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Rotational Grazing

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High-quality pasture is essential for Kentucky's cattle industry, but most fields are too big to be managed efficiently.

Much of Kentucky's land resource has rolling topography and would be used best by implementing sound rotational grazing systems for cattle.

Rotational grazing can help Kentucky farmers increase net profit by increasing yield of animal products per acre. At the same time, rotational grazing can:

- reduce cost of machinery, fuel, and facilities.
- reduce supplemental feeding and pasture waste.
- improve monthly distribution and pasture yield.
- improve animal waste distribution and use.
- improve pastures' botanical composition.
- minimize daily fluctuations in intake and quality feed.
- allocate pasture to animals more efficiently, based on nutritional needs.

Farmers and ranchers who have adopted improved grazing practices use a variety of terms for these practices. Just a few of them are *controlled grazing, intensive grazing, management intensive grazing, rotational grazing, and intensive rotational grazing.*

A rotational grazing program can generally be defined as use of several pastures with one being grazed while the others are rested. Continuous grazing is use of one pasture.

Kentucky's land and climate offer farmers the opportunity to grow large quantities of high quality pasture from cool- and warm-season grasses and legumes. However, only about one-third of the forages produced are actually used by grazing animals. In addition, much of the forage consumed is not as high in quality as it should be, resulting in low animal output per acre of forage grazed. This low-quality forage occurs particularly in pasture in late spring and summer and in much of the hay that is produced.

Kentucky pastures are generally too large for efficient management. With large pastures, the animal decides when, where, what, and how long to graze. Use of low-cost, versatile fencing to reduce pasture size can transfer decision making from the animal to the manager and usually results in more efficient utilization of available pasture and more control over pasture allocation by quality and quantity based on animals' needs.

Kentucky has great opportunity and potential in animal-based agriculture, and better utilization of forage is the key to realizing this potential. If pastures are managed for better production, captured in a higher-quality stage, and converted more efficiently to high-quality animal products, animal-based agriculture will without question increase Kentucky's agricultural income.

Rotational grazing allows the manager to make the best possible match between animal needs and forage production, as on this reclaimed mine site in Perry County.

Key Principles of Rotational Grazing

A sound rotational grazing system is worthy goal for Kentucky producers. Such a system involves three principles:

Principle 1: Nutritional needs of livestock can be met efficiently.

Rotational grazing helps managers make the best possible match of quantity and quality between forage and the livestock's nutritional needs, which will vary with age, body size, livestock class, and especially the production level to be supported. Growing animals, lactating livestock, and livestock under stress (cold temperatures, wet weather, etc.) need more nutrition than mature, nonlactating stock.

Pasture that is leafy and green and free from antiquality factors (such as the endophyte of tall fescue) will provide both high protein and high energy for grazing livestock. Pasture also must be made available in quantities that permit grazing animals to achieve their requirements.

Meeting the nutritional needs of livestock is also a function of intake. Grazing stock need to consume forage dry matter equal to 2 to 3 percent of their body weight daily—a 1,100-pound cow can require 22 to 33 pounds of dry matter from pasture daily. Pastures should contain 1,000 to 1,500 pounds of usable forage dry matter per acre in order for the quantity of pasture to not be a limiting factor in meeting the livestock's nutritional needs, which can vary from animal to animal. The amount of forage in 1,000 to 1,500 pounds can vary, too. It may represent only 4 inches of dense grass, or it may represent 8 inches or more forage if the stand is thin and open.

Keeping an adequate supply of forage before grazing livestock across the full grazing season is challenging for all managers. A rotational grazing system will require the use of a mix of forages to meet the seasonal needs of livestock. An almost infinite combination of forages can be used successfully in a grazing system.

Principle 2: Forage yield and quality and pasture persistence can be optimized.

Rotational grazing allows the manager to regulate the frequency and intensity of grazing to control quality, yield, utilization, and persistence of pastures. A sound rotational grazing system has benefits for forage production and utilization. These benefits fall into six main areas: yield, quality, regrowth, persistence, utilization, and nutrient cycling.

Yield: Moving to an improved grazing system will improve yield per acre beyond that of continuous grazing. Improved grazing systems allow for quick defoliation of the forage to a target residual height followed by enough rest time to allow the forage to regrow to a grazable height. An improved grazing system also will allow alteration of stocking rate to adjust to the forage's changing growth rates. Continuous grazing, on the other hand, does not allow for adjustment for changing forage growth rate or for rest periods that allow forage growth to occur. Continuous grazing will thus lead to overgrazing during slow-growth periods, and overgrazed pastures will not yield their potential.

Continuous grazing has been compared to planting a field of soybeans and then running a combine over the field all year long. Such a comparison makes it easy to see the negative effects of continuous grazing on pasture yield. In contrast, the graze/rest cycles of an improved grazing system allow for maximum regrowth of the forage, given limitations that may result from factors such as weather and soil fertility.

Quality: Compared to continuous grazing, rotational grazing systems are more likely to maintain pastures in an actively growing state than a continuous grazing system. Under continuous grazing, animals tend to return to the same area repeatedly and allow other areas to become mature. The net result is that the overall quality of the pasture declines. Under rotational grazing, selective grazing is limited, forage is more uniformly grazed, and paddocks will regrow more uniformly.

Rotational grazing keeps pastures higher in quality than continuous grazing and favors the growth and persistence of legumes.

A study at the Forage Systems Research Center of the University of Missouri compared the forage quality of continuously grazed orchardgrass-red clover pasture with similar pastures grazed in a six-paddock rotation. After the start of the grazing season, pastures in the rotational system had consistently higher forage quality than those in continuous grazing. Forage quality measured at the beginning and end of paddock grazing sessions showed cyclical fluctuation.

