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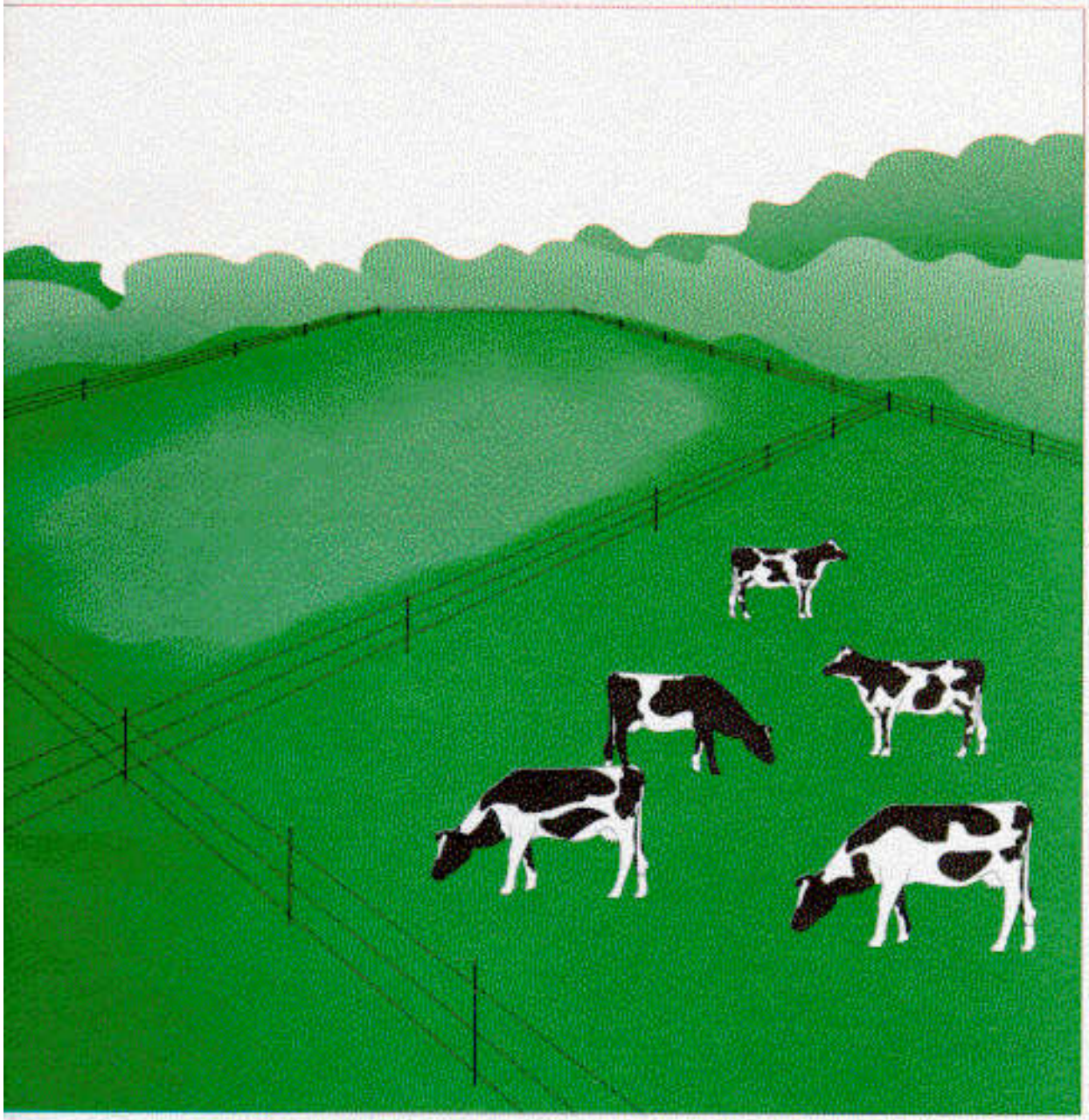
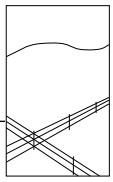
Pastures for Profit



A Guide to Rotational Grazing



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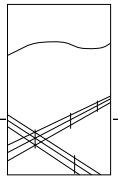


Introduction

WHY ROTATIONAL GRAZING?

Pastures represent a largely untapped resource for farmers. More than one quarter of the Midwest's agricultural land is in some form of pasture. Yet, 80% of these pastures suffer from poor, uneven fertility coupled with serious weed and erosion problems. Most farmers are reluctant to rely too heavily on pastures due to legitimate concerns that the meager amounts of low quality forage pastures typically yield will not adequately feed their high producing livestock.

The primary reason our pastures produce so badly is poor management. Most pastures are continuously grazed throughout the season. However, continuous grazing results in the lowest possible pasture yields since the forage is not allowed to recuperate between grazings.

To produce good livestock feed from pasture, we must manage our pastures differently. This bulletin outlines an alternative: rotational grazing. By using rotational grazing, you can make a profit from pastures without continual renovation. This bulletin covers the basics of setting up rotational grazing on your farm.

WHAT IS ROTATIONAL GRAZING?

Under rotational grazing, only one section of pasture is grazed at a time while the remainder of the pasture "rests." To accomplish this, pastures are subdivided into smaller areas (often referred to as paddocks) and livestock are moved from one paddock to another. Rotational grazing allows forage to renew energy reserves, to rebuild plant vigor, and to give long-term maximum production.

For rotational grazing to be successful, the timing of rotations must be adjusted to the growth stage of the forage. Unfortunately, rotational grazing has often been reduced to regular animal shifts from paddock to paddock based on rigid time schedules rather than in response to forage growth rate. Rigid schedules reduce the benefit of rotational grazing.

Rotational grazing can be practiced in a variety of intensities. Systems can range from 2 to 30 or more paddocks. Intensive rotational grazing involves a higher level of management with greater paddock numbers, shorter grazing periods, and longer rest periods. Generally the more intense the management, the greater the livestock production per acre.

This bulletin covers the basic principles underlying all types of rotational grazing. Intensive rotational grazing will be emphasized because it usually has a number of advantages over both continuous grazing and less intensive rotational systems, including

- more stable production during poor growing conditions (especially drought),
- greater yield potential,
- higher quality forage available,
- decreased weed and erosion problems, and
- more uniform soil fertility levels

There are many names for intensive rotational grazing: Voisin grazing, Hohenheim grazing, intensive grazing management, short duration grazing, Savory systems, strip grazing, controlled grazing, and high-intensity, low-frequency grazing. Although each term implies slight differences in management, they all refer to some sort of intensive rotational grazing system.

WHO IS USING ROTATIONAL GRAZING?

A number of farmers throughout the Midwest practice rotational grazing. These range from a large dairy farmer who rotationally grazes 1,600 head on his 2,100 acre all-grass farm to much smaller dairy, beef, sheep, hog, and even chicken operations. Most livestock have the potential to receive a substantial amount of their feed from pasture.

WHY USE ROTATIONAL GRAZING?

Everyone with livestock and grazing land can benefit from rotational grazing.

Economic Benefits

Most farmers are experimenting with rotational grazing because of the economic savings. Both start-up and maintenance costs are less than for

green chopping. The only capital cost specific to rotational grazing is fencing. Costs for new fencing range from $450 per mile for mobile electric fencing and fiberglass posts to $900 per mile for high-tensile electric fencing. Use of used materials can cut these costs considerably. Setting up the whole system (using new fencing, fencers, and water systems) costs from $40 to $70 per acre. The higher price range includes the cost of constructing livestock lanes.

If you haven't already invested in confinement feeding systems, this represents a tremendous savings; if you have, maintenance costs are reduced since your confinement system needs to be operated only during the cold months. Once in operation, grazing will reduce equipment, fertilizer, pesticide, and labor costs.

Feed costs, for example, which can account for 65% of total livestock production costs, can be drastically reduced. Studies by the Wisconsin Rural Development Center comparing rotational grazing to confined feeding systems document this. One dairy farmer saved an average of $130 per head in annual feed costs between 1987 and 1990 by using rotational grazing instead of green chopping. In addition, veterinary expenses, fuel, and labor costs were reduced. These savings were gained without any loss of milk production.

Time Savings

Many farmers are reluctant to try rotational grazing because of the time it takes to move livestock. However, on average, the farmer mentioned above found it to be less time consuming (3 hr/acre per year) than green chopping (8 hr/acre per year). Grazing may also decrease your need to make hay which takes an average of 7 hr/acre per season. This farmer spent only 15 minutes moving the fence each day. But to cut, haul, and feed greenchop required an hour per day.

What if you have to move a huge herd? A large-scale stocker farmer prefers to move 250 to 500 head at a time since he has found that it takes no more time to move large groups of cattle than it does to move small groups (such as 50 or less).

Environmental Benefits

Well-managed perennial pastures have several environmental advantages over tilled land: they dramatically decrease soil erosion potential, require minimal pesticides and fertilizers, and decrease the amount of barnyard runoff.

Data from the Soil Conservation Service shows that in 1990, an average of 4.8 tons of soil per acre was lost to erosion on Wisconsin cropland and an average of 2.6 tons of soil per acre was lost on Minnesota cropland. Converting erosion-prone land to pasture is a good way to minimize this loss since perennial pastures have an average soil loss of only 0.8 tons per acre. It also helps in complying with the nationwide "T by 2000" legislation whose goal is that erosion rates on all fields not exceed tolerable limits ("T") by the year 2000. Decreasing erosion rates will preserve the most fertile soil with higher water holding capacity for future crop production. It will also protect our water quality.

High levels of nitrates and pesticides in our ground and surface waters can cause human, livestock, and wildlife health problems. Pasturing has several water quality advantages. It reduces the amount of nitrates and pesticides which leach into our groundwater and contaminate surface waters. It also can reduce barnyard runoff which may destroy fish and wildlife habitat by enriching surface waters with nitrogen and phosphorous which promotes excessive aquatic plant growth (leading to low oxygen levels in the water which suffocates most water life).

Wildlife Advantages

Many native grassland birds, such as upland sandpipers, bobolinks, and meadowlarks, have experienced significant population declines within the past 50 years. Natural inhabitants of the prairie, these birds thrived in the extensive pastures which covered the state in the early 1900s. With the increased conversion of pasture to row crops and frequently-mowed hay fields, their habitat is being disturbed and their populations are now at risk.

Rotational grazing systems have the potential to reverse this decline because the rested paddocks can provide undisturbed nesting

habitat. (However, converting existing under-grazed pasture into an intensive rotational system where forage is used more efficiently may be detrimental to wildlife.) Warm-season grass paddocks which aren't grazed until late June provide especially good nesting habitat. Game birds, such as pheasants, wild turkey, and quail also benefit from pastures, as do bluebirds whose favorite nesting sites are fenceposts. The wildlife benefits of rotational grazing will be greatest in those instances where cropland is converted to pasture since grassland, despite being grazed, provides greater nesting opportunity than cropland.

Pesticides can be very damaging to wildlife. Though often short lived in the environment, some insecticides are toxic to birds and mammals (including humans). Not only do they kill the target pest but many kill a wide range of insects, including predatory insects that could help prevent future pest outbreaks. Insecticides in surface waters may kill aquatic invertebrates (food for fish, shorebirds, and waterfowl). Herbicides can also be toxic to animals and may stunt or kill non-target vegetation which may serve as wildlife habitat.

Increased Pasture Productivity

Rotational grazing can help improve long-term pasture quality and fertility by favoring desirable pasture species and allowing for even manure distribution. Rotational grazing also can increase the amount of forage harvested per acre over continuous grazing by 1000 to 2000 lb dry matter per acre.

Aesthetics and Human Health Benefits

One of the greatest advantages to using rotational grazing is that it is a "peaceful way of farming." It is quieter than mechanically harvesting your feed and it gives you the excuse to stretch your legs and take a look at what's happening in your pasture. You might even hear the birds singing or see a deer grazing as you move the fence.

Plant Growth

PLANT GROWTH CURVE

A good understanding of the basics of plant growth is key to establishing and maintaining profitable pastures.

Plants get the energy needed for growth from the sun through photosynthesis which occurs in green leaves. The plant immediately converts this energy to carbohydrates which can either be used right away for growth or stored for future use.

Forage growth is slow when plants are small (early spring growth or after grazing). When plants have few green leaves, they must rely heavily on stored carbohydrates for their energy. As leaves get bigger, photosynthesis increases dramatically, allowing for rapid growth. Prior to flowering, most pasture plants are growing as fast as possible if other factors are not limiting. As plants mature, growth slows since most energy is diverted to flower and seed production when forage heads out (figure 1).

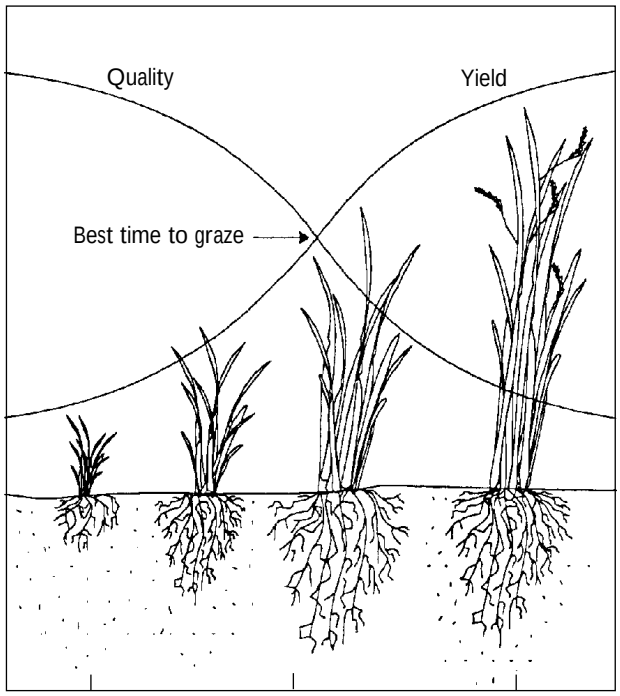


Figure 1. Forage growth curve

Forage quality decreases as plants grow older. This occurs because, as plants get larger and more stemmy, a greater percentage of nutrients and dry matter is tied up in non-digestible forms (such as lignin). Greater amounts of non-digestible fiber result in lower quality forage with decreased amounts of total digestible nutrients (TDN).

