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Forecasting Forage Production

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INTRODUCTION

The ability to forecast annual forage yield from weather data would be useful for making appropriate adjustments to stocking rates in order to achieve or maintain desired plant communities. Identifying the key weather variables that determine forage yield would help managers focus their attention on what to measure and when to make grazing decisions.

Stocking rate decisions are critical in determining long-range sustainability and productivity of range ecosystems and ultimately the financial success of ranches. Over-stocking of rangeland has led to reduced vegetative cover, increased runoff of water and sediment, and increased weedy forbs and woody plant species. All of these factors and others lead to a shift in species composition to less productive vegetation which negatively impacts animal production management opportunities. Therefore enhancing the grassland manager's sensitivity to seasonal influences of weather patterns on forage production will enable managers to make timely stocking rate adjustments. The earlier this information is available to the producer to make annual forage production estimates, the better the manager will be in position to initiate necessary grazing changes.

SPRING PRECIPITATION

Spring precipitation has been recognized as an important driver of annual production in northern Great Plains rangelands (Heitschmidt et al., 2005; Johnson et al., 1951). This phenomenon occurs because the predominant range vegetation is comprised of cool-season midgrasses mixed with warm-season shortgrasses. In western South Dakota, Johnson et al. (1951) recognized that spring precipitation (April, May, and June) influenced annual forage production more than summer precipitation. Since the warm-season grasses consisted of shortgrasses such as blue grama and buffalograss, late summer rainfall did little to increase the season's total forage production because the cool-season forages had already produced the majority of their biomass for that year. Heitschmidt (2004) confirmed this by examining 15 sites in the northern Great Plains and found that 91% of the annual forage was produced by July 1.

Spring precipitation (April-June) was found to be the best predictor of shortgrass dominated rangeland in western South Dakota (Fig. 2) (Smart et al., 2005).

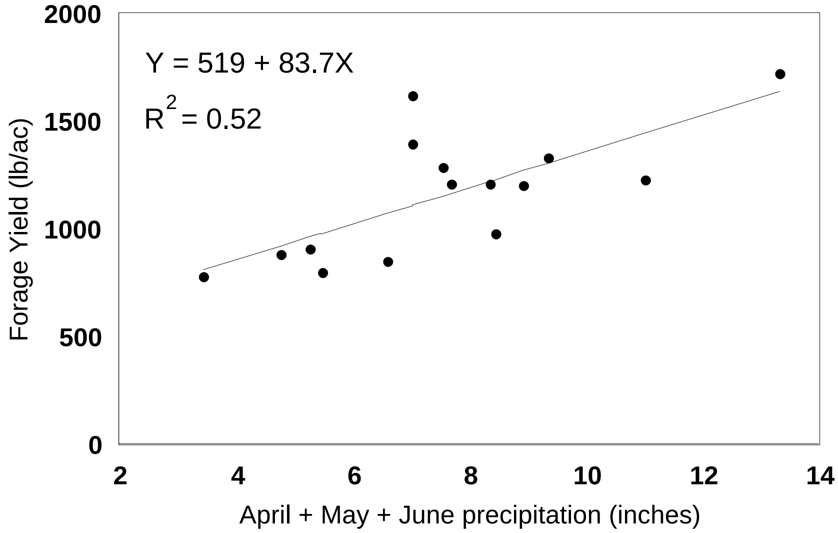

Figure 2. Annual forage yield (lb/acre) predicted by cumulative precipitation for April, May, and June from 1945 to 1960 for the Cottonwood Range and Livestock Research Station near Philip, South Dakota in the mixed-grass prairie (Unpublished data). Mean cumulative precipitation for April, May, and June is 7.67 inches.

Brown and Trlica (1977) showed that blue grama dominated range in eastern Colorado had two production peaks, one in late-July and one in early-September. The strong relationship between spring precipitation and forage yield in our study indicates that soil moisture was probably being stored as shown in Fig. 3 and described by Sala et al. (1992), for warm-season shortgrass production later in the growing season.

