Understanding pasture management and supplementing grazing cattle

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Introduction

Managing cattle on pasture is essential to profitable beef cattle production for many operations. Forage is the primary feedstuff for beef cattle and grazed forage is generally the least expensive source of nutrients. Maximizing use of grazed forage is a top goal for beef cattle operations, but forage does not always meet the nutrient requirements of the animals. Pasture and grazing management are key to maximizing the use of grazed forage. Management practices include agronomic practices to maximize production of forage, though this will not be the topic of this paper, as well as grazing practices to maximize consumption of grazed forage by the animal. However, care must be taken not to overgraze the forage plants as that can be detrimental to future forage production. Additionally, knowing when, what, and how much supplement to provide cattle at critical times of the production cycle allows rumen microbes to maximize fermentation of the forage material. The purpose of this paper is to provide an understanding of the principles of grazing management and supplementing beef cattle on pasture.

Grazing terms

Stocking rate and stocking density are often used interchangeably, but they are somewhat different and imply different meanings. Stocking density is defined as the number of animals per unit of land area such as 0.5 steers per acre[1]. However, stocking rate involves an aspect of time and is defined as the number of animals per unit of land area per unit of time such as 0.5 steers per acre per month. In many cases, stocking rate and density are expressed in animal units, which is an arbitrary unit used to equate grazing animals of different types. Typically, an animal unit has been defined as a 1,000-lb cow, but more important than body weight is the forage demand of the animal. The animal unit allows the ability to equate forage demand of different animals so that grazing pressure is understood when comparing different animals. In forage demand, an animal unit is defined as 26 lb of dry forage demand, and the associated animal units of different classes of livestock are adjusted according to their expected dry forage intake per day (Table 1). Since animal units are based on forage demand, carrying capacity of the land is often expressed using animal units along with a unit of time. For example, one animal unit day (AUD) is 26 lb of dry forage and one animal unit month (AUM) is 780 lb of dry forage.

Three terms are used to describe the amount of forage used by the animals during grazing. Utilization is defined as the percentage of the forage produced that is consumed and trampled by livestock and other wildlife; the remaining forage is called the residual forage or residue (Figure 1). Harvest is defined as the amount of the forage consumed by livestock, and harvest efficiency is the percentage of the forage produced that is consumed by livestock. Grazing efficiency is the percentage of the forage utilized that is consumed by livestock. For example, if 1,000 pounds of forage is produced and 400 pounds of forage is remaining after grazing, then the utilization is 60%. If the livestock consumed 300 pounds of forage, then the harvest efficiency is 30% and the grazing efficiency is 50%. Thus, grazing management systems are designed to increase grazing efficiency such that harvest efficiency is increased while maintaining optimal utilization.

Grazing management

Two primary goals of grazing management are 1) to maximize consumption of highly nutritious forage, and 2) to optimize utilization to maintain plant vigor and forage stand persistence. Maximizing consumption of highly nutritious forage is important to meet nutrient requirements of grazing livestock since grazed forage is typically the least expensive feedstuff available. Optimizing utilization is a balance between maximizing grazing days from the forage produced and minimizing plant stress to allow for adequate regrowth and survivability. By overgrazing plants (i.e., not leaving enough leaf area for adequate photosynthesis), plants must pull carbohydrate stored in the roots for energy to regrow, thus weakening the plant's ability to pull water and nutrients from the soil in the near future. If environmental stressors occur shortly after overgrazing the ability of the plant to survive is lessened. Additionally, by overgrazing plants over the entire season, there is less plant material to cover the soil leading to erosion and nutrient loss. Lesser plant material left at the end of the grazing season results in less organic matter going back into the soil leading to reduced water holding capacity, fertility, water infiltration, and microbial activity. Forage plants differ in grazing tolerance where some species can be utilized at greater levels than others (Table 2). For example, native prairie should not be utilized more than 50% otherwise negative impacts on plant vigor and persistence may occur, whereas many introduced forage species can be utilized upwards of 65 to 75%.

The crucial factor in managing grazing is stocking rate – how much forage demand for how much time (i.e., animal unit days). In order to get a handle on stocking rate, an estimate of annual forage production is necessary. There are some different ways to estimate forage production: 1) direct measurements, 2) indirect measurements, and 3) calculated estimation. A couple of ways to measure forage production is to use some cattle panels and create a few grazing exclosures in the pasture. Then using either a forage square (direct measurement) or forage stick (indirect measurement) determine the amount of forage in the grazing exclosure at the end of the growing season. A less precise method is to calculate the amount of forage produced based on previous grazing days. The following formula can be used

$$Pounds\ of\ forage\ produced\ per\ acre = \left[\frac{(number\ of\ grazing\ days\ \times number\ of\ animals\ \times expecteddry\ forage\ demand\ per\ day}{harvest\ efficiency}\right] \div number\ of\ acres$$

However, a good estimate of harvest efficiency is needed.

