitation from 1986 to 1988. However, 1988 yields were lower than in 1986 even though precipitation was greater, unlike sand bluestem. Below-normal precipitation in August and September of 1988 contributed to reduced aftermath yields of the single August defoliation treatment, the control, and the multiple defoliation treatments compared to the same treatments in 1986 and 1987.

There was no year of initiation × defoliation treatment interaction for bud and tiller number. Bud number was not different among treatments including the control. Differences among years (1986, 1987, or 1988) were significant with bud number in 1986 (259/m²) lower than in 1987 (537/m²) or in 1988 (520/m²). Lower precipitation prior to May and June of 1986, when prairie sandreed initiated buds and rhizomes (Brejda et al. 1989), may explain lower bud numbers in 1986. Tiller number was not different among defoliation treatments nor among years of initiation.

Cumulative Effect of 3 Successive Years of Treatment

Sand Bluestem

A year × defoliation treatment interaction occurred for annual DM yield for plots initially treated in 1986 with treatments repeated in 1987 and 1988 (Fig. 1). Annual DM yield in the third year (1988) of defoliation was reduced by 2 defoliations and a single August defoliation compared to the control. Annual DM yield from 3 defoliations and a single June or July defoliation was similar to the control. Comparing the 2- and 3-defoliation treatments, the August yield was greater for the 2-defoliation treatment but the additional harvest in July increased annual yield for the 3-defoliation treatment. Defoliating once in August reduced yield after 3 years whereas a single defoliation in June or July produced similar yields in year 1 and 3 (Fig. 1). Following 3 years of defoliation, a single June or July defoliation and a 3-defoliation treatment were similar to the control in annual DM yield. Similar annual DM yields between defoliated and control plants were not observed for little bluestem (Mullahey et al. 1990), big bluestem, and indiangrass (Vogel and Bjugstad 1968). Sand lovegrass clipped 3 times a year had died by the second year (Moser and Perry 1983).