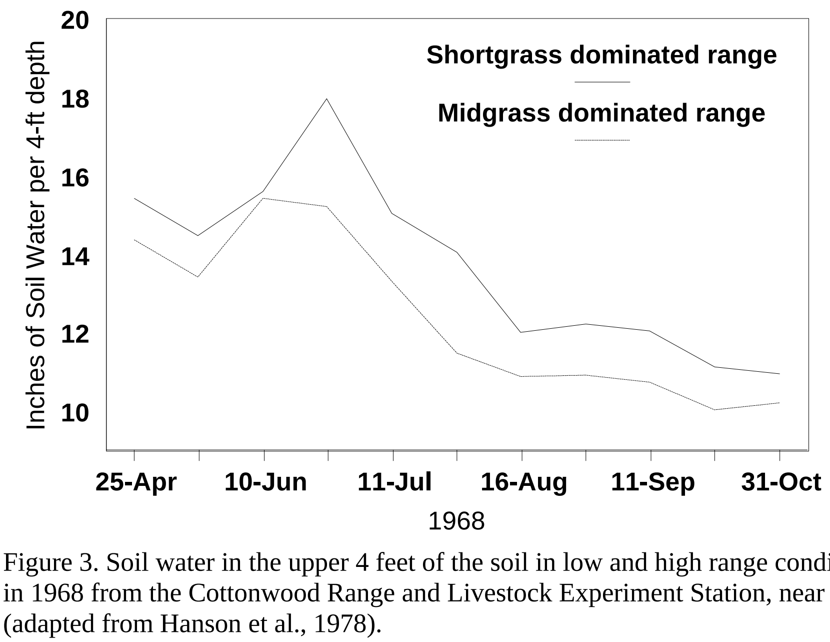

Figure 3. Soil water in the upper 4 feet of the soil in low and high range condition watersheds in 1968 from the Cottonwood Range and Livestock Experiment Station, near Philip, SD (adapted from Hanson et al., 1978).

TEMPERATURE

Cold temperatures, especially those below 32°F rupture plant cell walls and damage meristem tissue in plants (Pearce and McDonald 1978). We evaluated the last spring

calendar day when the daily minimum temperature was below 30°F and its effects on forage production (Smart et al., 2005). Pastures with western wheatgrass dominated plant communities have more cool-season mid-grasses and less warm-season shortgrasses than shortgrass dominated plant communities (Smart et al., 2005). Cool-season grasses such as western wheatgrass typically start growing in mid-April and peak in production by the end of June in the Northern Great Plains (White 1983). Fructans that provide chill tolerance decreases dramatically in the spring when plants are concurrently developing stem structure (Gonzalez et al. 1990). Therefore, grass plants in a rapid growth phase would be more susceptible to freezing temperatures. As a result, plant dry weight has been reduced after being subjected to low temperatures (Humphreys and Eagles 1988).

Annual forage production in western South Dakota pastures with a mixture of cool-season grasses and warm-season grasses was best predicted by spring precipitation (April-June) and the last spring calendar day when the daily minimum temperature was below 30°F (Fig. 4).

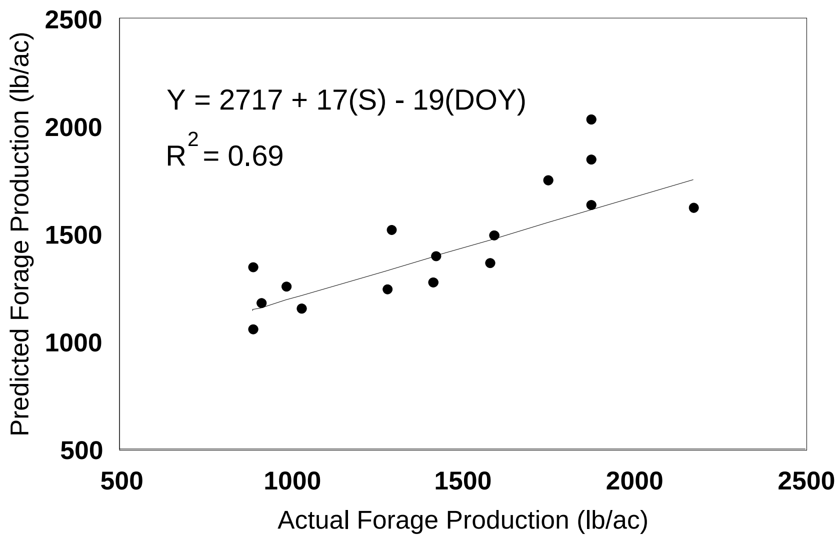

Figure 4. Annual forage yield (lb/acre) predicted by cumulative spring precipitation for April, May, and June (S) in inches and last spring calendar day when the daily minimum temperature was below 30°F (DOY) from 1945 to 1960 for the Cottonwood Range and Livestock Research Station near Philip, South Dakota.

