Seasonal Trends in Herbage and Nutrient Production of Important Sandhill Grasses[1]

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Highlight

Aboveground biomass and nutrient production of important grasses were estimated on two range sites in the eastern Colorado sandhills. Apparent seasonal net production of blue grama and western wheatgrass on the sandy plains site was 144 g/m² compared to 90 g/m² for blue grama, prairie sandreed, and needleandthread grasses on the deep-sand range site. Production rates for the grasses studied were 1.8 and 0.8 g/m²/day for the sandy plains and deep-sand range sites, respectively. Herbage biomass decline 28% from the peak standing crop to fall (October 2) on both sites. During the late summer and winter months the biomass declined 50% on the deep-sand site and 35% on the sandy plains site. The sandy plains site produced a larger amount of crude protein than the deep-sand range site. This was accounted for by a larger herbage biomass and a higher percentage of crude protein in grasses grown on the sandy plains site. This more productive site appears to retain more herbage of higher nutritive value throughout the winter than the deep-sand site.

Knowledge of nutrient cycling and energy flow in grassland ecosystems is essential for efficiently utilizing this valuable and renewable resource. Optimal use of the primary producers depends on accurate understanding of the amount and dynamics of herbage biomass and nutrient production. Knowledge of seasonal dynamics of primary producers is the first step in understanding nutrient cycling and energy flow. This paper reports a study of the biomass and nutrient production of important grasses on two range sites in northeastern Colorado.

Water, protein, crude fiber, carbohydrates (nitrogen-free-extract), crude fat, and minerals (ash) are important components of herbage biomass. The magnitudes of these components, their interrelationships, and their availability influence the nutrient flow to the consumers. Generally, moisture, protein, carbohydrates, and many of the minerals are positively correlated to each other; and these factors are negatively correlated to the fibrous and ligneous plant constituents (Sullivan and Garber, 1947; Cook and Harris, 1968). Similarly, nutrient components positively correlated with moisture usually comprise a higher percentage of the plants during early phenological stages. As plants mature and the fibrous and ligneous constituents increase, forage digestibility decreases (Cook and Harris, 1968).

Experimental Area and Procedures

Field work was conducted at the Eastern Colorado Range Station, midway between Akron and Sterling, Colorado. The azonal soils are highly permeable to water, and the topography varies from a dune type with no apparent drainage pattern ("deep-sand" range sites) to a more nearly level topography with defined drainage patterns ("sandy plains" range sites).

The soils on deep-sand range sites are loamy sand or sand at the surface with deep sandy subsoils. Moisture penetration is rapid and deep, and the moisture is readily available to plants. Field capacity is low, but the site is still favorable to tall, deep-rooted species. On the sandy plains sites, the surface soil textures are sandy loam or loamy sands. The subsoil is sandy loam, and the parent material is loamy sand or sand. Moisture intake and storage are fair to good. The sandy plains sites are generally transitional areas between the sandhills and heavier-textured soils.

The primary grasses on the deep-sand range site are prairie sandreed (*Calamovilfa longifolia* Hack.),[3] blue grama (*Bouteloua gracilis* Lag.), and needleandthread (*Stipa comata* L.), a cool-season species. The two warm-season grasses, prairie sandreed and blue grama, grow in close mixture in certain areas; and in other areas they grow in separate patches. The sandy plains range site favors blue grama and a cool season grass, western wheatgrass (*Agropyron smithii* Gaertn.), to the exclusion of prairie sandreed (Lovell, 1960).

Northeastern Colorado's climate is semi-arid, with a mean annual precipitation of 38 cm (15 inches). Most of this comes as rain during the frost-free period, about May 20 to October 20. During this study 26.7 cm (10.5 inches) of rain and 6.6 cm (2.6 inches) of snow occurred.

Two half-acre exclosures were established, with one located on a deep-sand range site and one on a sandy plains range site. Prior treatment for both exclosures consisted of summer and winter grazing at about 22 acres per animal unit month for the previous five years. This was a light to moderate stocking rate during most years, and the range condition on both sites was good and improving (Eastern Colorado Range Station, unpublished data). In each exclosure 15 groups of randomly selected plots (50 plots per group) were assigned sampling dates. Plot size was .49 × .91 m

[1] This research was supported by the Colorado State University Experiment Station and is published with the approval of the Director as Scientific Series Paper Number 1503. Received January 31, 1970; accepted for publication June 26, 1970.