Forage quality differs in different layers of pasture, especially with legumes and to a lesser extent with forage grasses. The upper half of an alfalfa or red clover canopy, for example, contains the majority of the leaf yield and stems that are much less mature than those in the lower half.

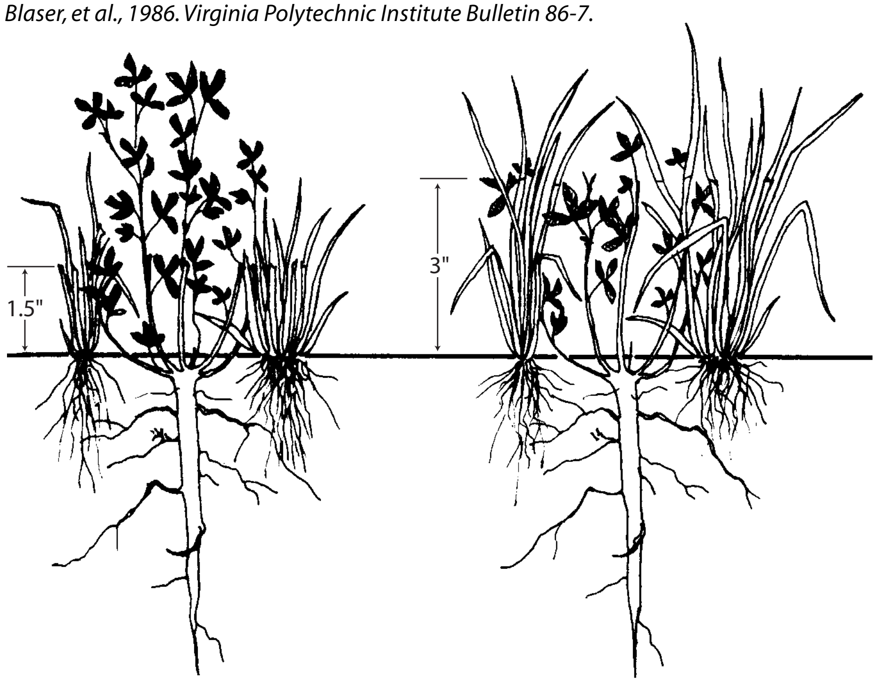
The forage quality of legumes is higher in the top half of the pasture than in the lower half. The crude protein in the top 6 inches of an alfalfa canopy can be twice that of the lower 6 inches. Energy content follows a similar pattern, although it is not as large in rate of decline.

This layering of quality has practical implications. Removal of the top half for maximum gains is a technique called *top grazing.* Stockers are excellent as top grazers because they select the highest quality forage and maximize their average daily gains. However, significant amounts of residual forage remains when top grazing is used. This residual material, though lower in quality, is still valuable for dry cows or other animals with lower nutritional needs. Following top grazers with dry cows or other livestock with lower feed needs is known as *leader/follower* or *first-and-second grazing.* This system allows for maximum forage utilization as well as high levels of animal output per acre.

Rotational grazing also gives an advantage to legumes in grass-legume pastures (Figure 1). This advantage is brought about by the quick and nonselective grazing of mixed stands. In mixed stands, grass regrowth tends to be faster than legume regrowth when grazing heights are high.

Regrowth: Rotational grazing and managing to maintain adequate root or stubble carbohydrate reserves and the proper residual leaf area will result in maximum regrowth rates. Regrowth by forage species after defoliation is driven by a combination of residual leaf area and carbohydrate reserves. Both drive growth by supplying energy.

Figure 1. Effect of grazing height on legume and grass regrowth in a grazed pasture. From Blaser, et al., 1986. Virginia Polytechnic Institute Bulletin 86-7.



A good rotational grazing system allows the use of high-quality forages such as alfalfa, which requires rest periods after grazing and in the fall.

Rotational grazing, with its graze and rest cycles, allows carbohydrate cycling species (such as alfalfa, red clover, big bluestem, switchgrass, and indiangrass) to maintain proper energy reserves to fuel regrowth. Rotational grazing can also benefit species that rely more on residual leaf area (tall fescue, orchardgrass, birdsfoot trefoil) because grazing pressure can be managed to leave enough green leaf tissue to power regrowth.

Removing most of the available top growth of grasses leads to death and sloughing of large portions of grasses' fibrous root systems. Small root systems lead to slow top growth and also to less water infiltration and uptake.

Persistence: Rotational grazing will result in greater persistence of forage species that regrow from stored carbohydrates and are sensitive to overgrazing or repeated defoliation. It also will aid in the persistence of species during periods of drought stress. In University of Missouri research, changing the method of grazing from continuous to weekly or daily rotations increased the persistence of big bluestem. Georgia researchers reported that repeated close grazing of endophyte-free tall fescue caused it to go out of stand. However, on those endophyte-free pastures that had 4 inches of residual growth maintained across the season, the fescue survived.

Utilization: In most pastures, there is a great deal of forage that is never consumed and eventually decays. Traditional continuous grazing systems may use only 30 to 50 percent of the available forage. The rest of the forage is either trampled, soiled, or of little value because it is overmature or dead. Most of this loss occurs with underutilized fall stockpiles and during periods of rapid growth where there is surplus beyond what is needed for cattle. Shortening grazing periods to 3 to 7 days increases utilization to 50 to 65 percent; to two days, 55 to 70 percent; and to one day, between 60 and 75 percent.

