Forages for Beef Cattle

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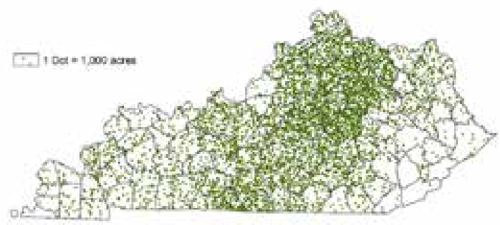
Forages in the form of pasture, hay and silage/haylage comprise almost all of the diet of beef cattle in Kentucky. Pasture and hayland total almost 6 million acres in Kentucky according to the USDA Agriculture Census of 2017 (Figure 2-1). Although the acreage is more concentrated in the central part of the state, forages are important in each of Kentucky's 120 counties.

The soil and climate in Kentucky supports the production of many different forages. Pastures and hayfields are primarily a mix of cool season perennial grasses and clovers. With good management, pasture can provide 300 days of grazing or more.

Developing a good forage system for beef cattle in Kentucky requires a holistic understanding of the land and forage resource, managing tall fescue and its toxic endophyte, focusing on forage quality, and learning how to efficiently harvest forage as pasture and hay.

Soils in Kentucky are variable, but in general are very productive for growing forage. The soil type and slope of the land will predict the productivity of pastures and hayfields. Producers can assess pasture and hayfield productivity by analyzing their acreage using the online tool of the Natural Resources Conservation Service (NRCS) called the Web Soil Survey (WSS) (Figure 2-2). The WSS will identify the soil types present on a given farm and their ability to produce forage for livestock, known as the carrying capacity. Carrying capacity refers to how many animals a farm or pasture can carry throughout the year without negative environmental impacts. The WSS reports carrying capacity as animal unit months (AUM), which is defined as the amount of forage needed for a 1,000 pound cow for a month. The WSS provides estimates of forage productivity for the land resource—the ability of the soil to produce forage for livestock. Proper pasture management is essential to reach production levels predicted by the WSS. Step-by-step information on using this online tool can be found in UK publication AGR-222: *Estimating Carrying Capacity of Cool-Season Pastures in Kentucky using Web Soil Survey.*

Kentucky Pasture and Hay Acres by County 2017



Forage	Acres
All Pastureland	3,951,952
Pasture Only	2,988,777
Cropland Pastured	357,344
Woodland Pastured	605,831
Hay	1,923,652
Total	5,875,604

Figure 2-1. Pasture and haylage acreage in Kentucky. Source: USDA 2017 Agriculture Census

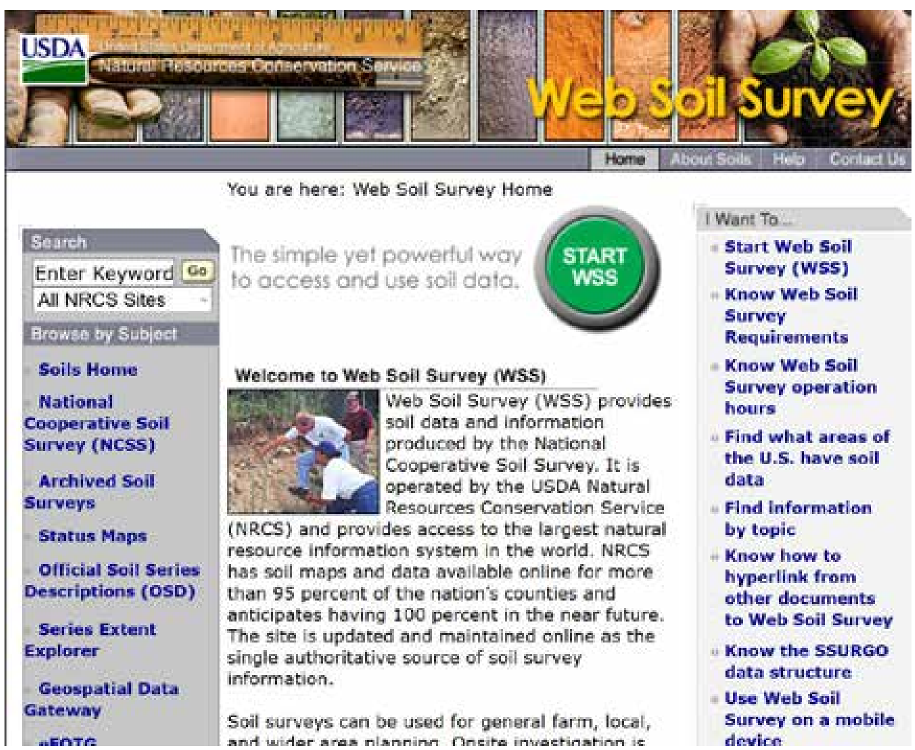


Figure 2-2. The Web Soil Survey (WSS) is an online tool of the USDA-NRCS that provides information on the soil types and productivities on a farm.

Soil Fertility and Forage Productivity

Pasture and hayfields require nutrients to reach peak productivity. These nutrients can be supplied from several sources including residual nutrients in the soil, the breakdown of manure and soil organic matter, nitrogen (N) produced by N-fixation in legumes and commercial fertilizer.

Soil testing is the only way to know what nutrients are available in the soil and what nutrients should be applied to support forage production (Figure 2-3). Producers should take soil samples once per year from hayfields and every two to three years from their pastures. Hayfields need to be checked more frequently since large amounts of nutrients are removed in hay.

Although phosphorus (P), potassium (K), and lime can be added anytime, N fertilizer should be applied when pastures or hayfields are actively growing. Nitrogen is the most limiting nutrient in forage production, especially with predominantly grass stands.

The best management practice to improve N levels in pastures is to interseed legumes (Figure 2-4). Legumes, such as red and ladino white clovers, have the ability to fix N from the air and convert it into a mineral form usable by plants. This is an excellent way to economically increase production of grass pastures.

In several situations, application of N fertilizer is required for optimal yields. Adding N when grass pastures begin to green up in early spring usually provides grazing seven to 12 days earlier than non-fertilized grass. Adding N 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. For more information on accumulating tall fescue in the fall see AGR-162: *Stockpiling for Fall and Winter Pasture*. Applying N to pure stands of annual and perennial warm-season grasses will increase growth during the summer months.

Urea (46-0-0) is the most commonly available form of N used by forage producers. Urea is generally safe to handle, easy to store, and the high analysis of N reduces handling, storage, and transport costs in comparison to some other forms of N fertilizer. However, urea is more subject to volatilization losses than other sources of N like ammonium nitrate or ammonium sulfate. Volatilization is more severe when urea is spread on moderate to heavy residues. Also, losses increase when applied at temperatures greater than 75° or on soils with a pH greater than 6.5. It is suggested that urea be applied in cooler temperatures. Apply urea when rain is expected shortly after application if possible. The use of a urease inhibitor can decrease loss potential and reduces volatilization losses by about 15 percent.

Figure 2-3. Make fertilizer applications according to a current soil test.

Table 2-1. Approximate pounds of nutrients removed by various forage crops at specified dry matter yield levels when harvested as hay[1].

	Species and assumed hay yield, tons/A			
	Alfalfa 5	**Tall Fescue 3.5**	**Sorghum-Sudan 4**	**Orchardgrass 4**
Nitrogen	255	130	120	108
Phosphate (P_2O_5)	60	42	38	39
Potassium (K_2O)	245	189	136	162
Magnesium	27	13	27	13
Sulfur	27	20	23	17

[1] Used with permission from 2017 Forage Crop Pocket Guide, 14th Edition, page 22.

Figure 2-4. Legume addition is the most cost effective way to add nitrogen to a pasture or hay system.

Nutrient Removal by Hay and Pasture

Forage crops harvested as hay remove large amounts of nutrients (Table 2-1). Fertilizer needs can be estimated from nutrient removal. Note that unlike most of the common blended fertilizers (e.g. 19-19-19 - 'triple 19'), hay removes about three to four times as much K as P. Maintaining good production on hayfields will require the replacement of these nutrients. In a well-managed pasture system, only a small fraction of the soil N, P, and K is removed by livestock. More than 80 percent of the nutrients in pasture return to the soil in the form of manure and urine. Rotationally grazed pasture will have better nutrient distribution than continuously stocked fields.

Whenever possible, base fertilization programs on a current soil test. Fertilizing according to soil test is more cost effective as it takes into account current nutrient levels in the soil, limiting the over and under application of fertilizer.

For more information on fertilizer applications for pastures and hayfields, see AGR-1: *2020-2021 Lime and Nutrient Recommendations* (http://www.ca.uky.edu/agc/pubs/agr/agr1/AGR1.PDF).