Grazing planning

After determining the annual forage production and appropriate stocking rate, a grazing management plan can be developed to improve grazing efficiency. The three tools that managers can use are 1) duration of grazing/rest periods, 2) stocking density, and 3) frequency of grazing, which are somewhat interrelated. Duration of the grazing period influences harvest efficiency (Figure 2) such that shorter periods result in a greater percentage of forage being consumed. When cattle are given limited amounts of forage, they tend to focus on eating and waste less. This has been seen with limiting the amount of hay provided to cattle or the time cattle have access to hay[2–4].Duration of the rest period is critical to prevent overgrazing. For example, think about the case of continuous grazing, where a herd of livestock have access to the entire pasture for the full length of the grazing season. Livestock will graze the most palatable plants, which in the case of continuous grazing is the regrowth of plants previously grazed resulting in some plants being only lightly grazed and some plants being overgrazed. And those plants that are overgrazed have little time to rebuild energy reserves before being grazed again causing loss of plant vigor and the forage stand. The ideal duration of the grazing period would result in all plants being grazed only once. The duration of the rest period must be long enough for the plants to recover from the previous grazing event and rebuild energy reserves.

In order to provide enough rest periods following grazing, there must be an adequate number of paddocks to graze before grazing the same area again. The number of paddocks necessary can be computed using the following formula

$$Number\ of\ paddocks = \left[\frac{Days\ of\ rest\ per\ paddock}{Days\ of\ grazing\ per\ paddock}\right] + 1$$

As the need for longer rest period relative to the length of the grazing period to provide adequate recovery time, the number of paddocks increases (Figure 3).

Grazing frequency is important both within grazing periods and between grazing periods. Plants can be grazed multiple times within a grazing period as long as the leaf regrowth is not being removed. Frequency of grazing between grazing periods is a balance of allow enough rest for plants to recover while maintaining highly nutritious forage for the animals to consume – too frequent grazing bouts will not allow time for the plant to recover adequately, and too infrequent grazing bouts will result in mature forage of low nutritional value. Grazing frequency is dependent upon the number of paddocks and the length of the grazing and rest periods in a set rotational grazing pattern.

Stocking density is another key management tool to increase grazing efficiency with increasing harvest efficiency as stocking density increases (Figure 4). As stocking density increases utilization increases to the point determined by the overall stocking rate, and the proportion of utilized forage that is consumed (i.e., grazing efficiency) increases. If the number of paddocks is planned correctly, then the stocking density and duration of the grazing period are related such that shorter grazing periods means greater stocking density.

Grazing systems

Grazing systems attempt to put the 3 management tools (duration, frequency, and stocking density) into a 'system' that anyone can follow; however, there are some problems with that which we will discuss in a later section. There are many different grazing systems out there that can be categorized in many different ways, but one way is continuous, pre-determined, and adaptive. Continuous grazing is the simplest system in which cattle are allowed access to the entire pasture on a specific date and removed from the pasture on a specific date. In a continuous grazing system, none of the management tools are being used to affect grazing and only stocking rate is determining utilization.

In predetermined systems, the duration, frequency, and stocking density are determined when the grazing plan is laid out at the beginning of the grazing season. Some predetermined systems are 12-paddock rotational, deferred-rotational, rest-rotational, etc. These systems follow a pattern of moving cattle to a new paddock after a preset number of days, having a set number and size of paddocks,and grazing paddocks in a preset sequence.

In adaptive systems, the duration, frequency, and stocking density are fluid throughout the grazing season depending upon changing conditions. Paddock sizes may fluctuate depending upon the desired duration of grazing, stocking density and/or duration may change depending upon the desired grazing pressure, or frequency may change depending the environmental conditions and the necessary rest period. Adaptive grazing systems are not really systems, but rather application of the management tools to the current conditions such that the operational objectives can be achieved.

Nuances

Application of the 3 management tools cannot be prescriptive and may not result in the same outcome depending upon differences in the conditions, and this is a large part of why pre-determined grazing systems fail. The first factor is the availability of nutrients in the soil such as water, nitrogen, and phosphorus to allow the plant to regrow leaf area.Soil moisture is a key factor in regrowth of plants after grazing. In wetter environments, regrowth after grazing is generally consistent but in semi-arid and arid environments precipitation is more sporadic potentially resulting in long periods of low soil moisture. In a predetermined grazing system, pastures would be grazed too frequently when precipitation is lacking and possibly too infrequently when precipitation is abundant.

Another factor is the physiology of the forage species. Cool-season forages such as tall fescue grow rapidly in the spring and put up reproductive seed-heads in late spring. Thus, long duration and infrequent grazing results in forage plants in other paddocks that mature quickly and have low nutritive value – short duration and frequent grazing is needed to remove reproductive plant parts during the spring. However, the response is not the same for all cool-season forages. For example, removing reproductive plant parts will stimulate more regrowth in tall fescue than in smooth bromegrass.

