Matching Pasture Production and Animal Demands

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Inland Pacific Northwest Pasture Calendar, Appendix Chapter 1, reprinted by permission of Washington State University Extension

Introduction

The amount and quality of forage produced by pastures changes throughout the year due to seasonal differences in temperature and moisture, and physiological changes that occur in maturing forage plants. Forage production often does not line up with animal feed requirements throughout the year. This paper will cover how the production and quality of different types of forage plants change over the year and how you can better match animal demand and plant production.

Forage Production

Plant growth requires the availability of moisture, heat, and sunlight. These resources tend to change over the seasons. In many locations around the globe including the intermountain west, moisture tends to be scarce when heat and sunlight is plentiful and vice versa. Different groups of forage plants have developed different adaptations and strategies to manage limited resources. These different strategies result in different seasonal patterns of growth for cool-season vs. warm-season species, grasses vs. legumes, and annuals vs. perennials. Adjusting the amounts of these different types of forages on the farm can help achieve forage production that is better matched to animal demand (Figure 1).

Cool-season species are adapted to grow well when temperatures are low, but water is plentiful and can be used efficiently. Higher temperatures increase evapotranspiration rates so a plant has to use more water to grow. Cool season perennial grasses can begin growing when temperatures are around 41 °F (4.4 °C) and are most productive when temperatures are between 60 °F (15.6 °C) and 80 ° F (26.7 °C). These grasses grow fastest when temperatures warm up in the spring. When temperatures peak in the summer, cool-season grasses are adapted to go dormant to survive limited water avail- ability. Even with irrigation, growth will slow during what is often referred to as the “summer slump.” Production increases again when temperatures begin to cool in the fall.

Cool-season winter annuals primarily grow in the fall and spring, but compared to cool season perennials, the growth of annuals is shifted more toward the winter. This means they can be used to provide extra forage early in the spring and later in the fall, extending the grazing season and reducing the need for hay.

Perennial legumes have deep tap roots that help them reach water stored deep in the soil profile, so they can maintain higher growth rates during the heat of the summer. Legumes such as clover and alfalfa tend to prefer warmer temperatures than cool season grasses. Legume growth follows a pattern that is similar to cool season grasses, but it begins later in the spring, ends earlier in the fall, and is more uniform throughout the summer, with a smaller drop in production in the heat of the summer.

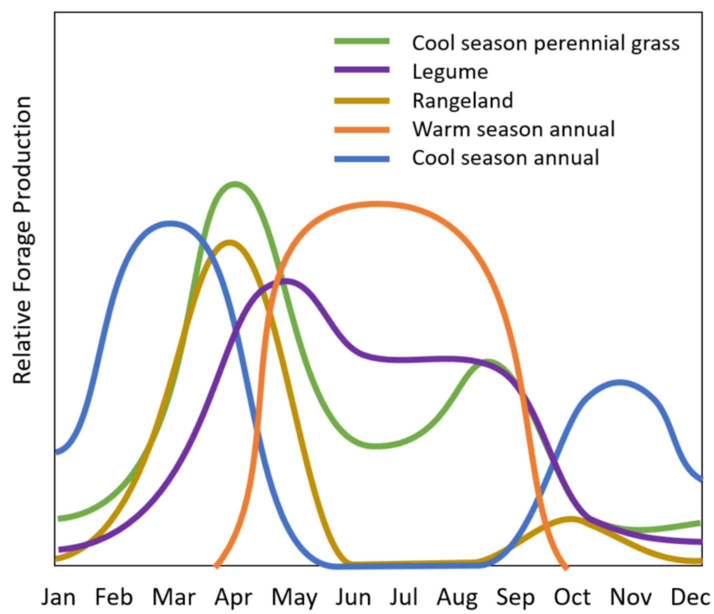

Figure 1. Seasonal variation in forage production for groups of forages. Different types of forages are productive at different times of the year.

Warm season species have adaptations that allow them to use water more efficiently during the summer. This allows them to take advantage of warm temperatures and abundant sunlight during mid-summer. Growing some warm season forages can help ensure that plenty of forage is available during the summer when cool season forages decline in productivity.

