Above-ground Biomass and Nitrogen Quantities in a Big Sacaton [*Sporobolus wrightii*] Grassland

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Abstract

Live and standing dead biomass, standing crop, and total nitrogen, within each component, were measured in a big sacaton (*Sporobolus wrightii* Monro) grassland in southeastern Arizona for 3 years to determine annual fluctuations in above-ground biomass and nitrogen. Mean live biomass varied from 150 kg/ha in February to 2,000 kg/ha in August. Standing dead biomass accumulated after the summer growing season and rapidly disappeared following either fall, winter, or summer moisture, but was the predominant vegetative component for about 49 weeks of each year. Standing crop (live plus standing dead) was greatest in August and averaged 4,450 kg/ha. Total nitrogen varied from 2 to 31 kg/ha in live biomass, from 5 to 15 kg/ha in standing dead biomass, and from 9 to 40 kg/ha in standing crop. The rapid disappearance of standing dead suggests that stocking rates should be based on standing crop just prior to the grazing period rather than peak standing crop after the summer growing season.

Big sacaton (*Sporobolus wrightii* Monro) grasslands produce abundant forage in summer (Gavin 1982) and pure stands once existed along the channels and tributaries associated with the San Pedro and Santa Cruz Rivers in southeastern Arizona (Griffiths 1901). These grasslands, which are located on low alluvial flats or flood plains (Wooten and Standley 1912), naturally spread flood waters, trapped sediments (Hubbell and Gardner 1950), limited soil erosion (Humphrey 1958), and provided a forage resource for one million cattle before 1890 (Cox et al. 1983).

Range managers and researchers have assumed for more than 100 years that the standing dead biomass of big sacaton disappears slowly, and this assumption has been used to justify the need for burning and mowing. Data to support this slow disappearance hypothesis is not available in the literature. Some work has been reported on the response of big sacaton following burning (Bock and Bock 1978) and mowing (Haferkamp 1982). However, information on the cycling of above-ground biomass and nitrogen in undisturbed big sacaton grasslands is currently unavailable.

The objectives of this study were to (1) investigate the seasonal dynamics of live and standing dead biomass and nitrogen of big sacaton grasslands under natural conditions, and (2) to interpret biomass and nitrogen dynamics in relation to annual climate.

Site Description

A study site representative of the big sacaton grasslands in southern Arizona, western New Mexico, west Texas, and northern Chihuahua (Soil Conservation Service 1979) was selected about 80 km south of Tucson in southeastern Arizona (31° 47′ N lat., 110° 37′ W long.) at an elevation of 1,370 m. The soil is a Pima silty clay loam, with a sandy loam subsoil (thermic Typic Haplustoll) (Richardson et al. 1979). These soils are recent alluvium, weathered from mixed rocks, moderately alkaline, slightly calcareous and greater than 2 m in depth. The site was in a flood plain with slopes of only 1 to 2%.

Big sacaton was the dominant vegetation. Other perennial grasses infrequently encountered were alkali sacaton [*Sporobolus airoides* (Torr.) Torr.], blue grama [*Bouteloua gracilis* (Willd. ex H.B.K.) Lag. ex Griffiths], and vine mesquite (*Panicum obtusum* H.B.K.). The study site was 50 m from a drainage channel. Several large mesquite [*Prosopsis juliflora* (SW.) DC.] trees were either within or near the site.

Total annual precipitation in the area has varied from 175 to 450 mm in the past 50 years (Sellers and Hill 1974). Approximately 60% of the annual precipitation occurs in summer (July–September) when mean daily air temperatures are above 30° C; and the remaining 40% usually comes in winter (December-February) when night-time air temperatures are frequently below 0° C. Fall (October–November) and spring (March–June) are cool, dry and windy.

Methods and Materials

A 2-ha study site was fenced to exclude livestock. Nine, 15 × 15 m plots were established in February 1980. Three plots were randomly selected and sampled every 6 weeks between 17 April 1980 and 6 February 1981. Three additional plots were selected and sampled on the same dates between 17 April 1981 and 6 February 1982. The remaining 3 plots were sampled between 17 April 1982 and 6 February 1983. Experimental design was a randomized block with 3 replications each year and sampling over 3 years.

