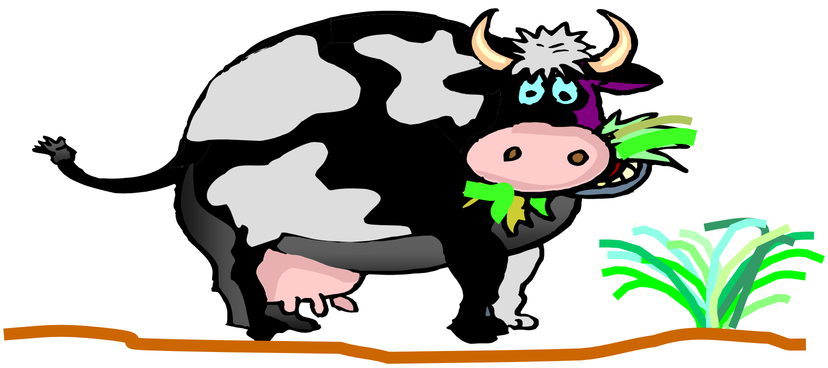
Managing Pasture as a Crop

A Guide to Good Grazing



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Prologue

Pasture has been a part of the Northeastern landscape since the first European settlers beached their boats on the rocky New England shores. In the early settlement period, there was little argument as to what livestock should be “fed.” In essence, the economics of labor dictated they should be fed as little as possible. There were no tractors running on diesel fuel, no food conveyer systems running on electricity, and no computerized ration balancing programs running on linear equations to indicate just how much corn silage, alfalfa hay, and grain a critter needed to be fed. When given the choice of tethering a critter to a shade tree and spending the day hand pulling or manually cutting and carrying grass to the animal, or sending the children out to sit under or climb a shade tree and watch over their critters as they efficiently foraged for themselves, it was as they say, a “no-brainer.”

In the time before cheap energy and fossil fueled machinery made feeding livestock as simple as pushing a button or flipping a switch, livestock were required to feed themselves. No matter how sharp the scythe, the critter could harvest its own food with much less effort and with a higher quality than any human. When forages were harvested by hand, it was generally only enough to get the animals through the harsh New England winters or at other times when grazed forages were in short supply. This was a period when people valued time as a currency and labor a commodity, and neither could be afforded to be wasted. Pasture was unquestionably the food of choice.

Pasture remained the primary food on dairy and livestock farms in New England into the 1940’s. Data from a 1941 Cornell University publication entitled “The Cost of Pasture” by Warren and Williamson indicates the extent of its use. In this study of 576 Northeastern dairy farms, during the grazing season, the average dairy cow obtained 75% of its food directly from pasture. The length of grazing season was 159 days for milk cows and 167 days for heifers. On average, 2.78 acres of pasture were required per milk cow per season. In terms of relative production costs, pasture supplied 100 pounds of total digestible nutrients (TDN) roughly four times cheaper than grain, three times cheaper than corn silage, and twice as cheap as alfalfa hay. Pasture was still the unquestionable food of choice.

New England dairy and livestock farmers relied heavily on pasture into the 1940s. However, the large per cow acreage requirements reported in the Warren and Williamson study (2.78 ac/cow) indicated that it was not intensively managed, and yields and harvest efficiencies were well-below potential. In essence, farmers had been trading acres for more intensive management, a strategy that up until that time, had served them well. However, during World War II and into the 1960s, there was an increasing demand for agricultural products, high government subsidies, low cost energy and labor, and equipment was relatively inexpensive. Farmers had a ready market for all the products they could produce, and with the profit equation screaming "maximum production = maximum profit," the large per cow pasture acreage requirement began to be viewed as an inefficient use of land and an impediment to profitability.

Farmers took their cows off pasture, borrowed money to buy tractors, machinery, and facilities, grew annually tilled row crops and alfalfa, and started feeding their critters in barns and feedlots. For the first time in the history of human- livestock interactions, the critters were no longer required to feed themselves, they were "fed." The era of confinement-based dairy and livestock production had begun. Pasture was no longer the food of choice.

Now here we are more than a half-century later, and it cannot be argued, confinement-based dairy and livestock production systems allow farmers to produce meat, milk, and fiber at unprecedented levels. However, there is more to profit than production. As compared with the post-World War WII economy, the relative demand for agricultural products has softened, the price paid to farmers for their meat, milk, and fiber has not kept up with inflation, and the cost of labor, machinery, energy, facilities, purchased feed, and interest on borrowed capital have all increased substantially. As a result of these factors, farmers today are now trapped in a cost-price squeeze that has made farming a low margin business. And with every increase in the price of oil, the margins are squeezed ever tighter.

As one confinement-based dairy farmer told me, "we make an awful lot of money on this farm; we just don't get to keep much of it, the cost of running this business takes all of the money we earn." (Note: this comment was made more than 15 years ago by a farmer with 120 registered Holstein dairy cows, who milked three times a day in a modern free-stall barn, and was making more than 21,000 lb. milk/cow/yr).

If history tells us nothing else, it tells us that the only constant in life is change, and the only real choice any of us have in regard to change is we either adapt or we die. In the case of the farmer mentioned above, the conversation occurred while I was laying out his grazing system. The farm has been pasturing cows for more than 15 years now, milks twice a day instead of 3 times a day, maintains a 20,000 plus herd production average, has added 50 cows, and the last I knew the farm was supporting two families instead of just one. Pasture on this farm is the unquestionable food of choice.

Sixty years ago, the economics of the day indicated taking livestock off pasture, feeding them in confinement, and following the "maximum production = maximum profit" model was the key to profitability. However, the economics of today suggest that for most farmers, putting livestock back on pasture, feeding them less in confinement, and adopting a “optimum production = optimum profit” production model will allow them to keep more of the money they earn.

Consider the Following:

Data from a Northeastern dairy farm business summary reported that between 2002 and 2007, the cost to produce a hundredweight (CWT) of milk averaged $14.25. The price received by the farmers averaged $15.58 per CWT. To calculate the per CWT profit, we need only subtract the cost of production from the price received. $15.58 - $14.25 = $1.33. To keep the math simple, suppose you had a herd of 100 cows making 20,000 pounds of milk per cow/yr. The profit would be 20,000 CWTs X $1.33 or $26,600 a year. So what happens if that is not enough money to live on, and you decide to increase production by 10%? Now we have 22,000 CWTs X $1.33 or $29,260. Sure enough, increasing production by 10% increased profit by $2,660.

Okay, so now let us look at what happens to profit if instead of increasing production by 10% we decrease the cost of production by 10%, such as by increasing the amount of food cows get from pasture. Subtracting 10% from the cost of production $14.25 - 1.43 = $12.82. Again, to calculate the per CWT profit, we need only subtract the new cost of production from the price received $15.58 – 12.82 = $2.76. Now when we multiply 20,000 CWTs by $2.76 we get $55,200.

In this example, increasing production by 10% increased profit by $2,660. However, decreasing production costs by 10% improved the profit by $25,940. It remains to be seen, just how much money an individual farmer can save by pasturing their cows. But one farmer in New York State that I used to work with reduced his purchased feed cost from $3.96 per cow/d to 91 cents per cow/d by grazing. He had 200 cows, grazed for 160 days, and saved $3.05 per cow/d. Do the sums. 200 X 160 X 3.05 = $97,600. In a low margin business, reducing production costs pays much better than increasing production.

When pasture is viewed as a crop and afforded the type of management that optimizes its yield, quality, and harvest efficiency, it is the single most economical source of food that dairy and livestock farmers in the Northeast region of the United States (US) can produce and utilize. In terms of relative production costs, the value of pasture is nearly identical to what Warren and Williamson reported back in 1941. Well-managed pasture can supply 100 pounds of total digestible nutrients (TDN) roughly four times cheaper than grain, three times cheaper than corn silage, and twice as cheap as alfalfa hay And unlike the 2.78 acres of pasture it took to feed a cow in the 1940s, with modern management techniques, today it only requires 1 to 1.5 acres. Additionally, with crude protein levels in the mid to high 20s and energy levels comparable to or greater than can be obtained from mechanically harvested forages, well-managed pasture is also of extreme high quality.

In today's economy, it is not enough to simply farm—farmers need to re-learn how to farm simply, smarter, more in harmony with Nature, and with reduced costs. No machine can harvest a ton of nutrients with higher quality and less cost than an animal can through managed grazing. And forages, irrespective of type, are less costly than grain. Thus when pasture is replaced by any other food, production costs increase and profit margins for farmers decrease. With the era of cheap energy having come and gone, farmers that continue to ignore the value of managing pasture as a crop and using it to its optimum economic potential are simply placing themselves at a self-inflicted economic disadvantage.

Pasture is the unquestionable food of choice!

Introduction

Pasture can be the most valuable crop on a farm. It can also exist as a perennial crop failure contributing very little of value to the economic health of the enterprise. The difference is in how it is managed.

With all crops, there are certain production, management, and utilization practices that must be adhered to in order to optimize the benefits of growing the crop in the first place. Pasture is not an exception to this rule. In fact, pasture is more difficult to master than many other crops because it involves the integration and management of a forage production system, a livestock production system, and a forage utilization system operating at the same time and in the same space.

In addition, pasture differs from all other livestock foods in at least three additional aspects. First, is in how it is defined. While very little guess work is required in the identification of other foods (crops) fed to livestock, such as corn, alfalfa, or soybeans, pasture is often used to describe any place an animal is when it is not in a barn or feed lot. Examples include weed patches, brush lots, swamp lands, mountain sides, and the always popular rock garden. However, none of these areas can be managed as a crop, and by default none can be considered a functional pasture.

A functional pasture is a unit of land on which exists a suitable amount, type, and distribution of vegetation that when utilized with a sufficient level of management complements or meets the nutritional requirements of the resident livestock for as long a time period as possible. Generally, this means a grass-legume-forb combination, grown on relatively dry flat land, with adequate fertility, and grazed with a well-planned and managed system (Pic.1). Pasture is not a single "thing" like corn or alfalfa; it is an assemblage of things that include the soil and land resources, plants, animals, and how it is managed.

The second way in which pasture differs from other livestock foods is that instead of being harvested and fed to animals as a preserved or conserved food in known quality and quantity, pasture is utilized while it is alive and actively growing. Therefore, it is continually changing in yield and quality over time (Fig.1). Although this makes balancing rations a bit more challenging for high producing dairy animals, much of the variability can be managed with a well-planned and managed system of grazing management. Keep in mind, optimum production pays better than maximum production anyway.

And the last way in which pasture differs from all other livestock foods is in the manner in which it is harvested. Pasture is harvested by an animal rather than a machine, and

Picture 1. Well-managed pasture consisting of grasses, legumes, and forbs.

unlike a machine that does not care what a plant looks, smells, feels, or tastes like; animals do care. And when the forage on offer is too short, too tall, or not suitable in species composition for the kind and class of livestock present (Pics. 2- 3 respectively), animal nutritional requirements are not met, performance is compromised, and pasture ceases to be a functional asset. This is not the fault of pasture; it is more the result of ineffective management.

In order for pasture to provide a consistent level of high quality food in a quantity that makes it an economic use of land, it must be managed as one would manage any other crop expected to return a profit. And this requires an understanding of soils, plants, and animals, and the combined interactions among soils, plants, and animals. However, once these variables are understood, planned for, and managed, having livestock harvest as much of their own food as possible from pastures reduces labor, energy, and machinery use, and results in one of the lowest cost home grown foods that can be produced and utilized anywhere in the Northeast.

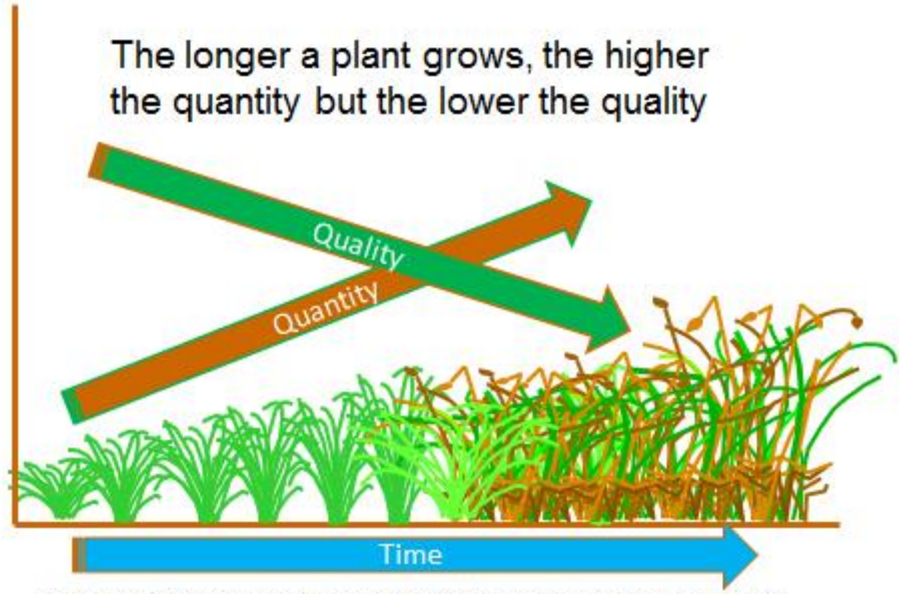

Figure 1. Over time pastures grow from high quality leafy vegetative plants into low quality reproductive stems and seed heads.

Understanding the Land-Soil Resource

Farm to farm, there are many reasons why pastures often do not provide the economic benefit of which they are capable. However, one of the biggest reasons is related to the land-soil resource; its type, fertility status, limitations, and its response to management. Not all land identified as pasture is. Unfortunately, these lands are not suitable for growing any other crop either. As a result, lands with off-drained, rocky, low natural fertility, shallow to bedrock, or steep slopes, often end up, by default, used for pasture, with the "hope" that livestock will at least get some amount of food from these lands.

The Right Kind of Land

It is recognized that there is a strong desire on the part of landowners to use the land one has bought and is paying taxes on for "something." However, sometimes the best use of some of this land will have nothing to do with livestock production, but rather timber production, berry picking, duck hunting, downhill skiing, or some other form of recreation. In fact, attempting to use some of these lands for pasture will more than likely decrease animal performance because of the energy cost incurred by the animal to negotiate steep slopes, slog through mud, or pick through "stuff" to find something edible to eat (Pic. 4), and this will likely increase the cost of production rather than decrease it.

Picture 2. Pasture that is too short.

The greatest economic response from pasture will come from using lands with the same soil potential to grow crops like corn, alfalfa, or soybeans. The better the land, the better the production is a universal concept that applies equally as well to pasture as it does to any other crop. So make sure that what you are calling pasture land really is.

Soil Influences

Soil is what the land is made of. It is comprised of both non-living (minerals, water, air, organic matter) and living components (microbes, plants, animals). These components, varying in size, chemical composition, and abundance are what make one soil different from another, dictate yield potential, and also determine a particular soil types' usefulness as pasture.

For example, soil types vary in their capacity to hold the water they receive. Course-textured free-draining soils dry out and warm the quickest in spring. Although this provides for a faster green up, and allows for a quicker turn out of cattle without fear of churning a pasture into a muddy mess, they also dry up fastest in the heat of summer.

In contrast, heavy clay soils hang on to their moisture and remain wet and cold longer in spring. Green up is slower, and if grazed too soon, there is potential for serious pasture damage through trampling. However, these soils provide a longer grazing period in the heat of summer. Other soils are intermediate between the two. Keep in mind every soil type has a maximum potential limit as to the amount of forage that it can produce under optimal growing conditions based on its biology, chemistry, physical properties, and its depth. And while this upper limit cannot be exceeded, your management—especially grazing management—can severely limit the yields of even the most productive soils (Fig. 2.)

Picture 3. Pasture that is too tall.

Picture 4. Pasture that is not suitable in species composition.

Soil Fertility

No pasture can provide an optimum economic yield of forage unless the pH and fertility of the soil is kept in balance with the requirements of the plants. Fast growing, intensively utilized pastures have high requirements for both macronutrients (nitrogen, phosphorus, and potassium) as well as micronutrients (calcium, magnesium, sulfur, boron, chlorine, copper, iron, manganese, molybdenum, and zinc). And there is no way to know the fertility status of the soil without taking a soil test. Soil testing should be done every three or four years and deficiencies corrected as soon as they are found.

Soil pH is a common problem on pastures. It is a primary reason why some pastures, despite appearing to have adequate fertility levels, do not produce optimum forage yields. When pastures are too acidic or too alkaline, soil microorganism activity is diminished and plant nutrient availability is reduced. For most pasture applications, pH levels should be in the 6.0 to 7.0 range. While most grasses can do well at a pH of 5.8, they will do better at 6.0-6.2. Legumes will do okay at a pH of 6.0, but they will do best at 6.5-7.0. Although lime does cost money, you are wasting money on seed and fertilizer if you do not correct soil pH before you plant or fertilize. Keep in mind, lime takes time to neutralize acidic soils. Thus, if you are planning on fertilizing or seeding a pasture, it will be best to apply lime a year or more in advance of your planned seeding date.

Picture 5. This land is so wet, these cattle are not on pasture; they are in it.

Generally, pasture growth is limited more by the lack of nitrogen (N) than any other macronutrient. Although N can be applied as a fertilizer, the preferred method is to obtain it naturally by ensuring that pastures have high legume content. Pastures with 50% or greater legume need no supplemental N. However, all grass pastures or those with limited amounts of legumes will generally see economic yield increases by applying up to 150-200 lbs. of actual N/ac/yr. Be aware of the law of diminishing returns, though. The greatest yield responses will occur with the first 100 lbs. of N, with decreasing yield responses to the last 100 lbs.

If N is applied, it should be applied in several applications of 50 to 75 lbs. of actual N/ac at a time. Keep in mind, animals will be harvesting this forage. If through the application of too much N, pasture growth exceeds that which the critters can consume, you will have wasted your money. Likewise, applying too much N on too many acres of pasture at a time, particularity in spring, may produce more forage than can be efficiently consumed by the livestock. As a rule, do not spread N on more than 25-35% of your pasture at a time, unless you plan to mechanically harvest the forage grown that is in excess of the needs of your grazing animals.

Phosphorous and potassium are used by plants primarily to initiate seedling growth and development, leaf growth, and reproduction. Pastures deficient in these nutrients do not establish well, they grow slower, and their total yields are much less than when phosphorous and potassium are in adequate supply. In addition, maintaining soil pH levels between 6.0 and 7.0 allows these nutrients to be utilized by the plants. Acidic soils bind these nutrients to soil particles and they are unavailable for plant growth.

