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Grazing Management with Variable Plant Production in the Nebraska Sandhills

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Introduction

Total plant production on native rangelands is dynamic and influenced by multiple weather-related factors. The most important factor influencing yearly plant production is the amount of growing season precipitation, which can vary widely in different years (see *Figure 1*). Plant production directly influences appropriate year-to-year stocking rates. In dry years with limited plant production, livestock forage demand often exceeds available plant production and livestock producers are faced with decisions of overutilizing pastures, selling cattle, or finding alternative feed resources. In years with above average precipitation, plant production supply may be greater than livestock grazing demand.

The ultimate goal of sustainable grazing management on rangelands is to appropriately match the forage demand from grazing animals with yearly plant production while maintaining or improving the forage resource. Grazing managers cannot control weather patterns, but the management response to variable precipitation conditions is one of the grazing manager's most important challenges. Adaptive management of rangelands with highly variable plant production requires frequent observations, adjustments in stocking rates based on changing growing season conditions, and flexibility in management to accomplish defined rangeland objectives.

This Extension Circular presents data showing the interannual variability in precipitation, plant production, and stocking rates from a 17-year dataset (i.e., 2001 to 2017) collected at the University of Nebraska–Lincoln Barta Brothers Ranch in the Nebraska Sandhills (*Figure 1*). The overall goal of this publication is to help livestock producers and grazing managers better estimate plant production and make

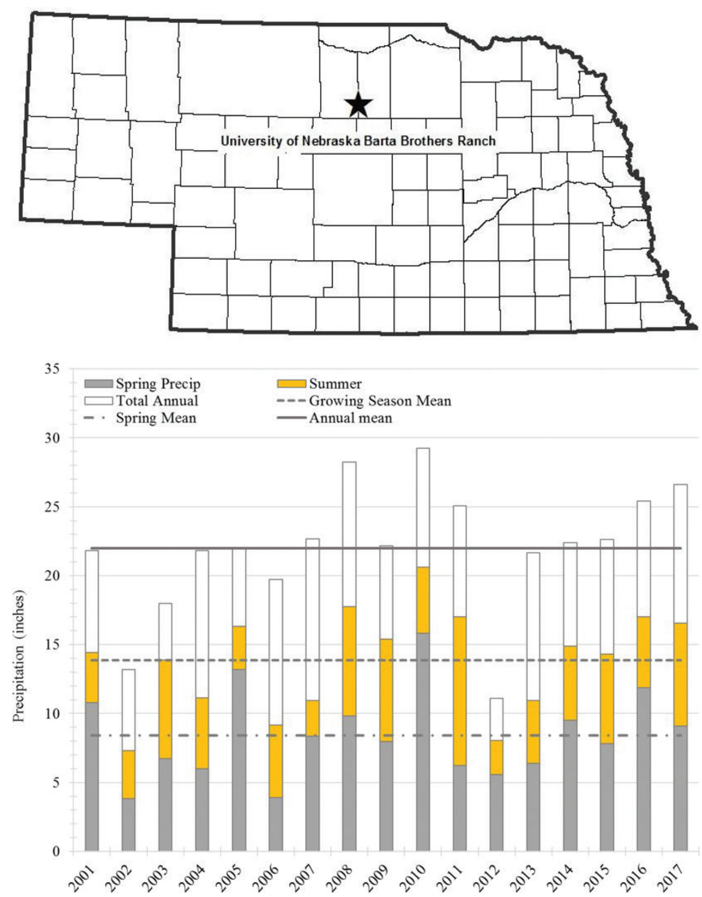

Figure 1. Spring (April 1 to June 15), summer (June 16 to August 15), growing season (April 1 to August 15), and total annual (January 1 to December 31) precipitation levels from 2001 to 2017 at the UNL Barta Brothers Ranch in the Nebraska Sandhills.

Table 1. Classification of wet, dry, and average precipitation during the spring (April 1 to June 15), summer (June 16 to August 15), and total growing season (April 1 to August 15) periods from 2001 to 2017.