Twenty, 0.3 × 2.9-m sampling areas were randomly located within each plot at each sampling date; no sampling area was sampled more than once. Big sacaton plants in 4 sampling areas were harvested at the soil surface and hand separated into live (green) and standing dead biomass (yellow and gray) components. Each measured component was weighed in the field and a modified weight-estimate technique was used to estimate both live and standing dead biomass components in the remaining 16 sampling areas (Pechanec and Pickford 1937). Harvested samples were dried in a forced-draft oven at 40° C for 48 hours. Regression techniques were used to correlate actual dry weights with estimated field weights (Campbell and Cassady 1949). These values were used to calculate biomass (kg/ha) for each vegetative component. Values were rounded to the nearest 50 kg/ha.

Initially, litter on the soil surface was to be collected in each of the harvested sampling areas at each sampling date. This practice was discontinued after 18 sampling dates because very little litter (less than 3% of the standing crop) accumulated on the soil surface between plants.

Dry plant samples of either live or standing dead biomass were composited for each plot and ground over a 40-mesh screen. Samples were thoroughly mixed and a sub-sample digested and analyzed for total nitrogen using a Technicon®[1] digestor and a continuous flow auto-analyzer (Schuman et al. 1973). Total nitrogen concentration (μg/g) of the component was multiplied by the calculated biomass (kg/ha) amount and rounded to the nearest 1 kg/ha.

Precipitation was recorded with a MRI®[1] mechanical weather station. Daily precipitation was accumulated for all dates between individual harvests (Fig. 1).

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[1]The mention of a commercial product is for the reader's convenience and does not imply endorsement by the USDA, Agricultural Research Service.

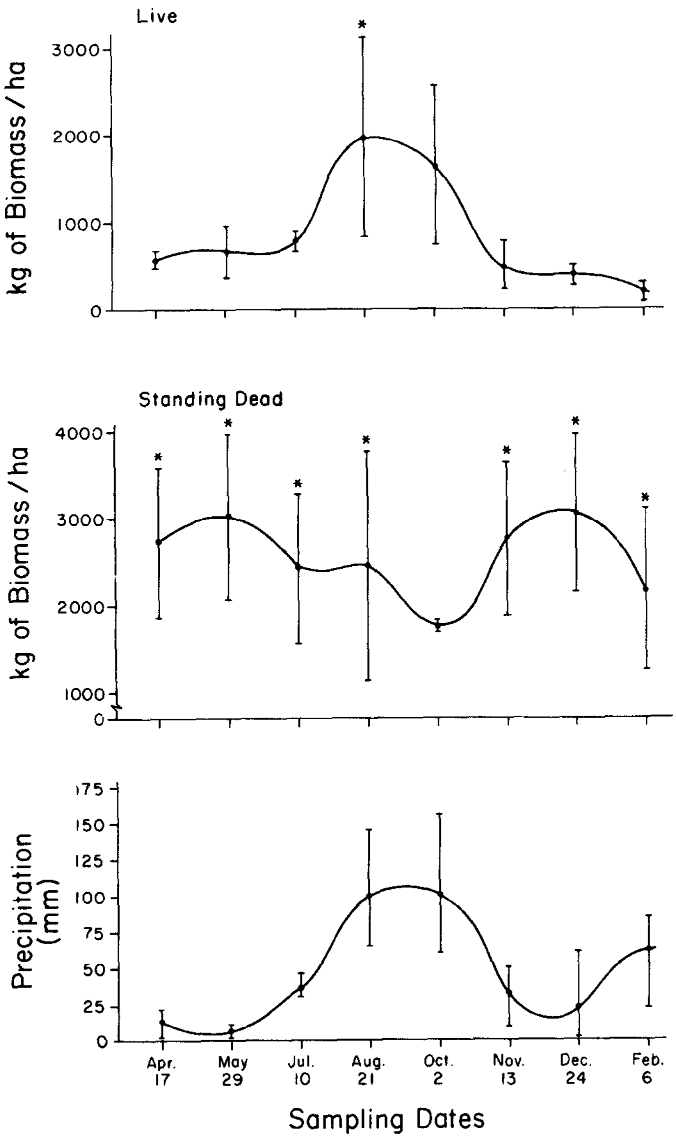

Fig. 1. *Three-year means and standard errors (kg/ha) for live biomass, standing dead biomass and precipitation (mm) at 8 annual sampling dates for a big sacaton grassland in southeastern Arizona. An asterisk (*) above the standard error notation indicates a significant difference (∝ = 0.05) among years at the same sampling date. Daily precipitation amounts were accumulated for the 6 weeks prior to sampling.*

Biomass and total nitrogen within each measured component at the same date were compared among years by analyses of variance. When *F* values were significant (∝ = 0.05) a Duncan's new multiple range test was used to separate means (Steel and Torrie 1960).