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[3] Botanical nomenclature follows Harrington (1954).

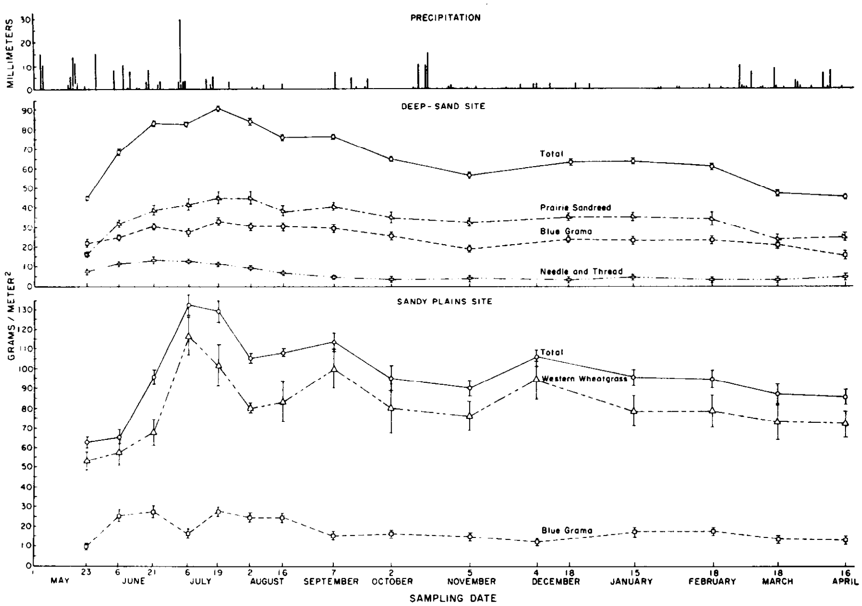

FIG. 1. Seasonal standing crop dynamics of important grasses on two range sites in northeastern Colorado, May 1, 1960 to April 16, 1961.

(1.6 × 3 feet). Clippings were made to near ground level on 15 dates, biweekly May through August, 1960, and monthly September 1960 through April 1961. The preceding year's growth, distinguished by its weathered and faded appearance, was discarded from the sample. Only the important grasses on each site were separated from each sample plot and weighed. Total herbage biomass was not measured. All data were converted to g/m². Blue grama, prairie sandreed, and needleandthread were the important grasses for the deep-sand range site. Western wheatgrass and blue grama were the important grasses on the sandy plains range site.

One composite grass sample for each species at each date was ground through a 1 mm screen and analysed for crude protein (N × 6.25), ether extract, ash, and crude fiber by Industrial Laboratories Company, Denver, Colorado. Nitrogen-free-extract was calculated by difference.

Results and Discussion

Net Primary Production

Deep-sand range site.

The primary grasses on this site reached a peak standing crop of about 90 g/m² in mid-July, 1960 (Fig. 1).[4] This represents an apparent net primary production rate of about 0.8 g/m²/day for these species on this site for the growing period from May 23, the date of first sampling, to July 19. Rates for prairie sandreed and blue grama were about 0.5 and 0.2 g/m²/day, respectively. Needleandthread, a cool-season grass, reached peak standing crop about June 21, a month earlier than the warm-season species. The apparent net primary production rate for this species was about 0.2 g/m²/day up to June 21.

After the standing crop of these three grasses peaked in mid-July, herbage biomass declined, with only minor fluctuations, through March, 1961. The standing crop declined 29%, or about 25 g/m², between July 19 and October 2 and an additional decline of 22%, or about 20 g/m², was noted by April 16, 1961. Somewhat favorable moisture and temperature conditions in October produced small increases in blue grama and prairie sandreed, but these two warm-season grasses generally declined. The standing crop of needleandthread, the cool-season grass that reached peak biomass production at an earlier date, declined at a much greater rate. By fall, a decline of about 60% had occurred followed by an additional 12% decline in standing crop through the winter.

