


Pasture Management Guide
for Livestock Producers


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Extension and Outreach
Iowa Beef Center

Acknowledgements

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Dedication

This edition of the Pasture Management Guide is dedicated to Stephen K. Barnhart who was instrumental in leading the development of the first edition. Dr. Barnhart served as extension agronomist for forages and pastures from 1979 until he retired from Iowa State University in 2014. He provided technical support for a wide range of forage management and utilization practices including all aspects of pasture management. Dr. Barnhart was committed to serving the interests and needs of Iowa pasture and livestock producers and in recognition of that spirit this volume is humbly and gratefully dedicated to him.

Cover photos by Erika Lundy (steer), Denise Schwab (horse), Trey Jackson (sheep), and Matthew Haan (dairy).

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Introduction

Iowa's pastures offer significant opportunities for producers who decide to manage them. Despite Iowa's soil wealth, about one-third of the state's land is highly erosive and unsuited for continuous row-crop production. Pastures can be a way to diversify production enterprises, improve returns, and spread risk —usually with a relatively low capital investment.

Ruminant animals are important to Iowa's economy because they can convert forage from land with relatively low productivity into high-value meat, milk, and fiber products while maintaining environmental quality. Iowa historically has been among the top 12 states in the number of beef and dairy cows, sheep, and goats.

Significant benefits to be gained by incorporating grazing livestock into a row-crop farming operation include:

- increased enterprise diversity,
- reduced soil erosion from water runoff and wind,
- improved wildlife habitat for nesting and shelter,
- improved water quality, and
- improved agricultural sustainability.

This publication provides an overview of pasture management: practices to increase production and returns by improving management on our grassland acres. This 2017 revision addresses new forage species and varieties, recent invasive weed species and weed control practices, and use of cover crops for grazing (Chapter 1); updates the nutritional requirements of grazing livestock, prevention and management of sulfate, nitrate, tall fescue, and blue-green algae toxicities, and shade and stream management (Chapter 2); reviews management of mob-grazing, the use of grazing management to enhance wildlife habitat and other ecosystem services, online tools for balancing forages and livestock numbers in grazing systems, and electric fencing and livestock watering alternatives (Chapter 3); and incorporates updated nutritional requirements and forage options in the risk management chapter (Chapter 5).

Good pasture management is not simple. It involves managing the interrelationships among animals, plants, and soil. The animals influence the plants, the plants influence the animals, and both influence the site—in terms of soil and water quality and wildlife habitat. These interrelationships are continually changing and are strongly influenced by the management practices used.

Photo by Trey Jackson.

Photo by Denise Schwab.

The manager's role, then, takes on great importance in pasture management. The manager in fact is the key to good pasture management. Pasture management is largely individualized. The manager must determine the best way to balance the changing components related to specific pastures and animals with the manager's chosen level of management and goals.

Pasture management improvements can range from very simple onetime changes with only modest improvement in pasture and livestock productivity to highly integrated renovation and managed rotational grazing systems.

When considering making pasture management changes, don't set unrealistic production goals. Although improvements offer opportunities, keep in mind that as the level of pasture management intensifies there is a greater level of risk and a greater need for commitment to running and manipulating the system. An integrated and well-managed system can efficiently use available skills and resources to meet goals.

Chapter 1: Managing pasture plants

In this section

- Aspects of pasture plants
- Growth and development of forage plants
- Pasture maintenance and improvement practices
- Renovating and establishing pastures
- Grazng cover crops

Photo by Erika Lundy.

Tall fescue is a cool-season grass adapted to variable soil and management conditions. Photo by Mike Collins.

One of the most challenging and exciting aspects of growing forages in pastures is the large number of plant species that can be grown in Iowa and other states in the upper Midwest. Because there are so many possible forages, it is difficult to discuss the characteristics of each in detail in this publication. Tables 1.1 and 1.2 highlight many of the most commonly encountered forage species and give a brief evaluation of their site adaptation, growth habits, and use alternatives. However, even though all these species can be found in Iowa pastures, relatively few are grown extensively.

Grasses generally provide the base forage in pasture production systems. Smooth bromegrass is the most widely adapted and used forage grass grown in Iowa pastures. Tall fescue is an important pasture grass in the southern part of the state. Kentucky bluegrass is naturalized in Iowa and can be found in many pastures. These are cool-season species that produce most of their growth in spring and early summer. Warm-season grasses such as switchgrass or big bluestem produce most of their growth in the summer and can be used to complement cool-season pastures in rotational grazing systems.

Kentucky bluegrass historically has been a popular cool-season grass, but it has limited summer productivity. Photo by Mike Collins.

Grasses are often grown in mixtures with legumes. Legumes add nutritional value to pastures because they contain more protein and generally have more digestible energy than grasses. They also have the ability to form associations with nitrogen-fixing bacteria, which can reduce or eliminate the need for nitrogen fertilization. The seasonal growth of many pasture legumes is intermediate to that of cool- and warm-season grasses, thus legumes can be used to offset the low productivity of cool-season grasses midsummer. Since legumes are compatible in mixtures with cool-season grasses, they can be grown in the same pastures as cool-season grasses. Red clover, white clover, birdsfoot trefoil, and alfalfa are the most common legume species found in Iowa pastures. Others are often present and may be important in particular situations, but are not widely or intentionally grown.

Legumes mixed with cool-season grasses provide improved yield and nutritive value during the summer months. Red clover legumes. Photo by Samantha Jamison.

Because each species has its particular advantages and disadvantages, single-species plantings (monoculture) carry a higher level of weather risk and are less flexible in season-long grazing management systems. An example would be a pasture of a single cool-season perennial grass such as smooth bromegrass or Kentucky bluegrass. These species are very desirable grasses and can be extremely productive. But both can be strongly summer dormant, and their use is limited primarily to spring and autumn in climates where midsummer heat and rainfall patterns are erratic. A pasture composed only of one of these grasses would be very limiting for use in season-long grazing and would allow little management flexibility to the grazing manager.

Planting and managing mixtures of pasture species with varying traits often provides a more flexible forage supply, generally with less risk to livestock enterprises. Mixtures of grasses and legumes will usually do best on farms and fields with variable soil, drainage, and fertility conditions.

Table 1.1. Forage crop description, relative tolerance of established forages to environmental stress, and ease of establishment (P=poor, F=fair, G=good, E=excellent, N=none).

Forage Crop	Annual or perennial	Winter survival	Autumn frost	Soil			Ease of establishment
				Drought	Wet	Acidity	
Legumes							
Alfalfa	Perennial	G	G	G	P	P	F-G
Alsike clover	2-3 yr Perennial	F	G	P	G	G	G
Birdsfoot trefoil	Perennial	F-G	G	F-G	G	G	P
Crownvetch	Perennial	F	G	G	P	G	P
Lespedeza (Korean)	Annual	N	P	G	P	F	G
Ladino & white clover	Perennial	F	G	P	F-G	F	F-G
Mammoth red clover	2-3 yr Perennial	F	G	F	F-G	F	G
Medium red clover	2-3 yr Perennial	F	G	F-G	F-G	F	G-E
Sweetclover (white & yellow)	Biennial	G	G	G	P	P	F-G
Sweetclover ('Hubam' white)	Annual	N	G	G	P	P	F-G
Berseem clover	Annual	N	G	F-G	G	P	G
Kura clover	Perennial	G-E	G	F	G	F	P
Cool-season Grasses							
Kentucky bluegrass	Perennial	E	G-E	P	G	F	P
Orchardgrass	Perennial	E	G-E	G	F	F	G
Redtop	Perennial	E	G-E	F	G	E	F
Reed canarygrass	Perennial	E	G-E	E	E	G	P
Ryegrass	Perennial	P	G	F	G	F	G-E
Ryegrass	Annual	P	G	P-F	G	F	G
Smooth bromegrass	Perennial	E	G-E	G	F-G	F	F
Tall fescue	Perennial	E	E	G	G	E	G
Timothy	Perennial	G	G-E	F	F-G	G	F-G
Warm-season Grasses							
Big bluestem	Perennial	E	P-F	E	P	G	P
Indiangrass	Perennial	F-G	P-F	E	P	G	P
Switchgrass	Perennial	E	P-F	E	F-G	G	P
Foxtail millet	Annual	N	P-F	G	F	F	G-E
Hybrid pearl millet	Annual	N	P	G	P	F	G
Japanese millet	Annual	N	P	F-G	G	F	G-E
Sudangrass	Annual	N	P	E	P	F	E
Sorghum-sudangrass hybrid	Annual	N	P	E	P	F	E
Other							
'Puna' chicory	Perennial	E	E	F	F-G	F-G	G-E
Rape and turnip	Annual	N	E	F	F	F	G

Not only will a mixture of plant species take better advantage of the variability in growing conditions of the site, but a mixture also will often provide a more uniform pattern of forage production over the entire growing season. When a forage legume such as a clover, alfalfa, or birdsfoot trefoil is in the mixture, the overall production and nutritive quality of the pasture forage is improved, particularly when nitrogen fertilization is not being used regularly. A pasture mixture should contain at least one grass and one legume. Generally, including more than three or

Table 1.2. Forage crop description, relative tolerance of established forages to environmental stress, and ease of establishment (P=poor, F=fair, G=good, E=excellent, N=none).

Forage Crop	Hay	Silage	Continuous pasture	Rotational grazing	Palatability	Anti-quality components[1]	Varietal selection[2]
Legumes							
Alfalfa	E	E	P	G	E	B	–
Alsike clover	G	E	P	G	E	B,Ph	
Birdsfoot trefoil	G	E	G	G	G	T	a
Crownvetch	F	G	G	G	G	Gly	–
Lespedeza (Korean)	P-F	F	F	G	G	T	b
Ladino & white clover	P	P	E	E	E	B	–
Mammoth red clover	F	G	P	P	G	B	–
Medium red clover	G	E	F	E	E	B	–
Sweetclover (white & yellow)	P-F	F-G	P	P	F	B,C	–
Sweetclover ('Hubam' white)	G-E	G-E	P	F-G	F	B,C	–
Berseem clover	G	E	P	G	E	–	–
Kura clover	G	G	E	E	G	B	–
Cool-season Grasses							
Kentucky bluegrass	P-F	P-F	E	E	E	–	–
Orchardgrass	E	E	G	E	F-E	–	c
Redtop	F	F	F	F	F-G	–	–
Reed canarygrass	G	G	F	G	P-G	A	d
Ryegrass, perennial	E	E	G	G-E	E	–	c,e
Ryegrass, annual	G-E	G-E	G	G-E	F-G	–	–
Smooth bromegrass	E	E	F	E	E	–	–
Tall fescue	G	G	G	G	P-F	A,ET	c,e
Timothy	E	E	F	G	G-E	–	–
Warm-season Grasses							
Big bluestem	F	F	P	G	G	–	c
Indiangrass	F	F	P	G	F-G	–	c
Switchgrass	F	F	P	G	F-G	–	c
Foxtail millet	F	F	P	P	G	–	–
Hybrid pearl millet	P	F	P	G	G	–	–
Japanese millet	F	G	P	G	F	–	–
Sudangrass	P	F	P	G	G	CGly	–
Sorghum-sudangrass hybrid	P	F	P	G	G	CGly	–
Other							
'Puna' chicory	F-P	F-P	G	G	E	—	—
Rape and turnip	P	P	F	G	G	Ph	—

[1] **Anti-quality components**

- A Alkaloids-decrease palatability
- B Bloat potential
- C Coumarin-hemorrhagic agent formed during spoilage of hay; reduces blood-clotting ability in animals
- CGly Cyanogenic Glycosides—may form hydrocyanic acid (HCN) or prussic acid poisoning
- ET Endophyte toxicity-ingestion of the alkaloids from this fungus may reduce blood circulation to appendages (dry gangrene)
- Gly Glycosides—may decrease palatability
- Ph Photosensitivization—may allow sunburn of animals with light-colored coats
- T Tannins-may decrease palatability

[2] **Varietal selection**

- a Select erect varieties for a hay option and prostrate-type varieties for pasture only
- b Limited to extreme southern Iowa; must allow plants to mature and reseed the stand for following years
- c Select more winterhardy varieties for use in Iowa
- d Select low-alkaloid varieties
- e Select endophyte-free or novel endophyte varieties for improved animal performance

four grasses and legumes in the seed mixture has little, if any, advantage. Warm-season pasture grasses such as big bluestem and switchgrass planted for summer pasture can potentially bridge the summer slump of cool-season grass pastures. It is not recommended to try to manage mixtures of cool- and warm-season grasses in the same pasture, but they can be effectively managed in separate pastures.

Warm-season grass species grow vigorously in the summer and can be beneficial when used for grazing in mid-summer. Photo by Mike Collins.

Old, long-term pastures

Most pasture managers have existing pastures. Although the pasture may seem to be made up of only a few dominant grasses, 8-10 other species of desirable grasses and legumes are often present and growing at a very low level of productivity. When grazed, their presence and distribution are related to how well they are able to survive the combination of soils, fertility, weather, and animal use patterns of the site.

The first recommendation for more efficient and effective management of an existing pasture is to manage the plants that are already present to the greatest potential. (See the sections in this publication on pasture fertilization, weed management, and grazing management for suggestions on how to work toward more productive pastures.) With even modest improvements in fertilization and grazing management, existing pastures can be made more productive. More productive pasture grass and legume species, and improved varieties of these species, can be added to existing pastures.

New pastures

Nearly all of Iowa's cropland is suitable for pasture production. Many producers who need grazing land will have at least some of their cropland in a short-term (3-10 years) pasture, sometimes classified as cropland pasture. Forage acres are often planted primarily for hay production, but used in later years as pasture. These carryover hay fields were planted with only hay production in mind, thus they often contain only a very simple mixture of a legume and perhaps only a single grass, suitable for hay, but not well-suited for continuous or close grazing. If planning to graze hay fields in later years, more complex mixtures and varieties suitable for grazing should be considered in the initial seeding.

Whether there are carryover hay field pastures or new pastures planted within the last five years, they may have limited productivity because of poor stands and inadequate fertilization. These pastures often can benefit from modest improvements in fertilization and grazing management. Thin hay field pastures also are very good candidates for some selective renovation to increase the number of plant species in the pasture, to correct for stand thinning or establishment problems, or to correct an oversight in the selection of the original seeding mixture. A general recommendation, however, is to first see what production gains can be made with fertilization and grazing management before attempting to fix the condition by starting over.

Newly planted pastures should be checked several times during the establishment year for excessive weeds and shading. Photo by Samantha Jamison.

Many cropland pastures, planted five or more years ago, are now productive and contribute to the pasture needs of the farm. Routine weed management, mindful fertilization, and good grazing management can keep them that way.

Planning for a new pasture

When planning for a new pasture planting, use Tables 1.1 and 1.2 to narrow the choices of forage species to three or four in a seed mixture. Choose species on the basis of intended use (continuous grazing, rotational grazing, hay), their adaptation to the soils and site conditions of the field, tolerance to the climatic extremes of the area, and any specific factors that would make them particularly desirable for the type of livestock and management practices planned.

New and improved plants for pasture use

Along with increased interest in grazing has come the hope that science and research will identify new forage species that will need little management and produce high yields of top-quality pasture under all environmental conditions.

That's likely to remain an unfulfilled hope. The traditional, adapted forage species such as orchardgrass, smooth bromegrass, tall fescue, reed canarygrass, red and white clover, alfalfa, and birdsfoot trefoil are still the most appropriate for grazing or hay production. New varieties of these traditional species continue to be developed for improved pasture productivity, persistence, and nutritive quality. These new varieties, when managed well, can improve profitability. However, new varieties, managed poorly, are not likely to fare any better than the old standbys.

Forage breeders also are evaluating new and different forage species and varieties in an effort to solve existing forage problems and meet producers' needs. It is worth the time to look for new varieties of a species to plant, especially when older varieties are known to have problems in a specific area.

Disease resistance in legumes

Forage breeders have made great advances in varieties with improved disease resistance. Alfalfa varieties now have multiple pest resistance for wilts, root rots, and nematodes. Disease-resistant red clover varieties are productive for three or more years.

More grazing tolerance in alfalfa

A significant step forward in recent years has been the development of alfalfa varieties with the ability to tolerate harsh, overgrazed conditions. Prior to these varieties, alfalfa had poor persistence to grazing unless it was carefully managed. New grazing-tolerant alfalfas offer better survival when pastures are overgrazed. However, bloat management must be practiced as with any alfalfa grazing situation.

The hay yields of the new grazing varieties are similar to those of hay-type alfalfas, so the crop can be used as a dual purpose (grazing and hay) forage crop. However, the high-yielding hay-type varieties still offer very little grazing tolerance unless managed under grazing to simulate a hay crop with good rotation and rest.

When choosing a grazing variety of alfalfa, make sure the variety has been selected and tested under harsh grazing conditions—otherwise its inherent grazing tolerance is unknown. New grazing-tolerant varieties are continually becoming available that combine higher yield, excellent disease resistance, and even better grazing tolerances.

Grazing tolerant alfalfa varieties offer better plant survival than hay-type varieties if grazing is not carefully managed. Photo by Erika Lundy.

Persistent pasture legumes

Producers have attempted to establish or improve pastures with legumes, only to have the legume plants die off in a few short years. Forage breeders are evaluating two new legumes in the search for long-lived pasture plants.

Pasture researchers had high hopes for rhizomatous birdsfoot trefoil being a persistent pasture legume. Rhizomes are short, underground stems that can produce new plants. A common problem of trefoil is crown and root rots that deplete the stand over time. The rhizomatous trait could potentially overcome that problem by continuously producing new plants to fill in when the original one dies. Unfortunately, this type of trefoil has yet to live up to potential. Adequate winterhardiness and seed production have been the major limitations. Kura clover is another legume that looks promising because it has shown remarkable winterhardiness and grazing tolerance. Seed supplies are improving and several adapted varieties now are available. Although its poor seedling vigor makes establishment difficult, once established kura clover is extremely hardy. It is one of the few legumes that competes well with grasses and persists under grazing.

Kura clover spreads with underground rhizomes. Photo by Mike Collins.

Herbicide resistant legumes

Alfalfa varieties that are resistant to glyphosate are available, but have limited value for most pastures because other desirable species present in the pasture cannot tolerate the herbicide. There are cases, however, when the use of one of these varieties might be desirable. Pastures that are extremely weedy might be improved by planting glyphosate resistant alfalfa and using the herbicide to eliminate or reduce persistent weeds. In this case, the pasture might be better used for hay production for a time and then renovated with desirable grasses as the alfalfa stand begins to decline. But it's important to note that herbicide resistant alfalfa varieties are no more persistent to poorly managed grazing than other hay-type varieties.

Improved varieties of well-known pasture forages

Continued advancements in adapted species through better varieties are the base of most forage breeding programs. In the upper Midwest, grass variety improvements include rust-resistant, late-maturing orchardgrass, smooth bromegrass that recovers better after grazing or cutting, and reed canarygrass with reduced levels of undesirable alkaloids. Other improvements in legume and grass varieties include:

- Sweetclover varieties with low coumarin, fine stems, and less hard seed are or will soon be available in both annual and biennial types.
- Several recent varieties of Ladino (large-leafed) white clover have been released but their adaptation to the upper Midwest is not known. Ladino types generally have poor grazing tolerance. Medium-leaf varieties are much better suited for pasture systems, though winterhardiness may be limiting in some New Zealand and southern United States varieties.
- Tall fescue, though well suited for pasture systems, has been plagued by an internal fungal endophyte that produces alkaloid chemicals that can cause considerable health and reproductive problems in grazing livestock. To reduce production of these toxic alkaloids, endophyte-free varieties have been developed. While grazing of endophyte-free varieties has improved livestock performance, there may be sacrifices in yield and persistence as the alkaloids provide resistance to insects, diseases, and drought. To improve plant persistence and vigor without adversely affecting grazing livestock, there has been the discovery of 'novel' or 'friendly' endophytes that produce alkaloids that prevent insect, disease, and drought problems, but are not toxic to livestock. Using 'novel' endophyte varieties has been very helpful in the southern Midwestern states where drought and pest problems are common, but it has not been evaluated under Iowa growing conditions. Endophyte-free varieties may be sufficient in northern regions of the Midwest. As the endophyte fungus can only enter plants through the seed, it is essential to remove seed from tall fescue plants and in the soil before seeding pastures with endophyte-free or novel endophyte tall fescue. In addition, tall fescue hay should never be fed on pastures containing endophyte-free or novel endophyte tall fescue as seed in the hay may contain the toxic endophyte.

Novel endophyte tall fescue produces alkaloids that improve persistence, but does not adversely affect livestock. Photo by Samantha Jamison.

New forage species being evaluated

An exciting activity among forage breeders is the testing and evaluation of forages new to the upper Midwest. Although many of these forages are not well suited to the region as they currently exist, minor improvements may make them viable alternatives for use in successful pasture management systems. Among these are:

Chicory mixes well in mixed pasture plants and its leaves are palatable. Photo by Dave Barker.

- Chicory, a broadleaf plant that is quite palatable in pastures. Several varieties have been marketed in this country. 'Puna,' developed in

New Zealand, can be grown in the upper Midwest but produces coarse stems after the seeding year and requires careful grazing to maintain palatability.

- Eastern gamagrass, a productive and high quality warm-season grass, has had limited success as a forage. Improvements in seed yield make it more available, but seed dormancy characteristics have made establishment inconsistent. Breeding and improved seed treatment techniques will greatly improve its potential.
- Annual and perennial ryegrass, though very important grasses in other parts of the United States and the world, have not been highly successful in the upper Midwest. Poor winterhardiness and a low tolerance to hot, dry conditions limit their usefulness. Even minor improvements in winter hardiness could make perennial ryegrass a useful forage option. However, most varieties being marketed still lack sufficient winterhardiness for average Iowa winter conditions.
- Berseem clover has had very mixed success in Iowa. It is a productive annual legume in mild seasons with good rainfall, but performs poorly during extended periods of dry weather. In contrast to adapted perennial legumes, it produces most of its growth later in the summer so it may improve the forage supply in late summer..

Eastern gamagrass is a productive, palatable warm-season grass. Photo by Mike Collins.

Understanding growth and development of forage plants

A measure of a pasture manager is how well they can "read" the forage growth and make educated assessments of the condition and feed quality present. The challenge of grazing management is then to balance the nutritional needs of livestock with the ability of pastures to meet those nutrient needs.

Some understanding of the growth and development of grasses and legumes is needed to be able to make good pasture management decisions. It is possible to improve the use of pastures and increase their production by carefully managing forage grazing. The idea of watching forages grow may not seem very appealing, but it is the key to successful grazing management.

Grazing management decisions are based primarily on the growth stage of the grasses or the grasses and legumes in mixtures. However, some consideration needs to be given to how grazing at a given time will affect the persistence of legumes. Legumes usually need a higher level of management than grasses to remain productive.

Berseem clover grows as an annual in Iowa. Photo by Ken Moore.

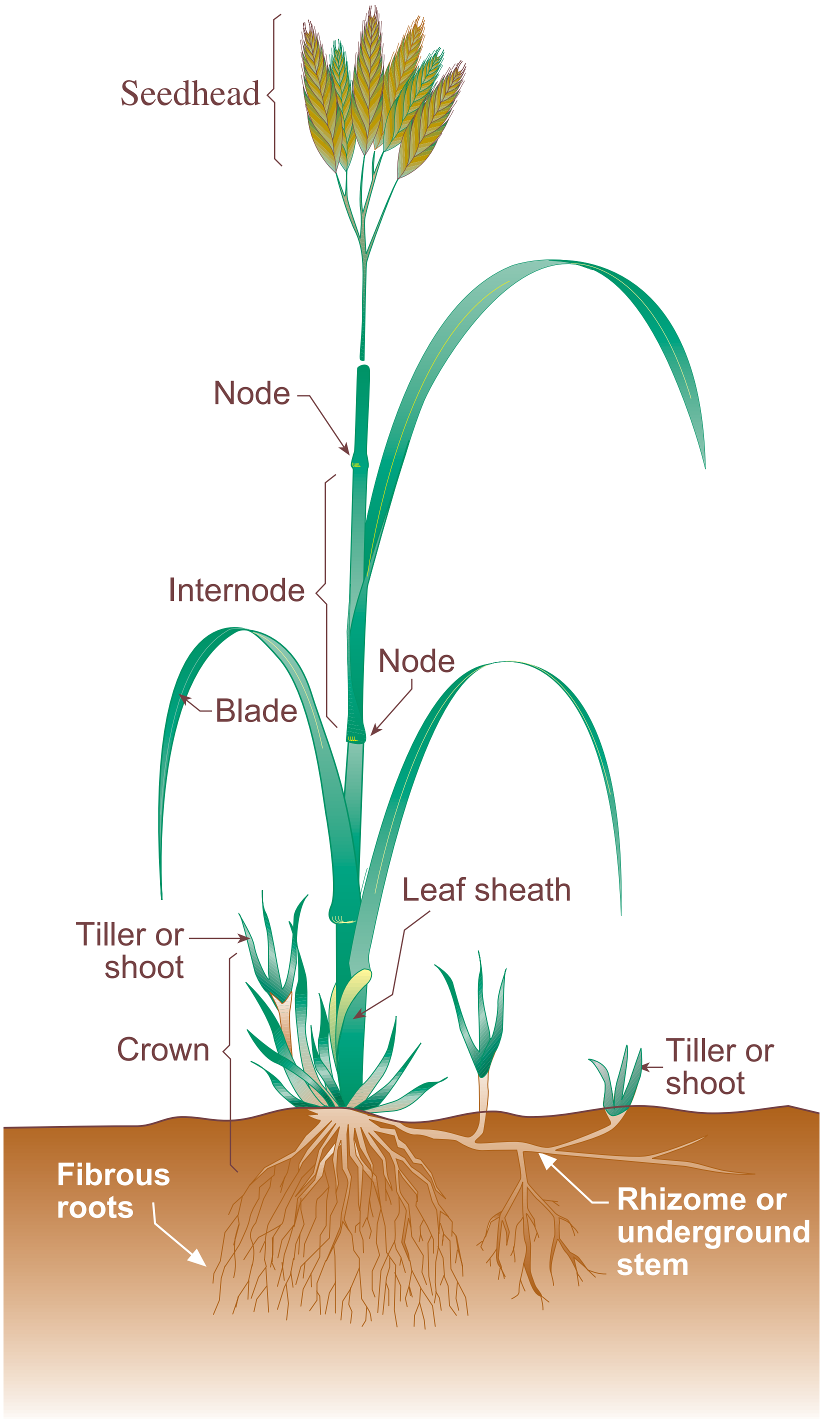


Figure 1.1. Parts of a grass plant. Learning plant parts and how pasture plants grow will your improve pasture management skills.

Structure of the grass plant

The structure of the grass plant is remarkably simple and similar among the many species of grasses (Figure 1.1). A grass plant is a collection of tillers or shoots that grow from buds at the base of the plant. Each tiller is composed of a series of repeating units consisting of a leaf, stem node, stem internode, and bud. Each leaf is attached to the stem at a node, and a dormant bud also develops at this point. Early in the development of a grass plant, the distance between nodes (internodes) on the stem is very short and the stem remains compact at the base of the plant. At the top of the stem is the growing point where new leaves and stems originate. As long as this growing point remains intact it is capable of producing new leaves. The growing point will undergo a change later in the development of the tiller as it stops producing leaves and begins developing the seedhead, or reproductive structure of the plant. After this, the growing point on this tiller is no longer capable of producing new leaves and grazing or clipping it has no impact on further leaf development. Once this transition occurs, some of the upper internodes will begin to elongate, eventually raising the seedhead to the top of the tiller. New tillers emerge from the plant crown as regrowth.

How grasses develop

Grass grows through a sequence of developmental stages. There are three primary growth stages in grasses that need to be recognized for grazing management: 1) vegetative; 2) elongation; and 3) reproductive (Figure 1.2). Leaves develop during the vegetative growth period. The stem with its growing point remains compact near the soil line. Once a critical number of leaves have developed on a tiller, the older and lowermost leaves generally die off at a rate that is about equal to the rate of development of new leaves. The number of leaves present on a tiller becomes relatively constant. Stem internodes elongate during

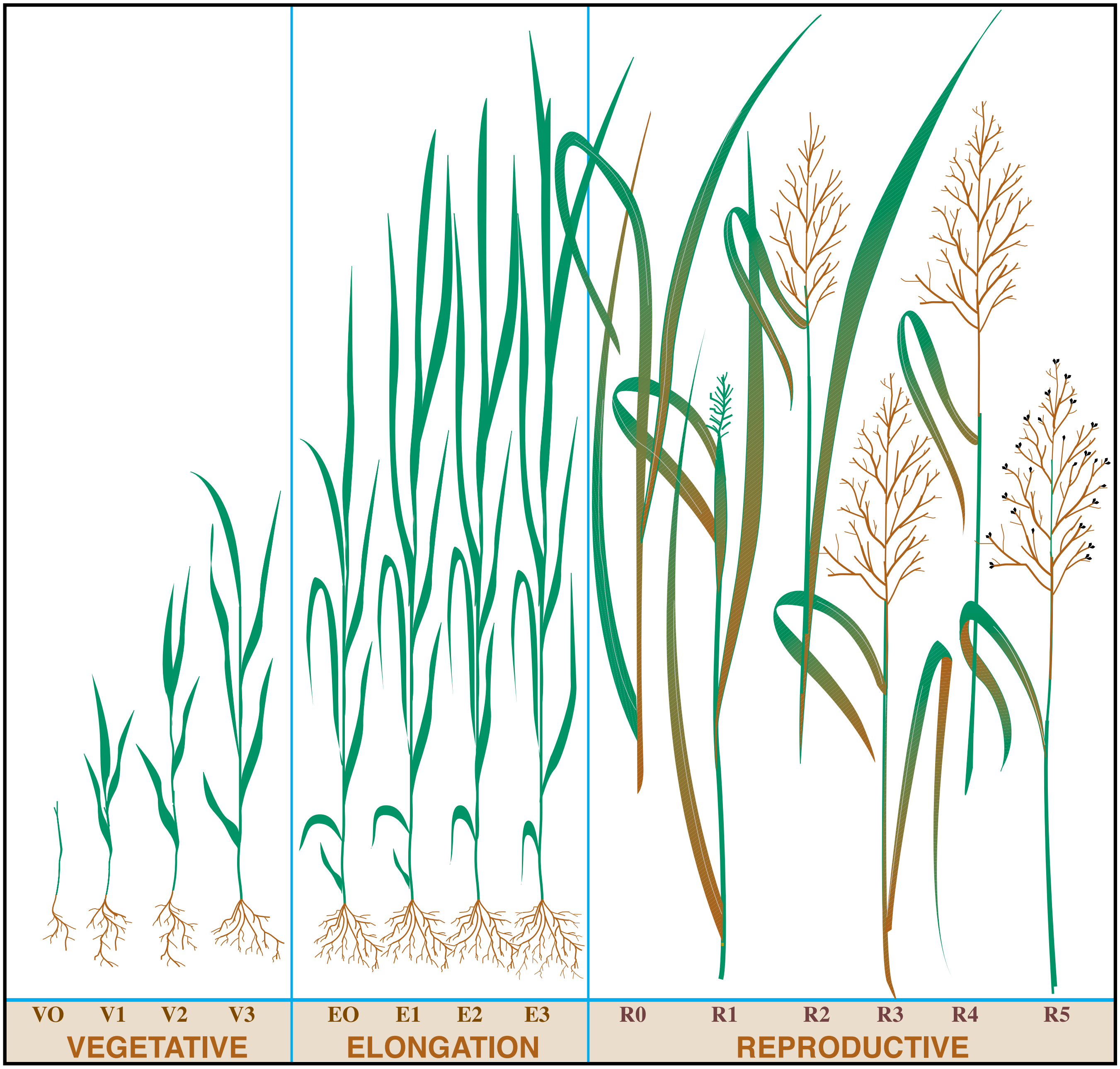


Figure 1.2. Stages of perennial grass development. The stage of a pasture plant's development relates closely to the yield of a forage and its nutritive value.

the elongation growth period, a process called jointing. The elongation stage usually begins in response to the changing day length. During this stage only, the uppermost internodes elongate. The lowermost internodes do not elongate and remain at the base of the plant. These lower nodes, internodes, and dormant buds, together with related tillers, make up the crown of the plant. When the developing seedhead just begins to push through the uppermost leaf sheath, the plant has reached boot stage, the end of elongation. The reproductive stage is the period when the seedhead develops and pollination occurs, resulting in seed development.

