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Management-Intensive Grazing in Indiana

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Knowledge to Go
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The USDA-Natural Resouces Conservation Service's Grazing Lands Conservation Initiative (GLCI) is a nationwide collaborative process of individuals and organizations working together to maintain and improve the management, productivity, and health of the nation's privately owned grazing land.

For more information, visit www.in.nrcs.usda.gov/programs/GLCI/glcihomepage.html

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Getting Started

Welcome to management-intensive grazing. This manual will help improve your understanding of basic grazing concepts. The information here should be applicable to any Hoosier grazier of any livestock species.

Grazing systems management is a combination of art and science. You will have to master the art as it relates to your farm, but this manual will get you started on the science.

The first section, "Getting Started," outlines the basics of grazing systems management. It includes chapters on why you should consider grazing systems management and how to assess your pasture's performance.

The second section, "Physical Components of a Grazing System," discusses the main elements that go into any grazing management system. This includes laying out paddocks, providing adequate water, establishing fencing, ensuring soil fertility, and selecting the right forage for your operation.

Section three, "Grazing Management Considerations," examines other issues you'll encounter in your grazing system. This includes chapters on determining how long to keep livestock in each paddock, stockpiling forages, streamside and woodland grazing, grazing behavior, and potential forage-induced disorders.

The fourth section shares the experiences of Indiana graziers who have implemented grazing systems management. Written by producers who have implemented and managed these systems, these accounts explain how and why they feel their rotational grazing system has been successful.

The last two sections of this manual are a glossary of basic terms and a list of additional resources.

Happy reading and happy grazing.

Chapter 1

Rotational systems can allow pastures to rest and regrow, distribute manure more evenly, and increase forage production.

Improving Pasture by Management

Traditionally, livestock producers have focused more attention on their animals than on the forages the animals eat. However, successful pasture-based production systems rely on producers who understand the connection between livestock and forages, and maintaining a healthy balance between the two. Mismanage the forage crop, and your livestock may develop nutrition deficiencies. Mismanage the livestock, and your pasture may not produce the quality and quantity of forage your grazing livestock need, nor will the pasture be environmentally sustainable.

One way to keep livestock and forages in balance is to think of ourselves as forage farmers; we raise the forages and the livestock harvest it for us. This change in thinking requires that we spend more time on forage management than we may have done in the past.

Types of Grazing Systems

There are almost as many ways to graze as there are graziers. But there are three basic kinds of grazing practices you should understand.

Continuous Grazing

Continuous grazing is a system in which livestock graze in a single large area for an entire season. This may be simple for the grazier in terms of costs and labor. In the long run, however, continuous grazing has many drawbacks, including lower forage quality and yield, lower stocking rate, overgrazing, and uneven manure distribution.

Rotational Grazing

Rotational grazing is a system that uses more than one pasture. In such a system, livestock are moved from one pasture to another based on their feed requirements and forage growth. Rotational systems can allow pastures to rest and regrow, distribute manure more evenly, and increase forage production. However, the costs for establishing such a system (water distribution and fencing) are higher than for a continuous grazing system.

Management-Intensive Grazing

Management-intensive grazing is a system that divides large fields into smaller paddocks. In this system, animals are moved frequently at high stocking rates. Management-intensive systems can provide the highest forage production and use per acre, control weeds and brush naturally, provide the most even manure distribution, give more forage options, and allow paddocks to rest and regrow completely. However, such systems require careful monitoring and greater startup costs for water distribution and fencing.

This manual focuses on rotational and management-intensive grazing systems. The most important aspect of such systems is an understanding of rest.

Give the Forages a Rest and Your Forages Will Take Care of You

Like all plants, forages undergo photosynthesis to store energy and grow. Photosynthesis, of course, cannot occur without energy from the sun. The vegetative parts of a plant (primarily the leaves and stems) capture that solar energy and convert it into digestible material. The greater the surface area of the leaves, the more energy they can capture, which results in more digestible material for the livestock as well as greater survivability for the plant.

Because perennial grasses and legumes can recover from mowing and grazing quickly, they are extremely valuable for forage and soil protection. But removing too many leaves through overgrazing retards forage production and reduces the plant's root system. For

that reason, the more residual forage that is left in a paddock, the quicker the paddock will produce new growth and be ready to graze the next time.

If allowed to do so, livestock will eat forages down to the ground. When that happens (and it frequently does in continuous grazing systems), the forages cannot capture as much solar energy, so they must draw upon their root reserves just to survive. Generally, root growth is unaffected when up to 50 percent of the plant is grazed. But if animals graze 60 to 90 percent of the leaves, then root growth drops by 50 to 100 percent. Overgrazing will slow new growth, and plants may die, especially if there are other stresses present. Even if the forage survives, it will be less vigorous and healthy because stress has weakened the roots.

Root growth is very important. Not only do roots deliver essential moisture and nutrients to the leaves, perennial plants store food in their roots, stolons, corms, and rhizomes after seasonal growth. Forages draw on these reserves to survive dormancy, to make the first new growth the next spring, and to start new growth after green leaves and stems are closely grazed or mown.

If livestock continually graze in just one pasture, animals are free to graze whatever and wherever they like. That's why it's important to have more than one paddock in your pasture management system to allow time for the forages to rest and regrow before being grazed again. As the livestock feed in one paddock, the other paddocks are resting, giving time for the plants to grow, build new root reserves, and maintain vigor.

The number of paddocks you have in your pasture, of course, will depend on many factors and your particular goals. But in the end, you want to have enough paddocks so that each one can be properly rested before the livestock graze in them again.

Better Forage Means Better Nutrition

Managing your paddocks provides many benefits. One of the most important is an improvement in livestock nutrition. Managing your forages allows you to produce a higher quality and quantity of feed than you would be able to produce on the same acreage under continuous grazing. That's because managed paddocks allow you to keep the forage growing and vegetative.

Vegetative forage is higher in available protein, energy, and essential nutrients than forage that has to draw on root reserves just to survive. Vegetative forage is also better than fully mature grass, because grasses tend to build up thicker cell walls once they mature, meaning there are fewer nutrients available for the livestock. You want to keep the forage in this growing state as long as possible.

Rotating livestock into paddocks with vegetative forage means better nutrition, and that means improved animal performance and more profit.

Better Management Requires Fewer Inputs

Animal health and profitability go hand in hand. Another benefit of managed grazing is the ability to extend the grazing season with less labor. Let the animals do as much work for themselves as possible. Why carry all that feed to them? They have four legs and are mobile. They often go some places that we don't even want to travel, especially on foot and impossible with some equipment. But more importantly, if they are working, then most likely, you are not. If they are grazing, you are spending much less money to feed them.

Not only do you have to work less, you'll spend less on fuel. If a wheel is turning, then you're spending money. So, the less a tire has to turn by hauling hay around on a tractor, the better. Most people see increased profitability as they extend the grazing season and start cutting back on the amount of hay they are feeding.

Better Management Improves the Environment

If you're not burning fuel, you're not just saving money, you're not emitting exhaust. Managed grazing also offers a number of environmental benefits, including:

- Less rain runoff because of better water-soil infiltration.
- Better water quality because growing forages trap sediment and nutrients.
- Improved animal waste distribution because waste is more evenly spread over several paddocks.
- Less erosion because dense, thick, vigorous forages reduce runoff.

Better Management Improves Livestock Health

Livestock have evolved to graze forages and stand on sod. Therefore, they are happiest and healthiest on lush, productive pastures. The direct benefits of improved forage grazing management include:

- Reduced foot and hoof problems.
- Increased calving percentage.
- Reduced parasite problems.
- Reduced incidences of displaced abomasums.
- Reduced somatic cell counts and instances of mastitis.
- Reduced fly problems.

Better Management Makes Livestock (and Producers) More Sociable

Managed grazing provides social benefits to livestock and producers alike. The social needs of livestock are very important. Social stress can affect productivity and performance, so the way we handle animals affects everything from their disposition to the quality of the meat. Animals quickly get used to being moved and know that the next stop is going to be a paddock with better forage.

Many graziers testify that changing to a grazing system would have been worth it just for the change in the way animals behave and react. They say things like, "They are not the same cows," and "I can move them within a couple minutes without a bucket and without help."

There are also social benefits for producers. The public typically perceives a good grazing system to be more aesthetically and environmentally pleasing. Consumers like to know that the products they are buying, especially when they are coming straight from you, are being produced by a more holistic method. Many producers are cashing in on this perspective and marketing their products as "grass fed."

But there is still more to it than that. Grazing management seems to offer to consumers a more wholesome, family-friendly operation with a more laidback, slower-paced lifestyle that many wish they could experience.

So, why should you divide up your pasture?

To take better control of your forages, your livestock, and your farm.

▸ Chapter 2

Dense forage stands indicate proper grazing and results in high forage intake and high sunlight interception.

Would Your Pasture Make the Grade?

In well-managed pastures, productivity is optimized for both the plants and the animals (which could include livestock and wildlife). Furthermore, well-managed pastures should not negatively affect soil, water, and air quality. Poor plant growth, high weed populations, soil erosion, increased runoff, poor animal performance, and impaired water quality are all signs that indicate problems within a pasture.

Before you begin any grazing management program, it's important to get a good, objective assessment of how your pastures measure up. One method of evaluating pasture management is to use a pasture condition score sheet. You can use the sheets on pages 11 and 12 to give your pasture's an overall "grade." In addition to an initial assessment, it is usually a good idea to keep track of your pastures' health by completing a score sheet every year. Pasture condition is useful to help you decide when to move livestock or plan other management actions. It also indicates improvements that are most likely to improve your pastures' condition and livestock's performance.

While you can evaluate your own pastures, it is usually a good idea to find someone else to do it and allow them to be honest with you. Chances are, you will be less objective with your own pastures than someone who doesn't see the same things you do every day. Also, when you walk or drive over the same ground day after day, you sometimes overlook or just stop noticing little changes.

The pasture condition scoring sheet at the end of this chapter involves the visual evaluation of 10 indicators. The purpose of the scoring sheet is to evaluate a current pasture's productivity and the stability of its plant community, soil, and water resources. The scoring sheet should also help you identify weaknesses and alternatives to improve pasture management.

Each indicator is given a score of one to five, according to what is seen in the field. Each condition ranges from very poor to excellent. Each is also given a weighted value according to its importance. The indicators included on the sheet are described below.

Desirable Plants

The desirable plants indicator measures the percentage of plants in a pasture (by weight) that livestock will eat and meet their nutritional needs. A desirable species is readily consumed, persistent, and provides high yielding, quality forage for most of the growing season. Undesirable species (such as woody invaders, noxious weeds, and toxic plants) typically are not eaten by livestock, cause undesirable side effects, or are likely to crowd out more desirable species. You want to estimate visually the proportion of the desirable species present by weight and score accordingly. Remember, the percentage is by weight. Just because there is a lot of short bluegrass in an orchardgrass stand does not mean the short bluegrass is 50 percent of the stand — by weight, it is probably only 20 percent or less.

Live Plant Cover

The live plant cover indicator measures the percentage of the soil surface that is covered by plants. This is an important factor for pasture production, as well as soil and water protection. Dense stands indicate proper grazing, high animal intake, and high sunlight interception. Plant cover also highly influences water runoff and water infiltration, which can be especially important during dry years.

Plant Diversity

The plant diversity indicator measures the number of different forage plants that are well represented in the pasture. Each species should make up at least 20 percent of the sward. Ideally, you want to see at least three species and include at least two functional groups. Functional groups include cool-season grasses, legumes, warm-season grasses, and annual forages.

Plant Residue

The plant residue indicator measures the amount of plant material in various states of decay. Residue, of course, provides additional surface cover and organic matter to the soil; however, too much residue reduces the feed value of the forages consumed and animal intake, and can inhibit new plant growth. Residue left over winter, however, can be very beneficial in the early spring to help balance out the grazing animals' rumens while they are consuming high-protein, highly digestible, high-moisture forages.

Plant Vigor

The plant vigor indicator measures how many of the desired forage species are healthy and growing at their potential. Plant color, size, rate of regrowth, and productivity all help determine vigor. Fertility is very important for good plant vigor and should be adequate but not excessive. Close, frequent, or continuous grazing, such as the shaved lawn mower look, often causes loss of vigor, reducing yields and ground cover. Low plant vigor makes weed problems more likely. Occasionally, the climate or soil is not appropriate for the species being grown, such as perennial ryegrass on a droughty soil. Weather, insects, and disease can also influence plant vigor.

Percent Legume

The percent legume indicator is important because legumes are a source of nitrogen critical for pastures. Legumes also improve the forage quality of a pasture mix, especially protein content and dry matter consumption when they are at least 20 percent of the stand. Thirty percent is a good legume goal. Some legumes can cause bloat, so consider using nonbloating legumes when appropriate (see table on pages 28 and 29 for nonbolating legumes).

Uniformity of Use

The uniformity of use indicator records observed animal grazing patterns. Grazing is considered uniform when all species (including desirable and intermediate ones) are grazed to a similar height. Grazing is considered uneven if you observe "clump syndrome," or when some plants are eaten to the ground and others are in full seed head. You can usually correct uneven grazing by increasing the stocking density, using smaller paddocks, and maintaining shorter grazing periods.

Livestock Concentration Areas

The livestock concentration areas indicator accounts for places in pastures where livestock return frequently and linger to be near water, feed, minerals, shelter, or just to be in shade. Typically, well-worn trails lead to these preferred areas. Depending on their locations, these trails can direct sediment, nutrients, and bacteria toward nearby water bodies.

Soil Compaction

The soil compaction indicator accounts for water infiltration rates and runoff. The lack of water infiltration decreases water availability in the soil for plant growth, potentially lowering production or sometimes survivability. Instead, water runs off, increasing chan-

Find out more

For more information, see, *Guide to Pasture Condition Scoring* by Dennis Cosgrove, Dan Undersander, and James Cropper, www.glti.nrcs.usda.gov/technical/publications/

A PDF version of the pasture condition scoring sheet on pages 11 and 12 is available at www.in.nrcs.usda.gov/technical.

nel erosion downstream, and carries contaminants such as nutrients from the site, reducing water quality. Compaction can be detected in the field using a soil probe, metal rod, or knife. As these tools are pushed into the soil, compacted soil layers interrupt their ease of penetration. Compare in-field resistance to penetration with areas such as the fence lines where animals are not able to graze.

Erosion

The erosion indicator measures the amount of soil loss in a pasture. Sheet and rill erosion increase as ground cover decreases. Erosion also occurs along streambanks, and in areas of high-water concentration, resulting in gullies. Frequency of use, livestock traffic patterns, and the attractiveness of some sites to livestock (including sunning, dusting, travel lanes, watering, and rubbing areas) can heighten erosion problems if left unchecked.

Pasture Condition Score Sheet
Standard for Midwest Cool-Season Grass/Legume Mixed Pastures
30- to 45-Inch Rainfall Zone

Cooperator:	*Date:*
Evaluator:	*Pasture Number:*

Evaluate the site and rate each indicator based on your observations. Write that number in the Points column, then multiply by the Weight, and enter that number in the Weighted Points (Wtd. Pts.) column. Scores for each indicator may range from 1 to 5. Add the indicator scores to determine overall pasture condition score. If an indicator does not apply, enter a 5.