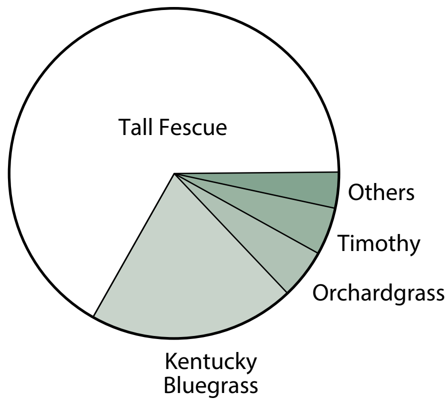


Figure 2-5. Kentucky's grass base.

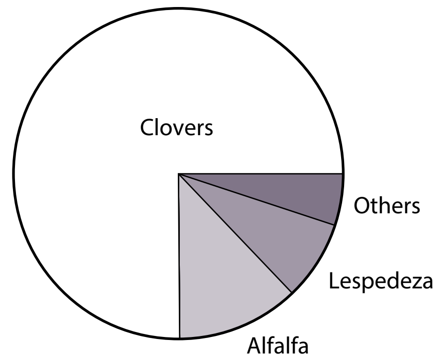


Figure 2-6. Kentucky's legume base.

Kentucky's Forage Base

Kentucky's forage base is composed primarily of perennial cool-season grasses and legumes. Tall fescue, orchardgrass, Kentucky bluegrass, and timothy occupy the majority of the forage acres in the state, with tall fescue occupying the largest number of acres (Figure 2-5). Clovers (red, ladino, white) are by far the dominant legumes found in Kentucky hay/pasture fields (Figure 2-6). Alfalfa is the highest yielding, highest quality legume in Kentucky, and is grown primarily for hay. Alfalfa can be part of a well-managed grazing system. Alfalfa is usually grown with a companion grass such as orchardgrass.

Cool-season grasses produce most of their forage in spring and fall (Figure 2-7). In contrast, warm-season grasses are extremely productive during the summer months. Warm season annual grasses include crabgrass, teff, sudangrass, sorghum-sudangrass, and pearl millet. Warm-season perennial grasses adapted to Kentucky include bermudagrass and the native grasses eastern gamagrass, switchgrass, big and little bluestem, and indiangrass. Cool-season annuals such as annual ryegrass, wheat, rye, oats, and barley can be helpful in extending the grazing season in the fall and early spring.

High temperatures and short-term drought stress in summer limit growth of cool season grasses. Warm-season annual grasses can fill this gap with relatively high-quality forage when properly managed (Figure 2-8). A productive forage system in Kentucky will often require a mix of cool- and warm-season annuals and perennial grasses complemented with legumes. The seasonal growth of the most common Kentucky forages is found in Figure 2-9. In addition, the University of Kentucky has one of the most extensive variety testing programs in the country. Go the UK Forages website (https://forages.ca.uky.edu) to access the most current variety reports.

Common Forage Legumes

White clover (*Trifolium repens*) is a perennial legume that spreads by aboveground horizontal rooting stems called "stolons" (Figure 2-10). White clover produces most of its growth in the spring and fall and is high in quality, but lower in yield than red clover and alfalfa. Because of its spreading nature and reseeding, white clover lasts longer without reseeding than alfalfa and red clover. When white clover

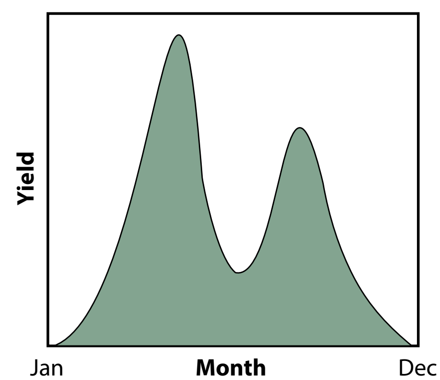


Figure 2-7. Seasonal growth of cool-season pastures.

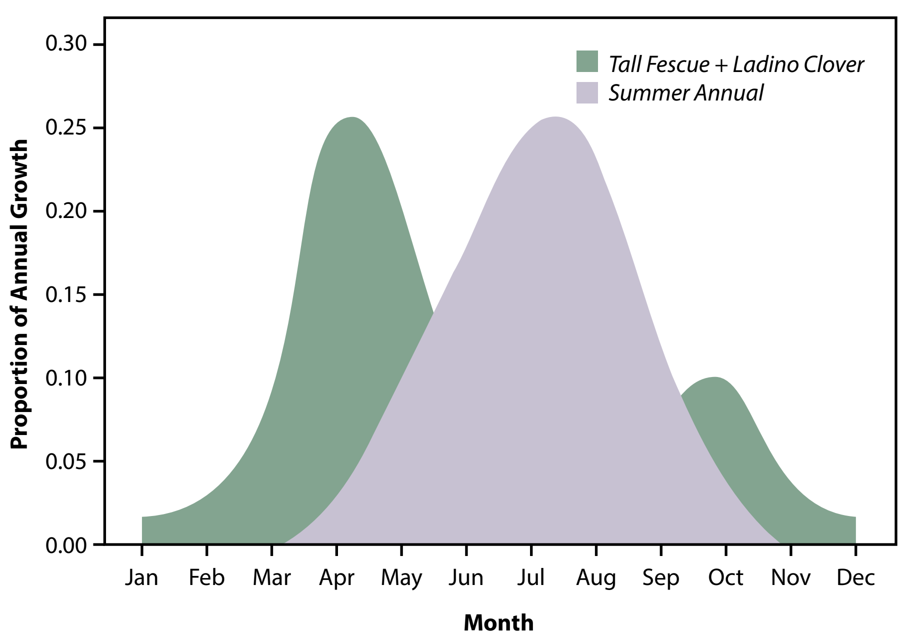


Figure 2-8. Relative monthly production of tall fescue plus clover versus a typical summer annual grass. Summer annual grasses are more productive than cool-season species such as tall fescue and clover in June, July, and August.

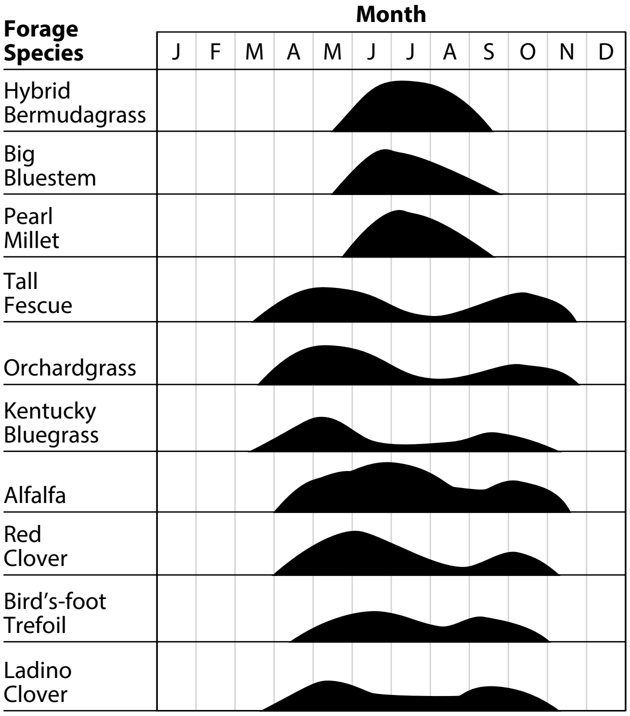


Figure 2-9. Normal forage availability by month.

exceeds 40 percent to 50 percent of the sward, it can cause bloat. The risk is highest when it is grazed during cool, rainy weather when growth is lush. Ladino or intermediate-type white clover varieties are recommended over common or Dutch white clover because of superior forage production.

Red clover (*Trifolium pratense*) (Figure 2-11) and **alfalfa** (*Medicago sativa*) (Figure 2-12) are erect legumes that regrow from crowns. Red clover stands last two to three years while alfalfa can persist for five years or more with good management. These erect legumes are most often harvested as hay with companion grasses, such as tall fescue or orchardgrass, but can be grazed effectively with good rotational stocking. Red clover has hairy stems that can cause the hay to be dusty.

Annual lespedeza (*Kummerowia striata* (common or striate) and *Kummerowia stipulacea* (Korean)) is a fine-stemmed, leafy, annual legume with shallow taproots. It produces forage in mid- to late summer and is non-bloating (Figure 2-13). Tolerant of low fertility and acidic soils, it grows 1 to 2 feet tall. Annual lespedeza leaves are a pale green color with light-colored, easily-visible veins. This legume flowers and sets seed in late summer and early fall and must set seed each year to persist. Annual lespedeza may fail to reseed if overgrazed, autumns are dry, or early frost occurs. Kobe and Korean are examples of annual lespedeza.

Figure 2-10. White clover.

Figure 2-11. Red clover.

Figure 2-12. Alfalfa.

Figure 2-13. Annual lespedeza (striate shown).