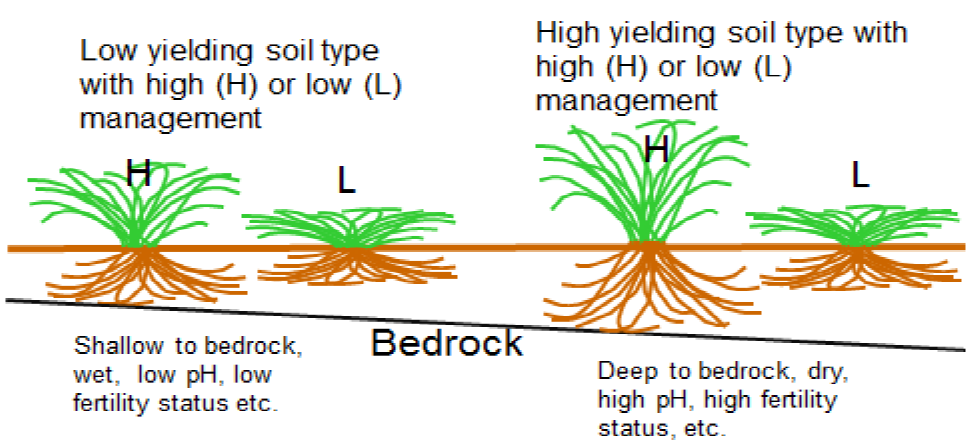

Figure 2. Each type of soil has an upper potential forage production limit based on its depth, chemistry, biology, and physical properties. However, this limit is often not achieved due to the lack of or poor management.

Macronutrients are required in larger amounts than micronutrients. However, this should not be taken to mean micronutrients are not as important as macronutrients. Pastures should be tested for both micro-and macronutrients and deficiencies corrected.

Manure can be used to supply nutrients to pasture. However, when applied during the growing season, it will very likely result in reduced animal intake. It is best to spread manure on pastures at the end of a grazing season after the last grazing but while plants are still growing. If the manure application has been applied early enough in the fall, and with a light enough volume to be assimilated by the plants, animals will generally accept the spring growth from these pastures. However, if they do not, then it is best to mechanically harvest these pastures first and graze them once they have re-grown post-mechanical harvest. As a safeguard, do not spread manure on all of your pastures every year. Leaving one-third to one-half of your pasture acres un-spread each year ensures that you will have a place to begin grazing come spring.

Pasturing land with low productivity soil types, inadequate pH or fertility, or with severe site limitations (steepness of slope, extremely wet, shallow to bedrock) not only limits the amount of forage produced, it can also produce forages that are lower in quality and higher in toxin content, which in turn, reduces livestock performance. In addition, grazing lands with low productivity soil types takes more acres of land to provide the same amount of food. Thus, animals have to walk further, graze longer, and spend more energy on meeting their nutrient requirements, which means nutrients that could have been used for producing meat, milk or fiber are instead simply used for maintenance. Using some of your best land for pasture does not cost, it pays.

Understanding the Plant Resource

In order to manage pasture as a crop, it is important to understand how plants grow and then, through management, provide them with what they need to not just grow, but to produce an “optimum” economic yield. Notice, I did not say “maximum” yield. Unlike crops such as corn, wheat, soybeans and sometimes hay, where total yield is the benchmark, in pasture systems, producing more is not always better than producing less. In order to provide livestock with a quality of food that allows them to maximize intake and performance, pasture is often best managed for lower total dry matter yields but higher yields of total digestible nutrients (TDN). As previously stated, machines do not care what plants look, smell, feel, or taste like. Animals do care, and when they do, intake and performance suffer.

Pasture systems should be planned with enough acres to provide a total dry matter yield adequate to feed the herd or flock for the entire season, but managed on a daily basis to ensure sufficient quality is maintained to meet the nutritional requirements of the kind and class of livestock expected to eat it.

Pasture Growth Dynamics

The vast majority of plants found in pastures in the Northeast region of the United States (US) are cool-season grasses, legumes, and forbs. These plants begin growth in spring soon after snowmelt and are most active when soil temperatures are in the 40 to 60 degree range. Root growth begins at cooler temperatures than shoot growth. With the increasing soil temperatures of summer, growth slows. However, once fall returns and soil temperatures begin to cool, growth rates pick back up. This change in growth rate over the growing season produces a distinct seasonal pattern of production in most all cool-season grass and legume pastures such that about 50% of the seasonal growth occurs during the first 2 to 2.5 months while the remaining 50% is produced over the remaining 3.5 to 4 months (Fig. 3).

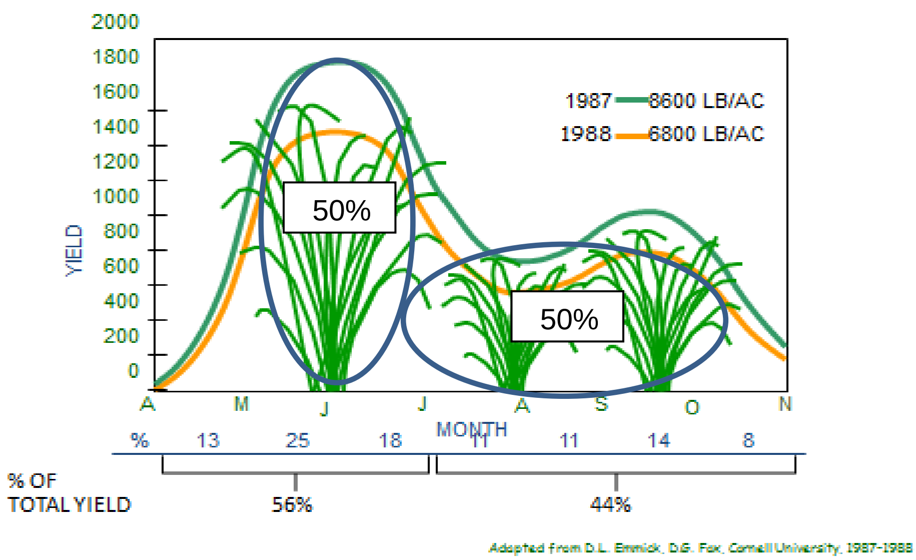

Figure 3. The seasonal pattern of forage production in cool-season forages. 50% of the yield is produced during the first 2 to 2.5 months, the remaining 50% is grown over the last 3.5 to 4.0 months

It is important to understand the relationship between pasture growth rates and the seasonal pattern of forage production because even though growth rates and yields are highly variable during a single year, as well as from one year to the next, the general pattern of production is fairly predictable. And knowing the general pattern of how fast plants are growing and when establishes the basis for logically planning systems of grazing management that promote high forage yields, enhanced forage quality, increased harvest efficiency, and optimal animal performance.

It is also important to know how plants grow and respond to grazing. Because controlling—through management--the frequency, intensity, timing, and duration of the grazing events so that optimal plant growth can occur is vital to attaining optimal dry matter yields.

For example research conducted at the Cornell University Hillside Pasture Research and Demonstration Project in the mid-1980s demonstrated the influence of grazing management on the productivity of pastures having the same soil type, fertility status, and plant species composition. Pasture treatments included a 16-paddock rotational system where cattle were moved to a new paddock every 2 days, a 4-paddock rotational system where cattle were moved every 7 to 10 days, and a season-long continuously stocked system. Potential hay yields for the soils on the project were 7,500 to 8,000 lb/ ac/yr. However, as observed in (Fig. 4) the only grazing system that allowed the pastures to produce as much forage as the site was potentially capable of producing was the 16-paddock rotational system. Conversely, the continuously stocked pasture produced less than half of the site's potential forage yield. In essence, you get what you mange for.

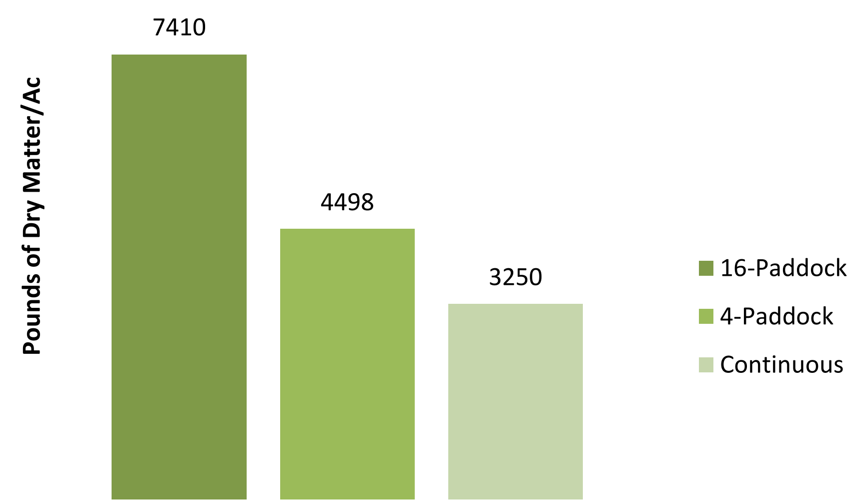

Figure 4. Pasture Yield by Grazing System

Connected and Dependent Parts

A pasture plant can best be described as a living system comprised of two connected and dependent parts. The above-ground leaves and stems are solar collectors that, through photosynthesis, convert light energy into carbohydrate energy for tissue growth. The below-ground roots and root hairs extract moisture and dissolved nutrients from the soil (Fig. 5). Some 90% of plant growth is directly related to photosynthetic activity in the green leaves and stems, with the remaining 10% of growth related to the function of roots, root hairs, and stored carbohydrate reserves. While 10% does not seem like much, it can be argued this is the first 10% of growth, without which the other 90% never happens. Keep in mind, a plant without water is not much different than a fish out of water; they both simply bake in the sun.

Root volume and leaf tissue exist in a co-dependent relationship that is best described as what happens to one directly influences what happens to the other. Roots and root hairs provide the conduit by which moisture and dissolved nutrients enter the plant where they can be used in the synthesis of leaf tissue. The photosynthetic activity of the leaf tissue provides the carbohydrates used in the production of roots. It is generally the case that plants maintain a dynamic balance between root mass and leaf volume. In other words, when there is a large volume of one there is a large volume of the other. Conversely, when there is a low volume of one, there is also a low volume of the other.

This is because the leaves produce the carbohydrates for root growth. Without a large volume of leaves, there is no source of energy to keep a large root mass intact, thus it dies back to a volume that can be supported by the amount of green leaf present. Thus when a plant is defoliated to a low volume of leaf tissue, either through grazing or mechanical harvest, roots stop growing and slough off proportionately.

Over time, frequent close defoliation--as encountered in pastures that are continuously stocked--not only reduces the amount of leaf tissue produced, it also causes a decline in root mass. Subsequently, this reduces the plant's ability to extract moisture and nutrients from the soil, which in turn reduces its capacity for growth even though adequate soil moisture and nutrients may be available (Fig. 6).

This same phenomenon occurs even when pastures are grazed using rotational stocking methods. However, unlike pastures that are continuously stocked; with rotational stocking, the plants have the opportunity to recover—not only in leaf tissue but also in root mass--before they are defoliated again. Thus even though leaf tissue is removed and there is a commensurate reduction in root mass, when provided with adequate recovery periods, plant productivity can be maintained at high levels (Fig. 7).

At one time, it was believed that plants stored an extensive reservoir of carbohydrate energy in their leaves and stems, rhizomes, stolons, and roots (depending on the kind of plant and species) where it could be mobilized to initiate new leaf growth after defoliation for many days in a row. Contemporary science suggests this is only partially correct. While legumes may store enough of this energy to “jump start” their regrowth after multiple defoliation events, most grasses only store enough for 1 or 2. The function of the remaining stored carbohydrates is to keep the plant alive over winter, to provide nourishment during periods of environmental stress, and to initiate growth in the spring. In addition, most of the carbohydrates that plants mobilize for regrowth following defoliation are stored in the bottom few inches of the stems and leaves and in the top few inches of the root mass. Thus, when plants are severely defoliated (less than 2-inches of residual leaf length) not only has the photosynthetic capacity of the plant been severely reduced, so has the amount of stored carbohydrate energy the plant would use to initiate regrowth. Collectively, these two influences slow plant recovery and production.

Biological Growth Response

Pasture plants grow at different rates at different times during the season. They also grow at different rates during a single growth cycle. There is an early slow growth period, a mid-rapid growth stage, and a late mature phase characterized by a decline in growth rate (Fig.8). Each time a plant is defoliated, its rate of growth passes through these three phases, taking different amounts of time depending on the time of year.

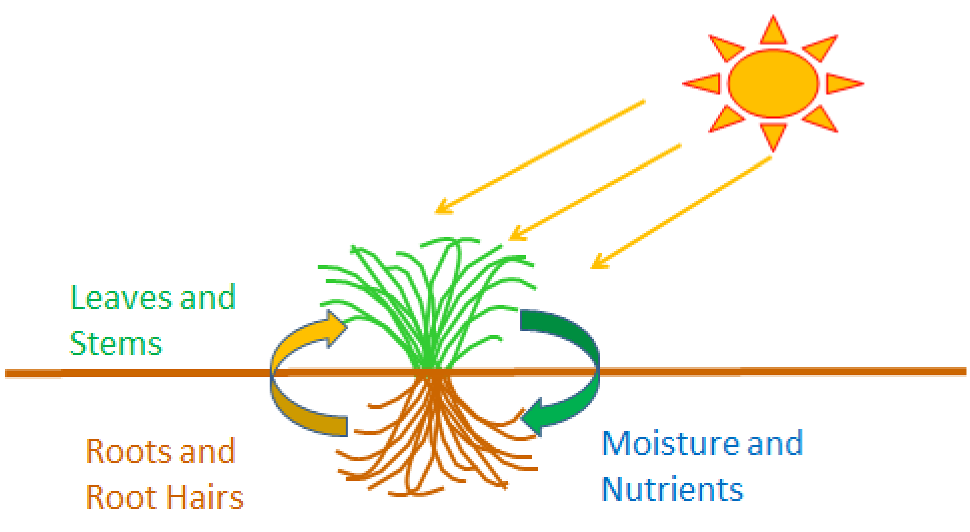

Figure 5. Nearly 90 percent of pasture growth comes directly from the sun shining on green leaf. The remaining 10% of plant growth comes from soil fertility factors and moisture.

In phase one, the plants are leafy and immature, high in quality, low in volume, and as a result of the lack of leaf area, growing slowly. In the second phase, growth rates are at their highest, the plants are leafy, growing toward maturity, and high in both quality and volume. In the last phase, the plants become stemmy and over-mature, grow slowly (if at all), yield is highest, but quality is at its lowest. During spring and early summer this phase is characterized by the appearance of reproductive tillers and seed heads. However, because some forages do not produce reproductive tillers later in the season, in summer and fall, there may not be reproductive tillers present, but the forage will consist of coarse low quality vegetation, with much of it in a state of decay.

Plant growth rates also change with the time of year. Spring and fall are generally times of accelerated growth rates, while summer is a time of reduced growth and lower forage yield (Fig. 9). The result of which is, the recovery period between subsequent grazings is about twice as long in summer as it is in spring.

Forage Availability

The amount of forage in a pasture available for grazing at any point in time is directly related to how fast it has been growing and the number of days it has been allowed to grow since it was last grazed. Because of the variability in pasture growth rates at different times of the year, there is no universal amount of time a pasture should be

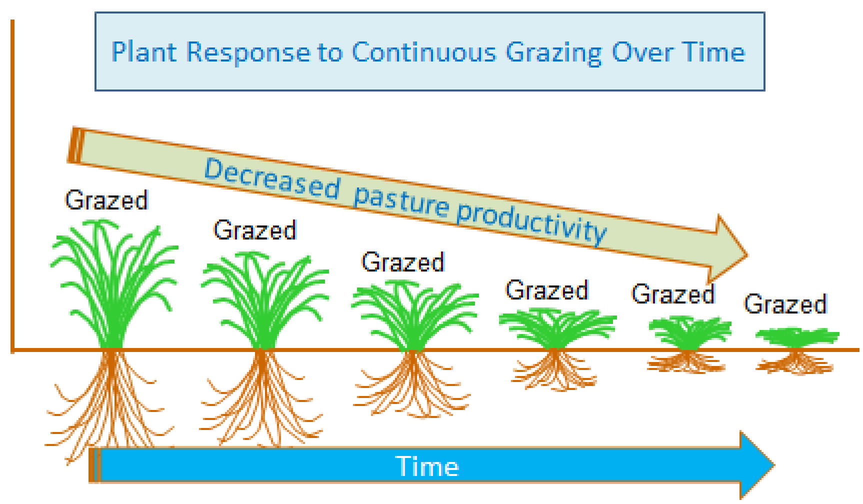

Figure 6. Uncontrolled leaf area removal over-time results in declining forage yield by disrupting the plant's ability to maintain an adequate energy balance between the above-ground and below-ground portions of the plant.

allowed to recover before being grazed again. However, research conducted at the Cornell University Hillside Pasture Research and Demonstration Project in Harford, New York in 1987 and 1988 provides a good place to start.

Actual measured growth rates on mixed Orchardgrass pastures averaged 100 lbs. of dry matter/ac./day during the May-June period, 40 lbs./ac/day in July-August, and 55 lbs./ac/day during the September-October period.

In the spring and early summer, after a 15 to 20 day recovery period, the pastures reached a height of 6 to 10 inches and contained 1200 to 2000 lbs. of dry matter/ac. available for grazing above a 2-inch residual stubble height. However, because growth rates were about 50% less in late summer and fall, as compared with those observed during spring, it required 30 to 40 days to reach similar plant heights and forage yields.

The goal for managing a pasture as a crop is to grow the maximum amount of green leaf, to minimize the amount of stem, and to graze it before leaf decay begins. In order to accomplish this, as depicted in (Fig. 10) pastures should be grazed when they are between 6 and 10 inches tall, which occurs about every 15 days in the spring and early summer increasing to about every 30 days in late summer and fall. Bear in mind pasture growth rates do not change abruptly.

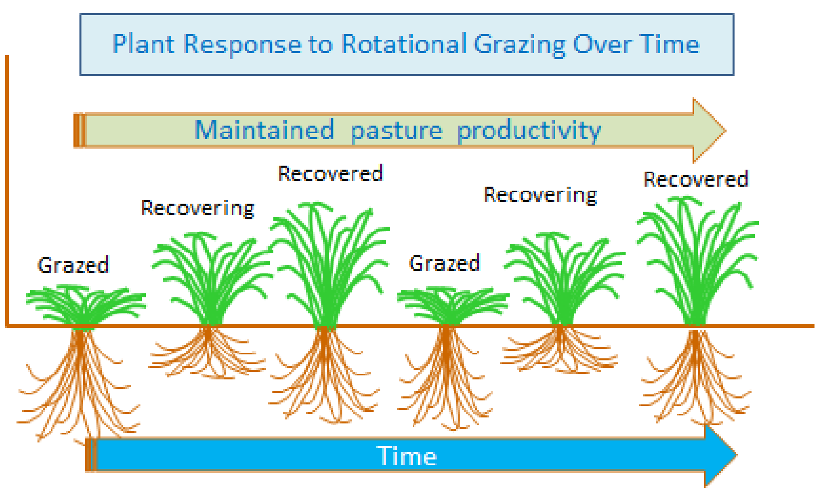

Figure 7. Controlling leaf-area removal and providing adequate recovery periods between successive grazing periods, allows plants to remain in a vigorously growing productive condition.

