Forages for Beef Cattle

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Kentucky's forage base is composed of cool-season grasses and legumes. Tall fescue, orchardgrass, timothy, and bluegrass occupy the vast majority of our forage land, with Kentucky 31 tall fescue occupying the largest number of acres (Figure 2-1). Clovers (red, ladino, white) (Figure 2-2) are by far the dominant legumes found in Kentucky hay/pasture fields.

Both cool-season grasses and warm-season grasses grow well in Kentucky. Cool-season grasses produce most of their forage in spring and fall. Warm-season grasses are extremely productive during the summer months. Warm-season grasses include annuals such as sudangrass, sorghum-sudans, and pearl millets and perennials such as big bluestem and bermudagrass. The seasonal growth of many common Kentucky forages is found in Figure 2-3.

Present Forage Status

Since Kentucky's forage base is characterized by cool-season growth patterns, shortages of both quality and quantity occur during the hot, dry summer months. Tall fescue dominates our forage base, and more than 90% of our tall fescue pastures contain an endophytic fungus that lowers animal performance. Most of our pastures are too large for efficient management/utilization. Numbers and locations of water sources on farms limit the subdivision of existing pastures and utilization of grazable acres.

Figure 2-1. Kentucky's grass base.

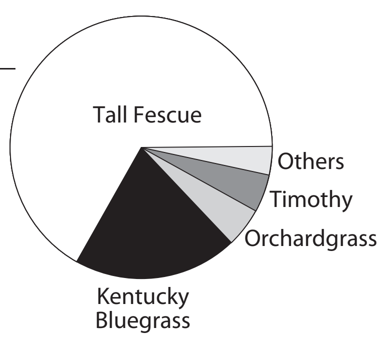
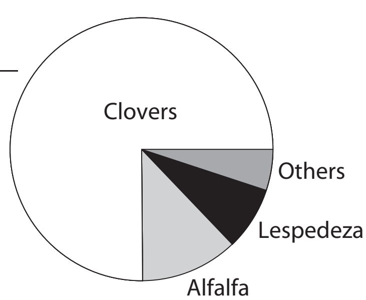


Figure 2-2. Kentucky's legume base.



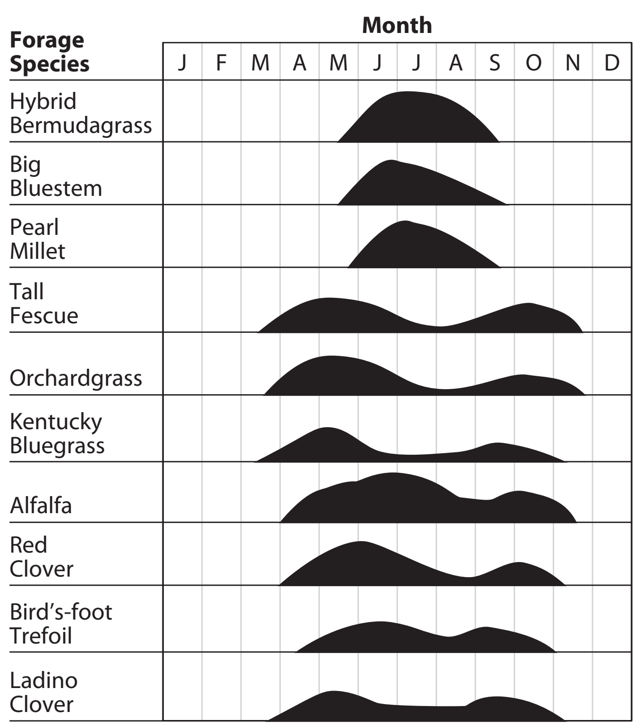
Less than 10% of the forage land is soil tested. Of the forage land that is tested, 40% is below pH 6.0, 45% is low in phosphorus, and 35% is low in potassium. Therefore, legume establishment and growth would improve by soil testing and subsequent fertilizer and lime applications.

Legumes are only being grown in about one-third of the acreage where they could be grown. The hay supply for winter feeding comes primarily from excess cool-season forage grasses in spring and is usually harvested too late for highest quality and animal performance.

The bulk of hay for beef cattle is stored in large round bales outside with minimum protection from weathering losses. Dry matter savings of 20% or more can be achieved by improved storage of round bales.

Surveys of farmer practices indicate improved varieties are not utilized to the extent needed for optimal forage production, quality, and profitability. Large differences in yield and persistence can be documented between the use of uncertified or common forage seed and that of newer improved and certified varieties.

Figure 2-3. Normal forage availability by months.



Keys to Profitable Forage Programs[1]

Forage typically accounts for more than half the cost of production of forage-consuming animals and provides most of their nutrition. Thus, it has a major impact on both expenses and income. The basic commodity is forage, and animals are the harvesters or consumers. Efficient forage production and utilization are essential to a profitable operation.

1. **Know forage options and animal nutritional needs.** Forages vary as to adaptation, growth distribution, quality, yield, persistence, and potential uses. Also, various types and classes of animals have different nutritional needs. Good planting decisions require knowing forage options for the land resources and nutritional needs of the animals.
2. **Establishment is critical.** Good forage production requires an adequate stand of plants. Mistakes during establishment often have long-term consequences. Use of high-quality seed of proven varieties, timely planting, and attention to detail lead to establishment success.
3. **Test the soil, then lime and fertilize as needed.** This practice, more than any other, affects the level and economic efficiency of forage production. Fertilizing and liming as needed help ensure good yields, improve forage quality, lengthen stand life, and reduce weed problems.
4. **Use legumes whenever feasible.** Legumes offer important advantages including improved forage quality and biological nitrogen fixation, whether grown alone or with grasses. Every producer should regularly consider on a field-by-field basis whether the introduction or enhancement of legumes would be beneficial and feasible. Once legumes have been established, proper management optimizes benefits.
5. **Emphasize forage quality.** High animal gains, milk production, and reproductive efficiency require adequate nutrition. Producing high-quality forage requires knowing the factors that affect forage quality and managing accordingly. Matching forage quality to animal nutritional needs greatly increases efficiency.
6. **Prevent or minimize pests and plant-related disorders.** Diseases, insects, nematodes, and weeds are thieves that lower yields, reduce forage quality and stand persistence, and steal water, nutrients, light, and space from forage plants. Variety selection, cultural practices, scouting, use of pesticides, and other management techniques can minimize pest problems. Knowledge of potential animal disorders caused by plants can reduce or avoid losses.
7. **Strive to improve pasture utilization.** The quantity and quality of pasture growth vary over time. Periodic adjustments in stocking rate or use of cross fencing to vary the type or amount of available forage can greatly affect animal performance and pasture species composition. Knowing the advantages and disadvantages of different grazing methods allows use of various approaches as needed to reach objectives. Matching stocking rates with forage production is also extremely important.
8. **Minimize stored feed requirements.** Stored feed is one of the most expensive aspects of animal production, so lowering requirements reduces costs. Extending the grazing season with use of both cool-season and warm-season forages, stockpiling forage, and grazing crop residues are examples of ways stored feed needs can be reduced.
9. **Reduce storage and feeding losses.** Wasting hay, silage, or other stored feed is costly! On many farms the average storage loss for round bales of hay stored outside exceeds 30%, and feeding losses can easily be as high or higher. Minimizing waste with good management, forage testing, and ration formulation enhances feeding efficiency, animal performance, and profits.
10. **Results require investments.** In human endeavors, results are usually highly correlated with investments in terms of thought, time, effort, and a certain amount of money. In particular, the best and most profitable forage programs have had the most thought put into them. Top producers strive to continue to improve their operations.

[1] Source: Dr. Don Ball, Auburn University, Dr. Carl Hoveland, University of Georgia, and Dr. Garry Lacefield, University of Kentucky. 2002.

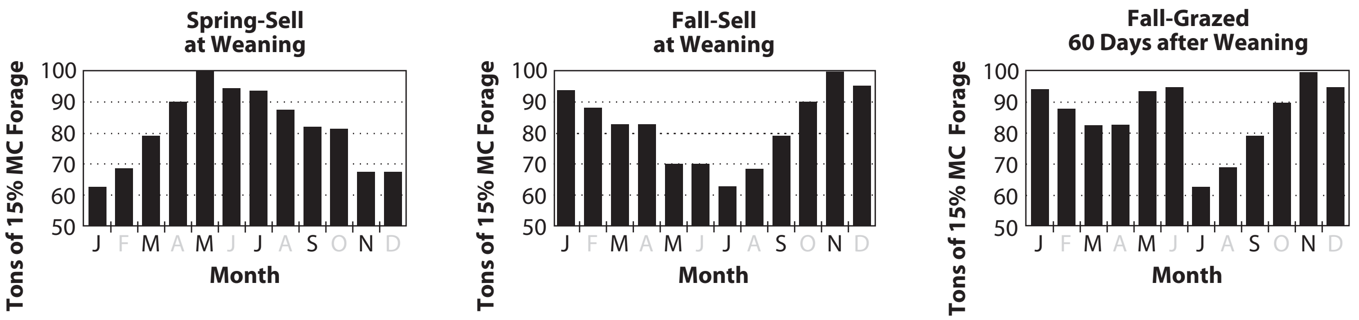
Developing a Forage Plan

Develop a simple, realistic forage plan with attainable goals for the forage resource on the farm. Part of this plan should address the soil types and fertility levels across the farm. Another part should address the types of forages growing on each field and the usage of each field (hay or other stored feed, pasture, or both). Also consider the storage and feeding methods for the stored forage. A good way to start a forage plan is to list each pasture or hay field and the acreage, present forage base, future plans, soil testing information (including date last tested), fertilizer applications, and other characteristics of the field.

Measure the forage production potential of the farm against the needs of the livestock to be carried. Quantity, quality, and seasonal needs of the cattle must be considered. For example, a fall-calving herd requires higher-quantity and -quality feed during periods of little or no forage growth than a spring-calving herd (Figure 2-4). In the spring, however, that same fall-calving herd will have weaned calves that can be used to convert the surplus of spring forage growth into cheap gains.

A simple pasture-balancing computer program, called KYBEEF, is available at no cost to Kentucky producers through county Extension offices. KYBEEF allows you to enter the inventory of animals to be carried on the farm, the forages present on the farm, plus

Figure 2-4. Animal forage needs—three calving systems (MC = moisture content).



the overall productivity of fields, and then determines times of forage surplus and deficit. It also allows buying and selling prices for livestock to be entered and generates a simple cash flow data sheet for the farm.

