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COOPERATIVE EXTENSION SERVICE
UNIVERSITY OF KENTUCKY—COLLEGE OF AGRICULTURE

Managing Livestock Forage for Beef Cattle Production on Reclaimed Surface-Mined Land

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Introduction

Decades of surface mining in the Central Appalachian region have created extensive acreages of reclaimed land that support an abundance of underutilized forage. Thus, reclaimed surface-mined land could be managed for beef cattle production to provide increased economic return in this region.

Many of the grass and legume species used to revegetate reclaimed surface-mined land are also used for beef cattle production in the region. However, the unique characteristics of reclaimed land often result in soil productivity limitations that should be considered when managing these same grass and legume species for pasture and/or hay production on mine sites.

Because the beef cattle industry already exists in neighboring areas, suppliers and markets necessary to support efficient cattle production are accessible from coal-mining areas in Kentucky and Virginia. Beef cattle production on reclaimed mine land can provide for a rapid return on investment and annual income. However, skillful management is required to sustain profitability, as shown by studies conducted by the University of Kentucky and Virginia Tech. This publication summarizes a number of cattle management issues that are important to cattle producers utilizing reclaimed mine land, including soil management, selecting the appropriate species and cattle production systems, water supplies, and grazing management.

Soil Management

Most reclaimed mine soils in the Appalachian region are high in coarse fragments (in some cases, greater than 75% on a weight basis), consisting primarily of sandstone, siltstone, and shale. These soils often have lower organic matter contents and lower water-holding capacity than do undisturbed agricultural soils. This lower capacity to hold plant-available moisture intensifies the effects of summer rainfall deficits by lowering both forage production and quality.

Another feature common to most unmanaged mine soils is a deficiency of nitrogen. Fertilizer nitrogen applied at seeding during reclamation is important for establishment, but losses of N due to leaching, denitrification, low organic matter content, and plant uptake usually return available soil N levels to low levels soon after revegetation.

The most economical approach to maintaining adequate levels of plant-available nitrogen is to include one or more legumes in the seed mix and/or manage established pastures and hayland so a significant legume component persists. Legumes fix nitrogen (i.e., from the atmosphere) symbiotically and have been shown to accumulate up to 90 pounds of N per acre. Maintaining a healthy legume component in pasture vegetation will help producers provide livestock with quality forage while minimizing the costs that would otherwise be associated with N fertilization.

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Phosphorus (P) is the second major limiting nutrient in mine soil material. In mine soils, P management is especially critical due to fixation, or binding to soil minerals in forms that are less available to forage plants. Even though P is typically applied at high rates during reclamation, mine soils in eastern Kentucky and southwestern Virginia are often deficient in plant-available P because commonly occurring mine-soil minerals have a high capacity to bind or "fix" P.