Sandy plains range site.

The aboveground standing crop of blue grama and western wheatgrass on this site reached a peak of 132 g/m² in early July (Fig. 1). The individual peak biomass for these species on the sandy plains site totaled about 144 g/m², 28 g/m² for blue grama on June 21 and 116 g/m² for western wheatgrass on July 6. Combined apparent production rate for these grasses was 1.6 g/m²/day between May 23 and July 6. Apparent net primary productivity for western wheatgrass between May 23 and July 6 was about 1.4 g/m²/day. Apparent net primary productivity for blue grama between May 23 and June 21 was approximately 0.6 g/m²/day. These data indicate that the sandy plains range site was more productive than the deep-sand range site for the 1960 growing season. Western wheatgrass was the most productive species studied and also responded more readily to winter moisture than the other species. Western wheatgrass biomass increased at about .6 g/m²/day, while the blue grama decreased in biomass at a rate of about .04 g/m²/day between November 5 and December 4, 1960, following winter precipitation.

On the sandy plains site the total standing crop of blue grama and western wheatgrass declined 28%, about 37 g/m², between July 6 and October 2. An additional decline of 7%, about 10 g/m², occurred between October 2, 1960 and April 16, 1961, making a total loss of 35%.

Compartmental dynamics.

The transfer rate of standing live vegetation to standing dead vegetation and litter compartments was about the same for the deep-sand range site and the sandy plains

[4] To convert to lb./acre multiply g/m² by 8.91 and to convert to kg/hectare multiply g/m² by 10.

Table 1. Seasonal trends (%) of crude protein of grasses on a deep-sand and a sandy plains range site, May, 1960 to April, 1961.

Date	Deep-sand site: Prairie sand-reed	Deep-sand site: Blue grama	Deep-sand site: Needle-and-thread	Deep-sand site: Avg.	Sandy plains site: Western wheat-grass	Sandy plains site: Blue grama	Sandy plains site: Avg.
1960							
May 23	12.8	10.8	12.4	12.0	13.9	13.2	13.6
June 6	9.2	9.9	9.4	9.5	10.5	9.1	9.8
June 21	7.4	8.0	7.3	7.5	11.2	9.1	10.2
July 6	6.1	7.1	6.8	6.7	9.4	9.1	9.2
July 19	6.4	6.0	7.2	6.5	6.8	8.3	7.6
Aug. 2	5.1	5.6	6.1	5.6	6.7	7.5	7.1
Aug. 16	4.1	5.3	5.8	5.1	6.2	7.8	7.0
Sept. 7	4.0	5.4	5.3	4.9	8.3	7.4	7.8
Oct. 2	3.7	5.6	5.7	5.0	5.5	6.6	6.0
Nov. 5	4.3	4.8	5.7	4.9	6.0	6.2	6.1
Dec. 4	–	–	–	–	5.6	6.9	6.2
Dec. 18	2.9	4.6	4.1	3.9	–	–	–
1961							
Jan. 15	2.7	4.4	4.3	3.8	3.5	6.2	4.8
Feb. 18	3.5	5.3	3.9	4.9	5.3	5.9	5.6
Mar. 18	2.6	4.4	4.4	3.8	4.7	6.1	5.4
Apr. 16	3.2	4.7	4.8	4.2	5.6	6.6	6.1

site. This was measured as the decrease in biomass from peak standing crop to the end of sampling. The rates of disappearance were about .14 g/m^2/day for both sites. Western wheatgrass, on the sandy plains site, had a much sharper initial decline in biomass weight, and thereafter the amount of this species remained at a level higher than the other species (Fig. 1).

In general, the dynamics of the species biomass on these two sites conforms closely to those mentioned in the literature. For example, Wiegert and Evans (1964) estimated the production rates in an *Aristada purpurescens* and *Poa compressa* field in Michigan at 0.38 to 4.43 g/m^2/day through the growing season. The estimates of production and production rates for the deep-sand and the sandy plains sites would be 5 to 20% lower than total production, since only the major grass species were studied, and total herbage biomass was not measured. However, the grasses studied on each site account for approximately 80 to 95% of the total standing crop (Eastern Colorado Range Station, unpublished data).