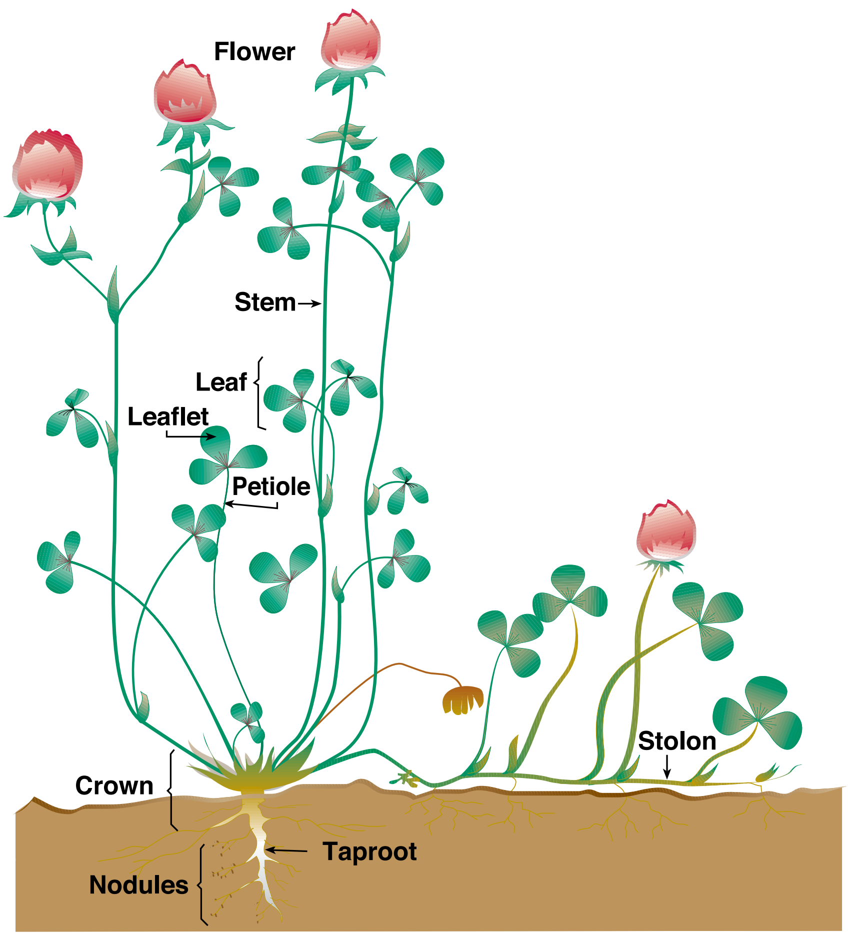


Figure 1.3. Parts of a legume plant. Each legume has a slightly different structure, which influences how animals graze and the nutritive value of the grazed forage.

Structure of legumes

Legumes are a special class of plant that can associate with nitrogen-fixing bacteria to "fix" nitrogen from the atmosphere. Legume development differs from that of grasses. Leaves of legumes are arranged alternately on opposite sides of the stem (Figure 1.3). Stems of legumes vary among species in length and amount of branching. Flowers and seeds differ in shape and color.

An obvious difference among forage legume species is the type of growth habit. Some legumes have an upright growth habit, some have an intermediate growth habit, and some grow along the ground.

Alfalfa has an upright growth habit. Red clover and birdsfoot trefoil have an intermediate growth habit. For these species, the stem elongates as the plant develops. The growing point of alfalfa is near the top of the plant and can be easily removed during grazing. The growing point of red clover and birdsfoot trefoil remains lower on the plant and may not be removed with moderate grazing. Legumes have many potential regrowth points. In addition to the buds at the stem tip and along the stem at each leaf-stem junction, these three species also have dormant buds at the stem base, or crown, of the plant. These crown buds are the source of the first growth in the spring and can quickly produce new, leafy regrowth when growing stems are grazed or clipped.

White clover is a pasture legume that grows close to the ground. The stems of white clover (stolons) lie flat on the surface of the soil and spread by buds along the stem, forming stem branches. The growing points are rarely removed by grazing but can be damaged by hooves.

Legumes develop from vegetative growth to an early stage of reproduction called bud stage. Buds are green, immature flowers that develop quickly to open bloom or flowering stage.

Forage growth

Forage growth is the increase in dry weight or size of the plant. Development refers to which plant parts are increasing in size or weight. Growth and development are related because generally as the plant increases in weight, it is also going through a series of developmental stages. Growth can be considered in two important ways. Figures 1.4 and 1.5 show that as a plant progresses from the leafy, vegetative stage to the flowering and seed production stages, it continues to increase in dry matter yield until seeds are ripe. The other important growth issue is growth rate, or how fast the plant adds new dry weight over a period of time.

Figure 1.4 shows the typical pattern of plant growth rate. When a plant is short with minimal leaf area, its growth rate is low. As the plant accumulates more leaf area, its ability to capture sunlight increases rapidly and its growth rate (increase in new yield per day) reaches its highest level (late vegetative phase). A plant's ability to grow (produce yield) is greatest when it is immature and leafy. As stems develop to flowering and seed production, few new leaves form and the lower, older leaves die off, thus reducing the plant's ability to add much new weight and its growth rate declines rapidly. At this point, the dry weight of the plant is not increasing but is being redistributed within the plant as stems mature and seeds develop.

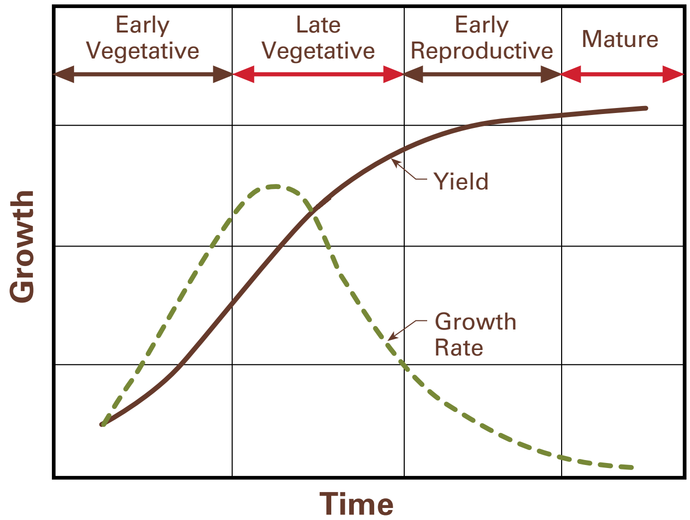


Figure 1.4. The growth rate and yield of a plant both increase rapidly in early stages of development. But as pasture plants mature, their growth rate slows. Grazing of pastures when plants are rapidly growing in the mid- to late vegetative stage is desirable for both the plant and the animals.

Productivity of forage plants in pastures varies throughout the growing season and by plant type. An important classification of pasture grasses is whether they have their highest growth rates during the cool portion of the growing season (cool-season grasses), or whether their growth rates are greatest during the warmer days of the growing season (warm-season grasses). Figure 1.5 shows that cool-season grasses (Kentucky bluegrass, orchardgrass, timothy) produce most of their seasonal yield in the cooler spring and autumn months, whereas warm-season grasses (switchgrass, big bluestem, sudangrass) are most productive during the warm summer months. Legumes such as alfalfa, clovers, and birdsfoot trefoil are generally less influenced by seasonal temperature than grasses and produce growth more uniformly throughout the growing season. Legumes, however, still grow most rapidly during the spring months.

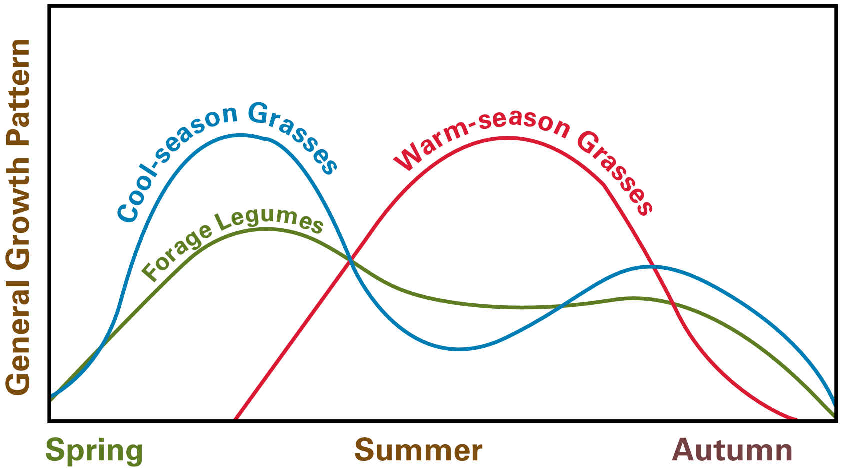


Figure 1.5. Pasture plants can vary greatly in their pattern of growth. Some producers find that pasture production is more uniform when legumes are grown with grasses, or when a warm-season grass is available for summer grazing.

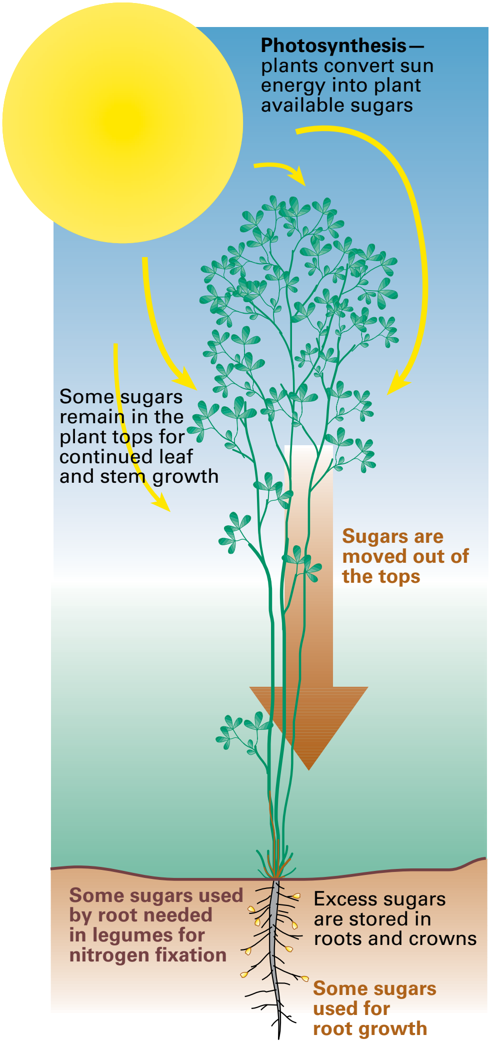


Figure 1.6. Plants use sunlight energy for growth. How you manage the removal of leaf area will greatly influence how well the pasture plants can maintain their growth and vigor.

The grazing manager then is faced with the challenge of having a group of animals whose nutritional needs are most often increasing over the course of the growing season, but whose pasture yields are fluctuating widely over the same period. This challenge is greatest for the producer with only cool-season grasses that are producing far less forage during the summer months than the grazing animals require. To stabilize the seasonal pasture growth, producers often add extra pasture acres, include legumes with their cool-season grasses, or include a pasture area of warm-season grasses for summer grazing.

The seasonal growth and productivity of the pasture as a whole is the visible result of the contributions of individual pasture plants. The vigor and productivity of the pasture as a whole depends on the well-being of its individual plants. The growth pattern shown in Figure 1.4 is the idealized pattern where nothing interferes with a plant as it grows. How an individual plant performs in a pasture and how well it reacts to grazing and site conditions are determined by how it is able to produce and manage its available carbohydrates (sugars and starches).

Plants "capture" solar energy with their leaves and convert it to plant-usable carbohydrates in the process of photosynthesis (Figure 1.6). Some of the energy is converted to new components like fiber and oils as the plant develops new leaves, stems, and seeds. Some of the energy is expended during respiration in the plant growth and development processes. Any unused carbohydrates accumulate or are stored in roots and plant crown tissues. The balance of these energy processes determines the health and vigor of each plant in the pasture.

Growth cycles and growing points

Each pasture plant begins its growth in the spring from dormant crown buds, using carbohydrates stored in the roots and crown during the previous growing season. The plant's early spring growth rate, though relatively slow, is strong with an ample supply of stored energy. Spring growth can begin as much as two weeks earlier when plant roots and crowns contain large amounts of carbohydrates. When stored carbohydrate energy levels are low because of overgrazing the previous year, regrowth and the production of new leaves proceeds at a very slow rate. As plants grow and leaf area increases, growth rate and plant development can proceed rapidly and restore the level of stored carbohydrates in the roots and crown.

In the spring, the leaves of cool-season grasses grow from an active growing point near the soil surface. Grazing will remove only leaf tips without greatly interfering with the activity of the growing point. As changes in day length and temperature cause the elongation of the stem, the growing point is elevated and becomes subject to removal by grazing or harvest (Figure 1.7). If the active growing point is removed, hormonal control over dormant basal buds is reduced and new leafy tiller growth can develop from new crown tillers. Cool-season grasses generally only produce stems in the spring. So once the initial grazing or cutting of forage in late spring removes the stems, only leafy vegetative growth is present for the remainder of the grazing season. Warm-season grasses undergo the same basic series of growth steps and recovery responses, only a month or two later, during the warmer summer months.

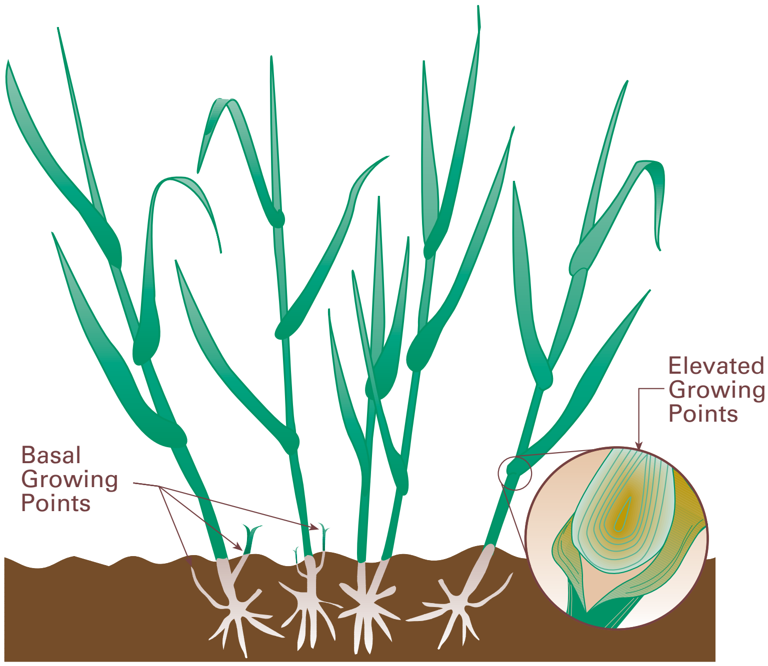


Figure 1.7. The growing points that produce new leaf growth in grasses are near the soil surface much of the growing season. During stem elongation, growing points are elevated above the soil line (as shown) and are subject to removal by grazing. Once removed, new tiller regrowth must again come from buds in the lower crown near the soil line.

For legumes, the location of growing points help determine the response to grazing. The growing point for alfalfa is near the top of the growing stem and as a result is very easily removed by grazing. The growing points of red clover and birdsfoot trefoil are lower on the plant and less susceptible to removal by grazing. Alfalfa, red clover, and birdsfoot trefoil will quickly produce new leafy regrowth from dormant crown buds and lower stem branches when the growing stems are grazed or cut. The growing points that produce new leaf points of white clover are at the soil surface on trailing stolons and are virtually resistant to removal by grazing, but can be damaged by hooves.

Nutritive value of pasture plants

The nutritive value (energy, protein) of plant leaves is very high. Plant stems and the leaf sheaths of grasses are more fibrous and lower in nutritive value. Old stems and lower grass tiller bases composed of only leaf sheaths are very low in nutritive value. Thus, as forage plants grow and develop, their nutritive value declines. For all practical purposes, once grass plants reach the reproductive stage their nutritive value is usually too low to support livestock production without some supplemental feeding. However, legumes must reach a very mature stage before this happens.

A grass pasture should never be allowed to enter into the later heading and seed stages before either being grazed or mechanically cut for hay (stages R3-R5 in Figure 1.2). Even though quality is highest during the vegetative stage, caution must be used to prevent grazing too early

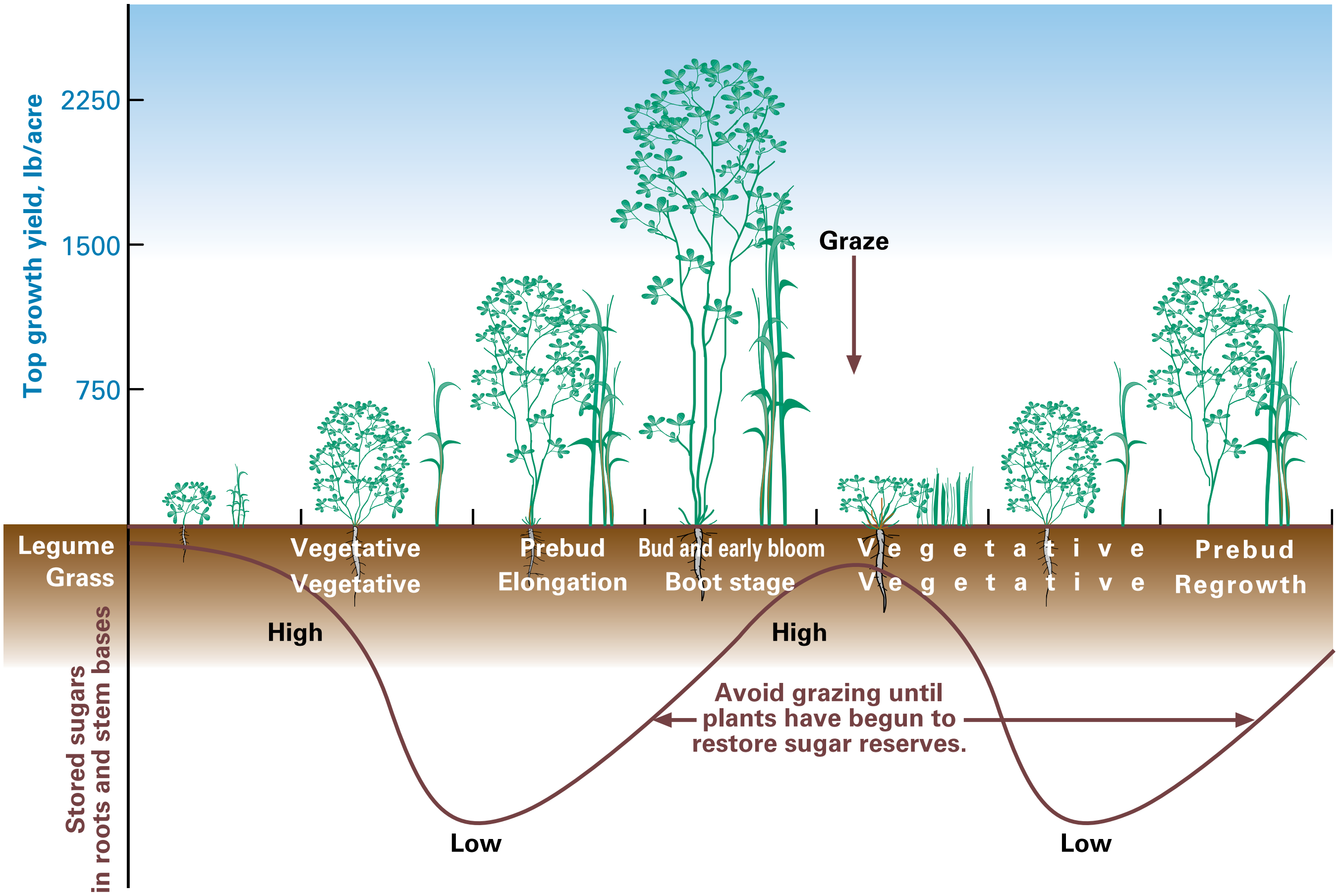


Figure 1.8. Pasture plants use and store sugars as they grow. Mature plants will regain their vigor as they grow and store excess sugars. Grazing new leafy growth too soon, before plants have begun to restore sugar reserves, should be avoided.

so that adequate stored energy (carbohydrates) is available to support regrowth (Figure 1.8). The general rule is that the optimum time to begin grazing a pasture is during the period of rapid growth rate just before stem elongation or flowering. This timing provides the optimum compromise between yield and quality, allows sufficient time for storage of carbohydrate energy reserves, and ensures the removal of the growing point, which will stimulate tillering and leafy regrowth.

Forage plant response to grazing

If grazing animals remove only a small amount of the active green leaf area, photosynthesis can proceed and the plant can replenish carbohydrate stores while top and root growth is progressing. But if grazing animals remove most of the available leaf area every few days (overgrazing), the plant allocates nearly all growth energy to new leaf growth, the root system begins to die, and less energy is stored.

This frequent leaf removal without adequate time for the plant to restore its vigor is the physiological basis of overgrazing. Overgrazed pastures produce far below their potential, maintaining only a low stand density and poor vigor.

The amount of rest that a grazed plant requires to recover its vigor and replenish an effective leaf area is influenced by the period in the growing season and the amount of active leaf area remaining following the grazing period. A cool-season grass can recover in 2-3 weeks during its ideal spring and autumn growing periods, but may require six weeks or more to recover during the more stressful months of July and August. Warm-season grasses, on the other hand, grow very slowly during the cool months of spring and autumn, but recover quickly following 4-6 weeks of rest during their ideal summer growing period. The rest (or recovery) period can be shortened somewhat by leaving more leaf area remaining following grazing.

This residual leaf area can contribute to photosynthesis energy quickly, supplementing stored energy reserves to aid in a much faster recovery. Cool-season grasses and mixed cool-season grasses and legumes should have 3-4 inches of residual leaf area for rapid recovery; about 4-8 inches of leaf area on warm-season grasses following grazing is recommended.

Forage quality and grazing animals

Most grazing animals can get nearly all their energy, protein, and some vitamin and mineral requirements from forage. Generally, in a pasture system, the limiting nutrient for production will be the amount of available energy in the forage. With cool-season pastures, high milk producing dairy cows are an exception to this rule. However, protein in mature warm-season grasses may be inadequate for beef cows (See Chapter 2, “Nutritional needs of grazing animals”).

Digestibility of forages is important because it largely determines the amount of available energy the animal can get from the forage. Immature, vegetative forages are more concentrated energy and protein sources with higher digestibility than mature forages. As forage grasses and legumes mature, the stems and entire plants become fibrous and less palatable to livestock. Quality declines to the point where ruminants are simply unable to consume enough digestible energy to meet their requirements for production potential. Ruminants cannot make large changes in intake to compensate for poorer-quality forage. Poorer-quality forages remain in the ruminant digestive system longer, reducing the amount that can be consumed. For example, stocker steers may simply be unable to consume enough digestible energy from poorer-quality forage to gain two pounds per day.

It’s not realistic to continually test pasture forages for nutrient content. The forages change quickly, and most producers don’t want to send forage samples to a testing laboratory every week or two. This is why careful observation of forages is essential to guide pasture management decisions and get the most out of pasture forages.

Total digestible nutrients (TDN) is a common measurement related to forage quality. During the growing season, the TDN content of forages often ranges from 50-70 percent. At 50 percent, TDN is barely sufficient to meet maintenance requirements of most animals. As TDN content increases, animals can more easily meet their production potential. Ideally, TDN content of forages should be 60-70 percent to achieve high milk production or body weight gain. The nutrient content of winter-grazed forage also must be considered. At the start of winter, the TDN concentration of corn crop residues and stockpiled forages ranges from 50-60 percent. Because of weather damage, the TDN concentration of corn crop residues or improperly managed stockpiled forages may drop to 40 percent or less by the end of winter.

The age and maturity of forage tissue are the most important factors determining the amount of available energy and protein in forages. Grasses typically are slightly lower in nutritive value than legumes. Legumes are often higher in protein and maintain quality longer with maturity than grasses. Thus, pastures of grass and legume mixtures will maintain nutritional quality longer than grass-only pastures.

One of the most common mistakes in grazing management is to delay grazing until after the plants start becoming fibrous and pasture quality is rapidly declining. As a general rule, the optimum time to graze a pasture is during the leafy, rapid growth rate period preceding stem elongation (Figure 1.2). This is a good compromise in the ability to harvest forage yield and quality with grazing animals.

The biggest challenge for producers is to control grass growth in May and June so that it does not develop past its most nutritive stage. Another challenge for producers who rotate pastures is the tendency to leave animals on a pasture or paddock too long in the spring, waiting for the animals to graze it down uniformly. Meanwhile, forage in other pastures or paddocks quickly matures and becomes less palatable and nutritious.

Animals graze selectively and will always favor the most palatable and easiest-to-eat portion of the plant. Different plant parts have different feed values and attractiveness. Plant leaves are highly digestible, high in protein, and generally palatable to grazing animals. Both grass and legume stems are fibrous and much less digestible than leaves. Young green stem tips, however, are very low in fiber and high in nutritive value. The flat, upright leaf blades of grasses are more digestible than the more fibrous leaf sheath portion of a grass leaf. In mid- and late-summer the vegetative leafy grass tillers have a significant amount of desirable leaf blades, but the lower tiller bases are mostly cylindrical leaf sheaths, which are more stemlike and of lower feed value.

Animals are similar to people in that they have preferences about what they eat first. If given the opportunity, grazing animals will eat their favorite plants over and over. If not given adequate time to rest and recover after grazing, these plants selected and regrazed every few days will decline in vigor or persistence. In many cases, the legume plants will be the first species to disappear. As pastures lose plant diversity, productivity will also be lost, while weeds and brush will invade the stands.

Where stocking density in either continuous or rotational grazing systems is too low, animals graze selectively and select very high quality diets, but the overall efficiency of pasture use is poor. Excessively high stocking density limits selectivity, therefore reducing diet quality as well as promoting overgrazing and very slow regrowth. Rotational grazing at a moderate stocking density will still allow livestock to select a diet that contains 10-30 percent more TDN and 5-35 percent more protein than the available forage. But, one of the greatest advantages of rotational grazing is that the managed rotation and rest prevents excess selectivity and regrazing by the animals, allowing faster recovery and improved plant vigor.

While allowing selection of a high quality diet, rotational grazing at moderate stocking density prevents excessive selection and overgrazing of a pasture. Photo by Erika Lundy.

Weed and brush control

One of the most often cited pasture management concerns of producers is weed control. A plant is classified as a weed:

- if it is toxic or unpalatable to grazing animals;
- if it is competing for light, fertility, or space to the detriment of desirable pasture plant species;
- if it is aesthetically unpleasant;
- or if it is otherwise noxious enough to be legally declared as such.

In some cases, a plant's classification as a weed is based on its maturity. Foxtail grasses are readily grazed when immature but become unpalatable when mature.

Multiflora rose infestations limit pasture productivity, but are controllable. Photo by Samantha Jamison.

Weeds can be grouped into several types. Perennial weeds and brush first become established from seed or root pieces and slowly colonize an increasingly larger area of the pasture. They are generally the most difficult type of weeds to control. Multiflora rose is a particularly troublesome pasture brush problem in the upper Midwest. See Iowa State University Extension and Outreach publication ***Multiflora Rose and Its Control*** (PM 863) (https://store.extension.iastate.edu/Product/4172). Eastern red cedar also reduces forage production, increases other brush species and parasitic flies, and reduces wildlife habitat. In addition, honeysuckle, sericea lespedeza, leafy spurge, and larkspur are invasive perennial weeds that have become serious problems in Midwest pastures. Biennial (two-year life) and annual (one-year life) weeds are opportunists, producing many seeds and spreading rapidly into areas where they can outcompete existing pasture plants. Several of the biennial pasture thistles, including the musk thistle and bull thistle, are an increasing problem in some areas. Annual and biennial weeds can be managed more easily than perennials.

Musk thistles can become a serious pasture weed if not controlled. Photo by Samantha Jamison.

Weeds, particularly rapidly-growing annual weeds, can be very damaging during pasture establishment. If addressing weed issues when converting land enrolled in the Conservation Reserve Program (CRP) to pasture, see ISU Extension and Outreach publication ***Converting CRP to Pasture-Managing Weeds and Fertility*** (CRP 11) (**https://store.extension.iastate.edu/Product/1097**). Toxic and poisonous plants are discussed in the, "Health considerations of grazing animals" section in Chapter 2.

Selective grazing in permanent pastures often leads to invasion by perennial weeds. Photo by Adam Janke.

Cultural weed management

Cultural weed management begins with good seeding practices and the establishment of a thick, uniform pasture stand. Once established, vigorous, well-managed pastures have few, if any, weed problems. Vigorous, well-fertilized sod is highly competitive against weed seedlings. Most pasture weed and brush problems are associated with overgrazed pasture and begin in the thin, noncompetitive sod areas and in bare and damaged areas in the pasture. An important step in weed control is to minimize sod damage from livestock and vehicle traffic patterns. As invasive weeds like sericea lespedeza may be introduced to farms or pastures in hay, producers should avoid feeding hay from weed-infested pastures or unknown sources in "clean" pastures.

Many weeds are unpalatable when mature but readily grazed when young. Grazing practices can greatly influence whether weeds are routinely grazed or selectively passed over until they become unpalatable and a management concern. A continuous low stocking rate in a pasture (few animals for the acreage) frequently leads to selective grazing with increasing weed and brush problems in heavily grazed areas. Continuous grazing at very high stocking rates will weaken the sod, allowing rapid weed invasion. Producers who have successfully implemented rotational grazing management often find that pasture weed problems begin to diminish within the first two years because of the improved sod competitiveness and regular grazing of weeds in their more palatable, immature form.

Mechanical weed management

Mechanical weed management involves the physical removal of all or part of the weeds and brush. Hand digging of the plant and root system is often an effective weed control measure but is only practical when weed and brush numbers are low. Mowing to remove leaf area and prevent the development of new seed is a much slower method of weed management. The timing of clipping is very important to its success as clipping after seeding is of little value. With diligence, and several clippings each year, annual and biennial weeds can be controlled. Mechanical weed control is much more successful when coupled with good fertilization and grazing management. Mowing is generally less successful on deep-rooted perennial weeds and brush.

Chemical weed management

The specific weeds present must first be identified for the most successful use of herbicides. Always read and follow the label when selecting and using herbicides. Some herbicide treatment options can be very costly, so consider whether spot treatment is more environmentally and economically appropriate for the site. Be aware that some herbicides have legal grazing withdrawal and reentry periods, which may influence day-to-day management. Some herbicides have very long-term residual effects on the site, which may restrict reseeding and crop production on the site in the near future. Contact an ISU Extension and Outreach field agronomist (**www.extension.iastate.edu/ag/crops**) for more specific weed and brush management recommendations.

Biological weed management

The browsing behavior of goats make them a useful tool for controlling weeds and brush like multiflora rose and sericea lespedeza. Photo by James Russell.

There have been several instances of predatory insects and infectious diseases being used to manage weeds and brush in pastures. One example is the musk thistle weevil. This parasite, though useful in some instances, should not be considered solely as a weed eradication method, but it may be used in conjunction with other cultural, mechanical, and chemical control methods.

Sometimes overlooked as biological weed and brush control agents are goats. Goats very efficiently eat weeds and brush as well as grass. Their browsing behavior is often very effective in the selective removal of weeds and brush from pastures. However, if unrestricted or overstocked, goats, cattle, and even horses can damage valuable trees in pasture areas.

Fire for weed management

Controlled burning of grasslands can be an effective control for some weeds and brush. While it is not effective on either larkspur or sericea lespedeza, it may be a useful tool to prevent red cedar encroachment as it kills seedlings and samplings less than five feet tall. Success of this practice is dependent on the amount of combustible materials and weather conditions at the time of burning.

Be aware that fire has different effects on different plants. For instance, fire may actually cause sericea lespedeza seeds to germinate, potentially increasing infestation. However, this may be an advantage if an herbicide is used after these seeds germinate. For best results, implement an integrated pest management plan for weed control. Contact an ISU Extension and Outreach field agronomist or U.S. Department of Agriculture Natural Resources Conservation Service (NRCS) advisor to develop the best plan for your farm.

Fertilizing pastures

Pasture plants can respond to adequate fertilization like any other crop. A common attitude among producers is that, "the grass is free, it grows without fertilizer." Though it is true that pasture plants can survive for a long period with no fertilizer nutrient inputs other than the return of animal wastes from the grazing animals, forage productivity is much lower than its potential. Research and producer experience show that even a modest fertilization program can increase pasture productivity 50-100 percent. Mindful pasture fertilization can be money well spent.

Soil sampling provides basic knowledge of the fertility status of the soil and helps in making fertilization plans. Photo by Samantha Jamison.

Start with a soil test

Begin with a soil test to plot a pasture fertilization strategy. (See ISU Extension and Outreach publication **"Take a Good Soil Sample to Help Make Good Fertilization Decisions"** (CROP 3108) (https://store.extension.iastate.edu/Product/3915). If testing for a new planting, collect soil samples to the expected depth of tillage. If sampling existing pastureland, sample to a depth of only 2-3 inches to represent the depth that surface-applied lime will influence. Sample to a six-inch depth for phosphorus and potassium recommendations when re-establishing a pasture. Use ISU Extension and Outreach publication ***A General Guide for Crop Nutrient and Limestone Recommendations in Iowa*** (PM 1688) (https://store.extension.iastate.edu/Product/5232) for interpreting soil test results and planning a pasture fertilizer strategy.

Soil and plants respond to liming and pH

Overall soil microorganism activity and plant nutrient availability are nearly optimum at a soil pH level of 6.0-6.5. Lime applications are made to increase the soil pH to a level appropriate for the crop being grown. For pasture grasses, a pH of at least 6.0 is recommended. Recommendations vary for pasture legumes. For clovers and birdsfoot trefoil, a pH of at least 6.5 is suggested. For alfalfa, sweetclover, and crownvetch, a pH of at least 6.9 is recommended. Pasture legumes respond most quickly to improved soil pH—so where the pasture planning strategy is to increase or introduce legumes into the pasture, correcting to the recommended pH is a must.