Nutrient Recycling: A ton of grass-legume forage harvested as hay removes 40 to 45 pounds of nitrogen, 10 to 15 pounds of P_2O_5, and 40 to 50 pounds of K_2O. Grazing animals excrete in their feces and urine between 70 and 90 percent of the N, P, and K they con-

General Comments on Designing Rotational Grazing Systems

- The whole farm should be planned, followed by the development of the rotational grazing system as time and money allow. This approach will limit the number of times fences will need to be moved.
- Lanes can be a positive force in the system. They are necessary if there is a dairy, and they also:
  - make separating sick cattle easy.
  - make AI breeding much easier.
  - allow cattle to be put where they need to be.
- Two lanes side by side, rotated back and forth, will control erosion.
- Lanes can also be a negative force:
  - 15 percent of the manure is left in the alleyway.
  - Cows will drink less if they have to travel far to water.
- Long, round corners make it easier to mow or crop when fencing around the better soils on the farm; fence for the best soils benefit.
- The squarer the paddock, the better. However, the smaller the paddock, the less critical the shape.
- Mix warm-season and cool-season forages.
- Both permanent and temporary fence should be used. Fencing should not be put up all at once; it should be a learn-as-you-go process.
- The forages already on the farm should be used. A manager should not reseed with all new varieties until learning how to manage what is already there.
- Current resources should be used. It isn't necessary to spend a lot of money in order to have water and fence.
- Fertilizing should be done where it will do the most good.
- To make rotational grazing successful, managers must think, make a plan, put a system in place, and then look to see which parts are working. The consistent part of setting up any rotational grazing system is the need to think, think, think!

Rotational grazing enables managers to use high stock densities and short grazing periods to increase utilization and decrease animal selectivity in grazing.

sume from forage. Manure can be a valuable resource in maintaining pasture soil fertility. Based on current fertilizer dollars, a beef cow excretes the equivalent of about $60 to $75 worth of fertilizer nutrients per year. For a 100-cow herd, that would be $6,000 to $7,500 per year.

Pasture fertility represents a real opportunity for Kentucky cattle producers. Kentucky surveys show that soil testing is done on only about 10 percent of pastures. Of the pastures that are soil tested, 40 percent are below pH of 6.0, 45 percent are low in phosphorus, and 35 percent are low in potassium. These low rates should be a concern to managers for all types of pastures but are especially critical for fields where legumes are to be established and grown. Ideally, plant nutrients should be applied to achieve desired levels of pasture production, and fertilizer should be applied to maintain that level of production thereafter.

Rotational grazing provides better manure (fertility) distribution than typical continuous grazing, in which most of the manure and urine is distributed close to shade and water. Research has shown that soil-test P and K values are often three to five times higher within 50 feet of shade compared to average levels in the general pasture. The smaller paddocks and shorter distance to water found in rotational grazing systems improve manure distribution.

Manure is more evenly distributed at higher stocking densities. When the travel area of the animal is restricted, grazing and manure distribution are enhanced.

Maintenance of pasture fertility based strictly on manure may be easy on some pastures and difficult on others. Realistic monitoring of pasture fertility through soil testing and grazing practices that encourage more uniform distribution should be considered key to maintaining pasture fertility with recycled nutrients from manure and urine.

How to Know When to Move to Fresh Pastures

The right time to rotate pastures depends on many factors. Making the following six observations can help with the decision:

Look down. Has the present paddock been used as much as desired, or is there too much forage left? In general, most new graziers tend to overgraze pasture. Leave a little more forage than seems necessary; cattle will therefore need to be moved sooner.

Look ahead. Is the next paddock ready for grazing? How fast is pasture growth? Fast growth may indicate the need to speed up rotation or harvest some paddocks for hay. Slow growth signals the need to lighten stocking rate, add acres, or feed hay.

Look at the animals. Do they appear hungry, and are they in good condition? Livestock can let a manager know when they want to move, but their desire to move may be too soon for high utilization. High-performing animals should be moved more often.

Look behind. How fast is the last paddock regrowing? Periods of slow growth may signal the need to slow the rotation, reduce stocking rate (by adding grazing acres or by selling or moving stock), or feed hay. Slowing the rotation (more days per paddock) increases days per paddock and makes animals graze closer and gain less. Future regrowth from these "overgrazed" paddocks will be slower.

Look at the weather. Approaching rain can signal the need to move from pure legume to grass-based pastures to prevent pugging of the soil and damage to the legume stand. Animals should be removed from johnsongrass and sorghum-sudan type pastures prior to frost.

Finally, look at the calendar. During the active growing season (April to October), residual forage height should be managed to allow fast regrowth. On fall and winter stockpiled pasture, graze longer and closer on each paddock to use forage that otherwise would be lost during the winter.

In general, pasture soils should be tested every three years.

University of Missouri researchers have conducted several studies over the past five years on fertility and manure management in pastures. Their work resulted in the following conclusions, summarized here:

- Alleyway access to water can result in a loss of manure nutrients from pasture, and this loss probably increases as the distance that cattle have to travel for water increases.
- Shade trees are sites of manure accumulation, especially in slow rotations. (However, shade is important in hot weather and is desired in most systems.)
- Grazing systems with more frequent rotations will result in more uniform distribution of manure across a pasture and ultimately less fertilizer inputs to maintain fertility.
- Fencing paddocks to minimize landscape variation within them will favor more uniform distribution of manure (for example, managers should fence slopes separately from draws and ridgetops).
- Square paddocks generally result in more even manure distribution than paddocks of other shapes.
- When setting up a grazing system, keep in mind that any landscape position that looks cool and comfortable to people will look the same way to cattle. Setting up paddocks and rotations to minimize the number of days that cattle can camp at these sites will improve the uniformity of manure distribution over the entire pasture.

Principle 3: Economic profit can be realized through improved efficiency and productivity of livestock.

Rotational grazing produces economic profit by improving grazing livestock's efficiency and productivity. Rotational grazing systems allow the manager to optimize animal performance and forage utilization. In general, by changing from a continuous grazing program to a rotational grazing program, animal gain per acre can be increased significantly while individual animal performance actually may be decreased slightly. In order to capitalize on all the benefits of rotational grazing in terms of quality and quantity of pasture growth, farmers must increase stock numbers.