Results and Discussion

Live Biomass

The amounts of live biomass were different (∝ = 0.05) at the August sampling dates and similar at the remaining sampling dates over the 3 years (Fig. 1). Summer thunderstorms began in early July and most of August was dry in 1980 and 1982, whereas thunderstorms began in mid July and occurred regularly through August 1981. As a result, live biomass was 2 to 3 times greater in August 1981 (3,250 kg/ha) as compared to August 1980 (1,600 kg/ha) and August 1982 (1,100 kg/ha).

Peak live biomass at a big sacaton grassland site in west Texas was 2,650 kg/ha and the peak occurred in August (Gavin 1982). The peak in live biomass measured in west Texas is within the values obtained in southeastern Arizona, but 25% greater than the 3-year average (1,980 kg/ha).

Standing Dead

The amounts of standing dead were similar (∝ = 0.05) at the October sampling dates and averaged about 1,750 kg/ha over the 3 years (Fig. 1). There was significant (∝ = 0.05) variation in the amounts of standing dead at the remaining sampling dates over the 3 years.

Standing dead averaged 3,200 kg/ha during the dry spring and early summer of 1980. About 50% disappeared between August and October, but a similar amount accumulated from the live component in November. Approximately 45% of the amount that accumulated in fall 1980 disappeared following 3 snowstorms in January 1981.

Standing dead averaged 1,750 kg/ha during the spring and early summer of 1981, and about 40% disappeared following 145 mm precipitation between 10 July and 21 August. Standing dead began to accumulate in fall, and the total amount on 24 December was about 350% greater than on 21 August.

Standing dead averaged 3,500 kg/ha during the dry winter and spring of 1981-82. Approximately 25% disappeared in early summer when thunderstorms began, and an additional 25% disappeared in late summer when the thunderstorm activity resumed. Cool-season precipitation in November and December was 110 mm and standing dead averaged 2,350 kg/ha. This amount is about 1,000 kg/ha less than on the same dates in 1980 and 1981 when precipitation was 20 and 40 mm, respectively. Approximately 36% of standing dead present in December 1982 had disappeared following 3 snowstorms in January and 1 snowstorm in early February 1983.

Standing Crop

Standing crop, the sum of the live and standing dead components, averaged 2,350 kg/ha in February and 4,450 kg/ha in August over 3 years (Fig. 1). The percent of the live component within the standing crop was less than 50% at all sampling dates except two, 21 August and 2 October 1981.

Peak standing crops varied from 3,900 kg/ha in August 1982 to 5,150 kg/ha in August 1980. Peak standing crop of big sacaton was 4,600 kg/ha in southcentral Texas (Haferkamp 1982) and 4,350 kg/ha in west Texas (Gavin 1982). Peak standing crop of 10 North American ungrazed temperate mid- and tall-grass prairies averaged 2,350 kg/ha and ranged from 550 to 5,250 kg/ha (Sims and Singh 1978). Peak standing crops of big sacaton stands in southeastern Arizona and Texas are generally equivalent, and appear to be intermediate between the temperate mid- and tall-grass prairies.

Nitrogen Quantities

Average N present in live above-ground biomass varied from 2 to 31 kg/ha over 3 years (Fig. 2). Live biomass in August 1981 contained 75% more N than live biomass in August 1980 and 1982. Total N was generally greater in live biomass in August 1980 and 1982. Total N was generally greater, but not significantly (∝ = 0.05) at the April, May and July 1981 sampling dates as compared to the same dates in 1980 and 1982.

Quantities of N in standing dead varied from 7 kg/ha in February 1983 to 15 kg/ha in November 1981 and May 1982 (Fig. 1). Total N in standing dead was similar at the same date over the 3 years. Summer precipitation does promote the disappearance of standing dead biomass and the leaching of N from the remaining standing dead. However, the rapid disappearance of standing dead in August and October and the corresponding rapid accumulation of standing dead in November and December makes it difficult to establish meaningful relationships between summer precipitation and quantities of N in live and standing dead biomass.