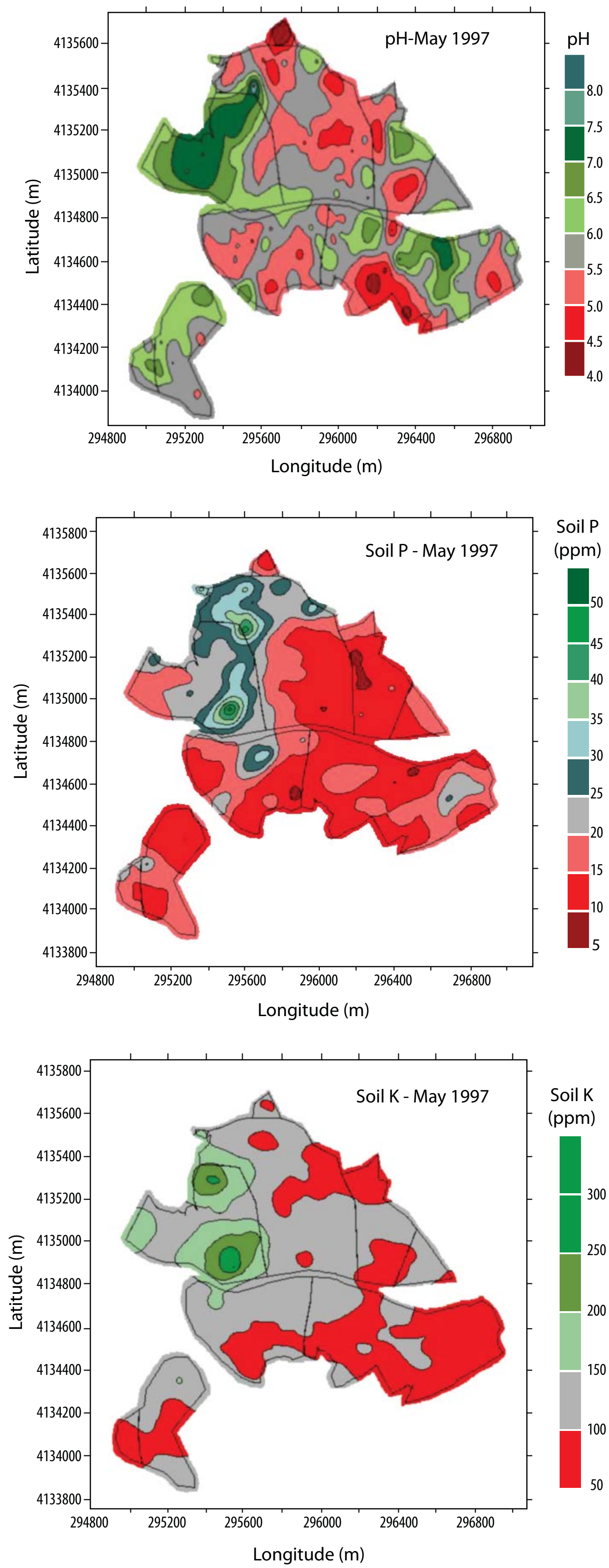
An essential component of soil P management on pasture sites is maintenance of soil pH in the 5.5 to 7.5 range. When soil pH falls outside of this range, the tendency of soil minerals to fix P into non-plant-available forms is increased. Although pH management is critical to P nutrition on both mined and unmined sites, mined sites create special challenges in this regard primarily due to two factors: 1) the prevalence of P-fixing minerals in some mine soils, and 2) the tendency of pH to change more rapidly than on typical natural soils—especially during the first few years after placement—as the mine-soil minerals weather. Mine sites constructed from mineral materials that stabilize in the pH range of 5.5 to 7.0 will make the best pasture sites. Where soil pH falls below this range, periodic liming will be required to maintain quality forages.

Maintaining adequate plant-availability of soil P also affects animal N nutrition, as low soil P will negatively affect the health and vigor of N-fixing legumes. Because plant uptake of N and P is linked, both nutrients should be considered together when making fertility decisions.

Potassium (K) fertilization may not be needed on some reclaimed sites since spoil materials can release significant quantities of plant-available K from mineral sources as they weather. The exception to this may occur in spoils with a significant sandstone component. Therefore, soil testing is highly recommended to determine plant nutrient needs (see University of Kentucky Cooperative Extension publication AGR-40, *Lime and Fertilizer Recommendations for Reclamation of Surface-Mined Coal Spoils*).

Mine soils are formed by placement of waste rock produced by the mining operation. In some cases, the soil materials forming an individual field will be far more variable on a mine site than would be typical on a natural soil, as the types of rock materials being handled by the mining firm changed in the course of landscape construction. As a direct result, plant nutrient levels across a reclaimed mine site can be highly variable, making soil sampling a challenging, yet very important, process.

New tools such as Global Positioning Systems (GPS) and Geographical Information Software (GIS) have improved our ability to study landscape scale variation on reclaimed mine land. Figures 1a, b, and c illustrate the distribution of pH, P, and K in a 360-acre mine land grazing research study conducted in eastern Kentucky. Researchers concluded that the source of variability was most likely related to the distribution of a calcareous rock stratum during reclamation rather than landscape position or distribution of lime and fertilizer applied during reclamation. (Refer to University of Kentucky Cooperative Extension publications AGR-40 and AGR-41, *Sampling Surface Mine Lands Before and After Mining*).



