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East Foundation

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We promote the advancement of land stewardship through ranching, science, and education.

# Don't Gamble on Stocking Rate: Knowing the Odds Makes for Better Bets

*Insights from the Coloraditas Grazing Research and Demonstration Area*

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## INTRODUCTION

The grazing of livestock, a primary use of rangelands, is also a powerful and fundamental tool for land managers. While forage growth is dependent on rainfall and site characteristics that are beyond the control of managers, **stocking rate** (the number of animal units (AU) per land area per unit of time) is the direct result of a (hopefully) informed managerial decision. Determining stocking rate is a primary way that managers deploy grazing strategy into their larger land management plan. Considering the implications of this decision can help land managers and owners better incorporate livestock production, wildlife habitat management, and other land resource goals into a broader plan that improves the efficiency and sustainability of the operation.

Stocking rate is an index of forage demand by grazing animals. Selecting a stocking rate implies a forecast of forage growth for that season or year. Because the 'average' is a measure of the 'expected value' of **forage production**, using average forage production to establish stocking rates is reasonable. However, averages are comprised of a range of values, and this annual variability creates risk of system failure – no single year is necessarily 'average.' To make effective management decisions, the likelihood of outcomes should be considered; the 'best' decision still has some risk of being 'wrong' when reality sets in.

Because stocking rate decisions have such a large impact on both the short-term productivity and long-term sustainability of a ranching system, managers need information that provides a clear understanding of the level of risk that is being accepted for a given stocking rate. The appropriate level of risk depends on operational objectives and capacity to adapt to evolving conditions. By understanding the likelihood of outcomes for different stocking rates, and the capabilities of the ranch to cope with these outcomes, managers can make more effective stocking rate decisions and develop robust contingency plans.

## BACKGROUND

East Foundation established the 18,538-acre Coloraditas Grazing Research and Demonstration Area (CGRDA or 'Coloraditas') on the northern portion of the San Antonio Viejo Ranch as a living laboratory for ongoing, long-term studies of the interactions of livestock grazing management and wildlife populations on South Texas ranches. Currently in Phase II of the long-term study, the area is subdivided into 10 pastures used in grazing studies and resulting demonstration efforts and supports diverse wildlife populations with species and abundance similar to the surrounding region. The long-term commitment to this effort includes a number of forage, vegetation, livestock, and wildlife measurements collected regularly to build a data repository that can be used to develop management strategies and improve decision making processes for land managers. This effort, and data from it, are foundations of the information in this bulletin. Related materials are available ***here***.

## CONCEPTS

Classical methods of establishing stocking rates are based on ***expected*** annual forage production (growth), and the amount of that forage production that can be consumed by livestock (**carrying capacity**). Leaving some **residual forage** is important for soil protection and plant health; a target of 50% of annual growth is the most common recommendation. It is also assumed that of the forage that disappears, only half is consumed by livestock. Therefore, the 'take half, leave half' approach to setting stocking rates aims to set livestock grazing demand at 25% of annual forage growth, also described as 25% **harvest efficiency**. Alternative recommendations based on ecological site have also been proposed, such as minimum residual forage levels of 750 pounds per acre for **mid-grass rangelands** like those with precipitation regimes common to South Texas; in this environment the minimum residue approach to setting stocking rates results in similar estimates as the 'take half, leave half' approach.

The challenge with these methods is reliance on forage growth data that are difficult to acquire, and which are even more difficult to predict due to highly variable rainfall across a ranch or across years. If the grazing strategy is based on long-term averages, then for any given year the ranch may be overstocked (if actual forage growth was below average) or understocked (forage growth exceeded expectation). Both have consequences for the short- and long-run productivity of the ranch. The frequency of these conditions for a chosen stocking rate represents the 'risk' in the outcome.

An important part of the overall grazing strategy is how management reacts and responds to forage surplus or deficits. If excess growth accumulates, to be consumed when new growth is below expectation, then a fixed stocking rate at the long-term mean of forage production is a viable strategy. If there are 'storage losses,' where excess forage is not carried over effectively, then a downward adjustment in stocking rate might be necessary to offset these losses. This is thought to be a 'conservative' stocking strategy, in which carryover accumulation, discounted for losses, is enough to offset low production years and allow grazing to continue without rangeland degradation from overgrazing.

## RESEARCH OUTCOMES

Using observed rainfall from the NOAA weather station at Hebbronville, Texas, from 1907 through 2015, **probability distributions** of annual rainfall were constructed (Figure 1). Many people are familiar with the 'normal' distribution, often described as a symmetrical 'bell-shaped curve', where the probability of observations a given distance above and below the mean are the same. The distribution that best described annual rainfall was a **gamma distribution**, an altered version of the bell-shaped curve which does not have to be symmetrical and can accommodate the skewed rainfall distribution at this location. (Notice in the figure that the curve is not a perfect 'bell' – it is stretched out a bit on one side; it is skewed). Using this approach to evaluate rainfall data allows one to quantify the likelihood of receiving (or failing to receive) a given amount of rainfall at the location of interest. With sufficient historical rainfall data, a similar distribution can be described for any location.