Rangelands are a source of forage for many livestock producers in the inland Pacific Northwest. Range adapted plant species often have a cool season growth strategy that allows them to utilize water from winter precipitation as the weather warms in the spring. In many areas, spring growth has largely completed by June because the plants run out of water. Fall forage production is dependent on precipitation and is often minimal. While forage production on the range occurs during a short time period, this forage is often utilized over a more extended period.

Forage Quality

Forage quality depends on several interacting factors including temperature, forage maturity and leaf to stem ratio. Because forage quality declines as plants grow and mature (Figure 2), producers must balance trade-offs between forage yield and quality. Management factors including the timing and height of cutting or grazing can be used to help maintain more consistent forage quality.

Temperature is the most consistent factor controlling forage quality. During the high temperatures of midsummer, forage quality declines along with productivity of cool season perennial grasses and legumes during the “summer slump”. While quality changes in response to temperature occur within species, warm season species generally have lower quality than cool season species.

The tissues of forage plants differ in their forage quality. Leaves, where photosynthesis takes place, are generally high in protein because the machinery for photosynthesis is high in protein. Stems are low protein and high in fiber to fill their role in structurally supporting the leaves (Figure 3). Because of these differences, a leafy plant will have higher quality than a stemmy plant.

The ratio of leaves and stems changes as plants grow and mature (Figure 3). During initial growth or regrowth, leaves are preferentially produced so that the plant can photosynthesize. Next, the plant begins to produce stems to hold new leaves above the canopy. Eventually, leaf production begins to level off once the plant has a full canopy because higher, newer leaves will shade lower, older leaves, causing older leaves to die. Perennial ryegrass, for example, will have at most three leaves per stem. The timing of these changes differs between species. Cool season grasses will have about 50 % leaves and 50 % stems at the boot stage, while this will occur at the bud stage for legumes.

Both leaf and stem tissues decrease in quality as they mature due to changes cell wall composition. Cell contents are highly digestible and largely made up of non-structural carbohydrates, as well as fats and proteins. Cell walls are structural and made up of slowly digestible and indigestible compounds such as cellulose, hemi- cellulose and lignin. Primary cell walls form when cells first develop, but secondary cell walls form after the cell has grown to its final size and begins to mature. When secondary cell walls form, the amount of indigestible material accumulates including increased lignin in legumes and increased silica in cool season grasses (Figure 4). The quality of forages declines as they mature, but yield increases because the forage is growing.

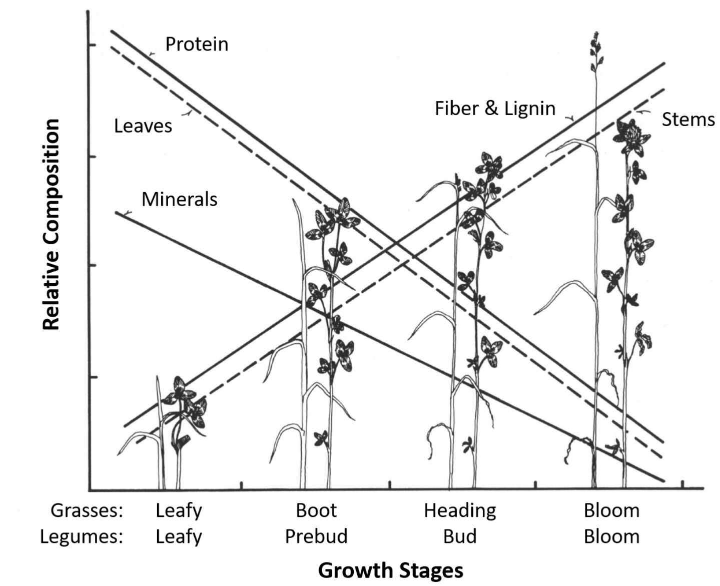

Figure 2. Relationships between forage maturity and quality. Source: Virginia Cooperative Extension, published in Blaser, R., R.C. Hammes, Jr., J.P. Fontenot, H.T. Bryant, C.E. Polan, D.D. Wolf, F.S. McClaugherty, R.G. Klein, and J.S. Moore. 1986. Forage–animal management systems. Virginia Polytechnic Institute, Bulletin 86-7.