Good management of pastures, paddocks, and rotation schedules can lead to increased gain per acre. For example, workers in several states have found that rotational grazing will increase beef per acre from 35 to 61 percent (Table 1). Increasing beef yield per acre can result in a reduced forage cost per pound of gain. More beef per acre at a lower cost of gain leads to greater potential profit.

Dairy net profit for rotational grazing in Pennsylvania was 72 percent greater than continuous grazing ($129 vs. $75, Table 2). Rotational grazing as a dairy farm enterprise was more profitable per acre than either hay or corn silage, based on Pennsylvania budgets.

Finally, a study from the University of Georgia (Table 3) showed several benefits from rotational grazing compared to continuous grazing. These benefits included an increase in stocking rate, total calf gain per acre, and a reduction in hay fed per cow, and they were realized without reducing calf weaning weight or pregnancy rate.

Table 1. Increase in gain per acre in rotational grazing compared to continuous grazing.

State	% Increase
Arkansas	44
Georgia	37
Oklahoma	35
Virginia	61

Table 2. Dairy enterprise budgets per acre for pasture and forage crops.

	Intensive Pasture	Continuous Pasture	Hay	Corn Silage
Gross return in field	$193	$112	$196	$313
Average storage loss	0%	0%	12%	13%
Gross return after storage	$193	$112	$172	$273
Total costs	$64	$35	$156	201
Profit	$129	$75	$20	$58

Source: Farmer Profitability with Intensive Rotational Grazing. L. Cunningham and G. Hanson, Penn State University. 1995.
Note: Feeding loss was not measured. Pasture was valued based on dry matter nutrient value compared to the nutrient value and market price of dry hay.

Table 3. Effect of year-round continuous vs. rotational stocking of endophyte-free tall fescue and common bermudagrass mixed grass pastures at Central Georgia Branch Station, Eatonton, Ga., 3-year average.

	Continuous	Rotational	Change, %
Stocking rate, cow-calf units/acre	0.50	0.68	+36
Calf weaning weight, lb	502	502	0
Total calf gain/acre, lb	251	342	+36
Cow pregnancy rate, %	94	93	0
Hay fed/cow, lb	2,390	1,690	-29

Source: Dr. Carl Hoveland, University of Georgia.

A good complement of cool- and warm-season forages is needed for a sound grazing system. This field of switchgrass in Owen County provides summer pasture for these stockers and complements tall fescue, which is used in spring and fall.

Physical Components of Rotational Grazing Systems

A good rotational grazing plan will include four main physical components: forage supply, fence system, water supply, and shade.

Forage Supply

A good rotational grazing system begins with a forage system that allows the maximum number of grazing days per year with forages that are suited to the land, livestock, and manager's abilities and desires.

Forage can be divided into two categories: cool-season and warm-season species. These categories differ in their seasonal ability to produce grazable yield. Cool-season species (tall fescue, orchardgrass, timothy, white clover) perform best in spring and after the weather cools down in the fall. Warm-season species (bermudagrass, eastern gamagrass, alfalfa, annual lespedeza) perform better in summer.

Forages should be matched to soils that will maximize their yield and growth. For example, tall fescue and white clover are well adapted to thin soils or steeply sloping sites that will hold water for growth during spring but will dry out during summer. These fields would be poor sites for warm-season forages because they hold little moisture for summer growth, which would be the period of maximum growth for these species. In another example, highly productive forages such as alfalfa should be planted on the deepest, most productive soils.

Forage systems in Kentucky are based on cool-season forages such as tall fescue, orchardgrass, white clover, and red clover and have an abundance of forage in the spring and most falls but are not productive in mid to late summer.

The two biggest challenges in assembling a balanced forage system are maintaining supplies of quality forage in midsummer and extending the grazing as long as possible into the fall and early winter. Many forages are available that

Goals in Designing a Grazing System

- Use as much of the usable forage as is possible to meet the nutritional needs of livestock and still allow forages to regrow.
- Make sure the soil fertility program does not limit either production or forage establishment goals for the field.
- Have water in every paddock.
- Construct good quality permanent fences where needed.
- Make paddocks as square as possible.
- Have a good mix of cool- and warm-season forages and a plan to use them.
- Integrate the fencing system with livestock handling facilities so cattle can be treated or moved to a handling facility from any paddock on the farm.

With the above goals in mind, following is a step-by-step procedure for setting up a grazing program:

1. Start with a good aerial photograph, the larger the scale, the better. These photographs are available at the local Farm Service Agency office. The agency has small scale maps or can order larger scale maps. Just be sure you have a scale map. A soils map is also a valuable tool. A soils map, a list of descriptions, and some professional guidance is available at the Natural Resources Conservation Service office in your county. A grid for counting acres is also handy. It will help you even up the odd-size fields in total acres.
2. Conduct a resource inventory. On your aerial photo, mark the property line, all roads, buildings, cattle-working areas, milk parlors, other permanent facilities, and existing water and shade.
3. Using the soils map, mark the major soils changes, considering both slope and quality of the soils. Then, adjust these lines to make them workable as markers for your first permanent fences.
4. Draw around any crop fields if they are different from the soil breaks. You may also want to identify areas with different forages, such as alfalfa or warm-season grasses. Divide the farm along existing water sources.

A leafy, high-quality mix of grasses and legumes can be achieved through well-managed rotational grazing.

are productive in midsummer, but they all seem to have disadvantages that rule out their use for some producers. Alfalfa, for example, requires deep, well-drained soils and a high level of management for best performance. Eastern gamagrass and other native warm-season perennial grasses are slow to establish, and seed is expensive compared to other forages. Stockpiled tall fescue is the best forage to use to extend the grazing season into the late fall and early winter. A balanced and well-planned grazing system will allow some acreage of tall fescue to be taken out of the summer forage rotation (due to the presence of summer forages) and rested and fertilized for use in the late fall.