Warm-season forages such as bluestems and switchgrass grow rapidly in late spring and summer putting up reproductive seed-heads in late summer. Thus, short duration frequent grazing is not necessary to remove rapidly maturing reproductive plant parts, and in fact, frequent grazing can be more detrimental to native grasses such as bluestems and switchgrass – longer duration, infrequent grazing works better for these forage species.

Heterogeneity within the confines of the ranching operation also impacts the implementation of grazing management and responses to grazing systems. With native prairies the plant community is highly diverse and cattle have preferences for some plant species over others. Low stocking density can result in only the preferred species being grazed or long duration and frequent grazing can result in overgrazing of preferred species and thus, grazing needs to be monitored and adjusted. Additionally, large ranches can have differences in soil type, land slope, and elevation across the ranch that results in different composition of forage plants and forage productivity. Grazing each area of the ranch the same may result in undergrazing some areas and overgrazing other areas. In contrast, smaller ranches with monoculture forage species generally have similar forage productivity across the ranch and less animal preference among forage plants.

In previous research, predetermined/prescriptive grazing systems have increased stocking rate and/or animal performance on small acreages with monoculture forage species[5–8]; however, they have not provided similar benefits in heterogeneous native rangeland systems[9]. Native rangeland systems are typically of larger scale with landscape differences in forage productivity, are in semi-arid and arid regions of the country where soil moisture changes dramatically and is not consistent from year to year, and have a diverse plant community where animal preferences impact forage plants within the pasture differently. Therefore, grazing management must be adaptive to be successful across production environments particularly in the semi-arid and arid native rangelands.

Supplementation

Terms

There are different fractions of protein in feeds that are digested differently in the gastrointestinal tract of cattle. One fraction is termed rumen degradable protein (RDP) and is the fraction of feed protein broken down by rumen microbes. Rumen microbes use RDP for their own protein requirements providing them the protein needed to digest carbohydrates and fats. The RDP fraction is the most critical for stimulating forage digestion. The other fraction is termed rumen undegradable protein (RUP) and is the fraction of feed protein that passes through the rumen without being digested. This fraction is mostly digested in the abomasum and small intestine providing feed protein directly to the animal. The amount of total crude protein as well as the proportion of RDP and RUP differs among feedstuffs. Non-protein nitrogen (NPN) is also found in feedstuffs in the form of ammonia, nitrate, and nitrite, or can be added to feed mixes as urea, ammonium nitrate, ammonium chloride, and others. Non-protein nitrogen is a rumen degradable providing nitrogen to the rumen microbes that they convert to amino acids and protein, and thus is a source of RDP.

Fiber is the termed used for structural carbohydrates that compose the plant cell wall, which includes pectin, hemicellulose, and cellulose. The amount of fiber increases as the plant matures and the proportion of the components changes such that cellulose becomes are larger proportion and pectin and hemicellulose become lesser proportions. Pectin and hemicellulose are more digestible than cellulose. Starch is the term used for non-structural carbohydrates stored in seeds and is composed of amylose and amylopectin. Plant material generally has little starch compared to seeds.

Energy is not a chemical compound that can be measured in feedstuffs, but rather what animals get from metabolism of carbohydrates, proteins, and fats in feedstuffs. An energy schematic is presented in Figure 5. Total digestible nutrients (TDN) is a termed used in cattle nutrition that is the sum of the digestible protein, fat × 2.25, fiber, and starch. The TDN of feeds is generally equivalent to the digestible energy concentration. Metabolizable energy (ME) is the amount of energy available for metabolic functions and net energy (NE) is the amount of energy available for productive functions – maintaining body tissues and producing new products (tissues or milk).

Supplementing grazing cattle

When supplementing grazing cattle, there are 3 pieces of information needed: 1) typical times of nutrient deficiency during the production cycle, 2) nutrient composition of available feed resources, and 3) when, what, and how much supplement. The times of nutrient deficiency depend on when the calving season begins and what the plantspecies comprise the forage resources. For example, a spring calving cow herd with a native prairie forage base will generally be deficient in TDN from November through April and will be deficient in protein from July through April. However, if the same cow herd was grazing tall fescue pasture, cows would be marginally deficient in TDN during July and August and never deficient in protein.