A good manager needs to balance pasture quality with pasture yield. As shown in figure 1, *the best time to graze is immediately following the most rapid growth but before flowering and seeding.* At this stage, sufficient carbohydrate reserves have been built up to allow for rapid regrowth; in addition, both yield and quality are high. If grazing occurs before this stage when the forage has not had time to rebuild its carbohydrate reserves, yield will be low, the next regrowth may be slow and reduced, and winter survival may be decreased. One of the cornerstones of a successful grazing system is having rest periods long enough to allow for rapid forage regrowth.

PLANT RESPONSE TO GRAZING

Grazing isn't "bad" for pasture plants. Plants from grasslands all over the world have special ways to cope with grazing. Grazing may actually stimulate pasture growth because old or dead leaves no longer shade young leaves.

Most pasture forages regrow from low-lying or underground stems, crowns, or roots which are not grazed off by livestock. Though their growing points are protected from grazing, few of these forages are well adapted to continuous grazing. Only plants such as Kentucky bluegrass, white clover, and many prostrate weeds whose low-growing leaves escape being completely grazed off, survive well under continuous grazing.

Taller growing forages, on the other hand, usually die out under continuous grazing since most of their leaves can be grazed off. They need rest between grazings in order to persist in a pasture, so are well suited to rotational grazing. If allowed to grow tall, they will shade out shorter forages and weeds. Pastures that are routinely rested may have less bluegrass and a larger percentage of taller growing species, even if tall species have not been recently seeded in the field.

SEASONAL PASTURE GROWTH PATTERNS

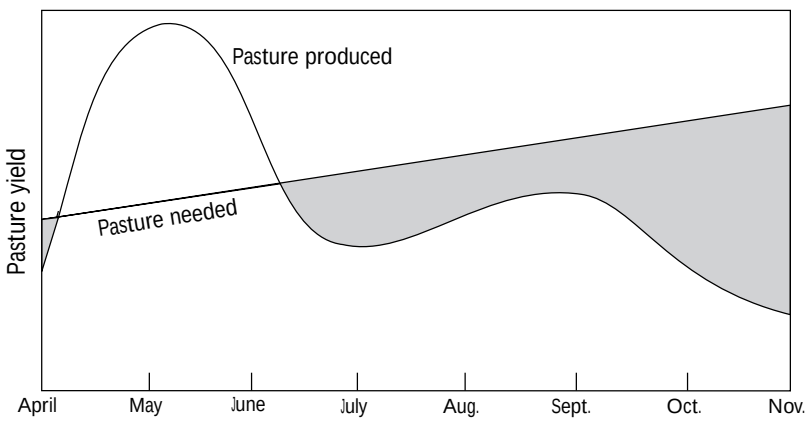
In order to make the most out of your pasture, forage production (or availability) should correspond with livestock needs. Livestock need forage all year round, but providing an adequate supply of yearly forage from pasture alone is difficult to do in the upper Midwest. First of all, the growing season is short, ranging from about 185 days in southern Wisconsin to 142 days in northern Minnesota. Secondly, pasture production is uneven during the growing season while livestock feed needs are stable or increasing (figure 2).

One way to lessen this problem is to make hay from some pastures during periods of rapid forage growth. Also, lambing or calving before rapid spring growth will allow the period of highest animal need to match the greatest production of quality forage. Some dairy farmers have switched to seasonal milking to achieve this goal. You can even out pasture production throughout the season and extend the grazing season using the methods described below.

Managing for More Uniform Pasture Growth

Healthy, unstressed plants will start to grow earlier in the spring, produce higher yields during the summer, and continue growing longer in the fall. Just switching from continuous to rotational grazing can extend the grazing season and boost yields, since rotational grazing, by virtue of its rest periods, is less stressful to the forage. A good fertility program will have similar results.

Figure 2. The typical pattern of pasture production during the grazing season.

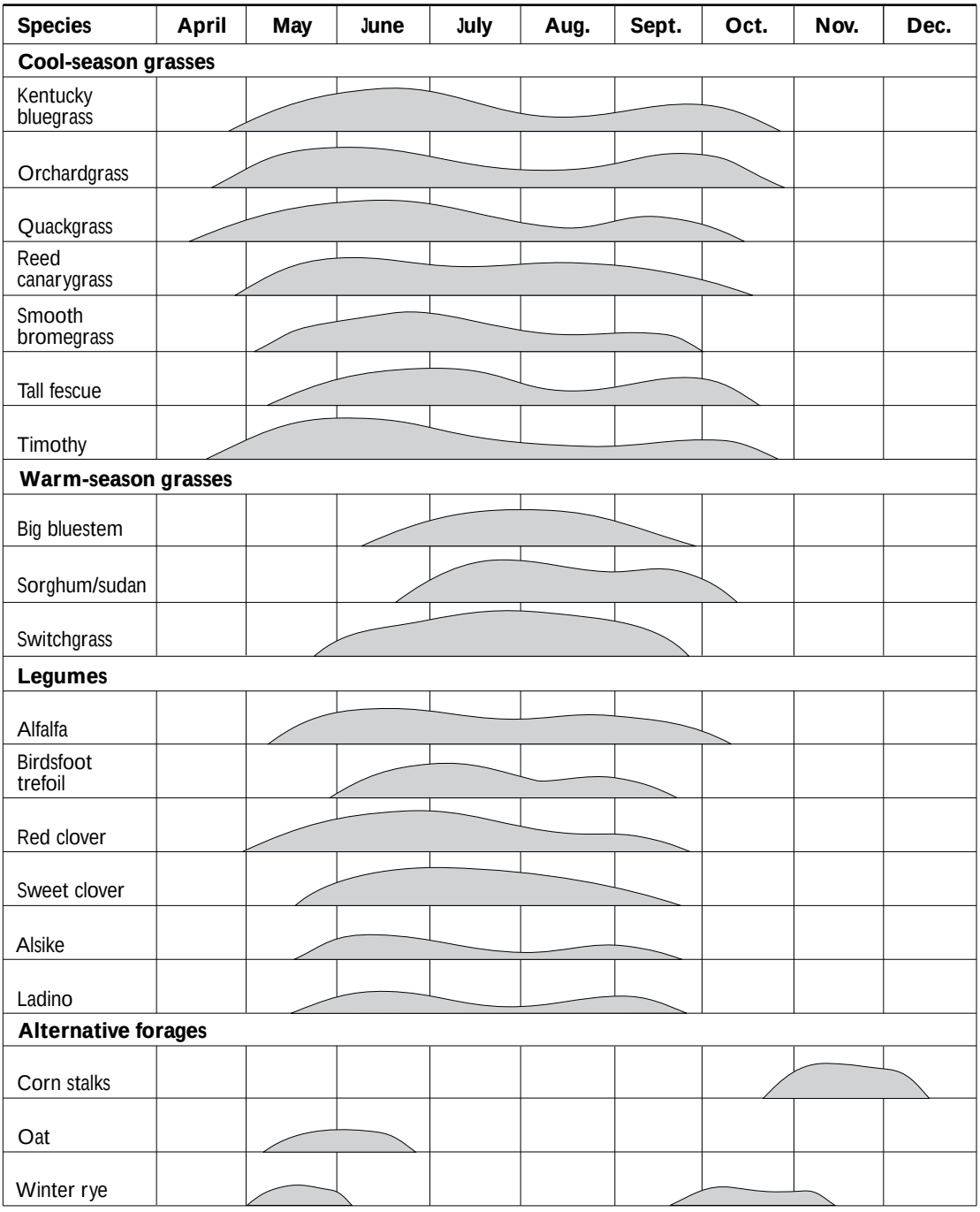


Combining Forages for Maximum Productivity

Different forages have distinct seasonal growth patterns (figure 3). To make the most out of your grazing season, grow several forages whose growth patterns complement each other to give uniform yields throughout the entire season. Forages may be mixed within a pasture if growth patterns are compatible (e.g., cool-season grass and legume) or grown in separate pastures (e.g., cool-season and warm-season grass).

Cool-season grasses such as timothy and Kentucky bluegrass, prefer cool temperatures. They are most productive in the spring and fall but go through a "midsummer slump" in production.

Figure 3. Seasonal growth patterns of forages



Legumes start growing a bit later in the spring but have fairly uniform growth patterns throughout the grazing season. Many are better able to withstand heat and drought than are cool-season grasses.

Warm-season grasses need warm soils for germination and actually thrive on midsummer heat which has slowed the growth of most other species. Both annuals (such as sudangrass) and perennials (such as switchgrass and bluestem) tend to be very drought tolerant.

Forage brassicas like turnips, rape, kale, and swedes are cool-season annuals which can be planted any time from early spring to early fall. Since they are cold hardy and able to withstand temperatures as low as 15°F, they are most often used in the cooler months as season extenders. Some farmers have grazed them with as much as 6 inches of snow on the ground. Seed costs are low and they are fast-growing and easy to establish.

Other alternative forages such as annual grains and crop residue (e.g., corn stalks) can also be grazed in the early spring and/or late fall. Be careful about grazing crop residue. It may be more valuable as a way to reduce soil erosion.

Stockpiling Forage

The length of your grazing season need not be restricted to the length of your growing season. A sheep farmer leaves 250 ewes on pasture all winter, giving them little supplemental feed until just before spring lambing. This is possible by stockpiling forage.

Stockpiling means allowing an accumulation of forage for later use. It is most commonly done in the late summer to provide fall forage which can be grazed after the killing frosts. A dairy farmer in southwestern Wisconsin follows this plan: he grazes one third of his pasture in September and October, grazes another third beginning in late October and November after a hard frost, and saves the remaining third (which was rested in September, October, and November) to graze first thing the following spring before much new growth has occurred. Livestock graze the dead forage left over from the fall. That way the spring grazing season can start long before the growing season.

One problem with stockpiling grasses, however, is loss of forage quality. There are a number of ways to address this problem:

- time your stockpiling so that the forage doesn't head out and become over-mature before it dies in the fall.
- stockpile a forage, such as birdsfoot trefoil, which maintains its quality when mature.
- use stockpiled forage for livestock that require low nutrient levels (such as dry ewes or dry cows).

A second problem is lack of pasture. If you have limited pasture supply, stockpiling forage is probably not a good option since you'll have to take some of your pastures out of production in the early fall when forage is already in short supply. Keep in mind, however, that you can also stockpile crop residue.

ESTIMATING FORAGE YIELD

Tables 1 and 2 give average forage yields for Minnesota and Wisconsin. These yields can be used for relative comparisons and preliminary planning but you should estimate yields of your own pastures because your yields may actually be considerably different than those listed, due to differences in soil type, fertility, and management. You can estimate your own yields by keeping a record of hay yields from any of the pastures to be grazed or by calculating animal grazing days and observing animal performance on the pastures.

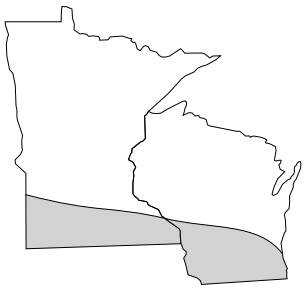
Table 1. Average forage yields for southern Minnesota and southern Wisconsin

Species	Quality	Yield (lb/a DM)	% Available by month					
			May	June	July	Aug.	Sept.	Oct.
Cool-season grasses								
Kentucky bluegrass	Good	5680	30	30	10	10	15	5
	Poor	1900	10	40	10	15	15	10
Orchardgrass	Good	6440	20	35	15	10	15	5
	Poor	2260	10	30	10	20	20	10
Reed canarygrass	Good	6180	20	30	25	10	10	5
	Poor	2720	20	30	20	10	15	5
Smooth bromegrass	Good	6080	30	30	15	10	10	5
	Poor	2620	25	35	10	10	15	5
Tall fescue	Good	7940	20	30	20	10	15	5
	Poor	2740	15	40	10	10	15	10
Timothy	Good	6260	25	35	10	10	15	5
	Poor	2340	10	45	10	15	15	5
Warm-season grasses								
Big bluestem	Good	5000	0	10	40	35	15	0
	Poor	2520	0	15	40	35	10	0
Switchgrass	Good	5000	0	15	35	35	15	0
	Poor	2500	0	15	45	35	5	0
Sudangrass	Good	5500	0	0	20	30	30	20
	Poor	3000	0	0	40	45	15	0
Legumes								
Alfalfa/grass	Good	5820	20	25	35	20	0	0
	Poor	3000	20	25	35	20	0	0
Birdsfoot trefoil	Good	5120	10	50	30	10	0	0
	Poor	2500	10	50	30	10	0	0
Red clover/grass	Good	5500	25	40	20	10	5	0
	Poor	2750	25	40	20	10	5	0
Alternative forages								
Oat	Good	3000	55	35	10	0	0	0
	Poor	1600	60	40	0	0	0	0
Winter rye	Good	2800	55	25	0	0	5	15
	Poor	1200	65	25	0	0	5	5
Winter wheat	Good	2800	55	25	0	0	5	15
	Poor	1200	60	30	0	0	5	5

Good=lime, P, K, and N (100 + 100 lb/acre, spring and summer) have been applied. Rotational grazing.

Poor=No fertilizer added. Continuous grazing.

Southern region



Northern region

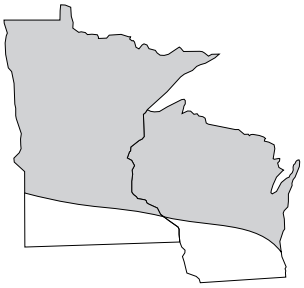
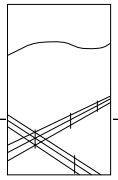


Table 2. Average forage yields for northern Minnesota and northern Wisconsin

Species	Quality	Yield (lb/a DM)	% Available by month					
			May	June	July	Aug.	Sept.	Oct.
Cool-season grasses								
Kentucky bluegrass	Good	4700	30	20	20	10	15	5
	Poor	1240	15	45	15	10	10	5
Orchardgrass	Good	5580	25	20	20	15	15	5
	Poor	1520	20	35	20	10	10	5
Reed canarygrass	Good	5460	25	20	30	10	10	5
	Poor	1940	25	30	20	10	10	5
Smooth bromegrass	Good	4900	35	20	20	10	10	5
	Poor	1780	30	30	15	10	10	5
Tall fescue	Good	6000	15	25	20	15	15	10
	Poor	1740	20	45	15	5	10	5
Timothy	Good	4800	25	30	15	10	15	5
	Poor	1600	15	50	10	10	10	5
Warm-season grasses								
Big bluestem	Good	3500	0	0	25	50	25	0
	Poor	2520	0	0	30	45	25	0
Switchgrass	Good	4830	0	0	35	50	15	0
	Poor	2170	0	0	30	45	25	0
Sudangrass	Good	5500	0	0	20	30	30	20
	Poor	3000	0	0	40	45	15	0
Legumes								
Alfalfa/grass	Good	5540	20	30	30	20	0	0
	Poor	3000	20	30	30	20	0	0
Birdsfoot trefoil	Good	4320	10	40	35	15	0	0
	Poor	2500	10	40	35	15	0	0
Red clover/grass	Good	5500	20	30	30	20	0	0
	Poor	2750	20	30	30	20	0	0
Alternative forages								
Oat	Good	2500	55	35	10	0	0	0
	Poor	1600	60	40	0	0	0	0
Oat + rape	Good	2410	30	45	25	0	0	0
	Poor	1600	30	45	25	0	0	0
Winter rye	Good	2300	55	25	0	0	5	15
	Poor	1200	65	25	0	0	5	5

Good=Lime, P, K, and N (100 + 100 lb/acre, spring and summer) have been applied. Rotational grazing.