Forage yield in shortgrass dominated plant communities was not related to the last spring calendar day when the daily minimum temperature was below 30°F. Since the major species of these plant communities are warm-season and given that the last spring calendar day when the daily minimum temperature was below 30°F averaged May 2 and ranged from April 6 to May 23, the last spring calendar day when the daily minimum temperature was below 30°F would not affect warm-season dominated pastures because the warm-season grasses would not have begun their rapid growth phase until June (Dickinson and Dodd 1976).

PREVIOUS SPRING PRECIPITATION

The effects of precipitation from previous years often have lag effects on current year forage yield (Lauenroth and Sala, 1992). For example, data from 1945-1960 at the Cottonwood station (Fig. 5) showed that forage yield was above the 16-year mean in 1949 when current spring precipitation was below normal, but because previous spring precipitation was above normal, there may have been abundant soil moisture for good growth that increased plant vigor in terms of roots and shoot buds for next year's season. Similarly, in 1951 forage yield was 850 lb/acre below the16 year mean when spring precipitation was only 1.34 inches below average, but because spring precipitation the previous year, 1950, was 57% below average, soil moisture and plant vigor was probably reduced in 1951. Favorable spring growing conditions (i.e. moderate temperature and adequate soil moisture) and light grazing are necessary to maintain western wheatgrass dominated plant communities.

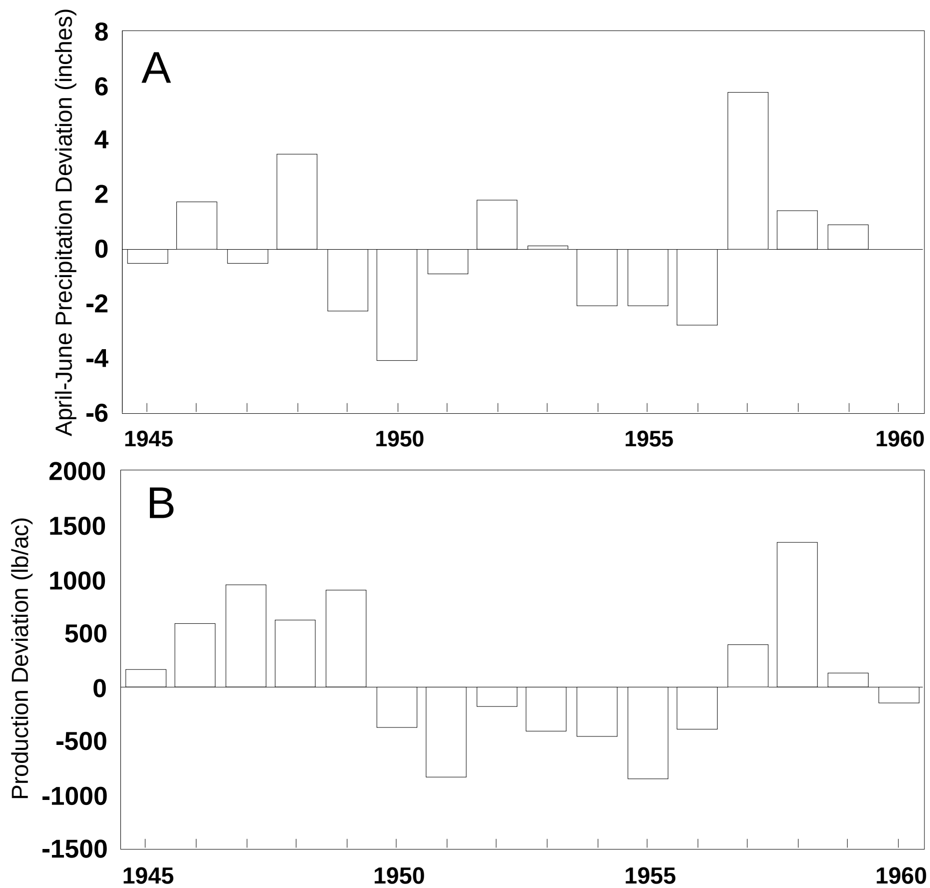

Figure 4. Deviation of annual values from the period 1945-1960 for (A) April-June precipitation and (B) forage production of pastures with western wheatgrass-dominated plant communities at Cottonwood Range and Livestock Research Station near Philip, SD.