Pasture plants respond to phosphorus (P) and potassium (K), if the soil nutrients are needed. Iowa State University recommends to soil test pastures for phosphorus and potassium levels and only apply P and K if the soil test is below the optimum level. Research has shown that correcting to the optimum level from a low or very low test level can improve pasture yields. However, adding additional P and K to a level above optimum will not likely lead to a yield increase. Soil testing to identify the existing soil levels can lead to wise uses of fertilizer dollars. Over fertilizing is not only costly, but it may contribute to surface water pollution. In an ongoing pasture liming and fertilization program, retest every 4-5 years to determine whether the fertilization strategy is effective.

Surface-applied lime and fertilizer will react slowly and only to a depth of a few inches over the next 2-3 years, so plan ahead if legumes are in a long-term pasture plan. When establishing a new pasture, lime and fertilizer should be incorporated into the soil during tillage.

Lime application to the appropriate pH is essential for releasing soil nutrients for plant use. Photo by Lynn Betts, USDA Natural Resources Conservation Service.

Nitrogen grows grass

Grass pastures can respond quickly to added fertilizer nitrogen (N). Nitrogen will not only improve dry matter yield and color dramatically, it will lead to increased plant crude protein content and dry matter digestibility as well. When, how much, what N form, and whether to add N are often the key questions related to N fertilization.

When

Grass will respond most efficiently to added N when conditions for rapid plant growth exist. For cool-season grasses, spring and late summer (for fall growth or stockpiling) are the most efficient times to apply fertilizer N; for warm-season grasses, mid- to late-spring is the most efficient time to fertilize with N. Under drought conditions, N fertilization is not likely to increase profitable forage yield.

How much

The first 30-50 lb/acre of N is the most efficiently used N. These rates may increase dry matter yields 40-50 percent. Fertilizing Kentucky bluegrass and warm-season grasses to 80-100 lb/acre and tall cool-season grasses (smooth bromegrass, orchardgrass, tall fescue, reed canarygrass) to 100-120 lb/acre in the spring can increase yields 80-100 percent over that of unfertilized grass. Modest additional applications (30-60 lb/acre) in late spring, late summer, or both can boost the annual yield even more.

What N form

Urea and liquid N forms containing urea are the most commonly used fertilizers for pastures. They are subject to some volatilization loss of N, particularly in warm, humid months. Addition of a urease inhibitor may limit this loss. To gain the greatest efficiency of N use, apply N just before a rainfall so the fertilizer is moved into the soil.

Timing nitrogen fertilization just prior to the time extra forage is desired may be its most effective use. Aerial fertilization is becoming more common. Photo by Mike Collins.

Whether to add N

Nitrogen will stimulate dry matter yield. A key management question should be, “Is more grass growth needed soon after the N would be applied?” Often the spring flush of grass growth is in excess of what the grazing livestock can effectively use. Nitrogen applied in early spring is used very efficiently by forages. Consider whether more early spring N-stimulated growth can be used, or will it just be wasted. Although not used as efficiently, a modest late spring or late summer N application might provide extra grass when needed.

Maintaining a third to half legumes or more in a pasture plant mixture can supply nearly all of the pasture's nitrogen needs. Photo by Samantha Jamison.

Biologically fixed nitrogen

Pasture legumes are frequently included in pasture mixtures or planted into existing grass pastures, in part, to supply nitrogen for the grasses to use. Although legume N is gradually available to the associated grass plants, about a third of the total pasture plants must be legumes before the yield of the combined pasture is equal to that of N-fertilized grass. Thus, if the pasture is not composed of at least one-third legumes, fertilization recommendations would suggest that the pasture be considered a grass pasture and should be fertilized similar to a grass pasture. The pasture manager might use some judgment on N rate and apply a moderate N rate to supplement a pasture that contains 20-25 percent legumes. Untimely or excessive N fertilization in mixed grass and legume pastures may cause the grasses to compete excessively with the legumes and limit their persistence.

Livestock wastes as a pasture fertilizer source

Grazing animals recycle about 90-95 percent of the plant nutrients (N, P, K, and others) that they consume back onto the pasture. Although some N is lost to volatilization, much of the animal waste nutrients are eventually used by the growing pasture plants. Grazing livestock generally do not choose to eat forage near their dung spots, resulting in some inefficiency in forage use. These random areas make up a considerable part of many pastures, particularly near water sources, shade, and traffic areas. Systematically confining animals in smaller areas in rotational grazing improves manure distribution.

When used in moderation, broadcast applications of additional livestock manure can serve as an economical source of plant nutrients. But several issues should be considered when using this nutrient source. With surface-applied manure, approximately 50 percent of the N is lost through volatilization. There is a risk that very high levels of P and K (above economic levels) can build up in soils with long-term or high application rates. Manure will often make the forage less palatable to the grazing animals. Ammonia burn of forage is likely when concentrated manure is applied to actively growing pasture forage. Application should only be made on unfrozen pastures at an adequate distance from streams and rivers to avoid the risk of P and K runoff.

Other pasture maintenance and improvement practices

Hay harvest

Rapid spring growth is often in excess of what grazing livestock can use effectively when palatable and nutritious. Some producers exclude livestock from a portion of the pasture (using an electric or permanent fence) to allow a harvest of some of the spring growth for hay. This practice restricts grazing animals to a reduced portion of the pasture area to force more efficient use of the spring forage growth. In many mixed grass pastures, a fourth to one-third of the area may be set aside for hay. On highly productive grass and legume pastures, one-third may be set aside for hay. But all of the pasture area is often needed if growth rates are slow in dry or cool springs.

Clipping

Some producers clip pastures once or more often each year. A common practice is to clip seedheads from the tall grass growth around manure pats in late spring or early summer. This is done for a number of reasons:

1) To allow the regrowth to come back more uniformly (and to look better). But it's likely that no significant grazing will occur around old manure pats for a month or more anyway. Clipping to stimulate uniform regrowth should be a benefit later in the grazing season.

2) To remove tall seedheads as a source of irritation to the eye. This reason is often linked with increased incidence of summer eye problems in grazing livestock.

3) To remove seedheads and stems as sources of fescue endophyte alkaloids. This is a recommended practice because the alkaloids associated with the endophyte fungus are more concentrated in these plant parts. Unfortunately, animals often eat the clipped stems and seedheads off the ground anyway.

4) To make the new regrowth come back sooner. However clipping generally does not make a significant difference on new shoot recovery rate or yield.

5) It is part of weed and brush control management. This practice, if timely, may be effective for controlling some annual and perennial weeds.

Natural reseeding

Some producers purposely defer grazing or clipping of some pasture areas to allow the forage (both grasses and legumes) to produce viable seed, which is allowed to shatter as a form of natural reseeding. This practice is most effective with legumes such as clovers, birdsfoot trefoil, and lespedeza. It is less effective for pasture grasses.

Managing the length of rest periods in a rotational grazing system to allow legumes like red clover or birdsfoot trefoil to produce seed may allow natural reseeding. Photo by Timothy Taylor.

Unfortunately, allowing plants to produce seedheads will also allow any undesirable species to reseed in addition to allowing endophyte-infected tall fescue to increase the concentration of toxic alkaloids. See Chapter 2, "Fescue Toxicosis" for information on managing tall fescue seedheads which could potentially be a problem for grazing animals.

Harrowing

Some producers harrow pastures one or more times. One reason for this practice is to spread manure pats. Although harrowing is somewhat effective, livestock will still avoid manure pat areas for several weeks anyway. Another reason for harrowing is to level gopher mounds and ant hills. This is for aesthetic benefit only and is probably not economical. However, it may be useful if the area will be mechanically harvested.

Burning

Prescribed burning may be recommended for management of warm-season grass pastures, but is not recommended as a routine practice for most cool-season grass pastures. Photo by Jesse Randall.

One recommendation for the maintenance of warm-season perennial grasses in pasture is to allow sufficient late summer and autumn growth to accumulate as a fuel source for a prescribed burn the following spring. Prescribed burning can stimulate warm-season grass growth by periodic removal of dead residue and competing cool-season species. It also exposes the soil surface for seedling development and earlier growth in the spring. Burning is generally only recommended every third or fourth year, and is not recommended for cool-season perennial grass pastures. Burning after spring growth begins will slow the recovery of both warm- or cool-season grass pastures and may allow the invasion of annual weeds. For help in planning a prescribed burn, consult with the NRCS or a local wildlife management agency for recommendations, precautions, information on liability, and any permits that may be required.

Aeration

Equipment designed to systematically aerate the surface of the pasture is available in the form of a heavy spikelike roller. The aerator can be adjusted to produce only holes or to produce severe sod displacement. A reduction in surface compaction can have a small benefit in improving the soil surface for broadcast or frost seeding. Although better water infiltration and stimulation of growth are cited as reasons for aeration, a consistent improvement in pasture yield has not been demonstrated.

Renovating and establishing pastures

On most farms changes in the vegetation of pasture and forage land will need to be made using reestablishment, renovation, or repair. Advantages of new forage species and varieties may include more forage production, higher feed value, lower amounts of toxic compounds, and improved distribution of forage availability during the growing season.

It is always difficult to know how much change to attempt. Each decision requires weighing the effect on short-term forage supply, the timeliness and weather risks for that particular seeding on that particular site, and the associated costs. New seeding attempts are not always successful and often require several years to become fully established. It is important to ask, “How can the desired result be achieved with the least risk at the lowest cost?” It is also important that the problem and desired results are clearly identified.

Producers who use better fertilization practices or rotational grazing often discover the amount, distribution of productivity, and the proportion of desirable grasses and legumes improve in a relatively short time without any additional seeding. Consider all of the pasture improvement alternatives before settling on a costly seeding effort. For cost estimates of pasture renovation and establishment alternatives, refer to ISU Extension and Outreach publication ***Estimated Costs of Pasture and Hay Production*** (AG-96) (https://store.extension.iastate.edu/Product/789).

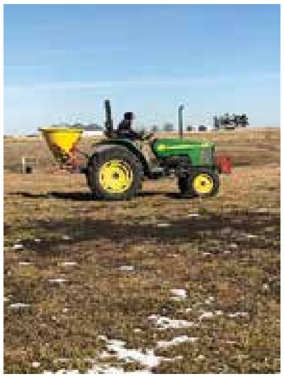
Frost seeding or interseeding existing pastures

The following information provides guidelines for several pasture seeding approaches. Some are more appropriate for minor, low-cost improvement, others for when significant changes are needed. See Tables 1.1 and 1.2 at the beginning of the chapter for guidance on selecting species appropriate for various sites, intended uses, and seeding methods.

Making major changes in pasture forage species can be very expensive. Minor changes can be done economically with frost seeding or interseeding.

Frost seeding

Frost seeding is a method where legume or grass seed is surface broadcast in late winter or very early spring (February and March in the upper Midwest) onto an existing pasture. Late winter freeze-thaw cycles and early spring rainfall improve the seed-to-soil contact.



Frost seeding is a simple and inexpensive way to renovate pastures, but has less consistent results than other methods. Photo by Logan Wallace, McNay Research Farm.

Frost seeding is simpler and less expensive than other pasture renovation methods, but is the least consistent in results. Research and producer experience have shown that most commonly grown legumes can be established by frost seeding. Red clover and birdsfoot trefoil are generally easier to establish with this method than alfalfa. Experience is limited in frost seeding forage grasses.

The best frost seeding successes are often when legumes are sown onto thin sod areas or a bunchgrass sod such as orchardgrass. Frost seedings are also often successful in bare and disturbed pasture areas. Frost seeding is more effective where forage has been grazed closely the previous fall and winter. A heavy cover of sod residue on the soil surface is undesirable. Planning a year ahead for frost seeding to allow for weed control and applying needed lime, phosphorus, and potassium will vastly improve results. Pre- and post-seeding management of competition from existing vegetation and weeds is needed for successful establishment. Avoid nitrogen applications and the excessive stimulation of sod the year before and the year of frost seeding. Frost seedings often establish poorly in years with abnormally dry springs and early summers.

Which grass(es) or legume(s) to use in frost seeding depends on soil conditions and intended use. Seeding rates should be at least equal and preferably higher than when seeding on a prepared seedbed. Although a short period of high density grazing in May may be used to reduce competition of cool-season grasses, maintaining moderate grazing and timely rotational grazing practices during the establishment year to reduce competition of grasses with the newly seeded species aids greatly in the success of frost seeding. For more information on frost seeding, refer to ISU Extension and Outreach publication ***Improving Pasture by Frost Seeding*** (PM 856) (https://store.extension.iastate.edu/Product/4158).

Steps for successful frost seeding:

1) Select a suitable site.
2) Control seeds during the previous growing season.
3) Test soil and apply needed lime and fertilizer during the previous growing season.
4) Graze closely the fall or winter before seeding.
5) Broadcast seed in late February or March.
6) Manage grazing to reduce competition after seeding.

Interseeding

Interseeding involves using a seeding drill to plant a legume or a more productive grass into an existing pasture. Interseeding is most effective in low productivity pasture sites. Successful interseeding offers the opportunity to double or triple the production of low-yielding pastures.

Interseeding can be done either in the spring (March through April in the upper Midwest) or late summer (mid-August to early September in the upper Midwest). Seed a legume alone where stands of desirable grass species are fair to good. Usually a single legume species is easier to establish and manage. A grass and legume mixture may be best where the present grass stand is thin, where a more desirable grass species is needed, or where a change in the proportion of grass species is desired.

As with frost seeding, it is essential to provide for adequate soil fertility and favorable soil pH. Adequate phosphorus and potassium are critical for rapid establishment of legumes. Nitrogen fertilization, however, will increase grass competition and can limit legume establishment. Preseeding grass suppression, weed control, and follow-up management of competing sod regrowth are also very important for successful interseedings.

Interseeding can be done with few field operations—opening of the grass sod, shallow seed placement, and seed coverage. The primary challenge to successful interseeding is to adequately suppress existing pasture sod and ensure shallow (1/4 to 1/2 inch) seeding depth with good seed-to-soil contact. Interseeding requires a specialized drill. Many drills are manufactured or have been modified to successfully drill forage seeds into untilled crop residue and sod. Equipment limitations for sod seeding implements sometimes can be overcome by operator experience and homemade modifications.

A grass drill being used to interseed legumes in a bluegrass pasture to increase production. Photo by Lynn Betts, USDA Natural Resources Conservation Service.

The drill and herbicide technology needed for the full-blown interseeding method make it an expensive option, and many producers choose to drop some components, accept more risk, and often achieve a lower degree of success.

An alternative similar to interseeding to consider where a total change in the pasture species is desired is to use no-till planting methods after completely killing existing sod. For more information on interseeding or no-till pasture renovation, refer to ISU Extension and Outreach publication ***Interseeding and No-Till Pasture Renovation*** (PM 1097) (**https://store.extension.iastate.edu/Product/4420**).

Steps for successful interseeding:

1) Select a suitable site.
2) Test soils at least a year prior.
3) Apply lime and fertilizer the previous growing season.
4) Graze closely the fall before seeding.
5) Control competition from existing sod plants.
6) Use correct seeding rates and mixtures.
7) Seed with a drill.
8) Observe and manage the new seeding.

Follow-up management

Managing the pasture during the seeding year is critical for good results with frost seeding or interseeding. A great effort and expense has been incurred to introduce more desirable species – use good follow-up management to keep them.

The pasture should be grazed somewhat heavily early in the growing season of the seeding year to help suppress the competing grass stand. Some mowing may be necessary to help control grass and weeds. Occasionally, grasshoppers, aphids, or other insect pests can seriously damage new seedings. Check new seedings regularly and be prepared to control insects if they reach damaging levels. As the newly seeded plants begin to establish, consider a rotational grazing plan for the remainder of

Allowing some grazing is an efficient way to reduce competition for new forage seedlings from established plants. Photo by James Russell.

the grazing season, and avoid close grazing. Be sure to provide for a 4-6 week rest period late in the growing season before frost.

After the seeding year, maintain fertility and manage grazing to encourage a productive and long-lived forage stand.

New seedings or complete renovation of pastures

Planning and thought needs to go into the selection of grasses and legumes for a renovation or new seeding. The correct selection needs to address the nutritional needs of the livestock to be fed; the adaptation of the species and varieties to the climate, soil, and expected plant disease characteristics of the site; and the compatibility of species and varieties in mixture with each other.

The two basic ways to establish a new pasture or completely renovate an existing pasture are to broadcast or drill in a tilled seedbed or use no-till methods in a killed sod.

Good preparation and management are part of successful new pasture seedings.

Soil testing and fertility

Take soil samples before the seedbed is prepared at the tillage depth. Lime and fertilize according to the needs shown by the soil test. Legumes generally require slightly better soil fertility and pH status than do grasses. Alfalfa is among the most sensitive species to soil acidity and is most productive on soils of pH 6.8-7.0. A pH of 6.5-7.0 should be a goal for clovers and birdsfoot trefoil. Grasses are tolerant of and remain productive at a soil pH of 6.0 and higher.

When the soil test shows that lime is required to neutralize acidic soils, try to apply needed lime at least six months to a year before the new seeding. The most efficient approach is to incorporate corrective lime applications during the seedbed preparation and before the new seeding. Where the new seeding is to be made with a no-till drill or interseeder, broadcast corrective lime six months or more before seeding.

Try to maintain at least a medium or optimum soil test index for good production of grasses and legumes. Corrective applications of phosphorus and potassium should be incorporated into the upper few inches of the root zone during seedbed preparation or broadcast before no-till seedings.

Time of seeding and seedbed preparation

Plant during a period favorable for seed germination and seedling growth. Spring seeding should be done as early as a good seedbed can be prepared. In the upper Midwest, late March to early May should be the target period for spring seedings (Figure 1.9). When seeding in late summer, August seeding dates ensure a 4-6 week growth period with moderate temperatures for seedling establishment.

Unpredictable soil moisture can limit late summer establishment success, but weed pressure is generally less.

Prepare a firm, moist seedbed to ensure adequate soil moisture for a few weeks around the germinating seed. Maintaining plant-available moisture in the top few inches of the soil is most favorable for continued seedling establishment. An ideal seedbed should have relatively fine granules with enough pea- to marble-sized granules to prevent crusting. A seedbed should be firm enough that someone walking on it will not sink deeper in the soil than their shoe sole.

The final depth of seed placement following final seedbed firming should be about 1/4 to 1/2 inches. Avoid seeding more than 3/4-inch deep. Seed depth should not be greater than 1 inch in sandy soils. Seed should not be disked in.

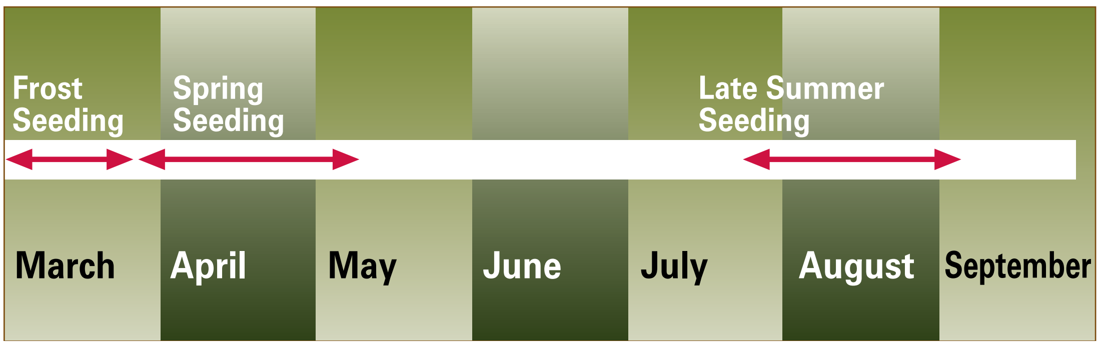


Figure 1.9. Recommended pasture planting periods for Iowa. Seeding dates should be selected to provide adequate soil moisture, suitable germination temperatures, and enough time for seedlings to develop adequately for survival.

Seeding rates

Seeding rates and mixtures needed for successful stands depend in part on soil characteristics and on the type of livestock being fed. See Table 1.3 for suggested seeding mixtures and rates. It is important to recognize that not all grass and legume species will work in all situations. Note in Table 1.3 that different species and mixtures are given for moderately to well drained soils, imperfectly drained soils, and poorly drained soils. There also are recommendations for drought stricken soils.

Planting disease-resistant varieties and using fertility and grazing or harvest management practices that maintain stand health and vigor are the most important and economical disease control strategies that forage managers can use.

Forage legume seed should always be inoculated with the proper Rhizobia bacteria prior to seeding. To ensure viable bacteria, either use fresh inoculum or preinoculated seed whose inoculant is not out-of-date. Preinoculated seed, stored for six months or more, should be reinoculated with fresh inoculant before seeding.

Table 1.3. Forage seed mixture recommendations (lb/acre)[1]

For rotational and permanent pastures with moderately to well-drained soils.

1.	Alfalfa	6-8
	Smooth bromegrass	6-8
	Orchardgrass	4-6
	Tall fescue (endophyte-free or novel endophyte)	6-8
2.	Alfalfa	6-8
	Timothy	2-4
	Smooth bromegrass	4-6
	Orchardgrass	3-4

(For 1 and 2, 4 lb/acre red clover for 1/2 the alfalfa seeding rate, or 6-8 lb/acre red clover can be substituted in place of alfalfa.)

3.	Smooth bromegrass	15-20

Imperfectly drained soils

4.	Red clover	6-8
	Ladino clover	.5
	Orchardgrass	4
	Tall fescue (endophyte-free or novel endophyte)	6-8
5.	Ladino clover	.5-1
	Orchardgrass	6-8
	Smooth bromegrass	8-10
6.	Birdsfoot trefoil	5
	Smooth bromegrass	6-8
	Timothy	3-4
7.	Birdsfoot trefoil	6
	Kentucky bluegrass	4-6
8.	Smooth bromegrass	15-20
9.	Tall fescue (endophyte-free or novel endophyte)	10-15
10	Switchgrass	5-7 PLS[2]
11.	Smooth bromegrass	10
	Orchardgrass	4
12.	Big bluestem	10-12 PLS[2]

Poorly drained soils

13.	Birdsfoot trefoil	5
	Smooth bromegrass	6
	Timothy	3-4
14.	Alsike clover	2-4
	Ladino clover	.5
	Reed canarygrass	8
	Timothy	3-4
	Tall fescue (endophyte-free or novel endophyte)	6-8
15.	Reed canarygrass	10
16.	Tall fescue (endophyte-free or novel endophyte)	10-15
17.	Ladino clover	1-2
	Kentucky bluegrass	6-8
18.	Switchgrass	5-7 PLS[2]

Droughty soils

19.	Alfalfa	6-8
	Smooth bromegrass	6-8
	Orchardgrass	4-6
	Tall fescue (endophyte-free or novel endophyte)	6-8
20.	Smooth bromegrass	15-20
21.	Tall fescue (endophyte-free or novel endophyte)	10-15
22.	Crownvetch	8-10
	Smooth bromegrass	6-8

Pasture for horses[3]

23.	Alfalfa	6-8
	Kentucky bluegrass	2
	Smooth bromegrass	6-8
	Orchardgrass	4-5
24.	Ladino clover	.5
	Kentucky bluegrass	3-5
	Timothy	2-4
	Orchardgrass	6
	Smooth bromegrass	6
25.	Birdsfoot trefoil	6
	Timothy	3-4

Pasture for hogs

26.	Alfalfa	8
	Ladino clover	2
27.	Forage rape	4-6
	Oats	1-2 bu.

For supplemental pasture

28.	Sudangrass	25-30
29.	Oats	2-3 bu.
30.	Hybrid pearl millet	30-35
31.	Winter rye	1.5 bu.
32.	Foxtail/German millet	20-25
33.	Forage rape	4-6
	Oats	1-2 bu.

1 Italics indicate forage choices to complete the mixture. For example, for mixture #1, mix alfalfa with either smooth bromegrass, orchardgrass, or tall fescue.

2 Pure live seed.

3 Special care is needed when feeding horses. Consider these cautions when selecting forage mixtures for horses. Sudangrass, sorghum hybrids should not be fed to any class of horses. Endophyte-infected tall fescue should not be fed to pregnant or gestating mares. Though not as serious as the above problems, alsike clover has caused photosensitivity and sunburn in horses, and red clover can cause horses to salivate excessively.

Companion crops

Companion crops (sometimes called nurse crops) are frequently used with new forage or pasture seedings for erosion control and as a source of feed grain, forage, or bedding. Oats are the most commonly used companion crop in the upper Midwest. A vigorous oat crop can be very competitive with the undersown forage seedlings.

For the most rapid establishment of the new forage stand, seed oats at 1-1.5 bushels per acre and harvest oats early at the boot stage of development as hay or silage to reduce the competition for the establishing forage. The boot stage is the stage of growth where the oat seedheads are nearing emergence from the top of the plant. If the oats are to be harvested as grain, try to spread the straw or bale windrowed straw promptly to avoid additional smothering of the forage seedlings. Oats may be grazed if soils are firm and dry and grazing periods are short. In a dry spring, consider removing the oats as early as possible to conserve moisture for the new seeding.

Shade competition from companion crops can greatly reduce the growth rate of new forage grass and legume seedlings. So graze, clip, or harvest companion crops early. Photo by Mike Collins.

Late summer pasture seedings made between August 15 and September 1 can be advantageous in years when soil moisture is adequate. Companion crops are not normally used at this time. Late summer seedings may fit well into crop rotations, such as following a summer-harvested cereal grain. In addition, there may be more time to devote to forage establishment activities in late summer. Stands successfully established in late summer often are ready for nearly full production the following year.

Follow-up management

Weeds must be kept to a minimum during the seeding year. If herbicides are used to control broadleaf weeds, follow label instructions. If mowing is used for weed control, clip as often as needed to control shading and limit the amount of clipped forage covering the developing seedlings.

If the field is to be grazed during the seeding year, graze rotationally and avoid overgrazing to maintain ground cover. Be sure to cease grazing during a 4-6 week rest period in September and October before a killing frost. Grazing after the killing frost is often possible but avoid grazing for extended periods into the winter and try to maintain 3-4 inches of residual plant growth.

If the field is to be harvested for hay during the seeding year, do not cut between early September and frost.

For additional information on establishing pastures, refer to ISU Extension and Outreach publication ***Steps to Establish and Maintain Legume-Grass Pastures*** (PM 1008) (**https://store.extension.iastate.edu/Product/4332**).

Cover crops can provide extra forage for use by livestock while also improving soil health and reducing erosion. Photo by Samantha Jamison.

Grazing cover crops

Cover crops, or double-crop forages, have been rapidly increasing in popularity due to their ability to reduce soil erosion, retain nutrients, and improve soil health. In addition to the improved soil profile, the extra forage resource is attractive to livestock producers, especially those with limited pasture acres. Integrating the row crop and livestock systems offers an opportunity to grow the livestock herd without sacrificing grain production. However, grazing cover crops does require some management decisions to successfully integrate the two enterprises.

Cover crop species

A variety of forage species including small cereal grains, brassicas, and legumes can be successfully used for cover crops. Small grains such as cereal rye, spring or winter wheat, or oats are the most common species particularly because they provide the fastest ground cover and result in the highest biomass yield. Brassicas, including radishes and turnips, are favored for their tap root to break up soil compaction. Lastly, legumes have the ability to fix nitrogen in soil, but are rarely used in Iowa since they are slow maturing and hard to establish in the fall.

While spring wheat and oats can provide rapid growth for fall grazing, these species will winterkill. Many Iowa acres are seeded to cereal rye or winter wheat for spring grazing because of their ability to withstand harsh winter conditions and rapidly grow even at near-freezing temperatures. Cereal grains are often seeded at rates of 1-2 bushels per acre.

Like spring wheat and oats, brassicas will typically not survive the winter in northern climates. Their vegetation is most useful for fall and early winter grazing, however, their roots may be consumed later in winter. If intended for grazing, brassicas should be seeded with a small grain because the brassicas are high in protein and highly digestible. Thus, brassicas are comparable to feeding a high concentrate diet and require supplemental fiber in the diet. Typically, brassicas are seeded at a rate of 5-10 lb per acre in addition to 1-2 bushels per acre of small grain.

Herbicide considerations

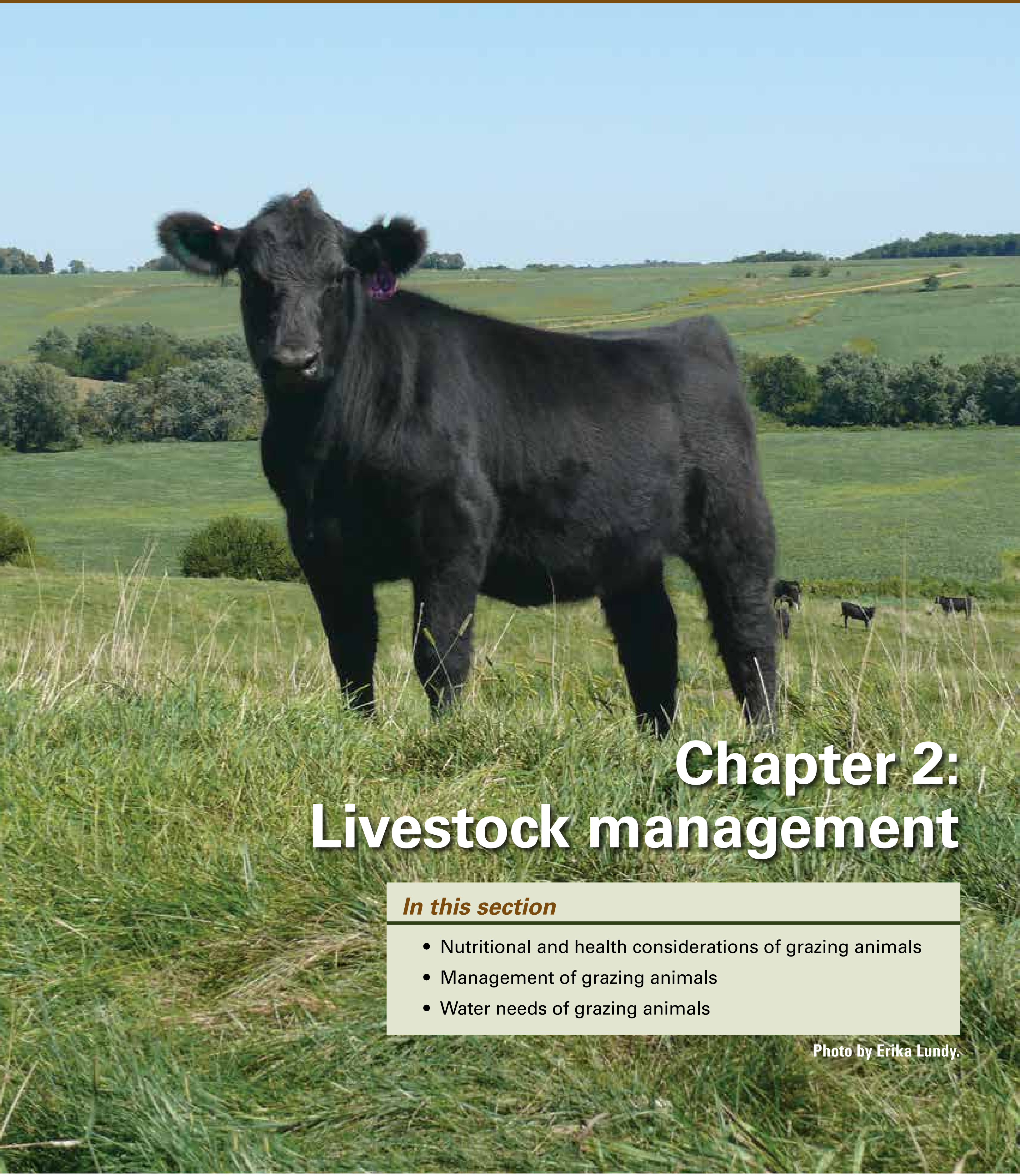
When considering which cover crop species to grow, the herbicide(s) used earlier in the cash crop growing season must be considered for two reasons. First, some herbicide labels restrict livestock producers from legally grazing specific cover crops, risking herbicide residues in the food chain. Second, herbicide residual may cause poor establishment of the cover crop. For additional information on which herbicides are legal for cover crop grazing, see ISU Extension and Outreach publication ***Herbicide use may restrict grazing options for cover crops*** (CROP 3082) (**https://store.extension.iastate.edu/Product/14454**).

Seeding methods

Cover crops are often seeded using three methods: aerial seeding, high-clearance seeding, or drilling. In general, the earlier a cover crop is seeded, the greater the biomass yield potential and winter survival. While aerial seeding and high-clearance seeding are an opportunity to establish the cover crop prior to harvest of the cash crop, good seed-to-soil contact is a concern, thus seeding rates should be increased. Post-harvest drilling results in the most successful stand rate, but the outcome is less available forage and poor winter survival due to the later planting date, unless drilled behind corn silage or other early harvested crops.