Identify Limiting Factors in Forage Production

A key move in integrated resource management of beef cattle is to assess areas of a farm before taking action. In this case, assess the whole forage program to find the most limiting factor(s). Put another way, find the part or parts of the forage program that would respond most to improvement. These practices often produce the most benefits for the additional input needed:

- rotating grazing systems (fencing and water)
- renovating grass pastures with legumes
- using better varieties
- stockpiling tall fescue to extend the grazing season
- increasing hay quality, and
- protecting round bales of hay from excessive weathering.

Determine a Forage System

Many questions must be answered to properly select the forage or forages that make up the optimal system for the beef enterprise. The producer must define the role of forage in the enterprise, forage production goal, method of use and "utilizer," level of management available, soil/land limitations, and time limitations.

Define the Role Forage Will Play

Define the role forage will play in the beef enterprise. Will it be the primary base grass in a pasture system or a supplemental forage interseeded into existing forage? Will the forage be a permanent (a perennial) or a temporary (an annual) addition to the system? What will be the primary season of use? A species selected for winter grazing is of little value during the heat of August. Likewise, a productive summer forage has a short (but productive) growing season compared to a species like tall fescue.

Define the Production Goal

Define the forage production goal for the species. Ultimately, a forage system must provide enough dry matter to carry a given set of animals for the year and meet livestock production goals, such as high conception rates, high weaning weights, and/or high stocker gains. Forages must therefore produce enough dry matter yield per acre to meet these needs. Also, that yield should come at a time when it can be used efficiently. The most efficient method of forage utilization is grazing. It is estimated that nutrients supplied by grazing cost approximately half of those supplied by stored feeds, such as hay and silage. Therefore, production during the time of animal need is highly desirable. Finally, the yield should be of the quality (protein and energy) necessary to allow good animal performance. Forage quality values of a number of Kentucky forages are known and vary by species and stage of maturity.

Forage grasses adapted to Kentucky are often grouped into categories called "cool-season" or "warm-season" grasses based on their optimal season of growth (Table 2-1). Tall fescue, orchardgrass, bluegrass, timothy, red clover, alfalfa, and white clover are cool-season forages, while sorghum-sudan, bermudagrass, pearl millet, and big bluestem are warm-season species.

Table 2-1. Grasses for Kentucky classified according to growth characteristics.

	Annual	Perennial
Cool-season grasses	ryegrass small grains brassicas	Tall fescue orchardgrass bluegrass timothy perennial ryegrass smooth bromegrass
Legumes	annual lespedeza soybeans vetch	alfalfa red clover white clover bird's-foot trefoil
Warm-season grasses	sudangrass sorghum-sudan hybrids forage sorghums corn silage pearl millet foxtail millet	bermudagrass Old World bluestems switchgrass big bluestem indiangrass eastern gama grass

Even though species like alfalfa and red clover are known to be more productive during midsummer than fescue or bluegrass, these are still cool-season species whose growth slows greatly during hot summer months.

Define How the Forage Will Be Used

A significant constraint to forage selection is the intended method of utilization. Systems that allow for a rotation of pastures and periods of rest/recovery from grazing offer many more forage selection options. On the other hand, systems that involve continuous grazing or suffer excessive traffic during dormant or wet seasons have fewer options. In extreme cases (such as winter feeding pastures), there may not even be a good, permanent solution. Often, you must answer the question, "Am I willing to rotate pastures?" early in the forage selection process. Not being realistic in this area can lead to unrealized expectations, disappointment, and often significant financial losses. For example, alfalfa is a species that must be rotationally grazed for maximum stand persistence and maximum economic animal performance. As good as it is, alfalfa will not persist or give proper animal performance when grazed continuously.

Define the User

In the grazing system, the animal is the marketed product. Therefore, all decisions about forage selection must be made with this "end user" in mind. Will the forage support the cow herd or growing stockers? Will it be used for pasture during early lactation and breeding (a time of maximum need for quality and quantity)? Will it be for the growth of replacement heifers or for backgrounded feeder calves? Growing animals and lactating animals require high quality (protein and energy) to meet production goals. In addition, these animals are sensitive to the effects of the endophyte of tall fescue, especially during hot weather.

Some forages can be used by more than just beef cattle. For example, native warm-season grasses can be managed as excellent cover for wildlife such as quail and rabbit. During winter, the standing stubble of these crops is more conducive to wildlife cover than the short, dense canopy of grasses like tall fescue or orchardgrass.

Define the Level of Management Available

Requirements for forage yield and persistence may include pasture subdivisions (to aid in good rotations), high soil fertility, weed control, rotational grazing, residual height management, fall rest for winter-hardiness, and insect control. Without pasture subdivisions and the ability to rotate pastures, certain forages (like alfalfa and native grasses) will not persist. Meeting fertilizer needs of a crop is necessary for production and persistence. Likewise, more intensive pest management is required for some crops, such as alfalfa. Controlling the alfalfa weevil and potato leafhopper does not always require the use of insecticides. However, the economic thresholds of treating each pest and other nonchemical controls must be understood and incorporated into the grazing plan.

The level of management available determines what can be achieved from a forage system. In particular, the ability to maximize forage growth rates by using a good, fast rotation (three to five days of grazing followed by 30 to 40 days of rest) allows the maximum production of high-quality forage per acre; consequently, animal output should be equally high. Also, soil nutrients must be managed to supply the mineral needs of the plant.

Define the Soil Resource

What are the soil limitations of the fields in the grazing system? Is the soil fertility and pH known on pasture fields? Surveys of Kentucky's pasture fields indicate that most are low in phosphorus and need lime to raise the pH. Low soil phosphorus and acidity are severe limitations to legume production. While some legumes, such as annual lespedeza and bird's-foot trefoil, are tolerant of acid soils and lower fertility, most are not productive or persistent under these conditions.

Other significant soil limitations include rooting depth, drainage, and topography. Shallow soils are droughty and stress forage plants during hot, dry weather. Poorly drained soils stress the root systems of forage crops and can be unsuitable for species like alfalfa and many native warm-season grasses. Because of its inaccessibility to planting equipment, severely rolling topography can prohibit the use of annual crops such as sorghum-sudan or pearl millet for forage systems. Even applying fertilizer and lime on these fields is a challenge in some cases.

Soil fertility is an addressable limitation in forage systems, and forage systems recycle a large portion of nutrients that plants take up during the growing season. However, seldom can all fields be "brought up to soil test" at one time. *The important point is to know what and where the fertility limitations are and to have a plan for best using these fields in the beef-forage system.*

Define the Time Constraints

Making changes in a forage system takes time. Making big changes in a forage system can take a lot of time. Some forages, by nature, can have an immediate effect, but the effect is often short-lived. Sorghum-sudan, pearl millet, wheat, and rye can have immediate effects, but these are annuals. Perennials like tall fescue, orchardgrass, big bluestem, and switchgrass have longer periods of usefulness. Forage system design must allow time for perennials to become established. This is particularly true in the case of species like bird's-foot trefoil and warm-season grasses such as big bluestem, indiangrass, switchgrass, and caucasian bluestem. In the case of native warm-season grasses, expect a 12- to 24-month period of establishment during which limited grazing or harvesting can occur. If impacts are needed immediately, these forages are not good options, at least in the short run. However, when time for adequate establishment is available, using these forages to supply summer grazing for an extended number of years can balance out the one to two years of limited use.

Summarizing Forage Characteristics in Kentucky

Forage crops differ in their abilities to withstand stresses and their agronomic characteristics. A summary of many agronomic characteristics of several forage crops that can be grown in Kentucky is shown in Tables 2-2 and 2-3. Also, estimates of forage quality of several forage crops are found in Table 2-4. Forage quality can deviate significantly from these values; always take a forage analysis to know the nutrient value of forages. Use these values to help decide whether a given forage will meet the needs of the intended animal.

Establish for Stand

Establishment of a good stand is a first and very important step in a successful forage program. One to two tons of forage crop production usually cover the costs of stand establishment. Do everything possible to ensure success because a stand failure can nearly double these costs. In addition, severe soil erosion can result from lack of cover. The following procedures are vital to establishing and maintaining good forage stands.

Match Plants to Soils

Almost every farm contains wide variation in soil capabilities. Soils differ in their capacities to supply nutrients, and they vary in slope, internal drainage, and other factors that affect both production and persistence of a given forage crop. In addition, different grasses and legumes and grass-legume combinations vary widely in their abilities to persist and produce on different soils. It is important to match the plant species or mixture of species to the various soils for greatest returns and proper soil and water conservation.

The best use of deep, well-drained land that is level to gently sloping is to plant the highest-producing crops, such as corn silage or alfalfa or a mixture of alfalfa-orchardgrass or alfalfa-timothy. Maintain steeper land in sod-forming grasses, such as tall fescue or bluegrass, to minimize soil erosion. Use alfalfa with a cool-season grass where soils are at least 2 feet deep and well drained. On soils that are less than 2 feet deep or poorly drained, use clover-grass mixtures or pure grass stands. Legumes may be established in grass-dominant sods through renovation. For more information on pasture renovation, see Kentucky Cooperative Extension publication AGR-26, *Renovating Hay and Pasture Fields,* available from your county Extension office or on the Web at www.uky.edu/Ag/Forage/.

Table 2-2. Characteristics of perennial cool-season grasses in Kentucky.

	Tolerance To:							
Grass	**Heat/ Drought**	**Flooding**	**Frequent Cutting**	**Frequent Grazing**	**Winter-Hardiness**	**Seedling Vigor**	**Sod-Forming Capacity**	**Adaptation to Kentucky**
Tall fescue—infected	E[1]	G	E	E	E	G	G	E
Tall fescue—noninfected	G	G	G	F	E	F	G	G
Orchardgrass	G	P	G	F	E	G	F	E
Bluegrass	P	F	G	E	E	P	E	E
Timothy	F	P	P	P	E	G	P	E
Matua prairie grass	F	--	P	P	G	F	F	F-G
Smooth brome	F	F	P	P	E	F	G	P-F
Reed canarygrass	G	E	G	G	E	P	E	G
Perennial ryegrass	P	P	E	E	F	E	P	F

[1] E = Excellent, G = Good, F = Fair, P = Poor. Values presented are estimates. Conditions and actual performance vary widely across Kentucky. Bluegrass, for example, is very well adapted to central and eastern Kentucky but not well adapted to southern and western areas.

Table 2-3. Characteristics of perennial legumes in Kentucky.