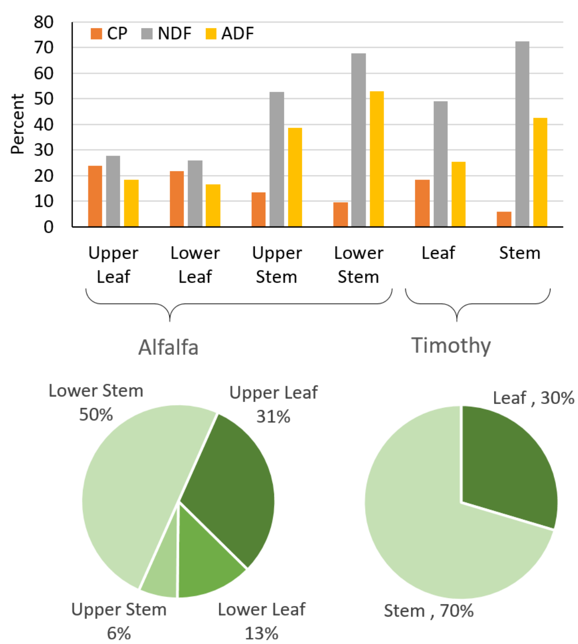

Figure 3. Distribution of forage quality throughout the plant. Top: Crude protein (CP), neutral detergent fiber (NDF) and acid detergent fiber (ADF) percentages for leaves and stems. Bottom: Relative contribution of leaves and stems to whole plant biomass. Alfalfa was separated into upper (last five internodes of each stem) and lower portions before leaves and stems were separated. Source: Collins, M. 1988. Composition and fibre digestion in morphological components of an alfalfa-timothy sward. Anim. Feed Sci. Tech. 19:135–143.

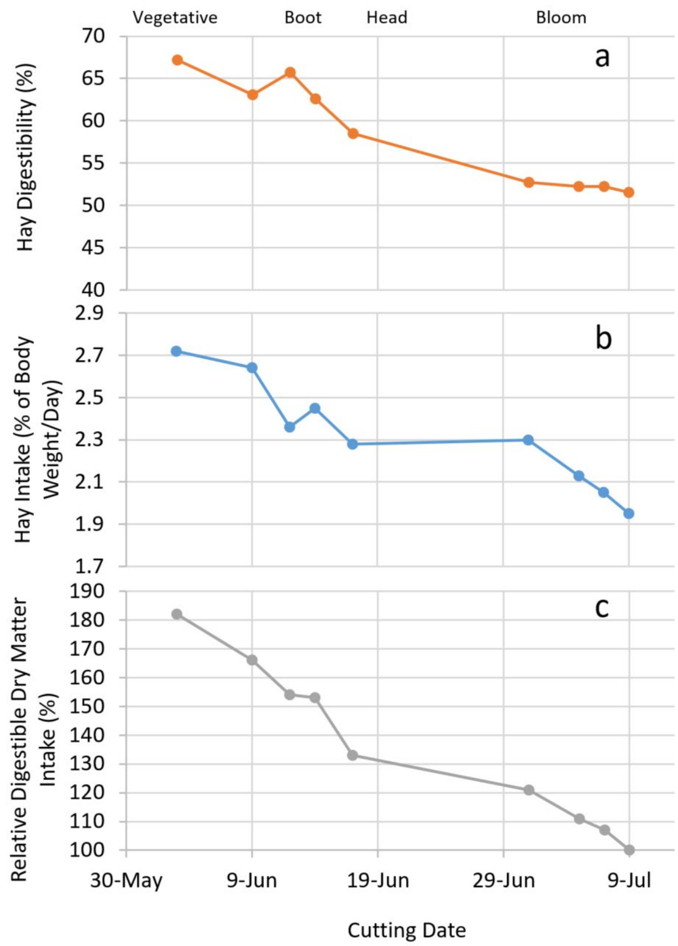

Figure 4. Hay digestibility (a), intake (b) and the relative intake of digestible dry matter (c) for grass hay harvested at nine different cutting dates spanning the vegetative stage to late bloom. **Source: Stone, J.B., G.W. Trimberger, C.E. Henderson, J.T. Reid, K.L. Turk, J.K. Loosli. 1960. Forage Intake and Efficiency of Feed Utilization in Dairy Cattle. J. Dairy Sci. 43(9):1275-1281. https://www.sciencedirect.com/science/article/pii/ S0022030260903143?via%3Dihub**