Forecasting annual forage yield by the end of June in western wheatgrass dominated plant communities in western South Dakota was related best to cumulative spring (April-

June) precipitation, the last spring calendar day when the daily minimum temperature was below 30°F, and spring precipitation from the previous year (Fig. 6).

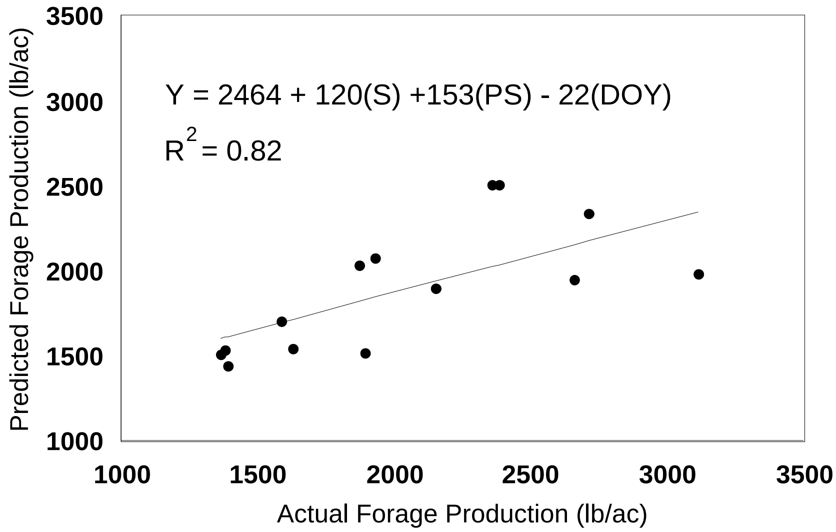

Figure 6. Annual forage yield (lb/acre) predicted by cumulative spring precipitation for April, May, and June (S) in inches and last spring calendar day when the daily minimum temperature was below 30°F (DOY) and previous year's spring precipitation (PS) in inches from 1945 to 1960 for the Cottonwood Range and Livestock Research Station near Philip, South Dakota.

The ability to explain 52-82% of the variation in forage yield from mixed-grass rangeland in the northern Great Plains, which varied in their degree of composition and complexity, using climatic information is important. However, compared to monocultures, the fraction of variation in forage yield explained by climatic variables was less. For example, Currie and Peterson (1966) were able to explain 88% of the variation in crested wheatgrass [*Agropyron cristatum* (L.) Gaertn.] yield from April precipitation, because much of the annual growth of crested wheatgrass was completed by the end of April (Currie and Peterson 1966). Sneva and Hyder (1962) also demonstrated that forage yields from seeded ranges could be predicted accurately (R^2 = 0.80 to 0.94) with crop-year precipitation. Forage yields from native rangeland have been predicted but, with less accuracy (Dahl 1963, Lauenroth and Sala 1992, Smoliak 1956, Sneva and Hyder 1962). It is likely that native rangeland, with greater species diversity and longer duration of forage production would be less predictable from a relatively small number of climatic variables compared to seeded pasture.

MANAGEMENT IMPLICATIONS

Key variables derived from this long-term data set offer a reasonable explanation for the main factors that influence forage yield on these diverse plant communities in the northern Great Plains. In mixed-grass prairie, April, May, and June precipitation events, the last spring calendar day when the daily minimum temperature was below 30°F, and spring precipitation from the previous year were useful in forecasting current annual forage yield by July 1. The usefulness is in the ability of managers to make stocking rate adjustments for the rest of the growing season. If forage is going to be below average then strategies, such as

early weaning or de-stocking might be necessary to avoid over utilizing forage resources. Likewise, if forage yield is going to be above normal, forage could be stockpiled for winter grazing or more animals could be grazed for a longer period of time.

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