Livestock health concerns

Although uncommon, a few animal health concerns when grazing cover crops should be considered. Fields that have been heavily fertilized by chemical application or livestock manure may be at risk for toxic levels of nitrates in the biomass. While the risk is probably greater with fall grazing, nitrate toxicity could still be a concern in the spring. Sulfur toxicity is also a concern with brassicas because they are naturally high in sulfur. The only way to be sure that toxic levels of nitrates or minerals are not present at toxic levels is to test the forage. Providing additional feed resources such as hay or other supplements and slowly adapting cattle to the cover crop are ways to mitigate the risks. The lush growth of cover crops in spring or fall may be low in magnesium, promoting grass tetany unless a magnesium-containing mineral supplement is provided. Other health problems like prussic acid poisoning from improper grazing of sorghum varieties or pulmonary emphysema, hemolytic anemia, or photosensitivity from grazing of brassicas are possible. Planting mixtures of cover crop species or providing additional feed resources may also assist in management of these potential problems.



Chapter 2: Livestock management

In this section

- Nutritional and health considerations of grazing animals
- Management of grazing animals
- Water needs of grazing animals

Photo by Erika Lundy.

Nutritional needs of grazing animals

To develop grazing systems that optimize profitability, the nutrient needs of the animals and factors affecting plant growth and quality must be considered. Animal performance will be optimized if animals receive a balanced diet, whether fed in confinement or through proper grazing management. Balancing the nutrient needs of animals with the forage supply is a challenge, however, because the quality and availability of different forages will vary throughout the year, nutritional quality of forage selected by grazing animals is affected by stocking density and system, and the nutrient requirements vary considerably among breeds and for individual animals at different times during their life cycle.

Breeding and lactating cattle and sheep

The energy requirements of female ruminants are primarily affected by their mature size and milk production potential (Table 2.1). For example, at peak lactation, the energy requirement of a large beef cow with a high milk production potential, such as a Simmental, will be 34 percent greater than that of the moderate-sized Angus-Hereford crossbred cow with moderate milk potential. Similarly, at peak lactation, the energy requirement of the large Holstein cow is more than 35 percent higher than that of the smaller Jersey.

Milk potential alone also affects energy requirements of animals of similar size. For example, at peak lactation the energy requirement of a Simmental cow is 12 percent higher than that of a Charolais cow, which has moderate milk production potential, and the energy requirement of a ewe with twins is more than one-third higher than a ewe with a single lamb. This milking potential effect persists even during the dry, maintenance period. The energy requirements of a dry Simmental cow are 12 percent higher than a dry Charolais cow of equal size.

Energy requirements change during lactation and pregnancy. The maximum energy requirements of cows and ewes occur at peak lactation, which is about 6-10 weeks after calving and 3-6 weeks after lambing. The increase in the energy requirement from the dry maintenance period to peak lactation can range from an increase of 80 percent for a ewe nursing a single lamb to about 250 percent for a high milk producing Holstein cow. In general, a diet of high-quality forages will meet the energy needs of lactating ewes and beef cows even at peak lactation. However, it is hard for dairy cows at peak lactation to consume enough energy from a forage diet alone, and they often require supplementation with higher energy feeds.

An adequate level of body condition (fatness) is required to maintain reproductive performance because lactating females will lose body fat reserves during early lactation. After peak lactation, total energy needs decrease gradually, but some surplus energy should continue to be provided to replace body fat reserves and condition. For beef cows, it

Table 2.1. Seasonal nutrient composition available forages; daily nutrient requirements of mature females calving or lambing in April.

	Month											
Nutrient	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
	Forages											
	Mixed pasture	**Corn-stalks**		**Cover Crop**	**Mixed pasture**		**Mixed pasture**			**Mixed pasture**	**Corn-stalks**	
NE_m/NE_l, Mcal/lb	.46-.59	.43-.58		0.60-.73	.52-.63		.49-.54			.49-.63	.45-.56	
CP, %DM	10-14	3-5		16-34	12-22		14-17			10-16	4-5	
RUP, %DM	2.5-2.8	1.2-2.1		2.4-5.1	3.0-5.5		3.5-4.3			2.5-4.0	1.2-1.6	
Ca, %DM	.55	.62		.36-.60	.6-1.8		.6-1.8			.55	.62	
P, %DM	.45	.09		.31-.60	.2-.3		.2-.3			.45	.09	
	Beef breeds Angus X Hereford (1,250 lb)											
NE_m, Mcal	12.1	12.7	13.6	14.4	15.4	15.3	14.5	13.5	12.8	12.3	12.3	10.8
CP, %DM	7.0	7.2	7.6	9.4	10.5	10.5	10.2	10.0	9.1	9.3	8.8	6.7
Ca, %DM	.24	.24	.24	.24	.29	.29	.28	.26	.24	.20	.18	.18
P, %DM	.15	.15	.15	.15	.19	.19	.19	.18	.16	.14	.13	.12
	Charolais (1,450 lb)											
NE_m, Mcal	13.5	14.5	15.5	16.8	18.6	18.5	17.8	16.4	15.4	14.9	14.8	12.2
CP, %DM	7.0	7.4	7.9	9.0	10.6	10.7	10.4	10.2	9.5	8.9	8.4	6.7
Ca, %DM	.25	.25	.24	.24	.29	.30	.29	.27	.24	.20	.19	.16
P, %DM	.16	.15	.15	.16	.19	.20	.19	.18	.17	.15	.14	.12
	Simmental (1,450 lb)											
NE_m, Mcal	15.1	16.3	17.4	18.5	20.7	20.7	19.8	18.1	16.7	15.9	15.5	13.8
CP, %DM	6.8	7.8	8.1	9.1	11.3	11.7	11.6	10.8	10.1	9.3	8.6	7.1
Ca, %DM	.25	.25	.24	.25	.33	.33	.31	.29	.26	.22	.20	.16
P, %DM	.16	.15	.15	.17	.21	.21	.21	.19	.18	.15	.14	.12
	Dairy breeds Holstein (1,500 lb, producing 25,000 lb milk)											
NE_l, Mcal	29.3	13.2	13.2	34.5	41.6	50.8	48.9	46.9	43.6	41.0	37.0	32.4
CP, %DM	16.7	10.7	11.2	22.0	22.4	20.7	19.6	18.9	18.3	17.5	16.7	15.5
RUP, %DM	7.5	1.6	2.1	11.5	10.4	10.7	9.6	9.0	8.3	8.0	7.2	6.1
Ca, %DM	.54	.27	.33	.82	.74	.67	.63	.60	.58	.57	.55	.53
P, %DM	.32	.21	.21	.44	.43	.42	.40	.39	.37	.36	.35	.33
	Jersey (1,000 lb, producing 15,000 lb milk)											
NE_l, Mcal	20.1	9.5	9.5	26.6	32.4	37.4	35.7	34.1	31.6	29.1	25.8	22.5
CP, %DM	15.8	10.1	10.7	20.9	20.5	19.4	18.3	17.7	17.0	16.5	15.4	14.8
RUP, %DM	6.8	1.6	2.2	10.2	10.0	9.4	8.3	7.9	7.5	7.0	6.1	5.2
Ca, %DM	.50	.36	.40	.77	.70	.63	.58	.56	.54	.53	.51	.49
P, %DM	.29	.27	.27	.38	.38	.36	.35	.34	.33	.32	.30	.29
	Large sheep breeds with single lambs											
NE_m, Mcal	1.9	1.9	1.9	2.5	3.7	3.7	2.5	2.5	1.7	1.7	1.7	2.8
CP, %DM	9.3	9.3	9.3	10.6	13.2	13.2	10.6	10.6	9.3	9.3	9.3	8.9
Ca, %DM	.26	.26	.26	.32	.36	.36	.32	.32	.21	.21	.21	.32
P, %DM	.23	.23	.23	.33	.29	.29	.33	.33	.22	.22	.22	.25
	with twin lambs											
NE_m, Mcal	1.9	1.9	1.9	3.0	4.4	4.4	3.7	3.7	1.7	1.7	1.7	2.8
CP, %DM	9.3	9.3	9.3	11.1	14.2	14.2	13.2	13.2	9.3	9.3	9.3	8.9
Ca, %DM	.26	.26	.26	.43	.36	.36	.36	.36	.21	.21	.21	.32
P, %DM	.23	.23	.23	.28	.28	.28	.29	.29	.22	.22	.22	.25

NE_m = Net energy for maintenance, NE_l = Net energy for lactation
Mcal = Megacalorie
CP = Crude protein, RUP = Rumen undegraded protein
Ca = Calcium, P = Phosphorus, DM = Dry matter

Requirements derived from the models for the Nutrient Requirements of Beef Cattle, Eighth Revised Edition. National Academies of Sciences, Engineering, and Medicine, 2016; the Nutrient Requirements for Dairy Cattle, Seventh Revised Edition, National Research Council, 2001; and the Nutrient Requirements of Sheep, National Research Council, 1985.

Figure 2.1A, 2.1B, 2.1C. Beef cows with a condition score of 5 on a 9-point scale by the beginning of the breeding season will have a better rebreeding rate. Cows that are thin (condition score less than 3; Figure 2.1A) or fat (condition score more than 7; Figure 2.1C) will have lower rebreeding rates. Because pasture quality varies throughout the season, it is best to have cows at a condition score of 5 (Figure 2.1B) at the start of the grazing season and manage the grazing to maintain that condition level. Photos by Dan Loy and Erika Lundy.

is essential to provide enough energy with grazing and, if necessary, supplementation to achieve a condition score of five on a 9-point scale by the beginning of the breeding season. Because pasture quality varies throughout the season, it is best to have cows at a condition score of five at the start of the grazing season and manage the grazing to maintain that condition level. Dairy cows should be at a condition score of 3.5 on a 5-point scale at calving and should be managed to prevent the condition score from dropping below 2.75 at peak lactation through appropriate grazing and nutritional supplementation. As dairy cows can more efficiently replenish body weight losses during lactation rather than try to recover body condition during the dry period, they should be at a condition score of 3.5 on a 5-point scale at the end of each lactation (Figure 2.1).

In sheep, the adverse effects of low body fat reserves during reproduction may be compensated for by "flushing" ewes with 50 percent more energy from two weeks before to three weeks after the beginning of the breeding season. This practice increases the number of ova fertilized and embryo survival. It can be done with either excellent pasture or supplemental feeding if pastures are of lower quality.

The dry gestation period provides an opportunity to reduce feed use. In all ruminant females, the lowest energy needs occur after weaning and remain low until the last trimester of pregnancy when rapid fetal growth increases energy requirements. Dry, pregnant females usually can be fed just enough energy to maintain body condition. However, the energy needs of animals kept outdoors are affected considerably by temperature, wind speed, and coat condition. The energy requirement of a pregnant beef cow will be 53 percent higher at -10°F and a wind speed of 10 mph than at 30°F and a wind speed of one mph if the cow has a dry hair coat. If the hair coat is wet and muddy at the colder condition, the energy requirement would almost be doubled.

The amounts of crude protein, calcium, and phosphorus required by beef cows and ewes also vary among breeds. However, most grass and legume forage species contain adequate quantities of these nutrients to meet animal needs throughout the year. When grazing corn crop residues, protein and phosphorus requirements as well as those of vitamin A, trace minerals, and salt are likely to be deficient and supplemental feeding may be necessary.

Magnesium needs of all grazing animals should be considered. Most grass and legume forages contain sufficient magnesium for animal needs, but occasionally the amount of magnesium in grazing animal diets is deficient. Low dietary magnesium and high nitrogen and potassium concentrations in lush, heavily fertilized grass forages may lead to a magnesium deficiency known as grass tetany.

Genetic selection for grazing beef

Phenotypic measurements and genetic indicators are available for use to predict improved efficiency in a grazing system. Selecting breeds that remain more moderate in their mature size and will finish at lighter weights can be beneficial because of their low maintenance requirements. Primarily, these would include British breeds such as Angus and Hereford. However other minor breeds such as South Devon, Dexter, and American Low-Line have been touted by some producers as better adapted to a grass-finished environment. Utilizing yearling and mature height expected progeny differences (EPDs) allows for selection of cattle that remain at a more sensible frame score and may be better suited for environments where grain is not incorporated.

Recent interest in genetic testing and experimental research has focused on feed efficiency traits including residual feed intake (RFI). RFI represents the difference between projected and actual intake based on growth; therefore, a negative value indicates an animal consumes less feed than their cohorts to gain the same amount of weight. While determination of RFI in a grazing system is incredibly difficult due to complication of monitoring intake, genetic testing may allow for more widespread incorporation of this index into breeding programs focused on grazing cattle.

Marbling EPDs may also be a useful tool for selection of cattle that will have an advantage in intramuscular fat and quality grade at lower body weights when they are finished in a grazing system. Combining selection pressure from the aforementioned traits may allow for production of cattle that will be mature earlier, finish at lighter weights, and maximize their genetic potential to grade before grazing resources deplete at the end of the growing season.

Dairy cattle

Lactating dairy cows often need more supplemental feeding than other grazing animals because of their high level of milk production. Because of increased energy requirements during the last trimester of pregnancy and the need for slow adjustment to the lactation diet, dairy cows should start receiving the lactation grain supplement at least two weeks before calving. Crude protein requirements also increase for dairy cows during lactation. The higher protein requirement often cannot be met from forages alone. To supply adequate amounts of protein and amino acids to dairy cows, some supplementation of a protein source which is not highly degraded in the rumen (called ruminally undegraded protein) such as heat-treated soybean meal, corn gluten meal, or ruminally protected amino acids is often necessary to meet the milk production potential of the energy supplied by the forage.

Similar to crude protein, the requirements of calcium and phosphorus for dairy cows vary considerably with the physiological state of the cow. During the dry period, it is preferable to feed low levels of calcium and potassium to minimize the possibilities of the cow developing a calcium deficiency called milk fever (hypocalcemia) during lactation.

Because grasses generally contain lower concentrations of calcium and potassium than legume forages, grazing grass pastures, or feeding grass hays during the early part of the dry period may be preferable to feeding legume forages. This feeding regime offers the possibility of a low-cost dry period diet.

Stocker and growing cattle

Unlike beef cows, the usual objective for growing cattle is to maximize daily gains rather than maintain a uniform body condition or weight. In general, a weight gain of two pounds per day for stocker cattle is the minimum that is economically acceptable. Similarly, to be able to achieve the necessary weight for puberty, replacement heifers must average daily gains of 1-1.5 pounds from weaning. To maintain a daily gain of two pounds or greater, the daily energy requirement increases by 38 percent as a steer grows from 600 to 900 pounds (Table 2.2). Growing cattle can compensate for this increased energy requirement by eating more, particularly if previously fed inadequate amounts of energy. Lightweight steers (less than 700 lb) require slightly higher levels of protein and amino acids in their diet than the grass pastures alone may provide, so supplementation with a ruminally undegraded protein source may be needed. Heavier steers can get sufficient protein from pasture as long as forage intake is not restricted. Calcium and phosphorus requirements of stocker steers also can be met from the pasture alone, but many producers provide supplemental minerals in the pasture or near the water source.

Table 2.2. Daily nutrient requirements of large-frame stocker steers.

	Month					
Body weight, lb	**600**	**660**	**720**	**780**	**840**	**900**
	Amounts required per day for an average daily gain of 2 lb					
NE, Mcal	10.5	11.0	11.5	12.2	13.3	14.5
CP, lb	1.76	1.78	1.79	1.94	1.96	2.12
RUP, lb	.47	.40	.33	.37	.27	.27
Ca, lb	.07	.07	.07	.07	.07	.07
P, lb	.03	.03	.04	.04	.04	.04
Predicted daily intake, lb DM	14.4	15.1	17.0	18.5	20.2	21.6
	Nutrient concentration needed for a daily gain of 2 lb at predicted intakes					
NE, Mcal/lb	.73	.70	.68	.66	.66	.66
CP, % DM	12.2	11.3	10.5	10.5	9.7	9.8
RUP, % DM	3.2	2.5	2.0	2.0	1.4	1.3
Ca, % DM	.48	.43	.40	.37	.34	.32
P, % DM	.24	.22	.21	.20	.18	.18

NE = Total Net Energy for maintenance
Mcal = Megacalorie
CP = Crude protein
RUP = Rumen undegraded protein
Ca = Calcium
P = Phosphorus
DM = Dry matter
Requirements derived from the models for the Nutrient Requirements of Beef Cattle, Eighth Revised Edition. National Academies of Sciences, Engineering, and Medicine, 2016.

Lambs are seldom finished on pasture alone in the Midwest. However, the nutritional requirements for finishing lambs are similar to those of stocker steers — both need high-quality pasture in abundant supply. Grazing lambs gain better on legume or legume and grass pasture than on pure grass pasture. Cover crops can be used to finish grazing lambs with good success. Cover crops, especially brassicas, provide excellent gains. Off flavors might occur with lambs harvested right off of brassicas. A month of feeding in dry lot should alleviate any potential quality issues. Predator and parasite control are essential to achieve acceptable economic returns from lamb grazing.

Horses

Although horses and mules are not ruminant animals, they can obtain a large proportion of their nutrient requirements from pasture forage. Because the digestive system of horses and mules is less efficient than that of ruminant animals, they often require a forage diet higher in nutritive value. Thus, extra management will be needed to provide higher nutritive value throughout the grazing season.

Lactating mares, weanling horses, and hard-working horses should be fed supplemental feed even if grazing excellent pastures. Photo by Denise Schwab.

For many classes of horses, pasture forage alone may provide adequate protein, calcium, and phosphorus, and should provide ample vitamin A. Some classes of horses may need to be supplemented with hay or a grain mix. Nutrient requirements for various classes of horses are shown in Table 2.3. Digestible energy requirements on a dry matter basis are 0.76 Mcal/lb for horses at maintenance, but this may increase to 1.14 Mcal/lb for mares in their first three months of lactation. As nonruminants, the crude protein requirements of horses are primarily based on meeting the requirement for the amino acid lysine. The dietary crude protein required for various classes of horses is foals (16-18 percent); weanlings (12-16 percent); yearlings, long yearlings, two-year olds, stallions, and lactating mares (all 8-12 percent); pregnant mares (8-10 percent); and mature working horses and mature horses at maintenance (both 6-8 percent).

Lactating mares, weanling horses, and hard-working horses should usually be fed some supplemental feed even if grazing excellent pastures. Table 2.4 lists expected daily feed consumption by horses as a percentage of body weight. For example, the table shows that a mature horse at maintenance will eat 1.5-2.0 percent of its body weight in dry matter each day. Thus, a 1,000-lb horse will eat 15-20 lb of air dry feed daily to meet its intake requirement. But during the first three months of lactation a mare will eat 2.0-3.0 percent of her body weight each day. Thus, a 1,000-lb mare on fresh forage will eat 20-30 lb of air dry feed daily.

It is extremely important to maintain a mare's body condition during pregnancy and lactation. A mare that is losing weight, regardless of body weight, has reduced reproductive efficiency. Failure to provide the mare with enough feed during lactation can lead to decreased milk production

Table 2.3. Nutrient concentrations in total diets for horses (DM basis).

	DM intake (% BW)	Digestible energy (Mcal/lb)	Crude protein %	Lysine %	Calcium %	Phosphorus %	Magnesium %	Vitamin A (IU/lb)
Adult no work								
Minimum	2.0	0.69	5.4	0.23	0.20	0.14	0.08	682
Average	2.0	0.76	6.3	0.27	0.20	0.14	0.08	682
Working horses								
Light exercise	2.0	0.91	7.0	0.30	0.30	0.18	0.10	1023
Moderate exercise	2.25	0.94	6.8	0.29	0.31	0.19	0.10	909
Heavy exercise	2.5	0.97	6.9	0.30	0.32	0.23	0.12	818
Very heavy exercise	2.5	1.25	8.0	0.35	0.32	0.23	0.12	818
Stallions								
Non-breeding	2.0	0.82	7.2	0.31	0.20	0.14	0.08	682
Breeding	2.0	0.99	7.9	0.34	0.30	0.18	0.10	1023
Pregnant mares								
9 months	2.0	0.82	7.5	0.32	0.34	0.25	0.07	1277
10 months	2.0	0.84	7.7	0.33	0.33	0.24	0.07	1244
11 months	2.0	0.86	7.9	0.34	0.32	0.23	0.07	1205
Lactating mares								
Foaling to 3 months	2.5	1.14	12.1	0.67	0.46	0.30	0.09	1091
3 months to weaning	2.5	1.03	10.6	0.57	0.31	0.20	0.08	1091
Growing horses								
Weanling, 4 months	2.5	1.44	15.9	0.69	0.93	0.52	0.09	823
Weanling, 6 months	2.5	1.30	12.5	0.54	0.71	0.40	0.08	816
Yearling, 12 months	2.5	1.06	10.5	0.45	0.47	0.26	0.07	821
Long yearling, 18 months	2.5	1.04	8.8	0.38	0.38	0.21	0.12	817
Two-year old, 24 months	2.5	0.92	7.7	0.33	0.34	0.19	0.12	817

DM = Dry matter
BW = Body weight
IU = International unit

Requirements derived from the Nutrient Requirements of Horses, Sixth Revised Edition. National Research Council, 2007.

Table 2.4. Daily feed intake by horses as percentage of body weight (air dry basis).

Class	Forage	Concentrate	Total
Mature (idle)	1.5-2.0	0-0.5	1.5-2.0
Mares, late gestation	1.0-1.5	0.5-1.0	1.5-2.0
Mares, early lactation	1.0-2.0	1.0-2.0	2.0-3.0
Mares, late lactation	1.0-2.0	0.5-1.5	2.0-2.5
Working horses			
Light work	1.0-2.0	0.5-1.0	1.5-2.5
Medium work	1.0-2.0	0.75-1.5	1.75-2.5
Intense work	0.75-1.5	1.0-2.0	2.0-3.0
Young horses			
Nursing foal, 3 months	0	1.0-2.0	2.5-3.5
Weanling foal, 6 months	0.5-1.0	1.5-3.0	2.0-3.5
Yearling foal, 12 months	1.0-1.5	1.0-2.0	2.0-3.0
Long yearling, 18 months	1.0-1.5	1.0-1.5	2.0-2.5
Two-year-old, 24 months	1.0-1.5	1.0-1.5	1.75-2.5

and poorly developed foals. To maximize reproductive efficiency, mares should be maintained with a body condition score between 5.5 and 7.5 on a 9-point scale. Mares who are thin (body condition score of less than four) at breeding will have normal weight foals but low reproductive efficiency. In addition, an increase in early embryonic losses may occur. On the other hand, obesity (body condition score of eight or more) does not appear to affect pregnancy, foaling ease, foal birth weight, or reproductive efficiency, but will decrease subsequent milk production.

Health considerations of grazing animals

Grass tetany

Grass tetany can be described as a metabolic disorder of ruminant animals whose intake of magnesium (Mg) is too low (hypomagnesemia). Cattle are more susceptible than sheep or goats, and lactating females are most susceptible. Older cows are more susceptible than young cows because their bones are harder which makes them less able to draw on skeletal Mg and because they often produce more milk. Symptoms vary with the degree of Mg deficiency, and whether grass tetany is due to a rapid change in body levels (acute) or whether it is a chronic condition. Early signs of grass tetany are nervousness and a stiff gait. As the condition worsens, animals stagger and become excitable. If the condition becomes more serious, animals lie down and convulse. If animals do not receive treatment by this advanced stage, they often lapse into a coma and die. With a low-level or chronic form of grass tetany, animals may walk stiffly and show a gradual decline in body condition. Animals with low-level grass tetany either get better or worse within a few weeks. Grass tetany symptoms are less distinct in sheep, and can easily be confused with conditions such as milk fever.

Grass tetany most often occurs in animals grazing in spring or fall on grass pastures that have been heavily fertilized with nitrogen (N) and potassium (K), and in some cases with poultry manure. High plant K levels depress plant Mg uptake, and high plant K and N levels both decrease Mg availability in the animal.

Problems of grass tetany can be minimized by using moderate levels of N and K fertilizer on grass pastures in early spring, maintaining legumes with the grass (legumes contain higher levels of Mg), using a dolomitic lime source that contains both Mg and calcium, and providing mineral-containing Mg. Magnesium is not highly palatable, so mineral consumption needs to be monitored closely to ensure adequate Mg intake.

To prevent prussic acid poisoning, sorghum/sudangrass hybrids should not be grazed until they are at least 28 inches tall. Photo by Matthew Haan.

Prussic acid poisoning

Prussic acid poisoning occurs in ruminant animals eating plants containing high levels of hydrocyanic acid (HCN). High levels of HCN can occur in very young, drought-stressed, frost-injured, or wilted plants of the sorghum family (grain sorghum, forage sorghum, sudangrass, and their hybrids, as well as sorghums commonly thought of as weeds such as johnsongrass and shattercane). A few other plants such as wild cherry and very immature Indiangrass also have potentially high levels of HCN.

In the animal's blood system, HCN poisoning is much like cyanide poisoning. Symptoms occur within minutes of eating high-HCN plants. The first signs are deep and rapid breathing and excessive foaming in the nose and mouth. The animal then lapses into a depression with severe difficulty in breathing, followed by death within hours. Diagnosis and treatment must be very rapid to save affected animals.

The best treatment for prussic acid poisoning is prevention. Delay grazing of sorghum plants until they are nearing maturity. Graze sudangrass after it reaches 15-18 inches or taller, and hybrid sorghum/sudangrasses when 28-30 inches or taller. Don't allow animals to browse fallen wild cherry trees. Sorghums have a higher potential for causing HCN poisoning for the first 7-10 days following a frost. Have animals fully fed with dry hay before turning them onto a sorghum-type pasture for the first time to reduce a rapid intake of potentially toxic forage. Plants will lose their HCN toxicity when dried and stored as hay.

Nitrate poisoning

Most nitrate poisoning in grazing livestock occurs when animals graze heavily manured, N-fertilized grasses or corn residue during and soon after a drought. (In rare situations, spilled fertilizer has caused nitrate poisoning.) Slow-growing plants absorb soil N, and it accumulates in the lower stems until it can be metabolized. Rumen microorganisms convert nitrate to nitrite, which moves into the animal's bloodstream and inhibits the oxygen-carrying function of hemoglobin. Maximum tolerable concentrations of nitrate is approximately 0.33 percent of dietary dry matter in pregnant animals and 0.66 percent in open animals.

Symptoms of nitrate toxicity may begin within a few hours or not be expressed for a day or more. Symptoms of chronic, low-level nitrate toxicity are reduced appetite, weight loss, and diarrhea. Acute toxicity is generally not apparent until hemoglobin's function is reduced to a level where breathing is labored and the mucous membranes of the nose and mouth take on a bluish color. Advanced symptoms are muscular tremors, collapse, coma, and death. Diagnosis and treatment should be conducted by a veterinarian.

Prevention of nitrate toxicity is the best management practice. Much like sulfur, water may present nitrates that add to total daily ingestion. Thus, testing water may be prudent if feedstuffs have nitrate concentrations that are approaching concerning levels. If forage is suspected of having high levels of nitrate, samples should be collected and tested. It is paramount that laboratory results are carefully evaluated, as different labs may report N as different compounds. Specifically, reports may indicate concentrations of nitrate, nitrite, or nitrate-nitrogen. Both nitrite and nitrate-nitrogen can easily be converted to nitrate through multiplication by factors of 10 and 4.4, respectively. However, misinterpretation of lab results could prove lethal. Therefore, having a veterinarian interpret your results is advisable.

Pastures with plants at elevated nitrate levels can often be safely used with careful supplementation, particularly with grain or low nitrate forages, and adaption of animals to the pastures. Plants with high nitrate levels do not lose their toxicity potential when dried. Therefore, hay and harvested corn residue will mimic nitrogen concentrations of the plants from which they were derived. However, ensiling the crop can decrease nitrate concentration by as much as 40-60 percent.

Sulfur toxicity

Excess sulfur has typically not been of great concern in grazing livestock; yet increased use of cover crops and biofuel co-product supplements in many grazing systems has raised the awareness of potential sulfur complications. Sulfur is required at relatively low levels (0.15 percent of dietary dry matter) in most beef, sheep, and dairy diets. However, total dietary concentrations in excess of 0.30 percent can bind to and diminish availability of critical trace minerals such as copper.

Forages such as grass and legumes contain between 0.10 and 0.25 percent sulfur, respectively. Brassicas, such as turnips and radishes, that have gained popularity as cover crops used for fall grazing, can often contain in excess of 0.3 percent sulfur. Furthermore, distillers grains, which are often used as an energy supplement to grazing livestock in the Corn Belt region, can easily be in excess of 0.7 percent sulfur. Brassicas and distillers grains, particularly if fed in combination, can quickly approach the maximum tolerable concentration of sulfur, which is approximately 0.5 percent in high roughage diets. Producers should be mindful of water sulfur concentrations, as these will add to the total sulfur intake by the herd and potentially magnify border-line excessive dietary sulfur conditions.

Sulfur toxicity is typically identified by the onset of polioencephalomalacia (PEM), a neurologic disorder of cattle characterized by blindness, ataxia, recumbency, and seizures. When toxic concentrations of sulfur are ingested, hydrogen sulfide is produced by rumen microbes. The hydrogen sulfide accumulates in the rumen gas cap, and upon eructation, can be inhaled by the animal. Inhaled hydrogen sulfide enters the bloodstream through the lungs, and once it reaches the brain, can lead to cell death and PEM. While there is no specific treatment for PEM, thiamine and glucocorticoids have proved beneficial in suppressing symptoms. Ultimately, removing the animal from sulfur sources is the best treatment in subacute cases.

Poisonous and toxic plants

Literally hundreds of plants grow in the Midwest that can be considered toxic to grazing animals if eaten in sufficient quantity. Each plant varies in its toxic component and toxicity symptoms. No livestock producer can be expected to recognize every plant. There are a few highly poisonous plants that are often spoken of, such as poison hemlock, water hemlock, white snakeroot, and bracken fern. Some cropland weeds such as black nightshade, jimsonweed, pigweed, cocklebur, and milkweed also can be toxic if eaten in sufficient quantities. Fortunately, poisonings are rare because animals seldom choose to eat toxic plants. Plant poisonings are most often associated with overgrazed pastures where animals are forced to eat them out of necessity. Surprisingly, many plant poisonings occur when animals eat the wilted leaves of trees downed in storms (red maple, wild cherries) and trimmings or flowers like buttercups, foxgloves, irises, poppies, Japanese yew, rhododendron, and azaleas from homesteads. Occasionally animals may eat toxic plants like acorns just for diversity or novelty. Most poisonings are subacute and are only noticed as temporary skin or mouth irritation, minor shaking or incoordination, elevated breathing rate, or slightly depressed appetite.

Prevention through good pasture management is the best cure for poisonous plants. Maintaining a thick, vigorous pasture eliminates nearly all of the forced consumption of toxic plants. Clipping, digging, or chemical control are management practices that can be used to further minimize the risk of livestock poisoning.

Bloat

Bloat can be a problem in cattle grazing pastures dominated by certain legumes and cover crops like wheat, cereal rye, and brassicas. Although sheep and goats can be affected by bloat, they are considered to be less susceptible. Individual animals within a herd or flock also vary in their susceptibility to bloat. Bloat is caused by the formation of a stable froth in the rumen of susceptible animals, preventing the normal belching of rumen gasses. The resulting accumulation of excess gas in the rumen produces pressure on the lungs and can eventually restrict breathing to the point of causing death by suffocation.

Legumes vary in their potential to cause bloat. White clover, Ladino clover, kura clover, and alfalfa are most often the legumes associated with incidence of pasture bloat. Although some alfalfa varieties are marketed as 'bloat safe,' no known alfalfa varieties are bloat risk-free. Other legumes such as birdsfoot trefoil, lespedeza, and crownvetch rarely cause bloat.

Bloat symptoms are a gradual swelling of the left side of the animal. It is apparent within 20 minutes to an hour after the onset of gas retention. If the condition is mild, normal movement of the animal will again allow normal release of excess gas and the condition diminishes. If the gas buildup continues, the animal will collapse and die from suffocation within a relatively short time. A veterinarian should be consulted for treatment as immediate treatment is necessary. .

Keys to bloat management:

- The bloat risk is greatly reduced when at least half of the forage consumed is grass.
- Avoid grazing young, immature legume and cover crop species known to cause bloat.
- Feed some hay before turning animals onto pastures with a high potential for bloat, then watch animals carefully for an hour or two. If swelling and bloat begin to develop, remove the animals from the pasture quickly.
- When rotational grazing is being practiced, plan to make paddock moves in mid-afternoon to minimize grazing of forage with heavy dew.
- When rotational grazing is being practiced, make paddocks small enough or use strip grazing so that animals consume a mixture of stems and leaves.
- Commercial antifoaming agents that contain poloxalene are available. They will help to minimize the risk of bloat when consumed regularly by the animals in grain or lick block. However, as poloxalene is unpalatable to some animals, intake should be monitored. Some producers also feel commercial feed additives called ionophores can help prevent and manage bloat, but results from this practice have been variable.

Proper management can greatly reduce the risk of bloat in cattle grazing alfalfa pastures. Photo by Erika Lundy.

Using a combination of these practices is most effective in bloat prevention.