Indicator	1 Point	2 Points	3 Points	4 Points	5 Points	Score: Points	Score: Weight	Score: Wtd. Pts.
Percent Desirable Plants 10% of overall score	Desirable species <20% of stand. Annual weeds and/or woody invasives are dominant.	Desirable species 20-40% of stand. Mostly weedy annuals and/or woody invasives present and expanding. Shade is a factor.	Desirable species 40-60% of stand. Undesirable broadleaf weeds and annual weedy grasses invading. Some woody species invading.	Desirable forage species 60-80% of stand. Remainder mostly intermediates and a few undesirables are present.	Desirable species exceed 80% of plant community with the remainder being scattered intermediates.		0.1	
Live Plant Cover (live stems and green leaf cover of all species at adjusted 3-4 inches tall) 15% of overall score	Canopy <50%. Photosynthetic area is very low. Very little plant cover to slow or stop runoff.	Canopy=50-70%. Photosynthetic area is low. Runoff is fast due to low plant cover.	Canopy=70-80%. Most forages are grazed close, with little leaf area to intercept sunlight. Runoff is moderate due to moderate plant cover.	Canopy=80-90%. Spot grazed so there is some loss of photosynthetic potential. Runoff is low due to good plant cover.	Canopy >90%. Forages are maintained in leafy condition for best photosynthetic activity. Stands are very thick stand with slow or no runoff flows.		0.15	
Plant Diversity (evaluate as a complete system) 10% of overall score	More than one dominant forage species from one functional group with differing growth habitats (>75% of DM wt.). Not evenly grazed, poorly distributed. (e.g., jointed grasses and nonjointed grasses).	One dominant forage species (>75% of DM wt.). Or, more than five forage species (all <20%) from one dominant functional group, not evenly grazed, poorly distributed.	Two to five forage species from one dominant functional group (>75% of DM wt.). At least one avoided by livestock permitting presence of mature seed stalks. Species in patches.	Three forage species from one functional group (each 20% DM wt.). None avoided. Or, one forage species each from two functional groups, both supply 25-50% of DM wt.	Three to four forage species with at least one being a legume (each 20% of DM wt. and total >75% of DM wt.). Well intermixed, compatible growth habit, and comparable palatability.		0.1	
Plant Residue 5% of overall score	Ground cover <1% No identifiable residue is present on soil surface. Or, heavy thatch is evident (>1 inch).	Ground cover=1-10% 1-10% is covered with dead leaves or stems. Or, thatch is 0.5-1 inch thick.	Ground cover=10-20% 10-20% is covered with dead leaves or stems. Or, there is slight thatch buildup (<0.5 inch).	Ground cover=20-30% 20-30% is covered with dead leaves or stems, no thatch present.	Ground cover=30-70% 30-70% is covered with dead leaves or stems, no thatch buildup.		0.05	
Plant Vigor 15% of overall score	There is no recovery after grazing. More than 80% of plants are pale yellow or brown, permanently wilted, or lost due to insects or disease. Yields are regularly more than 30% below site potential; or there is lodged, dark green overly lush forage, often avoided by grazers.	Recovery after grazing takes 2 or more weeks longer than normal, 50-80% of plants have yellowish green leaves, there is major insect or disease yield loss, or plants are wilted most of day. Productivity is very low, 20-30% below site potential.	Recovery after grazing takes 1 week longer than normal, urine/dung patches are dark green in contrast to rest of plants, there is minor insect or disease loss, or midday plant wilting. Yields are regularly 10-20% below site potential.	Recovery after grazing takes 1 to 2 days longer than normal; 50-80 % of crop plants are healthy green. There is minor insect or disease damage. No plants are wilting. Yields are near site potential.	Rapid recovery after grazing. More than 80% of crop plants are healthy green. No signs of insect or disease damage. No leaf wilting. Yields are at site potential for the species adapted to the site's soil and climate. Desirable plants competitive with invading species.		0.15	
Percent Legume 5% of overall score	Legumes are <10% by weight or >60% bloating legumes.	Legumes are <10% by weight or, 40-60% spreading legume with grass loss occurring.	Legumes are 10-19% by weight.	Legumes are 20-29% by weight.	Legumes are 30-60% by weight.		0.05	
Uniformity of Use 5% of overall score	>50% of the pasture spot grazed. Mosaic pattern found throughout pasture or identifiable areas of pasture avoided.	No more than 30-50 % of the pasture spot grazed either in a mosaic pattern or obvious portion is not frequented. Urine and dung patches are avoided.	No more than 20-30 % of the pasture spot grazed either in a mosaic pattern or obvious portion is not frequented. Urine and dung patches are avoided.	No more than 10-20 % of the pasture spot grazed. Urine and dung patches are avoided.	No more than 10% of the pasture spot grazed. 90% of the pasture falls within the minimum and maximum grazing heights for cool-season grass/legume mixtures (3–8 inches).		0.05	

Evaluate the site and rate each indicator based on your observations. Write that number in the Points column, then multiply by the Weight, and enter that number in the Weighted Points (Wtd. Pts.) column. Scores for each indicator may range from 1 to 5. Add the indicator scores to determine overall pasture condition score. If an indicator does not apply, enter a 5.						Score		
Indicator	**1 Point**	**2 Points**	**3 Points**	**4 Points**	**5 Points**	**Points**	**Weight**	**Wtd. Pts.**
Livestock Concentration Areas 10% of overall score	Cover >10% of the pasture or concentrated areas convey contaminated runoff directly into water channels.	Livestock concentration areas and trails cover 5-10% of pasture, most close to water channels, and drain into them unbuffered.	Isolated livestock concentrated areas and trails cover 5-10% of area.	Some livestock trails and one or two small concentration areas cover <5% of the pasture. Buffer areas are between concentrated areas and water channels.	No untreated livestock concentration areas in the pasture — e.g., gravel pads around waterers, possibly at gates, no evidence of trails in pasture.		0.1	
Soil Compaction (probe moist soil comparing the treatment unit to an ungrazed area — i.e., fencerow — and estimate compaction when soil is moist) 10% of overall score	Unable to push survey flag into soil. Infiltration capacity and surface runoff severely affected by heavy compaction. Excessive livestock traffic killing plants over wide areas.	Hard to push survey flag past compacted layers. Infiltration capacity is lowered and surface runoff increased due to large areas of bare ground and dense compaction layer at surface.	Soil resistant to survey flag at one or more depths within soil depth. Infiltration capacity lowered and surface runoff increased due to plant cover loss and soil compaction by livestock hooves.	Survey flag enters soil easily except at rocks. There are scattered signs of livestock trails and hoof prints, confined to lanes or small, wet areas.	Survey flag pushes easily into ground except for rocks. Soil is friable, and earthworm and dung beetle activity should be evident, especially around manure piles.		0.1	
Erosion (if present, rate streambank and gully erosion using national erosion categories) 15% of overall score	Erosion is active throughout pasture; rills are 3-8 inches deep at close intervals and/or grazing terracettes are close-spaced with some slope slippage. Active gullies are present caused by livestock trailing. Soil pedestalling is apparent.	Most erosion is confined to steepest terrain of unit; well-defined rills are 0.5-3 inches deep at close intervals and/or grazing terracettes are present. Trails are evident causing concentrated flows.	Most erosion is confined to heavy use areas, especially in loafing areas, concentration areas, and water sites; rills are 0.5-3 inches deep. Debris fans are found at downslope edge. Livestock trailing is evident.	No current formation of rills. There is some evidence of past rill formation, but they are grassed. Scattered debris dams of litter are occasionally present.	No evidence of current or past formation of sheet flow or rills.		0.15	
Overall Pasture Condition Score	Individual Indicator Score	Management Change Suggested			Overall Pasture Condition Score =		100	
45 to 50	5	No changes in management needed at this time.						
35 to 45	4	Minor changes would enhance resources. Do most beneficial first.						
25 to 35	3	Improvements would benefit productivity and/or environment.						
15 to 25	2	Needs immediate management changes; a high return is likely.						
10 to 15	1	Major effort required in time, management, and expense.						
Comments/Notes								

Definitions

soil pedestal: A relatively slender column of soil capped by a rock or less erosive soil. It's produced by undercutting as a result of water or wind.

terracette: A small, irregular, step-like formation on steep hillslopes, which are formed by creep or the erosion of surface soils by livestock trampling.

Physical Components of a Grazing System

When it comes to spending money, a careful consideration of the expected financial returns from any investment is crucial to farm profitability. Always evaluate the expected returns from any investment opportunity.

With grazing management, there are four major investment categories: fencing, water distribution, lime and fertilizer, and seed selection. Each category is unique in its payback potential, and each category is unique to the needs of every individual farm and grazier.

The first chapter in this section discusses the basics of paddock layout. The remaining chapters focus on each of the investment categories, offering you practical information you can use to assess investment values.

▸ Chapter 3

Laying Out Your Paddocks

Rotational grazing and management-intensive grazing systems depend on paddocks: smaller, fenced-in units within a larger pasture. Paddocks decrease the amount of area that animals can roam and give previously grazed forage in other paddocks more time to rest and regrow.

Laying out a paddock system can be as simple as dividing an existing field in two, or as complex as systematically dividing a field into multiple paddocks, complete with travel lanes to get animals back and forth to working areas, distant paddocks, or the milk parlor. However, there are a few basics to consider as you think about laying out your paddocks, including water, topography, soil types, shape, and frequency of animal movement.

Water Must Be Close and Visible

Water location is of primary importance in rotational or management-intensive grazing systems. Water should always be close (so animals don't have to walk far to get it) and visible (so animals will drink individually rather than as a group). It is optimal to have water within 400 to 500 feet for dairy cows and 800 feet for beef cattle. If you will be using natural water sources, such as ponds or streams, laying out the paddocks can be very challenging. Piping in water will probably make layout easier and more reliable in quantity and quality.

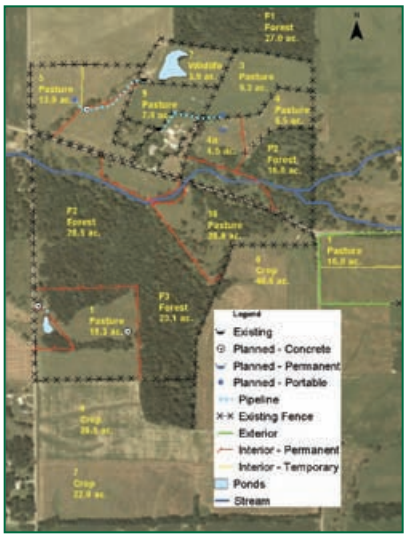
Match Paddocks to Landscape

The next consideration is topography. It is important that animals be able to see the water. That can be much more difficult in hilly areas than it is in flat fields. By constructing paddocks to match the different topographies in your field (hillsides versus flat areas), you will have more consistent grazing.

For example, if a paddock contains both bottomland and hillsides, then the two landscapes are typically grazed differently because of their differences in topography, fertility, water availability, and so on. You certainly would not want to mix a flat creek bottom with a very steep hill if you are grazing cows, because the cows would prefer grazing the lowland (which they would tend to overgraze) and avoid the high ground (which they would undergraze). If you graze sheep or goats in the same situation, then they will probably prefer the slopes and not the lower, potentially wetter ground. Thus, it is almost always better to split paddocks based on topography and soil type.

Understand Soil Productivity, Drainage

Topographical variations are directly



Construct paddocks to match the different topographies in your fields (hillsides versus flat areas) and to make the watering locations visible throughout the whole paddock.

related to changes in soils and productivity. Lighter or sandier soils can provide more desirable areas to sacrifice during rain events, but they produce less annual growth. Heavier soils, or soils that tend to stay wet, can often provide ample grazing during droughty periods, but may require restricted access during wetter periods.

Of course, matching forages that are best adapted to your soil conditions, is of the utmost importance. Ideally, each paddock should have similar soil types and forages. Whenever possible, you should seed specific forages in unique areas, such as frequently flooded or extremely droughty areas, then manage these areas as separate paddocks.

Keep Paddocks as Square as Possible

Water sources, topography, soil types, and natural barriers can sometimes restrict a paddock's shape. Whenever possible, however, the first choice should be to make your paddocks as square as possible; the second choice would be to make rectangular paddocks with a maximum side to end ratio of 3:1; and the choice of last resort would be a pie-shaped paddock. The paddock shape may also need to be varied based on the type of livestock. For example, horses, llamas, alpacas, and emus prefer longer, more rectangular paddocks.

Move Animals Twice or More per Week

The last decision you'll need to make regarding paddock layout is the size, based on how often you want to move the animals. This depends on the number of days the forage in each paddock will need to rest after being grazed and, of course, the amount of dry matter available (plants) and forage needs of the animals present. In general, you should move animals from one paddock to another at least twice per week. Any less frequently and animals will tend to regraze certain areas and weaken the plants. Frequent rotation is beneficial because it can increase the percentage of the available forage actually consumed (grazing efficiency).

The table below provides suggested ranges for optimal grazing periods. These recommendations are based on average forage production.

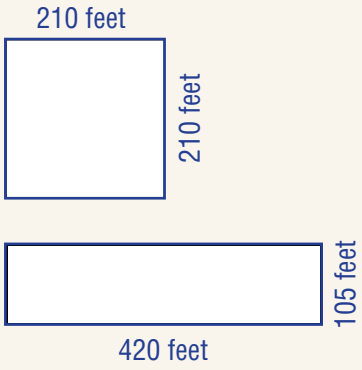
Other Considerations

Other paddock layout considerations are tied to specific needs. For example, lanes are important when you need to move animals regularly to a milking or working area. When setting up lanes, be sure to adjust locations to avoid climbing hills to help minimize erosion problems.

Putting all these factors together will enable you to set up a system of paddocks that not only provides your forage plants with the environment they need for maximum growth and persistence, it also helps maximize the productive potential of the livestock by offering forage that is higher in quantity and quality.

Rule of Thumb

Square paddocks can be grazed more evenly and efficiently than rectangular or pie-shaped paddocks. Keep pastures as near to square as possible to help reduce fencing costs and use land better. Long, thin paddocks tend to encourage livestock to graze nearest to water, minerals, or shade, and animals tend to avoid grazing in the far end. A square paddock that's 210 feet on each side requires 840 linear feet of fence (44,100 square feet). A paddock that has the same square footage but that's twice as long on one side (420 feet) requires 1,050 linear feet of fence.



The table below provides suggested ranges for optimal grazing periods. These recommendations are based on average forage production.

Livestock Operation	Time Spent in a Paddock Before Moving to Next Paddock
Cow/Calf	3-7 days
Stocker	1-3 days
Dairy	1/2-1 day
Ewe/Lamb	2-5 days
Feeder Lamb	1-3 days
Horse	5-7 days

▸ Chapter 4

Providing Water to Your Livestock

Water is the most important ingredient in any living creature's diet. We can survive for weeks without food, but only days without water. Plentiful water in the paddock is essential for good animal performance and grazing efficiency. When establishing your paddocks and determining your water needs, there are four major considerations: distance animals have to travel to water, location of water, size of water tank, and the amount of water to be delivered to the paddock.

Keep Water Close

Studies show that providing easy access to water improves animal performance. For example, providing adequate, high-quality, accessible water for mother and calf has been shown to increase the weaning weight of calves by more than 50 pounds. Logic tells us that restricting the availability of the cheapest component of the grazing system just does not make economic sense.

Distance from water is an important factor. The table below shows the farthest distances grazing animals should have to travel within a given paddock to get water. Making sure that animals have access to water within these distances maximizes animal performance and ensures even grazing in the paddock. When water is farther than these distances, animals tend to focus more of their energies acquiring water and less on their main purpose of harvesting forage and producing meat or milk. When establishing your paddocks, keep these distances to water in mind.

Make Water Visible

The next major consideration when putting adequate water in the paddock is finding a suitable location. If all paddocks were flat and square, it would be easy to find the best location. But in real life, more goes into that decision.

For example, it makes economic sense to locate water so it can service multiple paddocks (whenever possible). In general, you should always try to locate water so that it will be visible to animals from any location within the paddock. That way, you'll be able to use a smaller tank since animals will tend to come to drink individually if they have shorter distances to walk rather than make drinking a social event if they have to walk farther.

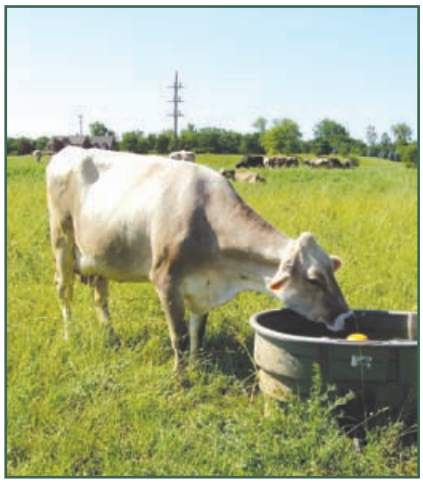
Keep the Water Fresh

Tank size is primarily about the quality and quantity of water you can provide. Of course, you want to have a sufficient quantity of water so that your water tank refills faster than animals can drink it. But you should also size your tank so that the water turns over every one or two hours to ensure it is cool and fresh. The longer water sits in a tank, the warmer and more stale it becomes. This makes it less desirable to the animals and, ultimately, they have to drink it to benefit from it.

Assuming your water tank has proper visibility within the paddock and that you have a full-flow tank valve to provide rapid refill, an easy formula for calculating the optimum tank size is:

number of animals x gallons per animal per day ÷ 24 hours = optimum tank size (in gallons).

There are other considerations when it comes to tank size, including the



Tank size depends on the amount of water you have available. A tank should refill faster than your animals can drink it.

Rule of Thumb

To calculate optimum water tank size, use this formula:

number of animals
x
gallons per animal per day
÷
24 hours
=
optimum tank size
(in gallons)

Grazing Animal	Water Should Be No Farther Than
Lactating Dairy and Goats	400-500 feet
All Other Ruminants	800 feet

Livestock Watering Systems, Energy Source, Costs, and Capability

System	Energy Source	Water Supply	Capability	Estimated Cost (2007 Dollars)		Additional Information
				Initial Pump System	Watering System and Pump	
Existing well	Electric or fuel	Ground water, etc.	Depends on well and pump size	Already in Place	$700+	Very reliable. Low cost. Suitable for intensive grazing.
Gravity fed	Gravity (change in elevation)	Spring, drainage tile, cistern, pond	Depends on water source	N/A	$700+	Low cost. Airlock problems are possible. Requires elevation survey. Overflow management at water source and/or tank may be required. Can restrict tank location and placement.
Nose pump (mechanical)	Livestock	Shallow water sources	20-30 head, 23-foot lift or 126-foot distance	$350	$400	Foot valve must be kept clean. Suitable for small herds. Low cost and maintenance. Must keep livestock within 600 feet of nose pump or you may limit water intake. Only one animal at a time can drink.
Hydraulic ram pump	Falling water	Stream, spring	10-30 foot lift per 1-foot fall depending on model.	$300- $1,000	$1,000+	Requires waterfall or a good slope. Detailed installation requirements. Continuous pumping system. Overflow management at pump and tank.
Sling pump	Flowing water (or wind)	River, lake	800-4,000 gallons/day, 26-82 foot lift (water powered models)	$1,000-$1,700	$1,700+	Requires sufficient water speed. Continuous pumping system. Overflow management at tank.
Solar-powered pump	Sun	Any	Depends on design	$1,500 +	$2,200+	Requires technical skills for installation and maintenance. Requires energy storage (battery or reservoir).
Wind-powered pump, air-activated	Wind	Pond, shallow well, etc.	20-foot lift or over a 980 foot distance	$1,100+	$1,800+	Requires some skills for installation. Requires water storage. Continuous pumping system. Overflow management at tank or reservoir.
Mobile (on wheels) water tank	Electric or fuel	Any	Depends on tank capacity	$0+	$1,100+ or about $0.01/gal	Labor intensive. Suitable for intensive grazing. Requires good water source for timely fill up, and a tractor or truck for delivery.
Gas- or battery-powered pump	Fuel or batteries	Any	Depends on model	$200- $900	$900+	Labor intensive. Requires water storage. Requires good water source for fill up. Not always practical.

amount of watering space and size of the water line. Watering space at the tank is especially important if your animals have to walk more than 1,200 feet to get to it. The greater the distance animals must travel, the greater the likelihood that the whole herd will come as a group. That means you will need to provide more drinking space to ensure that all animals get a drink before they head back to pasture.