Cool-season Perennial Grasses

Tall fescue (*Schedonorus arundinaceus)* is a long-lived perennial cool season grass that is adapted to a wide range of soil and climate conditions (Figure 2-14). Tall fescue is the most widely grown forage in Kentucky, and Kentucky 31 (KY-31) is the most common variety found. Since its release in 1943, this variety quickly became the most widely grown pasture grass in Kentucky and in the Southeastern United States. The original KY-31 variety was highly infected with the toxic endophyte of tall fescue. The presence of this internal fungus contributes to the persistence of KY-31, but adversely impacts animal performance. New novel endophyte tall-fescue varieties combine a beneficial endophyte that strengthens the plant, but does *not* produce the toxins that adversely impact animal performance. In most cases, producers should utilize novel endophyte tall fescue when establishing permanent pasture.

Orchardgrass (*Dactylis glomerata*) is an erect-growing cool season bunchgrass that provides high quality hay and pasture (Figure 2-15). Orchardgrass is in high demand as hay and is the preferred companion grass in alfalfa and red clover hay. Orchardgrass requires better management to persist, but stand life may not exceed four years. Orchardgrass stand life is reduced by grazing or cutting lower than four inches.

Kentucky bluegrass (*Poa pratensis*) is a sod-forming, fine-bladed cool season grass most commonly found on better soils in Central Kentucky (Figure 2-16). Kentucky bluegrass is slow to establish and goes dormant during hot, dry summers. High in quality but moderate yielding, it is better adapted for pasture than hay.

Perennial ryegrass (*Lolium perenne*) is a short-lived perennial cool season grass that is very palatable to livestock (Figure 2-17). Perennial ryegrass is easy to establish, has high seedling vigor and is often used to overseed damaged pastures. Stand life of perennial ryegrass is only two to three years, and less during hot, dry years.

Figure 2-14. Tall fescue.

Figure 2-15. Orchardgrass.

Figure 2-16. Kentucky bluegrass.

Figure 2-17. Perennial ryegrass.

Warm-season Annual Grasses

Warm-season annual grasses can provide high-quality forage during midsummer when cool season species are less productive (Figure 2-18). The advantages of summer-annual grasses include fast germination and emergence, rapid growth, high productivity, and flexibility of utilization. Disadvantages include the cost of establishment and the increased risk of stand failure due to variable rainfall in late spring and early summer.

Summer annual grasses are best used in a rotation with small grains or annual ryegrass to optimize productivity per unit of land area. They also have great utility as transition crops prior to the establishment of improved perennial forage species. The sorghum species have prussic acid potential and are hosts for the sug-

Figure 2-18. Warm-season annual grasses such as this sorghum-sudangrass hybrid provide needed forage during summer, when cool season grasses are less productive.

Table 2-2. Characteristics of commonly used summer annual grasses.

Summer Annual	Yield potential in Ky.	Seedling vigor	Tolerance to Soil acidity	Tolerance to Poor drainage	Tolerance to Drought	Suitability for Silage	Suitability for Hay	Suitability for Grazing	Host for sugarcane aphid	Nitrate toxicity potential[1]	Prussic acid potential[2]
Crabgrass	Good	Fair	Poor	Fair	Good	Fair	Fair	Excellent	Poor	Low	None
Forage sorghum	Excellent	Good	Poor	Poor	Excellent	Excellent	Poor	Poor	Good	High	High
Foxtail millet	Fair	Good	Good	Fair	Good	Fair	Good	Fair	- - -[3]	Low	None
Pearl millet	Good	Fair	Excellent	Poor	Excellent	Good	Fair	Good	Poor	High	None
Sorghum-sudangrass	Good	Excellent	Poor	Fair	Good	Good	Fair	Good	Good	High	Medium
Sudangrass	Good	Excellent	Poor	Fair	Good	Good	Good	Good	Good	High	Medium

1 See ID-217: "Forage-related Cattle Disorders—Nitrate Poisoning."
2 See ID-220: "Cyanide Poisoning in Ruminants."
3 Little information available.

arcane aphid. In addition, nitrate toxicity can be a problem for all summer annuals during drought conditions and high N fertilization. Concerns regarding prussic acid and nitrate toxicity are limited by careful management (See ID-220: *Cyanide Poisoning in Ruminants* and ID-217: *Forage-related Cattle Disorders: Nitrate Poisoning*.) The major characteristics of these grasses is summarized in Table 2-2.

Sudangrass [*Sorghum bicolor* (L.) ssp. *Drummondii*] is a rapidly growing annual grass of the sorghum family. It is medium yielding and well-suited for grazing. Sudangrass regrows quickly after harvest and can be grazed several times during summer and early fall. This grass has finer stems than most other summer annuals making it well suited for hay production. For more information, see AGR-234: *Sudangrass and Sorghum-sudangrass Hybrids.*

Sorghum-sudangrasses (*Sorghum bicolor*) are hybrids or crosses between sorghum and true sudangrass. The result is a tall growing annual grass that resembles sudangrass, but has coarser stems, taller growth habit, and higher yields. Like sudangrass, sorghum-sudangrass will regrow after grazing if growth is not limited by environmental factors. The coarse stems are difficult to cure as dry hay, therefore these grasses are best utilized for grazing, chopped silage and baleage. For more information, see AGR-234: *Sudangrass and Sorghum-sudangrass Hybrids.*

Forage sorghum (*Sorghum bicolor*) can reach heights of 6 to 15 feet and is best harvested as silage. Taller varieties produce high forage yield but can lodge, making them difficult to harvest mechanically. Dwarf varieties have been developed that are shorter with increased resistance to lodging. Like corn, forage sorghums are harvested once per season by direct chopping. While forage sorghum yields can be similar to corn, they are lower in energy. The primary advantage of choosing sorghum for silage production rather than corn is greater drought tolerance. For more information, see AGR-230: *Forage Sorghum.*

Foxtail millet (German millet) is fine stemmed, has no prussic acid potential and is well suited for hay-making. It is the lowest yielding of the summer annual grasses since it will not regrow after cutting. It is a good smother crop when used before notill seeding another crop such as tall fescue or alfalfa. Foxtail millet is also used for wildlife plantings to produce food and cover for doves, quail, and other birds. For more information, see AGR-233: *Foxtail Millet.*

Pearl millet (*Pennisetum glaucum*) is not related to foxtail millet and is higher yielding. It will regrow after harvest, does not have prussic acid potential and is not a host of the sugar cane aphid. Dwarf varieties are available which are leafier and better suited for grazing. Pearl millet is better adapted to acidic soils and drought-prone soils than sorghum, sudangrass or sorghum-sudangrass hybrids. For more information, see AGR-231: *Pearl Millet.*

Crabgrass (*Digitaria spp.*) is sometimes considered a weed, but possesses significant potential for supplying high quality summer forage. Crabgrass does not have prussic acid potential and is a poor host for the sugarcane aphid. Crabgrass is the general term for many Digitaria species. A primary advantage of crabgrass is that it is well adapted to Kentucky and occurs naturally in most summer pastures, especially those that have been overgrazed. It is also highly palatable and a prolific reseeder. With proper management, crabgrass stands can regenerate themselves each spring. Planting an improved variety of crabgrass is recommended because the production of naturally occurring ecotypes varies greatly. Although crabgrass is best utilized by grazing, it can be hayed. For more information, see AGR-232: *Crabgrass.*

Teff (*Eragrostis tef*) is an annual, warm-season grass native to Ethiopia. Teff is characterized by a fairly large crown, many tillers, fine stems, a very shallow root system, rapid growth and moderate yield. When vegetative, teff plants look somewhat similar to tall fescue in size and color. Teff tends to germinate quickly with good moisture and regrows quickly after cutting. With timely planting and good management, multiple cuttings are possible before fall. Teff is poorly adapted for temporary pasture because it tends to be uprooted when grazed.

Warm-season Perennial Grasses

Like annuals, warm-season perennials are very productive in summer and complement the seasonal production of Kentucky's cool season forage base (Figure 2-19). These grasses are somewhat slow and expensive to establish. However as long-lived perennials, the establishment costs can be spread over many years, lowering their annual cost of production over time.

Figure 2-19. Warm-season perennial grasses such as this eastern gamagrass can be important additions to Kentucky's cool season-based forage system.

Bermudagrass *(Cynodon dactylon)* is an introduced sod-forming grass used for hay and pasture. Bermudagrass spreads by underground rhizomes and stolons, and requires high levels of N and K fertilizer for best yields. Although found more frequently in the lower South, winterhardy types of bermudagrass can be successfully grown in Kentucky. Hybrid bermudagrassess are higher in quality and palatability than common types but are typically less winter hardy. Hybrids can only be established by planting vegetative sprigs. There are several seeded types adapted to Kentucky (see AGR-48: *Bermudagrass: A Summer Forage in Kentucky*).