The sandy plains site had a higher total biomass of grasses studied than the deep-sand site. In addition, a smaller percentage of grass biomass disappeared on the sandy plains site than on the deep-sand site.

Seasonal Trends of Nutrients

Crude protein concentration.

In general, the seasonal trend of the percentages of crude protein followed a typical pattern (Table 1). Protein content of grasses was highest during early growth and lowest when plants were mature. Crude protein varied from a high of 13.9% on May 23 to a low of 2.6% on March 18. Prairie sandreed and western wheatgrass had the greatest decreases in percentages of crude protein. Crude protein content of prairie sandreed decreased from a high of 12.8% to a low of 2.6%. The protein content of western wheatgrass decreased from a high of 13.9% on May 23 to a low of 3.5% on January 15.

The protein content of grasses on the sandy plains site was consistently higher than the protein content of grasses on the deep-sand site. Grasses on the sandy plains site averaged from 0.3% higher crude protein on June 6 to 2.9% higher on September 7 than the average of the deep-sand site grasses. Blue grama, a species common to both sites, averaged about 1.5% higher in crude protein on the

Table 2. The amount of crude protein (g/m^2, air dry basis) of grasses on a deep-sand and a sandy plains range site May 1, 1960 and April 1, 1961.

Date	Deep-sand site: Prairie sand-reed	Deep-sand site: Blue grama	Deep-sand site: Needle-and-thread	Deep-sand site: Total	Sandy plains site: Western wheat-grass	Sandy plains site: Blue grama	Sandy plains site: Total
1960							
May 23	2.0	2.3	0.9	5.2	7.4	1.3	8.7
June 6	2.8	2.5	1.1	6.4	6.1	2.3	8.4
June 21	2.9	2.5	1.0	6.4	7.6	2.6	10.2
July 6	2.5	2.0	0.9	5.4	11.0	1.5	12.5
July 19	2.9	2.0	0.8	5.7	6.9	2.3	9.2
Aug. 2	2.3	1.7	0.6	4.6	5.4	2.0	7.4
Aug. 16	1.5	1.6	0.4	3.5	5.2	1.9	7.1
Sept. 7	1.6	1.6	0.3	3.5	8.2	1.1	9.3
Oct. 2	1.3	1.4	0.2	2.9	4.4	1.1	5.5
Nov. 5	1.4	0.9	0.3	2.6	4.6	0.9	5.4
Dec. 4	–	–	–	–	5.3	0.8	6.1
Dec. 18	1.1	1.1	0.1	2.3	–	–	–
1961							
Jan. 15	1.0	1.0	0.2	2.2	2.8	1.0	3.8
Feb. 18	1.2	1.2	0.1	2.5	4.2	1.0	5.2
Mar. 18	0.6	0.9	0.2	1.7	3.5	0.8	4.3
Apr. 16	0.8	0.7	0.2	1.7	4.1	0.9	5.0

sandy plains range site compared to the deep-sand site.

Amount of crude protein.

Seasonal trends in the amount of crude protein per unit area did not follow the same trend as percentages of crude protein or that of herbage biomass. Since crude protein production is an interaction of the amount of herbage biomass and percent of protein in the biomass, an intermediate trend exists. Peak quantities of protein occurred in June or early July (Table 2), the amount of crude protein generally decreasing throughout the remainder of the growing season and winter. Western wheatgrass, the exception, showed an increase in both percent crude protein and herbage biomass and, hence, an increase in the amount of crude protein in early September.

The sandy plains site produced more crude protein than the deep-sand range site. The grasses on the deep-sand site produced 5.2 g/m² on May 23. This increased to 6.4 g/m² on June 21 and then gradually decreased to 1.7 g/m² on March 18. The production of crude protein for the sandy plains site was 8.7 g/m² on May 23, 12.5 g/m² on July 6, and 4.3 g/m² on March 18 (Table 2). The greater protein production on the sandy plains site can be attributed to both the greater biomass production and the higher protein percentage in the grasses.