Year	Spring Precipitation*	Summer Precipitation	Growing Season Precipitation
2001	Wet	Dry	Average
2002	Dry	Dry	Dry
2003	Average	Wet	Average
2004	Dry	Average	Average
2005	Wet	Dry	Average
2006	Dry	Average	Dry
2007	Average	Dry	Average
2008	Average	Wet	Wet
2009	Average	Wet	Average
2010	Wet	Average	Wet
2011	Average	Wet	Average
2012	Dry	Dry	Dry
2013	Average	Average	Average
2014	Average	Average	Average
2015	Average	Average	Average
2016	Wet	Average	Average
2017	Average	Wet	Average
	# of years		
Dry	4	5	3
Ave	9	7	12
Wet	4	5	2

*Dry = less than 75 % of normal precipitation, Average = between 75% and 125% of normal precipitation, and Wet = greater than 125% of normal precipitation. Normal precipitation calculated as the average precipitation between 2001 and 2017 for each period.

informed decisions on grazing management during drought, average, and wet years.

Precipitation at Barta Brothers Ranch

While precipitation for a given area is typically referenced as the average of several years, greater understanding on the relationships between precipitation and plant production can be gained by evaluating the extremes across the driest and wettest years. Drought is defined as “a period without precipitation during which the soil water content is reduced to such an extent that plants suffer from lack of water” (*Society for Range Management Glossary)*. Periods when precipitation is less than what is required for average plant growth can range from months to years, and the timing and extent of droughts can have a significant impact on plant production. Dry periods (drought) in this publication are described as any period during the growing season (i.e., spring, summer, or total growing season) when precipitation is less than 75 percent of the average precipitation. Wet periods are described as times when precipitation is greater than 125 percent of the average precipitation.

From 2001 to 2017, spring (April 1 to June 15), summer (June 16 to August 15) and growing season (April 1 to August 15) precipitation accounted for 38 percent, 25 percent, and 63 percent of the total annual precipitation, respectively (*Figure 1*). Average precipitation was 8.4 inches during the spring, 5.5 inches during the summer, 13.9 inches during the growing season, and 21.9 inches over the whole year from January through December. The three driest springs were in 2002, 2006, and 2012. Spring precipitation during these years was only 45 percent, 46 percent, and 66 percent of the long-term average, respectively. The three wettest growing seasons were in 2010, 2008, and 2011 with 159 percent, 128 percent, and 123 percent of the average growing season precipitation, respectively. From 2001 to 2017, there were four years with springs and five years with summers that were dryer than normal, and three years that exhibited dry conditions over the whole growing season (*Table 1*).

Data Collection

Plant production data were collected from 60 to 240 grazing exclosures in each year. Exclosures were created

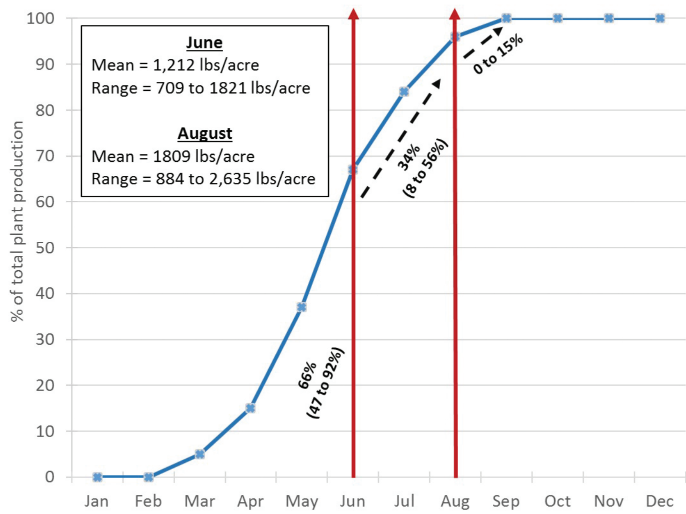

Figure 2. Growth curve (blue line) for total forage production at the Barta Brothers Ranch near Rose, Nebraska from 2001 to 2017. Red arrows indicate times when forage production data were collected in mid-June and mid-August. Black dashed lines and percentages represent the mean amount of forage produced by mid-June, between mid-June and mid-August, and potential additional growth from cool-season grasses in the fall of each year (parentheses indicate the range of values observed).

Image 1. Barta Brothers Ranch

with 4 ft by 4 ft wire panels and placed at different topographic positions (e.g., dune slopes or interdune swales) on upland rangelands at the Barta Brothers Ranch (*Image 1*). Plant production data were collected in mid-June and mid-August from 2.7 ft^2 quadrats placed on different sides of the exclosures. Research technicians at the ranch clipped all current-year herbaceous plant material at ground level and separated it into plant functional group categories of warm-season grass, cool-season grass, forb, and sedge. Technicians also collected current year growth from shrubs that were rooted within the quadrats. All clipped plant samples were oven-dried at 160˚ F for 48 hours, weighed, and values were recorded as pounds of dry matter per acre.