The water supply line's size plays an important role in determining how quickly the tank can refill. The smaller the line, the longer it takes for a tank to refill. In other words, the smaller your water line, the larger the tank you will probably need.

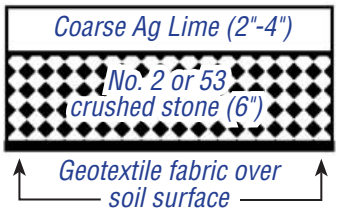
Provide 30 Gallons per Animal Unit

The exact amount of water each animal needs is determined by its physical characteristics (type, size, lactation/gestation stage, and metabolism rate) as well as environmental conditions (temperature, humidity, wind, and forage moisture). The standard rule in Indiana is to provide 30 gallons of water per day per animal unit (AU). One AU is 1,000 pounds of live animal weight. For example, two 500-pound heifers or five 200-pound ewes are 1 AU and should receive 30 gallons of water per day. A 1,500-pound cow is 1.5 animal units and should receive 45 gallons of water per day.

There are many paddocks that can pose challenges for a variety of factors, such as the distance from the water source. Even when a situation is less than ideal, an economical and practical solution can generally be found. Contracting an experienced planner can provide long-term satisfaction with the outcome and increase profitability.

Provide Erosion Protection for Watering Sites

To help avoid the problems associated with bare soils around permanent watering sites, producers should consider using geotextile fabric with rock or concrete. Geotextile fabrics are porous, so water and moisture pass through them while the rock is held in place. Recommendations are for 6 inches of coarse, crushed limestone (typically Number 2 or Number 53 stone) topped with 2 to 3 inches of a finer material like ag lime. The area protected by geotextile fabric and gravel or concrete should extend a minimum of 8 feet from water troughs, tanks, and other equipment.



Heavy Use Area Protection (HUAP) constructions like this can help reduce erosion and other problems around permanent water sites.

Find out more

For details about designing a geotextile/gravel pad, see Purdue Extension publication AED-45, *Using All-Weather Geotextile Lanes and Pads*.

To order, visit the Purdue Extension Education Store at www.ces.purdue.edu/new

Planning Your Fencing

Fences are a very important part of any grazing system. In most grazing systems, you'll need to consider both external (or perimeter) fencing and internal (or divisional) fencing. External fences keep your livestock from wandering off your property — and help keep other animals out. Internal fences keep livestock confined to a specific area, such as a paddock within a larger pasture. These fences are key to good pasture management because they allow you to control where your livestock graze, giving time for forage in other paddocks to rest and regrow.

The rest of this chapter looks at common external and internal fencing options, as well as special considerations for electric fencing.

External Fences Make Good Neighbors

The old saying, "Good fences make good neighbors" holds true in grazing, since it is wise to keep your livestock where they are supposed to be.

That's where external (or perimeter) fences come in. Since external fences must keep your livestock within the boundaries of your property, they need to be sound enough to effectively retain

▸ Chapter 5

External fences must be sound enough to effectively keep your livestock on your property.

Find out more

For more information about fence laws, see Purdue Extension Publication EC-657, *Indiana Farm Fence Laws*, www.ces.purdue.edu/extmedia/EC/EC-657.pdf

Rule of Thumb

Line posts for interior fences may be placed up to 50 feet apart on flat terrain.

your livestock. The Indiana state fence law describes such a fence as "a straight board and wire fence, a straight wire fence, a straight board fence, or a picket fence four (4) feet high . . . sufficiently tight and strong enough to hold cattle, hogs, mules, and sheep."

Having sound perimeter fences that will hold back your livestock won't just help you sleep better at night, they are the law. Although many different kinds of fences are allowed, Indiana law makes it clear that external fences must be tight and strong enough to hold livestock.

So while you have certainly seen one-wire external fences with 3/8-inch steel rod posts, such fences are not really physical barriers, but psychological barriers. For both practical and legal reasons, such perimeter fences are ineffective.

When it comes to selecting fencing materials and construction, you need to consider the livestock you want to control.

High-Tensile Wire

High-tensile wire is probably the most versatile perimeter fence material. Typically, high-tensile wire is extremely flexible (making it useful for turns and on land with major elevation changes) and easy to repair (usually only requiring the replacement of a few staples and retightening). Fences made with such materials are made from any number of wires stretched horizontally and attached to posts. The wires are spaced according to the livestock you wish to control. A minimum of two to three wires should be electrified to help control the livestock.

Wood or heavy fiberglass posts are the best option with high-tensile wire. If the fence is electrified, steel posts can drain voltage, shorts are more likely, and they may not stay in place in areas with abrupt elevation changes (especially dips).

Woven Wire

Woven wire easily controls most types of livestock with little effort, and high-tensile versions are also available. Woven wire is usually more expensive than high-tensile wire and is much more difficult to repair if damaged. Woven wire fences can be topped with barbed wire or one or two strands of electrified high-tensile wire.

Wood posts are usually the best option for woven wire fences, although steel "T" posts can be used for part of the line posts.

Barbed Wire

Barbed wire is an old fencing standby. But if you have ever had to tear down an old barbed wire fence and try and roll it up to dispose of or move it, then you know why many producers don't like it. Like high-tensile wire, barbed wire fences are made of four to six wires attached to posts. They can also be mixed with other types of fencing. Do not electrify barbed wire because it can be a hazard for children and young livestock. Barbed wire fencing is usually inexpensive and versatile. It is best when it is mixed with other types of fencing. For example, a strand of barbed wire near the ground can help reduce predatory animals from digging underneath it.

Barbed wire is very versatile and can be used with several different types of posts, wood and steel "T" posts being most common.

Internal Fences Aid Paddock Management

Good internal (or divisional) fences can be a great help for managing paddocks. The goal of an internal fence is to keep livestock in the paddock where you want them to graze and out of the other paddocks you want to rest. Internal fences can be simple or as rugged as your best external fence.

Your decision should be based on the livestock you have and how much control you want. You also want to decide whether internal fences need to be permanent or temporary.

Permanent Internal Fences

Permanent internal fences are typically made from the same materials as external fences, but don't necessarily need to be as rugged. For example, a single strand of high-tensile wire at a height of 30 inches will probably be all you need for most cows and will keep the majority of the calves in place. Placing a second wire at about 18 inches will do a good job of controlling calves. You can use wood or fiberglass posts as far as 50 feet apart on reasonably flat ground. To control smaller ruminants, you can use more wires and posts. In general, however, reduced wire fences should be electrified to be effective.

As with external fences, woven wire offers more small ruminant control. A shorter high-tensile woven wire fence (28, 32, or 36 inches tall) with one or two strands of electrified wire on top is an excellent internal fence option for smaller animals.

Regardless of the material you use, all permanent internal fences must be placed so they can be used long-term. In some circumstances, these permanent internal fences can double as laneway fences that help direct and move livestock across large areas, providing access to multiple paddocks along the way. These are especially handy for moving and managing individual animals.

Temporary Internal Fences

As the name suggests, use temporary fencing where you only want a fence for a very short period and need a lot of flexibility. Temporary fencing is great for subdividing larger permanent paddocks into smaller units and for strip grazing.

Temporary fencing allows you to make frequent changes in forage allocation based on animal needs, which is particularly important with growing animals and dairy operations. Because you can quickly take down temporary fencing, it also can make haying or clipping easier because you can work on a single large area instead of several small paddocks.

The type of temporary fencing you use also varies according to the livestock you want to control. For example, for most cattle and horses, a single strand of poly-wire or poly-tape works quite well. This type of fence can be installed and moved quickly with a reel for the wire and quality step-in posts.

For dairy operations in particular, temporary fencing is an extremely important asset for providing breaks for the milking herd. Breaks are important to ensure efficient pasture use and aid in grazing the paddock evenly while reducing waste and labor.

Electrified netting is a great tool for controlling small ruminants and for training calves to poly-wire. Most electrified netting comes in sections of 75 to 160 feet. These fences take a little more labor to move, but are very effective at deterring livestock and predators.

Only use a low impedance-type energizer with poly-wire and tape; solid-state energizers will melt the plastic.

Electric Fences Require Extra Attention

Electric fencing, of course, involves additional equipment and installation considerations. One of those considerations is what kind of energizer to use. To understand your energizer needs, it's important to know a few basic electrical terms: wattage, voltage, and amperage.

Watts are the basic unit of measurement of electric power. The higher the

> ***Rule of Thumb***
>
> For one-wire fences, place the wire so it is 2/3 the shoulder height of the grazing animal.

number of watts, the greater the amount of energy you use. Wattage is to electrically powered devices as horsepower is to engines. A joule also is a unit of measurement for electricity that is equal to the amount of energy required to produce one watt for one second.

A rule of thumb with electric fencing: use one joule per mile of electrified fence wire. So if you have five miles of electric wire, use a five-joule energizer.

A volt is a unit that measures the potential energy or pressure. In a way, voltage is similar to measuring the amount of pressure in a water line — the higher the pressure, the faster water can pass through. In an electric fence, this is the amount of energy that is flowing through the wire at any given moment. Voltage is important to get the electric shock through the animal's hair. The thicker the hair or wool, the higher the voltage you'll need.

An amp measures the amount of energy you pull from the line. Amperage, not voltage, causes the greatest amount of discomfort. Energy will keep flowing through a closed circuit, so circuit breakers and fuses are used to prevent excessive energy flow and to keep the fence from heating up and melting or causing other damage.

When determining which energizer to install, remember that there is no really good way to compare one brand of energizer to another. Low impedance energizers deliver large amounts of energy with very little resistance and are probably the best buys. These low impedance energizers are high amperage and high voltage, and deliver an extremely short, 0.0003-second shock. The "shock" is a lot more powerful with the high amperage than older energizers, and the short duration shocks animals and people but releases them more quickly.

Rule of Thumb

For energizers, figure on needing one joule per mile of electrified fence wire. So, five miles of electric wire will need a 5-joule energizer.

Rule of Thumb

For electric fencing, 4,000 to 6,000 volts is generally adequate for cattle and horses. Sheep and goats will probably require 6,000 to 8,000 volts, especially when training them to the fences.

Set Up Your Energizer Correctly

When it comes to energizers, the most important thing is to set it up properly. That includes using the correct wire, grounding everything, and installing protective devices.

Never use household wiring on your electric fence — it is usually rated for only 600 volts and you will have 4,000 or more running through your fence. Always use double insulated high-tensile wire made especially for the purpose. Running an electrical wire through a schedule 40 PVC pipe or conduit provides extra protection where heavy traffic is expected.

For an electric fence system to work properly, it must be grounded. Make sure to ground the energizer correctly according to the manufacturer's instructions. If the manufacturer says you need to use three rods, then use three rods. The grounding system should be directed out toward the center of the energized system. Keep everything in the grounding system of the same material (that is, use all copper, or all brass, or all steel). Rods should be about 1/2 to 3/4 inch in diameter and 6 to 8 feet long. Connecting wire should be 9-gauge.

Burying rods, clamps, and wires underground will help ensure good soil contact, but more important, it will help keep the system from being damaged by livestock and equipment. Remember, the grounding system should be heading out toward the center of the pasture system, *not* installed inside a building. The grounding system needs moisture to work correctly. The grounding system is probably better described as an "earth return" and acts as the energizer's antenna. Spend the money on a good

energizer and grounding system because without it, the rest of the fence will have a hard time doing its job.

Be sure to protect your energizer investment by installing a lightning arrestor and surge protector. Cut-off switches near the energizer and at new fence breaks are handy because they'll allow you to switch off sections of fence as needed for repairs, to locate shorts, or to reduce unused electrical load.

Cut-off switches are handy because they allow you to turn off sections of the fence for repairs and to locate shorts.

Maintaining Fertile Soils

Like any crop, forages require sufficient soil nutrients to grow and thrive. To make sure your pasture is healthy and productive you need to know the nutrients in your soil and whether they are sufficient for growing the desired forages. Soil nutrient deficiencies are a leading cause of seedling failures and poor yields, so it is in your interest to test your soil. This chapter examines the importance of soil testing, shows you how to accurately sample soils, and provides recommendations for lime, nitrogen (N) phosphorus (P), and potassium (K) for grass or grass-legume pastures based on soil test results.

Get Your Soil Tested

Soil tests will determine precisely how much lime and fertilizer your soil needs. Such precision affects your bottom line. Guess and apply too little, and yields will suffer; guess and apply too much, and you not only have an unnecessary expense, you can also cause unintended plant growth, animal health, or environmental problems. Soil test at least six months before seeding pastures. For established pastures, test soils every three to four years to determine the need for additional lime and fertilizer.

Find a good, reputable soil testing laboratory and follow their recommendations. You should never tolerate oversimplified fertilizer recommendations like, "Apply 300 pounds of a blended 12-12-12 fertilizer" because such recommendations either under apply or over apply nutrients. The effort you take to sample soils properly, interpret the test results carefully, and apply the recommended nutrients intelligently, will pay big dividends.

When you send your soil to a lab, be sure to request, at a minimum, that the results show:

- Soil pH (a measure of soil acidity).
- Buffer pH.
- Phosphorus (P) and potassium (K) levels.
- Organic matter.
- Cation exchange capacity (CEC).

You may also want to consider requesting the soil's magnesium (Mg) levels because low Mg levels may induce grass tetany.

Collect Good Samples

An accurate soil test begins with good samples. To take soil samples for testing, you will need a sampling tube, an auger or spade, and a clean plastic pail. Obtain soil sample containers and field and cropping information sheets from a commercial soil testing service. You will use the field and cropping information sheets to show the areas where you took the samples, and to indicate the field's past cropping and fertility practices. In general, you should take soil samples the same time each year. Sampling from late spring to late summer usually provides a more accurate K soil-value assessment.

▸ Chapter 6

Soil nutrient deficiencies are a leading cause of seedling failures and poor yields, so it is in your best interest to test your soil regularly and apply amendments accordingly.

Find a Soil Testing Lab

Purdue Agronomy Extension maintains an online list of certified soil laboratories in Indiana at www.agry.purdue.edu/ext/soiltest.html

Rule of Thumb

Animals excrete at least 85 percent of the phosphorus (P) and 50 percent of the potassium (K) they consume. The goal of effective grazing management is to distribute these nutrients from manure evenly throughout the pasture.

For the best sampling results:

1. Divide the pasture into areas (10 acres maximum) that are uniform in soil color and texture, and that have similar land use and management histories. Producers who have pastures subdivided into paddocks may consider sampling soil from each paddock (provided the soil types, and use and management histories within the paddock are similar).
2. Sample each area separately by drawing 15 random soil cores. In established pastures, draw the cores from 2 to 3 inches deep. For new pastures to be seeded, draw cores to the depth of tillage (6-8 inches).
3. Do not sample within 200 feet of a gravel road, along field borders or other distinctly different areas, such as sandy ridges, eroded spots, or areas where hay or silage have been fed. You can, however, sample these areas separately if you want soil test information about them.
4. If the soil cores are wet, let them dry on clean paper. Once dry, place the 15 random cores from each area in a plastic pail and mix them thoroughly. Put each sample in a separate mailing container with the appropriate information, and send them according to the soil testing laboratory's instructions.

Liming to Adjust Soil pH

Proper soil pH is a basic requirement for optimum plant growth. If soil test results indicate that your soil is acidic (low pH), adding limestone will be recommended. Preferably, limestone should be applied six to 12 months before seeding to ensure sufficient time to lower soil acidity (i.e., raise the pH). If the soil test recommends 5 or more tons of limestone per acre, apply half of the limestone before the primary tillage and the other half before a secondary tillage.

In the table on page 23, the liming rates for maintaining established pastures are about half of what's recommended for pasture establishment, because established pastures aren't tilled before limestone is applied.

Most limestone recommendations are based on a 9-inch plowing depth. If you have mineral soils and the soil pH is more than 6.0 on established grass pastures or more than 6.6 on grass-legume pastures, you do not need to apply limestone. The SMP buffer pH (or "lime index," as it is commonly called in soil test reports), measures how readily a soil's pH will change after a limestone application. Highly buffered soils (that is, soils with a high cation exchange capacity, or CEC) have lower lime index values and require more limestone than soils with a low CEC.

If the soil test results recommend a limestone application and indicate that soil Mg is less than 150 pounds per acre, consider applying dolomitic limestone because it contains up to 22.6 percent magnesium carbonate ($MgCO_3$). Applying dolomitic limestone may help you resolve two issues at once: low soil pH and Mg levels.