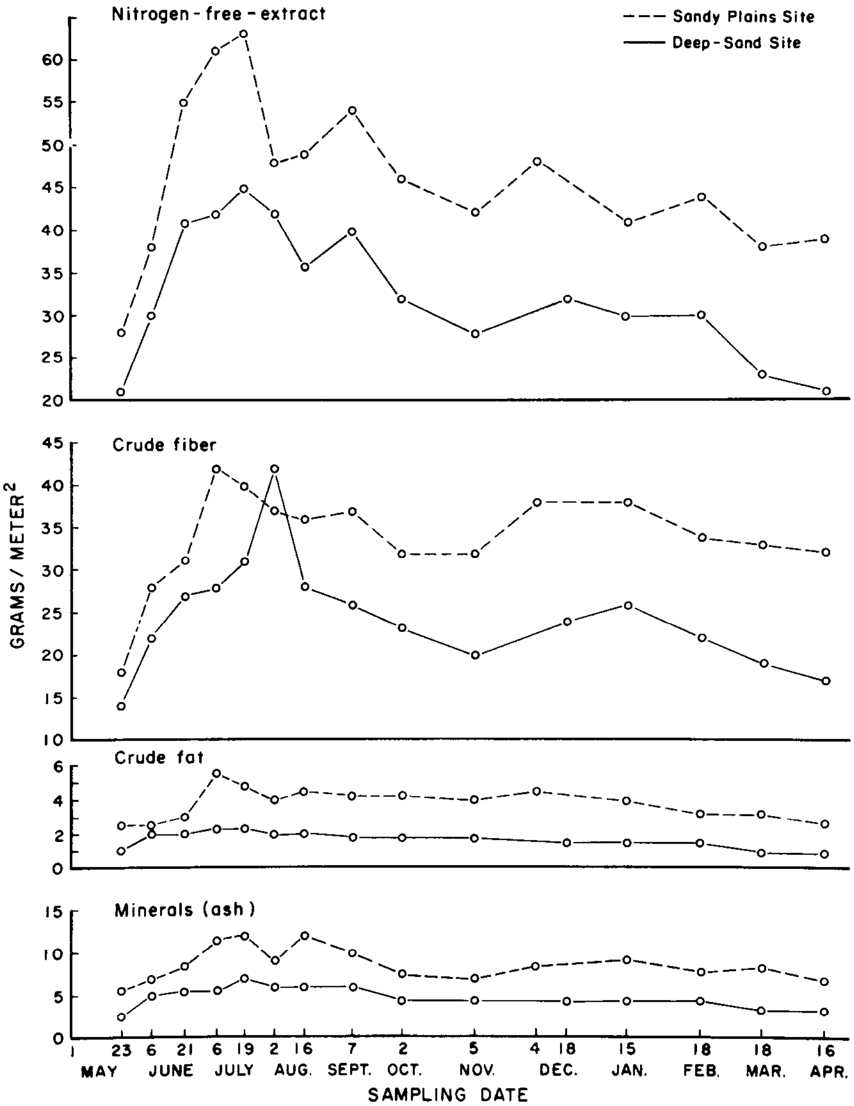

FIG. 2. Seasonal changes in the amounts of nitrogen-free-extract, crude fiber, crude fat, and minerals (ash) on a sandy plains and a deep-sand range site in northeastern Colorado, May 1, 1960 to April 16, 1961.

Amount of nitrogen-free extract.

Nitrogen-free extract (N.F.E.) is an index to the more soluble and easily digested carbohydrates. Since N.F.E. is determined by difference and contains errors inherent to the determination of other proximate components, the values are not exact but are useful for practical consideration (Maynard and Loosli, 1962).

Percentages of N.F.E. were fairly constant throughout the year for most of the grasses studied, varying from about 40 to 50%. Prairie sandreed was the only species that showed an increase in percent N.F.E. with maturity. N.F.E. content of prairie sandreed ranged from 44% in early summer and 51% in late summer and fall. Percent N.F.E. of grasses was usually 2 to 3% lower on the sandy plains site compared to the deep-sand range site.