Successful forage producers find a balance between yield and quality that meets the needs of their operations while also maintaining the health of their plants. The best time to graze or harvest is generally when the forage has reached a peak growth rate, but before it shifts to reproductive growth. When pastures are grazed, it works well to have a target maximum height when grazing is started, and a target minimum height when animals are moved to another paddock. The target heights will depend on species, but for many species grazing should start at 8 to 10 inches and stop at 4 inches (Table 1). When harvesting hay, the best balance between yield and quality is when grasses are in the boot stage, and legumes are in the late bud stage. Forage quality is unevenly distributed throughout the plant: the tops of plants are primarily high-quality leaves, while the lower portions of the plants are mostly fibrous stems (Figure 3). Cutting or grazing height will affect the quality and yield of forages. Raising the cutting height for hay will lower yield, but increase quality because more low quality forage is left in the field. Animals that are allowed to selectively graze in a field or paddock over several days will consume the highest quality forage first. Over time, the quality of forage consumed will decrease until the animals are moved to a new paddock. Fluctuations in forage quality can influence animal performance and can be seen in fluctuations in milk production in dairy cattle. Animals will consume more uniform amounts and quality of forage if they are in a paddock for a shorter period of time.

Table 1. When to begin and end grazing based on forage plant height.

	Forage height, inches (cm)	
Species	Begin Grazing	End Grazing
Tall growing cool season grasses and tall growing legumes	8 – 10 (20 – 25)	4 (10 cm)
Ryegrasses	6 – 8 (15 – 20 cm)	2 (5 cm)
Short growing cool season grasses and legumes	4 – 6 (10 – 15 cm)	2 (5 cm)
Warm season grasses	12 - 14 (30 – 35 cm)	4 – 6 (10 – 15 cm)
Cereals	8 – 12 (20 – 30 cm)	3 – 4 (7.5 – 10 cm)

Adapted from Undersander, D., B. Albert, D. Cosgrove, D. Johnson, and P. Peterson, (2002). Pastures for Profit: A guide to rotational grazing (A3529). Cooperative extension publishing. https://learningstore.extension. wisc.edu/products/pastures-for-profit-a-guide-to-rotational-grazing-p96

Perhaps the most important factor in achieving success in utilizing improved pastures is the thought process by which grazing/feeding programs are developed. The following are some key points to consider: In achieving optimum productivity (with grazing animals) in forage-based systems, producers of the major ruminant species all have the same general goals geared toward profitability: 1) feed economically; 2) reduce reproductive failure; and 3) keep the livestock healthy. The goals are straight forward, but each has unique animal demands attached to it. To realize success in productivity, producers have at their disposal best management practices and technologies that can assist in supporting their goals. While the major ruminant species, cattle [beef and dairy], as well as small ruminants [sheep and goats] generally respond similarly to management strategies, it is essential to apply the technologies as appropriate to the various classes of animals (age, maturity, physiological status, time in the production cycle) as a subgroup within each species to match the nutrient requirements to the nutrient availability of the pasture at various times throughout the production cycle.

Recently, producers have become aware of the fact that providing nutrients to pregnant females at strategic times during gestation can influence productivity of the offspring after birth. This concept called epigenetics or commonly referred to as "fetal programming" has been shown to influence productivity later in life of both male and female offspring. Figure 5 shows the times in gestation during which key development of economically associated traits occur and it is apparent that maternal nutrition can affect muscle and fat development that in turn play an important role in both yield and quality of beef.

Another key element when determining if the nutrient demands of a ruminant are being met by the available forage is the recognition that in essence ruminant feeding programs are geared toward providing nutrition to the rumen microbes that in turn provide nutrition to the animal (i.e. energy and microbial protein). Meeting the rumen microbe's requirement for protein and energy will ensure adequate delivery of nutrients to the host (i.e. cow, sheep, goat). Likewise, correcting for nutritional imbalances at the rumen microbe level is essential for optimum productivity.