Fertilizing

Rate of Application

The nitrogen (N), phosphorus (P), and potassium (K) fertilizer rates shown in the tables on page 24 depend on yield goals. P and K rates are lower for established pastures than they are for establishing or reestablishing pastures, because on established pastures grazing animals leave urine and feces that are high in these nutrients. Some estimates indicate that as much as 85 percent of the P and 50 percent of the K in consumed forage is recycled in the manure. One of the inherent advantages rotational stocking has over continuous stocking is that feces and urine are more evenly

Recommended Agricultural Limestone Application Rates for Grass and Grass-Legume Pastures[1]

Buffer pH (lime index)	Mineral Soils (less than 20 percent organic matter)	
	Soil pH <6.0 Grass Only	Soil pH <6.6 Grass-Legume
	For Renovation/Maintenance Tons of Limestone/Acre Needed	
> 70	0	1
68-70	1	1
67	1	2
66	2	2
< 66	3	4
	For Establishment/Reestablishment Tons of Limestone/Acre Needed	
> 70	1	2
69-70	2	2
68	2	3
67	3	4
66	4	5
65	6	8
< 65	7	8

[1]*These recommendations are based on certain assumptions about previous limestone applications, tillage depth, and limestone quality. Adjust rates for the following:*

1. *If limestone was applied within the last year, subtract the amount applied in the previous application from the amount recommended here.*
2. *The establishment/reestablishment rates are based on a 9-inch tillage depth. Adjust rates by 10 percent for every inch of difference in tillage depth (decrease rate by 10 percent for an 8-inch depth, increase by 10 percent for a 10-inch depth). Do not adjust rates by more than 30 percent (three inches).*
3. *Rates are based on 25 to 30 percent of the limestone passing through a 60-mesh sieve. If your liming product's fineness differs, check with your Purdue Extension Educator, crop consultant, or fertilizer representative for the appropriate adjusted rate at that level of fineness.*
4. *If you need to apply more than 5 tons per acre, a split application is recommended. Broadcast the first half and plow it down. Broadcast the second half and incorporate with a secondary tillage.*
5. *You may substitute 2 cubic yards of marl containing at least 70 percent calcium carbonate equivalent for 1 ton of standard agricultural ground limestone.*

distributed on the pasture surface. This better manure distribution, means P and K are also distributed more evenly, which helps maintain soil fertility and forage health — and that saves money.

The N recommendation table on page 24 recommends per-acre N rates for established grass pastures at various yield levels. Realistic pasture yield goals are 2 tons of dry matter per acre for Kentucky bluegrass and 4 tons of dry matter per acre for tall-growing, cool-season grass species, such as orchardgrass or tall fescue. Established pastures with more than 30 percent legumes require no additional N.

Nitrogen can be important to pasture establishment. For instance, 15 pounds of N per acre at seeding may benefit a grass-legume stand being established on light colored soils with less than 3 percent organic matter, and on coarse-textured (sandy) soils. For establishing a grass-only pasture, apply 50 pounds of N per acre prior to the last tillage on mineral soils.

The P and K table on page 24 recommends significantly higher K rates for grass-legume than grass-only pastures since grasses are much more competitive than legumes for available K.

Timing of Application

Application timing is just as critical as rate when it comes to N fertilization of perennial grass pastures. The best way to fertilize cool-season grasses is to ap-

Rule of Thumb

Test soils every three to four years. Test systematically based on planned management units, paddocks, or soil types.

Nitrogen (N) Recommendations for Grass-Only Pasture and Grass-Only Hay Production[1]

Crop Use	Recommendation When Per-Acre Yield (Dry Matter Basis) Is:		
	2 tons	4 tons	6 tons
	Pounds N/Acre		
Grass Pasture	55	100	150
Grass Hay	75	140	210

[1] *These recommendations are adjusted to credit the value of livestock waste based on 10 pounds of N recycled per ton of forage dry matter produced.*

Source: Purdue Extension publication ID-167-W, Maximizing the Value of Pasture for Horses, *www.agry.purdue.edu/ext/forages/publications/ID-167.htm*

Phosphorus (as P_2O_5) and Potassium (as K_2O) Recommendations for Grass-Only and Grass-Legume Pasture Renovation/Maintenance and Establishment/Reestablishment[1]

Soil Test Range			Grass-Only Pasture Recommendation When Per Acre Yield (Dry Matter Basis) Is:						Grass-Legume Pasture Recommendation When Per Acre Yield (Dry Matter Basis) Is:					
Bray P_1	Exchangeable K	Soil Test Level	2 tons		4 tons		6 tons		4 tons		6 tons		8 tons	
			P_2O_5	K_2O	P_2O_5	K_2O	P_2O_5	K_2O	P_2O_5	K_2O	P_2O_5	K_2O	P_2O_5	K_2O
Pounds/Acre[2]			Pounds/Acre						Pounds/Acre					
Renovation/Maintenance Levels														
0-10	0-80	Very low	80	60	100	120	120	180	100	240	120	360	140	480
11-20	81-150	Low	40	10	40	20	40	30	40	120	40	180	40	260
21-30	151-210	Medium	10	0	10	0	10	0	10	70	10	120	10	200
31-50	211-300	High	0	0	0	0	0	0	0	0	0	60	0	140
51+	301+	Very high	0	0	0	0	0	0	0	0	0	0	0	80
Establishment/Reestablishment Levels														
0-10	0-80	Very low	80	60	100	120	120	180	100	240	120	360	140	480
11-20	81-150	Low	60	50	80	100	100	150	80	200	100	300	120	420
21-30	151-210	Medium	30	40	50	80	70	120	50	150	70	240	90	360
31-50	211-300	High	20	30	40	50	60	90	30	80	50	180	70	300
51+	301+	Very high	0	0	20	0	20	0	20	0	40	120	50	240

[1] *The renovation/maintenance recommendations are adjusted to credit the value of livestock waste based on 85 percent of the P and 50 percent of the K being recycled in the forage dry matter. No adjustments are made when the soil test is very low.*

[2] *1 part per million = 2 pound per acre*

Source: Purdue Extension publication ID-167-W, Maximizing the Value of Pasture for Horses, *www.agry.purdue.edu/ext/forages/publications/ID-167.htm*

ply half of the recommended N in very early spring (mid- to late March), then a quarter of the recommendation in late spring, then the final quarter of the recommendation in late August or early September. This approach improves cool-season grass summer production when the moisture received is average or above average, and will result in greater late summer and early fall growth that can be stockpiled for use in late fall and early winter. The approach also keeps you from making mid- or late season applications, which could be a problem under drought conditions.

An alternative fertilization method is to apply two-thirds of the recommended N in very early spring, then the remaining third in late August or early September. If you can only make one N application each year, then make a broadcast application in the very early spring.

For warm-season grasses, apply N when the grass breaks winter dormancy, typically in the latter half of April.

Apply P and K annually according to yield goal and pasture type. Typically, late summer is the best time to apply K.

Do not apply K fertilizer in the late winter or early spring. K is generally not yield limiting until early summer and can have higher uptake by roots in the spring than is necessary for plant growth.

To reduce the risk of exposing animals to fertilizer, remove livestock from the pasture or paddocks to be fertilized until they receive a significant rainfall that will "melt" the fertilizer particles into the soil.

Source of N

For grasses, especially under dry soil conditions, ammonium nitrate is the preferred N source because it is less likely to volatilize to N gas. However, you can effectively use urea without volatilization loss if you make applications when the soil is moist or just before a rain. Some urea products also are formulated to have less volatilization loss. Ammonium sulfate contains readily available N, but creates more soil acidity than other N fertilizers.

Understanding the Fertilizer Analysis

You need to know how to read a fertilizer analysis to understand your fertilizer needs. That begins by knowing what the three numbers in a fertilizer analysis mean. For example, you may see something like "18-46-0." The first number is the percentage of N, the second is the percentage of P_20_5, and the third is the percentage of K_20.

Or simply, the numbers in an analysis are: percent N-percent P_2O_5-percent K_2O.

P and K rate recommendations (like those in the tables above) are based on oxide formulations (P_2O_5 and K_2O), while the N rates are on an elemental basis. It's important to remember that the actual application rates of fertilizers vary according to the fertilizer's elemental analysis; no fertilizer is 100 percent N, P_2O_5 or K_2O. For example, elemental N varies widely according to product, P_2O_5 (phosphate) contains about 44 percent elemental P. K_2O usually contains about 83 percent elemental K.

Knowing how to interpret the analysis and rates will help you accurately communicate your fertilization needs. Misunderstandings can result in costly misapplications. For example, you may know you need to apply 200 pounds of potash (K_2O) per acre, but an applicator may only apply 200 pounds of muriate of potash, which is 0-0-60, or 60 percent K_2O. Consequently, the applicator would have applied only 120 pounds of K_2O per acre, not the 200 pounds per acre called for in the recommendation.

▸ Chapter 7

In Indiana, pastures are usually composed of perennial cool-season grasses and legumes.

Find Soil Surveys

Find USDA-NRCS published soil surveys by state at http://soils.usda.gov/survey/printed_surveys or http://websoilsurvey.nrcs.usda.gov/app

Determining the Right Forage Species to Grow

Selecting the appropriate forage for your pasture is an important decision. There is a wide range of forage species available, and each has its own particular characteristics, making it more or less suitable for your intended purpose.

You must consider many factors when selecting forage species. One of the first things to consider is the need to match the forage species to your soil's characteristics (drainage, fertility, and pH). County soil survey books are resources that describe a particular soil's limitations for agricultural production, which can be helpful information, especially if the land hasn't been farmed before. You'll also need to decide how you will use your crop and how much time you want to devote to management. All these factors will help to decide if you should plant perennials or annuals, and whether the selected forage will be a pure stand or a mixture of adapted and complementary grasses and legumes.

Perennial Forages: Your Pasture's Backbone

On the majority of your long-term pastures, you should seed perennial crops, including cool-season grasses, legumes, and warm-season grasses. In Indiana, the base pasture is usually composed of perennial cool-season grasses and legumes. You should only consider adding a perennial warm-season grass component to your pasture after you have managed the base pasture successfully for a period. If you do add warm-season grasses, be sure their forage quality is not a limiting factor. Warm-season grasses are best managed separately from any cool-season forages.

Cool-season grasses grow best in the spring and fall when temperatures are cool, while warm-season grasses grow best when temperatures are warm. To make management easier, you should not mix cool-season and warm-season grasses together. Instead, sow them in separate paddocks. As a rule-of-thumb, your warm-season grass pasture acreage should not exceed 25 percent of the total system.

The graph below provides a general comparison of growth during the growing season for cool-season grasses, warm-season grasses, and legumes.

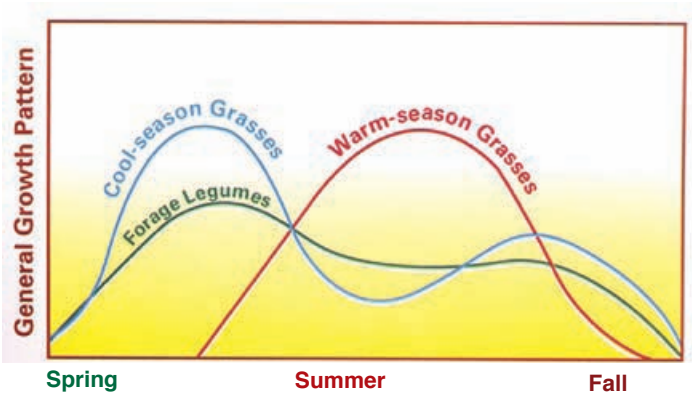
Mixed Stands vs. Pure Stands

Before you select a particular perennial crop, you need to weigh the benefits and drawbacks of pure stands and mixed stands, then determine which is best for you.

Pure Stand Advantages

Pure stands of cool-season grasses or legumes have a few advantages over mixed stands of cool-season grasses and legumes. Pure stands:

- Ease the amount of management you'll need to practice in order to keep all species within the mixture competitive.



Source: FFR Cooperative

Example of a Seed Mixture's Weight Compared to Potential Stand

Species		Hypothetical Seed Mix		Potential % of Stand
Name	Seeds per Pound	% of Seed (by weight)	Number of Seeds per Pound of Mix	
Alfalfa	227,000	40.0	90,800	22
Red Clover	272,400	29.3	79,750	19
Timothy	1,164,510	14.3	167,100	41
Orchardgrass	429,000	9.4	40,410	10
Alsike Clover	681,000	4.8	32,410	8
Other Crops		0.3		
Inert Matter		1.7		
Weed Seed		0.2		
Total		100	410,470	100

- Increase the number of herbicides you can use. Weed control options are more limited in mixed pastures.
- Improve forage quality. Pure legume stands are usually higher in forage quality than pure grass stands or mixed stands.

Mixed Stand Advantages

Mixed stands of cool-season grasses and legumes have a number of advantages over pure stands. Mixed stands:

- Eliminate or lower the need for nitrogen fertilizer. Pure grass stands need nitrogen, but legumes in a mixed pasture generally should provide enough nitrogen for grass growth when they compose at least 30 percent of the stand.
- Lengthen a pasture's lifespan because grasses typically remain even after the legumes are reduced.
- Reduce "heaving" damage to legumes. Heaving is caused by late winter and early spring freeze-thaws that raise legume plants from the soil surface. Grasses hold legume plants in place better than pure legume stands.
- Reduce soil erosion on steep slopes. Grasses have a more massive root system and are better for soil conservation purposes than pure legume stands.
- Improve livestock performance. A grass-legume mixture can improve animal gain and breeding performance over a pure grass stand, especially when the grass is tall fescue infected with the endophytic fungus. Mixed stands also can reduce animal problems associated with grass tetany or bloat.
- Can help reduce the summer slump of grass-only pastures if you add drought-tolerant legumes, such as alfalfa, birdsfoot trefoil, or red clover.

In any well-managed pasture, perennial grasses will last indefinitely. But perennial legumes in mixed stands tend to need reseeding more often than grasses. Consider renovating pastures when the legume contribution is less than 30 percent of the dry matter yield.

Avoid Prepackaged Mixes

Generally, prepackaged mixes of many grass and legume seeds offer no advantage. These prepackaged mixes do not allow you to match the best grass and legume species to the soil types on the farm. So, over time, just two or three forage species in the prepackaged mix will survive because of your soil type, grazing management, or fertilization program. Such a small number of forage species in the established stand is far less than the six or more species of seeds from the original mix. What's more, the

Rule of Thumb

Warm-season grass pasture acreage should not exceed 25 percent of the total pasture acreage.

Soil and Other Considerations for Selected Forages

Species	Soil pH (Minimum Adequate Level)	Soil Drainage[1]	Comments
Cool-Season Grass Perennials			
Kentucky Bluegrass	5.8-6.5	SPD	Excellent quality, low yield, drought intolerant.
Orchardgrass	5.5-8.2	SPD	Use late-maturing varieties when legumes are a component of a mixture. Select varieties with disease resistance.
Reed Canarygrass	5.8-8.2	VPD	Do not seed near natural wetlands. Use low-alkaloid varieties. Graze immature stages for best animal performance and to stop seed escape to natural wetlands.
Ryegrass	5.6-6.2	SPD	Excellent quality, drought intolerant, quick establishment. There are canopy growth differences among varieties (compact or tall). Annual ryegrass is actually a weak perennial.
Smooth Bromegrass	5.8-6.5	SPD	Do not graze regrowth too quickly or the stand can be depleted. Less productive at mid-season compared to tall fescue or orchardgrass.
Tall Fescue	5.4-6.2	SPD	Use low-endophyte or friendly endophyte varieties only. Drought tolerant, stockpiles well.
Timothy	5.4-6.2	SPD	Compared to other cool-season grasses, timothy is late to mature and there is less production after first use. Winter hardy but not long-lived.
Warm-Season Grass Perennials			
Big Bluestem	5.4-6.2	MWD	Not a good choice for lactating dairy.
Eastern Gamagrass	5.5-6.5	SPD	Nicknamed the "ice cream grass." Soak seed in water and chill before seeding.
Indiangrass	5.4-6.2	MWD	Not a good choice for lactating dairy.
Switchgrass	5.4-8.2	SPD	Earlier to mature compared to big bluestem or indiangrass. Less proportion of vegetative to seed head tillers compared to big bluestem, eastern gamagrass or indiangrass. Not a good choice for lactating dairy.
Annual Grasses			
Corn	6.0-6.5	MWD	Strip crop pasture. Allow livestock that do not require high forage quality to graze residues following grain harvest.
Foxtail Millet	>5.5	MWD	Excellent double crop alternative. Lower palatability than pearl millet, sudangrass, or sorghum x sudangrass. Does not have prussic acid.
Pearl Millet	6.2-6.8	MWD	Regrowth slower than sudangrass or sorghum x sudangrass. Excellent double crop alternative. Does not have prussic acid.
Sorghum x Sudangrass	6.0-6.5	MWD	Brown midrib hybrids are available. Prussic acid content is a concern. Higher yielding than sudangrass. Excellent double crop alternative.
Spring Oat	6.0-6.5	MWD	Good for fall or spring grazing. A good grass to include with turnip. Does not overwinter.
Sudangrass	6.0-6.5	MWD	Prussic acid content is a concern. Excellent double crop alternative. Brown midrib sudangrass hybrid is available.
Winter Rye	5.8-6.2	SPD	Winter annual. Late fall to early spring pasture. Very winter hardy.
Winter Triticale	5.8-6.2	SPD	Winter annual. Late fall to early spring pasture. A manmade cross between wheat and rye.
Winter Wheat	6.0-6.5	SPD	Winter annual. Late fall to early spring pasture. Can also produce a cash grain crop, provided livestock do not graze the elongating seed head.
Legume Perennials			
Alfalfa	6.6-7.2	WD	Has potential to cause bloat. Potato leafhopper-resistant varieties are available.
Alsike Clover	6.0-6.5	PD	Acts as a biennial. Can cause photosensitivity, so do not include in pastures used by horses.
Birdsfoot Trefoil	6.0-6.8	SPD	Do not overgraze. Complements Kentucky bluegrass. Low seedling vigor. Does not cause bloat.
Red Clover	6.2-6.8	SPD	Excellent pasture renovation crop. Weak perennial. Can cause bloat. Can cause slobbers in horses, especially during warm and humid conditions. Medium red clover is preferable to mammoth red clover.