Mean N quantities in standing crop varied from 11 kg/ha in February to 33 kg/ha in August over the 3 years (Fig. 2). More

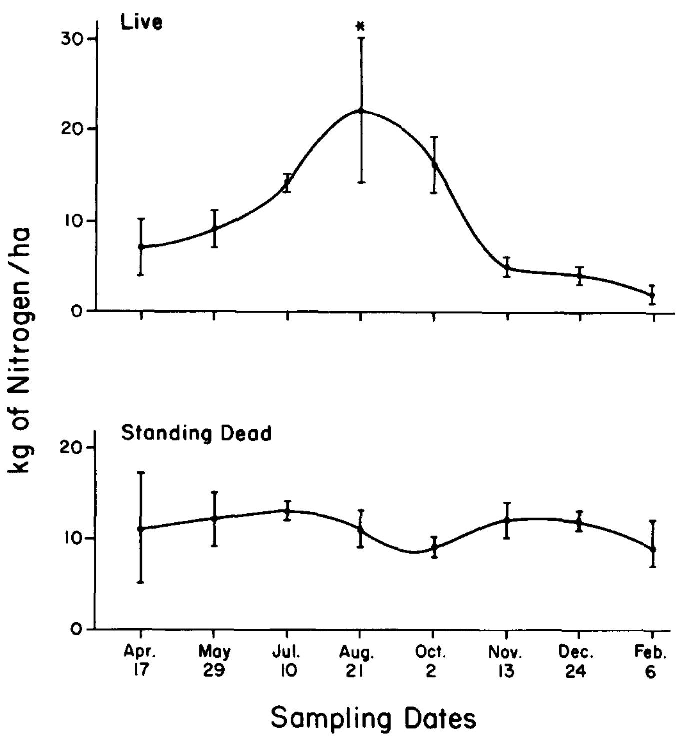

Fig. 2. *Three-year means and standard errors for nitrogen (kg/ha) in live and standing dead biomass at 8 annual sampling dates for a big sacaton grassland in southeastern Arizona. An asterisk (*) above the standard error notation indicates a significant difference (α = 0.05) among years at the same sampling date.*

than 60% of the N in the standing crop was distributed in the live component in July, August, and October in 1980 and 1981, and in August and October in 1982, whereas, the majority of N was distributed in the standing dead component during the remainder of the year.

The presented data clearly show that standing dead big sacaton biomass will rapidly disappear following precipitation in either fall, winter, or summer. These data do not support the commonly accepted belief that standing dead biomass disappears slowly under natural conditions (Griffiths 1901, Humphrey 1960). However, the logic which contributed to this belief is easily understood. Standing dead biomass is the predominant vegetation component within big sacaton grasslands for about 49 weeks of each year, and even though standing dead does disappear after precipitation, it does not accumulate on the soil surface between plants. Therefore, open areas between plants are litter-free for the majority of each year and this would suggest a gradual breakdown. Observations made during this 3-year study suggest that most standing dead biomass falls into the plant interior and is trapped within the remaining standing dead.

As standing dead disappears following either fall or winter moisture, litter accumulates within the remaining standing dead. This litter source may serve as an important N reserve which becomes quickly available for plant growth in summer through the processes of decay, nitrogen mineralization and nitrification (Sharrow and Wright 1977). The entrapment of N within the remaining standing dead probaby reduces N losses associated with flooding.

There are many problems associated with attempts to relate plant production and stocking rates. However, one specific problem becomes very apparent if standing crop, grazing period and cool-season moisture are collectively viewed, and the implications expressed in stocking rates. Ranchers normally set stocking rates based on the standing crop present in October, and big sacaton grasslands are grazed in the following spring and early summer (March to June). If cool-season precipitation in the form of snow occurs from November to February, standing crop may decline by 40% before the initiation of grazing, as in 1980-81 and 1982-83 (Table 1). Under such conditions stocking rates might well be 2 times greater than the forage base would support over the selected grazing period. However, if cool-season precipitation occurs in October and November through January is dry, then standing crop may decline by only 13%, as in 1981-82. Under this condition stocking rates based on October standing crop would be similar to stocking rates based on February standing crop.