As spring turns to summer, growth rates slow. As summer gives way to the cooler days of fall, growth rates generally pick back up (but not always). In late fall, they slow back down. The current year's growing conditions dictate the "real" number of days it takes a pasture to recover from its previous grazing, but it is not uncommon to graze pastures every 12 to 15 days in the early spring, every 15 to 20 days in early summer, every 25 to 30 days in mid-summer, and after a brief return to 25 or so days in early fall, up to a 40 day recovery may be required for late fall.

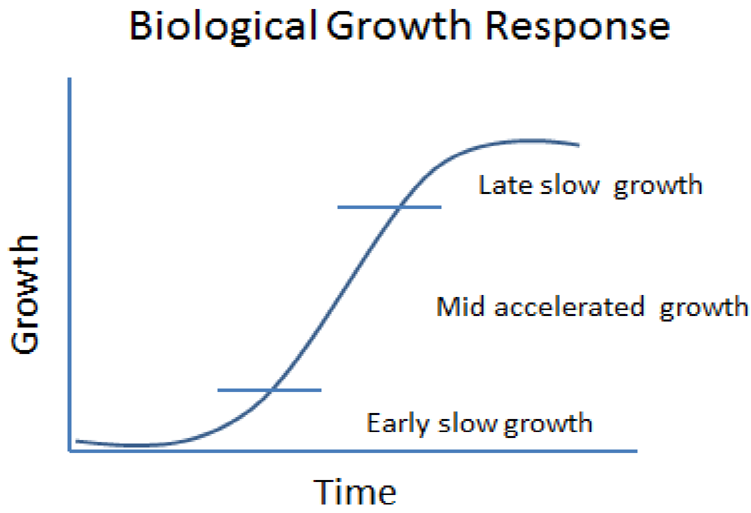

Figure 8. Plant growth rates progress through three separate phases represented by an early slow growth period, a mid accelerated growth phase, and a late or mature slow growth period.

Keep in mind however, during late fall, killing frosts may arrive before the pasture has had a 40 day recovery period. Because of this, it is generally best to stick with a maximum 30 day recovery period. Yields may be lower but the quality will still be great. In addition, it will be time to start transitioning back to the barn for winter feeding anyway, so it is not likely that much will be gained by waiting longer. Grazing heights are a compromise between doing what is best for the plant and what is best for the animal. Grazing taller plants (greater than 12 inches) and leaving higher residual stubble heights post grazing (greater than 4 inches) may speed regrowth times in the short term, and promote somewhat higher yields, but in the long term it creates a lower quality forage mass at the base of the plant which, in turn, results in an incremental and sequential loss in forage quality, an increase in forage refusal, and subsequently, a decrease in forage utilization (Fig. 11). The result of which is forage quality, harvest efficiency, and animal performance all suffer, along with production on a per acre of pasture basis.

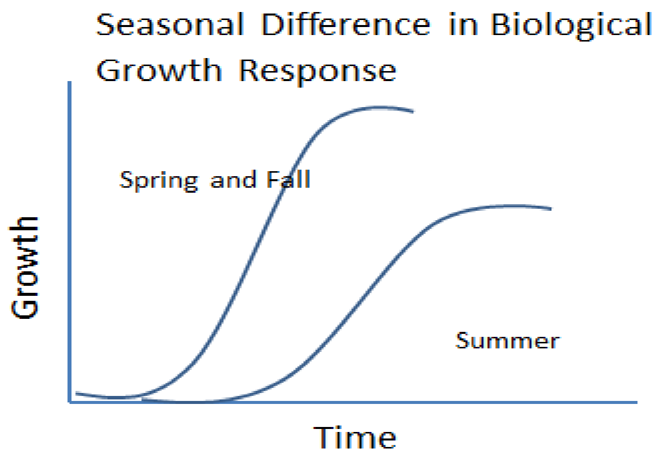

Figure 9. Spring and fall are times of maximum growth rate and forage yield. Summer is a time of reduced growth rate and forage yield.

Conversely, grazing shorter plants (less than 6 inches) and leaving very low (less than 2 inches) residual stubble heights, slows regrowth, reduces total yield, can eliminate taller growing more productive plants, and reduces animal performance.

To maintain healthy vigorously growing pasture plants, and concurrently maintain a high forage quality throughout the grazing season, it is generally best to graze most pastures when they are 6 to 10 inches tall (with the target height of 8 inches) (Pic. 5). And to ensure that there is enough leaf tissue left post grazing so that the majority of a plant's regrowth is the result of photosynthesis rather than carbohydrate mobilization, they should be grazed to a residual stubble height of 2 to 3 inches (with the target height of 2.5 inches) (Pic. 6). Grazing at this intensity prevents a buildup of low quality dead leaves and stems at the base of the plant, maintains a high forage quality, promotes high utilization throughout the grazing season, and ensures high animal output on a per acre of pasture basis (Fig.12).

There are times, however, when grazing pastures to less than 2 inches can be a useful management tool. During the high growth rate period of spring, it is not uncommon for the forage quality in some pastures to decline to unacceptable levels before the livestock are turned in. As a result, when there is no opportunity to mechanically harvest this forage, much of it, if grazed, will just be trampled and wasted.

One way to reduce this problem is to anticipate the rapid growth rates of spring, and graze 25 to 35% of the pasture acreage to less than 2 inches during the first or second grazing. This will slow the recovery period on this portion of the pasture, help create a

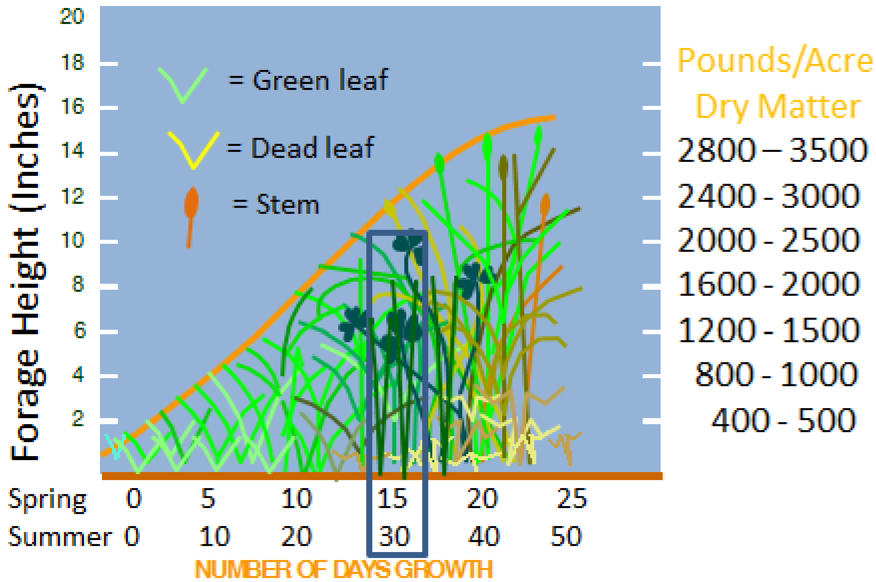

Figure 10. Relationship between forage height, yield and quality that indicates the optimal amount of green leaf occurs when pastures have grown 15 days in the spring and 30 days in summer.

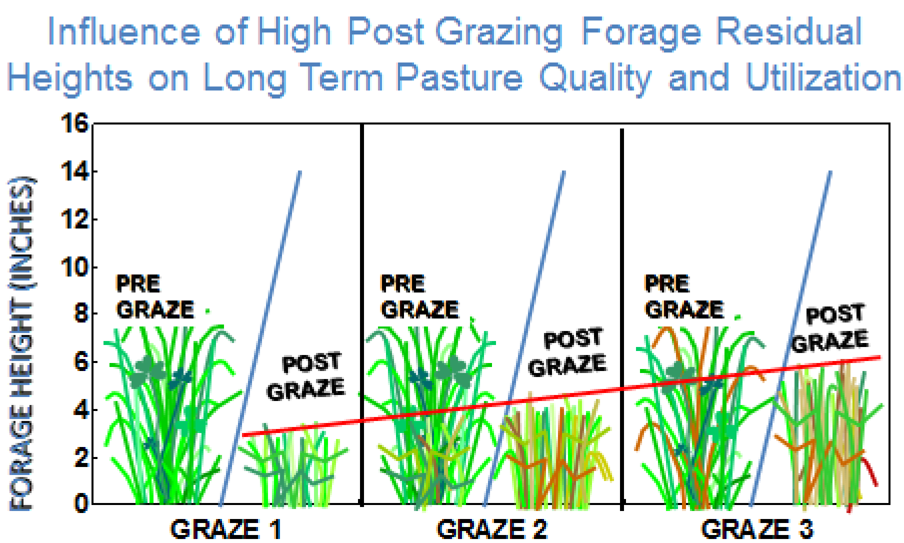

Figure 11. The more ungrazed plants or plant parts left behind post grazing, the lower the overall quality of the pasture at the next grazing and the greater the amount of forage refusal with each successive grazing.

staggered regrowth pattern, and this in turn will allow livestock to better keep up with the rapid growth on the remaining pastures. In addition, in spring and fall, with high soil fertility, close grazing increases tiller density, which creates thicker denser pastures.

Picture 6. To attain high dry matter intake, pasture quality, and to ensure plants have had ample recovery time between subsequent defoliations, they should be grazed when they are between 6 and 10 inches tall.

Collectively, these actions help condition the pasture to provide and maintain a more uniform and high quality forage over time. Use this technique sparingly though because in the long term, grazing pastures too low too many times can do serious damage to a pasture's productivity and health.

There are two other exceptions to the general grazing height guidelines presented. One is when grazing under very wet conditions where mud is a problem, and the other is when grazing during very dry conditions.

When soils are so wet that severe punching or pugging is likely to occur at the recommended grazing heights, it is best to allow the forage to get taller than the recommended heights before turning livestock in and take them off the pasture before it is churned into mud. Starting with a greater amount of forage in the pasture and leaving a higher residual behind forms a forage mat that reduces hoof penetration and pugging.

The other exception to the general grazing guidelines concerns grazing during hot dry conditions. Cool-season plants do not fare well when it is hot and dry. Rotation lengths may need to be extended for longer than 30 days, and residual forage stubble heights may have to be increased by 50% or more. Leaving a greater amount of forage behind can keep soil temperatures lower and reduce moisture loss.

The above two scenarios represent a planned or deliberate under-utilization of the forage supply in order to accomplish two different short-term management goals--in other words trying to make the best out of a bad situation. However, in doing so, there is a price to be paid.

Picture 7. To ensure that animals are not shorted on dry matter intake for too long, and that pasture productivity is not destroyed, pastures should not be grazed to lower than 2 inches.

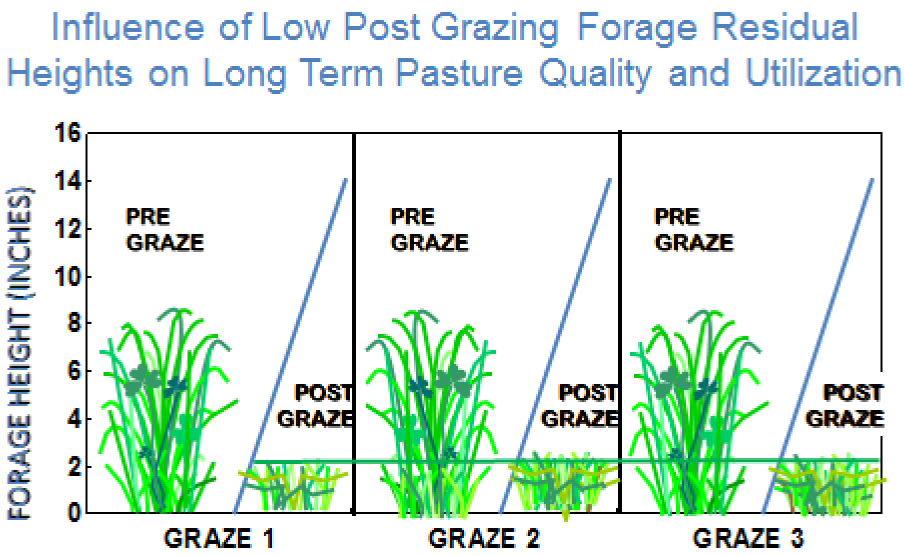

Figure 12. The fewer the ungrazed plants or plant parts that remain post grazing, the higher will be the overall quality of the pasture at the next grazing and the greater the amount of forage utilized

Not all leaves have the same capacity to collect and convert the sun's energy into growth. Young leaves are more photosynthetically active than are older longer leaves, but short young leaves have less surface area available for solar collection. Longer older leaves, while having greater surface area, are less photosynthetically efficient.

And really old long leaves are in a state of decay and rapidly losing both quality and quantity. Thus under-utilizing forages to meet short-term goals may lead to forage quality and intake problems in the long-term. In order to prevent this from occurring, anytime a pasture has been under-utilized (planned or not) it is recommended that these pastures be clipped or mechanically harvested as soon as possible in order to initiate new high quality leaf growth.

It should also be kept in mind, that there is more to forage yield than just its height. Yield is a function of plant height plus density. And the more dense a pasture is, the greater the amount of forage available for grazing per inch of forage height (Pics. 8 and 9).

Picture 8. Although the forage height is 8 inches, the canopy is so open the pasture yield estimating device can be clearly observed when laid flat on the soil surface. The forage yield is estimated at 900 lbs. of dry matter/ac.

Pasture Quality

While the quantity of forage tells us how many animals we can feed, the quality of the forage indicates how well they are being fed. The quality of food in a pasture at any point in time, when everything else is equal, is primarily related to the stage of plant growth and the relative abundance of leaves, stems, and dead plant material. Generally, the leaves of legumes are higher in quality than the leaves of grasses, young green leaves are higher in quality than old brown leaves, young green stems are higher in quality than old brown stems, and green stems are higher in quality than brown leaves. As a rule, the younger the plant or plant part the higher its quality. And from a whole pasture perspective, the higher the percentage of brown plant parts in a pasture, the lower its overall quality and the lower the animal performance. Conversely, the higher the percentage of green leaf, in particular the leaves of legumes, the higher the quality (Fig. 13).

Pasture is the only food we feed to livestock while it is alive and actively growing. All other foods are fed in preserved conserved forms in known quantity and quality. Because pasture plants are a living food, their yield and quality changes from morning to night (Fig. 14), from one week to the next, and over the season. In living growing plants, high quality can be attained, but it cannot be stored, it is “use it or lose it phenomenon.”

Yield and Quality of Grasses Grown with and without Ladino White Clover

BIG FLATS, NEW YORK 1996 AND 1997

SPECIES	CP	ADF	NDF	YIELD	SPECIES	CP	ADF	NDF	YIELD
PERENNIAL	21	31	55	Lbs/Ac	PERENNIAL	27	29	44	Lbs/Ac
RYEGRASS	**20**	**27**	**42**	**5595**	RYEGRASS	**24**	**25**	**37**	**11,046**
	17	21	30		& WHITE CLOVER	21	18	30	
ORCHARD-GRASS	20	35	54			25	28	45	
	17	**26**	**46**	**6407**	ORCHARDGRASS	**21**	**22**	**37**	**11,111**
	13	20	35		& WHITE CLOVER	19	16	31	
TALL FESCUE	17	35	56			21	33	43	
	14	**27**	**49**	**6352**	TALL FESCUE	**19**	**27**	**39**	**11,345**
	10	16	40		& WHITE CLOVER	15	16	33	

Figure 13. Grass-legume mixtures in pastures are higher in yield and quality than any single grass.

To ensure that animals are presented with the greatest amount of high quality leafy forage and not an accumulation of low quality stems, stalks, seed heads, and brown “stuff,” they must be grazed on a schedule that seeks to produce and maintain a maximum amount of green leaf. As previously stated, maximizing forage yield is not the objective, optimizing the yield of quality food is. Thus our strategy is to interrupt--through grazing--the normal biological growth and production cycle of the plants at a stage where they have had time to recover from their last defoliation, are ample in quantity so that animals are not limited in dry matter intake, but consist mostly of high quality green leaf.

Regardless of the time of year, do not wait too long to graze a pasture. While it is generally best to have the pastures a little ahead of the animals to ensure there is enough dry matter available to meet their needs, should weather conditions cause a

Picture 9. Although the forage height is only 6 inches, the canopy is so dense the pasture yield estimating device completely disappears. Forage yield was estimated at 1600 lbs. of dry matter/ac.

Plants also change in quality over the course of a few hours.

	Morning	Afternoon
CP	29.5%	26.8%
NSC	13.2%	19.5%
NEL	.69 Mcal/lb	.71 Mcal/lb

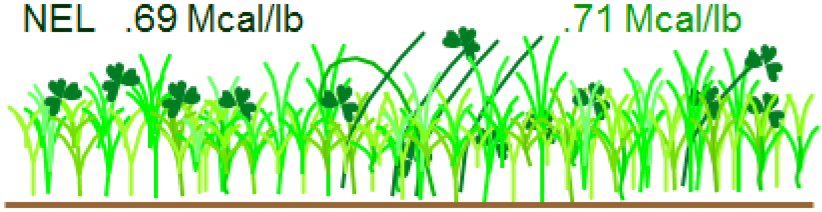

Figure 14. Plants increase in energy content from morning to night, but decrease in percent protein

slowdown in production, never fall into the trap of “if a little grass is good, more has to be better.”

Low light intensity is a primary cause of leaf death. As the height and mass of forage increases, the leaves in the upper canopy intercept most of the sunlight. Leaves further down in the canopy receive less light, and those leaves at the base of the plant become so shaded they just wither and die. Thus, the taller and denser a pasture gets, the less sunlight can penetrate the canopy, and in really tall dense pastures, leaf death at the base of the plant can equal leaf growth at the top.

In addition, once a plant has grown through the vegetative stage into the reproductive stage, generally, no new leaves will be produced until after flowering has taken place. At this time, plants are using energy to produce and ripen seeds. Once the reproductive phase has been completed, or when the flower head has been removed--either through mechanical harvest or grazing—the production of new leaves and tillers begins again.

Thus, when pasture plants are allowed to get too tall, several things happen to lower the food value of pasture. First, with increasing plant age, forage quality decreases, dry matter intake drops, and animal performance decreases. Second, yield per unit of time starts to decrease as the death rate of leaves at the bottom of the plant equal the growth of new leaves at the top, resulting in no net gain of quality forage. And third, because animals cannot generally eat much of such low quality food due to its high fiber content and low digestibility, much of what once was a high quality food and an economic asset, just gets trampled and wasted.

Anti-Quality Factors

There is more to a pasture than nutrients. Some plants contain toxins (plant secondary metabolites (PSM), some are poisonous; some have medicinal properties, and some highly nutritious plants, when eaten to excess, can act as a toxin and shut down intake. Other plants are defended by stickers, prickers, thorns, and growth form, and although they may be highly nutritious, they are difficult for animals to consume. Generically, these characteristics are referred to as anti-quality factors because they can reduce or limit intake, make animals ill, and in some cases cause death.