Soil and Other Considerations for Selected Forages (continued)

Species	Soil pH (Minimum Adequate Level)	Soil Drainage[1]	Comments
White Clover	6.0-6.5	PD	Commonly called ladino clover, although several different subspecies exist. Low yielding. Apt to cause bloat if it is a major pasture component. Excellent pasture renovation crop. Can cause slobbers in horses, especially during warm and humid conditions.
Legume Annuals			
Annual Lespedeza	5.5-6.2	SPD	Late summer pasture or hay. Must reseed itself annually to persist. Striate and Korean are types of annual lespedeza.
Forbs			
Turnip	5.3-6.8	WD	Not a grass or legume. The leaf:bulb ratio varies distinctly among varieties. Very high quality. Frost tolerant, but not freeze proof. Excellent double crop alternative.

[1] *VPD = very poorly drained*
PD = poorly drained
SPD = somewhat poorly drained
MWD = moderately well drained
WD = well drained

varieties in these mixes are often older varieties that may not have the same advantages as newer releases.

These mixes can also be a source of confusion when the percentage of each forage species' seed is listed by weight. Seed sizes vary among species. The table on page 27 provides an example of this problem. Let's say you have a seed bag that contains the seed percentages described in the table. The timothy, for example, contributes only 14.3 percent of the package's total weight, but could contribute up to 41 percent of the total stand. Seed size should influence the pounds of each forage seed ordered when mixtures are developed.

Annual Forages Can Improve Efficiency

Indiana and, more generally, the Midwest have distinct seasons that create unique double crop opportunities that can help you improve your grazing system's efficiency over perennial forages alone. For example, when used properly, annual crops can provide quick growing emergency or supplemental feed or extend the grazing season. Annual crops can also be rotational crops between alfalfa seedings, helping to reduce autotoxicity concerns or to convert less desirable forages (such as endophytic-fungus infected tall fescue) to improved forages.

Many annual crops grow best in particular seasons of the year, so you must consider carefully when you should use annual crops. Remember, annual crops must be found, purchased, and seeded in a timely fashion each year. There also is a risk that your stand can be variable from year-to-year.

If a double crop system can reduce your feed expenditures or provide benefits to the soil, then you should make double cropping part of your farming enterprise. Remember, there may be years when purchasing hay will be a cheaper, less risky venture than seeding double crop forages.

Specific double crop systems that warrant consideration include:

- Small grains (wheat, barley, and oat) harvested as grain and immediately followed with a summer-annual grass or forage turnip.
- A perennial hay crop harvested for the last time in spring followed by a summer-annual grass or forage turnip.

FIND OUT MORE

For more information regarding agronomic practices refer to Purdue Extension publication AY-263, *Producing Emergency or Supplemental Forage for Livestock*, www.agry.purdue.edu/ext/forages/publications/ay263.htm or AY-324-W, *Managing Alfalfa Autotoxicity*, www.ces.purdue.edu/extmedia/AY/AY-324-W.pdf.

You can find additional identification and crop use information on the following Web sites:

http://plants.usda.gov

www.agry.purdue.edu/ext/forages

http://forages.oregonstate.edu

- Corn silage harvest before early September followed by spring oat, forage turnip, a winter annual-small grain, or annual ryegrass.
- Soybean as an oilseed (grain) harvested in very late summer or early autumn followed by a winter-annual small grain or annual ryegrass.
- Corn residues grazed immediately after corn grain harvest. One could argue that this is not a true double crop system, but rather a more intense use of the corn crop.

Selecting Forages

Proper soil pH and drainage are critical considerations when selecting forages to meet your livestock's needs. The table on pages 28 and 29 shows the minimum levels of soil pH and drainage many forage crops need. Remember, you can increase soil pH by applying agricultural limestone and you may be able to improve soil drainage economically with tiling. The comments in the table should help you narrow your options to the strongest candidates. The table does not list all of the forages adapted to Indiana, but it does offer the best possibilities.

Grazing Management Considerations

After carefully considering all the physical components required for rotational grazing, it is time to turn your attention to management considerations to make it all work properly with your livestock and landscape.

The first chapter in this section will help you determine the size of your paddocks and how long your livestock should remain in each one.

The second chapter provides advice on stockpiling forages in the fall to increase your grazing season and reduce the costs of feeding hay.

The third and fourth chapters discuss the need to protect environmentally sensitive areas, such as streams and woodlands.

The fifth chapter discusses the importance of maximizing the grazing behavior of the livestock species you will be grazing.

The last chapter in this section examines selected plants that could affect the health or safety of your livestock.

▸ Chapter 8

Stocking rates are typically measured in animal unit months (AUM), or the amount of forage needed per 1,000 pounds of animal per month. As stocking density increases, the time that can be spent grazing a paddock decreases.

Determining Length of Stay in Paddocks

One of the most frequently asked questions about rotational and management-intensive grazing systems is, "How short should the pasture be grazed?" Or, put another way, "How long may animals remain in a paddock?"

The answers to such questions depend on several factors, but the two major factors are the amount of forage available at any given time and the stocking rate.

To estimate the length of stay in a paddock, you need to consider certain variables. For example, if animals enter the paddock when the forage is 8 inches tall and exit when it is 4 inches, there are 4 inches of usable forage. If the animals graze 60 percent of the available forage and the forage is producing 250 pounds of dry matter per inch per acre, the animals have 600 pounds of dry matter per acre available to them.

A 1,000-pound cow consuming 3 percent of her body weight in pounds of dry matter per day requires 30 pounds per day. Divide the 600 pounds that are available from the above calculation by 30 pounds, and the acre of pasture has 20 cow-days available. So, 20 cows could graze this acre for a day or 10 cows could stay for two days. Equations to figure paddock size and livestock-specific calculations are at the end of this chapter.

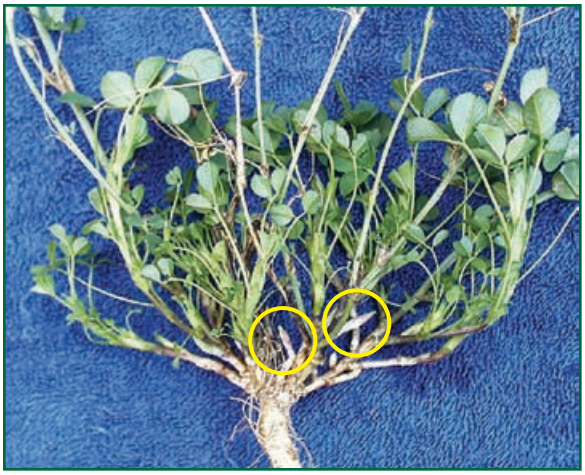
Another consideration is the amount of forage that a calf consumes as the grazing season continues. Twenty-five calves may need 150 pounds or more of dry matter per day.

As a summer slump in forage production develops, the "length of stay" could increase by half a day per paddock. If you have an eight-paddock system, then seven paddocks are resting. If you multiply the number of resting paddocks (seven) by this extra half-day, then you have an extra 3.5 days of rest per rotation for each paddock; a 16-paddock system would result in 7.5 days of extra rest.

Graziers face the dilemma of knowing how short they can graze or mow the pastures and still obtain maximum productivity during an extended period. The problem is compounded by varying climate conditions, growth habits of different plants, and livestock preferences for different plants. Plant growth also is affected by the time of the year and stage of the plant when harvested.

If you allow animals to stay in a paddock for more than four days, they will "regraze" some areas and allow others to continue growing and maturing. As a result, the paddock ends up with areas of very short forage, which will need a longer time to recover and regrow. The longer rest period will affect the length of rotation, plus such areas tend to be populated with unimproved white clover or bluegrass because they can tolerate frequent, close grazing. In the less grazed areas of the paddock, there will be tall, mature (hence, less desirable) forage.

All plants have growing points where new cells develop. In grasses, the growing points are just above the last complete joint of each stem. Early in the season, growing points are located at the bases of the plants. As the season progresses, the joints of most species elongate and push upward to produce a seed stalk. When that happens, the growing point is elevated and in a vulnerable position. When you remove the growing point by grazing or mowing, the plant responds by producing new leaves from its base and starts over as if it were spring. But starting over causes an additional drain on the root reserves and can weaken the plant.



The meristems (buds) shown on this alfalfa plant are essential for regrowth. If the developing meristems are grazed too quickly, the stand will decline.

Smaller paddocks and less time in each reduce the likelihood of paddocks with areas of tall and short growth.

Maintain a Balance

As you begin an improved grazing management program, keep both plant growth and animal performance in mind. Balancing plant and animal requirements is difficult, but necessary, for increased efficiency and profit. Generally, plants are favored when they are harvested at maturity. However, the forage quality is low at maturity and animal performance suffers. If plants are harvested when they have active growth and they are high in quality, animal performance will be optimal. The challenge for the grazier is to achieve the optimum balance between plant and animal requirements.

Rules of Thumb

- When grazing a paddock, take half and leave half.
- Leave 3 or 4 inches of cool-season grasses after grazing.
- Leave 6 to 8 inches of warm-season grasses.

Plants can be grazed quite short in the spring but more leaf surface must be left as the season progresses so that the plant can continue to build a strong root system. The better the root system, the better the plant can tolerate heat and drought stresses. Plants also recover much faster if a large amount of leaf surface remains to reactivate the production phase. Furthermore, fresh growth is the most palatable to livestock, so it just makes sense to graze the best and leave the rest to speed recovery.

In individual paddocks, it's still good to follow the "take half and leave half" rule. That means you should move animals into a paddock and let them eat about half the grass height and leave the other half. For most cool-season forages, a healthy height to leave behind is typically 3 to 4 inches. For most warm-season grasses, a healthy residual is typically 6 to 8 inches. Refer to page 35 for the specifics of each forage. Grass plants left at this height retain a sufficient amount of vegetation to allow them to continue capturing solar energy, which in turn, lets them recover and grow without drawing on their root reserves.

Make Your Calculations

Graziers may want to estimate the number of animals that can be assigned to a given area or they may want to estimate the number of days a group of livestock could graze an area.

The equations on the next page are followed with examples using the following assumptions:

- You have 4 inches of available forage.
- You have a forage that yields 300 pounds of dry matter per inch per acre.
- You have a two-acre paddock.
- Your animals have a 60 percent grazing efficiency.
- You have 12 steers that weigh 900 pounds each.
- Your animals will consume 2.5 percent of their body weight per day.
- You have a five-day rotation in each paddock

Strip grazing annuals greatly increases forage utilization and efficiency.

How Many Animals per Paddock?

Use the following equation to determine the optimum number of animals you can graze in a paddock:

$$\text{number of animals per paddock} = \frac{\text{available inches of forage} \times \text{pounds of forage dry matter per acre/inch} \times \text{paddock acres} \times \text{grazing efficiency}}{\text{animal weight} \times \text{daily forage dry matter intake (as percentage of body weight)} \times \text{days in the paddock}}$$

For example (using the assumptions above):

$$\text{number of animals per paddock} = \frac{4 \times 300 \times 2 \times 0.6}{900 \times 0.025 \times 5} = 12.8$$

So, you can graze:

- Approximately 13 animals in the two-acre paddock for five days.

or

- 32 animals in the two-acre paddock for two days.

How Many Days in A Paddock?

Use the following equation to determine the optimum number of days you can graze animals in a paddock:

$$\text{days of stay in a paddock} = \frac{\text{available inches of forage} \times \text{pounds of forage per inch/acre (dry matter)} \times \text{acres} \times \text{grazing efficiency}}{\text{animal weight} \times \text{daily forage dry matter intake (as percentage of body weight)} \times \text{number of animals}}$$

For example (using the assumptions above):

$$\text{days of stay in a paddock} = \frac{4 \times 300 \times 2 \times 0.6}{900 \times 0.025 \times 12} = 5.3$$

So, your 12 steers could remain in that paddock for about five days.

How Many Paddocks?

Use the following equation to determine the optimum number paddocks you should have in your pasture:

$$\text{number of paddocks} = \frac{\text{days of rest}}{\text{days of grazing}} + 1$$

So, if you plan to graze each paddock for five days and rest each paddock for 30 days:

$$\text{number of paddocks} = \frac{30}{5} + 1 = 7$$

So, you would need seven paddocks.

Grazing Efficiency

System	% Efficiency
Continuous	40
4 paddocks	45
8 paddocks	60
12 paddocks	65
24 paddocks	75

Daily Forage Dry Matter Intake

(as percentage of body weight)

Livestock	Intake
Dry Cow	2-2.5%
Lactating Beef Cow	3-4%
Lactating Dairy Cow	3-4% + grain
Stocker	2.5-3.5%
Horse	2-3% + grain
Sheep and Goat	3.5-4%

Estimated Dry Matter Yield

(pounds per acre per inch with 75-90% forage cover)

Forage	Pounds per Acre per Inch
Tall fescue + legume	200-300
Tall fescue + nitrogen	250-350
Kentucky bluegrass	250-400
Red clover or alfalfa	200-250
Orchardgrass + legume	250-300
Cool-season grass mix	200-300
Native warm-season grass	100-200

Lactating beef cows need to consume 3 percent to 4 percent of their body weight in forage dry matter each day.

Grazing and Hay Harvest Guide for Some Commonly Grown Forages in Indiana

Forage Species	Height to Start Grazing (inches)	Height to Start Grazing Regrowth (inches)	Height to Remove Livestock (inches)	Rest Period (days)	When to Cut for Hay, Silage, or Balage[1]	Height for Overwintering (inches)	Approximate Date to Begin Rest for Winter Protection	
							(Northern Areas)	(Southern Areas)
Kentucky Bluegrass	4-6	4-5	2-3	14-30	Boot	3	N/A	N/A
Orchardgrass, Tall Fescue, Perennial Ryegrass, Other Non-jointed Grasses	6-8	6-8	3-4	Spring: 14 Summer: 30-45	Boot, peak regrowth	3-4	[3]	[3]
Smooth Brome, Timothy, Reed Canary, Other Jointed Grasses	8	8	4	Spring: 14 Summer: 30-45	Boot, peak regrowth	5-6	Sept. 1-Oct. 1	Sept. 20-Oct. 20
Alfalfa	12	8-10	3-4	24-32	Late bud to early bloom	6	Sept. 1-Oct. 1	Sept. 20-Oct. 20
Birdsfoot Trefoil	10-12	10-12	5-6	24-45	¼ bloom to full bloom	5	Sept. 1-Oct. 1	Sept. 20-Oct. 20
White Clover	6-10	8-10	2	24-32	Early to ½ bloom	4	Sept. 1-Oct. 1	Sept. 20-Oct. 20
Red and Alsike Clovers	10-12	8-10	3-4	24-45	Early to ½ bloom	5	Sept. 1-Oct. 1	Sept. 20-Oct. 20
Sudangrass	18-20	18	8-10	14-30	Boot	N/A	N/A	N/A
Sorghum-Sudangrass Hybrid	24-30	24	8-10	14-30	Boot	N/A	N/A	N/A
Pearl Millet	18-20	18	4-6	14-30	Boot	N/A	N/A	N/A
Japanese Millet	12-18	12-18	4-6	14-30	Boot	N/A	N/A	N/A
Small Grains	8-10	8	2-3	N/A	Early head	N/A	N/A	N/A
Switchgrass, Big Bluestem, Indiangrass	12-18	12-18	8[4]	21-45	Boot to early head	8-12	Sept. 1-Oct. 1[2]	Sept. 20-Oct. 20[2]
Little Bluestem, Sideoats Grama	12-14	12-14	6-8[4,5]	21-45	Boot to early head	6-10	Sept. 1-Oct. 1	Sept. 20-Oct. 20
Brassicas	Fall: 12-14	12	4-6	14-45	N/A	N/A	N/A	N/A
Annual Lespedeza	6-8	6-8	3-4	14-30	Early bloom	6	N/A	N/A

N/A = Not Applicable
[1] Boot: most heads in upper leaf sheath, but prior to emergence.
Early Head: tips emerging on no more than 10% of stems.
Medium Head: about 50% of the heads emerged or emerging.
Full Head: most heads fully emerged but prior to flowering.
[2] Protection from fall grazing is recommended. Perennial warm-season grasses can have limited grazing after killing frost, when applicable.
[3] No restrictions with fescue, orchardgrass, and ryegrass.
[4] Leave 8 to 10 inches of stubble at end of season until after killing frost.
[5] 4 inches above the lowest node is the best indicator.
[6] Allow to set seed during season.

▸ Chapter 9

Livestock typically will graze through snow at least eyeball deep. They'll often turn down 'good' hay for stockpiled forage.

Using Stockpiled Perennial Forages to Your Advantage

Fall and winter grazing is a great way to reduce winter feed costs. Whenever you can extend the grazing season, that's money in your pocket.

Stockpiling forage for the winter allows you to extend the grazing season. The practice of stockpiling involves growing forage in late summer and early fall for grazing in the winter. Instead of harvesting this forage for hay, you allow it to stand in the field for your livestock to harvest later, after it has entered dormancy. Stockpiling, then, typically refers to fall growth.

The basic concept behind stockpiling is:

1. Graze or harvest a paddock in late summer.
2. Take that paddock out of rotation.
3. Apply nitrogen fertilizer to that paddock for greater yield.
4. Allow livestock to graze in that paddock after the end of the growing season, thereby extending the season.

Apply Fertilizer to Boost Growth

Toward the end of the summer and into the fall cool-season grasses begin growing quite well again. If August rain is plentiful, applying nitrogen fertilizer in mid-August to early September can increase the forage's dry matter yield, crude protein content, and digestibility.