Seasonal trends in the amount of digestible carbohydrates (N.F.E.) followed the general trend of biomass production. Highest production of N.F.E. occurred during midsummer, July 19, on both sites, 45 and 63 g/m² for the deep-sand and sandy plains range sites, respectively (Fig. 2). Thereafter, a gradual, although not steady, decrease in N.F.E. occurred.

The sandy plains range site yielded the most N.F.E. of the two sites at every sampling date. This was due primarily to the larger biomass of western wheatgrass. The N.F.E. production attributed to blue grama on the sandy plains site was approximately 30% less than the N.F.E. production attributed to blue grama on the deep-sand range site. The blue grama biomass from the sandy plains site was consistently lower than that from the deep-sand site (Fig. 1).

Amount of crude fiber.

Crude fiber values are indexes to the less digestible plant carbohydrates (Maynard and Loosli, 1962). The crude fiber production on a site may have an inverse relationship to the digestible nutrients and, therefore, have practical value in the analysis of site productivity. Crude fiber values were consistent for all species and from both sites. All species had about 32% crude fiber during the early summer, 34% during the summer and fall, and about 38% during the winter. The average percentage crude fiber for prairie sandreed, needleandthread, and western wheatgrass was 2 to 4% higher than blue grama during most sampling periods.

Total crude fiber production of grasses on the sandy plains site averaged about 9 g/m² higher than samples from the deep-sand range site (Fig. 2). However, this was not the case for blue grama, since the crude fiber of this species was usually higher on the deep-sand site than on the sandy plains site. Western wheatgrass, accounting for a very high percentage of the dry matter production on the sandy plains site, is somewhat higher in ligneous material and accounts for most of the crude fiber production on this site. Prairie sandreed was second highest producer of crude fiber, and needleandthread yielded the least amount of crude fiber.

Amount of crude fat.

The percentages of crude fat in grasses decreased with the maturity of the grasses on both range sites with the following exception. Needleandthread increased from 3% to 5% crude fat as the season advanced. Western wheatgrass had the highest percentage of crude fat, about 4.5% at peak standing crop and decreased to about 4% during the winter. All other species had from 2.5 to 3% crude fat during early summer and decreased to about 2% during the winter.

Crude fat production on the sandy plains site was about twice as high as the deep-sand site throughout the year (Fig. 2). Again, this was due to the high-producing western wheatgrass. Prairie sandreed produced the second highest crude fat percentage, and needleandthread produced least. Blue grama produced slightly more crude fat on the deep-sand range site than on the sandy plains site.

Amount of ash.

The percentages of ash in grasses did not follow a defined trend. On both sites, the ash content of blue grama increased from about 9 to 11% from the beginning to the end of the sampling period. On the deep-sand site, the ash content of prairie sandreed and needleandthread was about 5 and 7%, respectively, throughout the study period. Western wheatgrass on the sandy plains site had about 9 to 9% ash.

The mineral production, as measured by ashing, was highest on the sandy plains site. The ash content of grasses on the sandy plains site ranged from 2 to 5 g/m² higher than those on the deep sand range site. Western wheatgrass was the largest contributor of ash on the sandy plains site, and blue grama was the largest contributor to ash production on the deep-sand site.

Management Implications

The main advantages of the sandy plains site over the deep-sand site are three-fold: (1) larger biomass of the primary grasses produced, (2) slightly higher protein percentages in grasses, especially during the fall, and (3) greater quantities of crude protein, nitrogen-free extract, crude fiber, crude fat, and ash. Hence, the sandy plains range site would be more favorable for late summer, fall, and winter grazing than the deep-sand site. The forage on the sandy plains site would more nearly approach the nutritional requirements of grazing animals and cattle grazing this site would require less supplementation than those grazing the deep-sand range site.

The loss on both sites of about one-third of the biomass by early October in the absence of grazing by livestock must be taken into account when pastures are reserved for fall or winter usage. The nutrient loss on a unit-area basis is even greater than the biomass loss, inasmuch as the amount of nitrogen and N.F.E. decreased more than 50% by early October.

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