Eastern Gamagrass *(Tripsachum dactyloides)* is a coarse, tall growing native warm season bunchgrass. Eastern gamagrass has high yields and is highly palatable to livestock. It provides more uniform growth over the summer than switchgrass, big bluestem, or indiangrass. Eastern gamagrass will grow on wet sites. This grass is somewhat expensive to seed. Seed can have high levels of dormancy leading to slow, uneven emergence and establishment. It must be rotationally grazed and rested in fall to persist.

Switchgrass *(Panicum virgatum)* is a tall-growing deep-rooted rhizomatous native bunchgrass. Some varieties are tolerant of wet sites. Switchgrass can be used for hay, pasture and wildlife. Advantages include being drought tolerant, using N efficiently, and having seed that will flow through conventional seeders. Like other native warm season grasses, switchgrass is slow to establishment, has low seedling vigor and requires rotational grazing and fall rest to persist. Animal gains are poor when mature. The growth season of switchgrass also overlaps with cool season perennial grasses in late spring.

Figure 2-20. Cool-season annual grasses such as small grains can extend the grazing season in the fall and early spring (wheat shown).

Big Bluestem *(Andropogon gerardii)* is a tall-growing deep-rooted bunchgrass. It is more drought tolerant than most warm season perennial grasses and is suitable for hay, grazing and wildlife. Big bluestem is palatable over a wider range of maturities than switchgrass. It is an efficient user of fertilizer N but is slow and expensive to establish. Seed of big bluestem is light and requires no-till drills that can handle fluffy seed. Like other native grasses, it will not tolerate close, continuous grazing.

Indiangrass *(Sorghastrum nutans)* is a tall growing, deep-rooted bunchgrass. It is drought tolerant, and is spread by rhizomes and seed. Indiangrass matures later than switchgrass and big bluestem, which extends the grazing season into late summer. Like big bluestem, its seed is light and requires no-till drills that can handle fluffy seed. Like other native grasses, it will not tolerate close, continuous grazing.

For more information see AGR-145: *Native Warm-season Perennial Grasses for Forage in Kentucky*.

Figure 2-21. Annual ryegrass is an important forage when high quality spring pasture is needed.

Cool-season Annuals

Cool-season annual grasses that can be used for winter and early spring grazing include small grains (Figure 2-20) and annual ryegrass (Figure 2-21). Characteristics of these forage crops are summarized in Table 2-3. The annual forage crimson clover can be grown in a mixture with both the small grains and annual ryegrass.

Wheat (*Triticum aestivum*) is one of the most versatile small grains for a farming operation. Due to its excellent winter hardiness, wheat can be sown later in the fall than barley and has good potential for pasture, silage or hay production. Wheat will withstand wetter soils better than barley or oats, but tends to be less tolerant of poorly drained soils than rye, triticale, and annual ryegrass. Managed properly, wheat can be grazed in the fall, again in early spring, and finally harvested for grain, hay, or silage.

Barley (*Hordeum vulgare*) is generally more susceptible to winterkill than wheat, especially when it has been overgrazed. It should not be grazed as short or as late into the fall as wheat. Barley does best on fertile, well-drained soils. It is sensitive to acidic soil conditions and poor fertility. Barley produces high quality silage or hay with a higher digestibility than other small grains, but lower yields. Good quality grazing can be obtained from early seeded barley.

Triticale (X *Triticosecale*) is a high yielding forage crop that is gaining popularity. Triticale generally has a higher forage yield, but lower quality than wheat. It is a

Table 2-3. Characteristics of commonly used cool season annual grasses.

Cool season annual	Yield potential[1] Tons DM/A	Fall Growth	Winter-hardiness	Tolerance to		Suitability for		
				Soil acidity	Poor drainage	Silage/ baleage	Hay	Grazing
Annual ryegrass	3-4[2]	Good	Fair – Good[3]	Good	Good	Excellent	Good	Excellent
Barley	1.5-2	Good	Good	Poor	Poor	Excellent	Good	Good
Oats	2-2.5	Excellent	Poor - Fair	Fair	Fair	Excellent	Good	Good
Rye	2.5-3	Excellent	Excellent	Good	Fair	Good	Fair	Good
Triticale	2-3	Good	Good	Good	Fair	Good	Fair	Good
Wheat	2-3	Good	Excellent	Poor	Fair	Excellent	Good	Good

1 Harvested at boot stage.
2 Multiple harvests.
3 Dependent on variety.

cross between rye and wheat. As such, it is adapted to a wide range of soils. Tolerance to low pH is better than wheat, but not as good as rye.

Rye (*Secale cereale*) is the most cold tolerant and least exacting in its soil and moisture requirements of all small grains. Like wheat, rye can be sown in late August to provide fall grazing, excellent winter ground cover, and spring grazing. The rapid growth of rye, both in the fall and spring, makes it the most productive of the small grains for pasture. Rye is also the earliest maturing of the small grains. Rye tends to be a more consistent producer of spring pasture than wheat, although it quickly becomes stemmy and unpalatable in late spring.

Winter Oats (*Avena sativa*) produce very palatable forage and are best adapted to well-drained soils. They do not perform as well under extremely dry or wet conditions as wheat or rye. Although oats produce high quality forage, yields tend to be lower than the other small grains. As a rule, the hardiest winter oat variety (Kenoat) is considerably less winter hardy than common wheat, rye and barley varieties. In Kentucky, oats will usually overwinter 50 percent of the time. Similar to barley, winter oats must be seeded by mid-September to be well established before cold weather arrives. Spring oats are the most commonly planted early season annual hay crop and can produce 1.5 to 2 tons of forage in 60 days when planted in mid-March.

Annual ryegrass (*Lolium multiflorum*) is a cool-season annual that can provide late fall, winter, and early spring grazing. Attributes of annual ryegrass include ease of establishment, high yields, high nutritive value, and later maturity than the small grains. In contrast to small grains, annual ryegrass continues to regrow in the spring until high temperatures limit growth in early summer. Annual ryegrass is commonly used to overseed warm season summer pastures in the Deep South and can be used to thicken up thin cool season pastures in transition zone states like Kentucky. It is adapted to all soil types and grows best at a pH of 5.7 or higher. The highest yields are obtained on fertile and well-drained soils with high N fertilization.

Crimson clover (*Trifolium incarnatum*) is a winter annual legume with conical bright red blooms and dark green leaves densely covered with hairs (Figure 2-22). It can be used with small grains or annual ryegrass and is suitable for grazing, hay or haylage but quality is low when mature. Crimson is not adapted to poorly drained soils. The recently released variety "Kentucky Pride" is the most winter hardy crimson clover on the market.

Understand and Managing Tall Fescue and the Toxic Endophyte

Tall fescue is the most widely adapted and persistent perennial grass in Kentucky. Most tall fescue in Kentucky originates from the KY-31 variety found on the W.M. Suiter farm in Menifee County. Kentucky 31 tall fescue was quickly adopted by farmers across Kentucky because the agronomic characteristics were superior to all other cool season perennial forage grasses. Animal performance when grazing KY-31 tall fescue, however, was not.

Unknown at the time, the original seed was infected with a fungal endophyte (*Acremonium coenophialum*). The presence of this fungal endophyte causes the host fescue plant to produce compounds called ergot alkaloids that adversely impact cattle performance, especially during hot weather. This condition is called "summer syndrome," "summer slump," "fescue toxicosis," and "fescue toxicity." Baleage, hay, and/or seed from toxic tall fescue can negatively affect animals that consume them.

Figure 2-22. Crimson clover.

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

The ergot alkaloids in tall fescue cause a narrowing of the veins or vasoconstriction in the extremities of cattle which interferes with heat dissipation. Cattle grazing tall fescue in summer will show signs of heat stress, such as higher respiration rates, higher body temperatures and more time spent in ponds and shade (Figure 2-23). During cold weather, toxicosis symptoms may include loss of the tips of

Figure 2-23. Cattle grazing toxic tall fescue exhibit symptoms of heat stress and will spend excessive amounts of time in ponds or shade.

ears and tail and in extreme cases lameness and hoof loss (fescue foot).

Consumption of toxic tall fescue also causes lower forage intake, lower weight gains, lower milk production, rough hair coats, less time spent grazing, reduced blood serum prolactin levels, and reduced reproductive performance in both cows and bulls.

Surveys of Kentucky pastures consistently show that 80 percent or more of the fescue present is infected with the endophyte. The economic effect of toxic tall fescue on the beef industry is significant. Toxic tall fescue is known to reduce conception rates by 10 percent or more and weaning weights by 50 pounds. Across 1.1 million beef cows, this amounts to 110,000 fewer calves to sell and approximately 45 million fewer pounds to sell at weaning (900,000 calves x 50 pounds per calf). The lower calving rates alone could total $82.5 million if calves are worth $750. Beef cattle producers have an economic incentive to find ways to deal with toxic tall fescue.