The percentage and types of legumes in the sward will influence how much nitrogen you should apply to the stockpiled forage. When the sward contains 30 percent or more of legumes, do not apply additional nitrogen to the stockpiled forage.

When the sward contains 15 to 30 percent legumes, then applying 30 to 40 pounds of actual nitrogen per acre is beneficial, and will certainly boost yields if rainfall is above average. Such areas also could be grazed a little harder after dormancy in order to help open up the sward to enhance legume content the next spring.

When the sward contains less than 15 percent legumes, then you should apply 40 to 60 pounds of actual nitrogen per acre to boost yield and increase quality. Such areas should be grazed until less than two inches of residual growth remains, then overseeded with an adapted legume in late winter. Be careful not to overgraze the pasture. Your objective is to set the grass back a bit, not destroy it. Overdoing it can lead to excessive white clover (where there is a seed bank in the soil), or a weedy pasture.

Alfalfa can also boost fall grass growth and provide a fair amount of nitrogen, but it is not normally paired up with the most ideal cool-season stockpile grass, tall fescue. When alfalfa is a component of stockpiled forage, remember that alfalfa will not tolerate being grazed under wet conditions because of potential crown damage, and that residual grass cover reduces heaving of alfalfa plants.

Tall fescue, with or without the endophytic fungus, can potentially stockpile better than any other perennial forage adapted to Indiana. Tall fescue also can maintain its nutritional value throughout the winter.

Fall-grown tall fescue can average 13 to 18 percent crude protein (depending on how much nitrogen was available to the stand) and can maintain good nutritional value through the winter. Tall fescue seldom drops below 11 percent crude protein and 62 percent digestibility, even as late as early March. Those levels still make it better feed than some hay. Still, it is always a good idea to test forages to make sure they

are meeting your livestock's nutritional requirements.

Getting the Most from Stockpiling

Defer grazing (stockpile) at least one acre of pasture per 1,000 pounds of live weight. Here are some tips to make stockpiling more efficient:

1. Graze or hay the paddocks to be stockpiled in early to mid-August to initiate new, vegetative growth.
2. Apply 0 to 60 pounds of actual nitrogen (depending on the legume stand) in mid-August to early September.
3. Let the stockpiled area grow and rotate through the rest of the paddocks or other areas as long as possible.
4. Graze the stockpiled area after it is dormant to protect carbohydrate reserves.
5. Preferably, strip-graze stockpiled forage by allocating 2 to 3 days worth of forage at a time.

By allocating a small area for a short period of time, the animals do not waste as much forage by trampling. Step-in posts, electrified poly-wire, and a reel make strip-grazing a very easy practice. Strip-grazing is the practice of temporarily fencing off allotments of forages for use as feed for a particular time period. With careful observation when moving the fence to make additional allocations, you can make future allocations of stockpiled forage. Start grazing near the water source and work away from it. Back-grazing or back-fencing is not a concern; just move forward until that particular field/paddock is consumed, then move to the next.

Snow is not a problem; livestock will graze through snow at least eyeball deep. Animals will turn down "good" hay in preference to stockpiled forage.

A Plan for Streamside Grazing

There are some who say livestock should be permanently fenced away from all streams and water bodies, but there is another approach. Livestock can be working tools that, when used properly, can benefit the streamside ecosystem.

Flash Grazing is the Key

You probably still should fence off creeks, but streamsides can still be grazed periodically using a practice called flash grazing. Flash grazing, or removing forage from an area with a precise number of animals, can offer the best of both worlds: you can maintain more vegetation in the area by keeping animals away most of the time (which helps slow streambank degradation and runoff), plus you can harvest a fair amount of forage with grazing livestock while both feeding them and helping maintain the area.

You should install fencing far enough away from the creek (about 25 to 30 feet), so you can use equipment there if necessary. Leave larger areas on the ends, as needed, for equipment turnarounds.

The streamside can be subdivided into areas that provide no more than two days' worth of grazing. Of course, this depends on the number of animals in the herd. After livestock graze, rest these areas for at least 30 days before grazing them again.

Do not allow livestock to graze these streamside areas during wet periods when excessive compaction or erosion problems can occur.

▸ Chapter 10

Flash grazing riparian areas is an effective management tool to keep banks stabilized. In this practice, livestock are concentrated in a small area for a short time (usually less than two days) when banks are dry and compaction and erosion are less likely.

The fencing you set up near a stream can be very simple, particularly for a cattle operation. A single strand of high-tensile wire about 30 inches off the ground on wood posts is easy to maintain and is less likely to be taken out by flooding water. Depending on the terrain, you can space posts up to 50 feet apart with no problems.

Protect the Water

If livestock are watering directly from the stream or creek, then water quality is a concern not only downstream, but for the livestock, too. Several studies have shown that clean water is important to cattle performance. Cattle perform up to 20 percent better when they drink clean water.

Researchers in Minnesota and Canada actually found that cattle commonly access, drink, or cross watercourses without voiding. So, what's the big problem with cattle in the stream? Thinking beyond the major problems concentrated livestock might pose, livestock typically use streams for loafing and drinking. The researchers found that most problems with water quality arise from animals walking or standing in the water and stirring up sediment. That sediment is often very high in coliforms. So, while livestock may not be the source of the bacteria, they can stir it up.

The researchers learned that high bacterial concentrations are often found at cattle access points where actual disturbance of the streambed material occurs. These concentrations decreased rapidly over time after the disturbance stopped. However, sites that have solid or constructed rock bottoms were significantly lower in bacteria concentrations.

Clean drinking water can be obtained from streams when we build crossings and access areas. If natural rock crossings do not exist, then the next best thing is to build one. If you build one with number 2 stone, it is large enough to be uncomfortable underfoot, so livestock are not tempted to lounge in the water, but livestock will still use the crossing or access site. In some larger streams, you may need larger rock or concrete to keep rock in place. Crossings sometimes need a permit before building.

An alternative is to only allow livestock to flash graze the streamsides. You can provide water to the surrounding paddocks by pumping from the stream or alternative water sources.

Managed carefully, flash grazing streamsides can improve water quality, reduce valuable grazing land loss, help increase value to wildlife, reduce bank erosion, and, over time, increase the public perception that most Indiana livestock producers are trying to do a good job of protecting streamsides and water quality.

Rather than allow livestock to wade into creeks, you can pump water from the stream into a tank.

▸ Chapter 11

Cows make poor woods and woods make poor cows. Decide what your woodland lot is best suited for—timber or pasture — and manage for only one.

The Question of Woodland Grazing

Historical Perspectives

When European pioneers first came to Indiana, the state was primarily vast woodlands with some prairies and savannahs. If they wanted to start farming and raising crops, they had little choice than to start clearing ground. The pioneers used livestock as labor to help pull and remove the trees and stumps, and to help keep the area from growing back to trees. Over the years, ground that made the best cropland for row-crops pretty much stayed cropland. Land that was too steep or prone to excessive erosion went back to trees. No matter where you find it, if it is woodland, there is probably a reason why it is in trees.

That is a long introduction for the question this chapter answers: Should you graze woodlands, or not?

Some of the Pros

Graziers may offer several reasons why their livestock are in the woods; truffle hunting is not one of the better ones. Woodlands certainly have some desirable attributes. For example, woods can provide some shade on really hot days, they often have some water available, they have some browse that livestock will eat and might benefit from, they can provide an alternative place to run livestock while you're resting open pasture, they can provide some shelter during the winter, and grazing is an easy way to remove some unwanted woodland vegetation.

And a Lot of Cons

Now, some reasons for why you shouldn't allow livestock to graze in woodlands.

Livestock can and will remove small trees and understory, thus removing future generations of possible timber trees which could easily affect two or more generations of landowners. Livestock can also destroy the humus layer, or thin organic layer (floor), protecting the other woodland soil, which can lead to excess erosion and compaction.

Woodland lots are often on steeper sites that can include steep ravines already very prone to erosion. Livestock accelerate the erosion process. If left in the woods for any extended time, livestock will make a real mess, especially if there is water involved. They'll also destroy any aesthetic value, and that could take a decade or more to replace. So, grazing causes more long-term erosion damage to your land than any short-term advantages you could gain for your livestock.

Woodland grazing can have negative effects on your livestock. Under heavy canopy, there is very little true forage that would make good grazing. In fact, it often takes 15 or more acres of woodland to equal the food value of just one acre of open pasture.

Livestock are also quite susceptible to poisonous plants common to woodlands, including white snakeroot, black cherry, and up to 50 other toxic plants. Areas with deep ravines, very steep areas, wet areas, or streams should be managed solely for woodlands or wildlife because such areas are extremely challenging places to find newborns.

Livestock also cause long-term damage to harvestable timber by causing dark, ugly rings to appear in harvested lumber. That's because livestock often injure a tree's bark, creating points of entry for organisms that reduce timber quality. Because of the likelihood of staining or decay in the butt logs (usually the most valuable portion of a

tree), timber buyers discount the price on timber from woods that have been grazed. Soil compaction by livestock also affect the trees' feeder roots, which are in the upper few inches of the soil, making it difficult for the tree to absorb needed nutrients and water, which can reduce growth, cause crown dieback, and make the tree more susceptible to diseases and insects.

So, do we graze woodlands or not?

Pick One or the Other

First, you really need think about what you want from this ground. Do you want to manage it for timber, or do you want it for pasture? Which is it best suited for? People have certainly tried to do both and it rarely works.

After you decide, you will have more things to do. If you are going to manage the acreage for woodland and timber production, then get the livestock out. Well-managed woodland has the potential to create more income in a lifetime than pasture or row-crops on comparable soils and slopes. A trained forester can help you make the transition to an improved woodlot.

If you are going to manage the land for pasture, then you need to get it into the right condition so you will not negatively affect water and other resources, and actually provide something of value for your livestock.

Keeping Shady Places in the Pasture

If shade is one of the main reasons you keep livestock in woodlands, you have alternatives. Canopy is one of the biggest issues. If the woods have more than 30 percent canopy cover, which is very common, then it is almost impossible to grow, maintain, and sustain vegetative cover not only for livestock consumption, but also for erosion control. As the canopy's density grows, the harder it gets to maintain any permanent vegetative soil cover. If you want pastures with trees, then you must have less than 30 percent canopy cover. Such a pasture should look more like a savannah than a woodland or pasture. These few trees can provide sufficient shade even during the dog days of summer.

Another alternative for shade in the pasture is to plant some trees in specific areas, or to allow livestock to graze along the edges of the woods. Small corners and edges can provide adequate shade. They also limit damage and provide some winter protection while keeping the woodland protected. You'll make more money with livestock along the edge of the woods than you will with livestock in the woods. As one Ohio grazier once said, "Cows make poor woods and woods make poor cows."

Whatever you decide, you should plan to end up with a property that you and the next generation can be proud of. Keep on grazing; just perhaps not in the woods!

▸ Chapter 12

Each grazing animal species has unique physical attributes, grazing behaviors, and vegetative preferences. This makes some species more compatible together than others.

Livestock Grazing Behavior

To understand how and why a grazing system is successful, you should understand why animals graze the way they do. Each animal species, of course, has a unique set of physical attributes (nose, teeth, digestive system, etc), grazing behaviors, and vegetative preferences. This chapter covers the basics of livestock digestive systems, physical attributes, and grazing preferences.

Ruminants and Monogastrics

Grazing animals can be separated into two main groups based on their digestive systems: ruminants and monogastrics.

Ruminants (cattle, sheep, and goats) have four "stomachs," each playing a specific role in digestion. One of these stomachs, the rumen, is essentially a storage vat that begins fermenting the mass of forage consumed. Ruminants then regurgitate the cud, or solid material from the rumen, and chew it again to break it down into smaller pieces. Those pieces move on to the other three "stomachs" for final digestion and absorption of nutrients.

It is important that ruminants keep enough fiber or roughage in their systems to maintain a "mat" on the rumen to aid in nutrient absorption. If food passes through their digestive tract too fast (like it can in the early spring when forage is high in nitrogen — crude protein — and moisture) they will not reap all the potential benefits. Some roughage is needed at this time to help balance this out. Residual forages that were maintained from the previous year help to keep this in balance.

Monogastrics (horses and pigs) have a more linear digestive system than ruminants. In monogastrics the "hind gut" of the intestines absorbs most of the nutrients, which is much less efficient than ruminant digestion. Horses are modified monogastrics. They have a cecum, or fermentation organ, between the small and large intestine that further processes forages and improves nutrient absorption.

For ruminants, the process of chewing their cud takes time. That's why you will frequently see cattle or goats standing in the field but not grazing. Most cows, for example, spend eight hours a day grazing, while horses graze up to 18 hours. Horses can only consume about 2 to 2.5 percent of their body weight each day, while cattle can consume 3.5 to 4 percent of their body weight. This difference can be attributed to the digestive system's forage storage capacity. Because horses cannot store as much forage, they must consume small courses more often than cattle.

Big Mouths and Nimble Lips

Mouth structure also affects grazing behavior. Cattle have broad mouths, and because of the location of their eyes, they do not see exactly what they are biting. They use their tongues to grab swaths of grass. Sheep and goats, on the other hand, have small mouths and split nimble lips so they can select single leaves. Because of their mouthparts and selectivity, goats and sheep typically "out-graze" cattle for the better forage. Horses have broad mouths as well as nimble lips. They also have top and bottom teeth that allow them to crop forage very close to the ground.

Goats tend to graze from the tops of plants down, while cattle typically start at the bottom. So, cattle and horses do not make complementary grazers but cattle and goats do.

Forage selection also varies among species. Generally, cattle prefer grasses and legumes, sheep prefer grass then browse, goats select browse first,

and horses seek out new growth of grasses and forbs. Especially with small ruminants, the young learn a lot about what to eat and not to eat from their mothers. Ewes that learn to eat particular weeds or plants typically teach their lambs to do the same.

Remember, these are broad assumptions. Animal breed, growth stage, lactation, forage availability, time of year, and many other factors affect livestock forage selection. Overall forage intake is mainly determined by fairly complex interactions. Digestive feedback by the ruminant leads to preferences and aversions to particular plants helping the livestock select plants that provide them needed nutrition.

▸ Chapter 13

Pastures that are predominantly white clover can be a cause of bloat.

Potential Forage-Induced Animal Disorders[1]

Many forages adapted to Indiana can cause livestock disorders if the environment and management are conducive. A list of common livestock disorders caused by forages appears below, describing the symptoms, the forage species that cause the disorder, when the disorder typically occurs, the animals affected, and how to prevent or treat the disorder. You should acquaint yourself with these disorders and be alert for any symptoms in your herd or flock.

Bloat

Symptoms: Distended left side of rumen.
Forage Species: Most, but not all, legumes.
When: When animals are turned out on lush, legume pastures.
Animals Affected: Ruminants.
Prevention/Treatment: Maintain pastures with at least 50 percent grasses or give animals access to an anti-bloating agent. Feed hay before turnout. Turn out midday to dry forage. Use nonbloating legumes, such as birdsfoot trefoil.

Fescue Toxicosis

Symptoms: Reproductive problems, "poor doers," lameness, dry gangrene, fever, and death.

Forage Species: Tall fescue infected with nonfriendly endophyte fungus.

Animals Affected: Horses, cattle, and other ruminants on pasture or fed fescue hay.

Prevention/Treatment: Clip pasture to keep fescue vegetative. Move animals to non-fescue pastures during breeding season and late pregnancy. Test pastures for presence of the fungus. Include other forages in the pasture, especially legumes.

Grass Tetany (Hypomagnesemia)

Symptoms: Reduced appetite, dull appearance, staggering gaits, increased nervousness, frequent urination and defecation, and muscular tremors, followed by collapse, paddling of feet, and death.
Forage Species: Cool-season grasses.
When: Spring.
Animals Affected: Ruminants, particularly older females in early lactation.
Prevention/Treatment: Provide magnesium daily to at-risk animals. Include legumes in the forage consumed. Apply dolomitic lime if soil magnesium and pH are low.

[1]**Sources:** *Forages Volume 1: An Introduction to Grassland Agriculture* (2003, Robert F. Barnes, C. Jerry Nelson, Michael Collins and Kenneth J. Moore); and Purdue Extension publication WS-9, *Indiana Plants Poisonous to Livestock and Pets* (www.vet.purdue.edu/depts/addl/toxic/cover1.htm).

Nitrate Poisoning

Symptoms: Staggering, rapid pulse, frequent urination, and labored breathing, followed by collapse, coma, and death.

Forage Species: Sudangrass, sorghum, corn, and small grains fed as silage, hay, greenchop, or pasture.

When: This is especially a problem during droughts or in areas with excessive manure or nitrogen applications.

Animals Affected: Any that are fed high N forages; can also harm humans if they inhale gasses produced during ensiling.

Prevention/Treatment: Check crop nitrate (NO_3) levels before feeding. Levels higher than 3,400 to 4,500 µg N/g dry matter basis are considered potentially dangerous and should be mixed with safer feed for animal use.

Prussic Acid Poisoning

Symptoms: Staggering, labored breathing, spasms, foaming at the mouth, lying prostrate, thrashing about, and death.

Forage Species: Sudangrass (less concern), forage sorghum, and sorghum-sudangrass.

When: After freeze damage or during severe drought; after high N applications when the soil is deficient in P and K; and after consuming immature forage or tillers. Concern is greatest when feeding forage as pasture.

Animals Affected: Cattle and sheep are more susceptible than swine.

Prevention/Treatment: Use forage prior to freezing and do not graze when crop height is less than two feet. Ensile or hay instead of using damaged crop as pasture. Graze after a freeze only when forage is totally killed and after five or six days have passed. Feed ground cereal grain prior to turnout to pasture. Use heavy stocking rates and rotational grazing. Treat immediately with sodium nitrite and sodium thiosulfate.