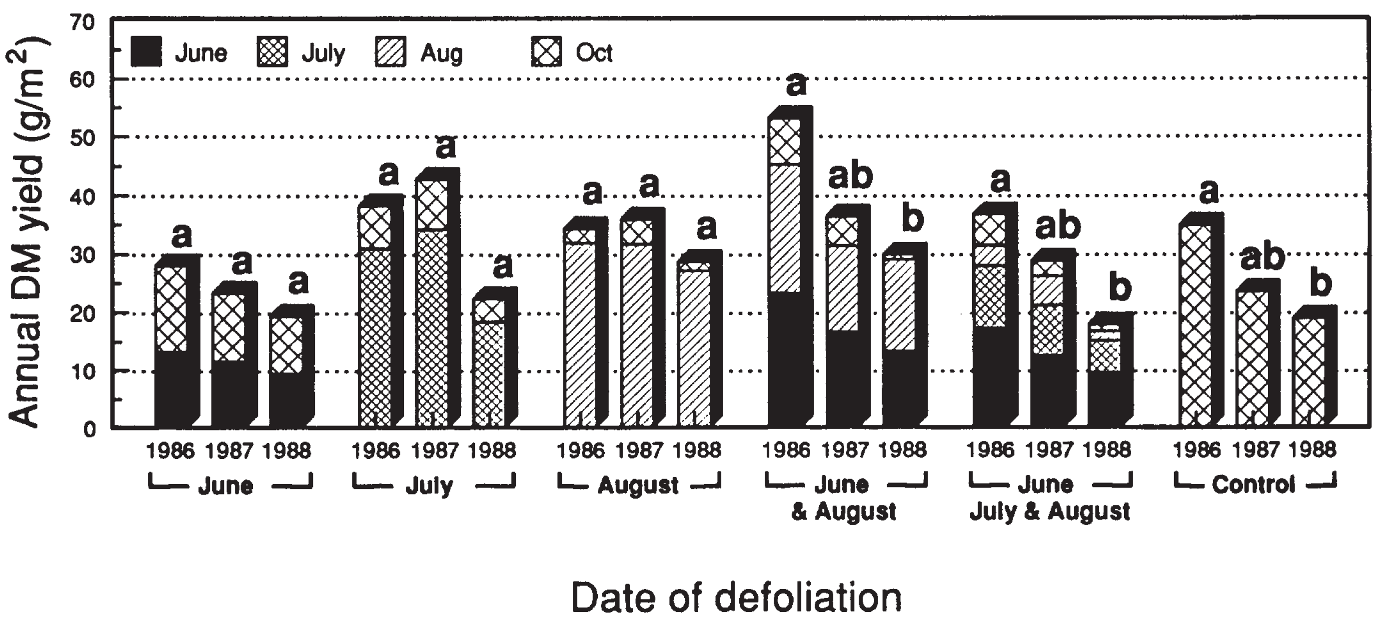

Fig. 2. Annual dry matter (DM) yield of prairie sandreed for different defoliation dates for 3 successive years (1986–1988) of repeated defoliations at the Gudmundsen Sandhills Laboratory, Whitman, Nebraska. Bars within a defoliation scheme having the same letter are not significantly ($p>0.10$) as determined by Fisher's F-protected L.S.D.

Bud and tiller numbers were averaged over years since there were no year × treatment interactions. A single clipping in August or 3 defoliations (June, July, and August) significantly reduced bud number compared with all other treatments and the control (Table 2). Two defoliations (June and August) did not have a detrimental impact on bud number relative to the control. However, bud number (year 1 to year 3) from 2 defoliations generally declined. This pattern, projected beyond 3 years, suggested that 2 defoliations would reduce bud number. Buds on control plants were larger than those on plants defoliated more than once. The number of newly initiated tillers (buds) of sand lovegrass was severely reduced by all clippings (1 to 3 times) compared to unclipped plants after 3 years of treatment (Moser and Perry 1983).

Table 2. Bud and tiller number of sand bluestem and prairie sandreed on plots with treatment initiated in 1986 averaged over a 3-year period (1986 to 1988) of repeated defoliation at the Gudmundsen Sandhills Laboratory, Whitman, Nebraska.

Date of defoliation[1]	Sand bluestem Buds	Sand bluestem Tillers	Prairie sandreed Buds	Prairie sandreed Tillers
	no./m²		no./m²	
Control	413a[2]	79a	101a	75bc
June	365a	92a	52c	56c
July	382a	77a	60bc	88ab
Aug.	248b	70a	57c	97ab
June, Aug.	396a	73a	75b	98a
June, July, Aug.	252b	67a	66bc	85ab

[1]Year × treatment interaction not significant ($p>0.10$).
[2]Numbers in a column with the same letter are not significantly different at the 0.10 level as determined by Fisher's F-protected L.S.D.

Following 3 years of treatment there was no difference in tiller number between the treatments and control plants. Three defoliations or a single August defoliation had the lowest mean tiller count. A single June or July defoliation appeared to be the most beneficial. Prior to culm elongation, tiller replacement in crested wheatgrass [*Agropyron desertorum* (Fisch.) Schult.] was not affected by heavy grazing (Olson and Richards 1988a). However, heavy grazing during or after culm elongation increased winterkill of fall-produced tillers. Tussocks grazed twice within the spring grazing season generally had lower overwinter tiller mortality and greater tiller replacement than tussocks grazed only once in late spring. Heavy grazing during or after culm elongation did not allow for maintenance of the crested wheatgrass tussocks. Olson and Richards (1988b) indicated that grazing rarely affected the number of replacement tillers/progenitor in crested wheatgrass tussocks. Considering annual yield, bud and tiller numbers, the single defoliations in June or July were the optimum treatment. Apparently, 3 years was not long enough for reduced bud number to affect yield.