Figures 1a, b, and c. Distribution of pH, phosphorus, and potassium on reclaimed mine land in southeast Kentucky.

Species Selection

The grass and legume species available for pasture and hay use on reclaimed mine land in the Appalachian region represent a wide range in adaptation characteristics (Tables 1 and 2). Even significant varietal differences may exist within grass and legume species. For example, the adaptation of tall fescue (*Festuca arundinacea* Schreb.) varies depending on the presence or absence of an endophytic fungus. Heat and drought tolerance are important characteristics to consider when selecting forage species for mine land pastures and hayland. Cool-season grass species range from excellent for endophyte-infected tall fescue to poor for perennial ryegrass (*Lolium perenne* L.). Orchardgrass (*Dactylis glomerta* L.) is considered to have good tolerance to drought, while timothy (*Phleum pratense* L.) and endophyte-free tall fescue have only fair tolerance to heat and drought.

Warm-season grasses can also be used to supplement cool-season grass production during drought and heat stress common on reclaimed mine lands. Research has shown that species such as switchgrass (*Panicum virgatum* L.) and caucasian bluestem [*Bothriochloa caucasia* (Trin.) C.E. Hubb.] are capable of producing five times more root mass than orchardgrass. Either adding legumes through pasture renovation or maintaining existing legumes increases forage yield and quality during periods of drought and heat stress when cool-season grass production is low. Deep taprooted legume species such as sweet clover (*Melilotus officinalis* Lam.), alfalfa (*Medicago sativa* L.), bird's-foot trefoil (*Lotus corniculatus* L), and sericea lespedeza [*Lespedeza cuneata* (Dum.- Cours.) G. Don] are able to avoid short-term drought compared to the very shallow root system of white clover (*Trifolium repens* L.).

Table 1. Adaptation of some perennial and annual legumes for reclaimed mine land in the Appalachian region.

	Tolerance						
Legume Species	Heat/ Drought	Wet Soil Conditions	Frequent Cutting	Frequent Grazing	Bloat Risk	pH Range	Anti-Quality Factors for Ruminants
Perennials							
Alfalfa	E[1]	P	E	F	Yes	6.5-7.5	
Bird's-foot trefoil	G	G	G	F	No	5.0-7.5	
Crownvetch	G	P	P	F	No	5.5-7.5	Tannin
Sweet clover	E	P	P	F	Yes	6.0-7.0	Coumarin
Red clover	F	F	E	G	Yes	5.5-7.0	
White clover	P	F	P	E	Yes	6.0-7.0	
Alsike clover	F	G	P	F	Yes	5.0-7.5	
Sericea lespedeza	E	P	F	G	No	5.0-7.0	Tannin
Annuals							
Korean lespedeza	E	P	F	E	No	5.0-7.0	
Kobe lespedeza	E	P	F	E	No	4.5-7.5	
Hairy vetch	F	P	P	F	Yes	5.5-7.5	

[1] Species rankings: E = excellent; G = good; F = fair; P = poor.
For additional information on pasture species characteristics, see Skousen and Zipper, VCE 460-122.

Table 2. Adaptation of some perennial grasses for reclaimed mine land in the Appalachian region.