Common warm-season grasses at the study site included prairie sandreed (*Calamovilfa longifolia*), sand bluestem (*Andropogon hallii*), and switchgrass (*Panicum virgatum*). Common cool-season grasses were needleandthread (*Hesperostipa comata*) and Kentucky bluegrass (*Poa pratensis*). The most common forbs and shrubs were western ragweed (*Ambrosia psilostachya*) and leadplant (*Amorpha canescens*), respectively. Mid-June and mid-August harvest dates were selected to correspond with the peak plant production of cool- and warm-season grasses, respectively. By the mid-August harvest date, most of the growth of important warm- and cool-season forage species had occurred, but in some years when precipitation and temperature were favorable, greater amounts of cool-season plant growth likely occurred after the mid-August harvest date and increased the total plant production.

Plant Production Growth Curve

Knowing the types of plants on a given rangeland and the variable growth windows for these plants is important for setting appropriate stocking rates at different times of the year. Sandhills plant communities are a unique mixture of both cool- and warm-season plant species. Cool-season species typically begin growth in mid-April and reach maturity by mid-June. In contrast, warm-season species begin growth in late-May and early-June and reach maturity in late-July and August. Precipitation at different times during the growing season influences these species differently. For example, precipitation during the summer is more critical to warm-season grass growth and production, while cool-season grasses are more sensitive to precipitation that occurs in the spring and fall.

Growth curves provide estimates of the amount of production that occurs at different times during the growing season (*Figure 2*). When averaged over the years of the study, approximately 66 percent of the total plant production collected in mid-August had been produced by mid-June. Thirty-four percent of the plant production occurred between mid-June and mid-August. There were years when forage production in mid-June was as low as 44 percent of the mid-August production. During the dry growing season of 2012, most of the plant production had occurred by the mid-June harvest and only 8 percent of the total production was recorded between mid-June and mid-August. In 2009, a relatively wet year during the summer, 56 percent of the total plant production occurred between mid-June and mid-August. It is estimated that in some years up to 15 percent of additional production may have occurred after the mid-August harvest date on

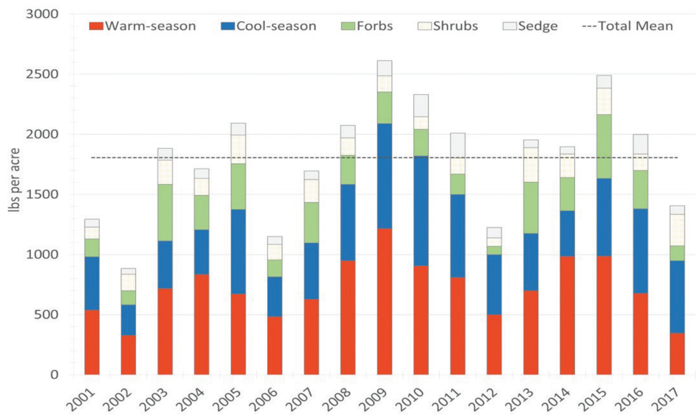

Figure 3. Total plant production of warm-season grasses, cool-season grasses, forbs, shrubs, sedges, and total average forage production (dashed line) harvested in mid-August at the Barta Brothers Ranch.

cool-season grass species, but this was not measured and was dependent on late summer and fall precipitation.

Interannual Differences in Plant Production

Over the 17 years of the study, there were large yearly differences in plant production on the native upland, Sandhills sites (*Figure 3*). The average plant production during the study period was 1,809 lb per acre at peak standing crop in mid-August. Grasses made up approximately 70 percent of the total plant production with warm-season grasses accounting for 40 percent and cool-season grasses accounting for 30 percent of the total plant production. The large amount of the total production that was warm- and cool-season grasses highlights the importance of these functional groups to the Sandhills plant community. Average forb, shrub, and sedge production accounted for 14 percent, 10 percent, and 6 percent of the total plant production, respectively.