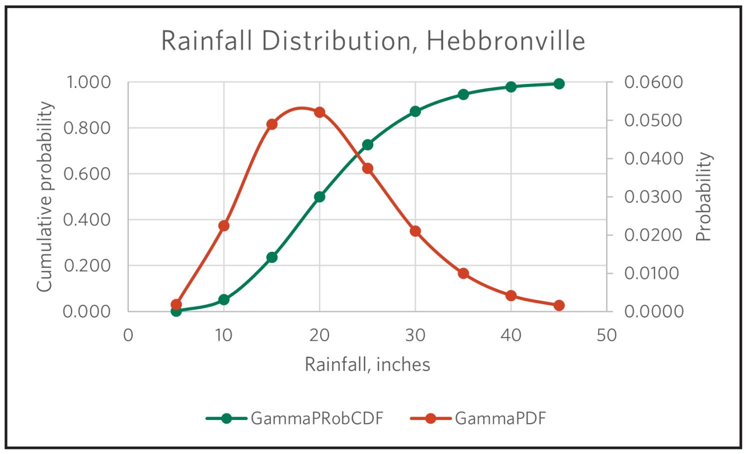


**Figure 1.** Probability density and cumulative density functions for annual precipitation, Hebbronville, Texas. The probability density function displays the probability (right axis) that a given amount of rainfall will be observed. For example, only 5.2% of years had exactly 20 inches of rainfall. The cumulative probability function displays the probability of occurrences up to a given amount, and the converse, the likelihood of exceeding a given amount. Again, at 20 inches, 50% of observed years had rainfall below this amount, and 50% above.

Rainfall is related strongly to forage growth. With data collected from the Encino Division of King Ranch and the San Antonio Viejo Ranch across several wet and dry years, the relationship between forage growth and total annual rainfall was estimated. Using this relationship, the amount (and range) of forage production expected for a given level of rainfall can be estimated (Figure 2). Also shown is the relationship between total forage production for the year and rainfall received in March, April, May, and June each year. This relationship is stronger but may not account for years with a pronounced fall growing season.

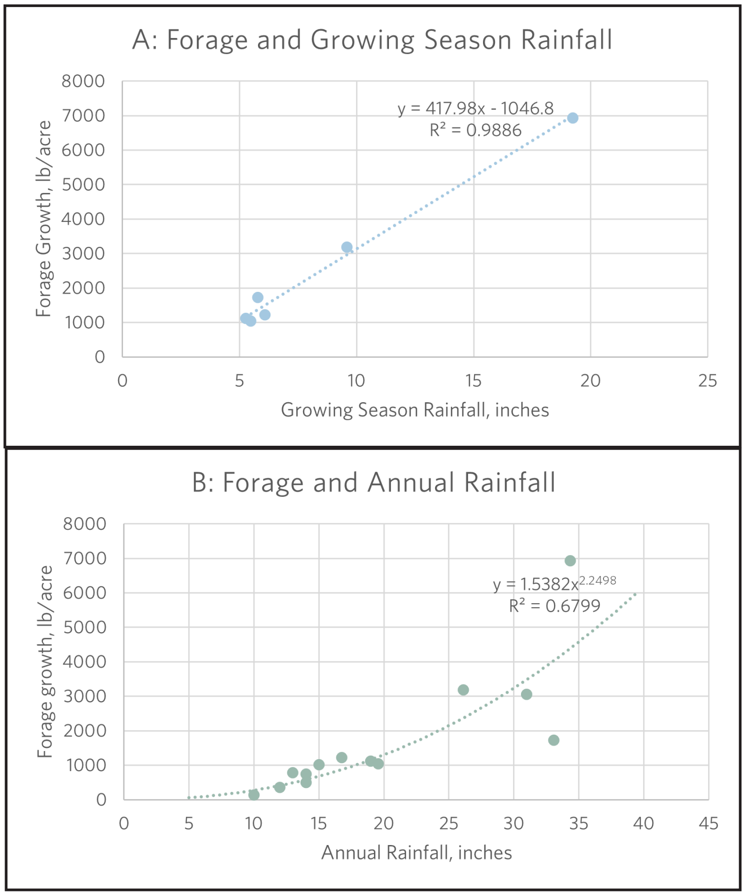


**Figure 2.** Relationships between annual forage production and growing season (March through June) rainfall (Panel A) or total annual rainfall (Panel B) on the King Ranch Encino Division and the East Foundation San Antonio Viejo Ranch, South Texas. These figures use rainfall during the growing season (March through June) or the entire year to predict total forage growth. Because forage growth is challenging to measure directly, but most managers keep track of rainfall, precipitation can be a useful indicator. These graphs quantify that relationship and show that every inch of growing season rainfall results in about 400 pounds per acre of additional forage, with a high degree of precision (over 98% of the variance in forage was explained by rainfall). The relationship between annual rainfall is more complex – it is a curve instead of a straight line, and not as precise an indicator (82% of the variance explained by the relationship), but still useful.