A balanced forage pasture plan should attempt to match pasture growth to animal needs so a minimum needs to be harvested and stored as hay or silage. Cow-calf systems will have the greatest forage needs in the calving and breeding season; forage needs will drop off after weaning. Spring-calving herds need the quality and quantity of the spring and early summer pasture but must rely on stored forage in late winter. Fall-calving herds rely more on hay or silage and forage crops that provide pasture during the fall and winter. These fall pasture options include stockpiled tall fescue, small grains, turnips or other brassicas, and annual ryegrass.

Stocker operations are usually either of two types:

- buying in the spring and selling in the fall.
- buying in the winter, overwintering on hay or stockpiled pasture, and then turning out on spring pasture.

Both systems provide the freedom to sell all or part of the stockers as forage growth slows. Stocker operations are much more sensitive to forage quality and quantity than cow-calf operations because the cow's milk helps to maintain the calf performance.

Your completed map should:

- be a basic grazing system with water in each field.
- be divided based on productivity.
- have enough fields to begin rotational grazing.

5. The next step gets more difficult and requires a lot of patience. Subdivide the permanent fields in near-equal sizes, keeping the paddocks as square as possible. Plan and plan again. Draw lines, think, erase, and try again. Even when you start to fence, use temporary fence so it will be easy to change. Try to use existing water if possible. Hopefully by this time you will have 10 or more paddocks and also will have nearly doubled your farm's productivity.
6. At this point you are already doing a good job of grazing, and it is time to refine the process. You should have enough paddocks so that your cattle will be moving every three days or less. Put water in every paddock. This practice will allow you to make the paddocks as square as possible. You should also have shade in as many paddocks as possible, especially those that will be grazed in the summertime.
7. At some point you will want a system that will allow you to move your cattle to any part of the farm as you need to, and it will require a system of lanes. All lanes should allow you to take a cow anywhere you need to if she has trouble calving, is sick, or needs breeding. This system will also allow you to graze more than one herd at a time. These herds might be cows and stockers or heifers. Or, you may be using more than one bull. You may also want to build some sorting squares to separate cattle as needed without moving them to the barn. This system will let you be in control of the grazing on your farm and would make it easy to move cattle to your handling facilities, chutes, or scales.

Right: High-tensile electrified wire is a viable and economic alternative to conventional fencing materials such as woven wire and is quicker to build.

Below: Temporary fencing materials such as tread-in posts and electrified polytape allow for quick subdivision of existing pastures.

Fence System

Rotational grazing usually relies on an electrified system to subdivide larger pastures. Development of high-voltage, low-impedance electric chargers allow fencing of large acreages without losing voltage because of fence line vegetation. These energizers send high-voltage, short-duration pulses down the fence. Although 2,000 volts is considered adequate to control most stock, most fence chargers and systems should start with around 7,000 volts on the fence.

There is no standard system for comparison of energizers, and every manufacturer has a different scale. Joules are the most common measure of power in energizers. The joule rating is calculated using a combination of voltage, amperage, and pulse duration, and changing any of them affects the joule rating. Generally speaking, fencing system needs will grow, so obtain enough energizer capacity to cover future needs. Energizers come in mains, or plug-in units, as well as battery and solar units. It is best to use a plug-in energizer, if possible, because it delivers more charge (joules) per dollar spent.

A good ground is essential for the effectiveness of any electric fence system. The ground system of the energizer is like radio antennae. A large radio collecting waves from a long distance needs a large antennae, and a large energizer powering a lot of fence needs a large ground system with a minimum of three 6-foot galvanized ground rods. These rods may be placed in the ground at an angle if there is less than 6 feet of soil. Ground rods should be driven in a damp place, if possible, such as under the drip of the barn roof or in a low area.

There are two ways to build an electric fence so it will work effectively. With the *all-live* system, every wire in the fence is energized, and the conduction of electrons back to the energizer depends on the soil. This system is generally effective in the southeastern United States because soils in this region have high mineral content and adequate rainfall.

The other system is the *hot ground* system. This system has one or more fence wires connected to the positive terminal of the energizer and the rest of the wires connected to the ground terminal. This system works well in sandy, arid areas—moist soil is not necessary to deliver a charge. Also, in an all-hot system, a limb or branch can fall across the wires, and the fence will remain energized. The main disadvantage of this system is that it requires high maintenance. If any charged wire touches a ground wire, the whole system shorts out.

In Kentucky, the most economical controlled grazing fencing system is often one that includes a combination of permanent, electric, smooth, high-tensile wire fence and temporary portable polywire (available on reels). An advantage of the reel is that it allows rapid setup and takedown of fence for temporary arrangements or strip grazing. Portable fiberglass fence posts are often used with the portable braided wire, us-

Electrified polytape (available in widths up to 1½ inches) is very visible and can be used for subdivision fencing for horse pasture. The twist in the polytape makes it flutter in the wind, resulting in greater visibility.

ing one strand of wire for grazing of large animals and two strands for calves. Since it is electrified, high-tensile wire for the permanent fence often can be installed using low-tension techniques.

Types of Fencing: Following is an overview of several types of fence and their appropriate place in a controlled grazing system:

The type of wire suggested for permanent boundary fence installations is New Zealand-type high-tensile wire. This is 12½-gauge high tensile smooth wire that is heavily galvanized (Class III). Also, smaller diameter high-tensile wire is now being used, particularly on interior division or paddock fences. This type of wire includes 14½-gauge and 16-gauge thicknesses. The use of such wire has implications for energizer selection (since smaller wire has a greater resistance to current flow) and in the length of fencing that can be energized.