Poor=No fertilizer added. Continuous grazing.



Estimating pasture productivity

You can make a direct estimate of a pasture's productivity by the following method:

1) Clip the forage in 1 square yard of pasture (clip at the height to which you would like to graze this varies with species).
2) Weigh all of the forage collected (take all measurements in pounds). Record the total weight of the sample (for example, 2.07 lb/sq yd).
3) Determine the % forage dry matter (DM):

   a) Weigh an empty paper plate. Record weight of plate (for example, 1 oz).

   b) Take a 1/2 lb (approximately) subsample of the forage. Place it on the plate and weigh it accurately. Record original weight of subsample (for example, 9 oz).

   c) Place sample in a microwave oven with a cup of water and turn the microwave on high for three minutes. Note: It is extremely important to leave water in the microwave throughout the drying process. Water reduces the chance of ruining the microwave or possibly starting a fire.

   d) Remove subsample and weigh it.

   e) Place subsample back in microwave for 1 minute.

   f) Repeat steps 3d and 3e until no additional weight loss occurs. Record final weight of subsample (for example, 3 oz).

   g) Calculate % forage dry matter (DM) as:

$$\%\ \text{Forage dry matter (DM)} = \frac{(\text{final weight of subsample}) - (\text{weight of plate})}{(\text{original weight of subsample}) - (\text{weight of plate})}$$

For example,

$$\frac{(3\ \text{oz}) - (1\ \text{oz})}{(9\ \text{oz}) - (1\ \text{oz})} = .25\ (\text{or } 25\%\ \text{Forage DM})$$

4) Determine pasture yield (lb/acre) as:

$$\text{Pasture yield (lb/acre)} = \frac{(\text{total weight of sample}) \times (\%\ \text{forage DM}) \times (43{,}560\ \text{sq ft/acre})}{(9\ \text{sq ft/sq yd})}$$

For example,

$$\frac{(2.07\ \text{lb/sq yd}) \times (.25) \times (43{,}560\ \text{sq ft/acre})}{(9\ \text{sq ft/sq yd})} = 2505\ \text{lb/acre}$$

Improving Pasture Productivity

If you want to make a profit from your pastures, you must think of yourself as a pasture farmer, putting the same amount of effort into establishing and managing your pastures as you would into any other crop. How many farmers would grow corn, wheat, or alfalfa with the same low level of soil fertility and low level of management that they use on their pastures?

Serious weed and fertility problems must be taken care of before you intensify your grazing system. Once weeds are under control and optimal fertility levels are reached, good grazing management will help maintain fertility while decreasing or even preventing further weed problems. If you fail to manage your pastures well, they will soon revert back to the same weedy, infertile condition and your dollars will have been wasted.

WEED CONTROL

Good rotational grazing systems will tend to keep most weeds out of pastures. Grazing management alone, however, will not normally correct serious preexisting weed problems without causing great losses in animal performance. Plants such as thistles, brush, and poisonous plants, may continue to be a problem even after you have intensified your system, since they are seldom eaten even at high stocking rates.

Before taking action, identify the weeds which are a problem in your pasture. Your county Extension agent can give you specific control recommendations. Thistles are by far the most troublesome weeds in pastures. But different kinds of thistles require different control measures.

Remember that not all plants which are considered weeds in row crops are a problem in pastures. Many so-called “weeds” such as quackgrass and lambsquarters are very nutritious at certain growth stages and need not be removed. Be concerned mainly about those plants your livestock avoid eating or that have low nutritive value such as goldenrod or hoary alyssum.

Cultural Control

Several cultural practices help maintain a weed-free pasture. Weeds are generally more of a problem in overgrazed, infertile pastures than in fertile, well-managed pastures. Good grazing management (with pasture rest periods) and good fertility will go a long way in keeping the forage healthy and able to compete with pasture weeds. To prevent spread of weeds, avoid spreading manure contaminated with weed seeds, clean equipment after working in weed-infested pastures, and keep fence rows free of problem weeds.

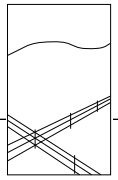
Mechanical Control

Repeated mowings, clippings, and hand weeding can diminish weed infestations. When in the bud to early bloom stage, cut weeds 3 to 4 inches above the ground. Some farmers clip each paddock after every grazing period. This weakens existing weeds by depleting root reserves and prevents further spread by preventing seed production. Bull thistle is controlled by cutting. Musk and plumeless thistles, however, commonly produce new shoots after mowing. If these shoots are not mowed, they will flower and set seed. Tillage can be used to suppress weeds as part of a pasture renovation program but is seldom used to manage weeds in a good pasture.

Chemical Control

Good management greatly reduces the need for herbicides. But even with the best cultural and mechanical methods of control, serious weed problems can persist and herbicides may be needed to control the problem. If the weed problem occurs over the entire pasture, herbicides can be broadcast sprayed. Keep in mind, however, that most pasture herbicides will remove desirable legumes as well as weeds. More frequently, weeds are patchy, making spot spraying the preferred method of control. Spot spraying is less costly than broadcasting.

Before deciding to use herbicides, be sure problem weeds have been accurately identified. As a general rule, avoid spraying until animals leave a paddock and do not graze treated areas until label restrictions allow.



Integrated Control

No single practice alone will produce or maintain weed-free pastures. An organized system that combines the appropriate preventative, cultural, mechanical, and chemical measures for each pasture is required. Start by evaluating the present status of your pastures and devise a 3- to 5-year plan of pasture improvement. Follow the above recommendations and with good management and perseverance, you will achieve more production from your grass and grass-legume pastures.

SOIL FERTILITY

The soil is a "bank" of nutrients for plant growth. An optimum "balance" of nutrients must be maintained in the soil so that pasture plants can make "withdrawals" for growth. "Deposits" or returns of nutrients are made when plant residue (dead forage and roots) decomposes, manure is returned or added, nitrogen is fixed by legumes, or fertilizer is applied.

To maintain good pasture performance, estimate current soil nutrient levels and manage so that soil nutrients are returned to the soil at the same rate they are removed. Once soil nutrient levels are at optimal levels, nutrients should cycle naturally in a well managed pasture through nitrogen fixation from legumes and livestock excrement. Since grazing animals normally return 60 to 80% of available pasture nutrients (providing their manure is returned to the pasture), some additional fertilization will probably be required depending on your management.

Many agronomic and environmental problems can be avoided by fertilizing at the correct levels. To determine fertilizer requirements, take regular soil tests and follow the recommendations given. When switching from one type of management to another (e.g., continuous to rotational grazing), sample yearly until your management has stabilized, then testing every 3 years should be sufficient.

To get a good representative soil sample, take several small subsamples (about 15) and mix them together. Use an auger (works best for compacted or frozen soil), probe, or spade; scrape an inch of surface soil to the side and sample to about 6 inches. Mix the subsamples together in a clean container to form your representative (or composite) soil sample. Transfer to a clean bag and label well. You should take one representative soil sample (about 2 cups of soil altogether) from each major soil type in your pasture or one for every 40 acres.

Fertilizer recommendations are based on a number of factors including soil type, climate, yield goals, future crop rotations, nitrogen credits from manure and legumes, pH, percent organic matter, etc. For this reason, it is important that you fully complete the soil test form. If you are not certain what types of soil are on your farm, you can obtain a soil survey report for your county from the Soil Conservation Service. Since local testing labs are more attuned to local soil types and climate, send your sample to the nearest reputable lab.

PASTURE ESTABLISHMENT/ RENOVATION

Before tearing up your current pasture, consider improving what is already there. Many naturally growing forages are well adapted to your pasture and will give adequate yields which can be improved with proper fertilization and good grazing management. In fact, just switching from continuous to rotational grazing can boost yields by up to 40%. Quackgrass, for example, is an excellent forage with high yields and crude protein values that may exceed 20%. Many farmers use grass/legume pastures to meet most of their production needs.

Seeding legumes into run-down pastures is the most common form of renovation. Legumes reduce the dependence on nitrogen fertilizers and complement grasses by balancing forage production throughout the season and providing more balanced nutrition.

The method of renovation you choose depends on a number of factors:

- How much money and effort are you willing to spend?
- How long are you willing to take a field out of production?
- How long are you willing to wait to get good establishment?
- Do you want to use tillage and/or chemicals?

There are a number of different approaches for establishing and renovating pastures. The following sections describe these methods.

Conventional Seeding

If you want to create new pastures from cropland, the best method is conventional seedbed preparation and planting. This works best in the spring when soil moisture is adequate for germination and when plants have the entire summer to establish. Seedings can also be made in late summer if there is adequate moisture.

Conventional seeding can also be used for renovating existing pasture. To renovate by conventional seeding, pastures are plowed or chiseled, worked up to reduce clods, and seeded. The advantages of tillage are that it eliminates competition from existing forages, it produces uniform pasture stands of desired forages, and it allows for incorporation of lime and fertilizer at planting (lime and phosphorous are more effective when incorporated). *Conventional seeding is highly effective, but costly, reducing production the year of seeding, and can lead to soil losses of up to 14 tons per acre*. (This figure is for a 15% slope which is fall-plowed and spring-planted.) To reduce erosion and to minimize pasture disruption conventional seeding can be done in strips over 2 to 3 years. Complete pasture renovation through conventional seeding is rarely needed.

Reduced Tillage or No-till

With this method, you drill seed into existing sod. Modified grain drills can be used, but no-till drills are recommended because they give better seed placement and are designed to penetrate sod. If you use no-till, soil erosion is only 1 to 3 tons/acre depending on slope. It is often necessary to reduce competition from existing sod, weakening it either by grazing the area heavily the summer/fall before seeding, applying a non-selective herbicide before seeding, or doing some limited tillage to kill up to 50% of the stand. Note, though, that disking causes average soil losses of 12 tons per acre on a 15% slope and 2 tons per acre on a 6% slope.

Frost Seeding

Frost seeding allows nature to do the planting for you. To seed, broadcast onto pasture in late winter or early spring just after snow melt. Soil heaving due to frosts will help bury the seed. This is a relatively cheap method but will produce non-uniform stands since late frosts may destroy new seedlings and not all seeds will be buried. Again, to reduce competition from the existing sod, weaken it in the fall using the methods mentioned in the above paragraph.

Livestock Seeding

Using livestock to do the seeding for you is by far the easiest and cheapest way of renovation. Not only do they disperse the seed but they add a little fertilizer and moisture! To produce a good stand, however, may take three to five years. Because of how animals manure, using livestock as your seeders will produce less uniform stands than the previously mentioned methods.

There are a number of ways to use livestock for seeding:

- Add some forage seed to the mineral mix (about 5 lb seed to 50 lb mineral), then put your animals in the pasture you would like reseeded.
- Allow a pasture of established legumes to go to seed, graze them and move animals to the pasture to be reseeded.
- Add seed to manure that you will spread on your pastures.

Selecting Appropriate Forages

It is most beneficial to grow a mixture of different forages in the same pasture. Every forage has its own susceptibilities and resistances. Planting your pasture to a single species is a “risky” venture since a single type of insect, disease, or environmental condition could easily wipe out the entire pasture. But planting a combination of forages with different strengths gives stability in the midst of changing conditions. Legumes can be an especially important component of pastures since they fix atmospheric nitrogen.

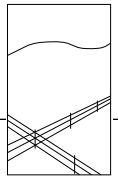


Table 3. Characteristics of forages

Species	Regrowth Potential	Legume Compatibility	Winter Hardiness[a]	Ease of Establishment	Drought Tolerance	Flooding Tolerance	Persistence
Cool-season grasses							
Kentucky bluegrass	Good	Poor	Excellent	Good	Fair	Fair	Good
Orchardgrass	Excellent	Poor	Good	Good	Fair	Fair	Good
Perennial ryegrass	Good	Fair	Poor	Excellent	Fair	Fair	Poor
Quackgrass	Excellent	Good	Excellent	N/A*	Good	Fair	Excellent
Reed canarygrass	Good	Poor	Excellent	Poor	Good	Excellent	Excellent
Smooth bromegrass	Fair	Good	Excellent	Good	Fair	Fair	Good
Tall fescue	Excellent	Good	Fair	Excellent	Fair	Fair	Fair
Timothy	Fair	Good	Excellent	Good	Poor	Poor	Poor
Warm-season grasses							
Big bluestem	Good	Poor	Good	Poor	Excellent	Poor	Good
Sorghum/sudan	Good	Poor	N/A	Excellent	Excellent	Fair	N/A
Switchgrass	Good	Poor	Good	Poor	Excellent	Poor	Good
Alternative forages							
Winter Rye	N/A	Good	Good	Good	Good	Poor	N/A
Oats	N/A	Good	Poor	Good	Good	Poor	N/A
Corn Stalks	N/A	Fair	N/A	N/A	N/A	N/A	N/A
Brassicas	Good	Good	N/A	Good	Fair	Poor	N/A
Legumes	**Regrowth Potential**	**Bloat Problem**	**Winter Hardiness[a]**	**Ease of Establishment**	**Drought Tolerance**	**Flooding Tolerance**	**Persistence**
Alfalfa	Good	yes	Excellent	Good	Good	Poor	Good
Alsike	Poor	yes	Good	Excellent	Poor	Good	Poor
Birdsfoot trefoil	Fair	no	Excellent	Poor	Poor	Fair	Excellent
Ladino	Poor	yes	Good	Excellent	Poor	Good	Poor
Red clover	Fair	yes	Good	Excellent	Poor	Fair	Fair
Sweet clover	Fair	yes	Good	Fair	Good	Fair	Poor

N/A=not applicable

[a]Winter hardiness assumes use of adapted varieties

*No seed available

Tailor the selection of the forage species to the needs of your grazing system (i.e., climate, soil type, moisture level, grazing intensity, desired length of grazing season, etc.) Table 3 identifies forage characteristics which are important to compare when planning a grazing system. All the forages listed in Table 3 have some place in pastures but no single forage is best suited to all situations.