Some of the years with the lowest plant production were during years with low spring precipitation (See spring precipitation in 2002, 2006, and 2012, *Figure 1*). Total plant production during the years with the three driest springs was only 49 percent (2002), 64 percent (2006), and 70 percent (2012) of the average total plant production. The especially low plant production in 2002 was likely the result of the cumulative effects of a dry summer in 2001 and a dry spring and summer in 2002 (See *Figure 1*, *Table 1*). The greatest total plant production was in 2009 with 2,635 lb per acre, or 45 percent above the average plant production. The four-year period from 2008 to 2011 had relatively wet spring or summer periods and above average total plant production in all of these years (*Figure 3*). These wet years prior to the drought in 2012 likely tempered the effect of the drought on plant production compared with the droughts in 2002 and 2006, which had dry summers in both of the previous years.

Plant production was 21 percent below average in 2017 and 28 percent below average in 2001. Even though growing season precipitation in these years was close to the long-term average (See *Figure 1*), the timing of precipitation was a primary driver in the reduced amount of plant production. In 2017, precipitation during the month of June was only 0.3 inches, less than 10 percent of the long-term average. Even though adequate precipitation was received later in the growing season, the exceptionally dry June affected early season growth of warm-season grasses and reduced the overall amount of plant production in this year.

In 2001, spring precipitation was above average, but summer precipitation was only 65 percent of the long-term average. The dry summer period likely limited the amount of forage produced later in the growing season. Plant production in 2001 and 2017 indicates that total plant production was affected not only by total growing season precipitation, but also by the time the precipitation was received during the growing season. Years with wet springs or summers may still have below average plant production if there are drought conditions at key periods during the growing season.

Influence of Plant Production on Stocking Rates

Harvest efficiency is the portion of the total plant production directly consumed by grazing animals. Typically, upland rangelands in the Sandhills are recommended to be stocked at moderate stocking rates with harvest efficiencies of 25 to 30 percent of the total plant production. These harvest efficiencies estimate that another 20 to 25 percent of the total plant production will be trampled by livestock and/or consumed by other herbivores, including insects and other wildlife. The remaining ungrazed plant material (around 50 percent of the total plant production) should be photosynthetically active leaf and stem material for plant recovery, maintenance, and growth following grazing.

Higher harvest efficiencies, as high as 35 or 40 percent, may be achieved when more intensively managed grazing strategies are used. Grazing management intensive practices with strategic fence placement and reduction in pasture size often improve grazing distribution by reducing grazing distance to livestock water and increasing homogeneity of topography and plant communities within each pasture.

The timing of grazing and recovery periods, applied management practices that are directly related to plant vigor and productivity in the Sandhills, also can be more effectively manipulated with strategic pasture rotation. However, more insight and understanding of grass recovery periods, appro-

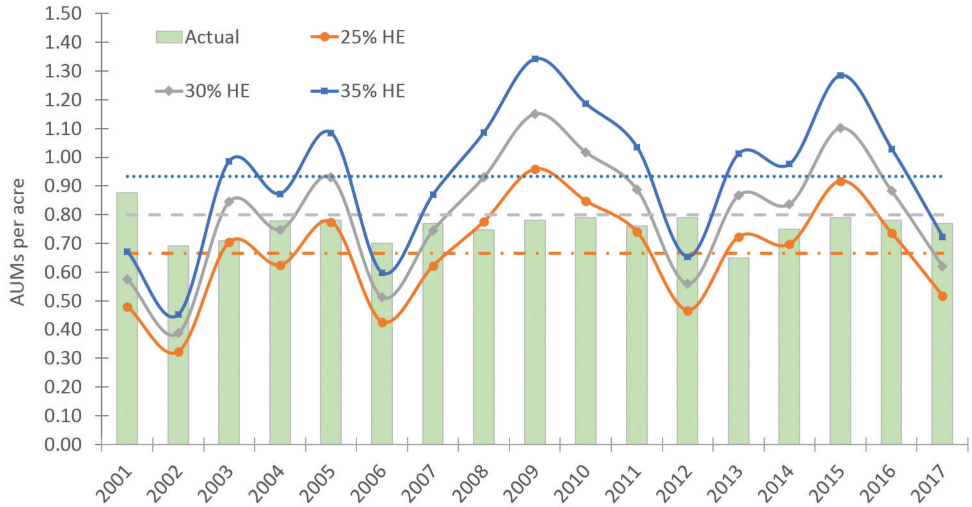

Figure 4. Estimated stocking rates (animal unit months, AUMs) based on harvest efficiencies (HE) of 25%, 30%, and 35% of the total mid-August plant production from 2001 to 2017. Green bars represent the actual stocking rates placed on the study pastures at the Barta Brothers Ranch in each year. Dashed lines represent the average estimated stocking rates for the three harvest efficiencies based on average plant production over the 17 years of the study.

priate utilization levels, and flexible adaptive management of livestock are needed to avoid repeated overutilization on key forage plant species, especially during critical drought periods. More information on research evaluating grazing strategies in the Sandhills can be found in the extension publication *Grazing Systems for Nebraska Sandhills Rangeland, EC127*.