The nutrient composition of some common feedstuffsare presented in Table 3 and a more comprehensive list can be found athttps://dairyone.com/services/forage-laboratory-services/feed-composition-library/. Corn and soybean hulls are low in protein for use as a supplement to grazing cattle. They have adequate protein if a large part of the diet, but in small amounts do not provide much protein. Soybean meal and corn distillers grains are better sources of protein; however, they differ in the proportion of RDP and RUP. At the same feeding rate, soybean meal will provide more nitrogen to the rumen microbes for forage digestion. Most of the carbohydrates in corn are in the form of starch (non-structural), but soybean hulls and distillers grains have little starch and greater concentration of fiber. Too much starch in the diet of cattle fed forages can have negative effects on microbial digestion of forage cell wall, and so we generally try to use feedstuffs that are high in highly digestible fiber to supplement energy, in the form of carbohydrates, to forage-fed cattle. Forage digestibility can be decreased when as little as 0.35% of body weight in starch is fed. As mentioned previously, fiber is composed of pectin, hemicellulose, and cellulose. The proportion of total fiber, measured as neutral detergent fiber (NDF), that is cellulose greatly impacts fiber digestibility. Soybean hulls and distillers grain's fiber is primarily pectin and hemicellulose and is highly digestible such that digestibility is 75 to 85% for these feeds. In contrast, fiber in forages is primarily cellulose, except when very young and lush, resulting in digestibility of 50 to 65%. Therefore, high fiber grain byproducts like soybean hulls and distillers grains are good supplemental feeds for grazing cattle because they provide a lot of energy with little starch.

Making the decision to supplement involves asking when, what, and how much. Figure 6 provides a guide to help in making the decision of when, what, and how much to supplement. Supplementation is necessary when the forage alone does not meet the nutrient requirements of the animal. Sometimes this is due to an interaction between the protein and energy available in the forage. In general, when forage protein drops below 7%, nitrogen availability in the rumen is limiting the ability of rumen microbes to digest forage cell wall. The cell wall is readily digestible but the microbes need more nitrogen to grow and reproduce, and in this situation a small amount of supplement to provide additional rumen degradable protein/nitrogen results in a large increase in forage digestibility.

What to supplement depends on whether protein, energy, or both are deficient. When forage protein is less than 7%, rumen degradable protein is needed in the diet. When rumen degradable protein is adequate either in the forage or through supplementation and the forage cell wall is still not well digested, then supplemental energy is needed and should be provided in the form of highly-digestible fiber rather than starch. A good method to determine which is the case is based on fecal pats. If the fecal pat is dry, hard and mounded, check forage crude and if found to be less than 7%, start with protein supplementation. If dietary protein is adequate and the fecal pat is dry, hard and mounded, then the rumen microbes are digesting the forage as best they can and supplemental energy is needed. Additionally, the color of the forage provides a reasonable evaluation of whether the protein concentration is above or below 7%.

How to supplement depends upon what is being supplemented, protein, energy or both, and the amount of forage available for consumption. If protein is the only nutrient lacking, small amounts (0.1 to 0.3% of body weight) of a high (>32%) protein supplement will work. However, if additional energy is needed due to lack of forage or cows needing to gain weight, the a greater amount of a moderate to low protein supplement will more cost effectively meet the nutritional requirements of the cows.

Conclusions

Managing pastures and grazing involves controlling grazing pressure through overall stocking rate (animal unit days) as well as controlling the defoliation of plants within space and time though stocking density, duration of the grazing period, and frequency of grazing individual paddocks. There are many different grazing systems developed and promoted but a single system likely doesn’t work for every ranch or even every year on a ranch. The best approach is to understand the principles of the 3 management tools to control defoliation allowing adaptation to different situations and environmental conditions on the ranch.

Supplementing grazing cattle should focus on maximizing digestion of grazed forage and filling nutritional gaps for the cattle. Knowing when cattle are likely to be deficient in energy and protein, what feedstuffs provide the correct nutrients, and how much feed to provide are the keys to a successful supplementation program. In general, supplementation should focus on providing enough rumen degradable protein for the rumen microbes to digestion the available forage and, if needed, providing highly-digestible fiber feedstuffs for additional energy.

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Figure 1: Illustration of grazing terms referring to the percentage of forage utilized and harvested by grazing livestock. 50% of the mass is not equal to 50% of the height. Adapted from Carter et al.[10]Picture from https://www.freepik.com/premium-vector/green-grass-background-with-white-background-green-grass-background_354678629.htm

Figure 2: The effect of grazing period duration on harvest efficiency. Data based on tall fescue pastures under high utilization. Adapted from Gerrish and Roberts[11].

Figure 3: The percentage of time spent grazing and resting each paddock depending upon the number of paddocks. Adapted from https://kerrcenter.com/oklahoma-sustainable-livestock/cattle/fence/

Figure 4: Change in utilization and harvest efficiency with increasing stocking density. Adapted from Smart et al.[12]

Figure 5: Illustration of the energy losses during digestion and metabolism of feed. Adapted from Ferrell[13].

Figure 6: Decision guide for supplementing grazing beef cattle. BW = body weight; CP = crude protein. Adapted from Mathis and Sawyer[14].