	Tolerance						
Grass Species	Heat/ Drought	Wet Soil Conditions	Frequent Cutting	Frequent Grazing	Sod-Forming	pH Range	Anti-Quality Factors for Ruminants
Cool-Season							
Tall fescue, infected	E[1]	G	E	E	G	5.0-8.0	Alkaloids, tall fescue toxicosis
Tall fescue, noninfected	F	G	G	F	G	5.0-8.0	
Orchardgrass	G	P	G	F	F	4.5-7.5	
Timothy	F	P	P	P	P	4.5-8.0	
Matua prairie grass	F	P	P	P	F	6.0-7.5	
Smooth brome	F	F	P	P	G	5.0-8.0	
Reed canarygrass	G	E	G	G	E	4.9-8.2	Alkaloids
Perennial ryegrass	P	P	E	E	P	5.0-7.5	Alkaloids, ryegrass staggers
Warm-Season							
Switchgrass	E	E	P	F	F	4.1-7.6	Photosensitization in sheep
Indiangrass	E	P	F	F	F	5.6-7.1	HCN, prussic acid poisoning
Big bluestem	E	P	F	F	P	6.0-7.5	
Little bluestem	E	P	F	F	P	6.0-7.5	
Caucasian bluestem	E	P	E	E	F	6.0-7.5	
Bermudagrass	E	P	E	E	E	5.1-7.5	Must be established by sprigs
Weeping lovegrass	E	P	P	P	P	4.0-8.0	Nutritional quality low

[1] Species rankings: E = excellent; G = good; F = fair; P = poor.

In general, grass-legume mixtures produce higher yields than grass-only stands of the same species. However, complex grass and legume seed mixtures compete for light, moisture, and nutrients. Therefore, it is important to carefully evaluate the compatibility of these species prior to seeding or renovation. Renovating reclaimed mine land in the Appalachian region with desirable grasses and legumes for livestock grazing can be challenging due to steep slopes, rocky mine soils, and the constant threat of soil erosion.

How to Renovate

(Refer to University of Kentucky Cooperative Extension publication AGR-26, *Renovating Hay and Pasture Fields* for details on how to renovate.)

Step 1. Have the soil tested and apply needed lime and fertilizer. Legumes need a higher soil pH and fertility level than grasses. However, nitrogen fertilization should be avoided at seeding if legumes and grasses are planted at the same time. Added nitrogen stimulates the growth of grasses, which increases competition with the legumes.

Step 2. Reduce competition from existing vegetation. This can be accomplished by heavy grazing or herbicide usage.

Step 3. Select the grass and legume species/varieties that are best suited for the site (i.e., fertility level, drought tolerance, grazing versus hay).

Step 4. Use certified seed and inoculate legumes with the appropriate strain of Rhizobium bacteria to ensure nodulation necessary for N fixation.

Step 5. Plant seed at recommended rates and dates so that it makes good contact with the soil. On non-erodible sites, this can be accomplished by light surface disturbance using a disk or chain drag. Broadcast seed followed by a second trip with a chain drag. Another method is to use a no-till renovation seeder. These do a good job of placing seed in good contact with the soil, but it is still essential to reduce competition from existing vegetation. *Caution: It is not safe to operate a tractor and renovation seeder on steep slopes.*

Cattle Production Systems

Cow-Calf Production

The most common beef cattle enterprise for surface-mined land is a cow-calf herd. Cow-calf producers maintain a herd of breeding cows and heifers year-round. Cows and heifers are typically bred in early summer, using either a bull or artificial insemination and a clean-up bull. Calves are born early in the following spring and grazed for 6 to 10 months prior to being sold.

Cow-calf enterprises with spring calving are well suited for reclaimed mine land. However, sustainability of this enterprise is highly dependent on livestock forage composition, grazing management, and stocking density. The following recommendations for beef production apply to management procedures for cow-calf operations on reclaimed mines.

Despite an annual rainfall of 40-plus inches in most portions of the Appalachian region, the low water-holding capacity of most mine soils results in frequent periods of short-term drought stress that affects forage availability throughout the growing season.

Cow-calf production is somewhat management intensive, and skillful management is necessary in order for this production system to be profitable. In the central Appalachian region, a beef cow-calf operation with a March-April calving season is well suited to the typical pattern of forage production on reclaimed surface-mined land.

Spring forage production is high, and high-quality feed is available for the lactating cow and calf since rainfall-stored water during this period will support a high rate of forage regrowth. This productivity is generally sustained long enough into the spring-summer period to provide good nutrition for a cow herd so that rebreeding can occur in early summer to maintain a relatively short calving season.