	Tolerance To:							
Legume	**Heat/ Drought**	**Wet-ness**	**Winter-Hardiness**	**Haying**	**Grazing**	**Acidity**	**Seedling Vigor**	**Bloat Risk**
Alfalfa	E[1]	P	E	E	F	P	G	Yes
Bird's-foot trefoil	G	G	G	G	F	G	P	No
Crown vetch	G	P	F	P	F	G	P	No
Sweet clover	E	P	E	P	F	P	G	Yes
Red clover	F	F	F	E	G	F	E	Yes
White clover	P	F	P	P	E	F	F	Yes
Alsike clover	F	G	P	P	F	G	G	Yes

[1] E = Excellent, G = Good, F = Fair, P = Poor.

Table 2-4. Forage quality values for selected forages.

Crop	CP, %	ADF, %	NDF, %	TDN, %	RFV
Alfalfa					
Bud	22-26	28-32	38-47	64-67	127-164
Early bloom	18-22	32-36	42-50	61-64	113-142
Mid-bloom	14-18	36-40	46-55	58-61	98-123
Corn silage					
High grain	7-9	23-30	48-58	66-71	105-138
Low grain	7-9	30-39	58-67	59-66	81-105
Cool-Season Grass					
Veg./boot	12-16	30-36	50-56	61-66	101-122
Boot/head	8-12	36-42	56-62	56-61	84-101
Warm-Season Perennial Bunchgrass					
Pre-boot	10-14	35-40	55-60	58-62	90-104
Mature/head	6-10	40-50	60-75	50-58	62-90
Warm-Season Annual Grass					
	10-14	35-40	55-60	58-62	90-104
Red Clover					
Early flower	14-16	28-32	38-42	64-67	142-164
Late flower	12-14	32-38	42-50	59-64	110-142
Ann. lespedeza	12-16	35-40	45-55	58-62	98-127

Match Plants to Intended Use

Plan for maximum quality and versatility in the forage program. Select plants that produce high-quality feed, and plan to use each field for hay, silage, and/or pasture as weather and feed needs dictate. Legumes generally produce higher-quality feed than grasses, resulting in higher animal performance. Use legumes as much as possible. Taller-growing legumes, such as alfalfa and red clover, are more versatile than a legume like white clover, which is used primarily for grazing. Grasses such as orchardgrass, timothy, and tall fescue are better adapted than bluegrass for hay and silage. Timothy-alfalfa mixtures give the benefits of a mixed alfalfa-grass stand in the first cutting while producing almost pure alfalfa in later cuttings (very little timothy growth occurs after the first cutting). The grass helps control weeds by filling in between alfalfa crowns and aids in getting the first hay harvest cured. With timothy-alfalfa mixtures especially, subsequent harvests during the season are almost pure alfalfa. Owners of horses or dairy cattle often prefer later cuttings because of their high forage quality and freedom from mold and weeds.

Select High-Quality Seed of an Adapted Variety

High-quality seed is an essential step toward establishment and longevity of a forage stand. Such seed should have high percentages of germination and purity, low percentages of weed seed, and freedom from noxious weed seed. Certified seed meets or exceeds minimum standards for purity, germination, and quality and has a blue tag attached to the bag. The best assurance of the genetic purity of the variety selected is to plant certified seed, if available.

In addition, the certified seed should be from an "improved" variety adapted to your farm. Improved means the variety has been selected for improved yield, quality, persistence, disease resistance, or other positive traits. If you are uncertain about a variety's adaptation and performance, refer to the University of Kentucky's forage variety test reports available from your local county Cooperative Extension office and on the Web at www.uky.edu/Ag/Forage/. It is never a good practice to plant large acreages to varieties of unknown performance or adaptation. Poor-quality seed and/or unadapted varieties are never a bargain.

A comparison of the performance of certified, improved varieties of red clover to that of common medium red clover found that the better seed yielded an average of 1,000 pounds more dry matter per acre in the year of seeding, 2,000 pounds more in the second year, and 3,000 pounds more in the last year. The differences between the best certified red clover and the worst common red clover were twice these amounts, or nearly 12,000 pounds more yield per acre.

Supply Proper Fertility

Just as humans and animals must have food to survive, plants need proper nutrition to survive and produce well. The soil is a reservoir of many nutrients needed by plants, but soils vary widely in their nutrient status and ability to supply essential minerals to plants. A deficiency of one element can limit forage plant growth and encourage weed encroachment. The most sensible approach to providing balanced fertility is to first test the soil to determine nutrient levels and then keep good records of fertilizer and lime applied to each field. A soil test is the most economical investment in your overall soil fertility program.

In Kentucky, the nutrients most limiting to growth are normally lime, nitrogen (N), phosphorus (P), and potassium (K). Boron (B) is also recommended for use where alfalfa is to be grown or where red clover is to be harvested for seed.

Prior to establishing a new stand, apply lime, phosphorus, and potassium as the soil test indicates they are needed. Where the cropping history of a field indicates nitrogen is needed at seeding, it is usually recommended at the rate of 30 pounds per acre on grass-legume mixtures and 50 pounds per acre for grass alone. Annual applications of fertilizer subsequently should be made according to soil tests and/or nutrient removal from hay, haylage, or grazing.

Prepare an Adequate Seedbed

To prepare an adequate seedbed, till the soil to incorporate lime and fertilizers, destroy weeds and other vegetation, and prepare a level, firm seedbed. Reduce ridges and depressions to a minimum to make the operation of harvest machinery easier. Remember that this stand may be in the field for several years, so it is worth a little extra effort to get the soil surface smooth.

Seeding without tillage (no-till) requires control of existing vegetation by methods other than plowing or disking to prepare the site for planting. Control may come from very close grazing, mowing, or herbicides.

Use Inoculated Legume Seed

You can inoculate legume seed, or use pre-inoculated seed. When properly nodulated, legumes such as alfalfa and clovers have a unique ability to convert large quantities of nitrogen from the air to a form plants use to make protein and other compounds necessary for growth. To ensure proper nodulation, inoculate all legume seed with the proper bacteria just prior to seeding, or use pre-inoculated seed. Check the seed tags for the expiration date of the inoculum. Inoculate legume seed even if it has been grown in the field previously. To ensure that inoculum is stuck to each seed, use an appropriate commercial adhesive or sugar solution. Satisfactory results are obtained when a small amount of sugar solution is first added to seed and thoroughly mixed to get all seed moist, not wet. Then add the inoculum and mix again. If done properly, the peat in the inoculum mix absorbs excess moisture so seed flows well through the seeder.

Use Proven Seeding Methods

Seeding can be done using drills, cultipacker seeders, cyclone-type seeders, or even aircraft. Each method can be successful if seeds are properly distributed, placed uniformly just below the soil surface (¼ inch to ½ inch), and firmed to give good seed-soil contact. Do not place seeds too deep, or they might not emerge. If they are placed at unequal depths, the stand will be uneven due to different emergence times. Also, remember that both the seed and the inoculum on legume seed must survive the seeding method. Seed germination and inoculum effectiveness can be lowered when mixed with fertilizer. Some cover over the seed aids inoculum survival and provides better seed-soil contact.

Seed at the Right Time

Seed at the right time with the correct amount of seed. Many cool-season grasses and legumes can be successfully seeded in either early spring or late summer. Alfalfa, red clover, and white clovers are usually most successfully seeded in spring; however, late-summer seedings can be successful if soil moisture is adequate. Many farmers prefer late-summer and early-fall seedings of such crops as alfalfa, fescue, bluegrass, timothy, orchardgrass, ryegrass, and small grains for forages because they can prepare seedbeds during favorable weather conditions and spread the year's work more evenly. In addition, there are often fewer weed problems than with spring seedings.

Lack of adequate moisture for germination and emergence is perhaps the major problem with late-summer seedings. Cultipacking to get good seed-soil contact is highly desirable. Legume seed might be germinated by a small shower of rain but then perish if an extended dry period follows. One technique for avoiding problems caused by dry conditions is to have everything ready to seed but wait for at least an inch of rain before seeding. Seed as soon after the rain as soil conditions permit. This usually ensures that enough soil moisture is present not only to germinate the seed but to get the young, developing roots into moist soil. If rain does not come early enough to get plants established, you may plant the seed the following spring. For information on seeding rates and dates, see Kentucky Cooperative Extension publication AGR-18, *Grain and Forage Crop Guide for Kentucky,* available from your local county Extension office or on the Web at www.uky.edu/Ag/Forage/.

Control Competition from Other Plants

Most forage crops have small seeds and, therefore, much less seedling vigor than crops like corn. Competition from existing vegetation or encroaching weeds is the single biggest cause of seeding failures in Kentucky. Control competitive plants by mowing, grazing, or applying labeled herbicides. Mowing or grazing should remove the weed competition without removing extreme amounts of the newly seeded forage crop.

Allow Forages to Become Established

Perennial forage crops need to develop an extensive root system; allow them to become fully established before heavily utilizing them. Allow new grass seedings to be cut for hay first before grazing. Allow spring seedings of legumes to show some bloom before the first harvest. There is no substitute for allowing pastures, especially, to become fully established before grazing. It might seem that there is not time to do this right, but stand failures demand more time to do it over.

Produce for Yield

The objective of the "establishment" phase of forage management is to get a good, thick stand of the species or mixture seeded. Good stands of forage crops have the potential for high yields, adequate nutritive quality, and acceptable stand persistence. Each of these components (yield, quality, and persistence) is critical to an effective, economical forage program. It can be argued, however, that yield is most critical.

Yield is important because it represents how many bales of hay, loads of silage, or days of grazing come from a particular field. Higher yield from the same or similar inputs ultimately means more profit.

Many factors affect forage yield. Weather, soils, fertility, species and mixtures, varieties, weeds, insects, diseases, age of plants, when harvested, harvesting method, and efficiency are some of the important factors. We as managers can control to some extent all of these factors except the weather. Our challenge is to control to

High-quality pasture and well-milking cows provide good nutrition for feeder calf production.

the extent possible those factors that have the greatest impact on yield consistent with acceptable quality and persistence.

Forage species vary in their abilities to produce dry matter yield. The highest-yielding forages in Kentucky include the summer annual grasses, corn silage, and alfalfa. However, timothy, tall fescue, orchardgrass, and red clover are also highly productive. Lesser-yielding species include bluegrass and annual lespedeza.

Many varieties are available for most species commonly grown in Kentucky. Most of these varieties are tested in locations across Kentucky. Careful consideration in selecting varieties of either grass or legumes can pay big dividends in your overall forage production program. For the latest University of Kentucky variety reports, check your county Cooperative Extension office or contact your state forage Extension specialist.