Through photosynthetic activity, plants convert sunlight into energy to maintain plant life processes and to provide structural and defensive compounds. As a result, plants exist as a complex of biochemical compounds such as carbohydrates, protein, minerals, vitamins, amino acids, fatty acids and fat, which are used by herbivores as a source of food, but they also contain hundreds of PSMs, compounds such as alkaloids, terpenes, saponins, cyanogenic glycosides, and phenols, which are synthesized by plants as defensive compounds to prevent themselves from becoming food.

Some plants can be highly nutritious, some plants can be extremely toxic, and some plants can be both. And some plants are used by animals as medicines. Plants can also change in nutritional and toxicological properties within a matter of hours or days and within a few yards of each other based on soil fertility factors, moisture, shade and position on the landscape. In addition, even different parts of the same plant can vary in nutrient density and toxic properties at different times. These factors in part explain why some plants are eaten with relish in some locations and at some times, but the same plant is not touched in the same or other locations at different times.

Despite the variability in nutrient content and toxicological properties of the various plants encountered in the foraging environment, animals are very adept at finding and eating foods that most closely meet their nutritional requirements and limiting intake of foods that do not meet their requirements (surplus or deficit) or which are toxic or poisonous. They sort out and select foods that are on average higher in nutrients and lower in toxins than is generally available in the foraging environment. This is not just “the luck of the bite” but rather, an expression of what animals have been doing best for millions of years; foraging for a living in a world where the only constant is change.

Understanding the Animal Resource

Much has been learned over the past 50 years about grazing systems, plant growth, the agronomy of grass-based systems, and animal husbandry. And on many farms today much of this knowledge can be observed being readily applied in methods and practices. However, the behavior of animals has been studied for thousands of years, yet little of what is known is considered common knowledge, and even less of what is known has made it to the farm or ranch in the form of methods, practices, or procedures. As a result, we often see animal behavior not working for us but, rather, us working against it. In many cases, this unnecessarily increases stress on both humans and animals alike, increases costs, reduces animal health, well-being and performance, needlessly degrades the condition and productivity of our lands, and reduces both the profitability and sustainability of farms and ranches.

However, with a basic understanding of what behavior is and what some of the controlling factors are, many of the common behavioral challenges encountered can be controlled or entirely eliminated. Instead of fighting the nature of the beast at the cost of time, money, oil, and effort, we learn the art of compromise.

What is Behavior?

By scientific definition, behavior is any activity that an organism engages in or does that can be measured. It can be fairly simple, such as a reflexive response to a single stimulus i.e., things like the knee jerk response, eye blinking, or jumping at the sound of a loud noise, or it can encompass more complex activities such as group dynamics, mating rituals, and foraging and diet selection. In the case of more complex behaviors, researchers argued for years which one was more important, genetic inheritance or learning through environmental experience. However, today we know the behavior of individual animals is a unique combination of both. Animals (including the human animal) behave the way they do partly because of their evolutionary histories, unique genetic endowments, and the result of social and individual learning that takes place throughout the animal's lifetime.

While the behavior of animals is often quite complex, understanding the mechanisms underlying their behavior is actually fairly easy. Behavior is a function of its consequences. Unfortunately, very few ever take the time to look past the immediacy of what an animal is doing at any given moment to try and understand what has motivated the animal to behave in a particular manner in the first place. Thus, many opportunities to take advantage of what is known about the principles of behavior to make our lives easier, the lives of our animals less stressful, and the overall operation of our livestock enterprises more efficient and profitable, have simply gone unrealized.

Behavioral Consequences

All animals, including humans, behave the way they do as a result of the consequences resulting from their behavior. And as we all know from our own experiences, not all consequences are the same. Some are good and some are not so good. However, something is learned from each. For example, if we perceive that a consequence of engaging in a particular activity is in some way favorable or enjoyable, we are very likely to continue engaging in the activity or even increase the rate at which we engage in it. Conversely, if we perceive the consequences of engaging in an activity as unfavorable or aversive, it is very likely we will either reduce the time we spend engaging in the activity or we will cease to engage in the behavior altogether.

The consequence of a behavior that maintains or increases the strength of a behavior is called reinforcement. The consequences are termed reinforcers.

The consequence of a behavior that decreases or eliminates the strength of a behavior is called punishment. The consequences are termed punishers.

Although not commonly recognized, reinforcement and punishment can be either positive or negative. While many people understand the notion of positive reinforcement and positive punishment, most confuse negative reinforcement with punishment. As you will see, they are not the same, and as a result, generate two different outcomes.

Positive and Negative Reinforcement

Positive reinforcement has the influence of maintaining or strengthening behaviors by providing animals with something they want or need. For example, animals are positively reinforced when they eat clover. Clover is high in protein, high in energy, is very digestible, and it can be eaten very quickly. The behavior is eating clover. The consequences are positive nutrient feedback and postingestive satisfaction. Chances are really good that when an animal eats one clover plant, it will eat more than one. In other words, positive nutrient feedback and postingestive satisfaction are positive reinforcers for having engaged in the activity of eating clover. Positive reinforcement is said to have occurred because the positive influence of the nutrients in the clover reinforced the behavior of the animal to seek out and eat more clover.

Negative reinforcement also maintains or strengthens behaviors, but not by providing things that an animal wants or needs but, rather, by removing something it does not want or need. For example, suppose an animal ate so much clover that it bloated and thus reduced its intake of clover. However, if the animal drinks a solution containing an anti-bloat compound, the rumen discomfort and postingestive dissatisfaction is eliminated and the intake of clover could then increase. Negative reinforcement is said to have occurred because the anti-bloat compound eliminated the postingestive dissatisfaction (negative reinforcer) and allowed the animal to increase its consumption of clover.

Any consequence (stimulus or event) that results in an increase in the rate of a behavioral response when it is presented is referred to as a positive reinforcer.

Any consequence (stimulus or event) that results in an increase in the rate of a behavioral response when it is removed or prevented is referred to as a negative reinforcer.

Positive and Negative Punishment.

Positive punishment has the influence of decreasing or eliminating a behavior when an aversive stimulus is applied or presented. By definition, punishment always works because if it does not change an animal's behavior then it cannot be considered punishment. For example, suppose an animal eats too much clover and it suffers rumen discomfort and postingestive dissatisfaction (bloat), which is an aversive stimulus. If the animal, the next time it eats clover, changes its behavior and eats less clover, positive punishment can be said to have occurred. Conversely, if the animal does not limit its intake of clover to avoid bloat, then bloat cannot be considered punishment; because the animal's behavior never changed. In order for bloat to be considered positive punishment, bloat has to change the animal's behavior, in this case the intake of clover.

Negative punishment also serves to reduce or eliminate behaviors, but in this case it is accomplished by taking away something the animal wants or needs. For example, suppose an animal prefers clover so much that every time it is placed in a clover pasture it eats clover until it bloats. Obviously bloat and postingestive dissatisfaction are not impacting this animal enough to change its behavior. So the animal is taken out of clover pastures and only allowed to graze in all grass pastures. Negative punishment can be said to have occurred because the animal's opportunity to eat clover has been taken away. However, if the next time the animal is placed in a clover pasture and it over-eats clover and bloats again, then as with positive punishment, if the animal's behavior did not change, it cannot be said that the animal was negatively punished. In this example, negative punishment can work, but the animal would probably have to spend the rest of its life in an all grass pasture.

Any consequence (stimulus or event) that results in a decrease in the rate of a behavioral response when it is presented is referred to as a positive punisher.

Any consequence (stimulus or event) that results in a decrease in the rate of a behavioral response when it is removed or prevented is referred to as a negative punisher.

Punishment, by definition, always works, and it generally works fast. But it should be limited and only used as a last resort. Punishment can cause anger, anxiety, stress, and fear in animals, as well as cause a reduction in animal performance and even death. And in some situations, animals that have been severely punished have been known to turn on their tormentors causing them to be injured or killed.

While positive reinforcement may take a little longer to achieve the desired behavioral changes in animals, providing animals with incentives for engaging in positive behaviors is not likely to result in any of the undesirable characteristics listed above, and promotes animal health, well-being, and performance.

Variables Affecting the Outcomes

It would be really helpful to the understanding of animals and why they do the things they do if the world operated in a manner such that all choices and subsequent behaviors could be evaluated according to a “yes” or “no” decision making strategy. However, seldom is it that simple in real-world situations. The real-world is fraught with “maybes.” While all behaviors are controlled by the reinforcing or punishing contingencies outlined above, they are, at times, difficult to sort out and are often constrained by extenuating circumstances.

For instance, there are many situations where animals engage in behaviors where they are simultaneously in receipt of both positive and negative consequences. As examples, one might see a cow reaching under an electric fence to graze a highly nutritious plant. Although the cow receives a shock when she touches the fence, the fence might have a heavy weed load on it causing the resultant shock to be relatively mild. As long as the perceived benefit from eating the preferred plant (positive reinforcement) is greater than the negative consequence of getting shocked by the fence (positive punishment), the cow is likely to continue challenging the fence. Keep in mind, by definition, punishment always works. Thus, in this example, despite the fact the cow received an electrical shock when she touched the fence; there was no punishment, just positive reinforcement from eating the plant.

The take home message in this case is if an electric fence is expected to control livestock, the fence needs to be “hot” enough to be punishing. If it is not, livestock will then be controlled by the positively reinforcing aspects of whatever is on the other side of the fence.

Characteristics of the consequence

As noted previously, the consequences of engaging in any particular behavior can be either reinforcing or punishing. However there are huge qualitative and quantitative differences in the characteristics of the consequences. For example, research has shown that the provision of small reinforcements given frequently generally results in faster rates of learning than large reinforcements given infrequently. Other things being equal, large reinforcers are more effective than smaller ones. However, this relationship is not linear. By this, I mean once a reinforcer reaches a certain size, making it larger will not increase the rate of responding. As an example, while many people will not stoop over to pick up a penny on the ground, a nickel will generally do the trick, and certainly anything larger than a dollar bill will always get picked up. The point is, once the minimum size or quality of reinforcer is reached, making it larger or higher in quality will not improve or increase the behavioral response.

Punishers operate in much the same manner. While strong punishers will generally alter a behavior, mild or weak punishers are not very effective concerning long term behavioral changes. Also, the introductory level of punishment is critical. For example, an electric fence that has a weak charge will not effectively stop an animal from breaking through to a high quality food source on the other side. On the other hand, if the fence provides a powerful shock the first time an animal encounters it chances are good it will not bother the fence again. Hence the statement, “when it comes to training animals to an electric fence, make their first encounter their worst encounter.” Do not begin with a weak electrical charge and gradually increase its strength. That strategy, although sounding kinder, only increases an animal’s tolerance for successively higher levels of punishment.

Contingency

The term contingency refers to the degree of correlation between a behavior and its consequence. Both reinforcement and punishment depend on contingencies.

For example, in order for an electric fence to be effective at controlling livestock, it must reliably provide a substantial shock each and every time an animal touches it. Receiving the shock, then, is contingent upon touching the fence. In order for reinforcers or punishers to be effective, the animal has to experience and learn from the consequence of having engaged in the behavior. In another example, sheep can be easily herded by dogs. This is because if the sheep do not go where the dog directs them, they get chased, barked at, and even nipped. All of these things are considered aversive by sheep. If the dog did not do these things, or only did them on occasion, sheep would not pay any attention to them. Consistency is important to learning.

Contiguity

The interval between a behavior and its consequence is called contiguity. Contiguity has a profound influence on the rate of learning. Generally, the shorter the time period between a behavior and its consequence, either reinforcement or punishment, the faster learning occurs. For example, if we are trying to teach a puppy to sit and offer a doggie treat each time the pup sits on command, we are far better off providing the treat the instant the pup sits rather than waiting any amount of time. This is especially important with young active animals. If reinforcement for the desired behavior is delayed, the animal could be engaging in another behavior by the time the reinforcement is provided. In the case of teaching a puppy to sit, if the treat is delayed, the pup could be up and jumping around before they get the treat. In effect, they would be getting reinforced for jumping up rather than sitting. The same is true for punishment. To be effective, punishment needs to be administered as soon after the misbehavior occurs as is possible. Otherwise the animal may be punished for engaging in some other activity totally unrelated to the behavior you thought you were punishing.

There are many other variables that influence the behavior of animals. However it is beyond the scope of this publication to delve into them all. Suffice it to say, attempting to understand why animals do the things they do is a fascinating topic. Even simple behaviors are complex, in that they are not controlled by an on or off switch, but rather by the relative nature or strengths of opposing positive and negative consequences, and these are often very difficult to discern. However, once the principles of behavior are understood, we can begin to see and understand the processes that have evolved over the millennia and begin to use this information to better manage our livestock, our pastures, our land, and ultimately our own lives.

Origins of Behavior

Although most livestock in the U.S. today have their needs for food, water, and shelter provided by humans, prior to domestication, their wild ancestors were obligate grazers. They searched for food, located places to drink, found shelter from the elements, and avoided predators. These things were all matters of life and death. Those that succeeded in living long enough to reproduce passed their knowledge along to their offspring. This knowledge is recorded in the genetic composition, morphology, physiology, and behavior of our modern livestock as a cumulative record and blueprint for survival. However, as previously stated, there is more to the behavior of animals than just their genetic predispositions and evolutionary histories, there is that which is learned through life experiences. While genetic predisposition endows organisms with the particular attributes of their species, allows them to live in various environments, and exploit specific niches, the ability to learn through experience allows them to change their behavior in response to changing environmental conditions.

While some folks view the foraging activities of grazing animals as little more than the aimless wanderings of animals looking for something to eat, and eating whatever is available, a closer look at these activities demonstrates that this is far from the truth. Selecting what to eat is, and always has been, dangerous. Consuming the wrong plant at the wrong time or eating too much of one plant and not enough of another can cause sickness, malnutrition and even death. Thus, herbivores, both wild and domestic have evolved a very sophisticated strategy for evaluating foods and selecting diets that closely match their ever-changing nutritional requirements. And despite an occasional glitch now and then, modern farm animals have a demonstrated ability to learn quickly, rapidly adjust to new environments, and they remain well-adapted to selecting, harvesting, and evaluating their own diets just as their ancestors and untamed relatives have done for hundreds of thousands of years.

Grazing is a Learned Behavior

All behaviors are a combination of genetic and environmental influences. Genes provide the blueprint that makes a sheep different from a bird. But life experiences acting on the genes create the individual. For example, birds have wings and feathers, thus they fly. However, upon taking that first plunge out of the nest, most birds end up on the ground. Flying is something birds can do based on their genetic blueprint, but getting good at it requires practice. Livestock are herbivores; they are genetically programmed for eating forage. However, an animal that has been raised and fed in confinement and fed conserved, preserved, or dried foods its entire life, will not recognize green plants in pastures as food or have a clue as to how to eat it. Grazing is a learned behavior, and as with all learned behaviors, animals must first have the necessary adaptations for discriminating and selecting among choices in its environment, the opportunity to learn, and enough time to adapt.

The Special Senses /Plus

Grazing animals having a full complement of environmental sensory adaptations they use to learn about the foods they eat. They have 2 eyes, 2 ears, a nose and well-developed senses of touch and taste. They also evaluate foods postigestively (after it is eaten), and do so with a great deal of accuracy. And while many think that as a result of domestication, animals are not as adept at using these senses as their wild ancestors and kin, a few years of barn rearing is nothing compared with a few hundred thousand years of evolution, adaptation, and survival. Modern grazing animals use all of their special senses to find and evaluate foods and to avoid becoming something else's food just as their ancestors did for hundreds of thousands of years.

Feedback Mechanisms and Behavior

Animals have a remarkable ability to select diets that are higher in nutrients and lower in toxins than the average available in the foraging environment. This is the result of the interactions of two interrelated systems; affective and cognitive. These two systems, working together, are expressed as a deliberate course of action (behavior) by the animal (Fig. 15).

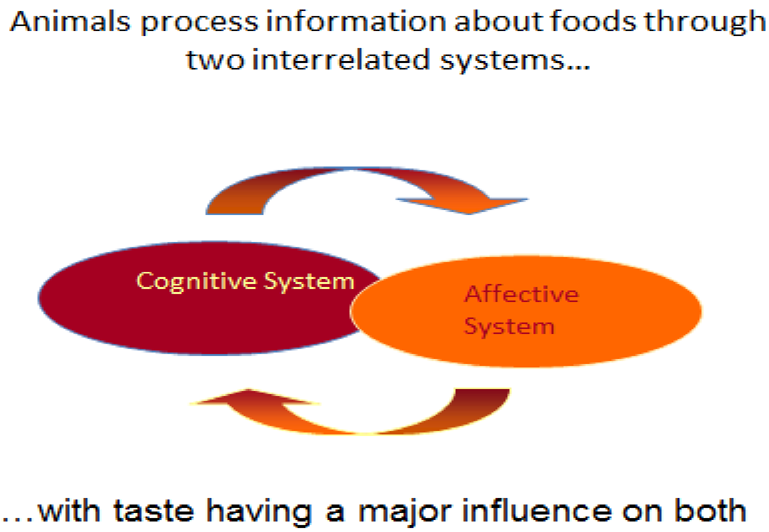

Figure 15. Animals learn about foods and select their diets through two separate but dependent systems; cognitive and affective, that are connected by taste.

The affective or involuntary system explains why some animals do or do not eat particular foods at particular times. This is a subconscious process that operates without any effort on the part of the animal that links the taste of a food with its postingestive (after it is eaten) consequences relative to the requirements of the animal.

Postingestive feedback is an information system that operates within animals at the subconscious level. This system utilizes chemical, osmotic and mechanical receptors within the gut of an animal to evaluate the unique chemical content of each food ingested relative to the particular animal’s nutrient requirements. This information is fed back to the brain where decisions about the food are made. Simplistically, if an animal eats a particular food item and, shortly after, feels sick, discomfort, or in some other way “not good” the taste of this food will be paired with the discomfort and the animal will likely shy away from or become averted to consuming this food item. On the other hand, if a food item is consumed and the animal feels satiated i.e., no ill effects or feels “good”, the animal will generally pair the flavor of this food with the feeling of satiety and develop a preference for the food item; and the item will likely become part of the preferred diet. The affective system is the fundamental means by which foods are evaluated and based on the outcome, preferences and intake adjustments are made.

The other system is called the cognitive or voluntary system. This system uses the senses of sight, smell, touch and taste along with information learned from mom, other members of the herd or flock and past trial and error encounters (previous postingestive consequences) to determine what to eat or not to eat. Experiences early in life and guided by mom are extremely important in determining what any animal will chose to eat, even years later. If mom eats it and baby watches, chances are, baby will eat what mom eats. However, this is only going to hold true for most, but not all situations. For example, if an animal has previously consumed a plant and experienced illness, the taste of the particular plant will become objectionable, and the animal will use its senses of sight and smell to avoid consuming the plant again.