The data presented in *Figure 4* show estimated annual stocking rates with harvest efficiencies of 25 percent, 30 percent, and 35 percent based on the total plant production in each year of the study. Actual stocking rates were recorded for the number of cow-calf pairs that were grazed on the pastures in each year. One cow-calf pair was estimated to be an animal unit equivalent (AUE) of 1.5 (1.2 AUE for a 1,200 lb cow and 0.3 AUE for a calf). Cattle grazed on the pastures in most years from mid-May to mid-October within a four-pasture deferred rotation. This rotation allowed each pasture deferment from grazing until the first part of September once in every four years. An advantage of a deferred rotation grazing strategy for the warm- and cool-season grasses in the Sandhills is the annual change in the timing of grazing and the periodic deferment from grazing until most plants have reached reproductive maturity.

Visual observations of the pastures were taken throughout the growing season to ensure that cattle were not overgrazing and that sufficient residual plant material was left on the pastures. Cattle were removed from pastures earlier than planned in years with lower plant production. For example, in 2002 and 2006, cattle were removed two to four weeks early from the ranch because of dry conditions. In all but the driest or wettest years, actual stocking rates were typically within the estimated 25 to 30 percent harvest efficiency and targeted 50 percent use in most of the ranch's pastures (*Figure 4*).

Predicting Plant Production

Predicting the amount of plant production in a given year is challenging, especially early in the growing season when forecasts for total growing season precipitation are uncertain and highly variable. However, several online tools are available to help make data-informed decisions. For more information on weather forecasts, visit the *National Weather Service Climate Prediction Center* for projections of weather conditions from a few weeks to several months into the future. The *UNL Drought Monitor* provides information on current drought conditions as they develop and subside across the United States. For estimates on forage production of grasslands in the northern Great Plains, *Grasscast* provides forecasts based on projected weather variables and previously established plant production and precipitation relationships.

Keeping accurate records of precipitation at the ranch location provides a finer scale understanding of the expected level of precipitation for different times during the year. If long-term weather records are not available, precipitation data from several locations across Nebraska are available at the *High Plains Regional Climate Center*. Long-term precipitation data provide valuable information for estimating plant production and setting trigger dates (i.e., dates when drought management decisions should be

Table 2. Rules of thumb for drought planning with a July 1 trigger date at different levels of precipitation from April through June.

	April through June Precipitation			
	Within 20% of the long-term average	**20% to 35% less than long-term average**	**35% to 50% less than long-term average**	**50% less than the long-term average**
Possible management actions	None	Potential reduction of stocking rate at 5 to 10%	Reduce stocking rate 10 to 25%	Reduce stocking rate 25 to 40%
		Delay Turn out	Sell cull animals	Seek out additional forage options
		. . .	Plan for additional forage	Plan to wean calves early
			. . .	Sell additional animals
				. . .

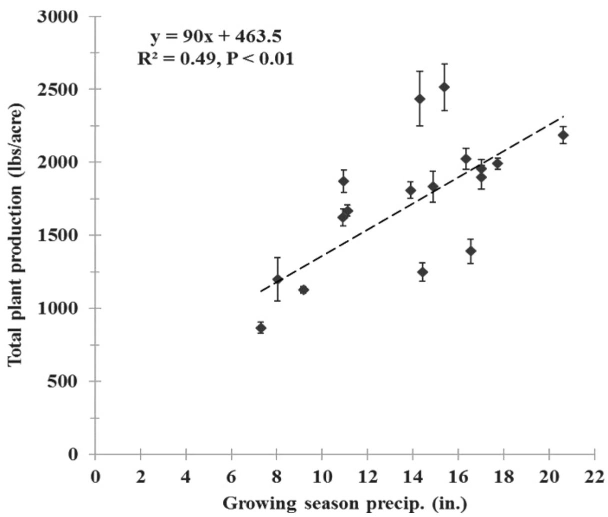

Figure 5. Relationship between total plant production and the amount of precipitation that occurred during the growing season (April 1 to August 15) at the Barta Brothers Ranch from 2001 to 2017.

made) for decisions when drought occurs. For example, if spring precipitation at the ranch is less than 65 percent of the average by June 1, then planning should be in place to either reduce the number of cattle or acquire additional forage resources to compensate for a potential reduction in forage later in the growing season (*Table 2*).