Soils and soil fertility vary greatly across Kentucky and even within most farms. Soils vary in depth, texture, structure, drainage, organic matter, water-holding capacity, and fertility. Although we can modify fertility, the remaining soil characteristics cannot be changed much, and major changes can require considerable time and expense. Soil characteristics determine the species or mixtures we can grow most efficiently over the longest period of time.

Soil fertility and fertilizer needs are best determined by soil testing. A soil test is the most important and economical investment in an overall forage fertility program. Kentucky data indicate that only 10% of pasture land has had a soil test. Of land that is soil tested, 40% is below pH 6.0, 45% is low in phosphorus, and 35% is low in potassium.

Nitrogen is the most limiting nutrient in forage production. On many Kentucky livestock farms, most of the nitrogen can be supplied through legumes. In several situations, however, application of nitrogen fertilizer could and should be considered. Applying nitrogen to warm-season annual and perennial grasses can produce high yields. Using nitrogen on cool-season grasses can extend the growing season for earlier and later grazing. Adding nitrogen when tall fescue begins to green up in early spring usually results in pasture available for grazing seven to 12 days earlier than nonfertilized grass. Adding nitrogen to tall fescue or Kentucky bluegrass in mid-August (stockpiling) and accumulating fall-grown pasture for late-fall/early-winter grazing can extend the grazing season and reduce the amount of stored feed required.

Table 2-5. Nutrients removed by hay crops.

Crop	Yield/Acre (in tons)	Approximate Lb./Acre Removed N	P_2O_5	K_2O
Alfalfa	5	255	68	245
Red clover-orchardgrass	4	136	47	204
Tall fescue, orchardgrass, timothy	3	87	29	144

Source: K. L. Wells and W. O. Thom. 1994. Estimated nutrient and uptake by Kentucky's Crops. Soil Science News and Views, Vol. 15, No. 4.

Forage crops harvested as hay remove large amounts of nutrients (Table 2-5). In addition to lime, P, and K, nitrogen and minor elements are also removed. To ensure optimal yields, add fertilizer elements. Consult the latest printing of Kentucky Cooperative Extension publication AGR-1, *Lime and Nutrient Recommendations*, for recommendations on lime, phosphorus, and potassium to be applied to grass, grass-legume, or legume-based hay fields. This publication is available from your local county Extension office or on the Web at www.uky.edu/Ag/Forage/.

Approximately 85% of all nutrients consumed by grazing animals are returned to pasture. The fertilizer elements in feces and urine can be valuable in a grazing program. Unfortunately, in continuous grazing programs, most of the manure and urine is concentrated around water and shade. You can distribute nutrients more evenly with more controlled grazing programs and timely use of chain harrows.

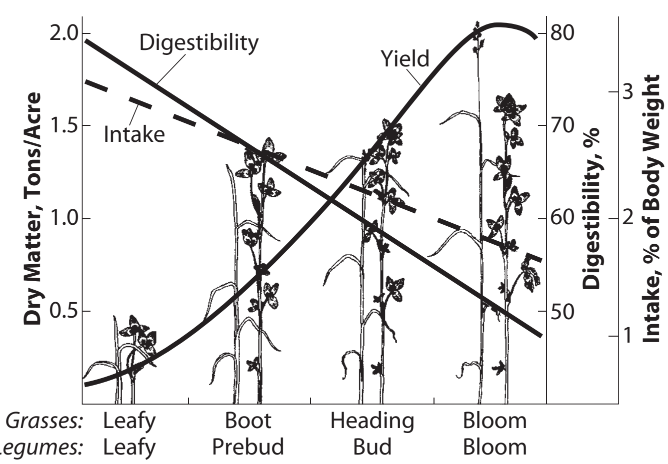
Weeds, insects, and disease can reduce yield of forage grasses and legumes. Weeds compete with hay/pasture plants for water and nutrients. In addition, certain weeds and other weeds at certain times of the year can be toxic to animals.

Insects and diseases often damage or destroy leaf tissue. Leaves are the highest-quality part of the plant. As leaves are damaged or destroyed, yield and quality are reduced.

Monitor weeds and insects, and control them any time a threshold level of infestation occurs. Select the most efficient, economical control measure available. Diseases are best controlled when selecting varieties. Choose an adapted, certified variety with as much resistance to problem disease as available.

Cutting management affects yield, quality, and persistence either directly or indirectly. As any perennial forage plant advances from the young (leafy) stage to the mature bud-flower-seed (reproductive) stage, several things happen (Figure 2-5). Most characteristics associated with quality, such as digestibility and intake, decline as yield increases. The challenge is to harvest at a stage that results in good yield, adequate quality, and acceptable stand persistence. This stage for legumes and first-cutting grasses is usually when they are changing from the vegetative stage to the reproductive stage.

Figure 2-5. The effect of advancing maturity on forage yield, intake, and digestibility.



Importance of Hay Quality

The ultimate test of hay quality is animal performance. Quality can be considered satisfactory when animals consuming the hay give the desired performance. Three factors that influence animal performance are: (1) consumption—hay must be palatable if it is to be consumed in adequate quantities; (2) digestibility and nutrient content—once the hay is eaten, it must be digested to be converted to animal products; and (3) toxic factors—high-quality hay must be free of components that are harmful to animals consuming it.

Factors Affecting Hay Quality

Stage of maturity when harvested is the most important factor affecting hay quality and the one in which greatest progress can be made. As legumes and grasses advance from the vegetative stage to the reproductive (seed) stage, they become higher in fiber and lignin content and lower in protein content, digestibility, and acceptability to livestock. The optimal stages of maturity to harvest for high quality and long stand life of many hay crops are listed in Table 2-6. Making the first hay cut early permits aftermath growth to begin at a time when temperature and soil moisture are favorable for plant growth and generally increases total yield per acre. The effects of stage of harvest on fescue hay quality and animal performance are shown in Table 2-7. Similar effects have been noted with alfalfa (Table 2-8). In both cases, early-cut hay resulted in high-quality feed and superior animal performance.

Table 2-6. Recommended stages to harvest various forage crops.

Plant Species	Time of Harvest
1. Alfalfa	Late bud to first flower for first cutting, first flower to 1/10 bloom for second and later cuttings.
2. Bluegrass, orchardgrass, tall fescue or timothy	Boot[1] to early head stage for first cut, aftermath cuts at 4- to 6-week intervals.
3. Red clover or crimson clover	First flower to 1/10 bloom.
4. Oats, barley, or wheat	Boot to early head stage.
5. Rye and triticale	Boot stage or before.
6. Soybeans	Mid- to full bloom and before bottom leaves begin to fall.
7. Annual lespedeza	Early bloom and before bottom leaves begin to fall.
8. Ladino clover or white clover	Cut at correct stage for companion plant.
9. Sudangrass, sorghum hybrids, pearl millet, and johnsongrass	40-inch height or early boot stage, whichever comes first.
10. Bermudagrass	Cut when height is 15 to 18 inches.
11. Caucasian bluestem	Boot to early head stage.
12. Big bluestem, indiangrass, and switchgrass	Early head stage.

[1] Boot is stage of growth of a grass just prior to seedhead emergence. This stage can be identified by the presence of an enlarged or swollen area near the top of the main stem.

Curing and Handling Conditions

Curing and handling conditions can greatly affect hay quality. Poor weather and handling conditions lower hay quality. Rain can cause leaf loss and can leach nutrients from plants during curing. Sunlight can lower hay quality through bleaching and lower vitamin A content. Raking and/or tedding dry, brittle hay can cause excessive leaf loss (Table 2-9).

Hay plants with an 80% moisture content must lose approximately 6,000 pounds of water to produce a ton of hay at 20% moisture. Crushing stems (conditioning) at time of mowing causes stems to dry at nearly the same rate as leaves. Conditioning usually decreases the drying time of large-stemmed plants by approximately one day and can result in leaf and nutrient savings. Raking and/or tedding while hay is moist (about 40% moisture) and baling before hay is too dry (below 15% moisture) helps reduce leaf losses (Table 2-9).

Hay Preservatives

Hay preservatives allow hay to be safely baled at greater than 20% moisture (small bales) and 18% moisture (large packages) when the preservatives are properly applied at baling. Effective hay preservatives prevent excessive heating and mold growth when applied uniformly and at the correct rate on moist hay.

The most proven forms of hay preservatives currently marketed in Kentucky are the propionic acid types. Early propionic acid products were either propionic acid or a mixture of propionic acid and acetic acids. Although effective, these products were not well accepted or widely adopted for many reasons, including their tendency to remove paint from balers, their offensive and penetrating odor, and the irritation of exposed skin that came in contact with the material.

Today the primary forms of propionic acid hay preservatives on the market are "buffered" products that are less volatile, less harmful to paint, and less offensive to nasal passages and exposed skin. When applied uniformly and at the proper rates for the moisture of the hay (Table 2-10), the buffered materials are effective in reducing hay heating and molding in storage. In a study at the University of Kentucky, alfalfa hay treated with a buffered propionic acid heated less and was less dusty than both untreated wet hay and hay treated with a hay inoculant. In contrast, the inoculant product did not decrease heating or dustiness compared to the moist control.

Hay handled in a rough manner before it gets to the animal can lose an excessive amount of leaves. For the average bale (14 inches x 18 inches x 30 inches), about 29% of its total volume is contained in a l-inch depth all around the bale. For large round bales, the outer 4 inches contain roughly 25 to 30% of its total volume. This means a large portion of the bale is exposed, and care in handling and storage should be practiced to minimize loss.

Adequate Amounts of Lime, Nitrogen, Phosphate, Potash, and Minor Elements

Adequate amounts of lime, nitrogen, phosphate, potash, and minor elements are needed to produce high yields of hay per acre and to maintain stands of desirable plants for a long period of time. Use a soil test as a guide in determining the amount of fertilizer and lime needed for economical hay production.

High yields of hay remove large amounts of nutrients (Table 2-5). Since properly inoculated legume plants are capable of fixing atmo-

Table 2-7. Effect of stage of harvest of fescue hay on quality and animal gain.[1]

Stage of Harvest	Dry Matter Intake (lb./day)	Percent Digestibility	Percent Protein	Lb. of Hay Fed per Lb. Gain	Lb. of Hay per Acre 1st Cutting	Lb. of Gain per Day
Late boot to head, cut May 3	13.0	68	13.8	10.1	1,334	1.39
Early bloom stage, May 14	11.7	66	10.2	13.5	1,838	.97
Early milk stage—seed forming, May 25	8.6	56	7.6	22.5	2,823	.42

[1] Holstein heifers were used: average weight, 500 pounds.
Source: Personal Communication, Monty Montgomery, University of Tennessee.

spheric nitrogen, mixtures containing more than 25% legumes usually do not give economical responses to nitrogen fertilization. With pure grass stands, nitrogen must be added for high levels of production.