For interior and temporary fences, a more flexible, low-tension wire is popular. Small-diameter high-tensile wire can be used, but many producers prefer a slightly softer grade of wire since it is somewhat easier to work with when moving and handling the fence. An excellent alternative for temporary installations is braided wire containing fine-gauge steel wires braided with polyethylene strands into a wire, ribbon, or tape. These wires work quite well for installations of up to 1,200 feet. Because of the lower cross-sectional area of steel, energizer requirements differ from those of smooth high-tensile wire. Some newer braided wires have more steel (thus less resistance), so they can be used in longer runs.

Water Supply

Water is possibly the most important, but least considered, nutrient for cattle. It is needed for virtually every body function. Many factors influence water intake. As air temperature increases above 40°F, water intake increases per pound of dry matter consumed (Table 4).

Table 4. Sample water requirements for cattle, gallons per head per day.

Temp, F	Gal/lb DM	500-lb Calf, 12 lb DMI	750-lb Calf, 16.6 lb DMI	1,100-lb Dry Cow	1,100-lb Nursing Cow
40	0.37	4.4	6.1	7.4	8.1
60	0.46	5.5	7.6	9.2	10.1
80	0.62	7.4	10.3	12.4	13.6
90	0.88	10.6	14.6	17.6	19.4

Source: Winchester and Morris, 1956.

Lactating cattle require more water than dry cows. At a constant temperature, cattle consuming more feed need greater water intake. Similarly, if water intake becomes limited, feed intake will decrease, and performance will be limited. Lush pasture can be 70 percent or more water and can decrease the amount of water that must be supplied in the water system, at least on a short-term basis.

Water intake restrictions can result from inadequate access of cattle to the water source, water temperature, and water quality. Quality is determined by total dissolved solids (TDS). High TDS levels may not pose serious health risks but may decrease total water intake. Water exposed to direct sunlight (tanks, ponds) can become quite warm in the hot days of summer, resulting in lower intakes.

Regardless of why decreased water intake occurs, performance will suffer. Cooling water has been shown to reduce heat load and allow increased feed intake. Studies with dairy cattle have shown the most acceptable water temperature to be in the 60° to 80°F range. Using insulated drinking receptacles or building shades over the water tank can reduce heating from the summer sun. Insulated or heated waterers will be needed for pasturing stockpiled forage during late fall and winter.

The location of water in the grazing site will greatly influence grazing distribution. During hot weather, cattle congregate nearer the water source, resulting in less use of pasture farther from the water source. Research has shown that the maximum distance cattle will travel to water and not decrease grazing uniformity is 800 feet. As travel distance increases above this amount, pasture use decreases.

An effective water distribution system is key to the grazing system. This permanent water tank was developed from a spring and provides an inexpensive source of water on a Metcalfe County farm.

Developing Water Sources: Each situation is different, and flexibility is rewarded when it comes to developing water sources.

Although there is a monthly cost, public water supplies many times are the best solution to livestock water needs when development, maintenance, and reliability are considered. At some point in developing a management system, a pressurized water system will become a necessity. It will provide water where it is needed instead of forcing the manager to work with a few water sites.

Consider using the raw water source of springs. They are an excellent source of water but are as different as grazing systems. A stream of water the size of a pencil and a large collection tank will water a lot of cattle, even up to 70 to 100 beef cows. Also consider ponds as a water source. Watering from tanks below ponds is strongly preferred to watering directly out of the pond. The pipe should be installed under the dam when building the pond. The pipe then can go directly to a tank or to a collection basin. Water can be pumped anywhere on the farm.

Shade

Shade is necessary to maximize performance of cattle. Heat stress in the absence of shade can have several effects. Black-hided cattle, for example, can suffer from heat stress on bright sunny days in late summer when air temperature is comfortable.

Cows with natural shade spend more time grazing and less time standing than cows without shade. Natural shade from large, well-canopied trees is the most effective. This type of shade intercepts radiation from the sun and provides some air cooling through evaporation of moisture from leaves.

Artificial shade also will reduce heat stress, but attention must be paid to the type, orientation, and square footage per head. Hay or straw on wire are the best types of artificial shade because they have high insulation value, low bottom surface reflectance, and loss of absorbed heat to the air by convection. Aluminum panels painted white on top and black on the bottom are also effective. Direct heat from the sun is well reflected by the white paint, and the black bottom absorbs the heat from the ground and animals. Snow fence or shade cloth may also be used, but they are less effective than the other materials mentioned here. Both let through some sun, thus not providing complete shading. For maximum shading, the long axis of the artificial shade should be oriented on an east-west line. Most research shows that 45 to 60 square feet per cow is desirable.

Layout and Design

Developing grazing systems involves subdividing large pastures into smaller pastures or paddocks (cells) that give the manager control over how long cattle are allowed to graze a particular area (paddock) before they are moved. There is no blueprint or single model to follow in setting up a grazing system that will provide the manager with the greatest control. Every Kentucky farm is unique, and many different solutions are possible and workable.

Laying out or designing a pasture system involves making many decisions, including how many paddocks the system will have, their size, the location of water sources, lane placement, and livestock flow around working facilities.

The most important factor in developing a rotational grazing system is to develop one that is right for the farmer, the farm's resources, and the land's capabilities.

In most situations, the best way to start rotational grazing systems is to make a few simple or basic improvements in the current system. This first step will start the learning process and allow the manager to develop the system at a comfortable pace. It will also minimize "improvements" that later prove to be less than optimal. A lot of progress is made by simply closing the gate between two pastures. Dividing an existing pasture in half is the start of a rotational grazing system.

Being flexible is key to putting rotational grazing systems together. The farmer should do what he or she thinks best, but be open to change—and plan, plan, and plan before driving the first post.

Temporary or seasonal water systems can reduce distance traveled to drink and increase pasture utilization. Small to medium-sized tanks can easily be moved from paddock to paddock.

