Aboveground Biomass Dynamics of Blue Grama in a Shortgrass Steppe and Evaluation of a Method for Separating Live and Dead

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Abstract

The relationship between live and dead biomass of blue grama and acetone extractable pigments was determined to assess its utility in predicting live and dead proportions of a mixed sample. We found the technique to be useful and recommend its use when exact separation is not required. Biomass dynamics of blue grama do not usually fit a parabolic model. Much of the variability in live biomass of blue grama can be explained by rainfall pattern during the growing season.

The shortgrass steppe from southeastern Wyoming and western Nebraska to southern New Mexico and Central Texas is dominated almost exclusively by blue grama *(Bouteloua gracilis).* Blue grama produces 50 to 90% of all forage on well managed ranges and is the species upon which management should be based (Costello 1944). Statements such as these are found frequently in the literature (Albertson et al. 1966; Bement 1969; Hyder et al. 1975; Uresk et al. 1975) and emphasize the importance of the ecology of blue grama to the management of shortgrass ranges.

Because of the tufted growth habit and low stature of blue grama, sampling live aboveground biomass is very time-consuming. In our efforts to circumvent this problem, we evaluated a technique to estimate live and dead biomass of a mixed sample based upon its pigment content (Hunter and Grant 1961). Our objectives here are to report on our evaluation and modifications of the separation technique and to discuss the resultant biomass dynamics data for blue grama.

Study Area

The study area is located in Weld County, northeastern Colorado at the Pawnee Site (the field research facility of the Natural Resource Ecology Laboratory, Colorado State University, Fort Collins, located on the Central Plains Experimental Range, which is administered by the U.S. Dep. Agr. Science and Education Administration). The plots were located within an exclosure on an Ascalon sandy loam soil. The exclosure was built in 1969 to exclude large animals. Previous to fencing, the area had been lightly grazed by cattle for at least 10 years.

The Pawnee Site is near the western border of the Great Plains, and the climate is predominantly continental. Approximately 70% of the 310 mm of annual precipitation falls during the April to September growing season. Mean monthly temperatures range from below 0° C in December and January to 22° in July.

The natural vegetation of the study plots is characteristic of a large portion of the shortgrass prairie and is basically a blue grama *(Bouteloua gracilis)* grassland. The major species in addition to blue grama are fringed sagewort *(Artemisia frigida),* scarlet globemallow *(Sphaeralcea coccinea),* plains pricklypear *(Opuntia polyacantha),* broom snakeweed *(Gutierrezia sarothrae),* and needleleaf sedge *(Carex eleocharis).* A detailed site description can be found in Lauenroth, Dodd, and Sims (1978).

Methods

Aboveground biomass of blue grama was estimated by harvesting 12 0.5-m^2 circular quadrats and estimating the weight of an additional but variable number of quadrats on most sample dates (Pechanec and Pickford 1937). Biomass of blue grama was separated into live and dead categories by a combination of pigment extraction, visual estimation, and hand separation. Weight estimates were conducted by live and dead categories (viz., current live, recent dead, and old dead). Recent dead represented current year's production while old dead was previous year's biomass. The data from visual weight estimates were combined with the harvested data by constructing regression equations for each treatment on each sample date based on data from those harvested quadrats which were also estimated. Weight estimated data were considered useful if the correlation coefficients were significant at the $\alpha = 0.05$ level.

The chemical method used to separate live and dead blue grama was a modification of the method described by Hunter and Grant (1961). The basic assumption of the technique was that the biomass of live and dead material in a harvested sample was proportional to the extractable chlorophyll in that sample. All chlorophyll extractions were performed on oven-dried material. On each sample date, standard 4-g mixtures of blue grama herbage were made ranging from 0 to 100% live in 20% increments. Three 1-g subsamples were taken from each standard mixture and the chlorophyll extracted from them. Chlorophyll was extracted by blending the sample with 100 ml of 80% acetone at high speed for 2 min. After blending, the mixture was filtered, placed in a 100 ml volumetric flask, and the volume was standardized at 100 ml. Absorbance was determined with a spectrophotometer at 625 nm using 80% acetone to adjust the zero. After all of the standards were extracted and absorbance measured, a linear regression of percentage live biomass on absorbance was calculated. Duplicate subsamples from each harvested quadrat were then extracted and percentage live biomass predicted from the regression equation. An outlier test was performed on the results before live biomass was predicted from the regression equation (Grubbs 1950). A separate set of standard mixes and regessions were used for each sample date. On those dates when the regression relationships were not significant, visual estimation of live and dead biomass was used.