Timothy and smooth bromegrass are the recommended pasture forages for northern and southern Wisconsin respectively, because of their high yield potential, high quality, and good legume compatibility. For optimal performance, however, they should be grown with other forages, since neither produces high yields of regrowth when grown alone. Timothy has poor tolerance for heat and drought and lacks resistance in southern Minnesota.

Orchardgrass has even higher yield than timothy and smooth bromegrass and recovers more rapidly after grazing but is extremely competitive so grow a competitive legume (such as red clover) with it.

Quackgrass is often overlooked as a forage because it has become such a serious weed problem in row crops. Quackgrass is an excellent forage, offering high yields of good quality forage.

Kentucky bluegrass easily survives on infertile, overgrazed pastures but produces good yields only if heavily fertilized.

Perennial ryegrass is an excellent choice if you want to include temporary pasture in your crop rotation. It is easy to establish, high yielding, and of high quality, but lack of winterhardiness shortens persistence to two years.

Tall fescue is not recommended for pastures because of reduced palatability and persistence. However, its fall growth is superior and it works well in areas with heavy traffic since it withstands a lot of trampling. It is commonly used in grass waterways since it establishes rapidly. Use fungus-free seed if intending to graze.

Switchgrass and big bluestem are native warm-season grasses which nicely complement cool-season grasses. They are slow to establish and poor competitors with weeds but once established, are persistent and vigorous. Switchgrass is easier to establish and lower in seed costs than big bluestem, but somewhat lower in quality as well.

Reed canarygrass may be the only forage option if flooding is a serious problem. Though it is difficult to establish, it is extremely persistent. Plant new, alkaloid-free varieties to avoid reduced animal intake because of low palatability. However, it is an extremely aggressive species and has the potential to invade and displace native plant communities, especially in areas of heavy silt deposition or other disturbances.

Alfalfa is the highest yielding legume with excellent summer regrowth, persistence, and drought tolerance. However, alfalfa doesn't tolerate flooding and bloat can be a problem in pure stands. Alfalfa will not tolerate overgrazing.

Birdsfoot trefoil has a number of desirable characteristics: 1) it maintains its quality better than any other legume or grass, making it a good choice for stockpiling; 2) it is the only commonly grown pasture legume which doesn't cause bloat; 3) it grows well on poor soils; and 4) it is by far the most persistent legume with stands known to be more than 80 years old! However, it is difficult to establish, relatively low yielding, easy to overgraze, and does not tolerate drought.

Red clover is a good choice for temporary pastures since it persists from three to four years. It is high yielding and the easiest and fastest legume to establish.

Sweet clover is often used for honey production but it is short lived and yields less than red clover. It has low bloat potential.

Ladino and alsike clovers are less persistent than red clover but perform well in heavily grazed pastures. They are high quality, lower-yielding forages that are tolerant of overgrazing. Alsike is especially well suited for poorly drained areas.

Animal Needs

ANIMAL DIGESTION AND NUTRIENT REQUIREMENTS

Ruminants, such as cattle, sheep, and goats are "natural grazers." They have a special organ in their digestive tract, the rumen, which is full of microbes that break down most plant fibers. Because of their efficient digestive system, ruminants can usually obtain most of the nutrients and energy needed for growth and production from good quality pasture alone.

Horses are "pseudo-ruminants." They don't have a rumen, but do have microbes in their digestive tract which digest some plant fiber. Therefore, horses must graze longer than true ruminants to get adequate nutrition.

Pigs and poultry are non-ruminants with smaller digestive tracts in which relatively little fiber digestion occurs. In addition to pasture forage, they must be fed high-energy supplements to get the nutrition needed for growth.

Figure 4 shows energy requirements of livestock in relation to the quality of various forage types. Quality, in this case, is represented in terms of total digestible nutrient (TDN) levels. As shown, each forage type has a different range of total digestible nutrient levels and each animal species and breed has a different range of nutrient requirements. Nutrient requirements vary with the animal species, sex, maturity, size, and whether or not the animal is lactating. To maximize production, you must match livestock nutrient requirements with forage TDN levels. High producing dairy cows, for example, could probably not get enough nutrients from cool-season annual grasses alone but must be given a high percentage of legumes or be fed supplement. Most animals can be maintained at TDN levels of 45 to 50%.

Most of the mineral needs of livestock can be met by the pasture alone (except if you are grazing crop residue, such as corn stubble). Salt, however, should always be provided to animals "free choice." When selecting a salt, it is a good idea to buy a trace mineralized salt just to make sure mineral requirements are being met.

ANIMAL WATER NEEDS

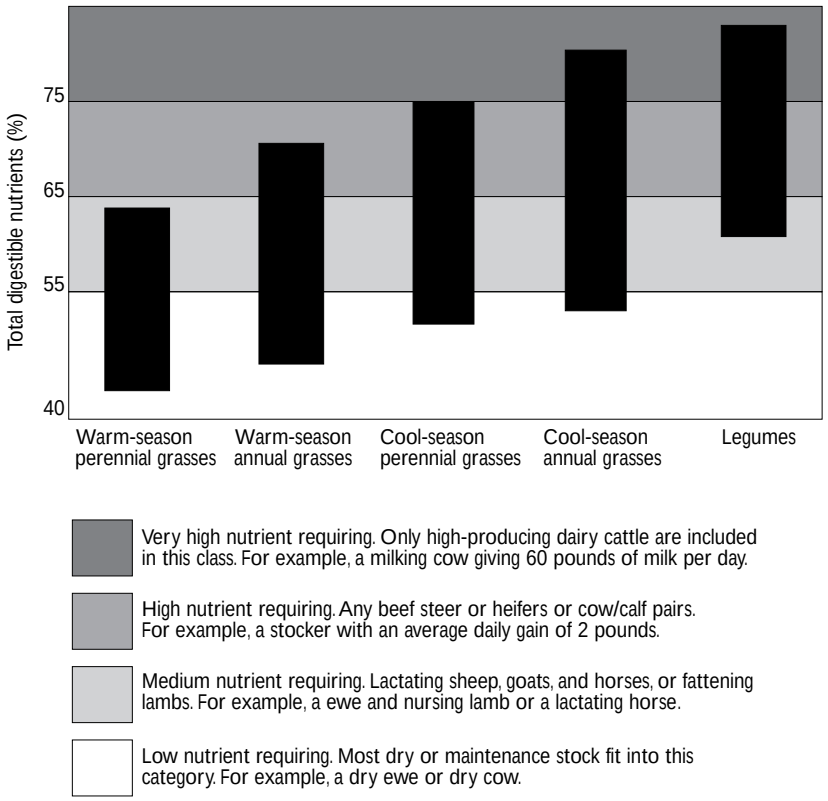
Although livestock can get the majority of their water from lush forage which is 70 to 90% water, a good supply of clean water is essential in a grazing system. Livestock water requirements are shown in table 4. But remember that water needs vary with temperature, humidity, animal size, milk production, and diet. For example, dry stock grazing lush grass or grazing in midwinter when there is snow cover may not need additional water.

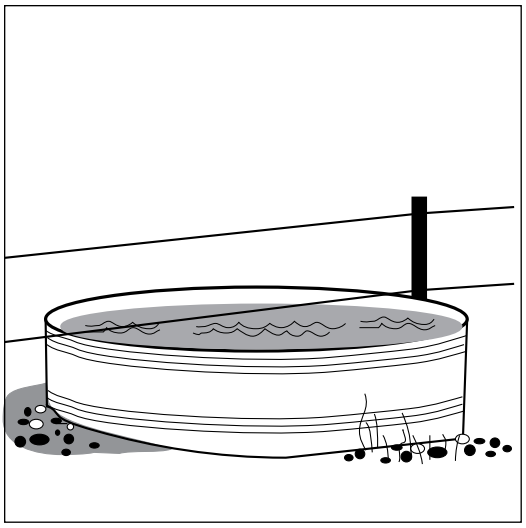
Table 4. Daily water requirements of grazing animals[a]

Animal	Gallons per day
Beef	8–10
Milking cows	30
Sheep	1
Horses	8

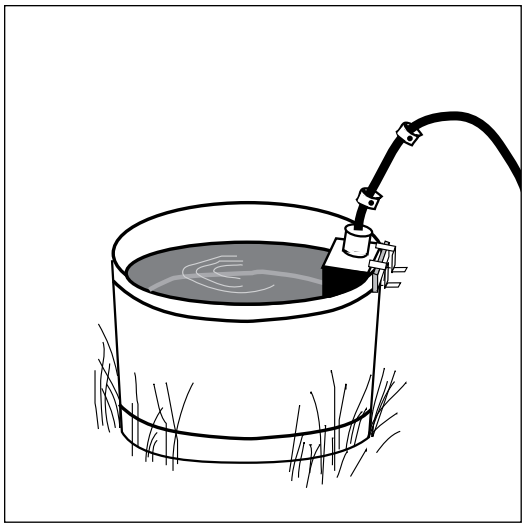
[a] These are average figures. Water needs will be greater on hot, dry days and/or when grazing on dry forage. Needs will be less on cool, rainy days and/or when grazing on lush forage.

Figure 5. Ruminant nutrient requirements





Single tank watering two pastures.



Movable 55-gallon drum fed by garden hose with float.

Access to Water

Most farmers use lanes to access a central watering site, but the ideal system is to have water available within every paddock. This reduces the distance livestock must travel to drink, discourages livestock from congregating around a central water source, and it also requires less fencing. Often, pasture is severely trampled and eroded near central watering sites, wasting forage and compacting the soil.

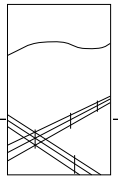
Even if you choose to use a natural water source, you should consider siphoning water to your livestock instead of bringing your livestock to the water source. This reduces disease and parasite problems and preserves water quality. To make pumping easier, moveable solar or battery powered pasture pumps are available.

Plastic tubing laid on top of the ground can be used for carrying water. That way it is movable and temporary. To maintain water pressure, it works best to use larger diameter tubing to transport water to the pasture and smaller diameter tubing to give water to the paddocks.

Size of Waterer

The size waterer you'll need depends on the distance between the water and your animals. Any time there is considerable distance between the herd and the water source, getting a drink involves travel and thus becomes a social function involving the movement of large animal groups. Under these conditions, use a separate water trough for each 50 to 60 head or have it large enough for 10% of the head to drink at one time.

Under intensive grazing (paddocks of less than 10 acres), where water is provided in every paddock, going to water becomes an individual function. Under these conditions, a portable 50-gallon tank (with a demand valve attached to a float to regulate water level) can easily water 100 head of cattle. Or, a 100-gallon container can serve two paddocks when located between them. A 10-gallon container with a demand valve will be large enough to water 100 smaller livestock such as sheep and goats. Portable waterers need not be fancy; 55-gallon drums cut in half will work. Tanks can be put on wheels or skids to ease movement. Lightweight plastic or fiberglass containers are available in various sizes.



Animal Grazing

GRAZING PATTERNS

Most livestock prefer not to graze during the hottest part of the day, so the heaviest grazing period occurs after sunrise for two or three hours. Grazing increases again as temperatures drop towards evening. A third grazing period may occur around midnight. On average, 60% of grazing occurs during the day, and 40% occurs during the night with livestock spending more time grazing at night following hot days.

Time spent grazing differs with species. Generally, cattle graze about 8 hours per day, sheep 7 hours or less, goats no more than 6 hours, and horses 12 to 16 hours per day.

The time spent grazing each day is roughly the same regardless of pasture quality or yield. Animals will quit grazing after the normal grazing time, whether or not they have gotten all the energy and nutrients they need for weight gain or milk production. To maximize production, livestock must receive a sufficient amount of high quality forage during their grazing period.

SELECTIVE GRAZING

Livestock are naturally selective in what they eat. The most nutritious, best tasting, easiest to eat forage will always be favored. Livestock favor certain forage types over others (forage favorites may change during the season) and younger plants over older ones.

Selective grazing can be a problem when the stocking density is too low. Some spots are grazed down, while other areas grow up and head out. As soon as a preferred forage plant begins to regrow after having been grazed, it will most likely be eaten again, since it tastes better (and its quality is higher) than other older forage in the pasture. This is called spot grazing.

Spot grazing causes yield losses in two ways: First, the areas that mature are lost because forage quality becomes too low. Second, the regrazed spots never have a chance to reach a height that allows rapid growth. Forage production in the heavily grazed spots is therefore reduced.

Spot grazing also favors poor forage composition in pastures. High-quality forage species die out from overgrazing, while unpalatable types flourish. Legumes are usually the first plants to be lost.

Spot grazing is reduced under rotational grazing (especially under intensive rotational grazing). Higher stocking densities in rotational grazing systems cause livestock to graze more uniformly and completely. High-quality forages, such as desirable grasses and legumes, thrive because they are given a rest period. Well-managed, rotationally grazed pastures usually have few weed problems.

Livestock selectively graze certain plant parts over others. Animals eat from the top down, taking the youngest, most nutritious leaves first, leaving less nutritious fibrous stems for later. Because of their small mouths, sheep and goats can graze more selectively than can cattle. For this reason, sheep need to graze more closely than cattle to get an even graze. If livestock are forced to graze a pasture down to the stems, however, they will perform more poorly (gain less weight or produce less milk) because they get less high-quality forage per bite. To best use your pasture, let high-producing livestock graze first followed by a "clean-up crew" of animals with lower nutritional needs.

AMOUNT OF AVAILABLE FORAGE

The amount of forage on offer also influences consumption. The taller and denser the forage, the more forage an animal will get per bite. If forage is tall (over 10 inches), however, forage is wasted because of trampling. If forage is short, animals waste energy trying to take in enough forage with little bites (kind of like eating corn on the cob or trying to eat with chopsticks if you're unaccustomed to them). When forage is too short, animal intake will decline and animal performance will suffer. Keep these factors in mind when deciding at which height to graze. Each forage species has a different height at which it does best when grazed. For more information, see the section on length of rest periods in "Setting Up a Rotational Grazing System."

GRAZING HABITS OF DIFFERENT ANIMALS

Different animal species have different grazing styles. Because of nose and jaw anatomy, cattle and horses cannot eat forage less than 1/2-inch tall. Sheep and goats can graze level with the soil surface. Close grazing by sheep and goats coupled with their sharp hoof action may lead to erosion problems, especially on overgrazed slopes.