Linear regression analyses provide opportunities to evaluate relationships between precipitation and total plant production observed in previous years. With this analysis, we can develop models that help predict, or make data-driven estimates, on current-year production (See *Figure 5*). The modeled relationship and equation for plant production at the Barta Brothers Ranch indicates that for every inch of precipitation accumulated during the growing season (April 1 to August 15), an additional 90 lb of total plant production per acre can be expected in mid-August.

Some caution should be taken with this model because of the variability in the data and the influence of other weather factors on plant production in a given year. For example, weather variables such as growing degree days, freeze dates, and the timing and frequency of precipitation events can also influence plant production. However, the values within the model provide an estimate of expected plant production with increasing growing season precipitation based on observed values from 2001 to 2017.

Grazing Management during a Drought

The overall objective of sustainable grazing management for livestock production is to maintain or improve the productivity of desirable forage species on rangelands. Repeated heavy grazing during times of drought on Sandhills rangelands is one of the main factors that can influence shifts in plant communities from higher- to lower-producing grass species. However, research at the Barta Brothers Ranch and other locations in the Sandhills has indicated that plant communities in these environments are resilient and typically respond positively when periodic disturbances (e.g., drought or heavy grazing) end and plants are allowed to recover.

Drought plans that include reduced grazing pressure in a drought year and options to allow greater recovery time in years following a drought will help desirable grasses recover. Grazing at moderate stocking rates, altering the time when grazing occurs on pastures in consecutive years, and providing adequate recovery periods can increase root development, and plant vigor, thus minimizing the impact of drought on grass productivity and increasing the ability of the plant communities to maintain proper ecosystem functions during and following drought.

Planning for Drought

While managing through a drought is never easy, developing a grazing plan that includes adaptive management options for drought periods provides a valuable resource for decision-making. More information on developing a drought

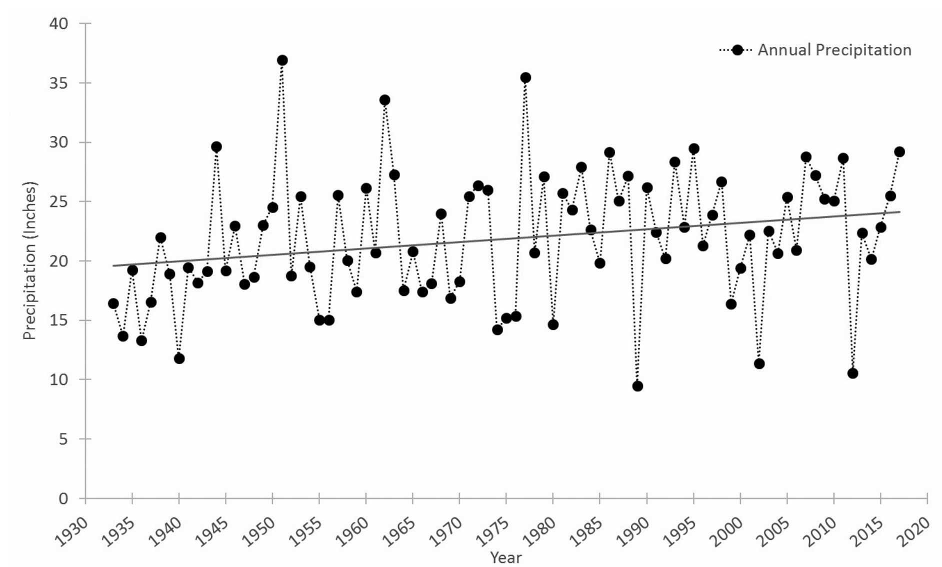

Figure 6a.