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Results and Discussion

Evaluation of Separation Technique

Data from the 1974 growing season were typical of those obtained during the study and are presented here to describe the performance of the separation technique. The relationship between percentage live biomass of blue grama and absorbance at 625 nm was linear and quite good for most of the samples analyzed. Coefficients of determination for regressions obtained in 1974 ranged from 0.84 to 0.99 (Table 1). The regression relationships associated with these worst and best case examples are typical of the relationships obtained for each sample date (Fig. 1). Greater variability was found for the May sample date presumably because of a greater proportion of young leaves in which chlorophyll synthesis was still occurring and a greater percentage of old dead biomass.

Hunter and Grant (1961) discussed sources of error influencing pigment extraction. They found that particle size was an important variable and emphasized that care in grinding is important in providing consistent results. All of our plant material was ground to pass a 0.5-mm sieve compared to the 2.45-mm sieve used by Hunter and Grant. We were satisified that we obtained uniform extraction by using the smaller particle size. They also mentioned that storage times and conditions influenced pigment extraction. The major source of error in our analyses was probably the result of variable storage times before pigment extraction. After drying, weighing, and grinding, the plant material was placed in amber vials and frozen. Although all of the samples within a date were treated equally, many times several months elapsed before extraction. To increase the utility of the method we recommend minimizing storage times and standardization of storage times for all samples. Since we were using sample material separated by species, we did not encounter the problem of differential pigmentation among species.

Table 1. Coefficients of determination (r^2) for regressions of percentage live on absorbance at 625 nm for calibration mixtures in 1974.

May 23	June 12	June 30	July 22	August 9	August 30
0.835	0.982	0.950	0.906	0.994	0.943

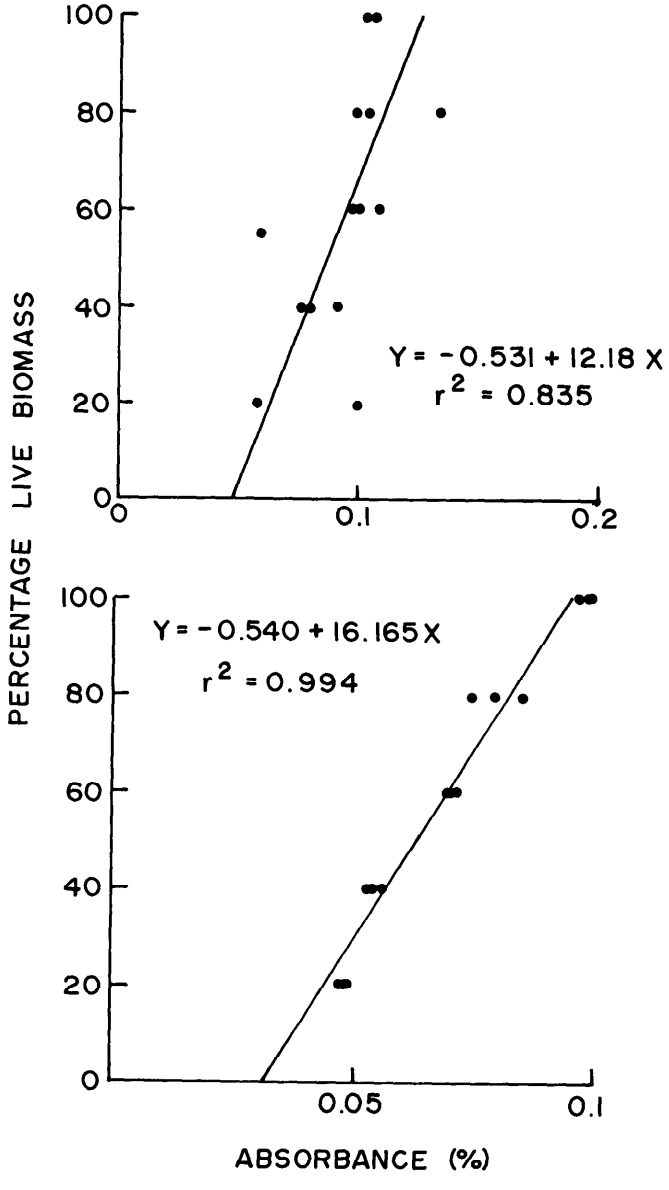

Fig. 1. *Regression relationship between percentage live biomass and absorbance for blue grama in 1974. Worst (a) and best (b) regressions obtained in 1974.*