Legumes

Legumes are normally higher in quality than grasses, but within each group there can be a wide range of quality. When both grasses and legumes are harvested at the proper stage of plant growth, legumes are usually higher in total digestibility, rate of digestion, protein, and many minerals and vitamins. A mixture consisting of an adapted grass and legume is usually of high quality when properly managed. In addition, grasses can improve the drying rates of mixed stands compared to pure legume stands. Perennials, such as alfalfa, orchardgrass, timothy, fescue, and bermudagrass, are usually more economical for hay crops than annuals, although annuals, such as sorghum-sudangrass hybrids, pearl millets, small grain, lespedeza and ryegrass, can be used effectively.

Certified Seed

Plant certified seed of adapted, improved varieties tested and proven under local conditions. For example, stands seeded with common medium red clover are visibly shorter and thinner than those from certified, improved varieties even in the seeding year. Over three years, improved varieties of red clover averaged 2.89 tons more dry matter yield per acre than common medium red clover. The maximum difference in total yield over three growing seasons between the best improved and worst common clover seed lot was 4.93 tons of dry matter per acre. The largest differences came in the third growing season when stands from common clover seed lots were essentially nonproductive.

Weeds

Weeds generally lower hay quality by adding material lower in palatability and digestibility. Some may be harmful or toxic. Certified seed is free from most weed seed, which is especially important in perennial hay crops.

Seeding Rates and Dates

Seed at recommended rates and dates for the desired forage crop (see Kentucky Cooperative Extension publication AGR-18, *Grain and Forage Crop Guide,* available from your county Extension office or on the Web at www.uky.edu/Ag/Forage/, for specific dates and rates for most Kentucky forage crops). Perform fall seedings early enough for establishment before cold weather stops or slows growth. Make late-winter and early-spring seedings early enough to provide a vigorous stand to survive summer drought and weed competition.

Table 2-8. The effect of alfalfa hay quality on performance of beef steers.[1]

	Good	Fair	Poor
Crude protein	18.7	15.9	13.7
Crude fiber	29.4	35.4	46.7
Animal performance			
Hay consumed, lb./day	17.1	16.5	13.8
Gain, lb./day	1.85	1.49	-0.06

[1] 550-pound beef steers.
Source: A. S. Mohammed et al., 1967. Tennessee Farm and Home Science Progress Report 61. pp. 10-13. University of Tennessee Agricultural Experiment Station, Knoxville.

Table 2-9. The effect of handling conditions on alfalfa hay losses.

		Losses			
	Raked and Baled Correctly (lb./A)	Raked Too Dry (lb./A)	Baled Too Dry (lb./A)	Raked and Baled Too Dry (lb./A)	Total Percent
Dry hay	2,900	700	100	1,000	34
Crude protein	660	210	60	290	44
T.D.N.	1,710	480	90	690	40

Source: Alfalfa Hay Quality. D. Ball, T. Johnson, G. Lacefield, and H. White. Special Publication. Certified Alfalfa Seed Council. Davis, Calif.

Table 2-10. The effect of hay preservative type on post-storage moisture concentrations, storage losses, and visual characteristics of alfalfa hay.

Treatment	Initial Moisture (%)	Final Moisture (%)	Peak Temp. (°F)	Dry Matter Intake (% of body weight)[1]	Dust[2] Rating
Wet control	21.6	13.0 b[3]	88	2.11 a	4.72 a
Buffered propionic acid	21.0	14.8 a	80	2.20 b	3.32 b
Inoculant	22.0	12.1 c	90	2.11 a	4.79 a
Dry control	12.2	12.4 c	75	2.32 c	1.96 c

[1] Dry matter intake = 110/neutral detergent fiber.
[2] Dust ratings are on a 1 to 10 scale, with 1 being dust-free and 10 being extremely dusty.
[3] Values within a column followed by different letters are statistically different.

Evaluating Hay Quality

Forage testing is the most practical way to determine the nutrient content of hay. If hay is stored so that a representative sample can be taken and analysis is done by a reputable laboratory, forage nutritional results can be used to assess quality and to determine the amount and type of supplementation needed for the desired level of animal production. Using an instrument to obtain a core sample of hay is one of the most reliable methods of getting a representative sample for nutrient analysis. Matching hay to different classes of livestock based on nutrient content of the forage and the requirements of the animal can lead to a more efficient forage-livestock program.

A visual estimate can be helpful in determining forage quality but is not as reliable as forage testing. Hay that is early cut, green, leafy, soft, and free of foreign material and that has a pleasant odor is high quality. However, color and visual appearance are not always good indicators of hay nutritive quality.

Important Terms on a Forage Analysis Report

Several terms are common to most forage analysis reports. Understanding the basic meanings of these terms is necessary to evaluating the quality of hay.

Crude Protein

Crude protein (CP) is the amount of nitrogen in the forage multiplied by 6.25. Total nitrogen in forages is used to estimate the amount of actual protein present. Since the ratio of protein to percent nitrogen in forages is constant at 6.25 to 1, the protein content of forages is estimated by measuring total N and multiplying by 6.25.

Acid Detergent Fiber

Acid detergent fiber (ADF) is the fraction of the forage most highly correlated to digestibility. All energy estimates on forage reports are calculated from ADF. Forages with lower ADF are higher in digestibility or energy and are more valuable to beef cows. ADF values rise with advancing maturity. Kentucky forages have ADF values ranging from 30 to 45 and higher. Energy estimates calculated from ADF include total digestible nutrients (TDN) and net energy (NE). ADF is also used to help calculate relative feed value (RFV).

Neutral Detergent Fiber

Neutral detergent fiber (NDF) is the total fiber present in the forage. NDF values also go up with advancing maturity. NDF is highly correlated to intake of the forage by beef cattle. As NDF goes up, potential intake by beef cattle goes down, making low NDF values desirable. The NDF values of Kentucky forages range from 40 to 65 and above. NDF is used to estimate intake and to calculate RFV.

Relative Feed Value

Relative feed value (RFV) is an index that allows forages to be compared based on their digestibility and intake as calculated from ADF and NDF. This index was adjusted so that full-bloom alfalfa would have an RFV of 100. Good legume or grass-legume hays should have RFVs above 110, while good grass hays should have RFVs of 90 to 100. (For more information see Kentucky Cooperative Extension publication ID-101, *Interpreting Forage Quality Reports,* available from your county Extension office or on the Web at www.uky.edu/Ag/Forage/.)

Relative Forage Quality

Relative forage quality (RFQ) is proposed as a replacement for RFV to provide a better index of how a forage will perform in an animal diet. The same concept and format that were used for RFV is kept for RFQ, except the Total Digestible Nutrients (TDN) would replace Digestible Dry Matter (DDM) in the index calculation. The overall RFQ calculation will be adjusted to maintain a similar mean and range as RFV. RFQ and RFV of 100 equals full-bloom alfalfa.

Coping with the Tall Fescue Endophyte

Tall fescue (*Festuca arundinacea* Schreb.) is presently grown on approximately 5.5 million acres in Kentucky. It is a versatile perennial used for livestock feed, various turf purposes, and erosion control. Commonly referred to as simply “fescue,” this widely adapted, persistent grass is easy to establish and tolerant of a wide range of management regimes and produces good forage yields. Laboratory nutritive analyses of fescue compare favorably to those of many other cool-season grasses. However, most older fields of fescue in Kentucky are infected with a fungus (*Neotyphodium coenophialum*) that results in unthrifty cattle conditions, especially during hot weather. This condition is referred to by the terms “summer syndrome,” “summer slump,” “fescue toxicosis,” and “fescue toxicity.” In studies, animals consuming endophyte-infected fescue have shown the following responses in comparison to animals grazing noninfected fescue: (1) lower feed intake, (2) lower weight gains, (3) lower milk production, (4) higher respiration rates, (5) higher body temperatures, (6) rough hair coats, (7) more time spent in water, (8) more time spent in shade, (9) less time spent grazing, (10) excessive salivation, (11) reduced blood serum prolactin levels, and (12) reduced reproductive performance. Some or all of these responses have been observed in numerous studies in dairy cattle, beef cattle, and sheep consuming endophyte-infected pasture, green chop, hay, and/or seed.

In Kentucky, more than half the plants were infected in 83% of the fields sampled, and more than half the fields had 80% or higher infection levels. This “fungus” is responsible for the loss of approximately $60 to $75 million annually to the Kentucky beef industry.

The fungus spends its entire life inside the fescue plant and is spread only by seed. The presence of the fungus does not change the appearance of the plant, and its presence can be detected only by a laboratory analysis. Because it is spread only by seed, a field established with noninfected seed can be expected to remain free of the endophyte unless infected seed is introduced through hay or manure.

Dealing with Existing Endophyte-Infected Stands

Producers with established fescue fields need to carefully assess their situations. Existing fescue stands should be tested on a field-by-field basis. County Extension agents for agriculture can provide information regarding cost, sampling methods, and laboratory addresses.

Once the level of endophyte in existing fescue pastures is known, a producer can select the best option for dealing with the problem. The best way to handle one field may not be best for another. Four general approaches are available:

Minimize the effects of the endophyte on animals with management practices. Grazing and/or clipping management that keeps plants young and vegetative results in better animal performance. Likewise, if fescue is cut for hay in the boot stage, better animal performance is obtained from late-cut hay. Other practices, such as chain harrowing, fertilizing, pest control, creep grazing, and rotational grazing, result in improved overall pasture quality and animal performance.

Avoid the endophyte by using other forage species. Using infected fescue in spring and fall with other grasses or grass-legume mixtures for summer grazing avoids the endophyte during the summer when fescue forage quality is low. Since animal performance is adversely affected by feeding infected fescue hay, feeding of hay of another species can also be helpful.

Dilute the endophyte or its products through the use of other feeds in the diet. Growing legumes with infected fescue is an attractive option. Many studies have shown increased pasture production, higher liveweight gains, and improved pregnancy rates when pastures are renovated to include legumes. This has been the number one strategy used by Kentucky producers.

Kill infected stands and replant. Low-endophyte, endophyte-free, or "novel" endophyte seeds are available. Several varieties of endophyte-free and "novel" endophyte tall fescues have been released, and others are expected.