Selenium Deficiency (White Muscle Disease)

Symptoms: Young die suddenly or are born dead. White muscle disease in calves and lambs.

Forage species: Any forage deficient in selenium.

When: Anytime.

Animals Affected: Calves and lambs.

Prevention/Treatment: Supplement with selenium.

Slobbers

Symptoms: Animals slobber excessively.

Forage Species: Red or white clover infected with black patch disease.

When: Anytime, particularly when conditions are warm and humid.

Animals Affected: Any.

Prevention/Treatment: Remove animals from areas with red or white clovers. Store hay for more than a year to reduce the cause of slobbers.

Sweetclover Poisoning

Symptoms: Bruising, prolonged or spontaneous bleeding, hemorrhaging, pale mucus membranes, increased respiratory rates, rapid and weak pulses, and death.

Forage Species: White sweetclover and yellow sweetclover.

When: Wet, humid weather during hay curing.

Animals Affected: Animals fed moldy sweetclover hay, mainly cattle.

Prevention/Treatment: Avoid feeding moldy sweetclover hay. Affected animals may benefit from a blood or plasma transfusion or vitamin K injections.

Indiana Graziers' Experiences

Among Indiana's many resources are innovative livestock producers. The following pages draw on that resource, giving you an opportunity to learn from these Indiana forage farmers and their operations.

While all these graziers might tell you that there is nothing special about their operations, one thing makes these operations (and many others like them) really stand out: they love what they are doing and are happy with their operations, although each will tell you they are working to improve something. That's progressive producers and graziers doing their best!

▸ Chapter 14

The graziers' goals are to minimize the amount of grain that is fed to their livestock and to maximize the amount forage their livestock eat.

One Acre Pasture Provides Forage for Boer Goats

Cassandra and Lyle Vondran, Allen County

My husband and I have been raising Boer goats since 2000, and our main interest is in raising and showing breeding stock. We have a very small piece of property with about one acre of pasture and decided that we wanted to make the most efficient use of our pasture, so we started looking into rotational grazing.

It is the perfect fit for us. We are constantly changing how and what we do to make the system work for the forage, the livestock, and us.

We worked with a grazing specialist to help give us a start. We began by reseeding our pasture field in the fall of 2002 with a mix of fescues, ryegrasses, chicory, and clover. We installed a temporary lane that enabled us to divide our one-acre pasture into six paddocks. For the watering system, we laid plastic water lines on top of the ground instead of trenching it, in case we wanted to move it somewhere else. We have plans to trench it this year now that we have a better idea of how it will work for us in our situation.

We currently have 12 breeding does and two young, replacement does. We had been up to 18 breeding does and found that to be too many for the acreage we had. We currently try to kid in the fall and winter to catch some of the 4-H markets, but we have contemplated kidding in the spring when the spring flush of grass is at peak production.

We do still supplement the goats with grain even while they are on pasture. We do not feed hay during the times when the pasture supply is ample, but do feed hay in the winter. We began using large, round bales this past year, and that has saved the time and expense of feeding small, square bales. Feeding round bales keeps a constant supply of hay in front of them. We have begun to monitor the amount of grain that is fed. Our goal is to minimize the amount of grain that we feed and to feed as much forage as possible.

We have used different types of temporary fence to subdivide paddocks. First, we tried electro-netting and found that to be too cumbersome to move and maintain a charge. We are now using two strands of the electric rope and twine. We do sometimes have a goat go through the fence, but since it is interior fence, they are still within the main pasture. Most of the time, the goat gets out because the food source is low in

the paddock it is in or, for one reason or another, the fence is not hot anymore.

I have heard the saying that if it does not hold water, it will not hold a goat! However, we have found that if the food source is good where they are and the fence is hot, the goats probably won't go anywhere you do not want them to go. Our animals are accustomed to the fence, so when new goats come to the herd, the more experienced goats help teach the new ones the system. That is not to say that the new ones do not test the electric fence, but when they do, the whole herd does not freak out and go running back to the barn. As far as the kids, they learn mostly from their mothers, but they also learn from their own experiences.

The amount of time the goats spend in each paddock varies based on the amount of available forage. During the spring flush, we ideally would move the goats through quickly enough to evenly graze the paddocks down to the point that when they come back through, seed heads have not formed. Goats do like to eat the seed heads. What's more, it appears that once seed heads have formed, they no longer like to eat the rest of the plant either. This has caused problems later in the season for us. We are still determining what the best approach is to clean up what the goats do not eat. We have considered getting a calf to do some multi-species grazing since cattle and goats graze differently. Ideally, we like the pasture to rest at least 18 days before grazing it again. We are also starting to watch for parasitism and the effect on the herd as well as individuals.

Raising and breeding Boer goats has become a passion for us in the few short years that we have owned them. One of our goals is to continue to learn new things about rotational grazing and apply them to our livestock operation.

Multi-Species Grazing Offers Greater Efficiency and Diversity

Gary Weilbaker, DeKalb County

Mixed species grazing not only increases utilization of the forage sward, but through synergism, this management practice actually results in a greater output than was possible from the same live weight of any one species.

My primary experience has been with grazing ewe-lambs/stocker steers. Sheep have smaller mouths and will graze more selectively and eat more browse and weeds. Cattle have larger mouths and consume the vegetative stems and seed heads that will be rejected by the much more selective sheep. Stocker cattle work well with ewe-lambs because the cattle can be removed after the fast growth in the spring and late summer. This will allow a surplus of forage for flushing and stockpiling in the fall. When grazing sheep and cattle, sheep will graze closer to cattle dung pats than cattle will. In addition, on hilly farms cattle prefer to graze the bottoms and shady slopes; sheep prefer the hillsides.

When setting up a multi-species grazing system, we needed to consider several factors. We installed five-wire, electric, high-tensile perimeter and paddock fencing powered by a 16-joule energizer. It is important to have an extra powerful energizer that can withstand some drawdown and still keep in livestock. One-inch plastic water lines were buried and run to each paddock with quick coupler risers to plug the hoses into. It is

▸ Chapter 15

Grazing management keeps both forages and animals highly productive. When cattle and sheep grazing are managed well, the paddock will look like you mowed it 4 to 6 inches high.

important to maintain water tanks that are relocated after each rotation to keep the manure spread out within the paddock. If entry gates are located on the corners of paddocks, then the animals will move easier. Good fertility and soil pH will help ensure a good, high yielding forage sward.

Grazing management is required to keep the forage and animals highly productive. When cattle and sheep grazing are managed well, the paddock will look like you mowed it 4 to 6 inches high. This is accomplished through matching paddock size and number of head versus grazing period. A ratio of five stocker steers and 10 ewes per acre is a good starting point. In order to thoroughly evaluate when to move the animals, you must view the whole paddock daily. Three to four days seems to work well, with four being the maximum. Otherwise, the animals will graze the regrowth and weaken the stand. In the spring, we usually leave a few paddocks to make hay on so we have enough animals to keep ahead of the remaining paddock's spring flush of growth. If some paddock forage ends up mature, then it should be clipped.

Moving the animals between paddocks is an important job and can be accomplished efficiently by training the animals to your call. Every time we move the animals, we call them by yelling, "come boss." After a few moves, the cattle will catch on. The sheep require more time, but eventually they will also respond to the call. Moving is a key time to watch for problem animals and evaluate animal productivity.

Foot rot, intestinal worms, pink eye, and bloat are the biggest animal health issues we face. Sheep require worming every 30 days in the summer with late July being the worst time. Cattle are wormed in the spring, June, and August. The cattle are vaccinated for pink eye, and the sheep are vaccinated for foot rot. Oxytetracycline is mixed with their free choice mineral in order to minimize foot rot and pink eye problems. Bloat is a big problem with high legume content forages that are grazed when wet. We never rotate animals to a new paddock if the forage is wet due to either rain or dew. If we must move the animals when it is wet, we use a special paddock that is grass only. In addition, we feed bloat blocks free choice. Sheep must have their feet trimmed every 6 months to prevent foot rot problems. Summer flies can be a problem, but we have found that by rotating several paddocks away that the flies can't follow the animals. Otherwise, pour-on insecticides can be used on the cattle.

Multi-species grazing allows you to manage your grazing operation more efficiently, diversify, and carry more animals than otherwise would be possible. Any size operation can benefit, and sound grazing management combined with a good attitude can help you achieve your objectives.

▸ Chapter 16

Low Inputs Help Sheep Farm Do More than Survive

Bill MacKenzie, St. Joseph County

For our particular operation, it is far more efficient and less costly to use the limited acreage for pasture than anything else. We raise a breed of hair sheep that can thrive solely on pasture during the growing season. By the end of lambing time there are usually close to 200 head on the property, which consists of only 17 acres of pasture. Most of the lambs are registered purebred and are sold for breeding stock. We keep our own breeding animals, replacement stock, and usually close to half of the yearly lambs to fatten for meat. If we were unable to graze, the cost of purchased feed would be so great that we would be unable to run anywhere near a profit.

The pastured acreage is pretty much a sandy loam soil that had been on a corn-soybean rotation for years. When we first started some 11years ago, we tried various pasture mixes. Since that time, the only seeding that's been done is to repair bare spots, usually with orchardgrass. In addition to this spot seeding, it seems that many species of other grasses are beginning to establish (or return), which the sheep readily accept. The whole grazing area has a woven wire fence perimeter with a central electric fence wire running the length of the property. Hooking poly-wire to the live electric fence created paddocks. This gives us great flexibility as we can make paddocks as big or as small as required.

The length of time that animals stay in any given paddock depends on the growth rate of the pasture. Any taller growth left in the grazed paddock is mown down to about 6 inches and allowed to regrow. The only fertilizer used on the pastures is what the sheep leave behind, which, I may add, is being deposited right where it's needed. Since all the animals are housed in barns during the winter, the manure is usually spread on one particular area when the barns are cleaned out in the spring. This area is allowed to rest for that season.

Our operation is somewhat specialized because we are raising a breed that was specifically developed to thrive on "slim pickings." My theory regarding our pasture is that it seems pointless to try and modify the native soil in order to sustain a particular plant species. The livestock use what forage is available to them. They are able to sustain themselves in excellent condition and produce a high-quality end product.

In effect, it seems we have struck a somewhat successful combination in that the pastures we have are perhaps not the most nutritious, but the livestock not only use what is there, they are able to sustain themselves in excellent condition and produce a high-quality end product, be that meat or breeding stock.

To quote an old saying, "One has to cut the suit to fit the cloth." Without grazing, we would be unable to survive financially.

The entire grazing area has a woven wire fence perimeter with a central electric fence wire running the length of the property.

▸ Chapter 17

Containing cows in smaller lots resulted in fewer weeds and more grass.

Longtime Beef Cattle Graziers Embrace Changes

Larry and Marlene James, Perry County

Our cattle herd began in 1976 on a 20-acre plot of ground. Those first five heifers that rotated between two fields of pasture, have grown to 48 spring calving cows, 45 fall calving cows, and two bulls.

This 30-year period with our cows has taught us a lot, and from experience we'll tell you, change is good.

Early in our journey, we were able to rent 120 acres adjoining our farm. That allowed us to increase our herd to about 25 cows, but there were major water problems. At the time, our goal was to still rotate the pasture in half with summertime water in the woods. A big glitch was that the herd spent a majority of their time at the water, not grazing!

The original farm gave access to a 1.25-acre lake. That helped, but it was a long distance for the cattle to walk. The 120 acres was rough and the cattle only grazed on the good fields close to the water. In the areas where we wanted them to graze, they would not stay long enough to consume much before heading back to water. That was not as much an issue in the early spring when tender grass was ample, but as temperatures increased, they quickly stopped walking very far.

A pumping plant was installed in the lake in the early '90s with five outlets on our 20 acres. Two of the outlets bordered the 120 acres of rented ground. We divided our 20 acres into five paddocks and quickly saw some pasture improvement. We then decided to try putting water lines on top of the ground to the 120 acres, dividing that pasture into four fields. After containing the cows in smaller lots and attending several grazing meetings, we were convinced by the results: fewer weeds and more grass! This started a rotational grazing system for 40 cows.

The next step came as we witnessed our cattle numbers growing. We added permanent interior divisional fences and used temporary tape with step-in posts to create smaller paddocks for spring. Now we knew where the water lines needed to be and were able to bury the aboveground lines. This created a watering system in the 120 acres of rented ground with 12 outlets. We also found it necessary to fence the herd out of the woods to keep them in the grazing areas we designated. Through all of these changes, there were obvious increases in our weaning weights and conception rates. Our numbers had now increased to approximately 60 cows, and we decided to split the herd into spring and fall calving groups.

We were told, and we found it very true, it is best to dry lot the cows during a very droughty August to give the grass a chance to grow back for fall grazing; not overgrazing during this period provided us a bountiful fall forage yield to graze than those who didn't stop grazing. Within the past year, we have used annual grasses to extend the grazing season. The cool-season grass hits a big slump in the hot summer months, so we use sudangrass to give the grass paddocks a little extra time to rest. This really helped to extend our grazing season later into the fall.

Running out of forage one spring forced us to try something new with a hay field that, in the end, dramatically improved the regrowth and quality of our grass in that field. This was late in the spring and the grass had grown to a stage not quite ready to cut. We were forced by running out of forage to strip graze small portions of a hay field. The field had been sectioned off by tape

in approximately 10-foot strips. The cattle grazed the new grass every day. After mowing the remaining half of the field for hay, we were able to watch the quality of the grass grow back in the coming weeks. The grazed part of the hay field had far fewer weeds and higher quality grass.

We picked up another farm to rent where the fields had not been used for livestock for about 20 years — it had been part orchard, part row-crops. The fall calving cows needed less nutritional value forage during the summer. The new farm was a good fit for our needs. The first thing we accomplished was developing a water system, perimeter fence, and an interior fence. By managing the cattle in the rotational grazing system, the pastures are improving through the seasons. The quality of the grasses for the fall herd in the summer is greater than when we first began at this farm.

Through the years, we have learned the grazing system must be flexible and everyone's cattle needs are different. For us, moisture levels, summer heat, and length of growing season are all variables that can dramatically change how well our herd eats. We like our management style simple. A rule of thumb for us: when we see the laces of our boots through the grass, it is time to move into another paddock. And you can bet the cows will tell us when to move. Once the cows are familiar with the routine of the system, they will tell you more than you think if you just watch them. Water and fresh grass are the key components to keeping the herd content, healthy, and growing.

The Dairy Perspective of Management-Intensive Grazing

Bob and Debbie Eash, LaGrange County

A dairyman's purpose in grazing is not much different than any other producer's, except that we generally do it more intensively. The reason for this is that our species of harvester is more likely to be affected by subtle feed changes than most other animal types and you notice the results quickly in the bulk tank. As a result, we are inclined to give the herd more frequent breaks in order to provide a more consistent quality of feed. These breaks can often be as frequent as two to four times a day, and almost never less frequent than once a day.

On our particular farm, the land (as is common in most of northeast Indiana) consists of many different soil types. This has created the opportunity to not only provide diversity in the forages that can be made available, but also provide for the feed needs during adverse weather (hot, droughty, wet, flooded, overwintering, etc.) without significantly affecting soil quality. We have experienced that the key to this is the successful matching of the forages to the soils on which they are to be grown.

One of our challenges is to time forage harvesting (whether by animals or mechanical means) to maximize both the feed quality at the time of that harvest, and to stage its regrowth for the next expected feed need. In our case, we have an area that floods each spring that has been seeded to reed canarygrass. This makes excellent feed during droughty periods while withstanding flooding from storm events. The challenge is that it needs to be harvested on a different rotation schedule than either the high-energy or deep-rooted forages, mak-

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Matching the forages to the soils on which they are grown helps ensure successful grazing.

ing for more intensive management. Maybe that is why they call this process, "management-intensive grazing."

By using a small acreage in annuals, it is possible to provide for those extreme times when nothing else is available. This also applies to before and after the normal growing season. It is during these times that not only can production be maintained (or the loss decreased), but also the high cost of using stored feed can be eliminated, or at least minimized.

Some food for thought:

- Manure generated during the feeding of the stored feed should ideally be applied to the area from which the stored feed was grown (preferably by the animals during feeding, or mechanically).
- Nitrogen loss is greater than for any other element and must be replaced the most.
- Adequate, fresh, cool water that's within 400 to 500 feet and visible from anywhere is a must for each paddock.
- More animals grazing smaller paddocks for shorter periods give you higher grazing efficiency and more even grazing, plus the paddocks require less clipping.
- Grazing could make veterinarians and foot trimmers obsolete.
- Milking cows this way is a whole lot more fun for both you and the cows; just watch them.