Within the dynamics of plant-herbivore interactions, it must be recognized that plants are a complex mixture of some chemicals that are used by animals as food i.e., carbohydrates, protein, minerals, vitamins and the like, and some chemicals that plants use to prevent themselves from becoming food i.e., alkoloids, terpenes, phenols and other toxic compounds. Thus, in order to avoid over-ingesting toxins and under-ingesting nutrients, animals have to be able to evaluate the nutritive value of foods as well as the toxic properties, and avoid the nutritionally deficient, nutritionally excessive, and toxic foods, and select those that generally meet their requirements

While the voluntary and involuntary systems function as two separate systems, they are integrated through the senses of sight, smell, taste, and postingestive feedback. Animals use the involuntary system to evaluate the postingestive consequences of consuming a food, and the voluntary system to change their behavior towards the food depending on whether the postingestive feedback was pleasant or not. Through this interactive exchange of information, animals are constantly able to monitor the foods they consume and alter their diets in response to their own ever-changing nutritional requirements and changes in the foraging environment.

Palatability vs. Preference

Palatability can be defined as the relative attractiveness of plants to animals as feed, whereas preference is more related to the actual selection of a particular plant or plants by an animal. Unfortunately, most definitions seem to avoid any integration of the two as though they were totally disconnected. In the plant-herbivore dynamic, however, while each is considered distinct by definition, they are viewed as inseparably linked through functional association.

It has been observed that animals will readily consume a particular plant in one location or at one stage of plant growth, but the same plant growing in another location or existing at another stage of plant development, will be largely or even totally ignored. As plants age, they tend to increase in fiber content and decrease in overall quality. As well, plants that grow in marginal or under less than ideal conditions generally differ chemically from the same plant growing under ideal conditions. To the animal, these plants are obviously not the same in palatability, and as a result can be either more or less preferred. In these two scenarios, the "packaging" of the plant is so dissimilar, that to the grazing animal, they are viewed as two different foods, each with its own palatability and expressed preference.

It is well known that an animal's nutrient requirements change over time with age, physiological condition and environmental factors. Thus, what is preferred at one point in time of an animal's life may or may not be preferred at another. Postingestive feedbacks calibrate the senses in accord with the utility of a food to meet an animal's requirements and, thus, determine preference. It is this collective interaction between palatability and preference that actually determines what an animal will eat, how much and when.

Although old definitions often die hard, palatability is best defined as *the relationship between a food's recognizable flavor, i.e., distinctive taste, texture and odor and its postingestive effects, which are the result of nutrients and toxins relative to the nutritional requirements of a particular animal, at a particular time and place.*

Conditioned Taste Aversions

Palatability and preference rankings can also change by another means. Instead of a food item's packaging being so dissimilar as to cause a change in preference, preference is altered due to the monotony of eating the same exact food, bite after bite, day after day, week after week. While familiarity with a food item that meets a particular nutritional requirement is a precursor to high initial intake, animals, over time, can develop what are known as "conditioned taste aversions". Conditioned taste aversions are believed to have evolved as a survival mechanism that inhibits animals from over-ingesting foods that may be nutritionally adequate but contain toxins, or foods that are inadequate (excessive or inadequate) in nutrients that, perhaps, taste good.

For example, some of us hold the fresh, hot-out-of-the-oven cookie in extreme high esteem. I personally can eat at least three and maybe even four of my wife's chocolate chip cookies and do so without breaking a sweat! However, by the time I get to the third cookie, somehow it does not taste quite as good as the first one. While the last cookie is exactly the same in content, texture, and delightful “gooiness” as the first, the last is just not as palatable as the first and, thus, my preference changes. Just like me eating chocolate chip cookies, grazing animals can over-eat even their most preferred or favorite foods, and end up wanting to eat something else. In the case of chocolate chip cookies, I simply drink a glass of milk….then I can eat another cookie!

Thus, diet selection is a dynamic process. At any particular time, the strength of an animal’s aversion to or preference for a particular food can, and frequently does, change from very strong to very weak. Just because a plant was palatable and, thus, preferred at one point in time does not mean that it will be at the next. Plants are alive, actively growing, and change in nutrient and toxin characteristics over time. Thus, if an animal recognizes and samples a previously preferred food item but the current postingestive feedback turns up negative, even the most, previously, preferred food item could become a food to avoid. In other words the plant is no longer viewed as palatable and, as a result, is no longer preferred.

Fear of Unknown Foods (Neophobia) and Foraging Locations

Food neophobia is defined as the fear or reluctance of animals to eat novel foods or foods they have not experienced before. Grazing animals are creatures of habit and most are neophobic. They like what they are familiar with and distrust that which is unfamiliar. Familiar foods and foraging locations are viewed as “safe”. Animals know where they are going and know what to eat when they get there. This affords animals a sense of comfort and safety, which increases foraging efficiency and animal performance. New or unknown foods and foraging locations are viewed as potentially “dangerous.” When animals are introduced to new locations with unfamiliar or novel foods, they do not have a clue as to what or where to eat, where to find a drink of water, a place to get out of the sun, wind or rain, or hide from predators. This elicits fear, discomfort, and stress, which decreases foraging efficiency and animal performance.

Keep in mind, the nutrient densities and toxic properties of plants can change in a matter of minutes or hours depending on environmental conditions. This applies to familiar plants in familiar locations as well as unfamiliar plants in unfamiliar environments. However, the challenges of foraging in unfamiliar environments and with unfamiliar plants are vastly more difficult. Eating the wrong plant at the wrong time can cause sickness, malnutrition and death. Thus, animals prefer to eat familiar foods to novel foods and they prefer to forage in familiar locations to unfamiliar locations.

Law of Least Effort

While few have ever heard the term “Law of Least Effort,” most are familiar with the concept, especially if you have ever watched a nature film featuring predators such as lions, tigers, cheetahs and the like. In essence, the premise of this law is that it makes absolutely no sense to continually chase after food items that constantly escape or in some way avoid consumption - that is to say, if a long, well-nourished and healthy life is your goal. Hence, the law of least effort suggests that if long-term survival is our goal, no animal - not me, not you, not lions, tigers nor beef cows, dairy cows nor sheep can afford to expend a greater amount of energy in the pursuit and acquisition of our food than we are going to get from the food once we have it consumed.

In the classic predator-prey example, seldom do you see a predator chase after or attack the biggest, fastest or strongest member of a herd or flock of prey. On the contrary, they generally seek out the member that can be caught with the least amount of effort i.e., the least amount of energy expenditure. These are generally, the young, the injured, the old, or the weak. These same principles apply to grazing animals in their search for nutrients, only in a little different way.

Grazing animals have more to do than simply walk around looking for food. Among other activities, they need to be on the watch out for predators, they have to socialize, they have to find water and drink, they have to swat flies, they have to thermo-regulate, they need to not only find food, they need to consume it and process it as well. All of these activities take time and energy, thus they must also take time to rest. With all of these activities competing for time, it is fairly obvious that grazing animals do not have a lot of time to spend on simply grazing, and thus when they do; it is to their advantage to be able to maximize their intake of nutrients on a per unit of time spent basis.

From a behavioral perspective, the dry matter intake of grazing animals is best described as a functional interaction involving the amount of time an animal spends grazing, the amount of bites taken per unit of time and the amount of dry matter taken in with each bite (Fig. 16). When grazing animals are placed in environments where plant densities and, thus, yields are low, they have a difficult time consuming enough forage to meet their requirements. Low yielding sparse pastures tend to result in animals taking in smaller amounts of feed with each bite, and because they often have to walk between bites, this reduces the number of bites taken per unit of time. To compensate for this, animals have to increase the amount of time they spend grazing and end up covering more ground.

Pastures that are too tall and rank also reduce dry matter intake. Tall forages tend to reduce the number of bites an animal can take per unit of time because the long leaves have to be manipulated more before they can be swallowed. In addition, the digestibility of the forage is lower, which also lowers the amount of food ingested (Fig. 17). These factors increase the amount of time an animal spends grazing, but lowers intake and performance. These are classic examples of the "Law of Least Effort". The animals work harder and longer but get less from their efforts. Depending on just how bad the pasture is, they may not even be able to meet maintenance requirements.

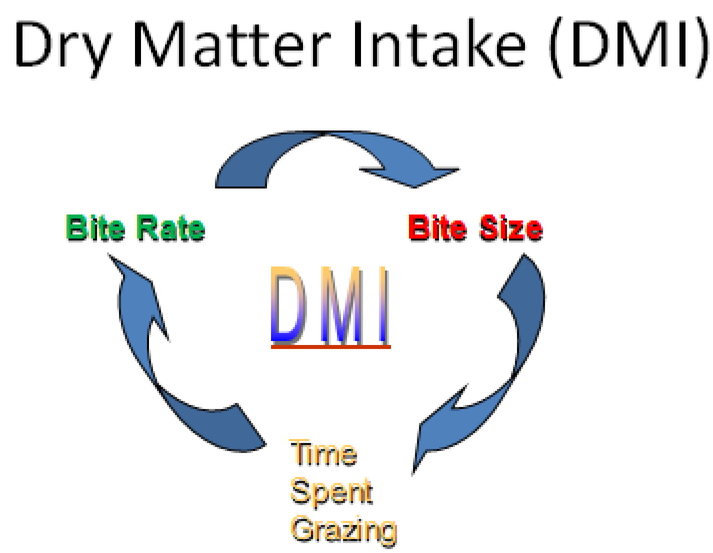

Figure 16. Dry matter intake is a function of bite rate X bite size X time spent grazing. Anything that interferes with this process will reduce DMI and thus animal performance.

In order to prevent the "Law of Least Effort" from reducing animal performance and profits, it is best to ensure that livestock are actually grazing on decent pastureland and not on some misnamed piece of real estate that is being called pasture.

A good pasture is a pasture where animals can easily harvest their own feeds with a minimum amount of effort. A good pasture needs to be on good land, not the poorest land on the farm or ranch. A good pasture will have an adequate kind, amount and quality of feed available to meet the nutritional requirements of your particular kind, number and class of livestock. And a really good pasture will be utilized with a high level of grazing management including, when required, soil fertility amendments, brush control, water management and reseeding to ensure a diversity of plant species. Making it easy for your animals to harvest their own feeds does not cost; it pays.

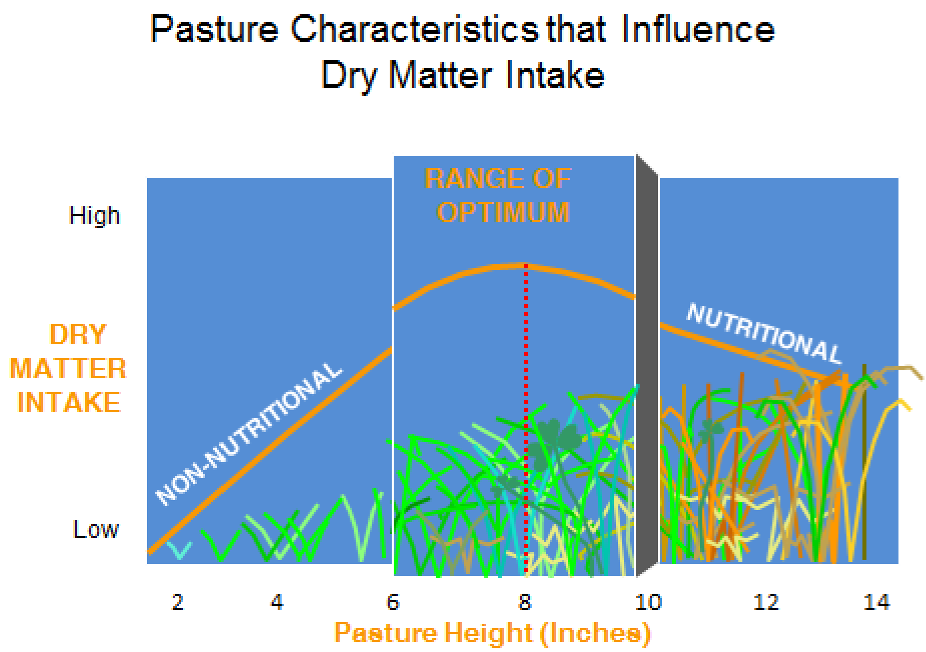

Figure 17. Dry matter intake is low when pastures are less than 6 inches tall because intake per bite is low. When pastures get taller than 10 inches, intake becomes limiting due to decreasing pasture quality.

Behavior-Based Grazing Management

I define behavior-based grazing management as the incorporation of behavioral principles in grazing management planning to enhance animal well-being, ecosystem health, and enterprise sustainability. Behavior-Based livestock management represents a divergence from contemporary livestock production systems (including most organic and pasture-based systems) in that it replaces "animal = machine" with the understanding that "animal ≠ machine." Rather, animals are living, breathing, social creatures that have likes and dislikes, feel pain, discomfort, and stress. They prefer familiar foods to novel foods, mixed diets to monotonous diets, familiar environments to unfamiliar environments, and they prefer to be with companions rather than strangers.

Unlike on modern factory farms where these attributes and characteristics are often viewed as impediments to efficient production, in behavior-based management, they are accepted as part of the natural behavior of animals to be understood, embraced, and incorporated into livestock production systems. In doing so, less fossil fuel, time, and labor are wasted in fighting the nature of the animal. Instead, low cost behavioral principles are applied that provide us opportunities to accommodate and nurture it.

In the following sections, I will share with you some of the behavioral principles and practices that can be used to replace the unnatural, mechanically forced, and fossil fuel driven livestock production system in common use today, with a more natural production system that uses less oil, wastes fewer resources, and works more in harmony with the natural processes which have fostered and evolved life for millions of years.

Start Livestock Grazing when Young

In order for livestock to be proficient at harvesting their own foods from pasture when they are adults, they should start grazing when they are young, and preferably be with their mothers. Although this runs counter to conventional practice on most dairy farms, the influence of mother as a social model is indispensable to the teaching of young animals about foods and places (Pic. 9).

Picture 9. The influence of mother as a social model for young animals to learn about foods is indispensable, even for modern dairy cattle.

With sheep, lambs are most attentive to what their mothers are eating from 4 to 8 weeks of age, the time when they are beginning to rely more on forage and less on milk. Thus, it would seem reasonable dairy calves should be left with their mothers (or foster mothers) at least this length of time. On farms where this is not possible, due to the logistics of the farm or concerns about disease transmission (for example, Johne's), calves should still be raised in pastures where they can at a young age begin to recognize pasture plants as food and acquire the requisite foraging skills necessary for its efficient harvest. Grazing is a learned behavior, thus delaying exposure to pasture increases the time it takes for animals to recognize it as food and reduces their harvesting proficiency.

Transitions Take a Little Time

Adult livestock put out to graze after having been conceived on concrete, born on concrete, raised on concrete, and fed on concrete their entire lives, are at a distinct disadvantage in learning how to graze efficiently. They have had no social model -- i.e., mom -- to teach them how to graze or what to eat, and they certainly don't view pasture as a familiar habitat. While most animals, including dairy cows, can, and do, make the transition from barn to pasture, animals are creatures of habit, and old habits die hard. Thus, the transition for dairy cows from confinement- to pasture-based production is often a discouraging process, fraught with frustration and stress for both the producer and cow alike. It is accompanied by a decrease in milk production and a desire on the part of producers to go back to dairying in confinement as they did in the past.

To avoid this situation, it is probably best to start by conditioning cows to the outside environment first. To do this, cows should be fed their normal ration in the barn and then turned out to a high quality pasture for a few hours each day, gradually increasing the time outside. At first, they may not be comfortable outside and will stand at the gate and bellow to be let back in the barn. However, this should not be done. Giving in and allowing cows back inside for food and water simply delays their learning to forage for themselves. Over time, cows get used to the routine of going outside after milking and staying out. Although they may not recognize pasture as food at first, and thus will eat very little, the greater the amount of time they spend on pasture, the more they will eat. Once cows begin to graze, the barn ration needs to be reformulated in both quantity and quality to account for the nutrients in the grazed forage.

Supplemental Feeding

Well-managed pasture is an extremely high quality food for livestock, including lactating dairy cows. However, it is not considered perfect. The protein is generally viewed as too high and the energy, relative to protein, is too low. Despite this, it is common practice for pasture-based dairy farmers to supplement their cows with even more protein in barn rations. The results of this practice are likely to be counter-productive.

Modern livestock represent the survivors of a long evolutionary history, and they are the product of natural selection. They evolved in high protein plant food environments, and are well-adapted for processing and eliminating the excess protein they ingest during the natural foraging process. However, the same cannot be said for protein that is force-fed to animals in barn rations.

Well-managed pastures are high enough in protein that feeding any supplemental protein in a barn ration will likely exceed the natural adaptation ability of the animal to process and assimilate it. Excessive total-ration protein interferes with an animal's ability to maintain dietary homeostasis, results in unhealthy rumen conditions, ammonia toxicosis, and results in the decrease in voluntary intake of pasture. This is particularly evident with clover.

Un-supplemented cattle and sheep prefer clover to grass by a ratio of approximately 70:30%. Clover is generally higher in protein, energy, and digestibility than grass. Cows can eat more clover than grass, and cows generally make more milk from clover than grass. However, when protein is fed in the barn ration, animals do not prefer to eat clover. Thus, by feeding protein in the barn, producers are in effect substituting high-cost purchased protein for the low-cost protein in clover. In addition, with high producing cows, the increased energy requirement to eliminate excessive protein can reduce milk production. As recommended total ration CP for lactating dairy cows is only 16%, and well-managed pasture can exceed 30%, it is recommended that dairy and livestock producers only supplement energy, and let the livestock harvest their own protein from pasture.

Accommodate the Natural Foraging Cycle of the Animal

Livestock are crepuscular in their feeding behavior, which means their major grazing periods occur around daybreak and dusk (Fig. 18), with the evening period the time when livestock take more bites per minute and spend more minutes per hour actively grazing. While feeding occurs at other times during the day and night, these periods are shorter and of minor importance unless the preferred feeding times have been compromised by climatic factors, grazing pressure, or farm management activities (such as milking) that interrupt the natural grazing behavior. Unfortunately, on most dairy farms, cows are in the barn being milked and fed concentrate foods at the times when they should be out on pasture. A better strategy to maximize intake of low-cost pasture and reduce intake of high-cost concentrate foods, is to alter milking times so that cows have maximum opportunity to be on pasture when they are naturally inclined to want to forage.

Animals do not eat what they do not Recognize

In order for livestock to readily consume a particular plant; the plant must be recognized as familiar by the animal and contain some desirable attribute. Dairy cows, like their herbivorous relatives and ancestors, use their senses of sight, smell, touch, and taste initially to locate and identify potential foods in the environment. Once a food has been eaten, the biochemistry of the food is postingestively evaluated with reference to the foods utility to the animal, which varies among other factors with the animal's age, physiological condition, and recent diet. Foods that more generally meet the specific nutritional requirements of an animal are preferred, while foods that are excessive in nutrients or plant secondary metabolites (PSM) are less preferred or avoided. In addition, known plants containing desirable nutritional qualities are readily consumed. Unknown plants or plants with undesirable qualities are ignored. Familiar foods are viewed as safe, while unfamiliar foods are viewed as potentially dangerous.