Pigs, natural rooters, may eat entire plants, root and all, which they dig and pull out of the ground with their snouts; this is very disruptive to a pasture. They are excellent grazers, however, when snout rings deter them from rooting.

Fowl will strip the soil bare if allowed to, eating everything including roots and soil insects. They can be used to weed and fertilize land for small scale planting.

DIET SELECTION OF LIVESTOCK

Grazing animals have different dietary preferences as shown in table 5. On one extreme, horses are extremely "picky" grazers, rarely touching weeds and woody species. Goats, on the other hand, actually prefer the leaves and stems of woody plants over grass and can be used to clear land. Sheep will eat more weeds. If grazing more than one species of livestock, it is best to graze the picky grazers first and follow with the less picky eaters (e.g., horses or cattle followed by sheep or goats).

Table 5. Diet selection of livestock

Type of diet	Horses	Cattle and red-tailed deer	Sheep	Goats and white-tailed deer
		% of diet		
Forage[a]	90	70	60	20
Weeds	4	20	30	20
Browse[b]	6	10	10	60

[a]A mixture of grass and legumes.

[b]Woody material.

ANIMAL IMPACT ON PASTURE

Livestock impact pastures in a variety of ways besides simply harvesting forage. They tread on the soil, trample the forage, and disperse manure.

Treading and Compaction

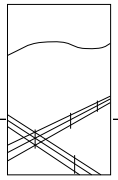
Some treading of the soil breaks up the soil surface allowing better water penetration and is not harmful to pasture plants. However, excessive treading (as seen in cow paths or livestock lanes) can lead to soil compaction. Under rotational grazing, compaction is minimized, since the soil is given time to recover after grazing. Keeping animals off of a pasture when it is very wet will reduce both soil compaction and stand damage.

Erosion, which can be a problem in continuously grazed pastures where animals walk or in camp areas (near shade, feed, water, gates, etc.), is minimized in a rotational system since livestock are prevented from treading on the same area day after day.

Manure

Just as livestock tend to cause erosion in areas where they congregate, they tend to manure more frequently in those areas. This causes some areas of the pasture to receive few nutrients while other favorite areas become over-loaded with nutrients. Fencing animals out of shady areas (or removing the shade) will cause them to stay on pasture rather than to rest, ruminate, and manure in the shady area. Higher stocking rates, and rapid rotations can also help to spread the manure out more evenly over a pasture.

Manure is an important contribution to a pasture providing both nutrients and organic matter. One cow can excrete 50 pounds or more of manure in a day! Animals will usually avoid eating near manure of their own species but will eat right up to manure of a different species. Cattle, for example, will avoid eating within a 12-foot radius of a fresh cow pie. At first, this avoidance is most likely due to odor which leaves after two to three weeks. Yet, by the time the odor has gone, the forage has had time to become more mature and less palatable than the surrounding forage and will consequently be avoided. *Spreading manure on*



one portion of a pasture is a good management technique to keep livestock off that portion of pasture.

Rejection of forage surrounding manure cannot be avoided but it can be lessened. Higher stocking rates will decrease the "zone of distaste" but animals should never be forced to eat right up to their own manure since it often contains harmful parasites. High stocking rates will also help break up manure (through hoof action), speeding decomposition. Following one species of animal with another will promote more uniform forage consumption and can help to break up parasite cycles. To obtain additional nutrients, some animals (such as pigs) will actually eat the manure of another species!

Setting Up a Rotational Grazing System

SETTING GOALS AND ASSESSING RESOURCES

The first step in starting a grazing system on your farm is setting management goals. Well-defined goals and an assessment of your pasture resources will determine how you design your system. The following questions may help you get started:

Goals

- Are you grazing to maintain a herd, to achieve maximum production, or to clear land?
- If grazing to achieve maximum production, do you want to maximize production per animal or per acre?
- How intensive do you want your management to be?
- Are you willing to fertilize?
- Are you willing to feed supplemental grain or hay?
- Do you want productive pastures right away or can you gradually work up to higher yields?
- Do you have severe weed problems such as thistle and brush, which must be taken care of before you intensify your system?

Resources

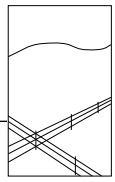
- How much capital do you have to invest for starting a grazing system?
- Do you have a shortage of pasture or an abundance?
- What forage species are currently in the pastures?
- What is the condition of the pastures? Fencing?

LENGTH OF REST PERIODS

How does a person determine the appropriate rest period to give a paddock? For optimum production, pastures should be grazed about a week before the grass heads out or when the legume is in the early or mid bud stage. (See Figure 1). Average heights at which to begin grazing are from 8 to 10 inches for most tall-growing cool-season grasses and legumes, from 4 to 6 inches for short-growing cool-season grasses and legumes, and from 12 to 14 inches for warm-season grasses. At these heights, pasture quality is high, forage is easy to eat, and recovery after the last graze has been sufficient.

The rest period required is closely related to seasonal forage growth (see figure 3).

- Cool-season grasses such as Kentucky bluegrass, smooth bromegrass, or timothy



need as little as 2 weeks of rest during cool weather and 5 to 7 weeks during hot weather.

- Legumes such as alfalfa, birdsfoot trefoil, or red clover need rest periods of about 3 to 4 weeks throughout the season.
- Warm-season grasses such as sorghum/sudan or big bluestem need to rest for 5 to 6 weeks during cool weather and about 3 weeks during hot weather.

Plants under stress (drought, cold weather, poor soil fertility, etc.) will require longer rest periods. Optimal growing conditions, on the other hand, decrease the rest period needed. If you must abuse a pasture (by overgrazing and/or using short rest periods), do it when growing conditions are optimal such as in the spring.

The above guidelines will help you get started but you must tune them to your own system. *It is crucial that you move your animals according to the forage not the calendar*. If you graze too early, the pasture will be set back, desirable plants may die out, and you may have weed problems. If you graze too late, the grass becomes bunchy, loses palatability, and your production might suffer. There are times when you'll want to purposely use shorter rest periods in order to weaken a pasture (say for interseeding legumes) or keep up with unusually fast growth. There are also times when you'll need to use longer rest periods in order to let forage reseed itself, renew its root reserves, or be stockpiled.

LENGTH OF GRAZING PERIODS

Controlling the amount of time a paddock is grazed is just as important as leaving adequate rest periods between grazings. If the grazing period is too long, newly grazed plants may grow back tall enough to be regrazed again within the same grazing period and can be damaged. Regrowth occurs after about six days during May/June and 12 days during August/ September so the maximum grazing period should never be longer than these averages.

Use short grazing periods. Since livestock graze selectively, they will eat highest quality forage when first turned out onto a paddock and be forced to eat lower quality forage each day they remain in the same paddock. They also tend to eat more when first turned out onto a fresh paddock. Therefore, shorter grazing periods will provide for more uniform forage intake. This is especially important for dairy farmers since change in forage quality shows up in milk yields. Many dairy farmers use one-day grazing periods; some move livestock after every milking. With other types of livestock, rapid moves are less beneficial and animals may be moved to new pasture every 2 to 6 days depending on the level of nutrition required.

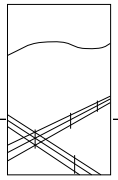
Do not overgraze pastures. The closer you graze a pasture, the longer the rest period required for forage recovery. The higher the stubble, the more quickly the plant will be able to recover after grazing. A good rule of thumb is to *leave 3 inches of stubble for cool-season grasses and legumes and 4 to 8 inches of stubble for warm-season grasses*. Try to adjust the length of your grazing period to allow for these stubble heights. If you can't leave these stubble heights, your forage will probably do all right if you give it adequate rest between grazing. A sure way to kill-off desirable species is to graze close and then graze the regrowth before allowing adequate rest.

If cattle are leaving excessive forage, you may wish to decrease your paddock size instead of lengthening the grazing period. You may have to lengthen the grazing period and/or increase the size of your paddocks midseason to correspond to decreasing forage growth rates.

Be careful when managing a grass/legume mix. Animals may eat clovers and birdsfoot trefoil all the way down and leave the grass. When these legumes grow back they may be set back because they are shaded by the grass.

GRAZING GROUPS

To make the most out of your pasture, it is often beneficial to divide livestock into different groups based on nutritional requirements for desired performance levels. This way, you can allow the animals requiring the highest level of nutrition to get the highest quality forage while saving the lowest quality forage for the animals with lower nutritional



requirements. There are several possibilities which should be modified to your own situation. A herd can be divided into two, or three groups. Table 6 shows examples of this.

There are two ways to best use forage to meet animal needs:

1) Graze more than one group on the same paddock sequentially. High producers should be grazed first (to consume the highest quality forage), animals with lower nutritional needs should graze second, followed by animals with only maintenance requirements (dairy cows followed by heifers followed by dry cows, or lambs followed by ewes).
2) Graze different groups in separate paddocks. If you have some poor quality pastures, let the animals with lower nutritional needs graze them.

   Note: Animals with only maintenance requirements can be used to clear land if used at high stocking rates (such as 170,000 lb/acre). Goats are especially good for this since they prefer woody forage. When using animals to clear land, however, don't force them to eat poisonous plants.

SPRING START-UP

There are two problems that you must deal with when getting started in the spring. The first is getting your animals used to consuming fresh feed after a winter of eating stored feed. Make the transition gradually to allow the rumen microbes to adjust. Don't turn hungry livestock onto pasture to start out with, they may eat too much and bloat. To guard against bloat, see bloat in "Possible Problems."

The second problem has to do with the pasture. The entire pasture will be growing at about the same rate. but you will be only grazing small sections at a time. This means that the paddocks you leave for last probably will overmature unless you compensate somehow. You can try one of three alternatives:

1) Spread spring green-up by staggering the last grazing in the fall.
2) Graze the first paddock when the plants are only 2- to 3-inches tall and move livestock rapidly from paddock to paddock until you reach a paddock in which forage has grown to the desired height. This will help stagger pasture growth throughout the season.
3) Make hay or mow pastures which get ahead. For instance, plan to make hay from about half of your pasture land (make sure it is not too steep, rocky, or wooded to be hayed) during the first grazing cycle.

During wet springs, avoid mud problems by grazing paddocks which are on high, dry land.

Table 6. Grazing groups based on nutritional needs

Livestock	High performance	Moderate performance	Maintenance
Dairy	dairy cows	heifers	dry cows
Beef	steers and heifers for meat production	cows with calves and growing heifers	dry cows
Goats	milking does	does with kids	dry does
Sheep	weaned lambs	ewes with lambs	dry ewes

SEASONAL FLUCTUATIONS IN PASTURE GROWTH RATE

There are a number of ways to provide high yielding, quality forage throughout the grazing season.

1) Reduce the number of paddocks grazed in the spring by using them to make hay. Put those paddocks back into the rotation in the middle of the summer and, if necessary, supplement your grazing animals with the hay made in the spring.
2) Plant warm-season grasses in paddocks to be grazed for the first time in late June or early July. An added benefit of warm-season grasses is that their extremely extensive root system gives them exceptional drought resistance and persistence in a field.
3) Plant legumes in cool-season grass pastures to provide more even summer growth (see figure 3).

DETERMINING STOCKING RATE

How many animals should I put in my pasture? It depends on your goals: if you have a limited amount of pasture land but a flexible herd size, you'll probably benefit from going to a more intensive system. The calculations below will give a rough estimate of the maximum number of animals that can be grazed on your land. If you don't plan on feeding supplement and/or are more concerned about individual animal gain than gain per acre, you may wish to stock at a lower level.

Calculating stocking rate

1) Determine total pasture acreage (PA) for the season (for example, 20 acres).
2) Estimate average pasture yield (PY) per acre. For average yields of various forage mixtures see table 1 or use your own figures if you have them. (for example, 4000 lb/acre).
3) Estimate the length of your grazing season (GS) in days (for example, May 15 through October 15 or 153 days).
4) Estimate the average weight (AW) of one of your animals for the season

$$\text{Average weight (AW)} = \frac{(\text{beginning weight} + \text{final weight})}{2}$$

Here are some guidelines:

dairy cow (Holstein)=1300 lb	horse=1250 lb
beef cow=1000 lb	goat=170 lb
beef bull=1250 lb	ewe and lamb=200 lb

5) Estimate the maximum animal numbers (AN) which can be grazed on your pastures during an entire season:

$$\text{Number of animals (AN)} = \frac{(\text{PA}) \times (\text{PY})}{(0.04) \times (\text{AW}) \times (\text{GS})}$$

The .04 figure is used because livestock need to have daily access to approximately 4% of their live weight in forage (2.5% intake, 0.5% trampling loss, and 1% buffer). This figure may be decreased if you are willing to feed supplemental hay or grain during periods of low production.

For example, for a ewe and a lamb:

$$\text{AN} = \frac{(20 \text{ acres}) \times (4000 \text{ lb/acre})}{(0.04) \times (200 \text{ lb}) \times (153 \text{ days})} = 65 \text{ ewes with lambs}$$

If you have a lot of pasture land and a fixed number of livestock, you might want to use a less intensive system which maximizes production per head rather than per acre. The calculations below will tell you the minimum amount of land required to pasture your herd. Remember, you can always use more than the minimum.

The minimum amount of land needed to pasture your herd:

$$\text{Pasture acreage needed (PAN)} = \frac{(\text{AN}) \times (\text{AW}) \times (0.04) \times (\text{GS})}{(\text{PY})}$$

For example, if you have 25 Holstein cows:

$$\text{PAN} = \frac{(25 \text{ cows}) \times (1300 \text{ lb}) \times (0.04) \times (153 \text{ days})}{(4000 \text{ lb/acre})} = 49 \text{ acres}$$

These calculations should be used only as guides to help you get started. Actual numbers will vary from site to site and year to year because of variations in the weather, soil type, and pasture condition.

MOVING LIVESTOCK

Moving livestock needn't be traumatic or time consuming for either you or your animals; an experienced rotational grazer can move 50 to 250 head of livestock in 15 minutes.

Minimizing the Stress of Moving

The key to fast moves is minimizing animal stress. Never force your animals to go somewhere they don't want to go, especially by hitting or yelling at them. Instead, make your animals want to move. Move them when they are hungry, during the day when they can see where they're going. Livestock are very habitual creatures. If you move them at the same time each day, they will anticipate this, stop grazing, congregate near the gate, and wait for you to come. As soon as you open the gate, they'll move themselves, anticipating fresh pasture. To minimize the stress of moving your animals, signal moves with a unique sign such as a whistle. Use this signal only when you are going to move them so that they don't stop eating and start bellowing every time you walk by or drive past in your truck.