When the nutrient requirements of grazing livestock exceed the available nutrients in the pasture, *supplementation* may be indicated. Supplementation is essentially a way to correct for nutritional imbalances. That is, provision of feed in addition to the available forage for grazing or harvested feed to correct for nutritional deficiencies. As noted previously, these deficiencies can be microbial or otherwise deficiencies to the host animal directly. It is important to note that the provision of supplemental feed may correct for the imbalances directly. For example, a pasture that provides inadequate energy for livestock may be supplemented with feed rich in energy such as corn, barley, or other grain. Alternatively, one can provide supplemental feed to enhance the utilization of the base forage. An example of this would be the provision of limited amounts of ruminally degradable protein (RDP) to very low-quality forages in the winter. The provision of the RDP stimulates the work of the rumen microbial populations and in many cases increases intake and digestion of the base forage thereby delivering more energy to the animal. Figure 6 shows the relationship between season and the energy requirements of spring calving beef cows and appropriate times to consider supplementation to achieve production goals. Fall and winter supplementation are classic times to provide the additional nutrients. It is also notable that due to less-than-optimal management such as soil fertility, grazing strategies, and water availability, supplementation may be indicated during other parts of the year and different times in the production cycle (Figure 6).

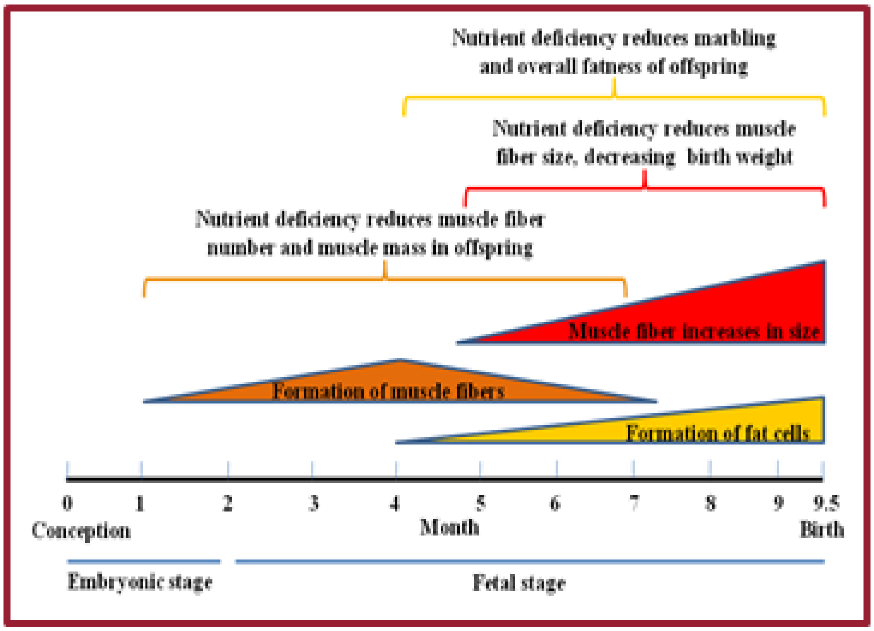

Figure 5. Nutrition of the pregnant cow: Mid-gestation is important for muscle fiber formation and late-gestation accounts for much of the increase in muscle fiber size. Mid-to late-gestation is critical for muscle fiber formation and growth, and late gestation is important for marbling development (Du et al., 2010).