Table 1. The amounts of precipitation (mm) between October 2, and February 6, and standing crops (kg/ha) of big sacaton sampled on October 2, 1980-82 and February 6, 1981-83.

Year	Precipitation (mm)	Standing Crop (kg/ha)	
		October 2	February 6
1980-81	105	3200	1900
1981-82	60	3950	3450
1982-83	195	2950	1700

Conclusions

The results of this study would suggest that: (1) live biomass is present throughout the year in big sacaton stands but peak production corresponds to July–September precipitation; (2) standing dead biomass peaks 60 to 90 days following the summer peak in live biomass; and (3) standing crop may decline by 40% following the occurrence of cool-season moisture. The occurrence of cool-season moisture is common in southeastern Arizona and ranchers should be aware that spring stocking rates based on standing crop in October will need to be reduced following wet winters. Conversely, cool-season moisture is uncommon in southern New Mexico, west Texas, and northern Mexico and stocking rates based on standing crop in October will be similar to standing rates based on stocking crop in February.

Literature Cited

Bock, C.E., and J.H. Bock. 1978. Response of birds, small mammals, and vegetation to burning sacaton grasslands in southeastern Arizona. J. Range Manage. 31:296-300.

Campbell, J.B., and J.T. Cassady. 1949. Determining forage weight on Southern forest ranges. J. Range Manage. 2:30-32.

Cox, J.R. 1984. Shoot production and biomass transfer of Big Sacaton *(Sporobolus wrightii).* J. Range Manage. 37:377-380.

Cox, J.R., H.L. Morton, J.T. LaBaume, and K.G. Renard. 1983. Reviving Arizona's rangelands. J. Soil and Water Conserv. 38:342-345.

Gavin, T.M. 1982. The effects of prescribed fire on the production, utilization and nutritional value of sacaton in Brewster County, Texas. M.S. Thesis. Sul Ross State Univ., Alpine.

Griffiths, D. 1901. Range improvement in Arizona. USDA-Bureau of Plant Industry. Bull. 4.

Haferkamp, M.R. 1982. Defoliation impacts on quality and quantity of forage harvested from big sacaton (*Sporobolus wrightii* Monro). J. Range Manage. 35:26-31.

Hubbell, D.S., and J.L. Gardner. 1950. Effects of diverting sediment-laden runoff to range and croplands. USDA Tech. Bull. No. 1012.

Humphrey, R.R. 1958. The desert grassland. Bot. Rev. 24:193-253.

Humphrey, R.R. 1960. Arizona range grasses. Arizona Agr. Exp. Sta. Bull. 298.

Pechanec, J.F., and G.D. Pickford. 1937. A weight estimate method for determination of range or pasture production. J. Amer. Soc. Agron. 29:894-904.

Richardson, M.L., G.D. Clemmons, and J.C. Walker. 1979. Soil survey of Santa Cruz and parts of Cochise and Pima Counties, Arizona. Nat. Coop. Soil Sur., USDA-Soil Conservation Serv., Forest Serv. and Arizona Agr. Exp. Sta. Washington, D.C.

Schuman, G.E., M.A. Standley, and D. Knudsen. 1973. Automated total nitrogen analysis of soil and plant samples. Soil Sci. Soc. Amer. Proc. 37:480-481.

Sellers, W.D., and R.H. Hill. 1974. Arizona climate (1931-1972). Univ. Arizona Press, Tucson.

Sharrow, S.H., and H.A. Wright. 1977. Proper burning intervals for tobosagrass in West Texas based on nitrogen dynamics. J. Range Manage. 30:343-346.

Sims, P.L., and J.S. Singh. 1978. The structure and function of ten North American grasslands. III. Net primary production, turnover and efficiencies of energy capture and water use. J. Ecology 66:573-597.

Soil Conservation Service. 1979. Planting Guide. *In:* USDA-Soil Conservation Serv., National Plant Materials Handbook.

Steel, R.G.D., and J.H. Torrie. 1960. Principles and procedures of statistics. McGraw-Hill Book Co., Inc. New York.

Wooten, E.O., and P.C. Standley. 1912. The grasses and grass-like plants of New Mexico. New Mexico Agr. Exp. Sta. Bull. 81.