Blue-green algae

Blue-green algae are a group of organisms called cyanobacteria. Cyanobacteria have been present for millions of years in fresh surface water. They produce toxins when they grow called cyanotoxins. In the United States, the most important fresh water cyanobacteria include Anabaena, Aphanizomenon, Cylindrospermopsis, and Microcystis species. These organisms and their toxins are a concern when animals use surface water as their drinking water supply. High rainfall events that carry nitrogen and phosphorus into ponds and streams followed by warm water temperatures and reduced precipitation are major risk factors.

Risks of blue-green algae in ponds may be reduced by preventing loading of nutrients in water runoff. Photo by Steve Ensley.

Small concentrations of blue-green algae are not a health concern, but when an algal bloom occurs the risk of cyanotoxins increases. Another factor that can increase risk of cyanotoxins is when the wind blows and concentrates the algal bloom on the downwind side of the pond.

Consumption of cyanotoxins can cause sudden death or liver toxicity. Therefore, providing an alternative water source would be desirable if ponds or streams are covered with blue-green algae. Risk of this problem may also be managed by preventing nitrogen and phosphorus loading of ponds and streams by limiting water runoff through the use of buffer strips along streams and maintaining adequate forage height within pastures.

Parasites

Parasite control is part of a good animal health care program. External parasites such as lice, ticks, mange, and flies, as well as numerous internal parasites, can cause livestock discomfort and may reach levels where animal performance is affected. External and internal parasites will be a concern to producers whether animals are grazing on a continuously stocked pasture or in a rotational pasture system. Sheep, goats, and horses are more susceptible to internal parasitism that hinders performance than beef cattle.

A major criticism of continuously stocked pastures is that animals congregate in favorite locations, allowing parasite numbers to build to very high levels, creating a constant parasite problem. But a common misconception about rotational grazing is that it controls internal parasites. This might be true in paddocks that are grazed closely to the ground. However, conditions favorable for pasture growth are also favorable for development and survival of parasite larvae. Therefore, if the paddocks are grazed to leave a proper residual leaf area, the tall, grassy canopy may actually enhance survival of parasite larvae. Parasite eggs hatch and develop into infective larvae within 7-10 days in warm, humid conditions, but this time can be prolonged in cool or dry conditions. Therefore, rotational grazing will frequently have animals reentering a paddock just as parasite larvae are reaching their most infective stage of development. Once ingested, larvae develop into adults within the grazing animal and begin producing eggs in approximately four weeks. Effective pasture management aims to reduce free-living parasites on pasture and decrease uptake of infective larvae.

Reducing the stocking rate of continuously grazed pastures or appropriate management of rotational grazing can reduce the uptake of parasites and the effects of ingested parasites on animal performance. Maintaining residual forage heights at a minimum of four inches for cattle and two inches for sheep and horses to optimize intake will also reduce consumption of parasites as most infective larvae are usually in the bottom two inches of forage. However, larvae may migrate higher onto the herbage in cool, dry conditions. Maintaining adequate quantity and quality of pasture forage can allow the grazing animals to perform even under heavy parasite loads. Rotational grazing can be used for parasite control if enough rest time is allowed between grazing events to kill larvae deposited previously. The amount of rest time necessary will vary between climates, with temperate climates needing shorter rest periods.

Deworming livestock before the grazing season is an important component of an effective parasite control program in conjunction with proper pasture management. If animals have low infestation levels when turned onto pasture, then usually only a low level of infective larvae will develop on the pasture. In most situations, the number of viable larvae that overwinter on pasture is low. So with good pre-grazing season parasite management, pastures should not have a large buildup of larvae.

It sometimes is necessary to deworm animals during the grazing season. One approach to improve the effectiveness of deworming is to rotate animals to “clean” (parasite free) forage following treatment. Any pasture that has not been grazed for the previous six months is considered clean. Hay fields that are incorporated into the grazing system after the first crop of hay is harvested would be an example of a clean pasture. Another approach, used in other countries, is to change the species of grazing animal every 6-12 months to break the parasite/host cycle. Sheep and goats are affected by different parasites than cattle. So rotating between sheep and goats would not be considered moving to clean pasture, but rotating between sheep and cattle would be considered good parasite management.

While deworming and good pasture management can help reduce parasite infections in grazing animals, genetic resistance to some deworming products has become a growing problem. Sheep, goats, and horses have had increased incidence of parasite resistance limiting the effectiveness of chemical treatments, although this resistance is less apparent in large ruminants. Resistance to deworming products may be managed by several approaches:

- Selectively treating some animals while not treating others to maintain a population of parasites that would remain susceptible to treatment.
- Using a combination of different categories of dewormers simultaneously to improve the effectiveness of treatment and reduce development of resistance in parasites. Always consult a veterinarian before using combination treatments.
- Monitor herds for resistance by comparing the numbers of parasite eggs in the feces before and after deworming. The time between treatment and second egg counts should be 8-10 days after treatment for benzimidazole dewormers and 14-17 days after treatment with macrocytic lactone dewormers. If egg reduction is less than 95 percent, there may be resistance within the herd or flock.

Many commercial products for controlling external and internal parasites are available. Proper use of these products is best determined by a veterinarian. Correct dosage and proper administration are very important for efficacy. Label recommendations and withdrawal periods should be closely followed to avoid violating food safety regulations.

Information on different aspects of parasite control in beef cattle is included in the ***Beef Cattle Handbook*** (http://www.iowabeefcenter.org/bch/InternalParasites.pdf). For additional information on sheep parasite control, see Iowa State University Extension and Outreach publication ***Sheep Health — Control of Internal Parasites of Sheep*** (PM 829-8) (https://store.extension.iastate.edu/Product/4143).

Flies

Much like internal parasites, external parasites such as flies can negatively impact performance of grazing livestock. Not only do these pests depress livestock performance, they are also vectors for diseases and can cause a number of health issues in a grazing herd. Several species of flies including horn flies, face flies, stable flies, horse flies, and bot flies can infest grazing herds causing different health problems in livestock. In order to implement the best fly control strategies, it is important to identify which species are most prevalent.

Fly tags are most effective at repelling flies for the first 45-60 days following application. Photo by Samantha Jamison.

Fly populations in grazing livestock may be best controlled by a combination of pasture management and chemical methods. Because many species of flies require intact fecal pats to deposit their eggs, harrowing pastures can disrupt larval development and reduce adult fly populations. Other species of insects like dung beetles can also break fecal pats. Proper waste management, reducing feed waste, and other sanitation practices can also reduce fly numbers. Horn fly numbers on grazing livestock may be reduced by using walk-through fly traps that brush flies off livestock and trap them in the walls. The key to these traps is placement in gates or near water troughs to ensure that the animals pass through them daily. However, this method is not effective on face flies or stable flies.

Chemical fly treatments may be applied as sprays, pour-ons, back rubs, dust bags, or feed additives. As these treatments are usually only effective for limited periods of time, they must be reapplied frequently according to instructions. Ear tags impregnated with pyrethroid or organophosphate insecticides can provide long-term protection from horn flies and face flies. While current fly tags offer protection for 12-15 weeks, they are most effective during the first 45-60 days. Thus, tags should not be applied too early in the grazing season to provide protection during peak fly season. To prevent resistance to these insecticides, pyrethroid tags and organophosphate tags should be alternated each year.

Pink eye

Animals on pasture occasionally will develop an infectious eye ailment commonly called pink eye. It is an inflammation of tissues surrounding the eye (conjunctivitis). Once inflamed, the condition generally requires medication. A number of irritants, particularly pollen, can induce pink eye and spread it to other animals in the group. Initial scratching of the eye by tall plants, grass seedheads, and weeds is commonly thought to initiate pink eye. Face and horn flies can also be a major cause of spreading, and fly repellents may help limit spreading.

A good control measure for pink eye is to use grazing management to prevent the development of tall, mature forage and weeds. Mechanical clipping of pastures is often done to remove the seedstems and weeds suspected of causing the initial irritation. For additional information on pink eye management, see ISU Extension and Outreach publication ***Pink Eye in Beef Cattle Herds*** (PMR 1017) (**https://store.extension.iastate.edu/Product/14167**).

Fescue toxicosis

A group of disorders in grazing animals are linked to the presence of a fungus in tall fescue and some ryegrasses. The fungus lives inside the infected grass plant as an endophyte, producing 30-40 different alkaloids. Some of these alkaloids are nontoxic, but others including ergovaline and other lysergyl alkaloids lead to health and production problems in grazing livestock.

A significant effect of the toxic alkaloids in the animals' system is the restriction of blood flow, interfering with the animals' natural ability to regulate their body temperature. In the summer, cattle grazing toxic tall fescue are hotter than normal, resulting in reduced weight gain, lower conception rates, and difficulty in maintaining body condition. Furthermore, cattle grazing toxic tall fescue during summer will stand in ponds and streams increasing risks of water pollution. In mares, the toxic alkaloids may cause abortions or difficult births and greatly reduce or stop milk flow. In winter, the toxic alkaloids can lead to poor blood circulation and the freezing and loss of ears, tails, or, in extreme cases, hooves in all grazing species.

The endophyte is concentrated, and alkaloids are in highest concentration, in mature fescue leaf sheaths, stems, and seedheads, but alkaloids also are present to a lesser extent in leaf blades. Thus, the highest concentrations of toxic alkaloids are found in mature tall fescue plants especially in pastures heavily fertilized with nitrogen. If used in a winter grazing system, freeze-thaw activity reduces alkaloid concentrations in tall fescue making grazing safer in late winter.

The only way that endophyte fungus can infect a pasture is in endophyte-infected tall fescue seed. It can be introduced to a pasture by seeding, transported by animals, or in mature endophyte-infected tall fescue hay.

Also, endophyte-infected tall fescue seed in the soil seed bank can re-infect a renovated pasture if management of endophyte-infected tall fescue removal was inadequate.

Tall fescue fields can be sampled and tested for the presence of the endophyte fungus. Green stems, collected during the mid-summer months can be tested by a staining method. An immunoblot antibody test can be conducted on stems collected from May until December. Seed can be tested using the immunoblot antibody method any time. However, as both nontoxic and toxic alkaloids are found in endophyte-infected tall fescue, measurement of the alkaloids in a laboratory is more useful in assessing plant toxicity. This needs to be done on at least 50 tillers per pasture and should be frozen and stored in a dark place prior to overnight shipping to a laboratory for analysis. Check with an ISU Extension and Outreach county office or veterinarian for commercial laboratories that do such testing.

Management of endophyte-infected fescue may include the following:

- Grazing during spring months to prevent seedstem formation.
- Suppressing seedhead development in endophyte-infected tall fescue by treatment with metasulfuron-based herbicides. Contact an ISU Extension and Outreach field agronomist or livestock specialist for appropriate herbicides, application rates, timing, and management.
- Clipping of seedstems when formed.
- Providing alternate pasture or forage and shade during periods of heat stress.
- Removing pregnant mares from known infected tall fescue pastures.
- Reducing consumption of toxic alkaloids through dilution with other grasses or legumes in pastures or with nutritional supplementation.
- As natural selection may result in animals that are at least partially tolerant of toxic alkaloids, breeding stock should be sourced from farms in states with the tall fescue belt when possible. Genetic tests have been developed at commercial laboratories to measure the susceptibility of beef cattle to tall fescue toxicosis. These tests may be used to identify cattle that may tolerate toxic alkaloids for purchasing, breeding, and culling decisions. However, heritability, mode of action, and correlation of this test to other performance characteristics needs to be determined.
- The most expensive management choice is destroying the infected fescue plants and renovating with a new pasture planting. Because alkaloids provide tall fescue with resistance against drought, insects, and disease, it may be most desirable to replace toxic endophyte-infected tall fescue with tall fescue containing novel endophytes that produce nontoxic alkaloids (See Chapter 1, “New and Improved Plants for Pasture Use”). However, regardless of the grass species used for pasture renovation, endophyte-infected tall fescue may return in a few years from infected seed or old plants unless seedheads have been clipped for a year or more before renovation and the old stand is completely destroyed.

Understanding grazing animals and their management

Animal care and behavior influence daily decisions about movement and animal-handling activities in grazing systems. Animals behave first as individuals in their grazing selectivity, reproductive cycle, and health, but practicality requires that animals be managed as a herd or flock, which generally improves the efficiency of animal handling. There are inherent group behaviors that should be considered in the design and management of the grazing system. Discussed in this section are some situations where animal needs and habits may influence daily grazing management decisions and animal performance.

Daily grazing behavior

Cattle graze 8-12 hours per day and sheep 6-8 hours. They break this active grazing time into about 5-6 separate grazing periods, with time required for ruminating and resting between grazing periods. During summer, grazing the first few hours after daybreak is normally the largest single meal of the day. In this early morning grazing, animals tend to eat a lot and are less selective in their diet. A second large grazing period occurs in late afternoon until about sunset, with minor grazing periods during other parts of the day and at night. During hot weather, animals tend to graze more at night. In winter, most grazing occurs from midmorning to midafternoon when temperatures are warmest.

Animal behavior can be useful when deciding when to move animals. Because the average nutritive quality of the forage declines the longer a group of animals is in a pasture, the early morning "quantity" grazing is a good time to get the animals to eat more of the lower-quality forage in the paddock. Under ideal conditions, if the nutritional requirements of the herd or flock are relatively low (dry, open, or gestating), leaving the group in a paddock for the morning grazing will remove the lower-quality forage remaining on the last day of a grazing period. But if the animal group is one that requires a high-quality diet for lactation or gain (dairy cows, stocker steers, or lambs), then turning the group onto the next high-quality paddock before a big grazing (daybreak or midafternoon) will permit a better level of nutrition in the diet. However, convenience and bloat management often dictate when groups are moved.

Herds and flocks often behave according to a leadership hierarchy. This is important when moving animals. Each animal group has leaders, followers, and subordinates. Disruption and conflict can arise if subordinates are forced into the leader or follower group as animals are being moved.

Herd effects

Groups of grazing animals prefer to be able to see each other at all times. When the lead animal begins to move to water or to a remote part of the pasture, all the members of the herd will move too. This is a great advantage when rotating to a different paddock in rotational systems, but can be a disadvantage when the group moves to a distant water source. It can interfere with grazing, use energy unproductively, particularly for high-producing animals (lactating dairy cows, stocker steers), and reduce manure nutrient distribution. Research shows that if animals are within 700-800 feet of the water source, they can generally see each other and are more comfortable going to water individually in coordination with their own grazing and ruminating preferences. Providing water in each paddock or at several locations in large pastures will improve the efficiency of grazing, animal production, and manure nutrient distribution.

In large pastures, grazing animals often prefer to graze near the water source and avoid grazing in distant corners. Some producers place salt and mineral supplements in locations away from the water source to encourage better forage use over the entire pasture.

Managing horses on pasture

Horses are forage-consuming animals and must have a daily supply of roughage provided either as pasture or hay. Horses will graze up to 16 hours per day. A horse's normal pattern is to graze continuously for several hours, rest, and then continue grazing. Even if horses are fed grain and have access to high quality hay, they will continue to graze. Increased pasture forage availability will decrease grazing time. Horses graze less during very hot or cold weather, and young horses graze less than mature horses. Horses graze more in a group than as isolated individuals.

Horses are selective grazers, which affects the productivity of a pasture. Horses prefer to eat young, immature plants and will graze some areas of a pasture down to the bare ground. In other parts of the pasture, they will allow the plants to grow to maturity, which lessens palatability and nutrient availability. This grazing pattern is often called spot or pattern grazing. Horses will not graze in areas where they defecate.

Laminitis (founder) may be a concern for some horses particularly in the spring season or when horses are first placed on pasture. Rapid intake of starches or fructans (a sugar) stored in pasture grasses can lead to laminitis. Introducing horses to spring pasture gradually will reduce the chance of laminitis. Depending on the individual horse, begin with 1-2 hours per day grazing and then gradually increase grazing time over two weeks to full-time grazing.

To maximize pasture use and nutrient availability, a number of management techniques can be followed. The length of time horses are maintained on pasture should be limited by rotational grazing or limit grazing. Limit grazing is limiting the amount of time a horse has access to a pasture. If adequate quantities of forage are available, a horse at maintenance can meet its dietary nutrient requirements with 4-5 hours of grazing.

It is very common to use electric fences to set up a rotational grazing system for horses. A rotational grazing system of three or four pastures is suitable for horses. Each pasture should be large enough to allow all the forage produced on it to be grazed in 7-14 days. In general, begin grazing short forage plants (bluegrass, perennial ryegrass) at 4-6 inches and tall forage plants (orchardgrass, timothy, smooth bromegrass) at 8-10 inches. Plants should be grazed to a height not less than two inches tall. If the pasture cannot be grazed to the recommended height, it should be mowed or made into hay. Following the 7-14 day grazing period, the pasture should have about a month's rest for forage regrowth before horses are rotated back.

Stocking rate will determine the number of days a pasture can be used. General recommendations for stocking rates per acre are difficult to give because of the variation among forage species and forage density. In general, two acres of legume and grass pasture with good management and growing conditions can provide most of the nutrients for one horse during the grazing season. With good rainfall or irrigation, less acreage may be required. When pasture productivity is poor and in drought periods, 3-5 acres of pasture per horse may be required. If the stocking rate is not high enough, more spot grazing will occur and the clipping of mature grasses will be necessary.

A sacrifice paddock is an area of pasture where grazing animals may graze and be fed supplemental feeds during inclement weather to protect the remainder of the pasture. Sacrifice paddocks or dry lots are often needed to properly manage horse pastures. During pasture establishment, poor weather conditions (excessive rain or drought), and in high traffic areas, a sacrifice paddock can protect pastures from damage. This is especially important for horses kept on small acreages.

Additional management techniques frequently used with horse pastures include breaking up manure piles by dragging a chain link or spike tooth harrow over the pasture, and alternating or mixing cattle and horses because cattle will eat more of the mature grass that horses avoid. Horse pastures should be free of pits, holes, stumps, and other hazards. Chewing on trees is also a common problem with horses. Wrap trees with close-knit, wire fencing.

Productive horse pastures require careful attention to forage supply and animal needs. Photo by Denise Schwab.

Animal grazing efficiency

If forage is too tall or too short, animals will be unable to consume enough during the time they will graze each day to meet their nutritional needs. Grazing animals cannot wholly compensate for inefficient bite size by grazing more hours during the day. Cattle graze by bringing in forage with their tongue and tearing or shearing it off with the teeth on their lower jaw. The most efficient forage height for a cow to graze is from 4-10 inches. It is difficult for them to get sufficient bites if forage is shorter, and it requires much more time for them to get longer forage into a form that they can swallow. Horses have both upper and lower teeth and graze by nipping forage.

Forage intake by grazing cattle will be reduced if the pasture is less than four inches tall. Photo by Matthew Haan.

Fences and rotational grazing put the manager in control of the grazing animals and help to ensure uniform pasture use. Having paddocks small enough so that 50 percent of the forage is eaten in six days or less can limit spot grazing. However, grass-fed beef and dairy cows will have to be moved much more frequently. Photo by Samantha Jamison.

Sheep use upper lips and lower teeth to graze nearly as close to the ground as do horses. Horses and sheep can both eat shorter forage more efficiently than can cattle, and their most efficient forage height for grazing is 2-6 inches. It is difficult for them to get sufficient bites if forage is very short. Sheep and horses also have more difficulty grazing forage that is much taller than their optimum.

Overgrazing and pattern grazing

Grazing animals, if given the opportunity, will eat selectively, choosing the plants and plant parts they like. Once grazed, pasture plants begin to regrow within a few days. If animals remain in that pasture, they have the opportunity to regraze the young, leafy regrowth. If the plant is regrazed before it has a chance to rebuild carbohydrate reserves, its recovery will be slowed greatly, a condition called overgrazing (See Chapter 1, "Understanding Growth and Development of Forage Plants"). Because of the selectivity and preferred grazing habits of animals, overgrazing is a plant-by-plant condition. This happens constantly in continuously stocked pastures, and often leads to overgrazing of most of the plants in the pasture during parts of the grazing season. To avoid overgrazing and to prevent the animals from "taking the second bite," the general management recommendation is to not let animals graze in the same paddock or pasture for more than five or six days, with the ideal being three or less days for beef cows and sheep and one or less days for grass-fed beef or dairy cows requiring consistent nutrition. Using this rule, there is some degree of regrazing or overgrazing of plants in rotational systems where animals stay in a particular paddock for more than six days.

Sheep and horse pastures nearly always show pattern grazing of very closely grazed areas and nearby areas where forage is hardly grazed at all. Although considered nonselective grazers, cattle will also pattern graze if stocked at low densities. It is difficult to prevent livestock from pattern grazing, particularly in continuously stocked pastures. The only solution to pattern grazing is to use rotational grazing of smaller paddocks in the pasture. Ungrazed areas need to be mowed to maintain vegetative growth so that less grazing selection occurs.

The plant heights in pastures stocked at moderate densities will be irregular. This is not necessarily bad. Some forage species tolerate closer grazing than others. Kentucky bluegrass, orchardgrass, and white clover are generally more suitable for continuous grazing settings and often persist as patches in many pastures and as the only remaining species in many continuously grazed sheep and horse pastures.

Estimate or measure several areas in the pasture to determine the average height of vegetation when making management or move decisions. A frequent approach used by rotational grazing managers is to estimate or measure the average height of the pasture when animals begin grazing a paddock and move the animals out of that paddock when the forage height is half its original height at the start of the graze period. This is commonly referred to as the "take half, leave half" approach. See Chapter 4, "Pasture Productivity, Measuring Forage Heights, and Techniques for Estimating Forage Quantity" for methods to measure forage height.

Grouping by nutrient needs

Management groups are groupings of animals that because of age, nutritional needs, or reproductive condition should be handled as separate groups. Some examples are dry cows versus lactating cows, and first-calf heifers (who should be serviced by a smaller bull) versus mature cows. Nutrient requirements are the major difference among management groups. These different management groups ideally can be grazed in different areas or can use leader-follower systems. For example, place first-calf heifers on the most productive pasture and mature cows on poorer pasture. Leader-follower examples would include having nursing cows following growing cattle; dry pregnant fall-calving cows following nursing spring-calving cows, or dry ewes following nursing cows through a paddock system.

Reproduction

Rotational grazing systems can improve reproductive performance. In many cases, reproductive rates will improve because of closer association between males and females. If pastures aren't excessively stocked, cows should have better body condition and nutritional status and, therefore, will have earlier rebreeding dates and a better likelihood of staying on a 12-month calving interval. The use of natural service works well. However, a single-wire electric fence separating bulls under pasture breeding situations may not be adequate. Where artificial insemination is used, it is important that the fencing system be designed to permit easy animal movement to a centralized chute for insemination during the breeding season.

Training to electric fences

Electric fences may be a new experience for individuals or groups of animals and are psychological, not physical barriers. Sudden electrical shocks may send an animal through the fence, separating it from the group or breaking the fence, allowing the entire herd to escape. Avoid a situation where animals unfamiliar with electric fences (newly purchased animals) are first introduced to an electric fence in an open pasture setting. It is more practical to hold newly purchased animals in a pen or lot for a few days where an electric fence is present (and working well) to permit the animals to become accustomed to and respectful of the fence while in the more controlled environment.

Because an electric fence is a psychological barrier and not a physical barrier, cattle unfamiliar to electric fence should be introduced to an operational electric fence in a smaller lot. Photo by Samantha Jamison.

Medication and routine handling

Immunizations, worming, and occasional treatment for injuries, eye infections, etc. are a part of good animal care. When planning a grazing enterprise, whether using one or many pastures, provide adequate facilities for animal confinement and treatment. Each producer will have their own set of objectives, limitations, and ideas for the best handling facility.

Shade

The value of providing shade for grazing animals has been a point of contention between graziers for decades. On the one hand, several problems are related to shade. Animals congregating under shade trees are not likely grazing. They can trample the forage underfoot and nearby, either destroying it or lessening forage quality. Furthermore, manure is not as well dispersed in the pasture, reducing distribution of nutrients. Instead, the concentrations of manure and urine damage forage and attract flies. If the shade is concentrated near streams or ponds, the bare ground and manure will increase sediment, nutrient, and pathogen loading of water resources.

Providing adequate shade will reduce heat stress in grazing cattle while improving distribution across pastures. Photo A by Erika Lundy and photo B by Matthew Haan.

On the other hand, extreme heat and humidity has resulted in impaired reproduction and death in grazing cattle without shade. These problems are aggravated by black-hided cattle, grazing endophyte-infected tall fescue, and changing climate. Therefore, in addition to providing comfort for grazing animals, shade may increase productivity and improve distribution of grazing cattle to enhance the uniformity of grazing and reduce damage of water resources.

There is little research evaluating the effects of providing shade on the productivity of grazing cattle in the Midwest. It is clear that it's inadvisable to have only one shade tree per pasture. Evidence from feedlot cattle indicates that a minimum of 35 square feet are required per cow to prevent heat stress. Shade should be distributed across pastures by having multiple sources or by using mobile shade structures to improve uniformity of grazing and prevent damage to streams and ponds. When weather forecasts indicate heat stress is likely, producers should rotate to paddocks with good shade availability or possibly allowing animals access to buildings.

Watering requirements

Water is often the single greatest factor restricting the development of more efficient grazing systems. Movement of grazing animals to and from water is unproductive time, often increases soil erosion along animal trails and lanes, and contributes to poor manure distribution. Water must be available, and it needs to be as clean and fresh as possible. There are several undocumented observations from producers that animal production is increased when the herd is switched from pond water to well water or a rural water delivery system. Be creative and open-minded in evaluating alternatives for providing water to the grazing herd. These are seldom easy and can be costly. The NRCS may have local cost share programs to install water improvements on grazing lands.

When calculating the actual water requirement of grazing animals, remember that it will not be uniform throughout the year. Lactating animals have higher water requirements than other classes of animals.

Environmental stress, particularly high temperature and humidity, can also drastically increase the water requirements of grazing animals. A general rule for planning water resource needs is that animals consume roughly three times the amount of water per day as they do dry matter. Using this guideline for a standard animal unit (one 1,000-lb cow with or without calf consuming 26 lb of dry matter per day), estimates show that the animal is drinking 78 lb of water, or roughly 10 gallons daily. However, animals under heat stress and during lactation may require two to three times this average daily water need. Table 2.5 provides comparable water use requirements for other classes of livestock. As fresh, lush grass may contain as much as 80 percent water, a portion of the total water requirement can be met by forage. However, as forage matures and temperatures increase, the moisture concentration of the forage decreases.

Table 2.5. Daily water consumption by livestock[1].

Livestock	Moderate temperatures	Hot weather
Beef cattle		
Growing	5-8	10-15
Dry, pregnant cows	8-12	-
Lactating cows	15-20	16-22
Dairy cattle		
Lactating	20-33	26-42
Sheep	2-3	3-4
Horses		
Idle	5-10	10-14
Working	9-12	20-25

[1] Approximate amounts in gallons per day (gpd)

Water quality can affect water consumption, health, and productivity of grazing livestock. Levels of total dissolved solids above 3,000 mg/L may reduce water consumption and levels above 5,000 mg/L may impair health, particularly in pregnant and lactating animals. Levels of nitrate-nitrogen in water above 20 mg/L may be harmful to cattle and sheep, particularly if grazing feeds high in nitrate. Horses may be able to tolerate higher levels of nitrates than ruminants, but levels have not been established. Levels of sulfur in excess of 500 mg/L in calves and 1,000 mg/L in adult cattle are toxic, particularly if consuming feeds like brassicas or distillers grains that contain high concentrations of sulfur. Even at lower concentrations, sulfur may reduce absorption of copper. Although water in ponds and streams may contain a number of protozoa (eg. Cryptosporidum, Giardia), bacteria (fecal coliforms, Escherichia coli O157:H7), and viruses (Coronavirus, Rotavirus), these organisms do not seem to affect health of adult livestock. However, ingestion of these organisms may cause diarrhea in young livestock. Water in ponds and streams covered with blue-green algae may cause death in livestock consuming it.

Grazing management research indicates that animals should be no farther than 800 feet from water for most efficient grazing in eastern and Midwestern pastures. There are basically two approaches to the water dilemma. One is to let the animals move to water. The second and more desirable approach is to move the water to the animals. There are many technologies for delivering water to grazing animals (See Chapter 3, "Watering Systems for Grazing Livestock"). The watering system must be designed to deliver water at a rate that exceeds the requirements of the grazing herd at peak water consumption. The water system must be designed to provide a minimum refill rate of 0.5 gal/minute/animal.

Information on water pressure, pipe sizing, and flow rates needed to match water delivery systems with animal requirements is included in MidWest Plan Service publication ***Private Water Systems*** (MWPS-14) (**https://www-mwps.sws.iastate.edu/catalog/water-septic-systems/private-water-systems-handbook**).

Water delivery systems with pipe buried below the frost line can permit year-long grazing opportunities. Systems with a hose or pipe on the soil surface restricts water delivery to the frost-free season and requires more care in placement to prevent damage to components and heating of water.

Producers should take advantage of the more experienced graziers in their area to observe the methods they are using to deliver water. Attend pasture walks and field days, or contact an ISU Extension and Outreach specialist to inquire about educational activities available.

Stream management in pastures

One area of concern in grazing management is the impact of grazing on water quality in surface water resources. Water quality of ponds, streams, and rivers is impaired by loading with sediment, phosphorus, nitrogen, and microorganisms and physical alterations reducing their depth while increasing their width and water temperatures. Although these changes are partially the result of natural processes like stream flow, freeze-thaw activity, and fecal deposition by wild animals, improper management of grazing animals accelerates this damage. Overgrazing by stocking at excessive animal densities for long periods with little or no time for recovery decreases vegetation while increasing bare, compacted soils which promote soil erosion and manure nutrient runoff in heavy rains and spring snow melt.

The key to preventing damage of surface water resources is maintaining a minimum forage height of four inches within riparian areas (the area in and near ponds, streams, and rivers) by controlling the timing, length, intensity, and frequency of grazing. If there is adequate forage outside riparian areas, the proportion of time grazing cattle spend in and near surface water sources is generally low even at high temperatures and may be further controlled by numerous methods in large pastures and rangeland. However, in small, narrow pastures frequently found in the Corn Belt and eastern states, grazing livestock have less opportunity to be outside riparian areas and more restrictive methods of controlling grazing may be needed to protect water resources.

Complete exclusion of grazing animals from streams and rivers within fenced buffers may seem to be the most effective method to improve stream qualities. However, the winding nature of Midwestern streams and rivers, and the need for the water source, often makes complete exclusion impractical. Frequent flooding of streams and rivers may require repeated repair of buffer fences and water gaps. Furthermore, brush and trees that accumulate in ungrazed areas may eventually shade out desirable grass cover, increasing soil erosion and making fishing and other recreational activities difficult. Full or partial exclusion might be possible if an alternative water source is provided or if stabilized water access sites are used. For more information on vegetative buffers and stabilized access sites, see the ISU Extension and Outreach publications Streamside Buffers—A Guide to Managing Pasture Water (IBC 804) (**https://store.extension.iastate.edu/Product/12801**) and Stabilized Stream and Pond Access Sites—A Guide to Managing Pasture Water (IBC 802) (**https://store.extension.iastate.edu/Product/12799**).

Limiting cattle access to streams within riparian paddocks as part of a rotational grazing system allows for the use of forage while inhibiting development of brush along the stream. Grazing to a forage height no shorter than four inches for periods of four days maximum in each rotation provides stream protection comparable to vegetative buffers. Using rotational grazing to maintain a minimum forage height of four inches in other areas of pastures will further reduce risks of damage to streams by reducing precipitation runoff and soil erosion.