If you have difficulty moving them, don't make any quick movements and don't try to push them directly from behind. Instead, stand slightly to the side of them, walk towards them and they should start walking away from you. Or leave the gate open and go away. They'll move themselves painlessly!

PADDOCKS: HOW MANY AND HOW BIG?

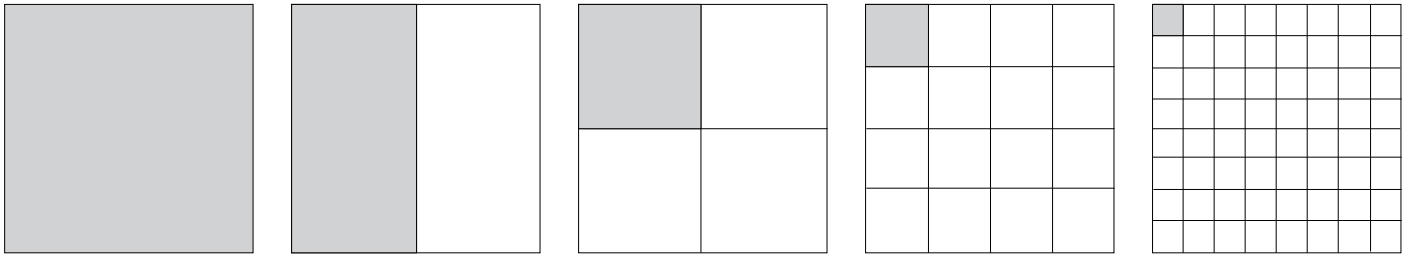
There is no "best" number of paddocks. Any number of paddocks is better than grazing a single pasture continuously. Initially, the number of paddocks in your rotational system may be determined by current fences, topography, access to water or access to a central collection corral or yard (as discussed in the next section). This may lead to a 2 to 8 paddock system and will result in great increases in pasture condition and animal performance.

The next step is to go beyond this into an intensive grazing system and let the length of grazing and rest periods determine the number of paddocks. Dividing a pasture into more paddocks increases the amount of rest per area while decreasing the length of time an area is grazed (figure 5). More paddocks are usually better than fewer for both the animals and the plants. But paddock numbers don't need to be rigid; they may be fenced with portable electric wire so that size and number may be changed as needed.

To determine the ideal number of paddocks for an intensive rotational grazing system, estimate the length of your longest rest period (during the slowest period of forage growth), the length of your grazing period, and the number of animal groups which will be grazing the same pasture sequentially. Paddock numbers (PN) can then be calculated from the equation below:

$$\text{Number of paddocks (PN)} = \frac{\text{(rest period)}}{\text{(grazing period)}} + \text{(number of animal groups)}$$

Figure 5. Relationship between paddock numbers and amount of rest per acre.



100-acre undivided pasture
Graze—100%; rest—0%

Two 50-acre paddocks
Graze—50%; rest—50%

Four 25-acre paddocks
Graze—25%; rest—75%

Sixteen 6.25-acre paddocks
Graze—6%; rest—94%

Sixty-four 1.57-acre paddoc
Graze—2%; rest—98%

(e.g., for 30-day rest periods with 3-day grazing period and 1 animal group: 30/3 + 1 = 11 paddocks needed)

Next, divide total pasture acreage needed by the number of paddocks needed to get paddock size required. Paddocks should be large enough to provide the optimum high quality forage for each grazing period (Calculate daily forage intake and fence off enough area in the paddock to meet animal needs).

PADDOCK LAYOUT

Most farmers have traditionally only pastured land which is not suitable for cultivation, but pasture needn't be relegated to your roughest land. In fact, after making good profits from pastures, many experienced rotational grazers have decided to turn some of their best land to pasture. Just about any land can be pastured except excessively steep hillsides or dense woodlands. Fencing livestock out of woodlands allows young trees to survive and results in more marketable, higher-value timber.

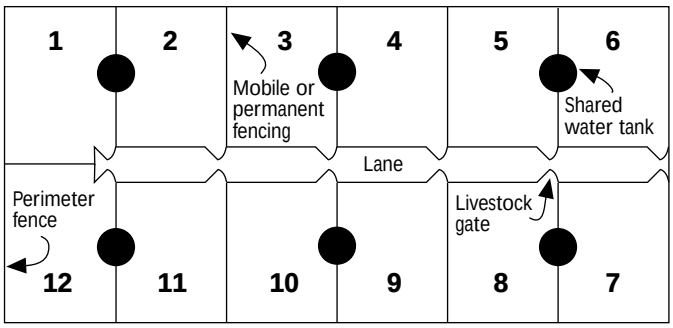


Figure 6. Square or rectangular paddock layout. This layout has a central lane with waterers shared between two paddocks. Paddocks are separated by mobile or permanent fencing.

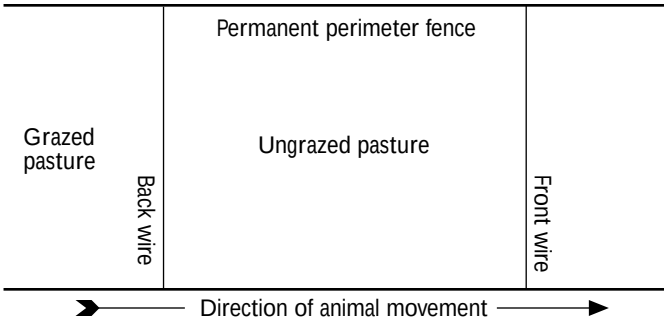


Figure 7. Strip grazing. The paddock has two wires which are moved along two permanent fences. Move the front wire according to pasture production and animal need. Follow with the back wire to prevent grazing of re-growth.

After deciding how much of your land you want to pasture, you must determine how much of it is unable to be hayed due to steepness of slope, rockiness, trees or other plants. If pasture forage is to be your only source of feed for the summer, you'll probably want about half of your pasture to be land which is able to be mechanically harvested so you can put up hay in the spring to compensate for high spring productivity while having sufficient pasture for the summer.

The easiest way to lay out fencing is to make square or rectangular paddocks of uniform size (figure 6). This way, paddocks can easily be subdivided with mobile electric fence and calculations are easier because of uniform paddock areas. Square paddocks will use the least amount of fence for the greatest area. Another option is to make rectangular pastures and strip graze as shown in figure 7.

Unfortunately, exclusively using square or rectangular paddocks is not possible on most farms due to variations within a pasture and irregular pasture shapes. *Paddocks should always be fenced so that the grazing environment within them is uniform*. If a pasture has variations (in slope, shade, soil type, forage quality, etc.), both forage growth and grazing will be uneven. The more rough the ground the more complicated the fencing system must be to ensure even grazing. In uneven pastures, proper paddock placement is important in a rotational grazing system and essential in intensive rotational systems.

You may wish to use a couple of tools in addition to your own knowledge to help you determine how to divide your pastures: a land use capability chart, a soils type map, a topographic map, and an aerial photograph of your pasture. To start out with, use the aerial photograph and maps to draw (or photocopy) a scaled map of your pasture land indicating the location of existing fencing, relevant buildings, roads, water sources, woodlands, and hills.

When separating pasture into paddocks, it is not necessary to completely change your current fencing system. Make changes slowly, with the following principles in mind:

Topography

- Separate different slopes into different paddocks. Because a south-facing slope gets more sun, it may be ready to graze as much as two to three weeks before a north-facing slope on the other side of the same hill. South-facing slopes usually dry out faster in midsummer.
- Lay paddocks out across the slope (on the contour) rather than constructing a paddock running from top to bottom of a hill.
- Hill crests and valleys should be separated from slopes. Livestock will often prefer to graze on level ground and will graze it more heavily than sloping land within the same paddock.

Forage Type

- Different forages will have different times for beginning spring growth and levels of summer growth (figure 3).
- Grazing may hurt certain forages at certain times of the year and reduce persistence. For example, avoid grazing legumes from September 1 to October 15).

Soil Type

- Try to separate different soil types as much as possible. Different soil types will have different levels of productivity. For example, paddocks with good soils can often be grazed more frequently than those with droughty soils.
- Make sure appropriate forage species are planted in areas prone to flooding or drought.

Shade and Water Availability

- Fence shady and sunny areas separately. This will prevent cattle from grazing the sunny areas and resting and leaving manure in the shade.
- Water should be accessible from each paddock.

Other Considerations

- Square or rectangular paddocks are usually a bad choice for hilly and/or non-uniform land.
- A pie layout around a central water source (figure 8) is commonly used in western rangeland where water access or ability to pump water is limited, but has limited value in the Midwest. This layout can cause problems since animals will tend to congregate near the water source, causing excess trampling of the forage and uneven distribution of manure. A better alternative might be to use livestock lanes around a water source (figure 9) or pump the water to tanks in each paddock (figure 6).
- Livestock lanes should be as short and narrow as possible since their forage is usually trampled and wasted. Lanes 12 feet wide work well for small herds (35 cattle or 350 sheep) but to allow passage of equipment and large herds, 18 to 24 feet widths may work better.
- Gates should be located in the corner of the paddock nearest to the barn.

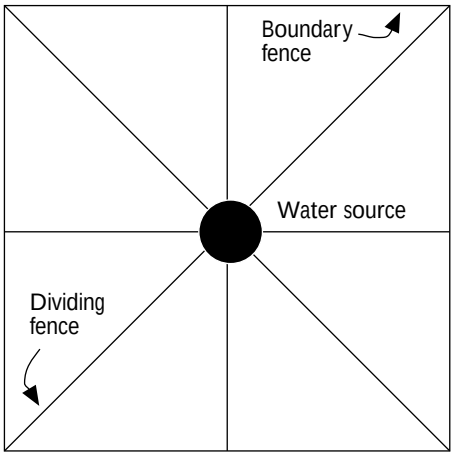


Figure 8. Access to a central watering site with paddocks in a "pie layout" *(not recommended)*

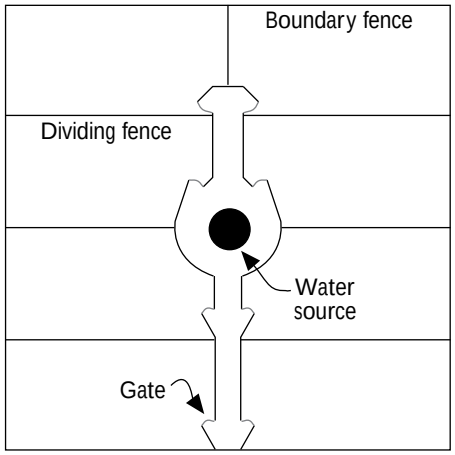


Figure 9. Access to a central watering site using livestock lanes

DESIGNING A PASTURE SYSTEM

Tailor paddock layout to your own farm. The most important part in setting up a grazing system is putting what you know about your farm to work. Figures 10 through 12 are examples of a "typical" farm which is taking the first steps in switching from continuous to rotational grazing. This farm has a 5-acre field at the top of a hill south of the buildings. There is a slope to the north and south of this pasture, a low area northwest of the buildings, and a south slope along the northern property line.

The land with buildings and perimeter fence is shown in figure 10. The farm has been divided into four paddocks (figure 11). To maintain water quality, the pond has been fenced off. Water will be pumped to a waterer in the barnyard. All paddocks have a gate at the barnyard. This avoids the need to create lanes and makes cattle handling easier; it also allows one water source to provide water for all paddocks. This setup is not necessary for most pasturing systems but essential for milking herds which return to the barn daily. The paddock northeast of the buildings was fenced separately because it is reasonably flat and could be left for hay making in periods of surplus forage. Different slopes were not fenced separately, but with just four divisions there are limits to how much fine tuning can be done according to the above considerations. This fencing division to four paddocks will result in a large improvement in production over the two paddock system of figure 10. The fencing can be either permanent or temporary and may be the final stage of setting up a 4-paddock system or the first step to establishing an intensive grazing system.

Figure 12 shows the next set of divisions that should be made to go to an intensive grazing system. Further divisions from the previous figure have been made with portable fencing and can be moved, increased or decreased in number. In this further fencing refinement, the south-facing slopes were all fenced separately from other areas because they can be grazed earlier than other paddocks in the spring and the low area northwest of the pond was fenced into a separate paddock because production would be much higher than other areas during dry spells. Note that the paddocks are not all the same size. It is more important that the paddocks yield roughly equal amounts of forage than that they have equal areas.

When deciding how to divide your pasture, think about what you have to work with: existing fencing, permanent buildings, water sources, etc. Use these resources as much as possible.

Designing a pasture system

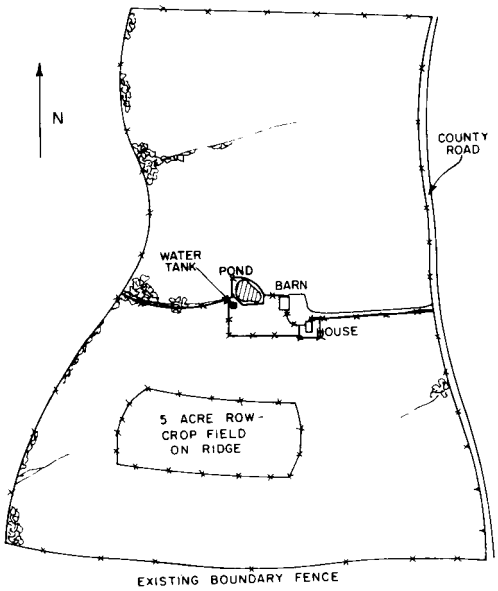


Figure 10. Add a division fence

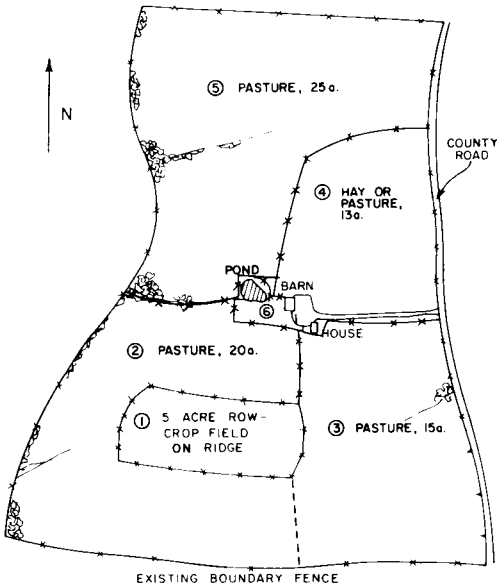


Figure 11. Subdivide the land into four paddocks using permanent (x—x) and temporary (– –) fencing

FENCING

Good fencing is a must in rotational grazing systems. The fencing system used for rotational grazing includes a permanent perimeter fence as well as permanent or movable fencing to separate paddocks. For more information about the fencing options described below, contact your local fencing distributor.