To prevent losses in DMI and animal performance while cows are evaluating and adjusting to pastures seeded to unfamiliar species or new varieties, it is best to seed pastures to complex mixtures rather than to monoculture. Providing a variety of species, some familiar and some unfamiliar, will allow animals to maintain DMI on the familiar species, and cautiously sample the unfamiliar. In situations where pastures are seeded to distinctly different combinations of plant species to accommodate differences in soil characteristics or to provide a more uniform seasonal distribution of forage, there should be enough of each different mixture seeded to allow animals time to familiarize themselves with the new species, evaluate their nutrient and toxic properties and to adjust intakes accordingly.

Generally, if dissimilar plant complexes are used, enough acres of each type should be provided to accommodate 10 to 14 days of grazing before the livestock are moved to a distinctively different complex. Because animals learn, and remember for long time periods, this is more important early in the transition to pasture and in the first encounter of a new forage species than it is after the animals have become conditioned to grazing or in subsequent encounters with the new forage species. In addition, animals can also be preconditioned to graze unfamiliar forages by feeding these forages as hay or green chop prior to going out on pasture. Although hay and green chop are not exactly the same as fresh forage in a pasture, animals can generalize based on similarity of smell and taste among the forages.

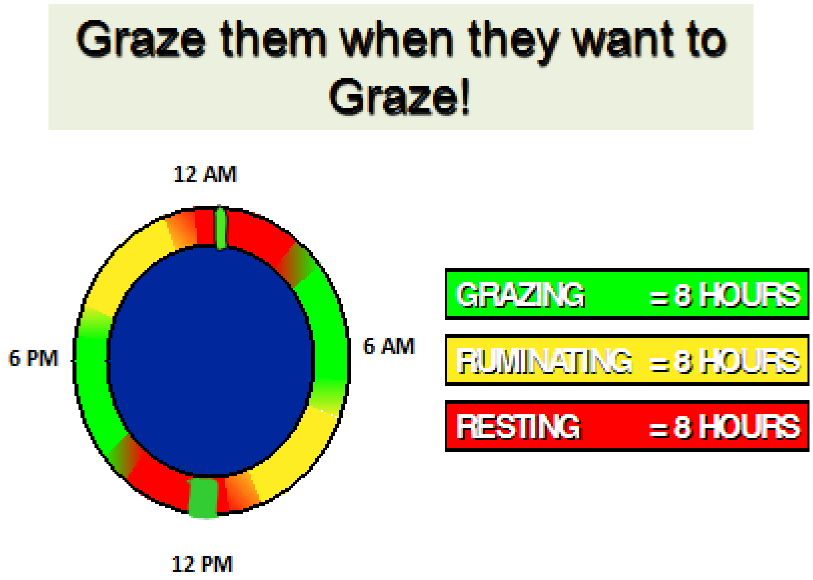

Figure 18. While animals may be observed foraging at almost any time, peak foraging activity takes place during the first and last four hours of day light.

Maintain Plant Species Diversity

Plants exist as a complex of chemical compounds, of which some are used by herbivores as food, i.e., carbohydrates, protein, minerals, vitamins, amino acids, fatty acids, and fats, while others (PSM) are synthesized by plants to prevent themselves from becoming food, i.e., alkaloids, terpenes, phenols, condensed tannins, and the like Although relatively little is known about the biochemical interactions that occur among nutrients in concentrates and pastures that through postingestive feedback ultimately determine what an animal will eat and how much, it is known that no single plant can meet all of the nutritional requirements of an animal throughout its life. Thus, maintaining high within pasture plant species diversity allows animals to select from a variety of plants and parts of plants diets that most closely complement their particular nutritional requirements. Monocultures, or single specie pastures, should be avoided if possible.

In addition, though many of the interactions and influences of PSM are yet to be identified, it is known that in appropriate dosages many have health benefits for herbivores. As an example, tannins (found in birdsfoot trefoil and chicory) are effective against internal parasites. Variety is not just the spice of life, it promotes a better life.

Maintain Adequate Forage Quality and Abundance

From a behavioral perspective, the feed intake of livestock on pasture can be expressed as the product of the time spent grazing or browsing, the rate of biting during grazing or browsing and the amount of herbage taken in with each bite. Anything that manager's do that interferes with this process will lower or limit intake and, as a result, decrease or limit animal performance. As previously indicated, un-supplemented cattle and sheep prefer clover to grass by a ratio of approximately 70:30. To accommodate this natural preference, primary emphasis should be placed on ensuring pastures are at least 40-50% clover. In addition, pasture height should not be reduced to less than 2 inches nor allowed to exceed 10 inches. In pastures less than 4 inches, intake/bite is reduced, which results in cows having to graze longer and take more bites to meet their DMI requirements. In pastures taller than 10 inches increasing neutral detergent fiber (NDF) levels limit how much forage an animal can eat. As both conditions adversely affect DMI, both reduce animal performance. When plant densities and yields are low, animals have to work harder and longer. They are forced to cover more ground, spend a greater amount of time foraging, and generally consume less feed.

Use the Seasons to Your Advantage

The natural calving season for free-ranging herbivores such as deer, elk, bison, and most other herbivores is in the spring when grass is at its peak in quality and abundance. It probably did not take too many millions of years of evolutionary history and adaptation to pair up lactating females with the highest nutritional requirements of the year and the time of year when the food source was at its peak in quantity and quality. By a simple process of elimination, those animals calving in the dead of winter or the peak of summer heat did not leave many offspring behind to perpetuate the folly. Thus, following a seasonal calving strategy is as natural as letting mom raise her own calf.

Law of Least Effort

To ensure that livestock do not work harder than necessary to meet their DMI requirements from pasture, managers must make certain there is an ample quality and quantity of forage available. In the long term, no animal can afford to expend a greater amount of energy in the acquisition of its food than it will obtain from the food once it has been consumed. In some instances, pastures may have to be completely renovated. In other situations, improving grazing management on existing pasture, using higher yielding land, controlling weeds, or liming and fertilizing may be required. Providing two acres of low plant density, low yielding pasture is not an equal substitute for one acre of high plant density, high yielding pasture.

In addition, to minimize production losses, travel distances should be kept to a minimum, and laneways should be well-maintained for easy travel. Dairy cows that have to travel long distances down laneways to pasture expend energy in walking and concurrently consume no food. This is particularly important for high-producing dairy cows. The further animals must walk and the longer they are away from feed, the lower the milk production. Travel distances from the barn should be kept to less than one mile, keeping in mind the topographical features of the landscape. The larger the body size of an animal, the lower will be its ability to negotiate steep slopes or rough terrain. Lactating dairy cows should be grazed on flat to slightly rolling land.

Always Provide Water

Water is not a luxury for animals on pasture, it is a necessity. Water is required for all of life’s processes, including nutrient transport, digestion and metabolism of nutrients, and the detoxification and elimination of waste materials and toxins. Most pastures are complex mixtures of grasses, legumes, and forbs (common weeds) that vary in macro- and micronutrients, vitamins, minerals, and plant secondary metabolites (PSM). The provision of adequate water to cows on pasture ensures nutrients are rapidly assimilated and the PSM are detoxified and eliminated.

Actual water requirements vary with weather conditions, the nature of the forage size of the animal, level of milk production, and how much water cows have had to drink in the barn. In the case of dairy production, milk is approximately 87% water. Thus, to prevent losses in production, water should be provided in ample quality and quantity within 300 feet of where cows are grazing. The closer water sources are to where cows are foraging, the less disruptive it is to the herd when an animal goes for a drink.

Maintain Soil Fertility

From an agronomic perspective, maintaining adequate pH and soil fertility improves forage yields and increases plant densities. While both of these are important, there is another reason to be concerned about soil fertility. The nutritive value and preference of any given plant can be modified by the environmental conditions under which it is grown. Plants growing in stressed or marginal environments--less than adequate moisture, fertility, pH or temperature--are less preferred than the same plants grown under ideal conditions. This is the result of variation in the chemical composition of the plants i.e., nutrients and toxic mineral or organic compounds which is expressed as a change in palatability. To reduce this variability, it is recommended that pasture fertility levels be maintained based on soil test results. The pH levels should be near 6.0 or slightly higher, as plant nutrient availability and soil microorganism activity are near optimum in this range.

Summary

Although modern livestock may not resemble their untamed ancestors or their wild relatives, they nevertheless share a common evolutionary history and developmental path. Searching for food, evaluating dietary choices, locating places to drink, finding shelter, and avoiding predators were matters of life and death, and there is little evidence to suggest that in the few short years livestock have been domesticated, they have entirely lost what took millions of years of evolutionary and natural selection to create. Thus, the more we recognize and accommodate the nutritional and behavioral needs of pasture-based dairy cows, rather than dictate what they are going to get and under what circumstances, the more contented and productive they and we will be, the less damage will be done to ecosystems, and the greater the potential return on investments.

Designing Your Own Grazing System Using the Prescribed Grazing Concept

This section is adapted with revision from D.L. Emmick and D.G. Fox

Prescribed Grazing Management to Improve Pasture Productivity in New York

September 1993

I define the term "Prescribed Grazing" as: the controlled harvest of vegetation with grazing or browsing animals managed with the intent to achieve a planned objective(s).

Conceptually, prescribed grazing views the physical acts of grazing and browsing as animal impacts on plants that, although not identical, are similar in their effects to the harvesting or manipulating of vegetation with machinery or fire. As a result, in much the same manner that the planned or prescribed use of machinery or fire can be used to enhance, maintain, or decrease the quantity, quality, and persistence of targeted plants or plant communities, so can grazing and browsing when administered by prescription.

In using the prescribed grazing concept, forage quality, quantity, palatability, and toxicity are considered the primary plant factors that impact animals. However, the influences of these factors on animal health, nutrition, and ultimately average daily gain, milk production per cow, or other measure of production are considered the consequences of grazing management which accrue through the implementation of a grazing prescription.

In order to effectively utilize the prescribed grazing concept, the management objectives for a particular plant, plant community, or animal production enterprise must first be clearly identified. Once this has been done, the frequency, intensity, duration, and timing of grazing events can be prescribed along with the method of stocking, and the kind, number, and class of animals required to meet the stated objective or objectives. When these factors are integrated with other planned forage and livestock management techniques they form a prescribed grazing management plan.

Grazing by Prescription

Grazing management is recognized as the single most important element in the efficient utilization of pasture. However, it must be remembered that each livestock enterprise exists as a unique combination of human interests, abilities, and management objectives as well as resource based assets, attributes, problems, and concerns. As a result, there is no one best method, plan, practice, or system that can be recommended as superior for all pasture situations.

Each prescribed grazing management plan will need to be developed as a specific treatment designed to accomplish a particular management objective or objectives. The plan can then implemented by prescription by taking into consideration such factors as the landowner's objectives, kind of pasture, number, kind, and class of livestock, and the land/forage resource base of each livestock enterprise.

As a general consideration, the greater the need to maximize control over the quantity, quality, or persistence of plants or plant communities, or desire to optimize animal performance, the more intensive the grazing management must be and, the more comprehensive the prescribed grazing management plan.

Stocking Methods

Stocking methods refer to how grazing and browsing animals are deployed on specific units of grazing land. Although the method of stocking is an integral part of a prescribed grazing management plan, it is not recognized as the primary factor influencing the outcome of grazing management. Stocking methods are simply management tools to enhance livestock control for the purpose of facilitating forage harvest.

The prescribed grazing concept is based on the recognition that there are many different kinds of pasture plants, grazing animals, and landowner production and/or management objectives with each requiring a somewhat different approach or level of grazing management. As a result, prescribed grazing places a greater emphasis on harvest management factors such as prescribing the frequency, intensity, timing, and duration of grazing events; and identifying the appropriate kind, number, or class of livestock than it does on arguing the merits of stocking methods.

Although the prescribed grazing management procedure will generate many different grazing management plans, there are only two methods of stocking used with this strategy—rotational and continuous. Because of the inherent differences associated with the methodologies and mechanics of the implementation, care should be exercised when recommending or implementing a particular method of stocking. Depending on the objectives, the method may not be ecologically required to achieve the planned objective(s) or, because of increased costs, be economically practical to implement.

Rotational Stocking Methods

Rotational stocking requires pastures to be subdivided into individual grazing units called paddocks. The size and number of paddocks depend on the level of pasture productivity, stocking rate of livestock, and the desired residency period. Individual paddocks are grazed one at a time, in a planned order, with livestock occupying each paddock long enough to harvest the existing forage, but not so long as to allow grazing of regrowth to occur. After each paddock is grazed to the desired forage stubble height (which depends on the plant species and grazing prescription), the pasture is allowed to regrow and regain vigor before again being grazed.

In a well-managed rotational stocking method, the forage supply is constantly monitored and adjustments to the stocking rate made by increasing or decreasing the amount of pasture acreage grazed during a particular time period (Figure 19).

Generally, development costs for water, fence, and management are greater for rotational stocking than for continuous stocking. However, because it is easier to maintain an effective balance between forage demand and forage supply, rotational stocking methods generally promote higher forage yields, more uniform levels of forage quality, improved harvest efficiencies, and as a result, maximize livestock production per acre of pasture.

Another advantage of using the rotational stocking method is that by controlling the frequency and intensity of grazing, plant species which are capable of producing higher forage yields can be utilized. With continuous stocking, the taller more productive plant species tend to decline in productivity and abundance. With the rotational stocking method, these plants can remain productive and persistent for many years.

The Use and Management of Rotational Stocking Methods

Generally, rotational stocking methods provide the greatest benefit for lactating dairy cattle and livestock with superior genetics for growth. These types of animals have the greatest need for large quantities of consistently high quality feed in order to maximize their genetic potential. Livestock operations seeking to maximize production per acre of pasture will also benefit from pastures grazed with a rotational stocking method.

In most instances livestock should not remain on an individual paddock for longer than 7 days, with 3-4 days a more preferred residency period. The exception to this occurs with lactating dairy cows. In order to maintain consistency of milk production, they should not remain in one paddock for longer than 2 days, with a half day residency period preferred. Although there are no optimum rest intervals between grazing periods, it is recommended that during the most active growth periods of spring and early summer, once a paddock is grazed it should be rested between 15 and 20 days, and during the slower growth periods of late summer and fall between 20 and 40 days.

The rotational stocking method is planned around having enough forage available for grazing during the mid-summer period. As a result, during the spring there will be nearly twice as much forage as the livestock need for grazing. Hence, approximately 50 percent of the planned acreage should be closed for grazing during the first two months of the pasture season and the surplus forage mechanically harvested or grazed with other livestock accounted for in the planning process. Once the forage growth rates begin to decline and there is a need for additional feed, the entire planned acreage will become available for grazing.

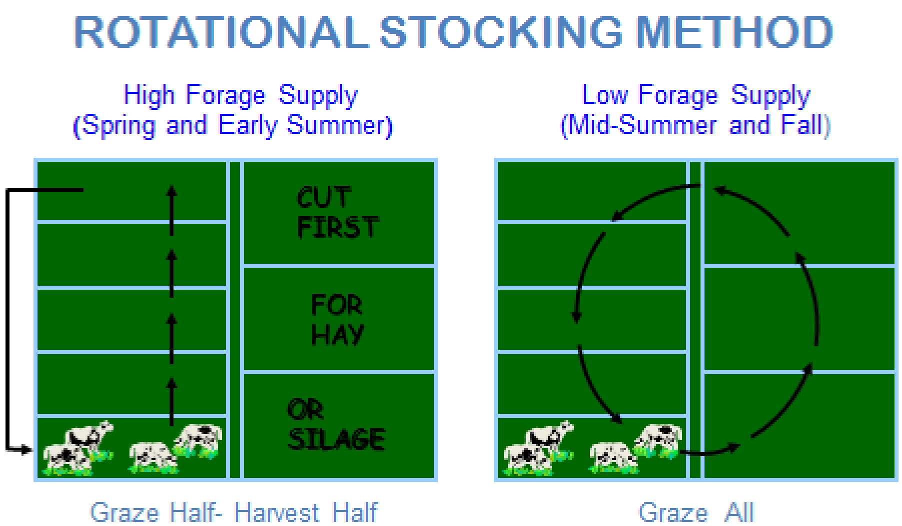

Figure 19. In using rotational stocking methods, the number of animals generally remain constant but the number of acres grazed changes over time.

Planning Procedures for Rotational Stocking Methods

Although there are a number of different ways in which to develop prescribed grazing management plans, the following procedures have been created to provide practical guidelines which can be applied to regulate forage quality, quantity, and harvest efficiencies at critical stages of the season, and without undue complexity of management or high cost.

Step 1. Estimate the Total Forage Requirement

The amount of forage dry matter required to sustain pasture health and productivity as well as achieve the desirable level of animal performance is called the total forage requirement or the forage demand. It is based on having enough forage available to meet the daily dry matter intake requirements of the herd or flock with an additional amount above that to ensure that overgrazing or other damage to the plant resource does not occur. This value is estimated by calculating the forage requirement per animal per day and then multiplying this value by the total number of animals.

The amount of forage dry matter required for each grazing animal i.e. its daily forage requirement is, among other factors, directly related to how much it weighs. As a general rule, livestock require an amount of dry matter per day equal to 2.5 to 3.5

percent of their body weight. Although a lactating dairy cow may require more than this, the remainder of the ration is generally provided in the barn and fed in response to a particular level of milk production.

To calculate the daily forage requirement for livestock other than lactating dairy cows multiply the weight of the animal by 2.5 percent (.025). For lactating dairy cows multiply the animal weight by 3.5 percent (.035). For planning purposes, it is better to err on the side of calculating too high of a forage demand and wasting some feed, rather than estimating too little and not meeting the livestock demand.

Animal weight X .025 or .035 = daily forage requirement/animal

Table 1. provides some examples of daily forage requirements.

To determine the daily herd or flock forage requirement multiply the per animal daily forage requirement by the number of animals.

Forage requirement /animal /day X number of animals = daily herd or flock forage requirement

In planning to meet the forage requirement for growing animals such as cow/calf or ewe/lamb pairs, steers, heifers, etc., keep in mind that these animals start the grazing season at a much lighter weight than when they finish. Subsequently, the forage demand starts out low but increases over the grazing season as the livestock gain weight. To plan a system for these kinds of animals, use an average weight that would be expected midway through the grazing season. For cow/calf, ewe/lamb, or other livestock combinations, use the combined average weight of the pair at midseason.

Step 2. Estimate the Forage Supply

Determining the forage supply is the most difficult part of setting up a prescribed grazing management plan. This is because of the variability encountered in plant species composition and density, and the factors which control plant growth and yield. These factors include climatic conditions, soil type, soil fertility, and the level of management. As a result, actual measured yields obtained from the pasture will provide the most reliable estimate of the amount of forage available for grazing because they are directly related to the soil, plant, climatic, and management variables most closely associated with the site.