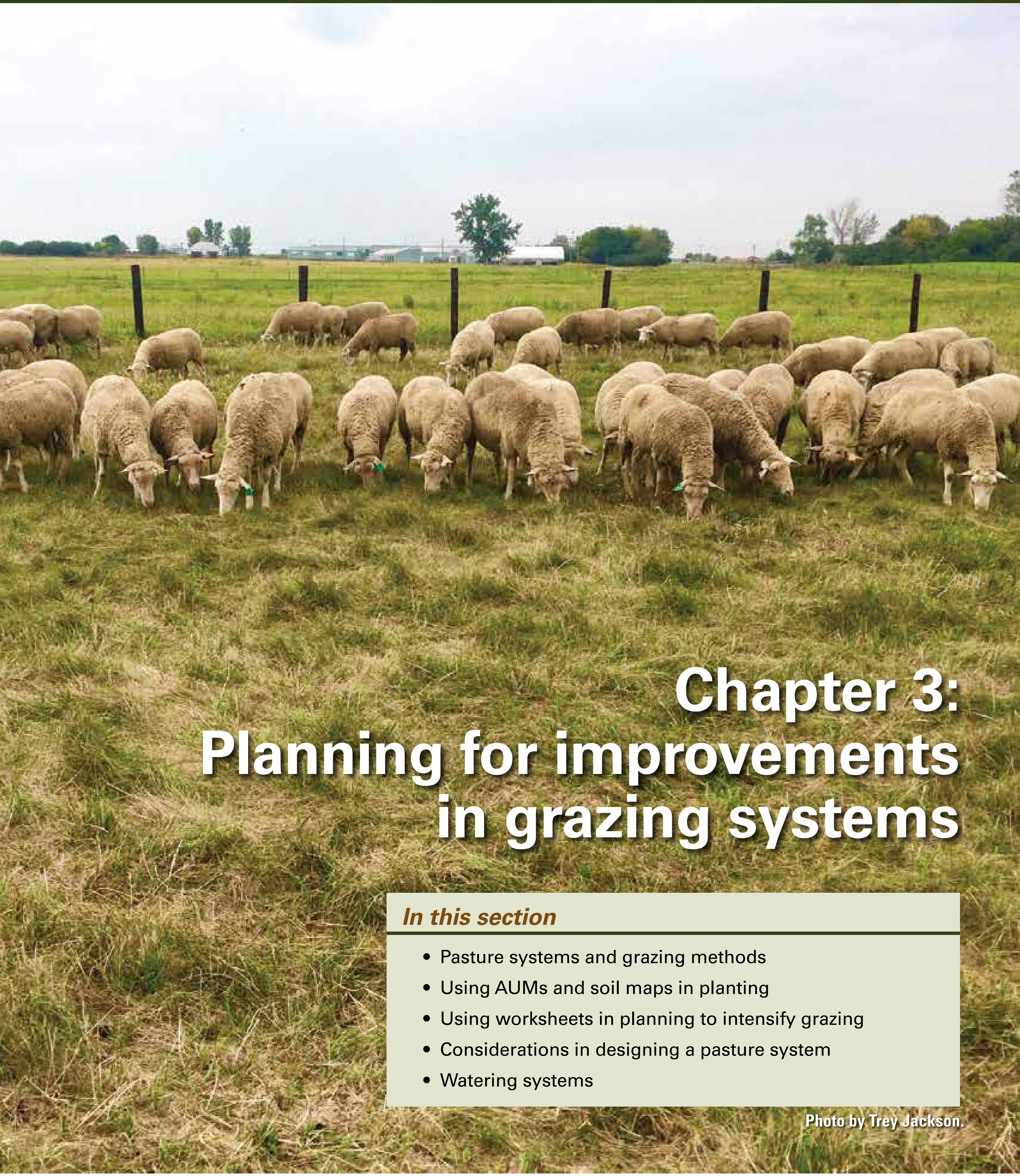
Off-stream water sources are commonly used to reduce the amount of time cattle are in riparian areas in western rangelands. However, the effects of off-stream water on distribution of grazing cattle are inconsistent in Midwestern and eastern pastures that are continuously grazed, being most effective at temperature-humidity indices less than 72°F. But providing off-stream water does provide a key component for a rotational grazing system.

Off-stream nutritional supplementation has been effective in reducing the amount of time cattle are in streams and rivers in western rangelands particularly when used with daily herding. Little research has investigated use of this strategy to control cattle location in Midwestern pastures. However, as supplementation sites usually have bare soil and high concentrations of manure and wasted feed, it is essential to place supplementation sites at locations far away from surface water resources to prevent loading with eroded soil, nutrients, and bacteria.

Because grazing livestock will use shade to prevent heat stress at temperatures greater than 72°F, shade may be used to alter distribution of grazing livestock. Unfortunately, when most of the shade within a pasture is along a stream or river, cattle will congregate near these water sources particularly in small pastures. However, if shade is provided off-stream in pastures large enough to allow cattle to freely range, cattle will spend more time away from streams for access to comforting breezes and to avoid insects.

Stabilized access sites may be used to provide water for grazing cattle from streams protected by buffers. Photo by James Russell.

Limiting grazing within a riparian paddock to a forage height of four inches for a period no longer than four days per rotation provides protection to streams similar to ungrazed buffers. Photo by James Russell.



Chapter 3: Planning for improvements in grazing systems

In this section

- Pasture systems and grazing methods
- Using AUMs and soil maps in planting
- Using worksheets in planning to intensify grazing
- Considerations in designing a pasture system
- Watering systems

Photo by Trey Jackson.

Pasture systems and grazing methods

Grazing management is the human manipulation of grazing livestock and pasture resources with the primary goal of producing a profit while maintaining productivity of the animals and pasture, along with the long-term stability of the site. Grazing management entails more than producing maximum animal product from pasture. It is more than fertilizing and controlling weeds; more than building fences and moving livestock from pasture to pasture. Grazing management integrates the use of many practices to maintain long-term productivity of the system. Simultaneously, grazing management provides the disturbance necessary for maintaining grassland health to enhance the quality of the air and soil resources while enriching the habitat of vertebrate and invertebrate wildlife.

There are good pasture managers who fertilize, control weeds, harrow, reseed, and carefully control the pasture grazing, but who often lose money because of faulty livestock management skills and costly extras. Likewise, there are excellent livestock producers who pay little attention to their pastures. Both types are likely to be unsuccessful overall because of excessive costs or major omissions in some part of the enterprise.

The approaches, styles, and successes of grazing management are as varied as the individual people involved in grazing enterprises. An individual's management is influenced by the land, animal, and capital resources, as well as by their goals, skills, mental attitude, and ability to adapt to the daily challenges of the enterprise.

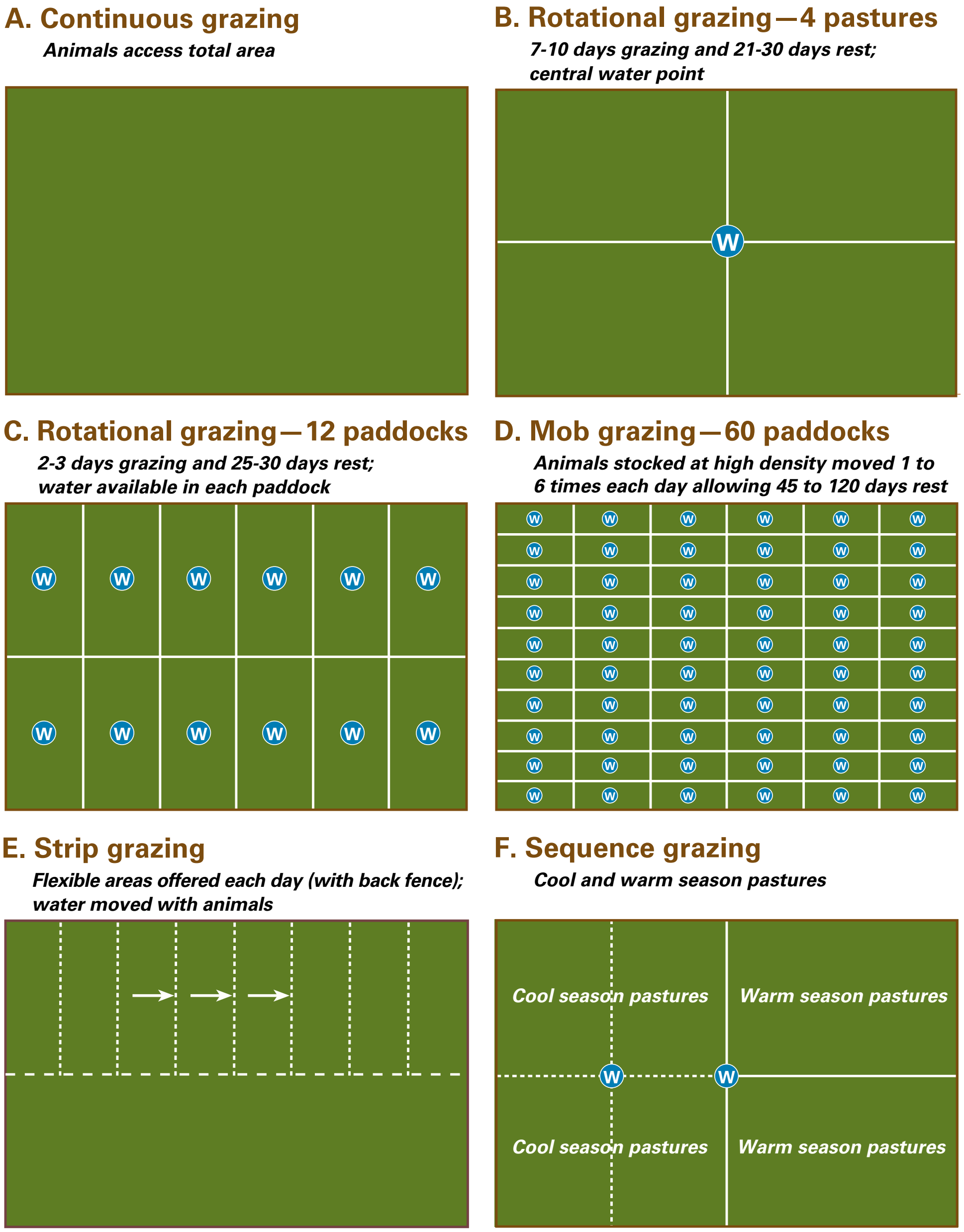


Figure 3.1. Commonly used grazing methods

It is difficult to separate grazing management from the grazing system or method being used. A pasture system in its simplest form includes how the pasture area is arranged and the general plan for handling the animals. Each grazing method has inherent advantages and disadvantages. Some grazing systems are simple but rigid and inflexible, limiting the manager's ability to adapt to even the normal problems associated with seasonal change, whereas other pasture systems are designed to be much more adaptable even when major challenges arise, such as a drought.

Continuous grazing or continuous stocking

The simplicity of a continuous grazing system comes at a cost – highly variable forage supply and quality, increased weed pressure, and risk of soil erosion often accompany continuous grazing. Photo by Denise Schwab.

With continuous grazing, more properly called continuous stocking, a group of animals have continual access to an area of land over a set time period. If the number of animals remains the same, this method is called set stocking.

Continuous stocking is one of the most common grazing methods. In the Midwest, a producer typically turns a group of animals from the winter feeding area onto the pasture to graze from April through autumn. A one pasture grazing system requires the least amount of capital investment and management because of its simplicity. But unrestricted access allows the animals to be highly selective during much of the grazing season, creating areas of overgrazed forage and areas of underused and wasted forage. Loss of desirable forage species, the invasion of weeds, upland and streambank erosion, and the nonuniform distribution of animal manure frequently are problems in continuously stocked pastures. Continuous stocking can be a reasonably successful grazing method if the stocking rate is set to the productivity level of the site during average or better-than-average growing seasons. Short-term, midsummer forage deficits will be common, with severe deficits in drier than average years. Producers may feed hay on the pasture, wean calves early, or move animals to an emergency pasture area to deal with forage shortages.

Rotational grazing

Rotational grazing, or rotational stocking, is a method that uses recurring periods of grazing and rest among two or more paddocks or pastures for a set time period.

A common rotational grazing system has 2-4 pastures, with animals grazing a pasture or paddock for at least seven days before they are moved to the next pasture. This allows a rest or recovery period of 10-30 days during each cycle. With rotational grazing management, pasture plants benefit from rest with more growth and vigor, animals gain from a more stable and more nutritious forage supply, and manure is spread more uniformly. When several pastures are used, each can be seeded or improved to supply different forage species for a better distribution of the forage supply over the grazing season. An example might be three pastures of cool-season grasses and one warm-season grass pasture.

Rotational grazing requires better records for integrating pasture resources and animal needs. Pasture plants benefit from the rest and animals from the more stable and nutritious forage supply associated with rotational grazing. Photo by Erika Lundy.

Rotational grazing requires more fence and slightly more labor than continuous grazing. Rotation through several pastures is still a relatively rigid system that does not compensate for the wide variations in forage growth during the growing season and from year to year. Forage deficits can still be a management concern. Rotational grazing or a well-balanced continuous stocking system can be successful, but rotational grazing provides for more productive and stable forage conditions and can reduce the need to use costly stored feed.

As a few more fences and paddocks are added to a simple rotational grazing system, it becomes what many refer to as intensive rotational grazing. Just where the transition occurs can be debated. Often a system of six or more pastures or paddocks in the grazing system moves it into the intensive category. A total of 8-12 paddocks for beef cow-calf herds or even up to 50-60 paddocks for dairy cows is not uncommon for experienced rotational graziers. Grazing management can begin being exercised with an increased number of paddocks. Extended recovery periods of up to 35 days will allow biennial legumes such as red clover and birdsfoot trefoil to reseed. Livestock will be less selective in smaller paddocks and consume the available forage more uniformly in a shorter period of time. The shorter grazing period is followed by a longer rest period, benefiting the vigor and productivity of the pasture as a whole. Improved seasonal production can often support several more animals on the same acreage of pasture. Damage to streams can be minimized by building riparian paddocks along them and managing grazing to maintain a minimum forage height of four inches.

This higher level of productivity requires higher capital inputs for fencing and water, and a greater commitment of labor and management time.

In managing a rotational system, an important distinction must be made between rotating animals through paddocks every three or four days and basing animal movement on the growth and recovery of the forage and the nutritional needs of the animals. Rigidly scheduled moves don't adjust for different paddock size and productivity. Another common result of a rigid rotation is that the forage growth is often so fast in the spring in the upper Midwest that up to a third of the paddocks can get ahead of the animals. If animals stay too long in the earliest paddocks grazed, the forage in other paddocks can become stemmy, unpalatable, and less digestible before those paddocks are grazed. As pasture regrowth slows during the warm summer months, a manager on a rigid move schedule will soon find that the paddock is out of grass one or two days sooner than the schedule calls for. The common reaction is to then move animals a day sooner, speeding up the rotation and often leading to moves every two days, then every day, until the pasture is completely out of grass.

Management intensive grazing

Management intensive grazing or MIG is a variation on the rotational grazing system that relies on dividing the pastures into numerous paddocks, enabling frequent (sometimes daily) rotation of animals among the paddocks. A key difference between rotational grazing through two or more pastures or paddocks and management intensive systems is that the latter emphasizes more management of forage consumption, quality, and regrowth. The successful manager takes the time necessary to study each paddock to assess how much forage the animals are using (or wasting) during the grazing period to determine whether the forage nutritive quality is sufficient for the expected performance needs of the livestock and, more importantly, to consider how rapidly the past and next paddocks are recovering.

More paddocks allow more flexibility for the manager. Paddocks are grazed on the basis of their growth and quality, and not always in the same order. If it appears some paddocks are growing (plants maturing) faster than the rate they can be grazed, decisions can be made to harvest the most mature paddock or paddocks for hay to allow better control of grazing in the remaining paddocks. The regrowth from harvested paddocks can be grazed later as needed. During periods of slow growth, some paddocks may be skipped for a few extra days or weeks until they are again suitable for grazing. With regular monitoring of the growth and recovery rate of paddocks in the entire grazing system, the manager can make decisions about the need for supplemental feeding, reducing the number of animals, or weaning young animals early to reduce the demand on a diminishing forage supply and avoid undue stress on the pasture plants. See Chapter 5, "Using several forages through the grazing season," to learn how grazing managers can deal with a variable forage growth cycle.

The key to a well-run management intensive grazing system is flexibility. Flexibility can be built into the system with a paddock design allowing varying amounts of temporary fencing, with portable water supply equipment, and by arranging gates, lanes, and livestock handling facilities to best accommodate occasional hay harvest and supplemental feeding. It is recommended that farmers meet with grazing advisors from Iowa State University Extension and Outreach and the U.S. Department of Agriculture Natural Resources Conservation Service (NRCS), as well as private consultants and other producers, when thinking about developing a management intensive grazing system to gather as many ideas and suggestions about resources and goals as possible. The most conservative approach is to begin with a minimal number of paddocks (5-8) to gain some experience with the types of observations and daily decisions necessary to make the enterprise successful. When developing the initial pasture layout, carefully consider water access and gate and fence placement with the idea that additional subdivisions and paddocks will eventually be added. Producers often determine that more paddocks allow more control over forage management, even in the first year of grazing the system. Other sections in this publication discuss guidelines for paddock layout, water supply, and coordinating a managed summer grazing system with fall and winter grazing opportunities.

Seek as much advise as possible when considering implementation of a management intensive grazing system. Photo by Erika Lundy.

Advantages and disadvantages of management intensive grazing

Advantages

- Increases forage production and quality.
- Improves diversity of forage species.
- Permits harvesting of excess forage in spring.
- Permits stockpiling of forage to extend grazing season.
- Maintains benefits from pasture improvement efforts such as legume establishment.
- Limits selectivity of grazing animals.
- Minimizes damage to streams, rivers, and ponds.
- Improves soil health.
- Provides better manure distribution and nutrient recycling.
- Allows for frequent animal-human contact, which makes animals easier to handle and monitor.

Disadvantages

- Requires initial investments in fencing and watering equipment.
- Requires slightly greater labor commitment.
- Requires commitment to management for success.

High density or mob grazing

Mob grazing is a grazing method in which a high number (greater than 48) of small paddocks or strips are stocked at high densities (100,000-1 million pounds of livestock per acre) for short periods of time (4-24 hours) with frequent movements (1-6 times per day) and long rest periods (45-120 days).

A considerable investment in labor, fencing, and water supply is required for this type of system. Because of the very high stocking densities, the major difference between mob grazing and other forms of rotational grazing is forage removal. Where approximately half of the forage is removed per grazing cycle in a well-managed rotational grazing system, 70 percent or more of the forage is removed per grazing cycle in a mob grazing system. Most forage that isn't consumed in a mob grazing system is trampled into the soil. This high removal and trampling rate reduces the amount of photosynthetic leaf area and is the reason that longer rest periods are needed for plant recovery. Flexibility in the movement and size of paddocks is necessary to prevent soil damage during periods of excessive precipitation.

While some claims on the benefits of mob grazing have been made in recent years, research results have demonstrated that season-long mob grazing:

- Reduces seasonal forage production because of the loss of leaf photosynthetic capacity resulting from excessive forage removal and trampling, requiring long rest periods for plant recovery.
- Does not affect or decreases individual animal performance because of increased animal activity and susceptibility to heat stress.
- Does not affect or decreases animal production per acre because of reduced individual animal performance and the lower seasonal stocking rate required to compensate for the long rest periods required for the forage plants to recover.
- Does not affect or lower soil organic matter in comparison to well-managed rotational grazing systems.
- Does not affect or lower soil compaction because of extended rest periods.
- Is not an effective control for weeds such as thistles.

While these results do not support the season-long use of mob grazing to promote animal production or soil health, mob grazing may be strategically used as a pasture management tool for several purposes.

Mob grazing can be used to increase the proportion of legume species in pastures by reducing cool-season grass competition in early to mid-spring. A single episode of mob grazing is particularly effective in establishing improved forage species if done during wet conditions in early spring when relying on the soil seedbank or in mid-spring after legume seed has been sown by frost-seeding or interseeding earlier. Similarly, by inhibiting cool-season grass competition, a single mob-grazing event can be used to increase bare soil, legumes, and forbs that create desirable habitat for game birds (pheasants, bobwhite quails, and turkeys) and pollinators in lands enrolled in the Conservation Reserve Program (CRP) and other long-term grasslands.

A single mob-grazing event may be used to increase biodiversity of grasslands to enhance pasture quality or wildlife habitat. Photo A by Margaret Chamas and photo B by James Russell.

Mob grazing can also be used to harvest forage in early August to initiate stockpiling of forage for winter grazing. Because 2-2.5 acres of stockpiled forage per cow are needed during winter, increased numbers of livestock such as stocker steers or growing heifers would temporarily be needed to enable mob grazing these acres in a short period of time.

Strip grazing

Just as reducing the paddock size improves the uniformity of pasture plant use, strip grazing can be used to make livestock eat the desired amount of forage by careful rationing. In strip grazing, a temporary fence (usually electric) is used to portion out only the amount of forage that the animals can eat in a particular short period of time. The strips can be arranged across an entire pasture or within paddocks of rotationally grazed pastures. Strip grazing helps prevent bloat in pastures containing a

Strip grazing can extend winter grazing by controlling selective consumption and trampling for corn stalks. Photo by Dan Loy.

high proportion of legumes because it forces animals to eat both the leaves and stems. Dairy producers who want their cows to have fresh, leafy, high-quality forage at all times may use temporary fencing to ration only a day's or even a half day's forage supply in a strip grazing system that may be the equivalent of a 50 or 60 paddock rotation.

Warm-season grasses are an alternative for summer grazing. Photo by Ken Moore.

Strip grazing can be used to make a herd or flock eat saved (stockpiled) pasture forage in the winter. Because more of the fibrous stems and grass leaf sheaths are being eaten in stockpiled grazing, a much higher proportion of the available forage is consumed (higher percentage of use). Dry and gestating animals with very low maintenance requirements are the most appropriate kind of animals for strip grazing of lower-quality stockpiled forage. But strip grazing of stockpiled forage can be used for lactating fall-calving cows. Strip grazing is used effectively in the Midwest to reduce the selective consumption and trampling waste often seen in grazing stockpiled forages and crop residues in the fall or winter.

Sequence grazing

Sequence grazing is the sequential use of two or more pastures that differ significantly in forage composition. Sequence grazing takes advantage of differences among forage species and species combinations to extend the grazing season, enhance forage quality, or achieve some other management objective. Examples of sequence grazing would be a cool-season grass/warm-season grass pasture system, or including the grazing of the second or third growth of a hay field as a summer pasture. Different grazing methods, such as rotational grazing or strip grazing, could be used in one or all of the differing forage types.

An example of a leader-follower system would be having dry, pregnant fall-calving cows following lactating spring-calving cows. Photo by James Russell.

Leader-follower grazing

Leader-follower (or first-last) grazing occurs when the first group of animals (those with the highest nutritional needs) has first access to the best forage in each new paddock, followed by a second group of animals with lower nutritional needs who graze the less desirable forage remaining in the paddock. One example of a leader-follower system would be having dry, pregnant fall-calving cows following lactating spring-calving cows. In the leader-follower method, animals can be different groups of the same species or groups of different species.

Variable stocking

Variable stocking is the addition or removal of a few animals from the main group to better match the animal use to the varying forage supply. It can be used with any of the aforementioned systems. An example would be to graze some stocker animals with a cow-calf herd during the first few months of spring to more uniformly use the excess spring flush of forage, then move the stocker animals to the feedlot. Another example would be to co-graze heavy and light groups of stocker animals for the first half of the grazing season, then move the heavy group to the feedlot as forage availability declines.

Managing grazing for environmental benefits

Grazing livestock are an integral part of developing and maintaining grassland ecosystems and the services grasslands provide. Grazing affects features of grassland ecosystems including botanical composition, soil characteristics and hydrology, nutrient flows, and many others. Beyond increasing yields and quality of forage for livestock, grazing has the potential to enhance grassland ecosystem services such as promoting diversity of plant and wildlife communities, sequestering atmospheric carbon, enhancing soil health, and increasing water infiltration and holding capacity. While grazing practices can simultaneously enhance a number of these services, the optimal conditions for other services may vary. For example, delaying grazing until after the nesting season of gamebirds will likely result in lower quality forage from cool-season grasses for grazing livestock. Furthermore, forage species and soil pH, fertility, and moisture will also have considerable effects on ecosystem services. For these reasons, producers need to target the type and intensity of the grazing practice used with other pasture management practices and climatic conditions to achieve the specific production and ecosystem goals desired.

Rotational grazing can increase the presence of legume species in pastures if soil pH and fertility are appropriate. Photo by Erika Lundy.

Grazing livestock in grassland ecosystems promotes a diverse plant community by creating disturbances at the soil surface. By doing so, annual plants are allowed to germinate, followed by succession to legumes and other forbs, depending on the seed present or applied, as well as soil moisture, pH, and fertility. This soil disturbance generally requires a short-term increase in stocking density by methods such as high density or mob grazing. However, a well-managed rotational grazing system will often enhance the proportion of legume or warm-season grass species in pastures by reducing the competition of the dominant cool-season grass plants for moisture, nutrients, and sunlight while also limiting forage selection by grazing livestock. The timing and level of disturbance will likely influence the species which increases or decreases in population. The greater plant diversity will increase forage productivity by advancing nutrient uptake from different regions of the soil profile and providing synergistic relationships between plant species as legumes fixing atmospheric nitrogen into the soil which may be used by grass species. The increased plant diversity within grasslands likely has its greatest effect during periods of climate stress by providing resilience against drought, insects, and other stressors. Furthermore, enhanced plant diversity also plays a key role in providing other grassland ecosystem services like carbon sequestration, soil health, and habitat for vertebrate (game birds) and invertebrate (pollinating insects) wildlife.

Appropriate integration of moderating stocking rate, rotational grazing, irrigation, fertilization, and legume establishment may increase soil organic matter. Photo by Joe Sellers.

Grazing management, along with other practices including irrigation, fertilization, and establishment of legume species, promotes the development of dense plant root systems and soil biota in grasslands necessary for carbon sequestration as organic matter from soil aggregates and plant root exudates. The increased organic matter is also enhanced by the rate at which plant available nutrients are returned to the soil. Feces and urine from grazing animals degrade at a faster rate than plant litter, increasing the rate of nutrient cycling through grazed grassland ecosystems. Additionally, in grass species adapted to grazing, the residue of plants previously grazed decomposes more rapidly than plant litter not exposed to grazing. Although the major improvements in soil organic matter are a result of moderating the stocking rates so grasslands are neither under- nor over-grazed, implementing a rotational grazing system will increase soil organic matter in pastures in Midwestern and eastern states, provided those soils are not already saturated with carbon. The increase in soil carbon and organic matter has local, regional, and global benefits. With greater organic matter, forage productivity will likely increase due to greater soil moisture and nutrient availability. Regionally, increased water infiltration associated with increased soil organic matter will reduce flooding and transport of sediment, nutrients, and pathogenic microorganisms in streams and rivers to reservoirs or coastal waters like the Gulf of Mexico. Globally, the carbon sequestration associated with increased organic matter in grazed grasslands provides a major deterrent against the global climate variability that will adversely affect agriculture and society in this century.

Wildlife habitat in grazing systems

Landscape heterogeneity necessary for wildlife habitat may be created through appropriate grazing management. Photo by Adam Janke.

Iowa's landscape was once over 80 percent prairie, maintained by grazing bison and elk and frequent fires set by humans or lightning. Much of Iowa's native wildlife became dependent on prairies for survival and reproduction. Iowa's landscape has been gradually transformed from a sea of perennial grasses and wildflowers to annual row-crop production, which presents challenges for many native wildlife species that rely on prairies. As a result, remaining pastures and other grassy areas play a vital role in conserving prairie wildlife, enriching the lives of rural residents with the sights and sounds of meadowlarks, northern bobwhites, bobolinks, and many others. The following information explores the needs of grassland wildlife and offers recommendations for ways to incorporate wildlife habitat into a grazing operation to ensure the sights and sounds of prairie wildlife will be around for generations to come.

Considerations for wildlife habitat on and around pastures can be broken into two broad categories. First are actions that can be taken within the pasture or grazing system to promote wildlife habitat, focusing specifically on the structure and composition of grasses and wildflower communities found in those areas. Second are actions that can be taken outside the pasture, including the field edges and along surface waters. This section will provide recommendations that could improve the quality of the pasture for wildlife, often in concert with ongoing or planned improvements in production systems or water or soil quality initiatives discussed elsewhere in this publication.

Wildlife habitat in the pasture

Rotational grazing may be managed to provide paddocks for nesting wildlife. Photo by Adam Janke.

Grassland plant communities created by the combination of fire and grazing in pre-historic prairies were far from uniform. Rather, variable intensity of grazing or exposure to fire created highly diverse landscapes, ranging from areas of intensively grazed grasses to areas with little disturbance and thus mature vegetation. This variation is called landscape heterogeneity. The key to providing wildlife habitat in modern pastures is to find ways to increase landscape heterogeneity that will maximize potential wildlife habitat. The primary components of wildlife habitat in grasslands are:

- Diversity of grasses, wildflowers, shrubs, and trees in the stand. The more diverse the stand, the greater the benefit to wildlife. A diversity of plants provides many potential food sources—nectar from flowers, insects attracted to flowers and plants, or seeds or fruits produced by plants—and creates structure that can hide wildlife, their young, and their nests from predators and weather extremes.
- Interspersion of bare ground and vegetation that allows wildlife to move around on the ground while still having overhead cover for protection from predators and weather. Dense, mature stands of grasses provide suitable habitat for fewer species than those with an interspersion of open spaces and vegetation all within a few square feet.
- Height of standing vegetation. Generally, few grassland-nesting birds will use pastures with vegetation grazed less than six inches tall for nesting, though a few species will use pastures as short as two inches.
- Density of standing vegetation, which is a product of many factors, including the height, interspersion of bare ground, and diversity of plants discussed above. Density is also impacted by the type of plants growing in the pasture and the accumulation of litter from the previous year's growth. Intermediate densities of vegetation are generally favorable, though some species, like the Henslow's sparrow prefer dense stands reminiscent of mowed grasses.

In light of these four factors that determine wildlife habitat quality in a grassland, producers can consider how a combination of practices can be tailored to create vegetation that is best-suited for wildlife inside pastures. The following practices are examples of ways to incorporate wildlife habitat considerations into a production operation.

Rotational grazing has been shown to have positive impacts on wildlife in pastures because of the diverse vegetation it creates through periods of rest, recovery, and grazing. More uniform, pasture-wide grazing strategies tend to result in more homogenous pastures, with the species in the pasture and height or density of the vegetation uniform in large areas and less attractive to wildlife. Rotational grazing can more fully utilize some forages while allowing other areas to recover and provide denser vegetation or flowering plants for wildlife. Research on grassland nesting birds has found many benefits from rotational systems, which can often complete full nesting periods between month-long rotations. Within a rotational system birds and other young wildlife, like fawning white-tailed deer, can substantially benefit from refuge areas such as paddocks not grazed during the primary breeding season from mid-May through June. Vegetation in these areas can grow taller and denser and provide important areas for young birds, deer, and other species to grow to be independent enough to escape when grazing is reintroduced later in the summer. Stockpiling forages for fall and winter grazing is another way to create habitat in a grazed system. Although stockpiling normally doesn't overlap with the primary nesting season, allowing vegetation to grow and flower during late summer and fall can provide important habitat for fall migrating birds or resident wildlife before snow accumulation makes grassland habitats unusable for most wildlife.

Incorporating paddocks or pastures of native warm-season grasses, such as Indiangrass, big-bluestem, eastern gamagrass, or switchgrass, is another opportunity to create quality wildlife habitat in a production operation. Native warm-season grasses are advantageous for wildlife because of their bunching growth strategy, which creates interspersed bare ground, and because of their delayed seasonal growth and maturation. That delayed seasonal growth and maturation relative to more common cool-season forages in pastures means the grazing window for warm-season grasses is generally later in the season, allowing for grassland nesting wildlife or other species that raise young in grasslands prior to midsummer grazing. Native warm-season grasses are also more structurally resilient during winter. If suitable residual vegetation remains after summer grazing, these areas provide important habitat during winter. Some producers report taking advantage of this winter cover in warm-season grass stands for natural cover on calving grounds as well, allowing wildlife and cattle to coexist during winter.

As discussed elsewhere in this publication, shade and natural protection from weather extremes is an important consideration in livestock production. Wildlife take advantage of natural features that create shade and windbreaks in the pasture. Trees and shrubs in the pasture provide important shelter and food sources for wildlife throughout the year and can be particularly important for some wintering wildlife such as northern bobwhite quail. The value of trees and shrubs in the pasture is higher when certain species of trees or shrubs, namely ones that produce soft fleshy fruits or nuts like oak trees, are promoted.

Wildlife habitat on the margins

The final consideration in creating or improving wildlife habitat in association with a grazing system is to think about wildlife habitat along the margins of the operation or any potential off-farm impacts of grazing practices. There are two primary factors when considering wildlife impacts of grazing systems outside the pasture. First, consider wildlife habitat along the margins of the pastures or around the farm. Odd areas, like wet spots, barn lots, or roadsides may not seem large or significant on an individual farm, but allowing them to grow flowering plants, while controlling noxious or exotic weeds, can make a real difference for many wildlife species. At a minimum, delayed mowing until August in many areas on the farm can help provide vital wildlife habitat while saving time and money for the landowner. The second consideration is to minimize potential off-farm impacts of grazing systems to surface water bodies. Practices that minimize erosion, nutrient, or bacterial enrichment of surface waters by maintaining adequate riparian forage are vital to ensuring practices in pastures don't hurt downstream wildlife. Providing upland watering sources away from flowing streams, excluding high-densities of cattle from streams with exclosures or with engineered crossing structures, or managed grazing of riparian paddocks are important practices in pastures. Additional considerations on managing water quality in surface waters is discussed in Chapter 2, "Stream management in pastures."

Set goals to direct a grazing plan

The low feeding costs associated with a grazing-based dairy enterprise may make it more profitable than conventional systems even if milk production is less. Photo by Matthew Haan.

The first step in planning improvements in a grazing system is to assess the available resources and set production goals that are measurable and specific. The goals may be production goals related to a desired rate of animal gain, level of milk production per cow, extension of the grazing season by a specified number of days, the number of animals on the same pasture area, or increasing pasture acres by incorporating grasslands managed for wildlife habitat into a grazing system. Production goals are of no value without some understanding of the economic implications of achieving that specific production goal.

Economic realities must be tied to every production goal. Be prepared to diligently collect records for measuring progress. Each marketable unit (milk, lamb, calf) comes at a cost. Be cautious when setting only "more is better" production goals as the cost of the extra production may exceed its value. It may be that, as with some successful seasonal dairy operations, producing 10-15 percent less milk at an even lower cost of production with grazing is the most profitable management goal. Economic goals in an enterprise may relate to some level of cash flow or net profitability within a specified number of months or years, or dollar sales per acre of forage land.