The discovery that the endophyte was to blame for the negative animal performance led to the development of tall fescue varieties that were free of the toxic endophyte. Animal performance from these varieties was superior, but persistence of these endophyte-free fescues was less than desired. New Zealand scientists discovered naturally occurring strains of the endophyte that did not cause the production of toxic alkaloids in tall fescue. These endophyte strains have been inserted into locally adapted tall fescue to produce novel endophyte varieties which have been commercially available since the late 1990s. These new products are also referred to as friendly, beneficial or non-toxic tall fescue varieties. Novel endophyte tall fescues have been observed to have greater persistence than comparable endophyte-free fescues. Novel or friendly endophyte varieties give animal performance similar to endophyte-free tall fescue, but their persistence is similar to KY-31 plants that contain the toxic endophyte as long as they are not overgrazed.

Since it would be impractical to replace all existing tall fescue acres in Kentucky with novel endophyte varieties, producers are encouraged to manage the toxic effects of endophyte-infected tall fescue using one or more of following methods:

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. If tall fescue is cut for hay in the vegetative or boot stage, better animal performance is obtained than from mature hay containing seedheads. Not only are the leaves higher quality that the stems, but tall fescue leaves contain lower concentrations of the toxin (ergovaline) that causes animal issues than the stem and seedhead. Other practices, such as chain harrowing, fertilizing, pest control, creep grazing, and stockpiled rotational grazing, result in improved overall pasture quality and animal performance.

Avoid the endophyte by using other forage species. Using infected tall fescue primarily for early spring and late fall grazing and other grasses or grass-legume mixtures for summer grazing avoids tall fescue endophyte issues during the summer when toxic effects are greatest and tall fescue forage quality is low. Feeding hay of another species can also be helpful.

Dilute the endophyte with clover. Growing legumes with infected fescue is an attractive option and is highly recommended. Many studies have shown increased pasture production, higher liveweight gains, and improved pregnancy rates when pastures are renovated to include legumes like red and ladino white clover. Clover introduction has been the number one strategy used by Kentucky producers for diluting the toxic effects of the endophyte.

Kill infected stands and replant. In some cases, it is beneficial to completely kill the existing toxic tall fescue and replace it with a more desirable forage. Options include orchardgrass or one of the perennial warm season grasses. Endophyte-free, or novel endophyte fescue varieties are options also.

The cost of converting existing fescue to an endophyte free or novel endophyte fescue can be significant in terms of herbicide, seed, drilling and lost production. However, costs are recovered in two to three years because of the significant improvement in animal performance.

For no-till seedings, completely kill the existing tall fescue with two applications of glyphosate spaced 4 weeks apart. The first application should generally occur by mid-July and the second application in late August followed by seeding in early September. It is important to have at least 4 to 6 weeks between the first glyphosate treatment and grass seeding to allow the killed grass to decay and not interfere with seedling emergence. Do not let tall fescue produce seed in the year of re-establishment.

Forage Establishment

The establishment of a good stand of desirable forage is essential to a successful forage program. High yields require thick, vigorous stands which will also prevent weed encroachment. In addition, thick stands prevent or minimize soil erosion. The following recommendations are the basics of successful forage establishment:

- Match plants to soils.
- Match plants to intended use.
- Select high-quality seed of an adapted variety.
- Supply proper fertility.
- Prepare an adequate seedbed.
- Use the best seeding method available.
- Seed at the right time and rate.
- Get good seed-soil contact.
- Control competition from other plants after establishment.
- Allow forages to become established before heavy use.

The goal of any seeding method is to place the proper amount of seed at the right depth and in good contact with soil (Figure 2-24). Prepared seedbeds should be fine-textured and firm enough so footprints are not more than ¼ to ½ inch deep.

Figure 2-24. A successful seeding method places the correct amount of seed at the proper depth and in good contact with soil.

Figure 2-25. Clipping pastures is an important tool in weed management.

Planting too deep happens frequently when seedbeds are too fluffy. To ensure proper depth and good seed-soil contact when planting on a prepared seedbed, pack the soil before and after seeding by rolling with a corrugated roller (cultipacker). A Brillion® seeder combines seeding and cultipacking in one operation.

With no-till seedings, soil moisture is preserved and residue is present on the surface to slow drying of the soil surface. No-till seeders are designed to cut through sod and crop residue. Adjustment of seeding depth may be required with each field. **Planting too deeply is the most common cause of seeding failures with no-till drills.** The press wheels of drills ensure good seed soil contact after depositing the seed in the furrow.

Frost seeding refers to the practice of broadcasting seed on top of the ground during winter, relying on freeze/thaw cycles to work the seed into the soil. Frost seeding is recommended only for clover. Pastures should be very closely grazed or clipped prior to frost seeding in late January or February. Seeding grasses via frost seeding is generally not successful.

An Integrated Approach to Weed Control in Pastures

In many cases, producers equate weed control with the use of herbicides. While herbicides effectively control many weed species commonly found in pastures, long-term weed control in pastures should have a broader strategy. The best weed control strategy is to have an integrated approach that includes cultural practices that encourage a healthy and vigorous sod, proper grazing management, timely clipping, as well as judicial use of herbicides.

Maintaining thick stands of perennial grasses. Thick, vigorous, well-fertilized stands of grass prevent the encroachment of most weeds. Proper grazing management that includes maintaining critical residual heights will help keep stands competitive and less prone to significant weed problems.

Clipping pastures. Mowing pastures can control or at least inhibit the spread of some weeds species, but the cost may be greater than other options (Figure 2-25). It is estimated that clipping can cost between $15 and 20/acre. If timed correctly, clipping can reduce weed seed production. However, if performed after weeds have produced viable seed, it can actually worsen weed problems by spreading seeds. Clipping is also less effective on plants with large underground root systems and plants that have low growth habits.

Herbicide use. There are a number of very effective herbicides to control difficult broadleaf pasture weeds. The UK publication AGR-207: *Broadleaf Weeds of Kentucky Pastures* shows pictures of weeds along with a chart that lists of the weeds, the herbicides that will control each one, and the time of the year that is best to spray (Table 2-4).

For weeds that grow or germinate in cooler months like bull, musk and plumeless thistle the time to spray is October to November or February to March. Spraying during these months kills the thistle plants when they are small. On the other hand, weeds like buttercup and poison hemlock often do not germinate until late winter, so the most effective time to spray is early March to early April. Other problem weeds only grow in the summer months. For example, the best time to spray tall ironweed is June-August or to spray ragweed is May-July. Spray at the right time and use the recommended products and soon your pastures and hayfields will be almost weed free. Remember the best weed control is good grazing and cutting management and a well fertilized forage stand has the best chance to outcompete weeds.

Commonly used broadleaf herbicides injure or kill clover and other legumes. In some cases, herbicides can be spot applied to smaller areas within pastures or applied with a wicking or wiping device to taller growing weeds to spare the clover. More information on herbicide use in pastures can be found in AGR-172: *Weed Management in Grass Pastures, Hayfields, and Other Farmstead Areas.*

Forage Growth and Grazing Management

Improved grazing systems allow beef cattle to more efficiently and economically harvest forage. Therefore, 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 leaf area is removed and the growing point stays intact. After grazing, grasses have more residual leaf area with which to support new growth compared to legumes which rely more 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. Grasses use stored carbohydrates in the base of each tiller for regrowth, therefore rest periods and