Pasture Number and Size

One of the most frequently asked questions by producers who want to start a rotational grazing program is "How many paddocks should I have?" There appear to be contradictory answers:

- One pasture can be grazed just as efficiently as many.
- Regardless of how many paddocks there are, divide them again and more money can be made.

The truth lies somewhere between these two extremes.

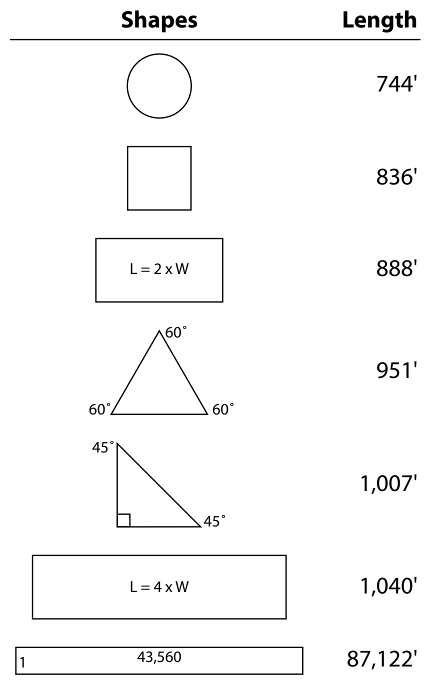
In general, one should consider starting with five to 10 paddocks in the rotational grazing program. This practice will allow a paddock to be grazed in three to 7 days and rested for 25 to 30 days. In most cases, four paddocks should be considered a minimum. Table 5 contains several formulas that can help determine paddock number and size.

Systems in the United States and New Zealand have as many as 30 to 60 or more paddocks. Many of these are dairy farms where pastures are changed after each milking. Several studies have been conducted in the United States and generally show that for most beef operations the added benefit above 8 to 12 paddocks may not be worth the additional cost of fencing, water, labor, and management.

University of Kentucky modeling studies compared beef production on endophyte-free tall fescue using continuous grazing, four paddocks, and eight paddocks. Beef production ranged from 683 pounds per acre for continuous grazing to 810 pounds per acre for eight paddocks. The most striking difference was the four-paddock system, which showed an increase of 112 pounds of beef per acre over the continuous system. The eight-paddock system showed a 127-pound increase in beef per acre over the continuous system. The rotational system increased returns by $77 to $103 per acre.

University of Missouri researchers compared the effect of three-, 12-, and 24-paddock systems on the performance of beef cow-calf and stockers grazing cool-season grass and clover. When all costs and returns were compared, the three-paddock system resulted in $84.36 increase above pasture, animal, and interest cost, the 12-paddock system showed a $115.43 increase, and the 24-paddock system showed an increase of $117.74. These results suggest that going to 12 paddocks yielded a profit of $31. Going from 12 to 24 paddocks resulted in only a $2.31-per-acre increase.

Figure 2. Effect of pasture shape on amount of fencing needed around one acre.



Source: Garry Lacefield, University of Kentucky.

Shape of individual paddocks is important. Within practical limits, square paddocks are the most efficient compared with other shapes (rectangle, triangle, pie, etc.). Square paddocks allow animals to obtain their daily ration of forages with a minimum of grazing time, effort, and trampling damage. Studies have shown that square paddocks are more economical to construct than other shapes (Figure 2). Having exactly square paddocks is not absolutely necessary, but avoid long, narrow paddocks. Whenever possible, fence across slopes rather than up and down the slope.

Table 5. Grazing mathematics.

$\text{Number of paddocks} = \dfrac{\text{days of rest}}{\text{days of grazing}} + 1$ Example: $\text{Number of paddocks} = \dfrac{\text{28 days rest}}{\text{4 days grazing}} + 1$ = 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 slow growth. • Days of grazing: Varies from 1 to 7 and up. Shorter times on a paddock yield greater season-long utilization and less waste, selectivity, and regrowth grazing.
Acres required per paddock = $\dfrac{\text{weight x \% DMI x number x days per paddock}}{\text{DM per acre x \% utilization}}$ Example: Acres required per paddock = $\dfrac{\text{500 lb x 3\% x 100 head x 4 days}}{\text{2,000 lb per acre x 60\%}}$ = 5 acres	• Weight: weight per head, in pounds. • Percent DMI: percent dry matter intake, ranging from 2% to 4%. • Number: number of head to be grazed. • Days per paddock: 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 to 7 or less. • DM per acre: estimate of total forage dry matter available per acre as the animals enter a paddock. • Percent utilization: portion of the available forage per acre that animals will consume during a grazing period. Improved grazing systems can result in utilization of 60% for grasses and 75% for legumes.
Total acres required per grazing cycle = number of paddocks x acres required per paddock Example: Total acres required per grazing cycle = 8 paddocks x 5 acres per paddock = 40 acres	• Number of paddocks will be determined by the length of the rest and grazing periods. • Acres required per paddock are 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 will vary with the growth rate of the forage. As the growth rate slows, the number of acres required to supply 3% DMI and maintain 4 days on and 28 days off a paddock will increase.
$\text{Stocking rate} = \dfrac{\text{number of animals to be grazed}}{\text{total acres grazed}}$ Example: $\text{Stocking rate} = \dfrac{\text{100 head}}{\text{40 acres}}$ = 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.
$\text{Stocking density} = \dfrac{\text{number of animals grazing on a paddock}}{\text{paddock size}}$ Example: $\text{Stocking density} = \dfrac{\text{100 head}}{\text{5 acres}}$ = 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).

Grazing Management

Good grazing management achieves the right balance between forage utilization and animal performance. The good manager stocks pastures heavy enough to graze available forage down to a target height that will allow for maximum regrowth (during the growing season) while not compromising the livestock's nutritional needs. A good manager will observe pastures frequently for overgrazing and undergrazing and will periodically adjust the stocking rate or movement of cattle as needed. Guidelines for beginning and ending grazing heights and usual days of rest for several pasture crops are contained in Table 6.