Prairie Sandreed

Generally annual DM yield declined for all defoliation treatments over the 3-year period (Fig. 2). The same pattern was true for the control plots indicating an environmental influence since there was no significant year × defoliation treatment interaction. Two defoliations produced the highest annual DM yield and it was different from 3 defoliations, a single June defoliation, a single August defoliation and the control when averaged over years. A single June defoliation was lower in annual DM yield (including end-of-season yield) than a single defoliation in July or August. All treatments harvested during the growing season produced more than the control except for the single June defoliation. Defoliation of prairie sandreed generally increased DM yield compared to the control while all defoliation treatments reduced sand bluestem yields compared to the control. Multiple defoliations (2 or 3) and a single June defoliation produced declining trends in yield over the 3 years (Fig. 2).

Bud number, averaged over all 3 years of treatment, for control plants was higher than for all treated plants (Table 2). Bud number was highest for the June–August defoliation treatment while plants with single June defoliation had the fewest number of buds. This pattern was consistent with yield data. Since prairie sandreed has a biennial tiller (Brejda et al. 1989), it began growth in early May and was susceptible to all defoliation treatments. In contrast, sand bluestem bud number was less affected by defoliation treatment since it initiated growth later and had fewer elongated tillers during the growing season. The relative abundance of buds varied by species, primarily resulting from a large number of axillary buds on sand bluestem rhizomes as an adaptation to burial (Brejda et al. 1989).

Influence of defoliation on tiller number was variable (Table 2). Date of defoliation did not have as much impact on sand bluestem tiller number as on prairie sandreed because most sand bluestem tillers were unelongated, resulting in the removal of very few shoot apices. Defoliation treatments of prairie sandreed that were clipped after June had the highest number of tillers and were significantly different from the single June defoliation (56/m²). There was no removal of shoot apices with the single June defoliation or control. Removal of shoot apices with later defoliations may have stimulated additional tiller development. Caucasian bluestem [*Bothrichloa caucasia* (Trin.) C.E. Hubb.] pastures that were heavily grazed from mid-May until late September produced more tillers per unit area than lightly grazed pastures (Christiansen and Svejcar 1988). In contrast Olson and Richards (1988c), found that grazing during culm elongation reduced relative tiller growth rates, but stimulated the growth of axillary tillers of crested wheatgrass. Grazing after tiller elongation did not stimulate axillary tiller production. Yield per tiller in this study was not greatly affected by defoliation treatment since yield at the end of 3 years of treatment was closely related to the average tiller number.

Annual Forage Yield

Three continuous years of defoliation significantly reduced annual plot yield (yield of all species in the plot for growing season plus end-of-season yields) for both multiple defoliation treatments and a single August defoliation. In the first year, all treatments resulted in higher annual plot yield than the control. By the third year, yield from control plots was highest followed by a single June or July defoliation. Multiple defoliations within a growing season reduced annual plot yield over time, resulting in the lowest annual yield of all treatments by the third year.

Conclusion

The effects of biomass removal on plant growth and development of sand bluestem and prairie sandreed are dependent upon time and frequency of defoliation within a growing season and the number of successive growing seasons with repeated treatment. Following the year of treatment initiation, bud and tiller number of defoliated plants were similar to those of the control; however, increased annual yield was generally favored by multiple defoliations. Although the magnitude of the response may be influenced by precipitation, 1 year of close, multiple defoliation should not reduce plant yield, bud and tiller number. Following 3 years of defoliation, a single defoliation in June or July optimized the yield and bud and tiller number of sand bluestem, whereas 2 defoliations (June and August) optimized the variables for prairie sandreed. Defoliating sand bluestem 3 times a season or a single August defoliation severely reduced bud number while a single June defoliation of prairie sandreed greatly reduced bud and tiller number. Grazing prairie sandreed in June would benefit a desirable species like sand bluestem while reducing bud number of prairie sandreed.

The vegetation responded favorably to close multiple defoliations in the first year with increased yield and relatively stable bud and tiller number compared to the control. However, the increased yield was not sustained and multiple defoliations resulted in the lowest annual plot yields after 3 successive years of treatment.

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