Table 2-4. Response of Pasture Weeds to Herbicides and Mowing.*

Weed Species	Life Cycle[1]	Preferred Time for Herbicide Treatment[2]	2,4-D	dicamba (Banvel/Distinct)	dicamba + 2,4-D (Weedmaster)	Crossbow	PastureGard	Milestone	GrazonNext	metsulfuron[3]	MOWING[4]
Amaranth, Spiny (Pigweed)	A	May-July	F/G	F/G	G	G	F/G	F	G	G	X
Aster spp. (White Heath Aster)	A	July-Sept	F/G	G	G	G	-	-	-	F	R
Burdock, Common	B	Feb-Mar	G	F	G	G	G	F	G	F	R
Buttercup spp.	A	Feb-Mar	G	F/G	G	G	F	F	G	G	X
Carrot, Wild (Queen Anne's Lace)	B	May-June	G	G	F/G	F/G	F	P	G	G	R
Chickweed, Common	A	Nov or Feb-Mar	P	F/G	G	F	G	G	G	G	X
Chicory	P	Feb-Mar or Aug-Nov	F/G	F/G	G	G	G	G	G	F/G	R
Clover, White	P	May-Aug	F/G	G	G	G	G	G	G	G	X
Cocklebur, Common	A	May-July	G	G	G	G	G	G	G	G	R
Dandelion	P	Oct-Nov or Mar-Apr	G	G	G	G	F/G	F/G	G	G	X
Deadnettle, Purple	A	Feb-Mar	P	F/G	G	F	G	G	G	G	X
Dock, Curly or Broadleaf	P	Feb-Apr	P/F	F	F/G	G	F/G	G	G	G	X
Dogbane, Hemp	P	May-Aug	F	F	F	F/G	G	P	P/F	P	S
Garlic, Wild	P	Nov or Mar-Apr	F	F	F	F	P	P	F	G	X
Goldenrod spp.	P	June-Aug	F	F/G	G	G	G	P	F/G	P	S
Hemlock, Poison	B	Nov or Mar-Apr	F/G	G	F	F/G	P	P	F/G	F	R
Henbit	A	Feb-Mar	P	F/G	G	F	G	G	G	G	X
Horsenettle	P	July-Aug	P	F	F	F	P	G	G	F	X
Ironweed, Tall	P	June-Aug	P	P/F	F	G	G	G	G	P	S
Jimsonweed	A	May-July	F	G	G	G	-	G	G	-	R
Lespedeza, Sericea	P	June-July	P	P/F	P/F	G	G	P/F	P/F	F/G	X
Marshelder (Sumpweed)	A	May-July	F/G	F/G	G	G	F	F/G	G	F	R
Milkweed, Common	P	July-Sept	P	F	F	F	P/F	P/F	P/F	P	S
Mint, Perilla	A	May-July	F	F	F/G	G	F/G	-	G	-	S
Multiflora Rose	P	Apr-June or Sept	P/F	P	F	G	G	P	P	G	X
Passionflower, Maypop	P	May-July	P	-	P	-	F	P	P	-	X
Plantain, Broadleaf or Buckhorn	P	Oct-Nov or Mar-Apr	F/G	F	F/G	G	F	P	F/G	F/G	X
Pokeweed, Common	P	May-July	F	G	F/G	F/G	P	F/G	F/G	P	S
Ragweed, Common	A	May-July	G	G	G	G	G	G	G	P	R
Ragweed, Lanceleaf	A	May-July	F/G	G	G	F	-	-	-	P	R
Sorrel, Red (Sheep Sorrel)	P	Sept-Nov or Mar	P	G	F/G	F/G	F	-	-	F/G	X
Thistle, Bull	B	Oct-Nov or Feb-Mar	G	G	G	G	F/G	G	G	F/G	R
Thistle, Canada	P	Prebud or Oct-Nov	P	P/F	F	F	P/F	G	G	F	S
Thistle, Musk	B	Oct-Nov or Feb-Mar	G	G	G	G	F/G	G	G	F/G	R
Thistle, Plumeless	B	Oct-Nov or Feb-Mar	G	G	G	G	F/G	G	G	F/G	R
Trumpetcreeper	P	Aug-Sept	P	P/F	P/F	F	F	P	P	P	X
Yarrow, Common	B	Feb-Mar	G	G	G	-	-	-	-	F/G	X

Control: **G** = Good or Excellent; **F** = Fair (suppression or partial control); **P** = Poor; **–** = No Information

1 Life Cycle: **A** = Annuals; **P** = Perennials; **B** = Biennials.

2 The preferred time for herbicide treatment will depend on environmental conditions and other factors.

3 Active ingredient in several products (e.g. Cimarron, Patriot, Purestand). May cause temporary yellowing, stunting and seedhead suppression of tall fescue (consult label).

4 Mowing: **R** = Timely mowing reduces top growth and seed production; **S** = Suppression of top growth; **X** = Not very effective

This table should be used only as a guide for comparing the relative effectiveness of herbicides to a particular weed. The herbicide may perform better or worse than indicated in the table depending on the species, weed size, time of application and/or extreme weather conditions. Consult herbicide label for weed height or growth stage and product amount. Read and follow all label directions and precautions before herbicide application.

Adapted from AGR-172: *Weed Management in Grass Pastures, Hayfields, and Other Farmstead Sites* (Revised 10-2012).

Listing of pesticide products implies no endorsement by the University of Kentucky or its representatives. Criticism of products not listed is neither implied nor intended.

*From: AGR-207: *Broadleaf Weeds of Kentucky Pastures*, J.D. Green and W.W. Witt, Plant and Soil Sciences.

leaving adequate residual heights can be important for grasses too. Rest and leaving adequate residual after grazing is especially important for orchardgrass (Figure 2-26).

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 high proportion of leaves. In most cases, grazing management should favor the legume which means shorter grazing periods and longer rest periods. Guidelines for rotational stocking of selected forages is found in Table 2-5.

Figure 2-26. Six-days regrowth of orchardgrass plants after being harvested weekly at one inch (left) or monthly at 3.5 inches (right). Close frequent harvest of orchardgrass greatly inhibits regrowth.

Benefits of Improved Grazing Management

Better grazing management benefits Kentucky producers in several ways, including improved 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 forage produced is actually utilized by the grazing animal. To better understand this aspect, one should first examine the difference between "temporal" and "full season" utilization. Temporal utilization is defined as how much of the existing pasture we utilize during a grazing period, and full seasonal is the amount of the pasture utilized over the grazing season. Because forage growth rate varies from one grazing period to another (temporally), rotational stocking will allow the manager to more nearly allocate pastures so less forage is wasted. In a continuous grazing program, the manager is less able to alter stocking rates with growth rates, leading to waste. Therefore continuous grazing programs only utilize a small amount of the total pasture produced for the season compared to well-managed rotational systems (Table 2-6).

Yield. Pasture plants grow at different rates throughout the growing season. Kentucky's cool-season grasses grow best in spring, well in late-summer/fall, and little during summer and winter. 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. In these systems, some plants are overgrazed, while others are avoided as they become mature. This uneven grazing is especially a problem during periods of spring surplus. With rotational grazing, it is possible to keep plants at a more efficient growth stage (i.e.vegetative) that can result in more animal product per acre (Table 2-7). During spring surplus, selected paddocks can be harvested for hay or haylage.

Quality. Forage quality is highest when pasture plants are young and vegetative. Pasture quality is very closely related to the proportion of leaves in the sward. With rotational grazing, one can usually manage leaf content, and ultimately

Table 2-5. Guidelines for Rotational Stocking of Selected Forage Crops.[1]

Crop	Target height, in: Begin grazing	Target height, in: End grazing[2]	Usual days rest
Alfalfa (hay types)	10-16	3-4	35-40
Alfalfa (grazing types)	10-16	2-3	15-30
Bahiagrass	6-10	1-2	10-20
Bermudagrass	4-8	1-2	7-15
Bluestem, big	15-20	10-12	30-45
Bluestem, caucasian	10-20	4-6	14-21
Bromegrass, smooth	8-12	3-4	20-30
Clover, white and subterranean[3]	6-8	1-3	7-15
Clovers, all others[3]	8-10	3-5	10-20
Dallisgrass	6-8	3-4	7-15
Eastern gamagrass	18-22	10-12	30-45
Fescue, tall	8-12	4-8	15-30
Indiangrass	12-16	6-10	30-40
Johnsongrass	16-20	8-12	30-40
Kentucky bluegrass	8-10	1-3	7-15
Lespedeza, sericea	8-15	4-6	20-30
Orchardgrass	8-12	4-8	15-30
Pearl millet	20-24	8-12	10-20
Ryegrass, annual	6-12	3-4	7-15
Small grains	8-12	3-4	7-15
Sorghum, forage	20-24	8-12	10-20
Sorghum/sudan hybrids	20-24	8-12	10-20
Switchgrass	18-22	8-12	30-45

1 These are merely guidelines. Stocking rates and growing conditions greatly affect forage growth. Also, the more closely pastures are grazed, the longer the rest period generally needs to be for species that are sensitive to defoliation.

2 The nutritional requirements of the livestock being grazed should be considered when deciding when to end grazing. The closer a pasture is grazed, the lower forage quality will be toward the end of that particular grazing cycle.

3 Clovers are typically grown with pasture grasses. White clover and subterra nean clover are quite tolerant of close defoliation; most other clovers are not.

Used with permission from 2017 Forage Crop Pocket Guide, 14th Edition, p. 37.

Table 2-6. 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 2-7. 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.

Table 2-8. 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.

quality, better than using most continuous methods (Table 2-8). In addition, quality for most of Kentucky tall fescue-based pastures is usually associated with legume content. With various rotational grazing methods, legumes can be better managed to keep them more productive and persistent than under continuous grazing methods.

The yield/quality relationship can be better explained by examining the gain per acre (yield) and gain per animal (quality) relationship (Figure 2-27). 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 percent. 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 a grazing method that permits time for rest and regrowth.

Animal Performance. 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 2-7).

Animal Health. When using a system that requires moving animals regularly, cattle are monitored more frequently, increasing the chance to catch 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 the environment, especially water quality. 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. Systems that keep animal manure and urine out of the water supply will improve water quality.