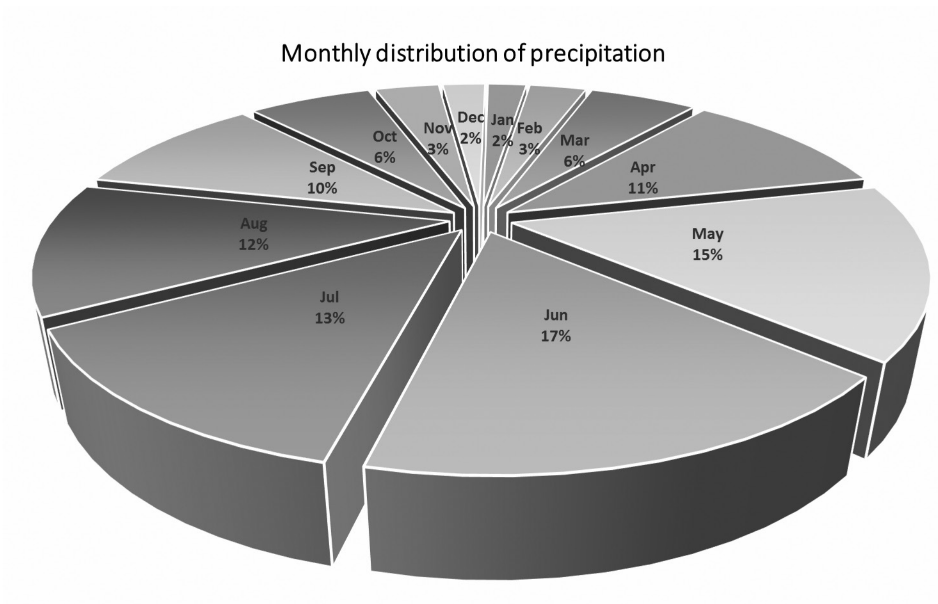

Figure 6b.

plan is available at the *UNL Drought Mitigation Center*. Every ranch scenario is different and the impact of drought will vary by location and previous management. Developing flexibility in your management plan will help reduce the potential negative impacts of drought. Flexible management options can include stockpiling forage as either hay or forage reserve pastures, managing a portion of your pastures with yearlings that can be readily sold during a drought, or stocking a portion of your pastures with outside cattle that can be pulled off pastures when spring and early summer precipitation are below average. Having flexible management options within a grazing management plan will reduce the likelihood of severely overgrazed pastures and limit the need to sell animals from the core cattle herd during periodic droughts.

Including a thorough economic analysis of different management options will help provide insight into the financial influence of drought on a ranching operation.

Questions to consider include:

- What will the cost of hay be during the drought?
- Can I economically feed hay or other commodities during a drought?
- What will I lose if I decide not to sell animals early in the growing season and the drought persists?
- What if I sell animals and the drought subsides?
- How did the last drought affect cattle prices at different times during the growing season?
- How does drought insurance fit into my operation to mitigate the economic risk of drought?
- Can I profitably manage yearlings and cow-calf pairs to provide an added layer of drought flexibility?
- How will overgrazing my pastures during a drought affect future forage production?

Most drought management decisions will have a financial impact, but with proactive planning, there is reduced risk that these decisions will have long-lasting negative effects on the economic sustainability of the ranch.

Summary

From 2001 to 2017, total plant production was less than 75 percent of the average in four years: 2001, 2002, 2006, and 2012. The consecutive years with drought conditions from 2001 to 2003 had the most significant negative effect on total plant production during the study period. For most of the other dry periods, the years preceding and/or following typically had close to average or above average precipitation. These average or wet periods were important for pasture recovery following the drought years.

Long-term precipitation records indicate that severe multiyear droughts (i.e., several years with below average precipitation) have occurred at different times over the last century (see *Figures 6a* and *6b*). Several shorter-term droughts have lasted one to two years. We saw these types of droughts from 2001 to 2003, in 2006, and in 2012. Extreme multi-year droughts have not been frequent in the recent past at the Barta Brothers Ranch, but they may become more common under projected climate change scenarios and should be prepared for in long-term ranch management plans.

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Referenced Links

Society for Range Management Glossary: *globalrangelands.org/glossary*

Grazing Systems for Nebraska Sandhills Rangeland: *extensionpublications.unl.edu/assets/pdf/ec127.pdf*

National Weather Service Climate Prediction Center: *http://www.cpc.ncep.noaa.gov/*

UNL Drought Monitor: *http://droughtmonitor.unl.edu/*

Grasscast: *http://grasscast.agsci.colostate.edu/*

High Plains Regional Climate Center: *http://hprcc.unl.edu/index.php*

UNL Drought Mitigation Center: *http://drought.unl.edu/ranchplan/Overview.aspx*

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