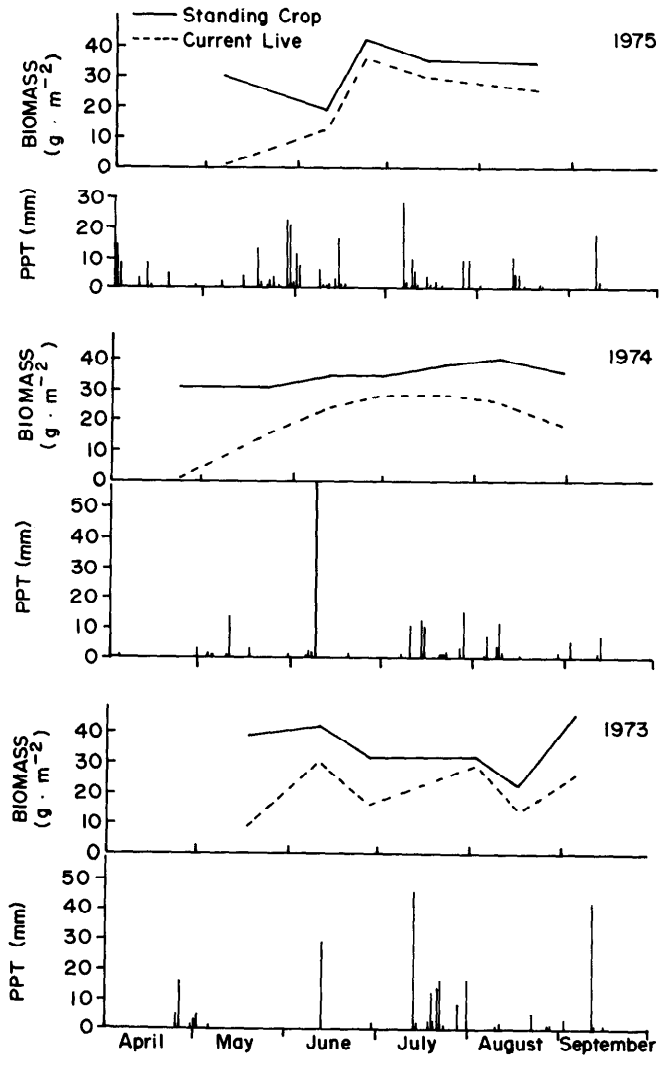

Fig. 2. *Daily growing season precipitation and seasonal biomass dynamics of total and live blue grama in 1973, 1974, and 1975.*

We concur with the conclusions of Hunter and Grant (1961) that while pigment extraction techniques will never replace hand separations where exact proportions of live and dead material are required, it is probably suitable for many studies, particularly when large number of individual samples are collected on each sample date.

Biomass Dynamics of Blue grama

Dickinson and Dodd (1976) described phenological progression of blue grama populations in northcentral Colorado and reported the following timing of important events: (1) first visible growth, late April to early May; (2) first floral buds, late June; (3) dispersing seeds, late August; and (4) senescence, late September. Timing of events in terms of biomass for 1973-1975 was as follows: (1) initial green biomass April 15 to May 15, (2) rapid growth May 15 to July 1, (3) peak live biomass June 10 to July 1, and (4) decline in live biomass June 1 to September.

Blue grama is noted for its ability to respond rapidly to rainfall events. Therefore erratic seasonal biomass dynamics curves are to be expected, rather than parabolic curves that characterize many other species (Turner and Klipple 1952; Bement 1969). Our data demonstrate three of perhaps an infinite number of biomass dynamics curves to be expected for blue grama. In 1973 a trimodal curve of live biomass dynamics was observed. The three peaks in biomass appear to be related to three periods of rainfall (Fig. 2). The early June peak coincided with a rainfall event indicating that had we sampled a week later we might have observed an even larger biomass. The second peak followed a 2-week period of rainfall from July 15 to August 1. The final peak in live biomass was initiated by several small rainfall events in late August and early September. The rainfall event on September 11, after our last sample date, leads us to the conclusion that we also underestimated this peak. In 1974 we observed a relatively smooth parabolic curve for biomass dynamics. Except for a single large rainfall event, the growing season in 1974 was relatively dry. Biomass accumulation in 1975 was characterized by a slow increase from early May to June, then a rapid increase in mid-June following a period of abundant rainfall. Peak live biomass in 1975 was 35 $g \cdot m^{-2}$, the largest of the 3 years. A moderate amount of rainfall was received after the peak in live biomass that seemed to sustain the biomass present rather than stimulating additional peaks. Live biomass declined from 35 to 25 $g \cdot m^{-2}$ from late June to late August. The explanation for the unimodal biomass dynamics in 1975 is the lack of significant drought periods as were observed in 1973.

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