Economics. Simply changing to a rotational grazing system will not guarantee a profit. Putting in more fences and water will increase costs and will fail to be profitable if they do not fit into the overall plant-animal-environment system. Improved grazing systems do offer many opportunities to improve the bottom line. However, the most economically sound systems will need to include adequate soil fertility, forage species and varieties matched to the land, well-managed plant pests, pasture quality adequate to meet animal needs, healthy animals that can make best use of pasture available, and an overall plan to optimize grazing and minimize stored feed required.

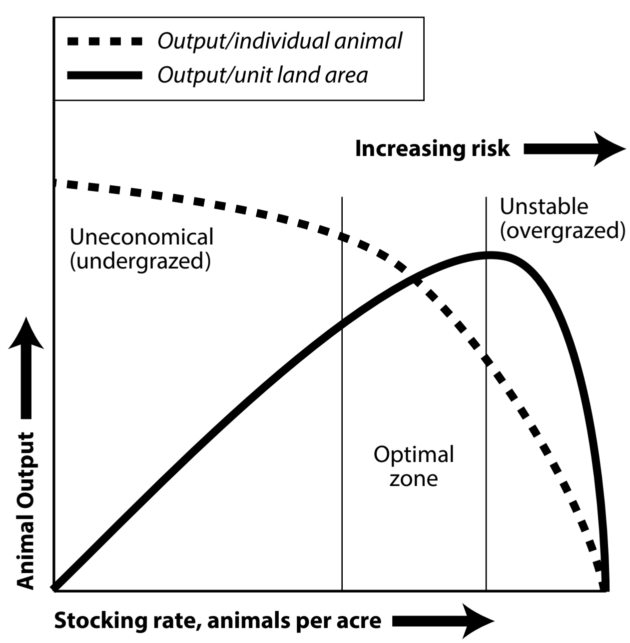


Figure 2-27. Effect of stocking rate on output per individual animal and output per unit of land area.

Developing a Planned Rotational Grazing System

Although producers will readily acknowledge the benefits of a planned rotational grazing system, they struggle to implement one. The following simple steps can help farmers develop an improved and effective grazing system on their farm.

Step 1: Set a Goal

A producer should first ask the simple question, "What do I want to accomplish?" The good news is there are really no wrong or right answers. While most tend to focus on production/economic related goals, lifestyle goals are also important. Some producers find it beneficial to write out their goal statement and keep it where it can refresh their memory on a regular basis. Going through the process of writing farm goals will clarify the process of developing a grazing system.

The following is an example of a reasonable goal statement:

"We want to implement a rotational stocking system that will allow us to feed less hay, maintain good body condition in our cattle herd, protect our soil and water resources, and allow us time to attend our children's extracurricular activities."

Step 2: Inventory Resources

The process of attaining farm forage goals starts by inventorying present system resources. This inventory should include soils, soil fertility, forage base, fencing, water sources and locations, cattle genetics and available labor. Soils, forages, fence and water are the key resources in a forage system.

Soils and soil fertility. Not all soils are created equal. Deep, well-drained, fertile soils have a much higher yield potential than shallow soils with a high percentage of rock fragments. The Web Soil Survey of USDA-NRCS will provide estimates of pasture and hayland productivity. Remember that even on very good soils, forage production can be severely reduced by low soil fertility.

Forage base. The types of forage species present will impact both forage productivity and availability during the summer and winter months. For example, a forage system based solely on cool-season grasses and legumes will have great production during the spring and fall, but limited growth during the summer. In this case, adding a warm-season grass could greatly improve summer grazing capacity.

Figure 2-28. Pasture utilization is more uniform when cattle do not have to walk more than 800 feet to water.

Figure 2-29. A sound rotational grazing system will depend on subdividing larger pastures to pastures to rest between defoliations. Temporary fence posts and polywire can quickly and easily subdivide larger pastures.

Water resources. Access to water is often a major factor restricting the use of rotational grazing (Figure 2-28). Research shows that if water is within 800 feet of cattle, pastures are grazed more uniformly and manure is distributed more evenly over a pasture. When water is farther away than 800 feet, pasture use decreases and overgrazing of areas closer to water occurs.

All potential water sources should be considered when developing a grazing system. Ponds, springs, streams, municipal water and wells are options and can all contribute to providing water to livestock. Using portable water systems initially while developing a grazing system can allow producers to evaluate waterer locations and make better decisions about where to place permanent waterers.

Fencing resources. Fence in a rotational grazing system is simply a tool to manage grazing. One of the most cost-effective ways to subdivide large pastures is to install a single electrified wire 30 inches above the ground on the inside of the perimeter fence using temporary fence posts and polywire (Figure 2-29). This practice creates a flexible system that can be changed and improved as more experience is gained. When starting out, try different temporary fencing components to determine what works best. For more information on fencing for grazing systems follow the link to the UK publication ID-74: *Planning Fencing Systems for Intensive Grazing Management.*

Step 3: Determine Forage Balance

To determine your forage balance, one will need to know how much forage is needed and the production (yield) capacity of pastures. To determine forage needs requires a little simple math. Needed for these calculations are the weight and number of animals being fed/grazed and their expected dry matter intake as a percent of body weight. In this example, there are 100 brood cows that weigh 1,200 lb./cow and four bulls that weigh 1,500 lb. each. All are eating on average 2.5 percent of their body weight each day. To determine their annual dry matter requirements, use the following formula:

DM Required Annually:
  100 cows x 1,200 lb/cow
\+ 4 bulls x 1,500 lb/bull
x 2.5%/100
x 365 days
= 1,149,750 lb

For forage supply calculations, annual pasture productivity will be estimated to be 3 ton/A or 6,000 lb. DM/A. Not all pasture grown will be consumed by grazing livestock, so an estimate of forage utilization should be made. Seasonal utilization rates can range from 40 percent to 70 percent and increase as the grazing management intensifies. For this example, set pasture acres at 225 acres with a seasonal utilization rate of 60 percent. Forage available to be grazed can be calculated using the following formula:

Available Forage:
  6,000 lb DM/A
x 60% utilization rate/100
x 225 A
= 810,000 lb DM

Calculate the forage balance by subtracting the available DM from the required DM. In this case, there is a deficit of 339,750 lb. DM or about 110 days of hay feeding.

Step 4: Setting a Stocking Rate for Your Farm

Stocking rates that are set too low tend to have the highest production per animal, but lowest production per acre. These stocking rates tend to waste pasture resources due to lower utilization rates and decrease overall profitability. Stocking rates that are set too high tend to have low individual animal performance and low output per acre. These stocking rates tend to be unprofitable because neither the pasture nor the animals are productive. The goal in setting sustainable stocking rates is to find the "sweet spot" where animal performance is good and output per acre is optimized (Figure 2-27). In Kentucky and other transition zone states, greatest net return is achieved when hay feeding is limited to about 60 days per year. Feeding no hay is not normally the most profitable model. However, it is important to note that the economics of hay feeding and grazing are NOT static, but rather change as the price of hay and grazing change.

Producing High Quality Hay and Haylage

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) intake—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.

Table 2-9. 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.

Factors Affecting Hay Quality

Stage of maturity at harvest is the most important factor affecting hay quality. 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 2-9. 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 hay quality and animal performance are shown in Tables 2-10 and 2-11. In both cases, early-cut hay resulted in better quality feed and superior animal performance.

Cutting tall fescue hay earlier can make a significant difference with growing cattle (Table 2-11). A Tennessee study measured the gains and feed efficiency of Holstein heifers fed three fescue hays cut May 3, May 14, and May 25. These dates corresponded to late boot/early head, early bloom, and early milk stage/seed forming, respectively. The latest cutting date, May 25, is still earlier than most fescue hay in Kentucky. Close analysis of the data in Table 2-11 reveals several key points (listed below). Taken together, these points strongly emphasize the value of cutting forages earlier, even tall fescue.

Table 2-10. 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
Feed efficiency,			
lb hay/lb. gain	9.2	11.1	---

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 2-11. Effect of stage of harvest of fescue hay on forage quality and animal gain.*

Stage of harvest	Date of cutting	Dry matter intake lb/day	Percent digestibility	Percent protein	Feed efficiency, lb hay fed per lb of gain	Yield, lb/acre	Gain, lb/ day
Late boot to head	May 3	13.0	68	13.8	10.1	1334	1.39
Early bloom stage	May 14	11.7	66	10.2	13.5	1838	0.97
Early milk stage—seed forming	May 25	8.6	56	7.6	22.5	2823	0.42

*Holstein heifers were used, average weight – 500 lb.
Source: University of Tennessee, reported in AGR-62: *Quality Hay Production*, University of Kentucky Cooperative Extension Service.