Goals should be realistic and attainable with the resources available. Can a pasture improvement goal be accomplished within the limitations of soil or site? Are the necessary capital and management skills currently available to make the grazing system successful? If not, how will the skills be obtained?

Planning and goal setting are always done, either consciously or unconsciously, within the level of risk acceptance of the planner. Change involves risk. There is no single grazing system that will be best for all producers. A manager whose overriding goal is to not increase economic risk will make few changes. However, managers who are willing to accept increasing levels of uncertainty and costs for the opportunity to gain higher returns will often make significant changes in their management plan. Some grazing livestock enterprises have a much higher profit potential than others and are often the ones most responsive to intensive rotational management (Table 3.1).

Table 3.1. Relative animal production response of livestock enterprises to management intensive grazing; suggested number of paddocks for the enterprises.

Livestock enterprises	Relative animal production response to high levels of grazing management	Suggested level of rotation—number of paddocks
Seasonal dairying	very high	50-60
Year-round dairying using pasture	high	50-60
Stocker calves	high*	25-40
Developing dairy heifers	high	15-30
Ewe flock—sell weaned lambs	moderate to high	6-20
Cow/calf—sell weaned calves	moderate	4-20

Note: Good animal production response does not guarantee favorable economic returns

* Fluctuating stocker calf and yearling prices make returns highly variable even with good gains on pasture.

Improvement is relative to the starting point. The producer who now uses continuous grazing of one pasture and who is satisfied with the current level of management inputs, risk, and returns is unlikely to seriously consider implementing a complex rotational grazing system. But they may wish to implement some improved fertilization and weed management. Another producer wishing to increase productivity from the same pasture area may implement a limited rotational (four pastures) system for a few years as an experiment, taking on little additional risk and at the same time learning new management skills. A radical management change by a dairy producer might be to adopt seasonal dairying by implementing a 60-paddock, half-day rotation system. In this situation, the producer will have many changes to plan and carry out.

Using animal unit months (AUM) as a planning tool

The first concern in any grazing situation is whether the pasture can provide enough forage to meet the needs of the grazing animals. This information is most useful when planning a grazing enterprise.

A useful planning approach is to use the concept of animal unit (AU) needs and animal unit days (AUDs) or animal unit months (AUMs) of forage supply. A standard animal unit often is considered to be one mature cow of about 1,000 lb, either dry or with calf up to six months old. This standard animal will eat about 26 lb of dry matter per day which equals an AUD of forage. Larger or smaller animals, young animals, and high milk producing animals will eat proportionally more or less dry matter than the standard animal unit.

Table 3.2 provides the relative animal unit size or need factors for various species of grazing animals. For example, a large beef cow (1,300-1,500 lb) with a high milk production has an AU index of 1.34, or a forage need of 34 percent or greater each day or month than a standard AU. Yearling heifers, meanwhile, will be less than one AUD or AUM.

An estimate of how much forage an animal will consume is needed to plan a grazing system. An animal unit month (AUM) is the amount of forage dry matter that a 1,000 lb cow with her calf will eat in a month. This total is about 780 lb (26 lb per day for 30 days), but needs to be adjusted for different body weights. Photo by Erika Lundy.

Table 3.2. Animal Unit (AU) adjustment factors. The animal unit day (AUD) or animal unit months (AUM) of forage required by animals different from the standard animal unit (1,000 lb cow with or without her calf present) can be estimated by the following AU index factors.

Livestock decriptions	Animal Unit (AU) index	Daily dry matter intake (lb)
Beef yearling steers—medium frame	0.83	21.6
Beef yearling steers—large frame	0.97	25.2
Beef yearling heifers—medium frame	0.83	21.6
Beef yearling heifers—large frame	0.97	25.2
Beef 2 yr heifers 800-1,000 lb; mod milk	0.93	24.2
Beef 2 yr heifers 1,000-1,200 lb; mod milk	1.08	28.1
Beef 2 yr heifers 800-1,000 lb; high milk	1.14	29.6
Beef 2 yr heifers 1,000-1,200 lb; high milk	1.26	32.8
Beef cows 900-1,100 lb; moderate milk	1.00	26.0
Beef cows 1,100-1,300 lb; moderate milk	1.10	28.6
Beef cows 1,300-1,500 lb; moderate milk	1.20	31.0
Beef cows 900-1,100 lb; high milk	1.11	28.6
Beef cows 1,100-1,300 lb; high milk	1.22	31.7
Beef bulls	1.50	39.0
Ewes—winter lamb—175 lb	0.21	5.5
Ewes—May lamb—175 lb (140% lamb crop)	0.24	6.2
Ewes—May lamb—175 lb (180% lamb crop)	0.26	6.8
Replacement ewe lambs—80 lb	0.13	3.4
Replacement ewe lambs—100 lb	0.17	4.4
Replacement ewe lambs—120 lb	0.17	4.4
Dairy cows 1,000 lb; 50% forage ration	0.77	20.0
Dairy cows 1,300 lb; 50% forage ration	1.00	26.0
Dairy cows 1,600 lb; 50% forage ration	1.23	32.0

Related terms

There are several interrelated concepts relating to AUMs—forage allowance, utilization rate, stocking rate, stocking density—used while reading and discussing improved grazing management. These concepts and terms are used to describe the relationship of animals being grazed and forage availability on any given land area.

Forage allowance is a forage-to-animal relationship measured in terms of forage weight available per animal unit at a given time. For example, 450 lb of dry matter per animal unit would be the forage allowance of a pasture with 4,500 lb forage per acre stocked at 10 animal units per acre. The forage allowance will be high the first day of a three-day grazing period, and low on the third. A very similar term, animal unit days of forage, also relates forage actually consumed on a per animal basis.

Utilization rate is the percentage of available forage (forage allowance) that is eaten. Utilization percentage can be interpreted and used in several different ways. It is most accurately used during a short-term grazing period where the estimate or measure of forage present at any time during the grazing period is compared with the forage available at the start of the graze period. For example, if there was 2,000 lb of forage per acre present at the beginning of a two-day grazing period and 1,200 lb remaining at the end, the utilization percentage during that grazing period was 40 percent (2,000-1,200)/2,000. From a practical standpoint, it is difficult and not necessarily desirable to achieve a utilization rate of more than 75-80 percent.

If the take half/leave half strategy is used, there should be sufficient leaf area remaining for rapid plant recovery during the following rest period. Photo by Denise Schwab.

The forage allowance must be appropriate for the grazing system being used and the amount of recovery time the plants or pasture will have following grazing. Where the goal or strategy for grazing is not to overgraze a paddock or pasture, the utilization rate should always be coordinated with a rest or recovery period adequate for the grazed plants to regain their vigor. For example, if an alfalfa pasture is being strip grazed by dairy cows in a rotational system, it may be appropriate to set a 70-75 percent utilization rate for a half-day grazing period if the strip or paddock will then have an appropriate 28-35 day recovery period to regain its vigor. Another example is a grazing manager who uses the take half, leave half grazing strategy in a rotational grazing system who plans to leave sufficient residual forage leaf area for a rapid recovery during the 20-25 day rest period that follows. The general rule for utilization percentage is that the shorter recovery time a pasture will have, the more leaf area that must be left for recovery and thus a lower allowable use of what is present.

How would this rule apply for appropriateness of utilization percentage to a continuously grazed pasture? With the uncertainty of rest for any one plant, all plants should be left with a significant residual or active leaf area. As a result, no more than a light grazing of all plants is necessary to maintain vigor and prevent overgrazing of the pasture as a whole.

For planning purposes, no more than a 30-35 percent utilization rate is appropriate for a continuously grazed pasture. Even then, some individual plants will be overgrazed because of animal selectivity resulting in spot grazing.

Stocking rate is a term frequently used in pasture planning and management to define the forage balance. Stocking rate is the number of a specific kind and class of animal grazing a specific unit of land for a specified period of time (for example, 50 cow-calf pairs in a 100-acre pasture for the 150-day summer grazing season or one half cow per acre per 150 days).

Stocking rate is limited in its usefulness to balance the forage need and supply because the forage availability on the land is not well-defined and can greatly misguide the manager. Stocking rate is most useful when the manager has a very good understanding of the long-term productivity of a pasture or farm and the size of the animals being grazed.

Long-term stocking rates on a pasture or farm, however, can be misleading. Simply because 50 cow-calf pairs have always grazed a specific pasture does not mean the forage supply was always adequate or that animal performance has been consistently good. The years that the cows were moved to another pasture or fed hay in mid-summer tend to be forgotten. A good long-term stocking rate decision often implies excess forage in the best years and a need to provide supplemental feed in the worst years. Yearly records of these occurrences, along with animal grazing days, can be helpful in long-term planning.

The goals for the grazing program must be considered when establishing stocking rates and the number of animals appropriate for the forage supply. Many producers still have a fixed stocking rate grazing goal for an area's entire growing season. To accomplish this goal, excess forage must be left during the fast growth portion of the spring to compensate for the reduced growth during summer.

If, however, the grazing season is only going to last from early May through the end of June, stocking rates in the spring can be extremely high, at more than one animal unit per acre to use the rapid spring growth efficiently.

Stocking density is the number of animals of a specific kind and class or the total weight of animals per area of land at any point in time. It is expressed as animal units per land area or pounds of live weight per land area. For example, the stocking density of 50 cow-calf pairs in a 100-acre field is 1/2 animal unit per acre; if the same 50 cow-calf pairs are in one of ten 10-acre paddocks within the 100-acre pasture, the stocking density at any point in time is five animal units per acre. If the 50 cow-calf pairs average a weight of 1,500 pounds yielding a total herd weight of 75,000 lb, then the stocking density of the entire 100-acre pasture is 750 lb live weight per acre and the stocking density of a 10-acre paddock within the 100-acre pasture is 7,500 lb live weight per acre.

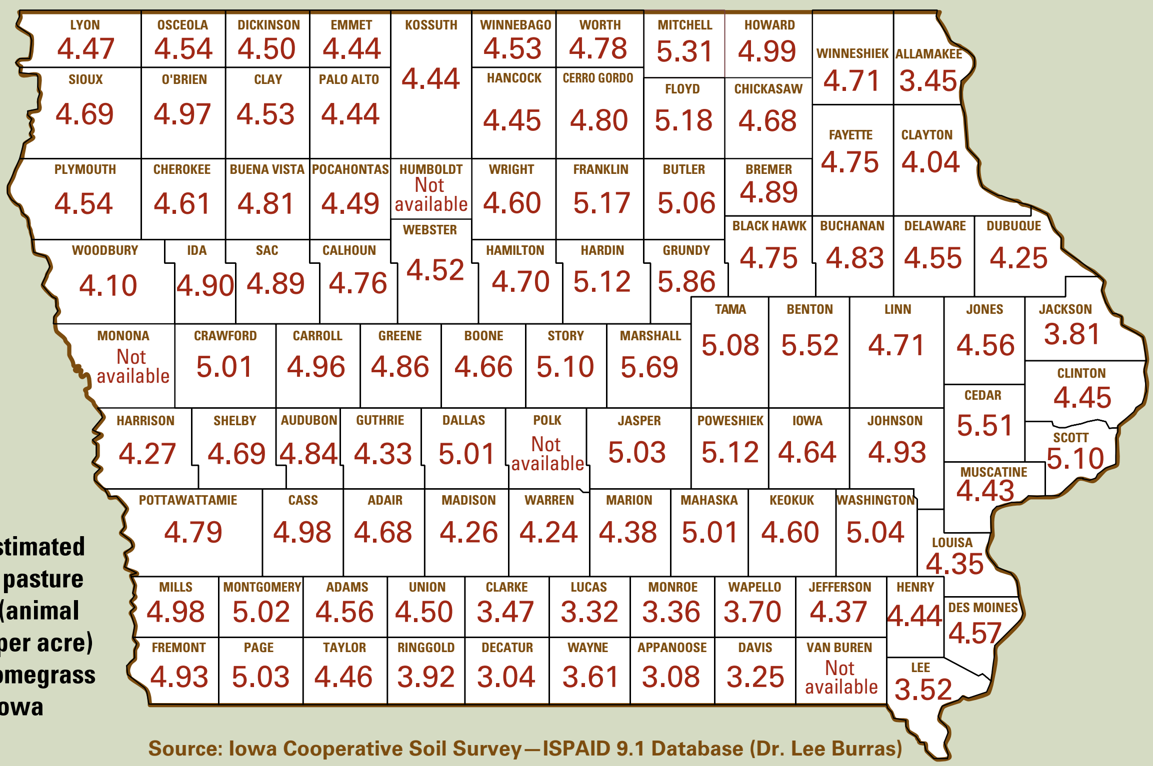
Grazing at very high stocking densities may increase forage utilization, but requires reduction of the stocking rate. Photo by Margaret Chamas.

It is very important to understand the difference between stocking rate and stocking density. Grazing at very high stocking densities by mob grazing (100,000-1,000,000 lb live weight per acre), even for short periods, may increase the forage utilization rates to greater than 75 percent which with trampling will result in the need for extended rest periods requiring reductions in the season-long stocking rate.

Estimating pasture productivity from soil maps

The seasonal production of pastures in any given year is affected by precipitation, soil characteristics, and the forage species present. As an example, alfalfa-bromegrass pastures in Story County in central Iowa have adequate forage to carry 53 percent more animal units than those in Lucas County located in south central Iowa.

Average productivity estimates from ISU Extension and Outreach for various pasture types can be found in Figures 3.2, 3.3, and 3.4, or in similar charts from NRCS guides. But to be most useful, producers need to recognize the productive capabilities of the soil and forage species in their own pastures and make management decisions accordingly.



Source: Iowa Cooperative Soil Survey—ISPAID 9.1 Database (Dr. Lee Burras)

Figure 3.2. Estimated season-long pasture productivity (animal unit months per acre) of alfalfa-bromegrass pastures in Iowa counties.

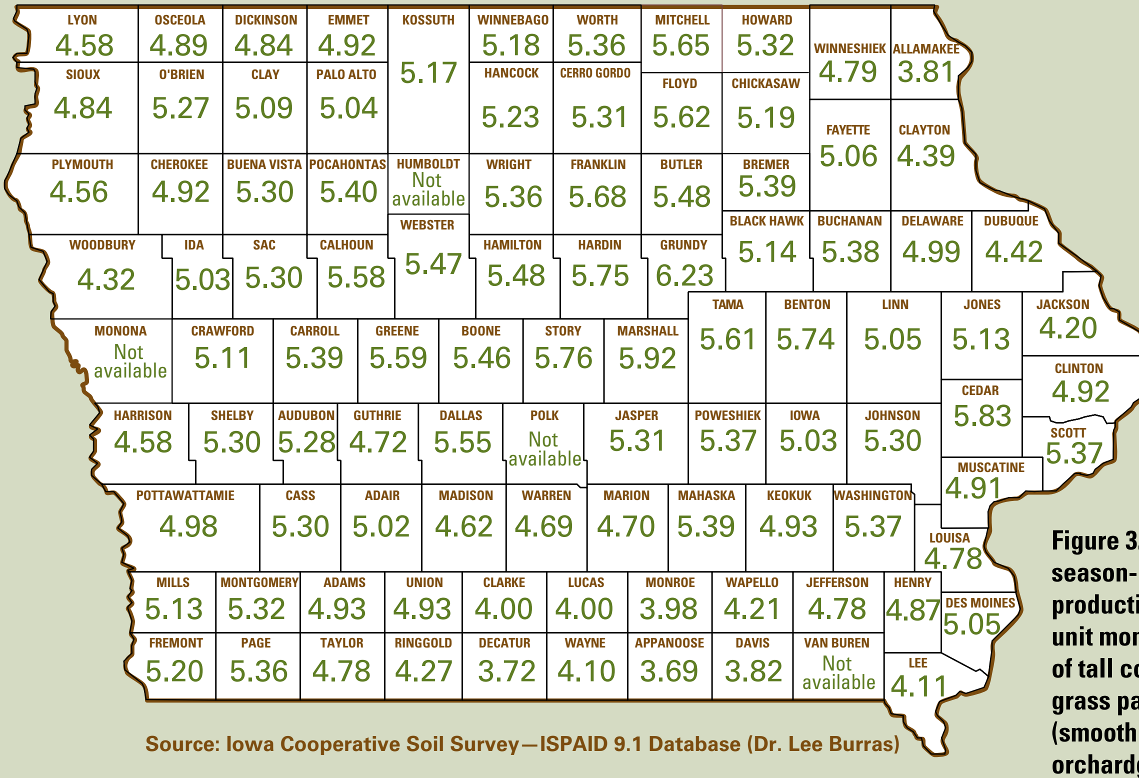


Figure 3.3. Estimated season-long pasture productivity (animal unit months per acre) of tall cool-season grass pastures (smooth bromegrass, orchardgrass, tall fescue) in Iowa counties.

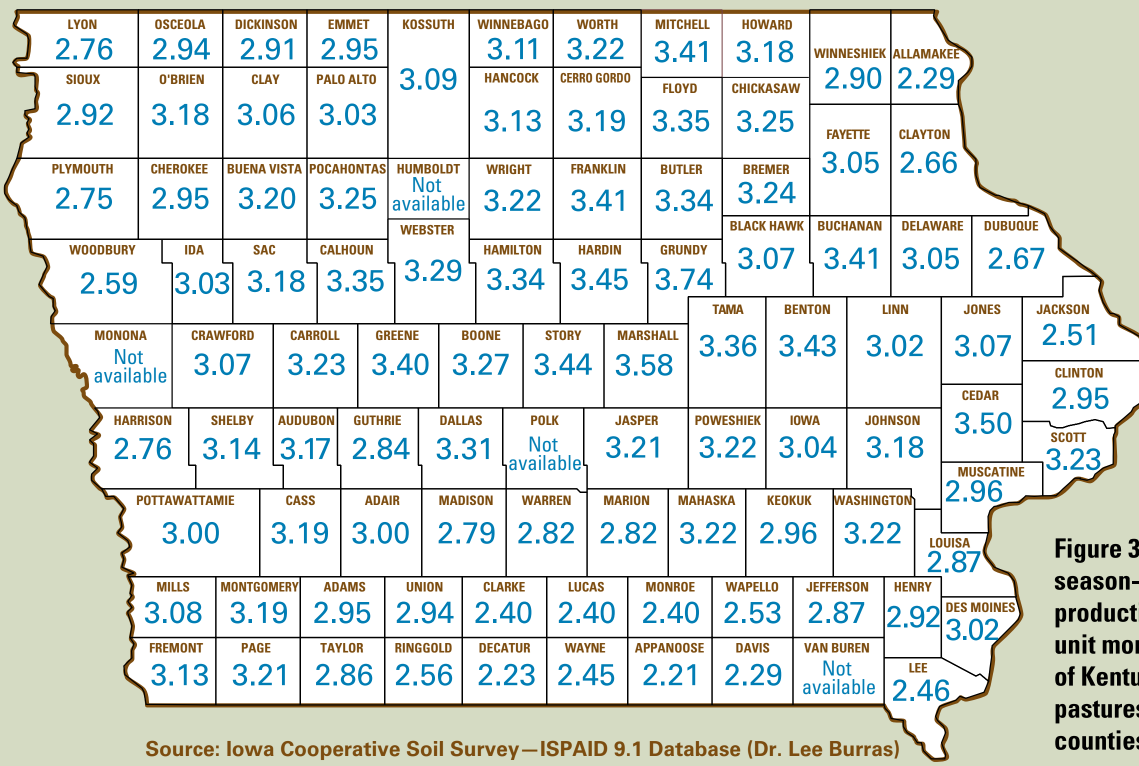


Figure 3.4. Estimated season-long pasture productivity (animal unit months per acre) of Kentucky bluegrass pastures in Iowa counties

For example, a typical mixture of soils from southern Iowa might consist of relatively fertile Nira and Sharpsburg soils on the ridges and Colo-Ackmore soils along a stream (Figure 3.5). The site also might have less fertile Lamoni, Shelby, Clearfield, and Clarinda soils on the hillside.

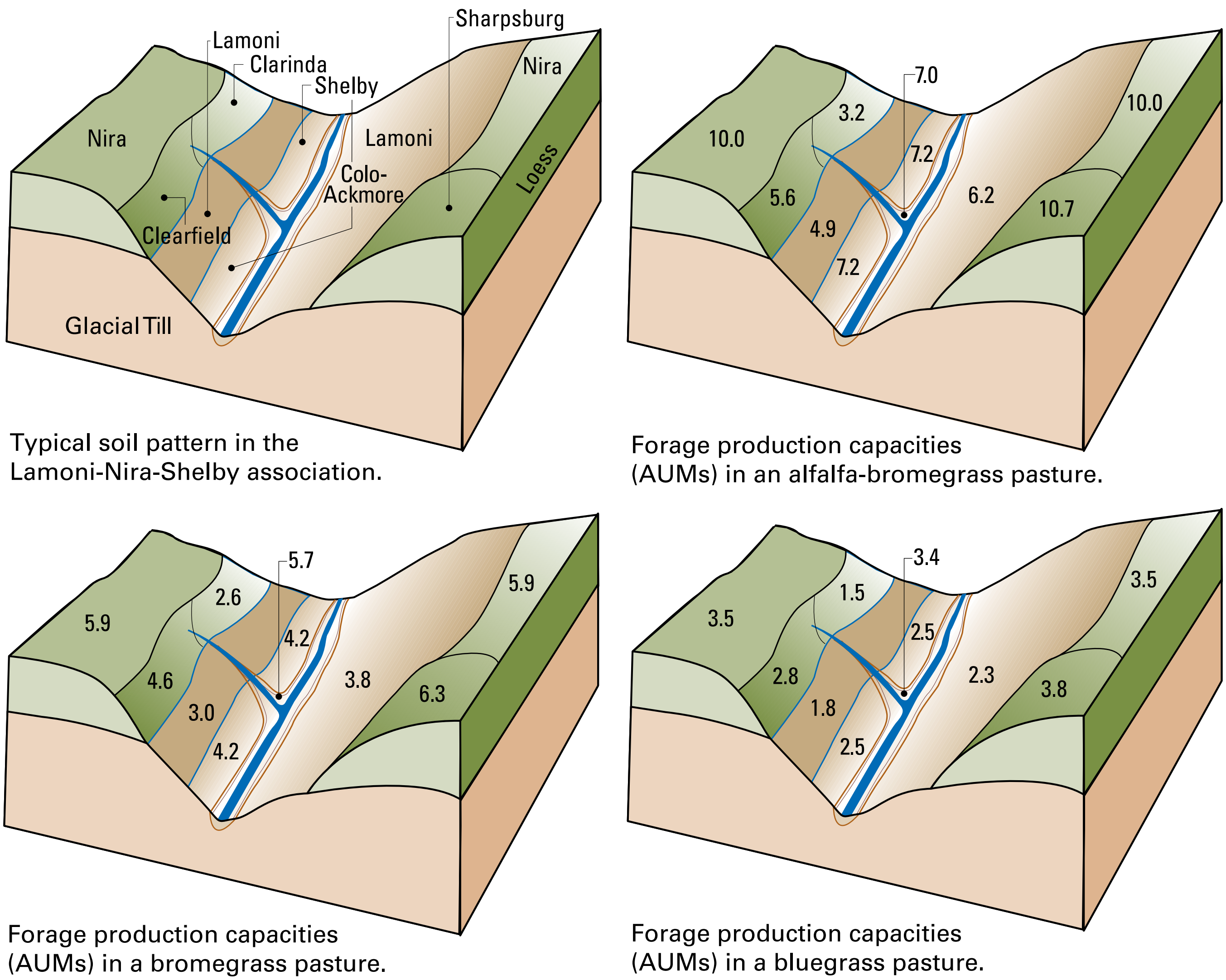


Figure 3.5. Types and season-long forage production capacities (animal unit months per acre) of typical soils in the Lamoni-Nira-Shelby association.

If the pasture on this site was seeded in alfalfa and bromegrass, productivity of the soils ranges from 3.2 AUMs on some hillside soils to 10.7 AUMs on the hilltop. From these seasonal yield estimates, it can be projected that it will require about two acres of the least productive pasture areas to supply the grazing needs of one AUM (cow-calf pair) for the six-month grazing season. Furthermore, the distribution of that forage would not be uniform throughout the grazing season. One acre of the most productive soils could probably supply the forage needs of at least one AUM for the entire grazing season, and perhaps part of the forage needs of a second cow-calf pair. If the pasture were bluegrass, however, its productivity would range from only 1.5-3.8 AUMs per acre, which would require as much as 2-4 acres of pasture to support a single cow-calf pair for the season. Estimated pasture productivity for soils in an individual county can be found in the Soil Survey Report for that county, available through ISU Extension and Outreach or NRCS offices.

If the estimated productivity potentials of different soils are available, the average productivity of the pasture can be calculated by multiplying the proportion of the total pasture containing a given soil type by the estimated productivity of a given forage type on that soil type. For example, assuming that the example pasture in Figure 3.5 was bromegrass and contained soils of 20 percent Lamoni class II, 15 percent Lamoni class III, 20 percent Nira, 15 percent Sharpsburg, 12 percent Shelby, eight percent Clearfield, six percent Clarinda, and four percent Colo-Ackmore, the estimated productivity of this pasture would be 4.6 AUMs (Table 3.3). About 1.2 acres of pasture would be required per animal unit for a 5.5-month grazing season.

To estimate the forage production potential of an entire pasture, producers need to recognize that the soils and forage species in the pasture vary greatly. Photo by Erika Lundy.

Table 3.3. Calculation of estimated productivity of a bromegrass pasture.

Soil type	Proportion of pasture area	Pasture productivity, AUMs	AUMs from soil type
Lamoni class II	.20	3.8	.76
Lamoni class III	.15	3.0	.45
Nira	.20	5.9	1.18
Sharpsburg	.15	6.3	.95
Shelby	.12	4.2	.50
Clearfield	.08	4.6	.37
Clarinda	.06	2.6	.16
Colo-Ackmore	.04	5.7	.23
Total	4.60		
Adjusted for risk			4.6 x .8 = 3.7
Adjusted for cow size			3.7 x .8 = 2.9

Web Soil Survey is an online program developed by the NRCS for determining the proportions of different soil classes and the potential productivity of a pasture (Figure 3.6). Pastures can be located using an aerial map within the program, and by drawing an area of interest (AOI). The soil map will be immediately drawn along with a table showing the proportions of the different soils. The vegetative cover category in the Soil Data Explorer may allow for calculations of the average productivity of the pasture for a given pasture species mixture. However, if the productivity of every different soil class is not present in the program's data bank, it will not calculate average production. In this case, average production can be hand-calculated using the average proportions of each soil class with the yields from the county Soil Survey Report as described above.

Figure 3.6. Use of Web Soil Survey for determination of the proportions of different soils in a pasture (NRCS).

Map unit legend

Lucas County, Iowa (IA117)			
Map unit symbol	**Map unit name**	**Acres in AOI**	**Percent AOI**
13B	Zook-Olmitz-Vesser complex, 0 to 5 percent slopes	2.5	5.0%
23C	Arispe silty clay loam, 5 to 9 percent slopes	14.7	29.7%
23C2	Arispe silty clay loam, 5 to 9 percent slopes, moderately eroded	0.6	1.1%
24D	Shelby clay loam, 9 to 14 percent slopes	4.1	8.4%
222C	Clarinda silty clay loam, 5 to 9 percent slopes	4.3	8.6%
222C2	Clarinda silty clay loam, 5 to 0 percent slopes, moderately eroded	2.9	5.9%
364B	Grundy silty clay loam, 2 to 5 percent slopes	2.8	5.6%
822C	Lamoni silty clay loam, 5 to 9 percent slopes	7.6	15.4%
822D	Lamoni silty clay loam, 9 to 14 percent slopes	10.1	20.4%
Total for Area of Interest		**49.5**	**100.0%**

In making these calculations, be aware that the estimated pasture productivity for each soil assumes optimal fertility, precipitation, and temperatures for forage growth. So it is often recommended that the productivity estimates be decreased by 20-30 percent of their potential levels to manage for risks associated with drought or other factors limiting forage growth. As a result, the pasture in our example can conservatively supply 3.7 AUMs per acre, about two-thirds of the needs of a standard animal unit for the grazing season. About 1.5 acres of pasture per standard animal unit would therefore be needed for the season.

Very few cow herds have "standard" 1,000-lb cows. If cows are larger, they can eat the equivalent of 1.20 "animal unit" cows. For cows of this size, the example now shows that each acre of the pasture realistically will supply 2.9 AUMs, or about half of the grazing needs of one cow for the season. Or stated another way, it will require slightly more than two acres of pasture to provide the forage needs of a cow for the growing season. If the pasture were bluegrass on only hillsides, it would require 3-4 acres to supply the seasonal forage needs of each cow in the herd. Even then the seasonal distribution of that production will not be uniform and may cause some periods of insufficient forage.

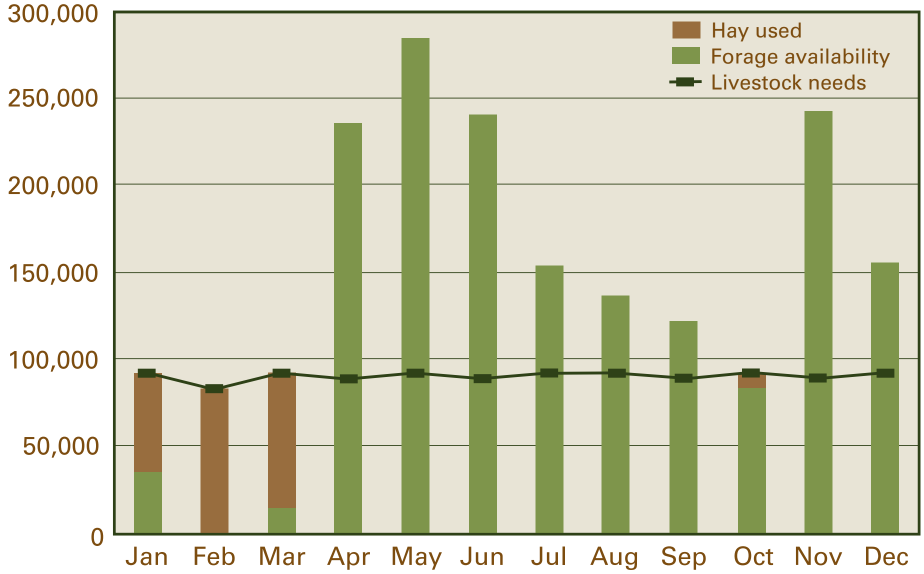
The NRCS offers a Forage - Livestock Balance Worksheet that can be used to identify months the pasture forage may be deficient or in excess, and the amounts of hay that may be produced and fed from the forage yields. This formula is based on acreages of different soil classes, forage species, and type of grazing management of all pastures or crop residue fields used for grazing and the numbers and size of different types and species of grazing livestock (Table 3.4). Similar to the Web Soil Survey, not all classes of soils have the vegetation productivity values in the program. In this case, the productivity of a forage species that is known from a similar soil class should be used. While this worksheet can identify likely periods when forage may be deficient and whether the amounts of hay harvested will be in excess or deficient, it can also be used to predict results from management changes such as converting to a rotational grazing system, interseeding legumes into a pasture, or cover crop grazing. While this worksheet is available online, it would be wise to consult with a county NRCS office to learn how to best utilize it on a specific farm. Similar to other areas, some online applications have been developed for pasture and livestock management by organizations such as the NRCS, USDA-Agricultural Research Service, Noble Research Institute in Ardmore, Oklahoma, and others. As the number and the rate of changes in these online tools makes mentioning each program futile, it is recommended that producers regularly search for the right tools to assist their pasture and livestock management needs.

Table 3.4. An example of the outputs from the NRCS Forage-Livestock Balance Worksheet. In this example, 50 cows with calves, 10 replacement heifers, and two bulls graze 180 acres of pasture, 120 acres of corn stalks, and 60 acres of rye cover crop with an additional 30 acres of alfalfa grown as hay. The herd would have to be fed hay for 82 days, but there would be nine tons of hay excess for either reserve or sale.