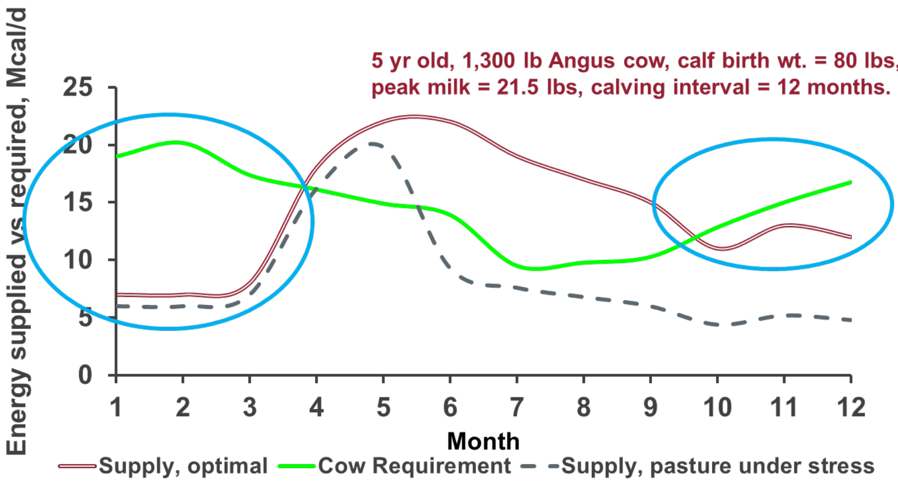

Figure 6. Matching the available forage energy resources to the nutrient requirements of spring-calving beef cows. The maroon- colored series shows the energy supply when management (i.e. fertilization, grazing, water supply) are optimal whereas the black-dashed series shows the potential reduction in nutrient supply when the pasture is under stress from less-than-optimal management. The blue circles depict the likely occurrences when the nutrient requirements exceed nutrient supply at which time supplementation may be indicated. This does not necessarily mean feeding extra energy at times encompassed in the blue circles. Also note that under stressful, less than optimal management conditions, that nutrient supply is less than the nutrient requirements for a significant part of the year. (Adapted from Marston, personal communication 2004).

Low quality forages present both a challenge and an opportunity for producers. The challenge is that in general they are typically not meeting the protein and energy requirements of the livestock. The opportunity is that ruminant livestock can economically utilize low quality forages in a very efficient way if adequately supplemented. An example of this scenario would be grazing or stockpiling of pastures that have reached vegetative maturity. While the pasture may have provided good dry matter yield, it may be low or defi- cient in crude protein. This is particularly common in fall and winter pastures. Protein is usually the first-limiting nutrient in low quality forages, defined as forages with < 7 % crude protein. Not all full vegetative, mature pastures are this low in quality, this is particularly true of cool season grass species in the Pacific Northwest.
The concept of the first-limiting nutrient means that if the first-limiting nutrient is not present in sufficient amounts in the forage, maximum productivity cannot be achieved even if all other nutrients are present to meet their requirements.

Producers often ask why livestock are more productive on high quality pastures or forages than when grazing low quality forages or crop residues? The answer to that question is based in “utilization” of the forage. Each forage is unique in chemical composition, and it is the chemical composition that defines the quality for the forage. It is essential to measure the forage quality of your pasture/forage by chemical analyses at various times throughout the growing season. Where the potential need for supplementation is concerned: “you don’t know what you need until you know what you have.” Forages are utilized to different extents based on the chemical composition. Young and immature plants are less fibrous and much more easily digestible. In general, young grasses are higher in protein as well. As grasses mature moving toward vegetative maturity, they also tend to accumulate anti-quality components such as silica, and phenolic compounds such as lignin all of which can chemically and physically inhibit degradation by rumen microbes leading to lower utilization and less energy delivered to the animal.

Supplementation of protein to livestock grazing or otherwise utilizing low quality forages has been shown to be very efficient (Llewellyn et al., 2006). The provision of limited amounts of RDP can unlock the energy in the base forage. Where improved pastures are concerned, what type of supplements can be used to provide supplemental protein? In the PNW, the classic protein supplement is alfalfa hay. Provision of alfalfa hay alone to ruminants overfeeds protein and is wasteful. However, when fed in limited amounts in conjunction with a low-quality hay or pasture, it is a great protein supplement. Likewise, other readily available feeds in the PNW can serve in the role as protein supplement, such as canola meal and dried distiller’s grains. Each can be fed to address protein deficiencies of late-season pastures and can usually be purchased for a reasonable price as this is written. Molasses-based supplements such as blocks, and lick wheel tanks can serve the same purpose as the hand fed supplements when forage quality needs to be addressed.

Finally, in some cases protein in the forage is adequate, but energy is deficient. In this circumstance an “energy supplement” may be indicated. It is also important to note that protein supplements can be mixed with energy supplements to balance for both protein and energy. Energy supplements can be found in several forms, but grains such as corn, barley, and triticale are typical energy supplements commonly used in the Pacific Northwest. An interesting dynamic in the use of energy supplements is that while they provide additional calories, they also reduce the efficiency of supplementation. In other words, they sometimes depress utilization of the base pasture/ forage rather than only unlocking the potential of the forage and cause the energy feed to “substitute” for the forage. However, this dynamic can be used as a tool when wanting to extend the pasture resource or to increase stocking rate.