- The heifers ate more of the early cut hay, 13 lb./day compared to 11.7 and 8.6 for later cut hay.
- Early cut hay had the highest digestibility and crude protein. The drop in digestibility was small between May 3 and May 14, but much larger over the next 11-day period. Crude protein dropped about the same (about 3 percentage units) for each 11-day delay.
- Gain per day ranged from 1.39 to 0.42 lb./day for the three hays. The earliest cut hay supported the best gains, as expected. The decline in average daily gain was about the same for each 11-day delay in cutting.
- Maturity decreased gains per day more than forage digestibility. A delay of twenty-two days dropped digestibility by 17 percent (68 percent to 56 percent). Over this same period, daily gain dropped by 70 percent (1.39 to 0.42 lb./day). Small changes in quality made big differences in gain.
- The highest quality hay had the lowest yield per acre. Some argue that 500 to 1,500 lb. per acre is enough justification to delay cutting, and that may be true for mature cows with low needs.
- Curiously, gain per acre was almost equal for each of the three hays (yield per acre divided by lb. of hay per pound of gain), 132, 136, and 125 lb., respectively. If you calculate how long it would take to get that gain on each hay, you arrive at 95, 140 and 298 days respectively. Hay cut on May 25 could produce the same gain as hay cut on May 3 but it would take *twice* as much hay and *three* times as long.
- The May 3 treatment also has the added benefit of 22 extra days of forage growth compared to the May 25 hay field—extra growth that translates to a higher yielding, higher quality second cutting.

Curing and Handling Conditions

Poor weather and poor 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 extremely dry hay can cause excessive leaf loss (Table 2-12). Raking and/or tedding while hay is moist (about 40 percent moisture) and baling before hay is too dry (below 15 percent moisture) helps reduce leaf losses.

Table 2-12. The effect of handling conditions on alfalfa hay losses.

	Raked and Baled Correctly (lb./A)	Losses			
		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.

Freshly harvested hay averages 80 percent moisture content and therefore must lose about 6,000 pounds of water to produce a ton of hay at 20 percent moisture. Crushing stems (conditioning) at time of mowing causes stems to dry at nearly the same rate as leaves. Conditioning decreases the drying time of larger-stemmed plants alfalfa, red clover, and warm season annuals by approximately one day and can improve leaf retention and forage quality.

Figure 2-30. Making haylage by wrapping high moisture round bales in UV-resistant stretch wrap allows the harvest of quality forage and helps avoid rain damage.

Legumes and Hay Quality

Incorporating legumes into hayfields will increase forage quality. When grasses and legumes are harvested at the proper stage of maturity, legumes are usually higher in total digestibility, rate of digestion, protein, and many minerals and vitamins. Legumes can improve summer growth and add N to the system through biological N fixation in their root nodules. A mixture consisting of an adapted grass and legume is usually of high quality when properly managed. Grasses will improve the drying rates of mixed stands compared those which are mostly legumes.

Producing Round Bale Haylage

The ability to harvest moist forage as haylage gives Kentucky producers many advantages, including timely harvest, higher forage quality, and less weathering loss over hay systems. The baleage system allows producers to utilize commonly available forage equipment (mowers, rakes, balers) rather than requiring choppers and silo structures or bags (Figure 2-30).

To better understand the quality of haylage in Kentucky, samples of a variety of types of haylage were collected in 2017-18 and analyzed for forage quality and fermentation profile (pH and volatile fatty acid content). The survey identified the following important considerations for making high quality haylage.

- Cut at the proper stage of maturity. The fermentation process is driven by the soluble carbohydrates present at cutting. Early cut forage has greater carbohydrates. All forages, cut at boot to early head (for grasses) and bud to early bloom for legumes will ensile.
- Bale when the wilted forage is between 40 percent and 60 percent moisture content (MC). In this survey, only excessively wet (80 percent MC, essentially unwilted) forage had an 'off' fermentation profile with excessive butyric acid.
- Bales should be as tight as possible to help exclude oxygen and accelerate the ensiling process.
- Wrap moist hay the day of baling. Delaying to the next day allows heating to begin.
- Wrap bales with six to eight layers of UV-stabilized, stretch wrap plastic.

Early work indicated that as few as four layers could be effective. However, top producers use six or more layers. In addition, UK research has seen clear feeding preferences for bales with at least six layers of coverage.

- Periodically check the wrapped bales and plug any holes present in the bales with special UV-stabilized tape.
- The ensiling process is complete within six to eight weeks, but bales may be fed at any time after wrapping. Bales that have not completely fermented will spoil quickly when exposed to air.

Figure 2-31. A representative hay sample is a composite of cores from 15 to 20 bales in a lot of hay.

Figure 2-32. The UK Beef Cow Forage Supplement Tool gives quick feeding solutions for available hay choices based on a current forage analysis, cow size, and stage of production.

Evaluating Forage Quality

Forage testing is the most practical way to determine the nutrient content of hay. Each lot of hay should be tested by taking a representative core sample from 15 to 20 bales using a forage probe (Figure 2-31). A lot is a group of hay that has been cut, baled and stored similarly. Once taken, analyze the sample for quality through a reputable laboratory such as those certified by the National Forage Testing Association. Use the quality report information to match hay to different classes of livestock and supplement accordingly.

Feeding Decisions for the Cow Herd – The UK Beef Cow Forage Supplement Tool

Wintering cost is the largest single expense for beef cow-calf producers. Manage this cost by making sound supplementation and hay feeding decisions using the UK Beef Cow Forage Supplement Tool (Figure 2-32). The UK Beef Cow Forage Supplement Tool is a simple web-based tool to estimate forage intake and supplementation rates.

To use the tool, producers need to know the quality of the hay to be fed (dry matter, protein, NDF and TDN) and the desired stage of production of the cows (cow size is fixed at 1,250 pounds). Once the forage and cow production stage is entered, producers choose from among several commonly available supplement options and the program calculates the amount to be fed to balance the forage.

The program was developed by beef specialists in the UK Department of Animal and Food Sciences and is designed to provide quick and simple feeding solutions for Kentucky producers. Remember that many variables such as weather conditions, body condition, animal health, and palatability of feedstuffs can affect actual intake and animal response to a feeding program. Actual feed/forage intake and body condition should be monitored throughout the feeding program. Cattle should also have access to a complete mineral supplement and clean drinking water at all times.

Hay Storage and Feeding Options

Most of the hay produced in Kentucky for feeding livestock is packaged as large round bales. Much of this hay is stored outside without protection from weather. Losses during outside storage of twine-tied round bales result from weathering and from moisture movement from the ground into the bale. Weathering is visually associated with a change in color and deterioration of the outer layers of hay following exposure to rainfall, sunlight, and other factors during storage. Weathered hay suffers substantial losses of both yield and forage quality and is much less palatable to livestock than undamaged hay.

Research has shown that twine-tied round bales stored outside and in direct contact with the ground can lose 25 percent to 35 percent of their dry matter. Net wrap reduces this DM loss to 15 percent to 25 percent. Breaking contact with the ground can reduce storage losses to 13 percent to 17 percent. Breathable hay wrap (B-wrap®) is being marketed with claims to allow moisture to leave the bale but prevent water penetration from soil or weather. Feeding studies have shown that B-wrap® stored outside has feed characteristics similar to barn-stored hay.

Inside storage is best for round bales, with many designs and options available. Many producers have added tarp-covered hoop structures for on-farm hay storage. Barn storage reduces DM losses to 4 percent to 7 percent (Figure 2-33).

Kentucky producers have many options for hay feeding, including ring feeders, unrolling, bale grazing, in-line fence feeders and of course, just setting out round bales (Figure 2-34). When using ring feeders, those with solid sheeting at the

Figure 2-33. Tarp-covered hoop structures provide cost-effective hay storage in Kentucky.

bottom reduce hay losses by 15 percent to 20 percent compared to those with just bars because cattle cannot pull hay from the ring as easily. Hay unrolling can be desirable to spread out hoof damage and provide better distribution of manure and urine in feeding areas. Finally, bale grazing is gaining in popularity and usage in some situations. With this system, bales are placed on a field before the feeding season and allocated by moving temporary electric fence. This system has the advantage of reducing tractor tire damage as well as good nutrient distribution.

Figure 2-34. The type of round bale feeder matters. Using round bale feeders with solid sheeting at the bottom can reduce hay losses by 15 to 20 percent.

Summary

Forages provide the majority of nutrients for beef cattle in Kentucky. Kentucky's land and climate are well suited for the production of cool-season perennial grasses and legumes. Forages are significant in every county in Kentucky. The most common perennial grass is tall fescue, and 80 percent or more of the fescue present in pastures is infected with the toxic endophyte of tall fescue. Cattle producers can be effective managers of forages by developing a plan to manage the endophyte of tall fescue, implementing a planned rotational grazing system and focusing on efficient harvest and feeding of stored forage.