Glossary of Terms[1]

alternate stocking
The practice of repeated grazing and resting of forage using two paddocks in succession.

animal unit (AU)
A measurement equal to 1,000 pounds of live animal weight.

animal unit month (AUM)
The amount of forage required to feed one animal unit for a month (30 days).

annual
A plant that completes its life cycle and dies in one year or less.

aspect
A position facing, or commanding, a given direction; exposure.

available forage
The portion of forage, expressed as dry matter of forage per unit of land area, that is accessible for consumption by a specified kind, class, sex, size, age, and physiological status of grazing animal.

back fence
The practice of using a temporary fence to keep livestock from grazing the last paddock they occupied.

bloat
A livestock disorder resulting from an accumulation of gas in the rumen or intestines caused by the fermentation of green forages.

biennial
A plant that lives for two years, producing vegetative growth in the first year, blooming and fruiting in the second year, then dying.

boot stage
A grass plant growth stage that occurs just before the seed head emerges from the leaf sheath.

brassicas
A group of erect, tall, branched plants of the mustard family that includes many edible plants, including turnips.

broadcast
The practice of applying seed or fertilizer on the surface of the soil. Tillage may be used to incorporate the material. Seeding rates typically double with this type of application.

bunchgrass
A growth habit of grasses (for example, orchardgrass), so-called because of their bunched appearance.

carrying capacity
The maximum stocking rate possible that will achieve a target level of animal performance and that will maintain or improve the vegetation or other resources. This may change from year to year.

cool-season plant
Plants that experience the major part of their growth during the early spring and fall.

continuous grazing
A grazing practice in which livestock are permitted to graze designated areas for an entire calendar year. Also called, yearlong grazing.

continuous stocking
A method of grazing livestock on a specific unit of land where 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.

cropland
Land devoted to producing cultivated crops. Crop residues (usually corn stubble) from such land may be used for grazing.

deferred grazing
The practice of deferring grazing in a nonsystematic rotation with other land units.

[1] The terms in this glossary come from *Terminology for Grazing Lands and Grazing Animals* (Forage and Grassland Terminology Committee, 1991) and the authors.

dry matter
Amount of forage (usually expressed as weight) once its moisture content has been subtracted.

endophyte
An organism that lives in another organism, usually a parasite — for example, endophytic fungi in tall fescue.

energizer
A device that supplies electrical energy to fences. It can be solar charged or electric.

feed
Mechanically harvested nutritional material fed to livestock.

flash graze
The practice of quickly removing a portion of forage from an area with grazing animals in a very short period of time from sensitive or fragile areas, such as streamsides.

follow-the-leader grazing
A grazing method using two or more groups of animals to graze sequentially on the same land (or, one group grazes the land first, followed by the next). Usually, each group has different nutritional requirements. This practice is also called, first-last grazing.

forb
Any herbaceous broadleaf plant that is not a grass and is not grass-like.

forage
Material found, harvested, and consumed by livestock themselves that fulfills their nutritional needs.

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 inverse of grazing pressure.

forage crop
Cultivated plants or plant parts produced to be grazed by livestock or harvested for use by animals.

frost seed
The practice of establishing heavy seeded forage species (typically clovers) by broadcasting seed during the late winter when soils are frost heaving.

germination
The stage at which plants begin to grow or develop; sprout.

gpm
Gallons per minute — a measure of the production or delivery of a watering system.

grass tetany
A livestock disorder that can occur in cattle on lush pastures that have soils that are generally low in phosphorus but high in potassium and nitrogen. This combination inhibits magnesium uptake.

grazable forest
Forestland that produces, at least periodically, sufficient understory vegetation for grazing and normally has less than 30 percent canopy cover.

grazing cycle
The time between the beginning of one grazing period and the beginning of the next grazing period in the same paddock. Each grazing cycle includes one grazing period and one rest period.

grazing land
Any vegetated land that is or can be grazed by animals.

grazing method
A defined procedure or technique of grazing management designed to achieve a specific objective(s).

grazing period
The time that grazing livestock occupy a specified land area.

grazing pressure
The closeness to which a pasture is grazed. It is a measure of the relationship between the stocking rate (animals per acre) and available forage (pounds of forage per acre). Grazing pressure is high if the stocking rate is high and/or the available forage is low. Grazing pressure is low if the available forage is high and/or the stocking rate is low.

grazing season
The period when grazing can normally be practiced each year or portion of the year. In Indiana, this is typically April to November.

grazing stick
An elaborate ruler that helps graziers measure and calculate available forage, stocking rates, grazing days, and other factors.

grazing system
A defined, integrated combination of animal, plant, soil, and other environmental components and the grazing methods by which the system is managed to achieve specific results or goals.

green up
The period of initial growth in plants following a dormant period. Generally, this is considered "spring green up," but there is also "fall green up."

hard seed
A live seed that needs to be scarified or otherwise treated to break dormancy.

haylage
A product that is the result of ensiling forage with about 45 percent moisture in the absence of oxygen.

heaving
The process in which plant roots are raised or lifted out of the soil, especially a problem with alfalfa. Generally caused by repeated soil freezing and thawing.

herbage
The biomass of herbaceous plants, generally aboveground but including edible roots and tubers.

herbivore
Any of a diverse group of animals with special adaptations for eating plants.

high-tensile
A type of highly conductive wire that is usually galvanized and is used for constructing fences.

inoculant
A seed or soil additive (especially for legumes) that contains nitrogen-fixing bacteria that facilitate nitrogen fixation in the subsequent crop. See: rhizobium.

intake
The amount of food eaten.

intensive grazing management
A grazing management practice that attempts to increase production, utilization per unit area, or production per animal through a relative increase in stocking rates, forage utilization, labor, resources, or capital. Not synonymous with rotational grazing.

internode
The portion of a plant's stem between two nodes.

legumes
A widely distributed family of plants, including peas, beans, alfalfa, and clovers, capable of fixing nitrogen and generally highly nutritious.

ligule
The part of a grass plant located at the junction of the leaf sheath and blade. Can be a membrane, ring of hairs, or absent.

macronutrient
Plant nutrients needed in relatively high amounts by plants. Macronutrients refer to nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), and sulfur (S).

management-intensive grazing
A grazing system management strategy that provides control of the grazing animal, emphasizing intensive management of several small paddocks rather than intensive grazing of large pastures.

microclimate
The climate of a small area that differs from the region's general climate, generally due to environmental differences, such as aspect, soil water availability, or wind exposure.

micronutrient
Plant nutrients needed in relatively small amounts by plants. Usually refers to boron (B), chlorine (Cl), copper (Cu), iron (Fe), manganese (Mn), nickel (Ni), cobalt (Co), and zinc (Zn).

mixed grazing
The practice of grazing two or more animal species on the same land unit within the same grazing season (not necessarily at the same time).

mob grazing
The practice of allowing a relatively large number of animals to graze an area at a high stocking density for a short period.

node
The solid construction in the stem of a grass plant.

nonselective grazing
The process by which grazing animals use forage so that all forage species and/or all plants within a paddock are grazed.

nose pump
An animal-operated watering device capable of lifting water 20 feet or pulling it 200 feet. Animals must be at least 200 pounds to operate it.

overseed
The practice of enhancing an existing pasture by introducing additional species into the stand.

paddock
A relatively small subdivision of a pasture generally fenced (permanently or temporarily) and used to control livestock grazing.

palatability
The degree to which feed is agreeable to an animal's taste; is savory and acceptable.

pasture
A grazing management unit, enclosed and separated from other areas by fences or other barriers, that's devoted to producing forage for harvest, primarily by grazing.

pastureland
Land devoted to the production of indigenous or introduced forage for harvest primarily by grazing.

perennial
Plants that have life cycles of three years or more.

pH
A scale (0-14) that measures the soil's acidity (<7) or alkalinity (>7). Neutral soils have a pH of 7.

PLS
Abbreviation for pure live seed. Seed purity and germination are expressed as percentages. PLS can be calculated by the formula: PLS = % purity X % germination.

poly-wire
A temporary fence made of polyethylene and stainless steel conductive wire filaments that comes in twine, tape, and rope.

prescribed burn
The process of burning grazing land to address problems that have been identified and that can be totally or partially addressed with a particular kind of burn.

prussic acid poisoning
A forage-induced animal disorder that interferes with the oxygen-transferring ability of red blood cells, causing the animal to suffocate. It is most commonly caused by johnsongrass, sorghum, sudangrass, sorghum-sudangrass, and wild cherry following a stress period. Symptoms include excessive salivation, rapid breathing, and muscle spasms and can occur within 10 to 15 minutes of consumption.

purity
The percentage of the desired species of seed in a quantity of seed that may include other species, weed seed, or foreign matter.

put-and-take stocking
The practice of using variable numbers of animals during a grazing period or grazing season. The number of animals is periodically adjusted to maintain desired sward management criteria, such as a desired quantity of forage, degree of defoliation, or grazing pressure.

renovation
The act of dramatically converting an existing pasture to a completely different species composition.

residue
Forage remaining on the land as a consequence of harvest (whether by animals or mechanical means).

rest
The practice of leaving an area of grazingland ungrazed and unharvested for a specific period. That period could be a year, a growing season, or a specified period prescribed by a particular management practice.

rest period
The time (usually expressed as a number of days) an area remains ungrazed.

rhizobium
A rod-shaped nitrogen-fixing bacterium that forms nodules on the roots of legumes. See: inoculant.

rhizomatous
A means by which grasses grow by producing rhizomes that form a sod.

rhizome
An underground plant stem; rootstock, usually rooting at the nodes and becoming upturned at the apex.

riparian area
The areas adjacent to streams or water bodies and the areas that may affect or be affected by them.

rotational grazing
The grazing systems management practice of moving livestock from one pasture or paddock to another to provide rest periods for recovery of grazed plants following a grazing event.

rotational stocking
A grazing method that involves regularly recurring periods of grazing followed by regularly recurring rest periods among two or more paddocks in a grazing management unit.

ruminant
A suborder of even-toed, cud-chewing, hooved animals that have a stomach with four complete cavities (for example, cattle, sheep, deer, bison, elk).

rust
Parasitic fungi that live on the tissue of higher plants, or the plant disease caused by such fungi.

seasonal grazing
The practice of restricting animal grazing to one or more specific seasons of the year.

seed head
The fruiting portion of plants.

set stocking
The practice of allowing a fixed number of animals to graze on a fixed number of acres for a fixed amount of time, usually the grazing season.

sodformer
Plants that can provide a dense sod. These plants are generally rhizomatous, stoloniferous, or both.

soil tilth
The soil's general suitability to support plant growth, specifically, root growth. It is the physical condition of the soil as related to ease of tillage, fitness of seedbed, and suitability for seedling emergence and root penetration.

step-in post
A short post used with temporary fences that is relatively easy to install and remove.

stocking density
The relationship between the number of animals and the specified unit of land being grazed at any one point in time.

stocking rate
The relationship between the number of animals and the grazing management unit utilized over a specified time.

stockpiling
The practice of saving a portion of the forage produced in one time period to be used at a later predetermined time.

strip grazing
The practice of confining animals to an area to be grazed for a relatively short period and where the paddock size is varied to allow access to a specified area.

stolons
In plants, the horizontal stem that grows aboveground and roots at the nodes.

surfactant
A surface-active agent often used with herbicide to assist in achieving fuller coverage on the plant's surface.

sward
A population of herbaceous plants, characterized by a relatively short habit of growth and relatively continuous ground cover including both above-ground and belowground parts.

taproot
The main descending root of a plant.

trifoliolate
A plant having three leaflets or leaf-like processes.

ungrazed
Grazingland that is not grazed by animals; or plants or plant parts that are not grazed by animals.

vegetative
In plants, the nonreproductive parts (including the leaves and stems).

variable stocking
The practice of allowing a variable number of animals on a fixed area of land during the time when grazing is allowed.

warm-season plants
Plants that experience the major part of their growth in late spring through summer, and are usually dormant during fall, winter, and early spring.

winterkill
Any plant injury that occurs during the winter.

Additional Reading and Information

Books, Extension Publications, and Pamphlets

Published Soil Surveys for Indiana (by County)

USDA Natural Resources Conservation Service

Soil survey books have maps that delineate the soils throughout a county. They also provide information that can be used to determine the proper uses and limitations of different soil types. Hard copies are available from your local NRCS Service Center. Electronic versions are available at http://soils.usda.gov/survey/printed_surveys/state.asp?state=Indiana&abbr=IN or http://websoilsurvey.nrcs.usda.gov/app.

Forage Field Guide

Purdue Extension publication ID-317

This pocket guide provides information on forage establishment, maintenance, pest management, harvest, and more. It is available from the Purdue Extension Education Store (www.ces.purdue.edu/new) or the Purdue Agricultural Communication Media Distribution Center at (888) EXT-INFO.

Grass Productivity

André Voison

This is a textbook of scientific information concerning every aspect of management "where the cow and grass meet." It is available from Island Press (www.islandpress.org) or by calling the Distribution Center at (800) 621-2736.

Grass: The Stockman's Crop

Harland Dietz

This publication gives an in-depth explanation of grass root growth and the need for managing pastures to maintain adequate root growth. Available from Sunshine Unlimited, Inc., Box 71, Lindsborg, KS 67456.

Greener Pastures on Your Side of the Fence

Bill Murphy

This book explains why and how to use management-intensive grazing, and shows a way to increase your farm's profitability and reduce its labor demand while properly and responsibly caring for the land and the plants and animals that live on it. Available from Arriba Publishing (www.arriba.se/english), 212 Middle Rd., Colchester, VT 05446, (800) 639-4178.

Management-Intensive Grazing

Jim Gerrish

This book provides simple explanations to walk graziers step-by-step from the person who invented the phrase, "management-intensive grazing." Available from Green Park Press, PO Box 9607, Jackson, MS 39286-9607, (800) 748-9808.

Missouri Electric Fencing for Serious Graziers

Missouri Natural Resources Conservation Service

This is an excellent publication that discusses everything from selecting the proper fence energizer to troubleshooting electric fence problems. The information in this publication is based upon the experiences of NRCS personnel and graziers, but is not intended to be an installation manual. Available from the Missouri NRCS State Office at (573) 876-0900 or www.mo.nrcs.usda.gov/news/news/MO%20NRCS%20Electric%20Fencing_low.pdf.

Missouri Watering Systems for Serious Graziers

Missouri Natural Resources Conservation Service

This publication discusses options for providing water to livestock. It is full of

color photos and diagrams that illustrate different ways to provide adequate amounts of quality water to livestock in all sorts of landscape settings. Available from the Missouri NRCS State Office at (573) 876-0900 or www.mo.nrcs.usda.gov/news/images/Watering%20Systemslow.pdf.

Selection of Alternative Livestock Watering Systems

R. T. Burns, and M. J. Buschermohle

This publication is an excellent resource on learning how to get livestock water to areas without electricity or where typical systems will not work. Available from University of Tennessee Extension Service (www.utextension.utk.edu/publications/pbfiles/PB1641.pdf) or contact Marketing and Communications Services at (865) 974-7141.

Understanding Grass Growth: The Key to Profitable Livestock Production

Steven Waller, Lowell Moser, Patrick Reece, and George Gates

This publication explains the basics of plant biology to improve the success of livestock grazing enterprises. Available from Trabon Printing Co., Inc., 430 East Bannister Road, Kansas City, MO 64131, (816) 361-6279.

Water Systems for Grazing Livestock

Ben Bartlett, DVM

This publication provides how-tos for setting up a watering system, explains the role water plays in livestock production, and helps determine the requirements for various water systems. Available from Ben Bartlett, Dairy and Livestock Extension, Michigan State University Extension, E3774 University Drive Box 168, Chatham, MI 49816, (906) 439-5880.

Weed Control Guide for Ohio and Indiana

Purdue Extension publication WS-16-W, Ohio State University Extension bulletin 789; Mark M. Loux and Jeff M. Stachler, Ohio State University; William G. Johnson, Glenn R.W. Nice, and Thomas T. Bauman, Purdue University

This publication provides an up-to-date review of all the pesticide options for controlling weeds in pastures and hay fields. Available online at www.btny.purdue.edu/Pubs/WS/WS-16/WS-16.pdf. Books may be ordered from Ohio State University Extension by calling (614) 292-1607.

Internet Materials

Hoos-Your Grazing Network and Newsletter

www.agry.purdue.edu/ext/forages/rotational/hoos-your_grazing/hoos-your.html

This Internet newsletter provides breaking news and topics for Indiana graziers.

Indiana Natural Resources Conservation Service

www.in.nrcs.usda.gov

A resource for soil and water conservation in pasture systems, and information about cost-share programs available to livestock producers to improve pastures and hay fields.

Indiana NRCS Conservation Practice Standards, Electronic Field Office Technical Guide

http://efotg.nrcs.usda.gov/efotg_locator.aspx?map=IN

A resource for determining proper grazing management, watering systems, pasture/hayland reseeding, and more.

Indiana Plants Poisonous to Livestock and Pets

www.vet.purdue.edu/depts/addl/toxic/cover1.htm

This Purdue Extension publication is an excellent resource for understanding plants that can have negative effects on livestock production.

The Maryland Small Ruminant Page

www.sheepandgoat.com

This Maryland Cooperative Extension Service site contains original documents and images, and a comprehensive list of links pertaining to small ruminants.

National Sustainable Agriculture Information Service

www.attra.org

This site provides information and technical assistance to farmers, ranchers, Extension agents, educators, and others involved in sustainable agriculture in the United States.

Purdue University Extension

www.ces.purdue.edu

An excellent resource for publications about pasture management and livestock production.

Purdue University Forage Information

www.agry.purdue.edu/ext/forages/index.html

This site contains up-to-date forage, pasture, and hayland information produced by Purdue University along with links to Indiana and National Associations devoted to grazing or forage production.

Safe and Effective Electric Fences

www.egr.msu.edu/age/extension_outreach/efence.pdf

This Michigan State University Extension and Michigan Agricultural Electric Council brochure (bulletin E-2706) describes how electric fences work and how to properly install the major components.

Samuel Roberts Noble Foundation

www.noble.org

This foundation provides research and education to assist livestock producers in improving pasture management and livestock production. The site is full of research on rotational grazing, improved forages, livestock care, and links to the leading Web sites dealing with these issues.

USDA Plants Database

http://plants.usda.gov

This site is a good resource for plant identification with excellent pictures.

PURDUE EXTENSION

United States Department of Agriculture

NRCS Natural Resources Conservation Service

Management-Intensive Grazing in Indiana

EXPERT REVIEWED

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