Permanent Fencing

Most farmers use permanent fencing for perimeter fences and movable fencing for individual paddocks. Other farmers have chosen to construct permanent paddocks for all or part of their pastures. The advantage of permanent paddocks is that, once they are established, fences do not have to be moved. If your livestock numbers are fairly stable, and you have become experienced in rotational grazing, this may be a viable option for you.

Before going out to buy new fencing, determine what permanent fencing you already have on your farm. Existing wooden or barbed wire fencing will work fine for the perimeter fence as long it provides an effective barrier for the animals. To separate individual paddocks, you'll probably want to use temporary electric fencing as described in the next section. Don't let your current fencing arrangement limit you. Fence in a way that makes the best use of your land.

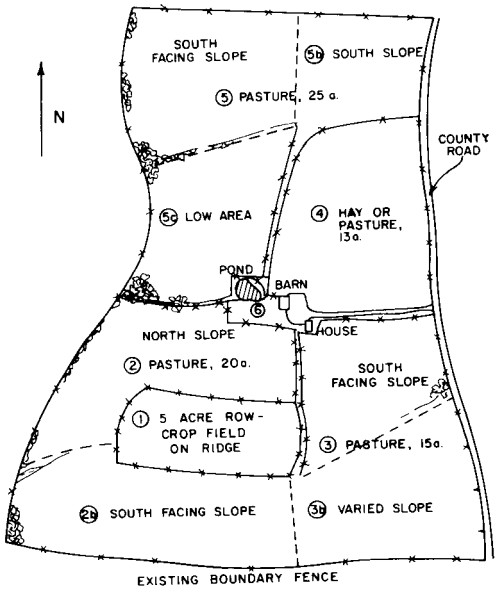


Figure 12. Subdivide the land into eight paddocks using portable fence

Consider the state of repair of the current fence. An old fence can be improved by adding a single electric wire on a strut that protrudes into the pasture (offset fence). Never electrify barbed wire since animals can cut themselves badly on the barbs when recoiling from a shock.

When constructing new perimeter fence, most farmers choose smooth, high tensile wire since it is relatively cheap, long-lasting (about 30 years), fairly easy to move (if necessary), and highly effective. These fences can be constructed so that some or all strands can be electrified.

Lightweight Movable Fencing

With movable fencing you can easily alter paddock size to meet changing conditions of forage growth or herd size. Pasture divided into temporary paddocks is easily accessed by machinery, or can easily be taken out of pasture all together.

Portable wires and tapes are made of polyethylene imbedded with stainless steel strands (the greater the number of metal strands, the longer it will last). Polywire is made as a braided wire and is available in a variety of colors and lengths. Brightly colored tape is more easily seen by livestock and therefore is good for training animals new to rotational grazing. Both kinds of fencing come on light reels which can be easily moved and hooked on to perimeter fences. A single strand is all that is needed between temporary paddocks since electric fencing is a fear barrier rather than a physical barrier. (A second strand may be needed when very young animals are kept with mature animals.)

Lightweight plastic or fiberglass posts can be used to hold up the polywire. They are so light that 20 or 30 stakes can be carried at a time. Their narrow ends are easily inserted into the soil by stepping on a side lip with your foot, or pushing down from the top. Beware of splinters if you use fiberglass.

If you choose to use polyethylene wire or tape, you'll need to carefully select your fencer since ordinary, weed-burning chargers will melt the plastic. The best type of energizer on the market today is the New Zealand type, low impedance pulsating high energy charger.

Electrified tape used to divide paddocks

These give extremely short (.0003 second), high-energy DC electrical pulses. Since the pulse is so fast and short, energy can't be drained off by weeds or by a section of fence that has fallen onto the soil. There is less need to trim weeds from underneath fences energized with New Zealand type energizers since they rarely short out.

DECIDING WHEN TO MOVE LIVESTOCK

For rotational grazing to be successful you must be flexible! Don't get into a rut of grazing every paddock in the "proper" sequence for the "proper" number of days and then follow your estimated rest period. The number of paddocks grazed and the lengths of the grazing and rest periods should vary as pasture growth rates change with the weather. The faster the pasture grows, the fewer paddocks you'll need to have and the shorter grazing and rest periods you'll need to take. During times of slow pasture growth, you'll need to have more paddocks and longer rest periods.

Suppose you estimate the longest rest period of the season to be 32 days so you figure you'll need 16 paddocks in all. Anticipating faster growth rates in the spring, you estimate that the rest period will need to be only about 16 days to start out with. You decide to split the pasture in half in the spring, harvest half for hay and graze the other half. You begin grazing paddock #1 moving sequentially through all eight paddocks. But it has been a dry spring. By the time you've finished grazing paddock #8, paddock #1 isn't ready to be grazed yet. What do you do? Graze some of the land you were setting aside to make hay until paddock #1 is ready to be grazed (or feed stored feed). A good manager would have anticipated this slow growth earlier and slowed down the rotation.

On the other extreme, it is midsummer, the weather has been rainy and cooler than usual. You are on paddock #10 in a 16-paddock rotation when you notice that paddock #1 is ready to be grazed again. If you follow your planned rotation, paddock #1 will over-mature by the time you get to it. What do you do? Graze paddock #1 out of sequence. You can mow or hay the paddocks that you didn't get to in this round so they'll be ready later in the season.

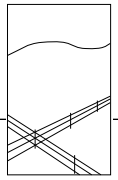
What if you don't want to (or can't) make hay during periods of rapid forage growth? Move the animals faster from one paddock to the next. The animals will "top" the paddocks, grazing the most nutritious forage, leaving the rest. Under this system, forage is wasted but only the lower quality forage will be lost. The alternative is to use the same grazing period length you would have used under "normal" growing conditions. Because of rapid growth, the paddocks yet to be grazed would become over-mature and even more forage would be lost.

Since livestock's heaviest grazing occurs in the morning, it is best to move them to a fresh paddock early in the morning, near sunrise.

EVALUATING AND IMPROVING YOUR GRAZING SYSTEM

If you are interested in intensifying your current grazing system or making a transition from confinement feeding to pasturing, do so gradually. It takes a while to attain good stand establishment and good pasture forage yields. Rotational grazing requires new forage management skills which take time to develop.

In order to evaluate and improve your rotational grazing system, it may be helpful to draw up a "pasture calendar." This calendar should span the entire year and be subdivided into monthly and weekly sections. Leave



enough space to record timely observations of your pasture and animals, management plans, and new ideas.

1) Animal observations

Try to match animal needs with forage production.

- Record animal health problems you think might be related to grazing.
- Keep track of stocking rates. Are the rates high enough to prevent spot grazing?
- Are your livestock developing "camp" areas? How can this be avoided?
- Are your livestock getting enough feed from pasture? Why or why not? Is there significant trampling loss? Are you feeding them too much non-pasture feed in the barn?
- Is production at desired levels? Do you need to feed supplement or renovate your pastures?

2) Pasture observations

- Keep track of rest and grazing periods. How is your pasture responding to these? Are your pastures being set back? Are they getting ahead of you? How do you respond?
- Keep track of which pastures you grazed so you know how much rest they need.
- Keep track of the growth stage of your forages. How long does it take to reach the optimal stage for grazing?
- How much stubble are you leaving? Is pasture recovery fast enough?
- How do you plan to deal with the midsummer slump?
- How will you extend the grazing season?
- If you plan to stockpile, how much forage do you need?

Possible Problems

PARASITE

Grazing livestock (especially grazing intensively) can lead to increased parasite infestation. Since signs of an infested herd are not always obvious, producers often fail to treat animals until they see visible symptoms such as diarrhea, sunken flanks, or "bottle jaw." By this time, significant herd production losses have already occurred. Infected animals show greater susceptibility to disease, general lack of vigor, slow growth, low milk production, and low weight gains. Although parasites affect young animals most severely, all livestock are detrimentally affected.

Understanding the general parasite life cycle aids in being able to control or prevent infections. Infected animals spread parasites quickly and effectively, putting an entire herd at risk. One cow can shed up to 400,000 worm eggs per day in its manure. Under warm and moist conditions, these eggs hatch into infective, mobile larvae which move out onto pasture forage. After being eaten by livestock, the ingested larvae become egg-laying adults in about three weeks, eventually releasing thousands more eggs which come out with manure. Though hot, dry weather kills most larvae, some survive in soil, in manure pats, or under vegetation. Surviving larvae overwinter beneath the snow to reinfect livestock the following spring.

The key to parasite control is prevention. It is best to de-worm livestock before they are put to pasture in the spring to kill any adult worms still in their bodies. (Check product label for product restrictions before de-worming pregnant stock.) Since livestock will probably ingest overwintering larvae in the pasture while grazing, worm them again 3 to 4 weeks later when larvae have matured but before they release more eggs. A follow-up worming in another 3 to 4 weeks is also advisable. Try to treat immediately before livestock are moved to a new paddock to prevent contamination of new paddocks.

De-worming is simpler than it used to be due to de-wormer blocks, feed premixes, and medicated mineral salts which eliminate the

need to round up livestock separately for treatment. Make sure to use the new broad-spectrum de-wormers which are effective against all larval and adult stages of worms.

BLOAT

Bloat is most often a problem when grazing high-quality, lush legume pastures (except birdsfoot trefoil) or lush young grasses or brassicas. Foam-producing compounds in the immature plants cause stable foam formation in the rumen of susceptible animals, prohibiting them from belching rumen gas. This condition, if not treated immediately, can lead to death. Individual animals differ in their susceptibility to bloat.

Bloat can be a serious problem if hungry livestock are turned out on young, lush legume pasture (greater than 50% legumes). Listed below are some ways to prevent bloat:

1) Don't graze hungry livestock on pure legume pastures (except birdsfoot trefoil). Play it safe by planting grass with your legume. Also, feed them with hay before turning out and let them graze only a short time the first 2–4 days. And finally, once on pasture leave livestock there continuously so they don't gorge themselves
2) Don't graze legumes or brassicas with lots of rain or dew on them, especially in autumn.
3) Don't graze grass or legume pastures at immature stages, before they have regrown.
4) Feed poloxalene, an anti-foaming agent. Give to cattle before turning onto pasture and continue throughout the season. The effectiveness of poloxalene depends on daily consumption. Mix with a daily feed supplement. Supplying as a block or mineral mix will allow non-uniform daily feeding and be less effective.
5) Plant birdsfoot trefoil, a non-bloating legume.

Bloat can "sneak up on you." One farmer, in his first year of rotational grazing, complained of having bloat problems on a pasture which never gave any problems when grazed continuously. It turns out that he was leaving his cattle on one paddock so long that in the last days before moving, they were grazing extremely poor quality forage and were very hungry. When turned onto a fresh paddock, they gorged themselves on lush legume/grass forage and bloat became a problem.

NITRATE POISONING AND POISONOUS PLANTS

Certain plants, such as, lambsquarters, pigweed, and annual grains, tend to have a greater concentration of nitrates than others. Nitrate accumulation is especially a problem during periods of slow growth initiated by drought, shade, or herbicide application. Application of manure and/or nitrogen fertilizer also increases nitrate content of forage. Nitrates can also be high in well water which cattle drink. If you suspect nitrate poisoning, have your forage tested. Levels above 0.1% may affect production (depending on animal age, nutritional requirements, and whether or not pregnant). Levels above 0.35% nitrate-nitrogen may be potentially lethal.

To decrease the risk of chronic nitrate toxicity, forages with potentially toxic nitrate levels should be supplemented with low nitrate forages, unnecessary fertilization should be avoided, and pastures with high numbers of lambsquarters and pigweed should be avoided during periods of drought.

Poisonous plants are seldom a problem in the midwest because they generally taste bitter and will be avoided as long as other forage is available.

DROUGHT

During drought years, the greater the intensity of management the better. Rest between grazings becomes more and more crucial as drought stress increases. As a general rule: the slower the grass growth, the more intensive the management should be. Also, if possible, during drought periods, more stubble should be left after grazing.

Some farmers have set land aside to be grazed only during a drought. This should be extremely drought tolerant forage such as warm season grasses.

Early weaning of beef calves (at 3 months of age) is an appropriate pasture management technique during drought. Calves should be turned onto good quality pasture and be supplemented with several pounds of grain. Dams or ewes can then be maintained at a lower level of feed intake.

Practical Examples of Rotational Grazing

LARGE-SCALE DAIRY OPERATION

Charles Opitz
2,100 acres in Mineral Point, Wisconsin

With about 2,000 livestock, Charlie Opitz runs one of the largest dairy farms in Wisconsin. Initially, he got into grazing to provide low-cost feed for his heifers and dry stock. But his system worked so well that he now rotationally grazes his 600 to 800 milking cows while maintaining a herd average of almost 15,000 lb. Charlie views well-managed rotational grazing to be the most economical way of feeding dairy cows.

Charlie has an "all grass/no grain" farm. About half of his land is in pasture while the rest grows alfalfa hay or silage. On his most fertile soils, Charlie grows a mixture of bromegrass (which tests up to 21% crude protein), quackgrass (which often tests 30% crude protein), and legumes, along with many naturally growing forages. This forage mixture can be grazed five times a year. On infertile pastures, Charlie concentrates on legumes which he routinely allows to reseed themselves.

Charlie's pasture land is divided into 89 permanent paddocks which he subdivides with pasture tape if necessary. These paddocks are not all the same size, but were constructed so that forage yield is roughly the same in each paddock. To construct paddocks, Charlie uses a combination of high tensile and mobile electric fence. Waterers (greater than 50 gallon capacity) are shared between two adjacent paddocks. They are located in the middle of a dividing fence so that a paddock can be divided in half while retaining easy water access. He also moves mobile mineral feeders into the paddocks being grazed.

Since all food and water needs are provided in each paddock, heifers and dry stock rarely need to return to the barn. Most of these animals are kept in paddocks without lanes. For dairy cows, Charlie has constructed a series of 12- to 13-foot-wide lanes of sewer rock topped with lime. Dairy cows are moved through permanent lane gates to fresh pasture every two days.

Charlie emphasizes that to be successful at rotational grazing "you must always be watching the grass." You'll know you're overgrazing when recovery times take too long and desirable forages die out. You'll know you're undergrazing when pasture growth is uneven and bunchy, and when weeds are invading. In general, he follows the guidelines listed in the next paragraph but emphasizes that for successful rotational grazing, you must fine-tune general guidelines to match your own system. This takes from 3 to 5 years.