Because a stocking rate is really an index of total forage demand, then the above relationship can be used 'in reverse' to estimate the amount of rainfall required to produce at least the required amount of grazeable forage. Once the rainfall amount is known, the distribution can be used to determine the likelihood of a forage shortfall due to lack of precipitation. Therefore, the risk associated with a stocking rate decision can be evaluated (Table 4).

Table 4. Implications of stocking rate choice and associated risk related to precipitation variation. Forage measurements are expressed as pounds per acre, rainfall is expressed in inches. Italicized rows are stocking rates evaluated in the Phase I project, Coloraditas Grazing Research and Demonstration Area, San Antonio Viejo Ranch.

| Acres per Animal Unit (AU) | Implied Forage Production | Implied Rainfall | Risk of Overuse |
|---|---|---|---|
| 20 | 1898 | 23.7 | 67% |
| *35* | *1085* | *18.5* | *42%* |
| *50* | *759* | *15.7* | *27%* |
| 65 | 584 | 14.0 | 19% |
| 100 | 380 | 11.6 | 9% |

The 35 ac/AU stocking rate is, by most standard definitions, a moderate stocking rate for this area based on expected average forage production. The implied expectation is about one inch below the median rainfall. However, because of the high year to year variation in rainfall, in four of 10 years the system will be 'overstocked' to some degree. Reducing stocking rate to 50 ac/AU reduces this risk, placing the implied expectation of rainfall at approximately 75% of historical average, which is the threshold definition for drought.

However, the risk of not achieving this amount is only reduced to 2.7 out of ten years, which may not be as 'conservative' as managers believe; this difference is equivalent to three inches of rain during the year. As an example, in a three-year study conducted using these stocking rates on the Coloraditas Grazing Research and Demonstration Area of the San Antonio Viejo Ranch, rainfall in two of the years was high enough that both stocking rates performed well. However, in the third year, rainfall was low enough that neither stocking rate could be sustained, and cattle were removed to avoid damage to the range resource. To reduce this risk to one in 10 years, management would have to accept a production level of only one-third that of the 'average' stocking rate. While the risk profile may be attractive, this strategy sacrifices significant livestock production potential.

### TAKE HOME MESSAGE

Selecting a stocking rate implies an expectation about forage growth and rainfall. Using available information, the risk of failing to achieve the forage supply implied by a given stocking rate can be estimated. Our efforts on the Coloraditas indicate “moderate” stocking rates in South Texas might be in excess of forage supply in four of 10 years, and even those stocking rates considered “light” are likely to generate forage demand in excess of growth in three of 10 years.

Managers can use the risks associated with different stocking rates to generate contingency plans while selecting stocking rates that balance livestock, wildlife, and rangeland management objectives. An analysis of risks associated with stocking rates considered ‘typical’ for the region suggest that adaptive strategies should be adopted, and that they may improve the sustainability of ranching in South Texas.

Grazing research on the Coloraditas study site continues as part of the long-term study (now in Phase II), and future data acquired from the study will be provided in future East Foundation Management and Technical bulletins, articles, and related reports.

## SUGGESTED CITATION

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### CONTRIBUTOR

JASON SAWYER, Ph.D. is the Chief Science Officer for the East Foundation in San Antonio, Texas. He leads the Science mission of the Foundation, integrating research programs within the Foundation’s ongoing ranching operations to develop translatable knowledge and innovative solutions for stewards of working lands.

Jason has over 20 years of experience in applied research and management, where he has led and coordinated applied research in livestock production systems in both intensive and extensive settings. His primary interests are the development of strategies to enhance the sustainability of beef production systems, the application of nutritional strategies in these systems, and the development of valid indicators of sustainable production.

Previously, Jason served as Associate Professor and Research Scientist at the King Ranch® Institute for Ranch Management, where he worked to develop innovative solutions in ranching systems. He has also served in research, teaching, and management roles at Texas A&M University’s Department of Animal Science and the McGregor Research Center, and in research and extension roles at New Mexico State University’s Clayton Livestock Research Center.

Jason has a B.S. in Rangeland Ecology and Ranch Management from Texas A&M University, and M.S. and Ph.D. degrees in Range Nutrition and Beef Cattle Management, both from New Mexico State University. He has authored or co-authored over 120 peer-reviewed and invited publications, over 250 abstracts, proceedings, and technical reports, and given over 125 presentations at meetings, workshops, and conferences.

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