However, if there is no site specific information available, estimated potential grass-legume hay yields based on soil type may be substituted. This information is available in various soil databases which can be provided by either the USDA-Natural Resources Conservation Service (NRCS) or the University Cooperative Extension.

Table 1. EXAMPLES OF DAILY FORAGE REQUIREMENTS

Lactating dairy cow weighing 1300 lbs.
1300 X .035 = 45.5 lbs dm/day

Beef cow/calf pair with a combined weight of 1400 lbs at midsummer
1400 X .025 = 35 lbs dm/day

Ewe/lamb pair with a combined weight of 200 lbs at mid-summer
200 X.025 = 5 lbs dm/day

Steer, Heifer, or other growing livestock weighing 650 lbs at mid-summer
650 X .025 = 16.25 lbs dm/day

Table 3 is a chart that estimates the amount of forage predicted to be available for grazing. It uses grass-legume hay yield estimates reported in **Tons/Acre/Year** as a reference point or index to link the productivity of a particular pasture to its soil type, and then provides an estimate of how much forage is expected to be available for grazing every 15 days in the spring and 30 days in the summer expressed in P**ounds/Acre/Rotation.**

Table 3. FORAGE AVAILABILITY ESTIMATES FOR USE WITH ROTATIONAL STOCKING METHODS

Hay Yield Tons/Acre/Year	5.5	5.0	4.5	4.0	3.5	3.0	2.5
Forage Availability Pounds/Acre/Rotation	2200	2000	1800	1600	1400	1200	1000

Maximum spring rotation length 15 days.
Maximum summer rotation length 30 days.

To use this table, first, locate the pasture on a soil survey map and determine the major soil type. Second, obtain the grass-legume hay yield from a soil yield database or provide your own actual yields. Third, locate the hay yield estimate in the table and reference it to the corresponding forage availability factor.

Step 3. Determine the Paddock Residency Period

As previously indicated, lactating dairy cows have the greatest need for very short residency periods. In order to maintain high and consistent levels of milk production, one-half day residency periods are recommended but can range between one-half and 2 days. Most all other classes and kinds of livestock can meet their nutritional requirements grazing pastures with longer residency periods. However, where maximizing pasture production and harvest efficiency is indicated, residency periods of no longer than 3 days are recommended.

Step 4. Calculate the Paddock Size

Once the forage demand, forage supply, and residency period have been determined for a particular livestock operation the size of individual paddocks can be estimated by dividing the forage demand by the forage supply and then multiplying this number by the residency period. The result will be the paddock size in acres.

(Forage demand ÷ forage supply) X residency period = paddock size in acres.

Step 5. Determine the Number of Paddocks Required

The number of paddocks required for a particular grazing plan is based on having enough available to provide an adequate regrowth interval during the slowest growth period of summer. As previously indicated, the combined experiences of many producers in the Northeast indicates that a 30 day maximum regrowth interval provides a reasonable compromise between maximizing forage quality and promoting maximum yield.

To calculate the number of paddocks required, divide the maximum regrowth interval (30 days) by the residency period selected and then add one additional paddock.

(30 ÷ residency period) + 1 = number of paddocks needed

Step 6. Estimate the Number of Acres Required

Once the planning process has gotten this far along calculating the total number of acres required is fairly straight forward. Simply multiply the size of the paddock by the number of paddocks and you have it.

Paddock size X number of paddocks = number of acres planned

Although there are computer-based planning spreadsheets available through the NRCS to help farmers calculate the number of acres of pasture required for their grazing plan, appendix 1 offers a simple but effective means to do the same thing.

Implementing the Plan

Prescribed grazing management plans which utilize a rotational stocking method need to be designed and implemented in a manner that allows for as much management flexibility as forage growth rates are variable. Plans should not be so costly to develop or complex to manage as to prove impractical. However, they need to be substantive enough in construction and design to facilitate the management required to regulate forage quality, quantity, and harvest efficiencies at critical times during the season.

In using the methodologies described in this guide to create prescribed grazing management plans, the forage supply (number of acres of pasture required) is calculated to meet the forage demand (total forage requirement) during the midsummer period when forage production is at a minimum. During the spring, when forage growth rates are at their peak, there will be approximately twice as much forage available as can be effectively grazed by the number of livestock planned. To efficiently utilize as much of this forage as possible, part of the planned acreage should be mechanically harvested or, as an alternative, livestock numbers should be doubled for the first 60 days of grazing. However, as pasture growth rates begin to decline, the number of livestock must be reduced in order to achieve the planning objectives.

The plan is primarily designed to facilitate grazing, and at some point all of the acreage required in the plan will be harvested by grazing animals. Enough fencing must be constructed to provide structural and managerial integrity, but not so much that it interferes with the use of equipment for mechanical harvesting of surplus forage, or creates logistical problems when clipping, fertilizing, or attempting other management activities.

Harvesting forages with grazing animals requires a different level and kind of management than harvesting forages with machinery. To facilitate the efficiency of harvest, the grassland should be divided into two separate management units based on the first or primary intended use of each unit (Figure 20).

Management Unit I is designated as primary pastureland because the forage produced in this unit is primarily intended to be harvested by grazing animals. Management Unit II is designated as primary hayland because the forage produced in this unit is in excess of that required for grazing during the spring (unless the double stocking method is used instead of mechanical harvest). Therefore, it generally will not be grazed until after it has first been mechanically harvested. However, as forage growth rates slow in midsummer and the forage supply in Management Unit I is not able to keep up with the forage demand, Management Unit II will then be utilized as pasture.

The main organizational difference between the management units is that the primary subdivisions in Management Unit II are purposefully larger than the primary subdivisions in Management Unit I in order to facilitate machinery harvest. However, if the primary pasture subdivisions are large enough to allow for a reasonable machinery usage, this may not be necessary.

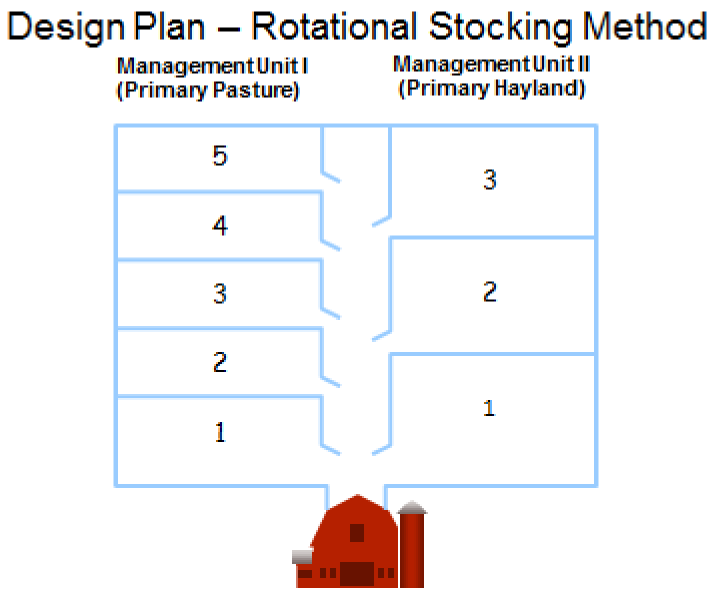

Figure 20. Permanent or semi-permanent steel wire is used for the perimeter, laneway, and major subdivisions( )

Management Unit I should be subdivided into 5 major subdivisions using permanent or semi-permanent wire. Within each of these subdivisions enough forage should be planned to provide three days of grazing. Use the planning process outlined to calculate the number of acres required for one day's worth of grazing, and then triple this amount. If the system operates exactly as planned, by the time all five subdivisions have been grazed, approximately 15 days will have passed since the first paddock was grazed. In other words, the rotation length on Management Unit I would be approximately 15 days.

For a dairy herd, each major subdivision would be further subdivided into three paddocks with either temporary or semi-permanent wire and allocated to the herd one paddock at a time for each of the three days. Should the paddocks be too large (more forage available than the livestock can consume in three days) they can be made smaller. Should the paddocks be too small (not enough forage available for the livestock) they can be made larger (Figure 21). In using this design for other classes or kinds of livestock, each one of the major subdivisions serves as an individual paddock. They are calculated to contain enough forage to last for three days. If the paddock is too large or too small, it can be grazed for a greater or lesser number of days rather than changing the size of the paddock (which could also be done).

Design Plan – Rotational Stocking Method

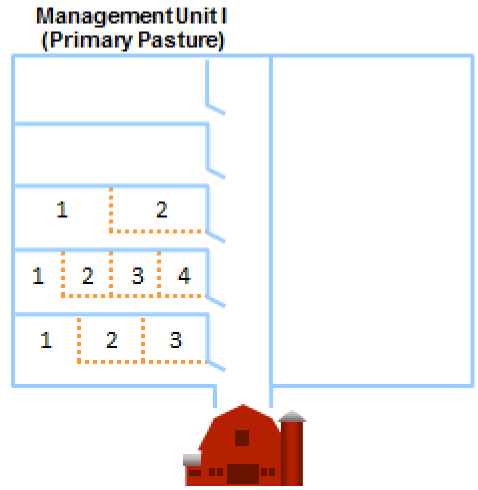

Figure 21. 5 major subdivisions – created with permanent or semi-permanent steel wire (——)
Each major subdivision is planned to provide forage for 3 days of grazing. Use temporary wire to divide into smaller or larger paddocks (- - -) depending on forage availability.

The system can be planned for a dairy herd or some other class or kind of livestock, because each of the major subdivisions in this design is delineated with a structurally sound perimeter fence. Through the use of temporary or semi-permanent wire, there is an unlimited amount of flexibility created to easily change the size of a paddock in response to the actual amount of forage that is available.

Management Unit II, ideally, would be subdivided into 3 major subdivisions using permanent or semi-permanent wire. Within each subdivision there should be enough forage to provide five days of grazing. Because the first intended use of this management unit is for mechanically harvested feed, the subdivision should be large enough to easily accommodate harvesting machinery. However, the subdivision should not be so large that it can't be easily subdivided into paddocks with temporary wire after the first cut of hay or silage is taken (Figure 22).

If the plan operates exactly as predicted, by the time all three major subdivisions have been grazed, approximately 15 days will have passed since the first paddock in the unit was grazed. In other words, this would provide a 15 day rotation length, the same as for Management Unit I.

During the spring of the year, Management Unit I is grazed on a maximum rotation length of 15 days. A first cut of hay or silage is taken from Management Unit II. After Management II has been mechanically harvested it will then be subdivided into

Design Plan – Rotational Stocking Method

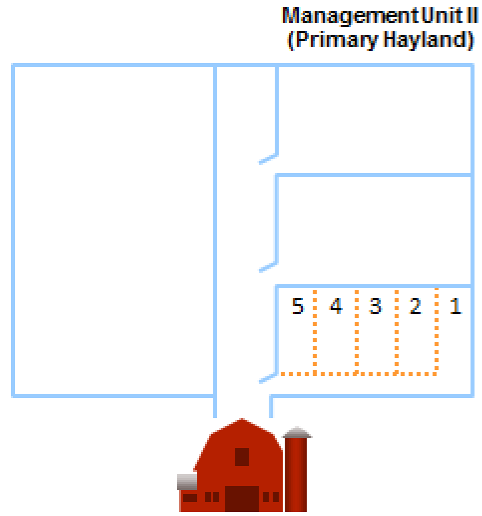

Figure 22. 3 major subdivisions- created with permanent or semi-permanent steel wire (——). Each major subdivision is planned to provide forage for 5 days of grazing. Use temporary wire (- - -) to divide into smaller paddocks after hay is cut.

paddocks with temporary or semi-permanent wire and then grazed as necessary. Once both Management Units are used for grazing, the rotation length increases from a maximum 15 days, when 50% of the planned acreage is utilized, to a maximum of 30 days when the entire system is grazed. Actual rotation lengths will depend on forage growth rates. Therefore the 15 day planned rotation length may vary between 12 and 20 days, and the 30 day planned rotation length may vary between 20 and 40 days.

Although the previous figures all depict pasture on the left, hayland on the right, and a laneway up the middle, each farm represents a unique combination of characteristics. These include, among other things, the kind of grazing animal, forage type, soil type, topography, water supply, and location of the barn in relationship to the pasture. There will be many ways in which to actually implement a grazing plan, however, the most important concerns are the system must fit the lay of the land, provide enough flexibility to allow for efficient forage harvest and management, and must be practically suited to the kind and class of livestock. However, to the greatest extent possible it is best to locate the primary pasture closer to the barn and have the primary hayland furthest away. This will allow livestock to spend the greatest amount of time grazing closer to the barn and limit the amount of time livestock have to travel to the more distant pastures.

Continuous Stocking Methods

The continuous stocking method is a method of livestock deployment where livestock have the continuous or uninterrupted use of a unit of pasture throughout the time period in which grazing is allowed.

As commonly practiced, the continuous stocking method can be described as a minimum management practice. A set number of animals are turned out on a given number of acres of pasture and allowed to graze for as long as the forage supply lasts. Although development costs for water and fencing are low with this method, it is extremely difficult to control the grazing events, and thus, it is nearly impossible to maintain an effective balance between forage demand and forage supply. When stocking rates are set too high, animal nutritional requirements are not met and individual animal performance is reduced. When stocking rates are set too low, forage is wasted and production per acre is reduced. In either case, the result is often a highly variable forage quality and an inefficient conversion of forage into a saleable product.

Generally, the continuous stocking method is not very productive in terms of liveweight gains per acre or in maximizing the length of grazing season. However, as long as there is an adequate supply of forage, gains per animal are often equal to or greater than those obtained from more intensively managed rotational stocking methods. This is primarily the result of selective grazing.

When provided with a surplus of forage from which to choose, grazing animals have the ability to select a diet that is higher in overall quality than the average quality of the pasture. In other words, they select the best and leave the rest. Unfortunately, the forage that is left behind is wasted, and it is this non-utilized feed that accounts for the reductions in liveweight gains per acre and length of grazing season.

Another problem with continuous stocking is that over time it can weaken or eliminate many of the more productive plant species. Forages such as birdsfoot trefoil, red clover, alfalfa, bromegrass, timothy, and orchardgrass do not survive well under close continuous grazing. As a result, pasture yields are often reduced along with a loss of quality.

The Use and Management of Continuous Stocking Methods

Because of the increased amount of wasted forage associated with the continuous stocking method and the highly variable forage quality, it is not recommended for livestock operations where maximizing production per acre is the primary objective or for livestock possessing high genetic potentials for growth or milk production. However, for many livestock operations where the forage supply exceeds the forage demand, and there is no demonstrated need for the surplus forage, continuous stocking may be the most appropriate method or all that can be economically justified.

An improved management strategy for increasing the harvest efficiency of pastures which are continuously stocked is to alter the number of grazing animals in response to the amount of available forage. This is generally described as a "put and take" style of grazing management. Although pastures that are managed using this strategy may be continuously stocked during the period of time in which grazing is allowed, the forage supply is constantly monitored and adjustments to the stocking rate made by increasing or decreasing the number of grazing animals in response to the available forage supply.

As depicted in (Fig. 23), in the spring of the year, pastures should be stocked with approximately twice the expected summer stocking rate. As forage growth rates slow in midsummer, the stocking rate should be reduced by at least 50%.

This method is particularly effective if there are haylands available which can be grazed after the first cutting of hay is taken, or when animals of different age classes are grazed together and some of the animals can be sold, placed in feedlots, or in some other manner removed from the pasture.

With the continuous stocking method, there are always some livestock present on a pasture during the time period in which grazing is allowed. As a result, there is very little opportunity to directly control the frequency and intensity of grazing events. Therefore, it must be done indirectly by establishing grazing height guidelines. During the grazing period, the height of the forage should not be allowed to exceed 6 inches nor decrease to less than 3.0 inches.

Another use for the continuous stocking method of grazing is where the prescribed grazing objective is to weaken or eliminate a particular plant or plant community. By over stocking a unit of pasture and grazing with the continuous stocking method, grazing and browsing animals can harvest vegetation with a frequency, intensity, duration, and timing that is not conducive to its continued survival. Once the plant community is weakened or suppressed, the pasture can be over-seeded with a more desirable plant species.

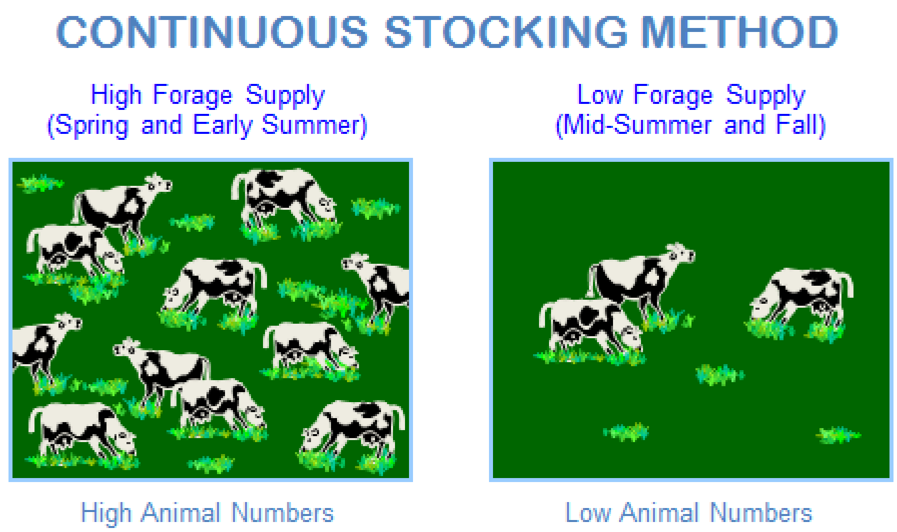

Figure 23. In using continuous stocking methods the acreage generally remains constant but the number of animals change over time.

Planning Procedures for Continuous Stocking Methods

Step 1. Estimate the Total Forage Requirement

Estimating the forage requirement for the continuous stocking method is the same procedure as for the rotational stocking method.

Animal weight X .025 = daily forage requirement/animal

To determine the DAILY HERD/FLOCK FORAGE REQUIREMENT multiply the per animal daily forage requirement by the number of animals.

Forage requirement/animal/day X number of animals = daily herd or flock forage requirement

Step 2. Estimate the Forage Available for Grazing

The amount of forage available for grazing with the continuous stocking method is based on the total hay yield in Tons/Acre/Year minus 40% for losses due to trampling, fouling with manure and urine, and reduced growth. Table 2 is a chart that estimates the amount of forage predicted to be available for grazing based on grass-legume hay yield estimates.

Table 2. FORAGE AVAILABILITY ESTIMATES FOR USE WITH CONTINUOUS STOCKING METHODS

Hay Yield Tons/Acre/Year	5.5	5.0	4.5	4.0	3.5	3.0	2.5
Forage Availability Pounds/Acre/Year	6600	6000	5400	4800	4200	3600	3000

Step 3. Determine the Grazing Period

In most parts of the northeast, the period of grazing will range between 150 to 215 days depending on the local environmental conditions.