Charlie Opitz discusses grass farming at a summer field day

For maximum forage production, Charlie puts his animals on a paddock a few days to a week before the grass heads out. This works out to resting a paddock 3 to 5 weeks in spring, 5 to 7 weeks in midsummer, and 4 to 5 weeks in fall. He separates his herd into grazing groups of no more than 250. Milkers are moved every two days followed by some dry stock and heifers to clean up. He shoots for stocking densities of 40,000 lb per acre for at least the first couple of rotations. He has found that a high stocking density is needed for even grazing, uniform manure spreading, and good weed control.

Charlie adjusts rest periods, grazing periods, and stocking densities according to management objectives and the weather. He overgrazes pastures to weaken them for reseeding; moves cattle faster in wet weather to minimize soil compaction and keep up with forage growth; uses heifers and dry stock at increased stocking rates for weed control; and evens out summer feed by stockpiling some spring growth to be grazed by dry cows in midsummer.

Charlie's heifers graze from late March until December. His milkers and dry stock usually start grazing 2 to 3 weeks later in the spring and

come off pasture 2 to 3 weeks sooner in the fall. To have such a long season, Charlie stockpiles forage for deferred grazing in the late fall and early spring. Two thirds of the pasture land is rested during September and October. One half of this is grazed after a hard frost in late fall, and half is left to be grazed first thing in the spring. His "freeze-dried" forage (largely quackgrass and bromegrass) tests 14 to 18% protein.

This method of stockpiling provides staggered spring pasture growth. The pasture that was rested the longest in the fall is the first to green up in the spring. In addition, Charlie starts grazing spring forage when it is as short as two inches. "Starting the first graze early sets you up for the rest of the season." He also makes sure he grazes close in the spring since he has found this encourages the formation of a thick sod (a thick sod keeps weeds out and enhances production).

Charlie's preferred method of pasture renovation is to mix legume seed with the mineral mix (which he provides free-choice in every paddock) and turn cattle into an area needing reseeding. This works especially well with trefoil. To control weeds, he clips twice a season before weeds go to seed, spot sprays the pasture if necessary, and sprays the fence rows.

Peter and Hilary Wood with quintuplets

SHEEP FARM

Peter and Hilary Wood
163 acres in Blanchardville, Wisconsin

Peter and Hilary Wood raise Finn-Rambouillet breeding stock. Their home flock of 250 ewes and 12 rams includes some of the most long-lived, prolific sheep in the country. They produce about 600 lambs per year, the majority of which are sold as ewe replacement lambs or ram lambs. Though their emphasis is on breeding, Peter and Hilary view pasturing as key to raising such healthy, productive animals. Well over half of their farm is in pasture and is grazed for up to 10 months out of the year, while the rest is fairly equally divided between hayland and woodlots. They have been rotationally grazing sheep for more than eleven years.

The farm is divided into 14 permanent legume/grass pastures which were fenced using exclusively used materials. To keep predators out, they use a net perimeter fence and keep a guard dog named Genghis. The 14 pastures are subdivided as needed into paddocks by 1- or 2-strand electrified polywire (they have found that 2 strands work best for untrained sheep, but 1 strand works fine for sheep that remember where a shock comes from). Each pasture has a permanent gate which goes into a wooded mineral feeding and watering area which can also be used as a holding pen.

After each grazing period, the animals are channeled through the gate into the holding area while the mobile fencing is moved (they find it difficult to get sheep to cross the old temporary fence line). No matter which side of the pasture the new paddock is on, a lane is always made to the gate with the mobile fencing so that the sheep can walk themselves into the new paddock.

Peter and Hilary try to allow a pasture to regrow to 8 to 10 inches tall before turning sheep in to graze, but emphasize that they are flexible. "If you need a pasture, you can regraze it at 6 inches." Like Opitz, in the spring they put their animals to pasture at shorter forage heights and make hay to encourage staggered forage growth. Unlike most rotational grazers, they let their sheep graze down right to the ground before they move them. They have found that since sheep are such selective

grazers, you must graze them "tight," otherwise weeds and coarser grasses take over and legumes die out. Even with tight grazing, they have found that birdsfoot trefoil can regenerate from "nothing" if given adequate rest.

The Woods try to match the nutritional requirements of their animals with the productivity and quality of their pastures. Lambing is done only once a year in early April so that the high-nutrient-requiring nursing lambs and their mothers receive the highest quality forage of the year. After the lambs are weaned, they become their own grazing group for the rest of the summer. They graze first, eating mostly the high-quality legumes needed for growth. The ewes follow to clean up the grasses. The ewes actually lose weight in the summer which is desirable so that they don't become overweight but can put on weight before lambing. For 2 to 3 weeks before and after breeding, they put the ewes on high-quality pasture to encourage ovulation and embryo retention. During mid-pregnancy the nutritional needs of the ewes decline, allowing them to survive along with the rams by grazing stockpiled forage and hay stubble throughout the entire winter with little or no supplemental feed. About one month before lambing, the ewes are taken off pasture to be fed the nutritious grain and hay needed to build up their energy reserves for lambing and to prevent pregnancy toxemia.

Length of winter grazing depends on the amount of stockpiled forage available. They estimate this amount by averaging ewe grazing days from previous years. They don't rotationally graze the sheep during winter since forage growth has stopped and parasites are inactive.

Peter and Hilary see many advantages to rotational grazing. From an economic standpoint they feel that "the cheapest, most energy-efficient harvester is the sheep itself." Peter estimates that it costs 2.5 cents per day to feed a ewe on improved pasture, 5 cents per ewe per day on unimproved bluegrass pasture, and greater than 10 cents per ewe per day feeding both hay and grain. Rotational grazing also confers tremendous health advantages. The two major health benefits on the Wood farm are decreased incidence of contagious diseases and fewer respiratory problems.

STOCKER BEEF OPERATION

Larry Smith
300 acres in Viroqua, Wisconsin

Larry Smith *(second from left)* **shares his experiences with farmers at a sustainable agriculture field day**

Larry Smith runs a seasonal beef operation. Each spring, 450 to 600 head are delivered to his farm. He rotationally grazes them all summer on about 300 acres of legume/grass pasture, supplements the feed with some ground ear corn in September/October, and sells them in late fall as feeder cattle. With this type of operation, Larry has very little capital investment (less than $15,000 in equipment), doesn't need to worry about putting up winter feed, and doesn't even need to have a barn. He also can easily alter his herd size from season to season to suit his needs. Larry farms a hilly area of Wisconsin and views pasturing as the best return he can get on the land without eroding it. With pasturing, he is able to net 65% more profit than he could by growing corn.

Larry uses a combination of temporary and semi-permanent paddocks. It takes less time to move cattle between permanent paddocks (by simply opening and closing gates) but cattle in temporary paddocks usually have greater weight gains per acre since the size of a paddock can be adjusted according to the productivity of the forage.

He has divided half of his pasture land into 31 semi-permanent paddocks of approximately equal forage productivity. Since forage productivity varies from site to site, these paddocks range in size from 2 to 6 acres. In one of these paddocks, he puts enough animals to consume the forage in no more than two days (anywhere from 60 to 240 head per acre depending on forage growth).

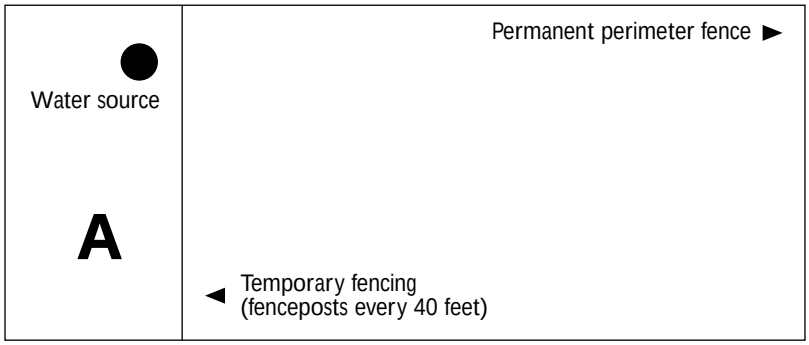
The other half of his pasture land is divided as needed into temporary paddocks of varying sizes. In these pastures, he moves the portable fencing every two days. Larry has found it takes no more than twenty minutes to move a herd of 50 to 250 cattle between temporary paddocks. He moves three sets of mobile fencing which he carries on portable reels: a front fence, a back fence, and a lane fence which provides access to water (see figure 13.)

When rotational grazing, it is important to have a back fence. "If you don't have a back fence to keep the animals from grazing the regrowth, you are not rotational grazing," says Larry. Without a back fence, the forage never gets a chance to rest. Larry prefers to use polytape to subdivide his pastures since it is lightweight, has no sharp edges, and can be easily seen by both livestock and deer. He also uses aluminum cable which he has found to be strong enough to hold up to deer. Larry says he would use the cheaper polywire if deer were not a problem.

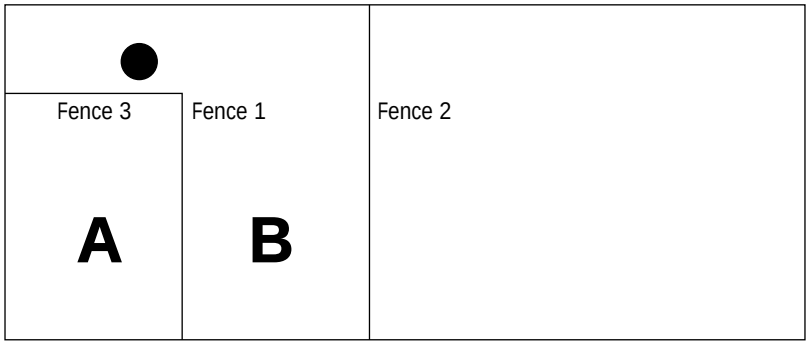
Ideally, Larry tries to stock at about 2.5 head per acre at the beginning of the season but often sells his heaviest cattle in midsummer and early fall to compensate for decreasing forage production coupled with increasing forage needs by his animals. He also makes all of his hay before mid-June when forage growth is high.

Larry determines the length of paddock rest periods according to the growth stage and/or height of the forage. For legume/grass pastures, he concentrates his management efforts on the

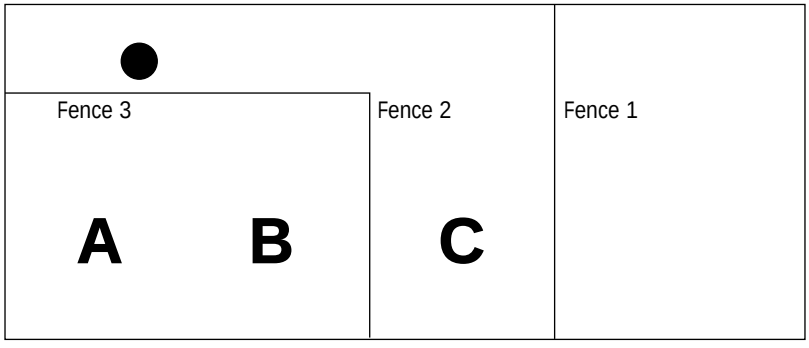
Figure 13. Larry Smith's method of moving fence



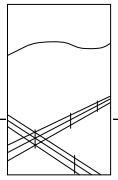
Day 1— Cattle are in paddock A for two days.



Day 3— Fence 2 is laid down to form paddock B. Fence 1 is rolled up to allow cattle to move in and a lane is made to the water source with fence 3.



Day 5— Fence 1 is removed and used as the new back fence. Fence 2 is rolled up to let cattle move in; fence 3 is extended.



legume. Alfalfa is grazed when in the early bud stage (this typically requires 30-day rest periods throughout the season) and birdsfoot trefoil is grazed when it is about 10 inches (this requires 30 to 60 days, depending on the weather). He allows cool-season grass pastures to grow to about 8 to 9 inches tall before they are grazed (he manages for the predominant high-quality grass) which requires a rest period of 15 to 65 days depending on the weather.

The amount of time animals are left in a paddock depends on forage availability. If there is excess forage growth, he moves the cattle faster through the circuit. If there is a forage shortage, he moves them slower. As a general rule, he tries to move cattle to a new paddock every two days. In rainy weather he moves the cattle more frequently to reduce stand damage. Larry has found short grazing periods to be especially important for alfalfa whose crown can be easily damaged by too much hoof action.

Larry routinely rests his productive legume/grass pastures in September to allow them to build up root reserves. During this time, he heavily grazes his poorest legume/grass pastures and then renovates them the following spring.

To have a successful pasture-based stocker operation, strategic de-worming is a must. Larry also uses implants but warns against using estrogen-based implants if you are planning to graze legume-rich pastures since he has found the incidence of prolapses to increase. To guard against bloat, Larry feeds bloat preventatives.

Larry compares running a successful stocker operation to investing in stocks. Just a few cents difference in the buying or selling price can “make or break” you for a season. To minimize buying costs, Larry buys a diverse mixture of cattle mostly from southern markets in the late fall/early winter from a reputable seller who overwinters the cattle and preconditions them. He also buys some local holstein steers. He notes that he would make other arrangements if he found them to be more profitable. At selling time, Larry prefers to use a video auction which is less hassle than hauling his cattle to an auction and gives him more flexibility in pricing and delivery dates.

Resources

GLOSSARY

Browse. Leaves and twigs of woody vegetation which can be eaten by livestock.

Continuous grazing. Grazing livestock on the same, non-divided pasture throughout the grazing season.

Forage quality. The concentration of protein, other nutrients and energy in forage.

Grazing period. The amount of time livestock spend grazing a single paddock before being moved to another.

Intensive rotational grazing. Rotational grazing with a high level of management. This practice usually involves many pastures, short grazing periods, long rest periods, and high stocking densities.

Paddock. A subdivision of a pasture usually separated from other areas by fencing.

Photosynthesis. The process by which plants use the sun's energy to convert carbon dioxide and water into oxygen and high energy carbohydrates.

Rest period. The time elapsed between grazings on the same paddock.

Rotational grazing. A grazing method where livestock are regularly moved from paddock to paddock.

Stocking density. The number (or weight) of grazing animals per acre in a single paddock during a grazing period.

Stocking rate. The number of grazing animals per acre in an entire pasture system for the entire grazing season.

Stockpile. The practice of allowing uncut forage to accumulate in a pasture for later use.

Total digestible nutrients (TDN). A measurement used to estimate digestible energy content of forage.

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