The cost of converting from high- to low-endophyte or novel endophyte fescue varies. Where fescue is used in rotation with other crops, the only difference in cost is the small price difference between low-endophyte or "novel" and high-endophyte seed. Where the sod is killed with a herbicide and the seed drilled into the killed sod, the cost may be $60 to $80 or more per acre. Where existing fescue is destroyed by tillage and immediately replanted, the cost may be $80 to $100 or more per acre.

Prevent fescue seedhead formation by heavy grazing, clipping, or chemical application. Do not allow any infected fescue field that is to be replanted to produce seed during the re-establishment year. This is for the purpose of preventing seed production that could lead to the establishment of volunteer infected plants.

"Novel" or "friendly" endophytes have been selected that give animal performance similar to endophyte-free tall fescue, but they give the plant stress tolerance, so persistence is similar to endophyte-infected plants. The first "novel" endophyte variety was Max Q followed by ArkPlus. Others are being developed.

Methods of Replacing Endophyte-Infected Stands

Rotating with other crops, followed by seeding endophyte-free fescue, is an excellent approach to replacing endophyte-infected stands. Options range from no-till corn or a summer annual grass to longer-term rotations involving a perennial such as alfalfa or two or three annual crops. With any rotation option, careful consideration must be given to herbicide residues, erosion hazards (leave all waterways—it is better to have a highly infected sod waterway than a noninfected gully), and complete destruction of the old fescue.

Plowing can help destroy the old sod. Endophyte-free or "novel" endophyte tall fescue may be replanted into the prepared seedbed. However, it is often difficult to completely destroy an old fescue sod by tillage alone.

Chemical kill of infected stands followed by no-tillage planting might be the only option remaining if crop rotation or plowing are not viable options. This technique can be used to go directly from infected fescue to noninfected or "novel" endophyte fescue, or other forage crops can be used in a rotation. It is critical that chemicals be used effectively, killing all the existing infected fescue. Furthermore, in some cases, there may be common bermudagrass or other species that must also be killed, requiring the use of more than one herbicide or a higher herbicide rate. Effective sod kill requires attending to label instructions and striving for optimal environmental and plant conditions that permit greatest chemical effectiveness. Consult state recommendations on chemical, rates, and time of application.

Best results from no-till tests have been found with late-summer or early-autumn seedings of fescue. Although spring plantings into killed vegetation have been successful, summer drought and competition from warm-season annual weeds tend to reduce stands of spring-seeded fescue.

Using no-till plantings of annual forages after killing infected fescue is a particularly effective approach. For example, infected fescue can be chemically killed in the spring, and a summer annual grass can be drilled into the killed sod, followed by no-till planting of noninfected fescue in the fall. Similarly, fescue can be killed in the fall followed by sod planting of winter annuals and, if desired, sod planting of a summer annual grass the next spring. In this case, noninfected or "novel" endophyte fescue would be planted one year after the infected fescue was killed. Use of annuals in this manner "smothers" fescue plants that escaped the chemical treatment and reduces the likelihood of insects in the old fescue sod damaging seedling fescue plants.

Grazing

There are many significant benefits for cattle producers who increase their efficiency through improved grazing systems. Most of Kentucky's pastures are too large to be efficiently utilized. Forage is often overgrazed and undergrazed in the same field in the same year, even several times a year, because the stocking rate is not changed or pastures are not rotated.

Overstocked pastures lead to weak, slow-growing plants that do not produce to their genetic potential. Forage that gets overmature due to lax grazing pressure lowers animal production. Some overmature forage dies before it is consumed, which is forage yield grown but never consumed. Finally, the cost of supplying a cow's daily protein and energy needs by grazing is about one-third to one-half that of stored feed.

Improved grazing systems offer exciting possibilities for making beef cattle operations more efficient. First, it is very important to understand how grasses and legumes grow and how these plants respond to defoliation by grazing.

The growing point of grasses is at or near the soil surface, while that of legumes is elevated above the ground (white clover is an exception). When grasses are grazed, only the leaf area is removed and the growing point stays intact. After being grazed, grasses have more residual leaf area with which to support new growth rather than relying mostly on stored carbohydrates.

With upright legumes, such as red clover and alfalfa, grazing removes the growing tip. New shoots must come either from crown buds or from the lower portions of shoots. The energy for this new growth comes almost totally from carbohydrates stored in the crown. These carbohydrates need to be replenished during a "rest" period following grazing.

Overgrazing of grasses takes away the residual green leaf area needed to support new growth. Therefore, grasses also use some stored carbohydrates for regrowth, and rest periods can be important for grasses too.

Frequent defoliations hurt legumes more than grasses because legumes rely more on stored carbohydrates for regrowth and because grazing removes their growing point and a greater proportion of their leaf area. In most cases, grazing management should favor the legumes present.

Grazing Mathematics: Defining Paddock Number, Size, and Total Acres Needed for a Grazing System

Several questions arise in the development of a grazing system, such as how many paddocks to have in a given pasture system, total number of acres required, stocking rate and density, and acres required per paddock. These can be estimated rather easily given the following formulas (Table 2-11).

Logically, managers often start by trying to figure how many divisions or paddocks are required for their improved grazing system. The number of paddocks per grazing system should fluctuate within a season. System designers recommend that, initially, no internal fences be permanent since adjustments will need to be made as managers better understand their given pasture systems. However, rotating a grazing group among six to eight paddocks most often results in the proper lengths for the grazing and rest period of a paddock. The actual number of paddocks required is determined by adding 1 to the ratio of the rest period to grazing period. For a rest period of 28 days and a grazing period of four days, the number of paddocks required would be 1 plus 7 (28 divided by 4), or 8.

Table 2-11. Grazing mathematics.

Number of paddocks =
[(days of rest)/(days of grazing)] + 1

Example: *[(28 days of rest)/(4 days of grazing)] + 1 = 8 paddocks*

- Days of rest values range from 10 or less for grasses during periods of rapid growth to 30 for legumes and even more for periods of very slow growth.
- Days of grazing values vary from 1 to 7 and up. Shorter times on a paddock yield greater season-long utilization, less waste, less selectivity, and less regrowth grazing.

Acres required per paddock =
(weight) x (% DMI) x (number) x (days per paddock)/ (DM per acre) x (% utilization)

Example: *(500 lb.) x (3% DMI) x (100 head) x (4 days)/ (2000 lb./acre) x (60%) = 5 acres per paddock*

- Weight is weight per head, in pounds.
- % DMI is the percent dry matter intake, ranging from 2 to 4%.
- Number is the number of head to be grazed
- Days per paddock is the amount of time that animals are to be allowed to graze in a given paddock. Values can range from 1 to 7 and up. To keep animals from grazing regrowth, keep days per paddock 7 or fewer.
- DM per acre is an estimate of total forage dry matter available per acre as the animals enter a paddock.
- % utilization is the portion of the available forage per acre that animals will consume during a grazing period. Improved grazing systems can utilize 60% for grasses and 75% for legumes.

Total acres required per grazing cycle =
(number of paddocks) x (acres required per paddock)

Example: *(8 paddocks) x (5 acres per paddock) = 40 acres*

- Number of paddocks is determined by the length of the rest and grazing periods.
- Acres required per paddock is determined by amount of forage needed each day by the grazing herd divided by the grazable forage dry matter per acre.
- The number of acres needed per grazing cycle varies with the growth rate of the forage. As the growth rate slows, the number of acres increases that are required to supply 3% DMI and maintain 4 days on and 28 days off a paddock.

Stocking rate =
(number of animals to be grazed)/(total acres grazed)

Example: *(100 head)/(40 acres) = 2.5 head per acre*

- Stocking rate and stocking density are often confused.
- Stocking rate applies to an entire grazing period (in this example, 32 days) or can be thought of as a season-long or whole-farm statistic.

Stocking density =
(number of animals grazing on a paddock)/(paddock size)

Example: *(100 head)/(5 acres) = 20 head per acre*

- Stocking density is the stocking rate at a given point in time. In this example, 100 steers are grazing in a 5-acre paddock, which is a stocking density of 20 head per acre. Stocking density can be expressed as the number of pounds of grazing animals per acre at a given point in time (in this case, 10,000 pounds per acre).

Next, it is helpful to know how many acres are required to carry the grazing group or herd for the desired number of days per paddock. While the formula for this calculation looks rather intimidating, it can be thought of as simply estimating the forage needed by the herd for a given number of days divided by the grazable forage per acre. The daily forage intake per animal varies by animal size and stage of production and is most often expressed as a percentage of body weight. Dry cows may only need about 2% of their body weight each day, while stocker steers may need 3% or more.

Benefits of Improved Grazing

Grazing represents the cheapest way to feed ruminants on the basis of cost per pound of nutrient. Stored feed is usually the single largest item in livestock budgets, and cost or amount of stored feed is usually the best prediction of potential profitability in most beef cattle operations.

Controlled grazing, intensive grazing, management intensive grazing, rotational grazing, and intensive rotational grazing are only a few of the terms frequently used by grazing enthusiasts. Rotational grazing can help Kentucky farmers to directly affect net profit by:

- increasing animal products per acre
- reducing the cost of machinery, fuel, facilities, etc.
- reducing supplemental feeding
- reducing wasted pasture
- improving the monthly distribution and yield of pasture
- improving distribution and use of animal waste and fertilizer
- improving botanical composition of pasture
- minimizing the daily fluctuations in intake and quality feed, and
- more efficiently allocating pasture to animals based on quality needs.

As we realistically look at our state and think of the future of animal-based agriculture, it is easy to get excited about the opportunities and potentials. Improving the utilization of the forage produced in Kentucky is a great way to capitalize on the opportunities in animal-based agriculture.

We produce a lot of pasture in Kentucky. We also waste a lot of the pasture produced. Our assessment of Kentucky pastures is that we have the resources for producing outstanding quantities and quality from cool- and warm-season grasses and legumes. In general, our pastures are too large for efficient management. Statewide, we are only utilizing about one-third of the forages we produce. Much of what our animals consume is not as high in quality as it could be. This is especially true of pasture in late spring and summer and of a significant amount of the hay produced.

The good news is that *if* we can utilize more of what we already produce in a higher-quality stage and be more efficient in converting more of the state's tremendous forage base to high-quality animal products, then without question, animal-based agriculture will play a major role in increasing Kentucky's agricultural cash receipts.

Potential Benefits of Improved Grazing Management

These benefits include utilization, yield, quality, a longer grazing season, stand persistence, animal performance and health, environment, and economics.