Summary

A sound rotational grazing system is worthy goal for Kentucky producers for three main reasons. Such a system:

- helps managers efficiently use forage to meet the nutritional needs of livestock.
- helps managers optimize forage yield, quality, and persistence.
- increases profit by improving grazing livestock's efficiency and productivity.

The components of a good rotational grazing system are a balanced forage system, a electric fencing system, distributed water supply, and adequate shade for livestock. These components can be designed and customized to fit the needs of each farm.

Table 6. Guidelines for rotational stocking of selected forage crops .

	Target Height (inches)		
Crop	**Begin Grazing**	**End Grazing**[a]	**Usual Days of Rest**
Alfalfa (hay types)	10-16	2-4	35-40
Alfalfa (grazing types)	10-16	2-4	15-30
Bahiagrass	6-10	1-2	10-20
Bermudagrass	4-8	1-2	7-15
Big bluestem	15-20	10-12	30-45
Caucasian bluestem (and other Old World bluestems)	10-20	4-6	14-21
Clover, white, and subterranean [b]	6-8	1-3	7-15
Clovers, all others [b]	8-10	3-5	10-20
Eastern gamagrass	18-22	10-12	30-45
Fescue, tall	4-8	2-3	15-30
Indiangrass	12-16	6-10	30-40
Johnsongrass	16-20	8-12	30-40
Kentucky bluegrass	8-10	1-3	7-15
Orchardgrass	8-12	3-6	15-30
Pearl millet	20-24	8-12	10-20
Ryegrass, annual	6-12	3-4	7-15
Sericea lespedeza	8-15	4-6	20-30
Small grains	8-12	4	7-15
Smooth bromegrass	8-12	3-4	20-30
Sorghum, forage	20-24	8-12	10-20
Sorghum/sudan hybrids	20-24	8-12	10-20
Switchgrass	18-22	8-12	30-45

Source: Excerpted from *Forage Pocket Guide*, Developed by Don Ball, Garry Lacefield, and Carl Hoveland. 1999.

Note: 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.

[a]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. Greater residual heights may be desired for animals with higher nutritional requirements (for example, stocker cattle vs. cows and calves).

[b]Clovers are typically grown in pastures in mixtures with grasses. White clover and subterranean clover are quite tolerant of close defoliation; most other clovers are not.

Grazing Terminology

Aftermath: Forage grown following a harvest.

Animal unit day: The amount of dry forage consumed by one animal unit per 24-hour period.

Carrying capacity: The maximum stocking rate that will achieve a target level of animal performance in a specified grazing method that can be applied over a defined time period without deterioration of the ecosystem.

Continuous stocking: A method of grazing livestock on a specific unit of land in which animals have unrestricted and uninterrupted access throughout the time period when grazing is allowed.

Creep grazing: The practice of allowing juvenile animals to graze areas that their dams cannot access at the same time.

Deferred grazing: The delaying of grazing in a nonsystematic rotation with other land units.

Extensive grazing management: Grazing management that uses relatively large land areas per animal and a relatively low level of labor, resources, or capital.

First-last grazing: A method of using two or more groups of animals, usually with different nutritional requirements, to graze sequentially on the same land area.

Forage allowance: The relationship between the weight of forage dry matter per unit area and the number of animal units or forage intake units at any one point in time; a forage-to-animal relationship. The opposite of *grazing pressure.*

Forage crop: A crop of cultivated plants or plant parts (other than separated grain) produced to be grazed or harvested for use as animal feed.

Forward creep: A method of creep grazing in which dams and offspring rotate through a series of paddocks with offspring as first grazers and dams as last grazers. A specific form of first-last grazing.

Grazing land: Any vegetated land that is grazed or has the potential to be grazed by animals.

Grazing management unit: The grazing land area used to support a group of grazing animals for a grazing season. It may be a single area, or it may have a number of subdivisions.

Grazing pressure: The relationship between the number of animal units or forage intake units and the weight of forage dry matter per unit area at any one point in time; an animal-to-forage relationship. The opposite of *forage allowance.*

Intensive grazing management: Grazing management that attempts to increase production or utilization per unit area or production per animal through a relative increase in stocking rates, forage utilization, labor, resources, or capital.

Mixed grazing: Grazing by two or more species of grazing animals on the same land unit, not necessarily at the same time but within the same grazing season.

Mob grazing: In the management of a grazing unit, grazing by a relatively large number of animals at a high stocking density for a short time period.

Nonselective grazing: Utilization of forage by grazing animals so all forage species and/or all plants within a species are grazed.

Paddock: A grazing area that is a subdivision of a grazing management unit and is enclosed and separated from other areas by a fence or barrier.

Pasture: A type of grazing management unit enclosed and separated from other areas by fencing or other barriers and devoted, primarily by grazing, to the production of forage for harvest.

Put-and-take stocking: The use of variable animal numbers during a grazing period or grazing season with a periodic adjustment in animal numbers in an attempt to maintain desired sward management criteria; that is, a desired quantity of forage, degree of defoliation, or grazing pressure.

Rotational stocking: A grazing method that uses recurring periods of grazing and rest between two or more paddocks in a grazing management unit throughout the period when grazing is allowed.

Short-duration grazing: Not an acceptable term.

Stocking density: The relationship between the number of animals and the specific unit of land being grazed at any single point in time.

Stocking rate: The relationship between the number of animals and the grazing management unit used over a specified time period.

Stockpiling forage: To allow forage to accumulate for grazing at a later period.

Sward: A population of herbaceous plants characterized by a relatively short growth habit and relatively continuous ground cover, including both aboveground and belowground parts.

Vegetative: Involving nonreproductive plant parts (leaf and stem), the nonreproductive stage in plant development.

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