Fall-calving systems are not as well suited to reclaimed areas and are generally less economical than spring calving. The nutritional requirements for a lactating cow in the fall occurs when forage growth and quality are often low. This can lead to problems of rebreeding during the winter.

Stocker Production

The alternative to cow-calf production is known as "stocker production." This system is only suitable for the highest-quality surface-mined land capable of supporting a high level of forage production and quality. Stocker producers purchase young animals, feed them on forages grown on the land, and sell the grown steers or heifers. Stocker production can be successful without the need for hay production and the challenges of reproduction if certain conditions apply:

- good fencing is in place,
- a sustained water source is available,
- forage growth is adequate, and
- typical weight gains of nearly 300 pounds in a season can be sustained.

Water Supply

An adequate supply of drinking water for cattle is an absolute necessity. Generally, this can be supplied in ponds constructed during the mining process. Water can also be pumped from other locations, such as ponds or springs at lower elevations (Marsh 2001; VCE 442-755). Water quality in ponds constructed on reclaimed sites is generally satisfactory for livestock use. Information on water quality in ponds on recently reclaimed sites in Kentucky may be available from the Department of Surface Mine Reclamation and Enforcement.

Several watering sites should be provided so as to distribute grazing pressure over the entire pasture area and minimize overgrazing of areas close to shade or water. Research has shown that the maximum distance cattle will travel to water and not decrease grazing uniformity is 800 feet. As travel increases above this distance, pasture use decreases (see University of Kentucky Cooperative Extension publication ID-143, *Rotational Grazing*).

The quality of water used for cattle will be critical to the livestock operation's success. It is especially important to verify the quality of water being produced by groundwater discharges (springs or seeps from abandoned deep mines) in mining areas. Although such water can be of excellent quality for livestock purposes, there are cases where such discharges are sufficiently acidic or alkaline to be unsuitable as a water source.

Highly acidic water from coal mines can often be distinguished visually from the red-yellow coloration that commonly occurs due to iron contamination. However, a water source's suitability should be determined based on pH test results, not coloration. Some acidic discharges run clear, and these cannot be distinguished visually except by the limited vegetation and insect life that provide evidence of the water's toxicity. There are also numerous examples of water carrying high levels of iron coloration despite not being highly acidic. At the Powell River Project Research and Education Center in Wise County, Virginia, for example, an iron-bearing deep-mine water source is being used successfully to meet livestock needs. This water is being made available to livestock in a trough that is sufficiently large to enable most of the iron to settle out prior to livestock consumption. Despite a lack of aesthetic appeal, this water source has proved to be adequate to support the livestock herd during those times of year when other sources are not available.

Mineral Supplementation

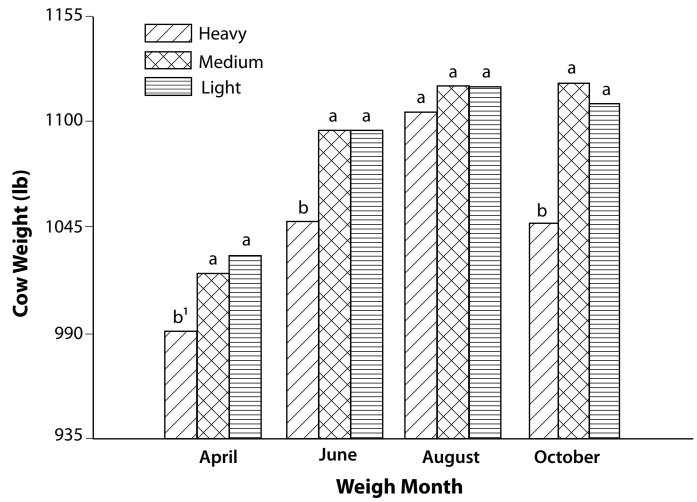
Good mineral supplementation is essential for beef cattle grazing reclaimed surface-mined land. Forages produced on these sites are likely to have an abnormal mineral profile compared to undisturbed agricultural soils. Water sources on these sites may be sufficiently high in iron and/or sulfur to act as an antagonist to the uptake of other essential trace minerals. A complete mixture of salt, macro, and trace minerals should be available to cattle at all times when grazing reclaimed surface-mined land. In cases where antagonism levels are high, chelated forms of some or most of the trace minerals may be necessary in the mixture. Homemade mixtures have been used by producers, but adequate intake of essential trace minerals cannot be accomplished in this manner.