Utilization

Grazing methods dictate how much of the overall pasture produced that is actually utilized by the grazing animal. To better understand this aspect, we should first examine the difference between "temporal" and "seasonal" utilization. Temporal utilization is defined as how much of the existing pasture we utilize during a grazing period, and "seasonal" is the amount of the pasture utilized over the grazing season. In a continuous grazing program, these two are the same and can help explain why most continuous grazing programs only utilize a small amount of the total pasture produced for the season (Table 2-12). With rotational grazing or other grazing methods, we can improve our utilization, thus wasting less (Table 2-13).

Table 2-12. Amount of forage utilized with different grazing methods.

Method	% Utilization*
Green chop	85 - 95
Haylage	80 - 95
Hay	70 - 85
Strip grazing	70 - 85
Rotation two times/day	70 - 80
Daily rotation	60 - 75
Rotation every two days	55 - 70
3- to 7-day rotation	50 - 70
3- to 5-week rotation	40 - 60
Continuous grazing	20 - 50

* These values should be used only as a guide. Considerable variation can exist within and among categories.

Table 2-13. Increase in gain per acre with rotational compared to continuous grazing.

State	% Increase
Arkansas	44
Georgia	37
Oklahoma	35

Yield

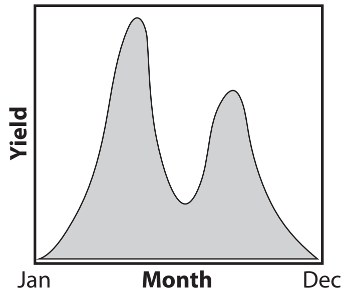
Pasture plants grow at different rates throughout the growing season. In Kentucky, our cool-season grasses grow best in spring, well in late-summer/fall, and little during summer and winter (Figure 2-6). Amount of growth during each period is dependent on temperature and moisture. With continuous grazing, it is difficult to keep pasture plants in their most efficient photosynthetic growth stage. Some plants are often overgrazed, while others are not grazed and become mature. This is especially a problem during our spring surplus. With rotational grazing, we can keep plants at a more efficient stage that can result in more animal product per acre (Table 2-14). During spring surplus, we can harvest selected paddocks for hay or haylage.

Table 2-14. Increase in production from alfalfa-orchardgrass with rotational and continuous grazing.

	% Increase over Continuous
Carrying capacity	43
Milk production	40

Source: VPI Bull. No. 45.

Figure 2-6. Seasonal yields of cool-season grasses in Kentucky.



Quality

Forage quality is highest when pasture plants are young and vegetative. Pasture quality is very closely coordinated with amount of leaves. With rotational grazing, we can usually manage "leaf" content, and ultimately quality, better than using most continuous methods (Table 2-15). In addition, quality for most of Kentucky tall fescue-based pastures is usually associated with legume content. With various rotational grazing methods, we can usually manage our legumes and keep them more productive and persistent than under continuous grazing methods.

Table 2-15. Percent leaves and persistence with different grazing methods.

	Grazing Method	
	Rotational	Continuous
Percent leaves	46 - 49	31 - 36
Percent stand (3rd yr.)	84	62

Source: Mathews et al. Univ. of Florida. 1994.

The yield/quality relationship can be better explained by examining the gain per acre (yield) and gain per animal (quality) relationship (Figure 2-7). As stocking rate is increased, less forage is available per animal. Individual animal output decreases as animals compete for forage and have less opportunity to select green, leafy forage. As a result of increased forage utilization, animal output per acre increases with stocking rate until individual animal gains are depressed to the point that the additional animals carried do not compensate for the loss. At high stocking rates, photosynthesis is reduced due to insufficient leaf area, plants are weakened, and forage growth is depressed.

Longer Grazing Season

When improved grazing methods are used, forage utilization usually increases and "waste" decreases. With decreased waste, more pasture is available for grazing over a larger period of time. Missouri workers used a strip-grazing approach to utilize stockpiled tall fescue. Allocating a new strip of stockpiled fescue every three days rather than every two weeks increased carrying capacity by 56%. Farmers consistently find that during drought conditions, rotational grazing methods result in more pasture over a longer period of time compared to continuous grazing.

Stand Persistence

Many pasture plants can be grazed continuously and continue to persist. Examples include Kentucky bluegrass, bermudagrass, endophyte-infected tall fescue, and white clover. Other plants will not persist for long when continuously overgrazed. Examples include alfalfa, most warm-season perennial grasses, and warm-season annuals. Even the plants capable of withstanding continuous grazing will usually be more productive under some grazing method that permits time for rest and regrowth.

Animal Performance

As discussed previously (see Figure 2-7), performance per animal can decline under intensive grazing because the animals cannot be as selective in what they consume. However, gain per acre can increase if stocking rates are increased to consume available forage in a timely manner (Table 2-16).

Figure 2-7. Effect of stocking rate on output per individual animal and output per unit of land area.

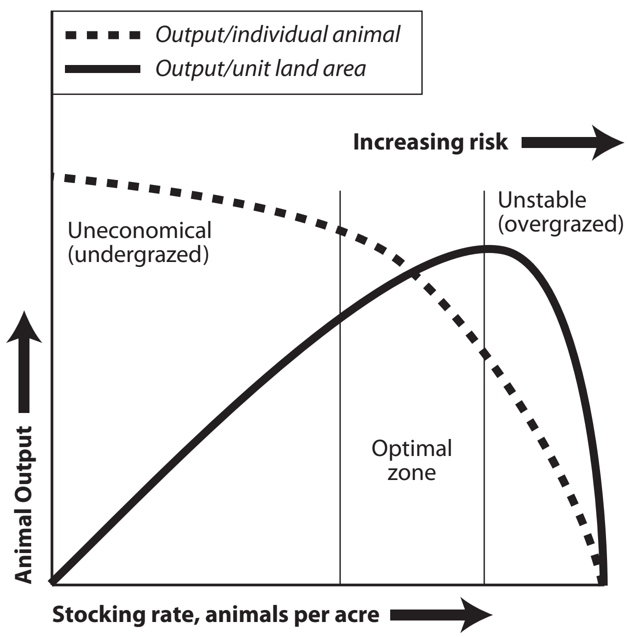


Table 2-16. Gain per acre, gain per animal, and hay required for wintering a beef cow using different grazing methods.

	Percent Change of Rotational over Continuous Grazing
Stocking rate	+38
Calf gain/acre	+37
Hay fed/cow	-32

Source: Dr. Carl Hoveland, Univ. of Georgia.

Animal Health

When using a system that requires you to move animals on some schedule, you have a chance to observe more frequently for any herd health problems. Controlling problems before they get serious is a health benefit for the animal and an economic benefit for the owner.

Environment

Improving grazing systems can have a positive impact on various environmental issues, especially water. Most improved grazing systems involve reducing pasture size, creating more water points, and often fencing animals out of ponds and streams or designing limited access. Each system that keeps animal manure and urine out of the water supply can have a potential environmental benefit.

Another issue involves manure and urine distribution. Approximately 75 to 85% of nutrients consumed by grazing animals are returned through animal manure and urine. With large pastures grazed continuously, much of the manure and urine is deposited near the water source and shade. Research has shown that other grazing methods can result in better distribution.

Economics

Making more money by changing your grazing system is not automatic. Putting more fences and water in may just cost you money and time if it does not fit into the overall plant-animal-environment system. Improving your grazing system certainly offers many opportunities and indeed the opportunity to improve the bottom line; however, a "system" is needed that consists of adequate fertility, matching plant species and varieties, managing plant pest problems, matching pasture quality to animal needs, having good-quality, healthy animals that can make best use of pasture available, and an overall plan to optimize grazing and minimize stored feed required.

The greatest opportunity for "improvement" rests squarely under the "grazing" umbrella. There is no other principle or practice that offers the Kentucky beef cattle producer more potential. Some data from Pennsylvania (Table 2-17) show what farmers have observed using four different forage harvesting and utilization systems. In these studies, rotational grazing returned more profit per acre than continuous grazing, hay, or corn silage.

A grazing method is a tool that allows producers to efficiently harvest the forage with livestock and maintain the pasture in a productive state. Several methods can be used, and each method requires management control to be most successful. This involves variable stocking rates that may be achieved by altering animal number per acre; altering the size of the land area to a fixed number of animals; harvesting surplus forage for hay, haylage, or round bale silage; and/or mowing excess growth and weeds.

Table 2-17. Enterprise budgets for pasture and forage crops.

	per acre			
	Intensive Pasture	Continuous Pasture	Hay	Corn Silage
Profit	$129	$75	$20	$58

Source: Farmer Profitability with Intensive Grazing. L. Cunningham and G. Hanson. Penn. State Univ. 1995.

How to Know When to Rotate

As a general rule, individual fields should be grazed for two to seven days followed by approximately four weeks of regrowth. Fields should be sized or stocked so that the desired amount of forage can be removed in two to seven days. Shorter times on each paddock or subdivision result in less wastage, less spot grazing, and greater season-long utilization rates. Longer grazing periods allow animals to graze regrowth of forages, leading to uneven forage growth and reduced yield and persistence of forages in the overgrazed areas.

The following guidelines also aid in deciding when cattle should be moved to the next field.

Look at the Cattle

Are the cattle acting hungry? Are they grazing at their usual times, or are they just standing at the gate?

Look at the Present Paddock

Keep enough forage before the cattle so that intake is not limiting. Evaluate the quality of the remaining forage and decide if it will support the level of production desired.

Look at Their Next Paddock

If the next paddocks are getting too tall or too mature, consider moving animals before they have completely finished with their present paddock. This happens frequently during the spring or times of rapid growth. Some paddocks may need to be taken out of the rotation and harvested for hay rather than letting them get overmature.

Look at Their Last Paddock

Observe how fast the paddock is growing back after grazing. Slow growth may be an indication that growth rates are slowing down and that paddocks should be given more rest between grazing. Often this may mean adding more pasture to the system or selling off the heavy end of a group of calves or just feeding some hay until growth catches up.

Look at the Sky

Take into consideration what the weather is supposed to do. If heavy rains are expected, move to sacrifice paddocks of grass so legumes are not trampled out of stand.

Extending the Grazing Season

Nutrients in the form of pasture usually cost one-third to one-half as much as nutrients in stored feed. Extending the grazing season can provide quality pasture later in the season and reduce the amount of stored feed required.

Crop residue can be a source of feed, especially for dry, pregnant beef cows. Use of cornfields for grazing has been found to lower winter feed cost from $20 to $30 per cow. Before grazing crop residues are utilized, be sure no pesticide with a grazing or utilization restriction on the label was used on the crop. Avoid grazing weedy cornfields just after the first hard frost because of potential toxicity from the prussic acid in johnsongrass that may be present.