Step 4. Calculate the Number of Acres Required

The number of acres required for a continuous stocking grazing plan is based on having enough forage available to meet the season-long forage requirement. It is calculated by multiplying the daily herd/flock forage requirement by the expected grazing period and dividing this number by the forage availability factor selected in step 2.

<u>(Daily herd/flock forage requirement) X number of days in the grazing period) ÷ forage supply = number of acres planned</u>

See appendix 2 for a prescribed grazing management plan worksheet to be used with continuous stocking methods.

Implementing the Plan

By definition, when using the continuous stocking method, livestock remain on a grazing unit the entire time in which grazing is allowed. However this does not mean the stocking rate (number of animals per acre) has to remain constant or that grazing on a particular piece of land will be season-long.

For example, in some situations, hay fields may be grazed after the first cut of hay is taken. In other cases, hay fields may be grazed after the second cut. In either situation, livestock are not present the season-long. However, once the livestock are deployed, they may be continuously stocked until the forage supply is depleted.

During the spring of the year, the livestock in the previous example may well have been on a pasture or pastures that were also grazed with a continuous stocking method. However, as the forage growth rate declined there was not enough forage available for the entire herd or flock. As a result, some, but not all of the animals were moved to the hayfields. The pasture is still being grazed (continuously stocked) only with a reduced number of animals.

In order to reduce the amount of forage that is wasted or conversely, improve the harvest efficiency on pastures that are grazed with the continuous stocking method, it is recommended that the number of animals per acre of pasture be adjusted seasonally according to the amount of available forage. To facilitate this process, the following guidelines are recommended:

First, follow the planning procedures previously outlined for continuous stocking methods in order to balance the forage supply with the forage demand. Second, create two management units.

Management Unit I will be designated primary pastureland because, as with the rotational stocking method, this unit is primarily intended to be used for pasture. Management Unit II will be designated primary hayland. Its primary or first use will be for hay production (Figure 24).

In the spring of the year, Management Unit I would be stocked with the entire herd or flock of grazing animals.

Management Unit II would be harvested for hay. When the forage supply on Management Unit II has recovered to a point where it will support livestock, rather than wait for Management Unit I to be overgrazed, split the herd or flock and re-allocate to both Management Units.

Although each Management Unit will be continuously stocked during the time period in which grazing is allowed, the periods of grazing are different for each unit as well as the number of animals present.

How effective the prescribed grazing plan will be in meeting the planned objective(s) is determined by maintaining an adequate control over the balance between the total amount of forage required by the livestock and the amount of forage available in the pasture. This controls the frequency and intensity of individual plant defoliations which ultimately has influence over forage quality, quantity, and persistence, as well as harvest efficiency, and animal performance**.**

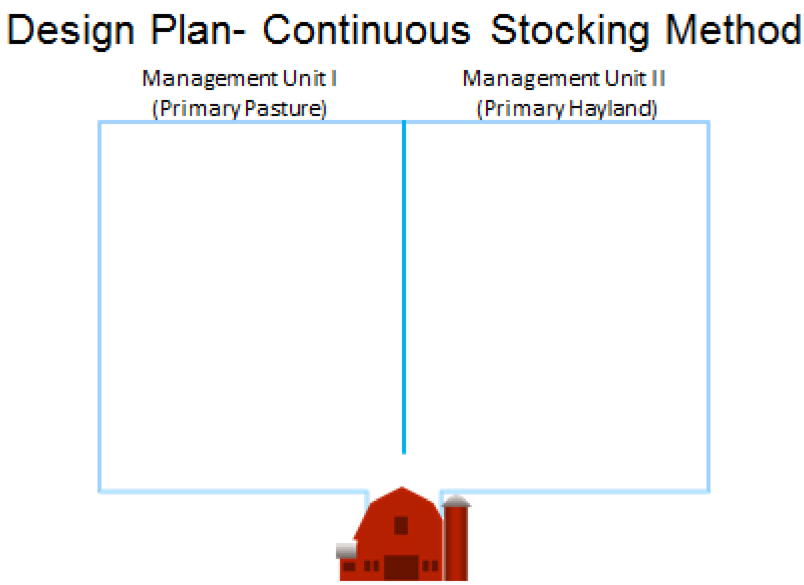

Figure 24. Use permanent or semi-permanent wire for perimeter, and major subdivisions (—).

Other Important Considerations

Once a prescribed grazing management plan has been developed, there are several other important factors to consider.

Water

Water is an extremely important part of a grazing plan and the more accessible it is to the livestock, the better. However, this does not mean that every paddock requires a separate stock tank. In some cases a stock tank can be placed in a fence line and serve 2 or more paddocks, or with some creative fencing, one source of water can supply the entire planned acreage. In addition, by using a main water line with plug in points and a 100-foot garden hose, stock tanks can be placed in different locations within paddocks thus eliminating trampling losses and mud (Pic. 10). The primary concern is making sure that water is available to the livestock at all times and that it is of adequate quantity and quality. Grazing management plans for lactating dairy cattle should include a source of water at least every 300 feet. Other classes and kinds of livestock should have a source of water at least every 1000 feet.

Shade

Under normal northeastern conditions, there are but a very few days during a summer when the lack of shade would be a concern. In fact, providing shade for lactating dairy cows may do more to harm milk production than to help. Livestock are a lot like people in that sometimes things are done, not out of necessity, but out of desire. When a lactating dairy cow stands in the shade on a 75 to 80 degree day with a cool breeze blowing, it is not because she needs to. It's because she wants to. Unfortunately, while she is standing in the shade she is not eating and, as a result, milk production is reduced. However, during those few days when temperatures exceed 85 degrees and there is little or no breeze blowing, dairy cows can still graze mornings and nights. During the heat of the day they can be put in the barn or on a pasture with shade. For other classes and kinds of livestock, having them in pastures with shade and water on the hottest days is all that is required.

Shape of Paddocks

Livestock like to cruise fence lines to locate their boundaries or escape points. In doing so, a greater amount of forage is trampled and wasted through deposition of manure and urine. To help reduce these impacts, paddocks should be as square as possible. Rectangular paddocks are also acceptable as long as they are no more than four times as long as they are wide. Although other shapes can be used, in particular when fence lines have to follow natural land forms or boundaries, the use of circles, triangles or other odd shapes should be kept to a minimum (Fig. 25) Keep in mind that just because a fence is already in place does not mean that it is in the best place.

Picture 10. Having water supplied through a main line with plug in points along the way allows garden hose to be used to place the water tank in various locations within the paddock and eliminate mud.

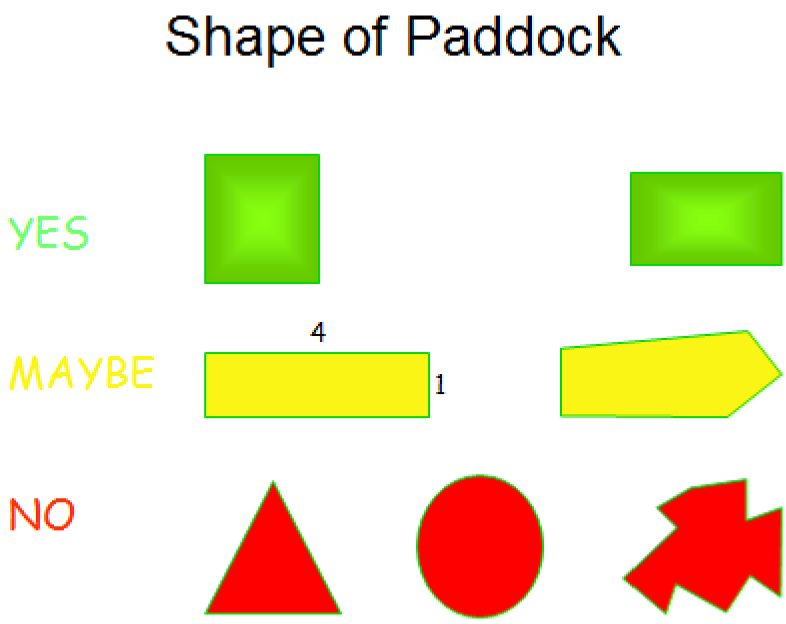

Figure 25. Paddock shape should be kept as square as possible. If rectangles are used, their length should not exceed their width by more than a four to one ratio. Other odd shapes should be avoided.

Paddock Orientation

Forage growth rates, forage availability, and forage utilization are all impacted by, among other things, differences in forage type, topography, and soil suitability. As a result, paddocks need to be oriented in such a manner that variability is kept to a minimum. In other words, a single paddock should not include steeply sloping hillsides with hilltops and flatlands, soil types that vary significantly in suitability due to wetness, stoniness, inherent differences in fertility, etc., or forage species that differ greatly in growth or yield characteristics. Also, paddocks should not be oriented up and down hillsides. In particular, if the water supply is located at the bottom of the hill, livestock will tend to overgraze the lower slope and undergraze the upper slope. As a result, whenever feasible, paddocks should be oriented on the contour.

Gate Location

Gates need to be located so they do not interfere with the natural movement of livestock as they travel to and from the barn or water (Fig. 26). Generally, gates should be located in the corner of the paddock that is closest to the direction the livestock need to travel. If they are not, although some of the livestock will find their way out of the paddock, there will always be a few that will end up trapped in a gateless corner trying to figure out how to destroy a fence.

Laneways

Laneways should be constructed so that livestock can be easily moved from one paddock to another, to the water supply, and to the barn or other facility. The laneway should be wide enough to get harvesting or other machinery through. In heavy traffic areas, gravel, shale, crushed limestone, concrete, or other substrate may have to be utilized to prevent livestock from turning the laneway into a wallow. If necessary, a culvert pipe may be needed or a bridge built. Being able to get livestock to the pasture is as important as producing the forage in the pasture (Pic. 11).

Clipping Pastures

Clipping pastures should be done if there is a need, but not done just to make the pasture look pretty. A good prescribed grazing management plan has a planned amount of forage that will be harvested by livestock and an additional amount that must be mechanically harvested. However, even with the best management, some of the pasture may still get ahead of the livestock and become overmature, or there may be a problem with weeds. If the livestock rejected the forage the first time they came into contact with it, chances are they will reject it the second time as well. In these instances, clipping is not only desirable; it is a key to maintaining high quality pastures.

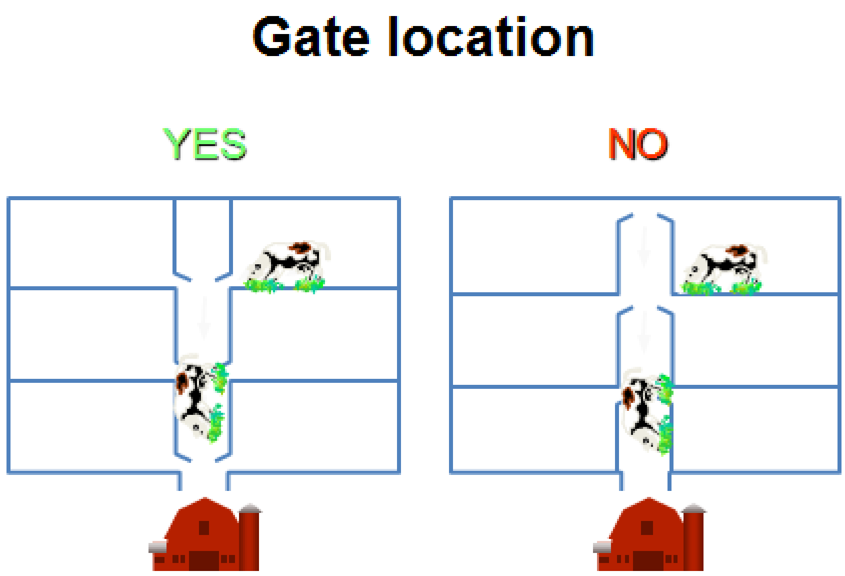

Figure 26. To prevent animals from getting caught in dead-end corners, ensure that gates are located so that they do not inhibit the natural flow of livestock to water, to the barn or other handling facilities, or the next paddock.

Dragging Pastures to Spread Manure

The more intensive the grazing management, the lesser the need for dragging manure. With rotational stocking, livestock do a fairly good job of spreading their own manure. However, with continuous stocking, livestock have the opportunity to congregate or camp out in favorite areas, such as around watering facilities, mineral feeders, feed bunks, or in shaded areas etc. As a result, there will be a greater accumulation of manure in and around these areas, and dragging will be required to redistribute the nutrients back to the pasture. If dragging is done, it should be done late in the season, after the pasture is grazed for the last time.

Picture 11. Laneways are an essential part of any pasture system. Livestock need to be able to easily get from one paddock to the next, to water, or handling facilities.

Soil Fertility

Although the lack of grazing management is the primary cause of pasture failure, the second most important cause is the lack of fertility management. For a pasture to produce large volumes of high quality feed, there must be an appropriate amount and balance of nutrients available in the soil. If essential plant nutrients are lacking, or unavailable as a result of low pH., plant productivity will be reduced. Ideally, soil testing should be done at the same time the grazing system is being planned, and soil nutrients added prior to implementing the system. A pH level near 6.0 should be maintained and phosphorus and potassium levels should be in the medium to high range for grass/legume forages.

Pasture Seeding

As a general consideration, seeding a pasture should be the last step in a three step process. In many cases, controlling the negative influences of grazing animals by implementing a sound prescribed grazing management plan, followed by correcting deficiencies in soil fertility, will be all that is required to bring an existing pasture up to an acceptable level of production. However, there are occasions where seeding pastures may be necessary, such as to replace an undesirable species composition or when starting from bare ground. In these situations, ensure you plant about 15 pounds of pure live seed (PLS) per acre consisting of 10-12 pounds of grass and 3-5 pounds of legume.

In situations where there is a need to add to an existing forage base, no-till seeders work well and so does using a “stomp and plop” method. To do this, I suggest wait until spring when the soil is firm but “thumb print damp;” and fence off small sections of the pasture at a time. Then run cattle in to break up thatch and eat the existing vegetation, so as to reduce the competition for the new seedlings. Then, once there is some bare ground beginning to show, broadcast up to 2 pounds of Ladino white clover and 3-5 pounds of red clover and/or birdsfoot trefoil per acre, along with your favorite grass, and let the animal’s hooves plant the seed. Because livestock prefer legumes over grass by a 70:30 margin, ensure at least 40% of the stand mix is in legumes.

USDA - Risk Management Agency (RMA)

There are few guarantees in life. The unknown and even the uncertainty of the known can place farmers at financial risk on a daily basis.

While adopting a grassland-based production system and optimizing the use of pastures managed as crops can lower production costs and decrease some of the financial risks associated with dairy and livestock production, sometimes even that is not enough.

RMA offers sound risk management solutions to farms of all sizes and levels of production. Some types of insurance policies are made to cover smaller more diversified operations. Some are better suited for larger operations. As well, some lenders are now requiring crop insurance as a condition for financing.

While no payments are made for losses due to mismanagement, negligence, or wrong-doing, insurance is provided against revenue loss due to any unavoidable natural occurrence during the current or previous crop year, or to market fluctuations during the current insurance year.

RMA offers known solutions to help with the unknown. More information can be found at www.rma.usda.gov or www.agrisk.bog.uvm.edu

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Appendix 1. Prescribed grazing management plan worksheet to be used with rotational stocking methods.

Step 1. Estimate the Forage Demand:

The forage demand is the amount of forage dry matter (DM) required to feed the herd/flock for one day. It is calculated based on the rule of thumb that grazing animals require an amount of forage dry matter equal to about 2.5% of their body weight per day. *Note* For lactating dairy cows use 3.5%.

_________________________ X .025 or .035 =_______________ X
average weight/animal (lbs) lb Dm/head/day

____________ = Total Forage Demand_____________
# of animals lb/day

Step 2. Estimate the Forage Supply:

This is the amount of forage dry matter that is predicted to be available for grazing after a 15 day growth period in the spring and a 30 day growth period in the summer and fall. *Note* Actual pasture growth rates are extremely variable. As a result, the numbers presented are for planning purposes only. Optimum growth periods may be longer or shorter than those indicated.

Unless actual measured yields are available, use estimated data-base yields for grass-legume hay. Use the following table to convert to forage availability on a rotational basis.

Forage Availability Estimates

Hay Yield tons/acre/year	5.5	5.0	4.5	4.0	3.5	3.0	2.5
Forage Availability lbs/acre/rotation	2200	2000	1800	1600	1400	1200	1000

Forage Supply_________________
lbs/acre/rotation

Step 3. Select Residency Period:

In other words decide how long you want your livestock to remain in a particular paddock. One-half day is recommended for lactating dairy cows, three to seven days for all other livestock. *Note* For maximizing harvest efficiency, use the shortest residency period indicated for the type of livestock operation.

Residency Period____days

Step 4. Determine Paddock Size:

The paddock size is based on meeting the total forage demand for the number of days of grazing indicated by the residency period.

______________ divided by ______________ = _____________
forage Demand forage Supply

X _________________ = Paddock Size ____________
residency Period acres

Step 5. Calculate the Number of Paddocks:

The number of paddocks required is based on meeting the longest regrowth interval recommended, i.e. 30 days.

30 divided by _____________________ =__________ + 1 =
residency period

Number of Paddocks Needed____________

Step 6. Estimate the Total Number of Acres:

_____________ X _____________________ =
paddock Size number of Paddocks

Number of Acres Planned____________

Appendix 2. Prescribed grazing management plan worksheet to be used with continuous stocking methods.

Step 1. Estimate The Forage Demand:

The forage demand is the amount of forage dry matter (DM) required to feed the herd/flock for one day. It is based on the rule of thumb that grazing animals require an amount of forage dry matter equal to about 2.5% of their body weight per day. *Note* for lactating dairy cows use 3.5%.

____________________________ X .025 or .035 = ______________ X
average animal weight (lbs)   lb DM/head/day

_________ = Total Forage Demand________________
# animals   lb/day

Step 2. Estimate the Forage Supply:

The amount of forage available for grazing with the continuous stocking method is based on the total hay yield in tons/acre/year minus 40% for losses due to trampling, fouling with manure and urine, and reduced growth.

Unless actual measured yields are available, use data-base estimated grass-legume hay yields, and use the following table to convert forage availability on a season long basis.

Forage Availability Estimates

Hay Yield Tons/Acre/Year	5.5	5.5	4.5	4.0	3.5	3.0	2.5
Forage Availability Pound/Acre/Year	6600	6000	5400	4800	4200	3600	3000

Step 3. Determine the Grazing Period:

In most part of the northeast, the average grazing period will be approximately 160 days. However, it may range between 150 and 215 days.

Grazing Period_______ days

Step 4. Calculate the Number of Acres Required:

The number of acres required for a continuous stocking grazing management plan is based on having enough forage available to meet the season long forage requirement.

______________ X ______________________ = ______________
forage demand grazing period (days)

divided by _______________ = ___________________________
forage supply number of acres required