Placement of the minerals can be used to encourage more uniform grazing of the site. Intake of minerals should be monitored, and if it falls below desirable levels, the minerals should be placed closer to the water site to encourage greater intake.

Before calving season begins, a high magnesium-containing mineral should be available to cows as a preventative for grass tetany (see University of Kentucky Cooperative Extension publication ASC-155, *Trace Mineral Supplementation for Kentucky Beef Cows*). After the danger of grass tetany has passed, discontinue the use of a high-magnesium mineral and return to normal levels for improved product intake.

Herd Size

Based on a five-year grazing study conducted on mine land in southeast Kentucky, a stocking rate between 3 to 6 acres per cow-calf unit may be the most sustainable for a cow-calf operation. Figure 2 illustrates the effect of stocking rate on cattle

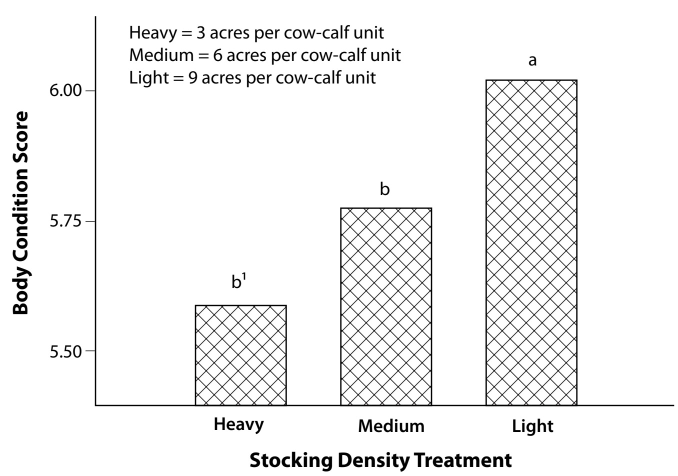


[1]Bars within a weigh month followed by the same letter are not significantly different according to LSD (P<0.10).

Figure 2. Effect of stocking rate on cow weights during the grazing season on reclaimed mine land in southeast Kentucky. Heavy = 3 acres per cow-calf unit; medium = 6 acres per cow-calf unit; light = 9 acres per cow-calf unit.

weights during this grazing study. In the spring, cows grazing at a stocking rate of 3 acres/head weighed less than those at 6 and 9 acres/head. This trend continued at the June weight date. When the animals were weighed in August, there were no differences in cow weights; however, by October, cows at 3 acres/head weighed less than those at the 6- and 9-acre/head stocking rates. Based on body condition scores (ASC-162, *Managing Body Condition to Improve Reproductive Efficiency in Beef Cows*), cows at the 9-acre/head stocking rate were in better condition in October than those at the 6- and 3-acre/head stocking rates. However, body condition scores of cows on all the stocking rate treatments were within the acceptable range for rebreeding (Figure 3).

Huge fluctuations in forage availability on reclaimed mines sites can make it difficult to determine the appropriate stocking rate for the entire grazing season. This is especially important



[1]Bars followed by the same letter are not significantly different according to LSD (P<0.10).