Winter annuals, such as wheat and rye, can be used for late-winter and early-spring supplemental pasture. Fall production is greatest with rye but can be highly variable because soil moisture is often limiting during late summer. Rye is the most likely to support significant fall grazing and then only when planted on good, deep soil with some available moisture. Rye is also the earliest small grain to begin growth in the spring. Therefore, cereal rye is used most often to extend the grazing season.

Interseeding small grains of any kind into overgrazed (and often moisture-stressed) cool-season pasture during late summer is not a reliable way to produce fall pasture. The failure to produce much fall growth is most often caused by limited soil moisture for germination and growth of the small grain.

Applying nitrogen in the late winter/early spring can speed up the initial growth of grass pastures and get cattle onto pastures seven to 10 days earlier in the spring. In addition, a few acres of cereal rye can provide excellent early-spring pasture in most years.

Stockpiling is a powerful and effective way for many cattle producers to take advantage of the late-summer/fall growing conditions to obtain high-quality pasture for fall and early-winter grazing. Questions relative to stockpiling that need to be answered include: Which grass species is best for stockpiling? When should stockpiling begin? When, what kind, and how much fertilizer should be applied? When should the stockpiled material be used? What classes of cattle should be given access to stockpiled pastures? What grazing system should be used for most efficient use?

The best grass for stockpiling is a cool-season grass that retains its green color and forage quality later into winter. In addition, the grass should be somewhat resistant to low temperatures and have the capabilities of forming a good sod. Kentucky has two adapted grasses with these characteristics: tall fescue and Kentucky bluegrass. Tall fescue produces more fall and winter growth than bluegrass (Table 2-18).

Late July/early August is the time to begin stockpiling for fall and winter use. Remove cattle in late July or early August, apply necessary fertilizer, and allow the grass to accumulate growth until November or December.

During the stockpiling period, August 1 to November 1, other available forages, such as sorghum-sudan hybrids, sudangrass, bermudagrass, grass-lespedeza, and grass-clover, should be utilized. After frost, alfalfa-grass and clover-grass growth should be grazed first before moving to grass fields.

Table 2-18. Yield and crude protein content of Kentucky bluegrass and tall fescue produced from Aug. 15 to Dec. 1 under different levels of N fertilization at Lexington (average of three years).

Nitrogen Applied (lb./acre)	Bluegrass		Fescue	
	Yield (lb./acre)	% Protein	Yield (lb./acre)	% Protein
0	700	12.8	1,700	11.1
45	1,600	15.5	2,800	11.8
90	2,100	19.1	3,900	14.8

Source: T. H. Taylor and W. C. Templeton Jr. 1976. Agron. Jr. Vol. 68, Mar.-Apr.

Fertilize with the phosphorus, potassium, and lime deemed necessary by a soil test. Nitrogen should be topdressed at the rate of 40 to 60 pounds of actual N per acre on bluegrass and 40 to 100 on tall fescue. Kentucky researchers have shown that bluegrass fertilized with 45 pounds of nitrogen per acre had a yield increase of 20 pounds of dry matter for each pound of nitrogen applied when nitrogen was applied August 15 and yields were taken December 1. In the same study, tall fescue showed an even greater nitrogen use efficiency with 24.4 pounds of dry matter for each pound of nitrogen applied. Additional studies have shown the greatest response for early application of nitrogen (Table 2-19).

Table 2-19. Effect of time of nitrogen application on production efficiency of Kentucky 31 tall fescue.

Date N Applied	Nitrogen Efficiency (lb. DM/lb. N added)
Aug. 1	27.2
Aug. 15	25.8
Sept. 1	19.2
Oct. 1	10.8

Source: Lloyd W. Murdock. University of Kentucky Agronomy Notes, Vol. 15, No. 2. April, 1982.

Nitrogen applications before August 1 may encourage the growth of summer grasses, such as crabgrass, and subsequently reduce the production of bluegrass and tall fescue. Source of nitrogen influences efficiency (Table 2-20). These studies show that urea was approximately 85% as effective as ammonium nitrate on an equivalent nitrogen basis. These studies also have shown that with wise use and timing of fertilizer, high production can be obtained during fall and early winter. However, what is the quality of tall fescue in fall? The crude protein and digestibility of tall fescue is better during fall/early winter than any other time of the year. This increased quality in fall has been shown in many studies that agree with the data in Table 2-21 from the University of Kentucky.

Utilize grass legume fields quickly after frost before the plants deteriorate. After these fields are grazed, the stockpiled grass field or fields should be grazed. Light stocking causes a lot of waste as a result of trampling. To make most efficient use of the high-quality feed in stockpiled fields, install a temporary electric fence across the field dividing it so the area to be grazed first has a source of water and minerals. Once

Table 2-20. Pounds of tall fescue 10 weeks after nitrogen application.

Application Date	None	Nitrate	Urea	Urea/Nitrate
Early August	786	1,683	1,406	84
Mid August	741	1,438	1,287	89
September	372	1,076	852	79

Source: R.C. Buckner. 1975. University of Kentucky Coop. Ext. AGR-44.

Table 2-21. Seasonal percentage changes in chemical composition and digestibility of tall fescue.

	Spring	Summer	Fall
Sugars	9.5	8.5	19
Protein	22	18	19
DDM[1]	69	66	74

[1] Digestible dry matter.

Source: R.C. Buckner. 1975. University of Kentucky Coop. Ext. AGR-44.

the animals have grazed this area off, move the fence back, opening up a new strip. Repeat this system until the entire field is grazed.

The high-quality stockpiled grass is an excellent choice for fall-calving cows. The stockpiled forage can be used after calving and during the breeding season when the cows' nutritional needs are greatest.

Spring-calving cows may benefit most from grazing stockpiled grasses if they are in thin body condition in the fall. They can regain condition while grazing and be in better shape going into the winter. Spring-calvers in mid-gestation that are in good body condition might not need as high-quality feed and could use lower-quality feed. Overconditioning cows in late gestation can increase birth weights of their calves.

Growing, weaned cattle also can be grazed on stockpiled fescue. Backgrounders can lower the feed costs of their operations by utilizing stockpiled grasses.

Liveweight gains of both weaned stock and mature cows are good on stockpiled tall fescue. These gains are a response to the high crude protein and digestibility of the fall growth of tall fescue. In particular, the sugar content rises to very high levels in response to lower temperatures and shortening day length. This nutritional change does not take place overnight due to the first frost but is spread over time.

Gains of calves grazing fall-accumulated tall fescue are affected by several factors, including the endophyte status of the fescue and the length of the grazing period. The presence of the fescue endophyte decreases gain (Table 2-22) even with the cooler temperatures of fall. Calves grazing endophyte-infected, fall-accumulated fescue gained 1.49 pounds daily in a Kentucky trial and 1.85 pounds in an Oklahoma trial. Calves on the endophyte-free tall fescue gained 2.17 in the Kentucky trial and 2.47 in the Oklahoma trial. While performance of cattle in the Oklahoma trial was greater than that of those in the Kentucky trial, the magnitude of difference was almost identical (0.68 pounds for Kentucky, 0.62 pounds for Oklahoma). A third treatment, the addition of clover, was included in the Oklahoma trial. Clover increased gain by 0.17 pounds over infected tall fescue but was 0.45 pounds less than noninfected tall fescue.

The extent of deterioration of the fall-accumulated tall fescue also affects gain. In studies where calves were grazed from early November to mid-December, gains were 2 to 2.13 pounds per day (Table 2-23). However, extending the period of grazing to early January in other trials produced gains of 1.27 to 1.47 pounds per day. Gains can be kept high if grazing ceases before grass quality declines. If cattle are forced to clean up lower-quality grass by continuing to January, gains decrease.

The grazing season for the cow herd is extended by grazing stockpiled fescue, decreasing the need for stored feed. Studies also have shown that grazing stockpiled tall fescue can reduce labor requirements to 25% of that for conventional hay feeding of the beef herd. In a summary of using stockpiled tall fescue for dry, mature Angus beef cows for fall and winter pasture, researchers at the University of Kentucky found tall fescue produced 66 days of grazing and allowed the cows to gain 1.24 pounds per day while keeping the hay fed to an average of 564 pounds per cow during the same period (Table 2-24).

Summary

Forages supply most of the nutrition for beef cattle in Kentucky. The ability to produce pasture and hay inexpensively and efficiently is Kentucky's competitive advantage in beef cattle. Developing a forage program that is integrated into the overall beef cattle enterprise involves setting goals and determining the areas that will respond most to inputs. Most good forage programs have a plan that may include matching forage production closely to animal needs, maximizing the length of the grazing season, managing the effects of the tall fescue endophyte, producing quality hay that is protected from excess weathering losses, seeding certified seed of improved varieties, and using improved grazing systems. Any of these areas is a good place to begin assessing a beef-forage enterprise.

Table 2-22. The effect of the endophyte on calf ADG when grazing fall-accumulated tall fescue.

ADG, lb. Endophyte Level	Kentucky, 1986	Oklahoma, 1986
E+	1.49	1.85
E-	2.17	2.47
E+ and clover	——	2.02

Source: Garry Lacefield, Jimmy Henning, John Johns, and Roy Burris. 1996. Stockpiling for Fall and Winter Pasture (AGR-162). University of Kentucky Cooperative Extension Service, Lexington, Kentucky.

Table 2-23. Gain of calves grazing fall-accumulated tall fescue.

Trial	Grazing Days	ADG, lb.
Kentucky, 1982	59	1.27
Kentucky, 1985	57	1.15
Kentucky, 1986	56	2.00
Oklahoma, 1986	42	2.13
Kentucky, 1990	63	0.97
Illinois, 1992	56	1.76

Source: Garry Lacefield, Jimmy Henning, John Johns, and Roy Burris. 1996. Stockpiling for Fall and Winter Pasture (AGR-162). University of Kentucky Cooperative Extension Service, Lexington, Kentucky.

Table 2-24. Performance of dry, pregnant cows[1] grazing stockpiled tall fescue (four-year average).

Grazing Dates	11/6 to 2/10
ADG	1.24 lb.
Stocking rate	1.33 cows per acre
Gain per cow	119 lb.
Hay fed per cow (11/6 to 2/10)	564

[1] Mature Angus cows bred to calve in March.

Source: Neil Bradley et al., 1984 Beef Cattle Research Report, UK College of Agriculture Progress Report 282, pp. 11-12.