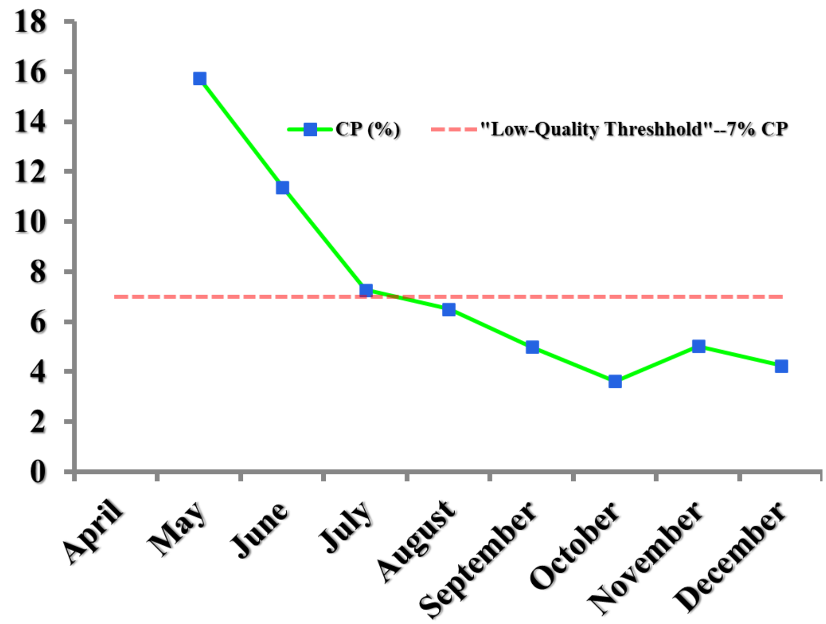

Figure 7. Seasonal changes in crude protein (CP; %) content of Bluebunch Wheatgrass across two years (1992 and 1993). Adapted from Ganskopp and Bohnert, 2001.

Managing pastures in the Northwestern United States requires an inexorable link between matching the nutrient requirements of livestock with the available forage, using techniques and technologies to increase forage utilization (getting the most out of the available forage), and managing in a way that is consistent with maintaining healthy forage resources into perpetuity (i.e. sustainability). Using beef cows as an example: Figure 7 depicts the seasonal changes in crude protein during the grazing season, (the dashed red line denotes 7% crude protein, below which is considered to be of low quality. During those periods forage quality may be low (i.e. crude protein content less than 7%) and cows may benefit from supplemental protein to satisfy the rumen microbes needs for nitrogen and thereby unlock more potential energy from the available forage as a result of increases in forage intake and/or digestion. Using Bluebunch Wheatgrass as an example, a significant portion of the grazing season is characterized by only modest forage quality (less than 7% CP). For spring calving cows in the third trimester of gestation, nutrient demand is low (pasture Growth Periods 3a, 3b, and 4). In fact, during this stage in the cows' production cycle, it is possible to realize very efficient body weight and body condition score gains when supplemented appropriately with protein (Llewellyn et al., 2006), even though the availability of protein in pastures during this period is typically deficient (Figure 7). Another key point is that for spring calving cows, forage quality is at optimum when calves are young and the cows' demand for protein are greatest with cows in early lactation (matching Growth Periods 6a and 6b). Shifting calving season to fall may have benefits for marketing, conserved forage and labor availability, or other reasons that apply to individual and unique operations. However, cows producing winter calves (i.e. born in November—

January) will have the greatest demand for nutrients during pasture Growth Periods 4, 5a, and 5b requiring significant amounts of supplemental feeds for the cows and later for the calves until weaning. Upon weaning, forage availability for fall calves should be adequate in pasture Growth Periods 6a and 6b.

There is a temptation to “turn out” onto pastures too early (pasture Growth Periods 5a and 5b). This is especially true when supplemental winter and spring feed is expensive. However, the long-term implications may be costlier than otherwise expected: Reduction in total forage production for the grazing season; Potential for the detrimental effects of infestation of winter annuals in the pastures; Reduction in the animal carrying capacity; and finally, the cost of rehabilitation of those pastures to reestablish the favorable forage species. Time and patience are key to managing pastures. Allowing sufficient time for soils to warm and forages to establish new and viable root systems and have sufficient top growth (pasture Growth Periods 6a and 6b) will go a long way in achieving healthy and sustainable forages.

Meeting animal demands requires careful assessment (through observation and forage testing) of the amount and quality of available nutrients and then to match those resources to the nutrient requirements of the species and class of livestock utilizing the pasture. In doing so, optimum productivity can be achieved.

Resources

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