Figure 3. Effect of stocking rate on cow body condition score for beef cattle grazing reclaimed mine land in southeast Kentucky.

for cow-calf producers who need to keep cows in good condition for rebreeding. Kentucky research found that pregnancy rates of cows at the time spring calves were weaned were significantly higher at the 3-acre/head stocking rate compared to the 6- and 9-acre/head rates (Figure 4). A possible explanation for this unexpected result is that some cows at the 6- and 9-acre/head stocking rate were approaching an over-conditioned state that may have negatively impacted conception. However, reduced forage availability at the 3-acre/head stocking rate may result in lower calf weaning weights and overall performance. In the Kentucky study, calves gained 1.89, 2.4, and 2.4 pounds per day for the 3-, 6-, and 9-acre/head stocking rates, respectively. In general, cow weights, body condition scores, and breeding data from Kentucky are consistent with results from grazing demonstrations on reclaimed surface-mined land in Virginia (Gerken and Eller, 1982). Both studies indicate that mine land pastures in Appalachia produce adequate forage for beef cows to maintain weight and reproduce.

Grazing Management

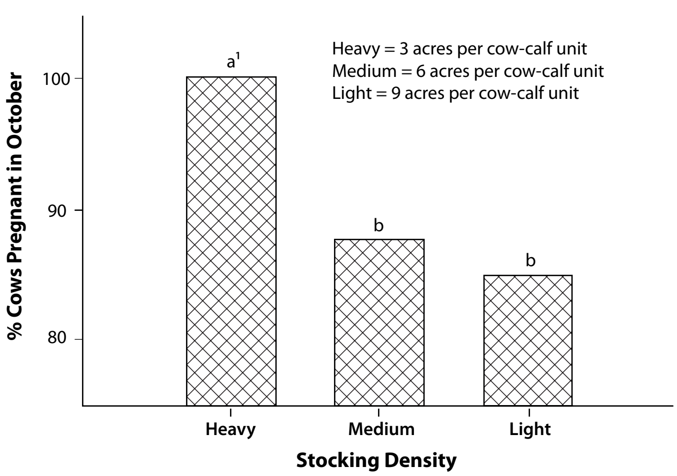
Grazing systems on reclaimed mine land tend to be extensive in nature, and large capital investments may not be justified. Therefore, careful planning of pasture size and layout is critical for the economic success of the grazing enterprises. When possible, producers should work with mining companies during reclamation to establish water sources for livestock. Topography should also be considered when establishing water sources. In a continuous grazing system, placement of water and mineral sources should encourage cattle to move into and graze the less-desirable areas of the pasture, including steep slopes.

Fencing pastures to encourage cattle to graze less-desirable areas can greatly increase overall pasture utilization. Cattle tend to avoid grazing the steep areas of a pasture until reduced forage availability forces them onto these slopes. The plant composition of a pasture also influences grazing activity. Sericea lespedeza, which dominates many mine land pastures, contains significant amounts of tannins that reduce its palatability. Although sericea's early spring growth is palatable and nutritious to livestock, its suitability as a forage declines as the growing season progresses. If allowed to grow higher than 8 to 10 inches, sericea becomes stemmy and low in forage quality. Therefore, pastures with large amounts of sericea lespedeza should be heavily grazed in the spring to maintain it in a vegetative state.

Research has demonstrated that sericea-dominated pastures can be converted to more favorable forages by careful and strategic management over a two-year period (Dove and others, 1991; VCE 460-119).

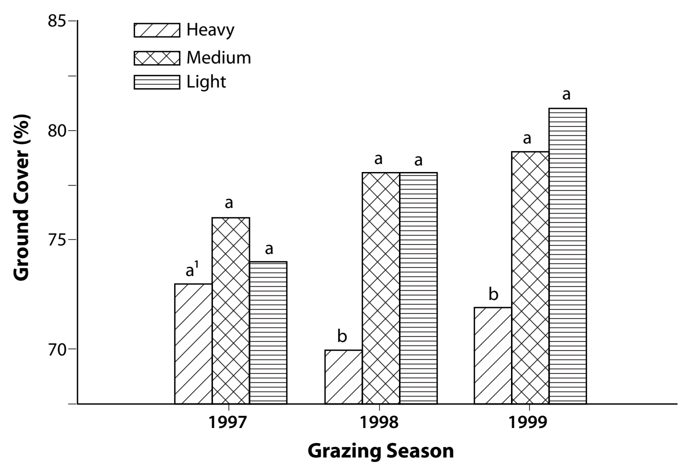
Careful planning of permanent fencing along with the use of temporary fencing can encourage cattle to graze areas of the pasture they would normally avoid. Managing grazing for the stockpiling of fescue and fescue-lespedeza pastures significantly reduces the need for stored winter feed. In the Kentucky study, cattle continuously grazed at the 9-acre/head stocking rate had forage available well into December. In contrast, continuously grazed pastures at the 3-acre/head stocking rate during the peak growing period had less ground cover and significantly greater grazing activity over the entire pasture area (Figures 5 and 6).

Producers with limited land resources should consider a rotational grazing system over a continuous grazing system if enough good-quality water is available. Pasture size should be adequate to provide one to two weeks of grazing. Paddock numbers in the rotation should be sufficient to allow for a four- to six-week recovery period, especially during the dry summer months. Forage regrowth on reclaimed mine land does not occur as quickly as on most natural soils that have more favorable properties. Also, forage on mined land is more likely to be overgrazed, which increases recovery time or may reduce ground cover.



[1]Bars followed by the same letter are not significantly different according to LSD (P<0.10).

Figure 4. Effect of stocking rate on cow pregnancy rate when grazing reclaimed mine land in southeast Kentucky.



[1]Bars within a grazing year followed by the same letter are not significantly different according to LSD (P<0.10).

Figure 5. Percent ground cover as affected by beef cattle stocking rate in southeast Kentucky. Heavy = 3 acres per cow-calf unit; medium = 6 acres per cow-calf unit; light = 9 acres per cow-calf unit.

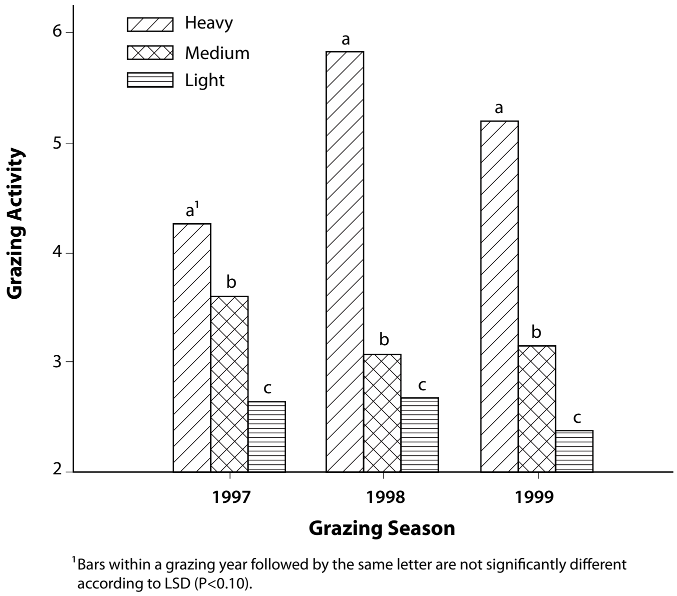


Figure 6. Effect of stocking rate on grazing activity on reclaimed mine land in southeast Kentucky. Scale: 1 = none; 2 = light (<20% tillers defoliated); 3 = light+ (21-40% tillers defoliated); 4 = moderate (41-60% tillers defoliated); 5 = moderate+ (61-80% tillers defoliated); and 6 = heavy (> 80% tillers defoliated). Heavy = 3 acres per cow-calf unit; medium = 6 acres per cow-calf unit; light = 9 acres per cow-calf unit.

Additional Information

Additional information on cattle production is available through your local Cooperative Extension office or on the Internet:

- For University of Kentucky publications, see http://www.ca.uky.edu.
- For Virginia Cooperative Extension publications, see http://www.ext.vt.edu/resources/ for access to all available publications, and http://als.cses.vt.edu/prp/VCE_Pubs.html for access to those publications dealing with management of lands created by coal mining.

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