Pasture forage availability																	
						Pounds dry matter available per month											
Field no.	Forage	Acres	# Forage DM/year	Utiliz. rate	# DM avail/fld	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	TF/Mix Gr/	120	998390	0.6	599034	0	0	0	35942	125797	131787	131787	89855	59903	29952	17971	0
2	Mix TG/Le	60	516430	0.6	309858	0	0	12394.32	74366	108450	108450	46479	46479	61972	46479	15493	0
3	Corn stalks	120	714000	0.5	357000	35700	0	0	0	0	0	0	0	0	0	178500	142800
3	Cereal rye	60	357000	0.7	249900	0	0	2499	124950	49980	0	0	0	0	7497	29988	12495
						0	0	0	0	0	0	0	0	0	0	0	0
						0	0	0	0	0	0	0	0	0	0	0	0
Totals		**360**	**2585829**		**1515792**	**35700**	**0**	**14893**	**235258**	**284227**	**240238**	**154305**	**136334**	**121875**	**83927**	**241952**	**155295**

Livestock needs															
				Forage needed per month											
Kind of livestock	No. of animals	Animal weight	# DM per day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Cow	50	1300	1950.0	60450	54600	60450	58500	60450	58500	60450	60450	58500	60450	58500	60450
Calf not weaned	50	400	600.0	18600	16800	18600	18000	18600	18000	18600	18600	18000	18600	18000	18600
Bull	2	2100	105.0	3255	2940	3255	3150	3255	3150	3255	3255	3150	3255	3150	3255
Yearling/ replacement	10	1050	315.0	9765	8820	9765	9450	9765	9450	9765	9765	9450	9765	9450	9765
None			FALSE	0	0	0	0	0	0	0	0	0	0	0	0
None			FALSE	0	0	0	0	0	0	0	0	0	0	0	0
Total Table 3 livestock needs/year			**1084050**	**92070**	**83160**	**92070**	**89100**	**92070**	**89100**	**92070**	**92070**	**89100**	**92070**	**89100**	**92070**
Total Table 1 forage availability/year			**1515792**	**35700**	**0**	**14893**	**235258**	**284227**	**240238**	**154305**	**136334**	**121875**	**83927**	**241952**	**155295**
Table 1 - Table 3 difference			**674742**	**-56370**	**-83160**	**-77177**	**146158**	**192157**	**151138**	**62235**	**44264**	**32775**	**-8143**	**152852**	**63225**
Table 2 - Hay available			**243000**	**186630**	**103470**	**26293**	**26293**	**26293**	**26293**	**26293**	**26293**	**26293**	**18151**	**18151**	**18151**

Herd grazing days/paddock															
Field no.	Forage	Acres	Utiliz. rate	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	TF/mix Gr/ legume	120	0.6				12.5	42.4	45.9	36.3	30.3	20.8	10.1	6.3	
2	Mix TG/ legume	60	0.6			4.2	25.9	36.5	37.7	15.6	15.6	21.6	15.6	5.4	
3	Corn stalks	120	0.5	12.0										62.1	48.1
3	Cereal rye	60	0.7			0.8	43.5	16.8					2.5	10.4	4.2
Totals		**360**	**acres**	**12**	**0**	**5**	**82**	**96**	**84**	**52**	**46**	**42**	**28**	**84**	**52**
Surplus	**Herd grz. day**	**294**					**52**	**65**	**54**	**21**	**15**	**12**		**54**	**21**
Shortage	**Herd grz. day**	**48**		**19**		**26**							**3**		
May-Oct	**Herd grz. +/-**	**164**													
Days of	**Hay feeding**	**82**			**Total herd grazing/hay days:**				**665**						
Herd description		**50 cows, 50 calf not weaned, 2 bulls, 10 yearling/replacement**													



Implementing or intensifying a rotational grazing system

The previous section describes simple forage supply and animal use balance approaches by using standard animal units. The estimate is generally useful for all grazing systems, especially in the first year of a new system. The approach, however, probably is most useful for establishing a base stocking rate for continuous grazing and three- to four-pasture rotational grazing systems.

When planning a simple rotational system, or a more intensive rotational grazing system, it is important to determine the number of paddocks, the size of paddocks, and the number of animals that are most suited to a system with the proposed frequency of rotation. Information needed for preliminary planning includes acres being used and their average productivity, the type and size of livestock being grazed, the average grazing period on each paddock, the average rest period for each paddock between grazings, and the appropriate utilization rate of forage.

Paddock size and number of paddocks are interrelated. The more paddocks in the operation, the smaller the required paddock size. In a six-paddock rotational system, animals generally will graze a single paddock for about 5-6 days, allowing paddocks to rest for about 82 percent of the time. As seen in Figure 3.7, little additional rest is achieved with more than 8-10 paddocks. Increasing the number of paddocks above 8-10 can increase management flexibility and forage utilization rates but will add to the cost of the system.

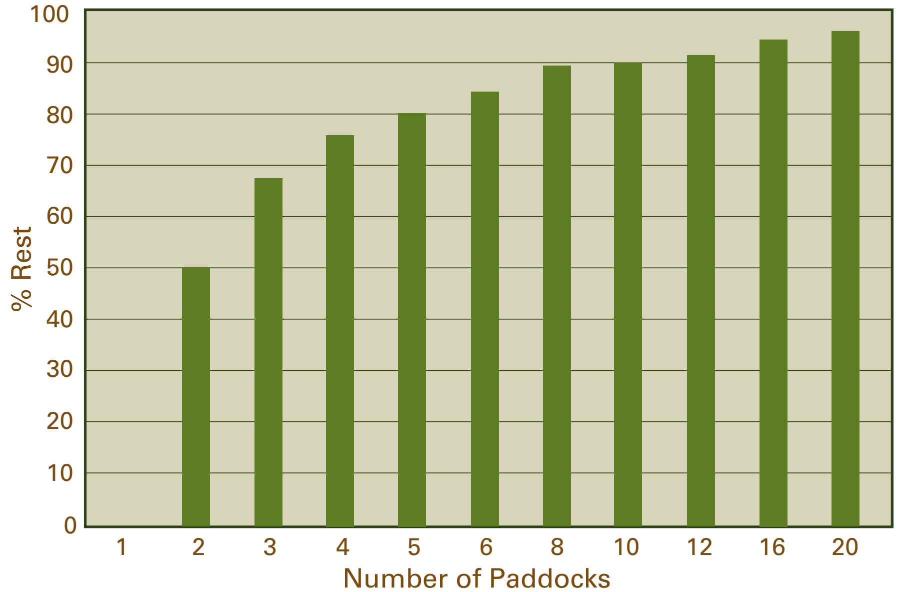


Figure 3.7. The relationship between number of paddocks and amount of rest.

Worksheet tools

Worksheets can be useful in accurately calculating the balance of animal needs and pasture production or evaluating paddock or pasture numbers and sizes in an intensive rotational system.

Use Worksheet 1 to determine the number of paddocks, paddock size, and the total acres needed for a specific number of grazing animals. When calculating forage needs in Step 2 for an estimate of the proportion of the available forage consumed—the utilization rate—refer to the guidelines accompanying Worksheet 1 which suggest appropriate percentage utilization rates for various levels of rotation frequency. In Step 3 of the worksheet, an estimate of the amount of forage available for an average grazing period is required. For the example in the worksheet, each inch of standing forage height in a good mixed pasture is estimated at 350 lb per acre of available forage. Assuming this pasture was 10 inches tall, available forage yield would be 3,500 lb per acre. The guidelines can be used to help determine an estimate for other pasture types. Also, see Chapter 4, "Pasture productivity, techniques for estimating forage quantity," for a discussion of estimating forage yield based on measured height.

The example shown in Worksheet 1 is for a producer who plans to graze in a rotational system with a small herd of beef cows with calves and a bull. The producer plans to use an average grazing period of seven days on a paddock followed by an average of 35 days rest. A utilization rate of 50 percent is appropriate, according to the guidelines. For purposes of planning, it is assumed paddocks will be about 10 inches tall each time the animals start grazing. The calculations for the example show that six paddocks are needed to supply the necessary 1,882 lb of forage dry matter per day. At the 50 percent utilization rate of the available forage during the seven day grazing periods, it would require 3.8 acres per paddock, for a total of 22.8 acres of pasture in the six-paddock rotation.

When using Worksheet 1 as a planning tool, the level of grazing frequency can be adjusted to see the “what if” result of more or less frequent rotations. However, keep in mind that the suggested utilization percentage should also be increased with increasing frequency of rotation and paddock numbers.

Worksheet 2 can be used when the producer needs to determine the number of animals for a specific size of grazing system. This tool is especially helpful if the producer wants to estimate whether more animals can be grazed by using a more management intensive grazing plan. This worksheet is most useful for a single-type grazing herd, such as a cow-calf herd, a dry ewe flock, or a group of stocker steers. It is less useful for mixed species or operations with both a cow-calf herd and stocker steers, although it still can be used. In the example shown in Worksheet 2, the grazing period is seven days and the rest period is 35 days. The pasture is 54 acres of fair mixed pasture with an average height of 10 inches. There is approximately 2,000 lb of forage dry matter per acre, which is assumed to be 50 percent utilized. The calculations show that the 54 acres of f orage managed in a six-paddock rotation are providing 36 percent more forage (1.36 adjustment factor) than the current herd will use. The planning worksheet indicates that the number of cows could be increased to 27 head (1.36 x 20).

A note of caution when using either worksheet. The estimates of forage supply give a reasonable yield estimate for a given time, but they should not be considered to be accurate measures for the entire growing season. The estimates should be used with particular caution when seasonal production varies greatly with weather conditions. (Blank copies of Worksheet 1 and 2 are included in the appendices and an Excel file is also available.) It is suggested that these worksheets be used for estimating stocking numbers for the first year of a grazing system and that stocking rates be set conservatively until a better understanding of the productive potential of the site can be determined through actual grazing experience. To determine the productivity, keeping accurate records is essential. (See Chapter 4, “Monitoring and evaluating the grazing system.”)

A constant utilization rate is difficult to implement in practice throughout a growing season. Err on the conservative side when entering utilization percentage in these worksheets. Because most forage in a pasture eventually disappears, producers often overestimate how much is used. The proportion of potential nutrients wasted is often greater than can be seen because of the combination of the reduced quality of mature forage and the actual wasting of dying forage. Grazing managers frequently indicate they learn a lot about their pasture systems during the first grazing season and can make better adjustments based on their experiences.

Guidelines to worksheets 1 and 2

Utilization rate guidelines

Rotation schedule	Utilization rate (full season)	Average*	Utilization rate (spring growth)	Average*
Continuous grazing (1 pasture)	30-35%	32.5%	30-35%	32.5%
14 days or greater (2-4 paddocks)	35-40%	37.5%	40-50%	45.0%
6-8 days (3-7 paddocks)	45-55%	50.0%	50-55%	52.5%
2-3 days (6-15 paddocks)	55-60%	57.5%	55-60%	57.5%
Daily (25-35 paddocks)	60-70%	65.0%	55-60%	57.5%
2 times per day (45-60 paddocks)	70-75%	72.5%	55-60%	57.5%

Utilization rate should follow these general rules

During rapid spring growth:
For 4 paddocks or fewer, utilization rates can be higher in the spring than during the rest of the season because of rapid forage growth.

For 5 or more paddocks, utilization rates should be lower in the spring than during the rest of the season to keep the rapidly growing forage from getting ahead.

Season long:
With short grazing periods and long rest periods, higher utilization rates are possible.

With long grazing periods and less rest, more leaf area should be left so lower utilization rates are necessary.

Rest period guidelines

During rapid growth:
20 days may provide adequate rest for plant recovery.

During summer growth:
40+ days may be needed for adequate plant recovery.

Season-long rest interval:
30-35 days is the basic recommendation for planning purposes.

Estimating forage availability

Estimated lb dry matter per inch per acre for forage type and pasture condition.

	Pasture condition		
Forage type	Fair	Good	Excellent
Smooth brome + legumes	150-250	250-350	350-450
Orchardgrass + alfalfa	100-200	200-300	300-400
Mixed pasture	150-250	250-350	350-450
Bluegrass + white clover	150-250	300-400	450-550
Tall fescue + legumes	200-300	300-400	400-500
Tall fescue + nitrogen	250-350	350-450	450-550

Note: Forage height is measured as natural plant position (leaves are not stretched or extended).

* Use the average in worksheets 1 and 2 when asked for utilization rates

Example of Worksheet 1

Worksheet 1: Determining paddock number and size and total acres needed for a specific number of grazing animals

Step 1. Daily feed consumed by the grazing herd

			Weight		Total Weight		Intake (%)		Daily feed consumed
No. of beef cows, ave. milk	20	x	1,200	=	24,000	x	3.0	=	720
No. of beef cows, high milk		x		=		x	3.5	=	
No. of calves	19	x	300	=	5,700	x	3.0	=	171
No. of bulls	1	x	2,000	=	2,000	x	2.5	=	50
No. of stockers, repl. heifers		x		=		x	3.0	=	
No. of ewes, dry		x		=		x	3.0	=	
No. of ewes, lactating		x		=		x	4.0	=	
No. of nursing lambs		x		=		x	3.0	=	
No. of rams		x		=		x	3.0	=	

Total lb. daily forage dry matter (DM) intake 941

Step 2: Determine amount of forage required adjusting for utilization rate (see Worksheet Guidelines)

lb. daily forage DM intake (Step 1) 941

Utilization rate* 50 %

= 1,882 lb. standing forage DM needed daily

**use the average of given rate on Worksheet Guidelines*

Step 3: Determine lb. DM per acre

Estimated lb. DM/inch/acre* 350 x Height in inches 10 = 3,500 Total lb. DM per acre

**See Worksheet Guidelines*

Step 4: Determine acres needed daily

lb. standing forage DM needed daily (Step 2) 1,882

Total lb. DM per acre (Step 3) 3,500

= .54 Acres needed per day

Step 5: Determine paddock size

Acres needed per day (Step 4)		Number of days on paddock (per cycle)		Acres per paddock
.54	x	7	=	3.8

Step 6: Determine number of paddocks

Rest period (21-42 days) 35 + No. of days on paddock 7

No. of days on paddock 7

= No. of paddocks 6

Step 7: Total acres required for a specific number of grazing animals

Number of paddocks (st. 6)		Acres per paddock (st. 5)		Total acres needed
6	x	3.8	=	22.8

Example of Worksheet 2

Worksheet 2: Determining the number of animals for a specific size of grazing system

Step 1: Determine number of paddocks

Rest period (21-42 days, see guidelines) **35** + No. of days on paddock **7**

No. of days on paddock **7**

= No. of paddocks **6**

(This should be consistent with the value used for utilization rate from the worksheet guidelines)

Step 2: Determine paddock size

Pasture size **54** acres

No. of paddocks (step 1) **6**

= Acres per paddock **9**

Step 3: Determine acres available per day

Acres per paddock **9**

No. of days on paddock **7**

= Acres per day **1.28**

Step 4: Determine lb. dry matter per acre

Estimated lb DM per inch per acre **200** x Height in inches **10** = Total lb. DM per acre **2,000**

Step 5: Determine lb. dryy matter available per day

Lb. per acre (step 4) **2,000** x Acres per day (step 3) **1.28** = Lb. DM available per day **2,560**

Step 6: Determine lb. dry matter consumable per day

Lb. DM available per day **2,560** x Utilization rate (guidelines) **50** = Lb. DM consumable per day **1,280**

Step 7: Daily feed consumed by the grazing herd

			Weight		Total Weight		Intake (%)		Daily feed consumed
No. of beef cows, ave. milk	20	x	1,200	=	24,000	x	3.0	=	720
No. of beef cows, high milk		x		=		x	3.5	=	
No. of calves	19	x	300	=	5,700	x	3.0	=	171
No. of bulls	1	x	2,000	=	2,000	x	2.5	=	50
No. of stockers, repl. heifers		x		=		x	3.0	=	
No. of ewes, dry		x		=		x	3.0	=	
No. of ewes, lactating		x		=		x	4.0	=	
No. of nursing lambs		x		=		x	3.0	=	
No. of rams		x		=		x	3.0	=	

Total lb. daily forage dry matter (DM) intake 941

Step 8: Determine adjustment ratio for grazing herd in step 7

Lb. DM consumable per day (step 6) **1,280**

Total lb. daily DM intake (step 7) **941**

= Adjustment ratio for herd **1.36**

Step 9: The adjustment ratio provides a basis on which to make changes in animal numbers for stocking the system.

A ratio less than 1 indicates a need to consider reducing animal numbers proportionately.

A ratio greater than 1 indicates an opportunity to increase animal numbers to better use the forage.

Rotational grazing—paddock layout and construction

Once the decision has been made to develop a rotational grazing system and the preliminary calculations are made, there should be some idea of the basic plan of how many paddocks or pastures will be needed and their approximate size. The next challenge is how to best fit the basic plan to the conditions of the specific site. There are few hard rules for paddock layout, but there are some good guidelines. The most important consideration in layout and design is to design with flexibility in mind.

One guideline often suggested to maximize flexibility in the start-up year of a system is to not build or install anything that cannot be easily moved or shifted. If the site has no preexisting fences or water sites, this ultraflexible approach may be feasible. But many sites already have some existing permanent fencing, water sites, and handling facilities that may be suitable to include in the layout design. There is always the risk, however, that too much of the existing fencing will be kept in an effort to economize at the sacrifice of a more flexible or efficient layout. Don't be afraid to invest in temporary fencing and water distribution materials in the early years of a rotational grazing system. Many producers are not really satisfied with their first design and are generally glad it was not permanently installed.

In the start-up year of a rotational grazing system, it is best not to build or install anything that can't be easily moved or shifted. Photo by Erika Lundy.

Other possibilities for flexibility that should be considered include laying out a few paddocks initially with the intent of further divisions in the future; installing some main fence lines and lanes with permanent fencing materials but using temporary or semi-permanent fencing for all other internal divisions to allow for more efficient hay harvest and fertilization. Temporary fencing can also be used to create variable-sized paddocks as the season and regrowth characteristics dictate, an example being the daily or half-day strip grazing practiced by dairy graziers.

One design component that is often overlooked is a **sacrifice paddock**. A sacrifice paddock is an area where animals can be placed during periods of excessive rainfall, extended drought, or other times during which animal presence on the regular paddocks would cause plant or soil damage. A sacrifice paddock is not necessarily large, nor expected to provide significant forage. It should be located with ready access to water and accessibility for supplemental feeding. Storage of hay bales protected with temporary fence in the sacrifice paddock can minimize tractor traffic in muddy conditions. The sacrifice paddock can be used as a short-term grazing paddock if there is sufficient forage present. A sacrifice paddock may be damaged—that is what it is there for! Because it may be necessary to renovate the sacrifice paddock, it should be located away from surface water sources on a relatively level site that is suited to easy renovation and less subject to erosion resulting from poor sod cover during renovation.

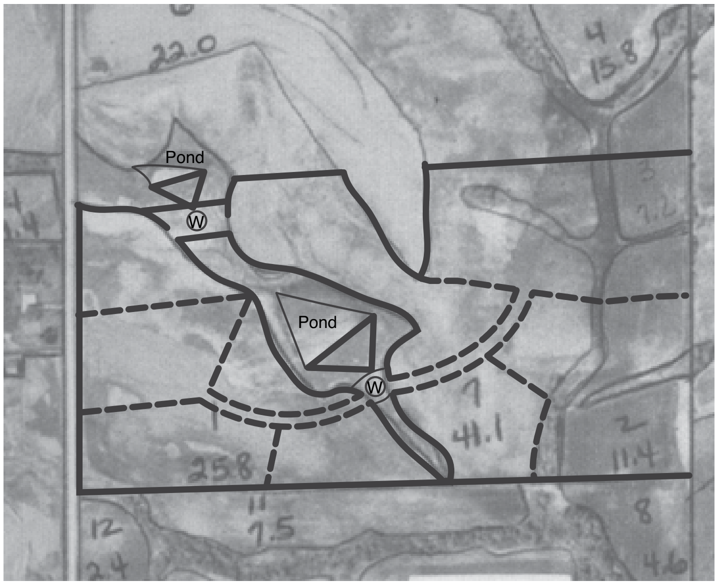


Figure 3.8. A practical place to begin the pasture layout process is on an aerial map or soil map of the pasture. Many alternate fencing plans can be evaluated before going to the field.

Seasonal dairy operations create constraints upon the grazing system because animals must travel twice daily to and from the milking parlor. Ideally the parlor should be centrally located within the grazing area. However, in most situations, producers will not build new parlors when starting a rotational grazing system or use a dairy operation that extensively uses pasture.

For every site there will likely be several good and workable layouts. Get a good to-scale map of the site, and walk across the site to get a sense of the general lay-of-the-land, paying special attention to ditches, drainage areas, trees, existing livestock trails, and other features that may influence or interfere with livestock movement. (Figure 3.8). Consider paddock and lane arrangements by using the list of guidelines and examples of correct and incorrect design features in Figure 3.9.

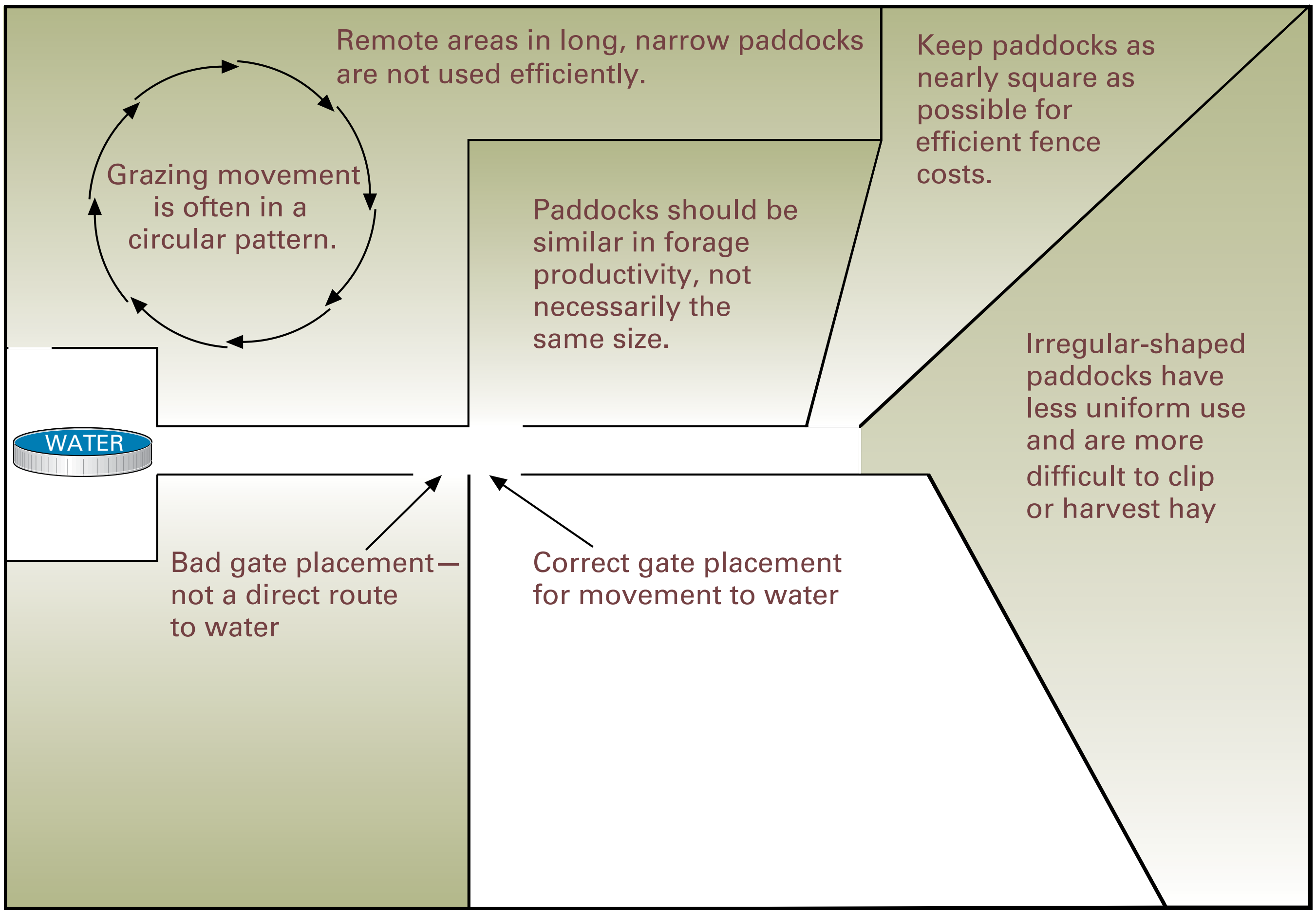


Figure 3.9. Some correct and incorrect paddock design features.

Guidelines for paddocks

- Paddocks should be as square as possible (no more than 3:1 length:width).
- To lessen erosion, avoid aligning paddocks from the top of a hill to the bottom. If possible, make hilltop paddocks, sidehill paddocks, and bottomland paddocks.
- If pasture forage types vary across the pasture, attempt to confine the different forage types to separate paddocks.
- It is more important that paddocks be as equal as possible in forage productivity than equal in area.
- Forage on south-facing slopes grows at a different rate than that on north-facing slopes. If possible, fence slope orientations separately.

Guidelines for lanes and gates

- Avoid orienting lanes up and down slopes. If possible, orient lanes on the contour.
- Avoid directing lanes through wet or low areas.
- Place paddock gates in the corner of the paddock and nearest to the water source.
- Make lanes wide enough for free movement of vehicular traffic and easy access to paddocks.
- Make paddock gate widths equal to the width of the lane, so the open paddock gate can be used to block animals from unneeded parts of the lane.

It will not be possible to accommodate all of these guidelines in every design. Draw several alternative layouts on paper and select the two or three that require the least amount of fencing. View these in regard to their potential to add additional water sites in the paddocks. A goal should be to have a water site within 800 feet of all areas of the system; a water point in each paddock is considered to be best.

Take the two or three best designs to the field and view the areas again with the alternative designs in mind. Use flags or stakes on proposed fence lines. Have grazing advisors from ISU Extension and Outreach, NRCS, consultants, or other experienced rotational graziers visit the pasture to provide additional suggestions and comments. Visit other grazing systems for guidance about mistakes made, precautions, and features that others feel are desirable.

Are management intensive grazing systems in your future?

A rotational grazing system gaining interest and acceptance is one that relies on pastures divided into numerous paddocks, enabling frequent (sometimes even daily) rotation of animals among the paddocks. This type of grazing system has many names. The name gaining favor by producers and grazing advisors is management intensive grazing. Other names for such a system include intensive rotational grazing, Voisin grazing, intensive grazing management, holistic grazing, adaptive regenerative grazing, and controlled grazing.

The advantages of management intensive grazing frequently outweigh the disadvantages. These advantages include the following:

- Increased production and plant diversity from pastures as a result of adequate rest and a faster plant recovery between periods of grazing.
- Maintaining benefits from renovation and pasture improvement practices.
- Once producers establish control, both forage quality and quantity can be greatly increased. This generally improves animal performance in terms of both reproduction in breeding animals and weight gain per acre where higher stocking rates can be achieved.
- The greatest advantage in many situations, especially with animals that are highly selective grazers such as sheep, is that intensively managed pastures do not allow excess selectivity by the grazing animals.
- An opportunity to harvest excess forage from some paddocks in the spring.
- Better production and use efficiency during the growing season may allow for some stockpiling of forage for an extended fall or winter grazing season.
- Improved manure distribution and nutrient recycling within the pasture. Animals are moved on a more regular basis and do not establish consistent bedding grounds where an excessive amount of manure and urine is deposited.
- Animals become easier to manage and handle because they routinely are exposed to humans.
- The animals are confined to much smaller grazing areas, making it easier to observe their general health and condition.

Management intensive grazing is not without its disadvantages. It will require an initial investment in fencing and watering equipment. Generally the initial outlay for fence materials can be recovered within one or two years from improved animal performance. It may require a slightly longer period to recover the costs of more substantial fencing and water systems.

A second disadvantage of management intensive grazing is a slightly greater time commitment required to maintain fences, monitor the growth rate and forage availability in paddocks, and rotate animals to the appropriate new paddocks at the correct time. Controlled grazing may be less feasible in operations that already have excess labor commitments.

The greatest problem with management intensive grazing for most producers is failing to make the serious mental commitment needed to make the system work. Simply building fence and moving livestock will not make it a success. The skills and expertise to make appropriate observations and decisions in an intensive grazing program can only be learned through experience. This requirement can create some difficulties in the early stages of intensive grazing systems. The learning process takes time. Some mistakes will be made, so it is generally recommended that a producer begin with a simple system featuring 5-8 paddocks. Time spent at grazing field days, pasture walks, and workshops discussing management decisions can be very helpful.

Management intensive grazing may allow for better management of the roller coaster pasture growth in Iowa. Most cool-season grasses have a very rapid growth phase in May and June and depressed forage productivity in July and August. It is common to set the season's stocking rate to match the productivity of the summer period. With this stocking level and controlled rotation, it is possible to harvest and conserve some of the excess forage from a few paddocks early in the growing season. As calves and lambs begin consuming more forage in the summer months, the paddocks harvested for hay can be incorporated into the grazing rotation during July and August when pasture growth is slower and more forage is needed.

The economics of developing and implementing an intensive grazing system will vary from operation to operation. Paddock size and number is an important economic factor because fencing costs increase with the number of paddocks. The average cost for purchasing and constructing cross fences for subdividing an 80-acre pasture into six or 12 paddocks would be about $95-125 per acre, depending on the number of wires in the cross fencing.

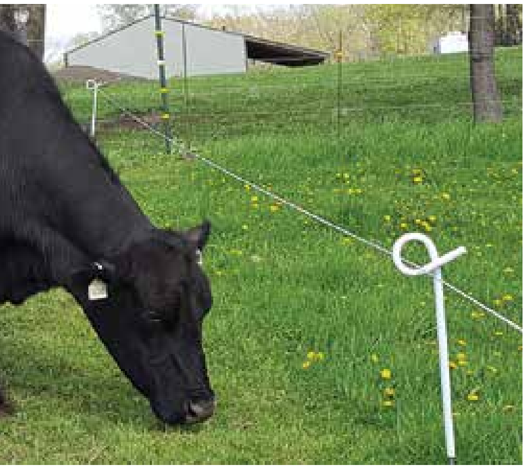
A second major cost in establishing a management intensive grazing system involves developing a water delivery system. The long-term objective of all intensive grazing systems should be to provide water in each paddock. Too often management intensive grazing pasture systems are not implemented on the excuse that a water system cannot be developed.

However, very successful management intensive grazing systems can be established with limited permanent and moveable water delivery materials. The cost of a water system can vary greatly depending on whether an aboveground or buried line system is used. But fortunately a water system does not necessarily need to be expensive if an adequate source of reliable water already exists.

The economic returns from implementing a management intensive grazing system will depend on the levels of increased animal productivity achieved from the better forage quality and quantity available. In addition, be sure to include the hay harvested during the early portion of the grazing season as an income source for calculating the return on the investment.

The rate of return also depends on the animal species. Sheep have a slightly higher cost per acre because they require multiple strands of wire per cross fence.

Two additional factors must be considered when figuring economic returns. Consider the improved pasture stands. And if legumes are used and can be maintained, fertilization costs will be reduced because less nitrogen will be needed.



Lightning strikes along the electric fence line can damage the fence energizer. Use a lightning choke, as shown here, or another form of lightning protection. Photos by Samantha Jamison.

Good wire connectors throughout the fence system help ensure proper fence operation. Photo by Abbey Wilson.

Fencing

Once a design is chosen, begin assessing the suitability of existing fence. Use what is still useful, but seriously consider the costs and benefits of new construction. There are many new fencing technologies available, whether permanent, semi-permanent, or temporary. All can be adapted to electrification. Begin to acquire fencing and water distribution materials, and begin installing the layout. Two publications available online that may be useful are ***Electric Fencing for Serious Graziers*** (https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs144p2_010636.pdf) from the USDA-Natural Resource Conservation Service and ISU Extension and Outreach publication ***Estimated Costs for Livestock Fencing*** (PM 1855) (https://store.extension.iastate.edu/Product/1845). The following list suggests some do's and don'ts for the installation of electric fencing.

Electric fencing tips:

Do

- Use a low impedance energizer that provides one joule of power per mile of fence or follow manufacturer's recommendations.
- Plan the system for less than ideal conditions.
- Install a surge protector.
- Use adequate ground rods (three feet per one joule of output, preferably in a moist area). Longer or more ground rods are needed under dry conditions. Space multiple three foot ground rods at least five feet apart and multiple six foot ground rounds at least 10 feet apart and connect with insulated wire.
- Install lightning protection.
- Use good quality materials and use them properly.
- Make good connections — wire nuts, clamps or compression sleeves where needed.
- Use adequate wire gauge from the energizer to the line fence.
- Use a fence tester to check power.
- Bury insulated wire under gate openings.
- Place gates for natural animal flow.
- Use visible gates.
- Wire electric gates so they are energized only when closed.

Don't

- Use an underpowered energizer.
- Electrify barbed wire.
- Use low quality materials.
- Turn out untrained animals.
- Overbuild or underbuild.
- Use low quality insulators.
- Crowd the grazing herd.

Lanes and gates

Most rotational grazing systems incorporate a system of lanes and gates for movement of animals through the system. Gates and lanes require significant extra fencing materials and labor, so keep the length of lanes to a minimum. A few producers have virtually no gates, and move animals by simply raising the electric fence between paddocks during paddock changes.

Avoid designing lanes or gate placement in low-lying or potentially wet areas or orienting lanes up and down slopes, although sometimes this cannot be avoided due to the lay-of-the-land. Strategic use of crushed stone and geo-fabrics might be considered in known wet areas in lanes. Polyethylene webbing may be used to trap crushed rock on slopes like streambanks. Lanes on dairy grazing operations often are void of vegetation and prone to mud and erosion because of the very frequent traffic. Some pasture dairy systems have successfully used crushed stone in the most heavily traveled lane segments. If forced to orient a lane up and down a slope, consider forming low diagonal berms on the slope to intercept runoff and divert it into the paddocks to minimize erosion. Lanes are normally designed to be sufficiently wide for easy animal movement and, if necessary, vehicular traffic. A few producers have chosen to construct unusually wide lanes to minimize sod damage from animal and vehicular traffic paths. These lanes may have enough forage to be used as a short-term grazed paddock.

Watering systems for grazing livestock

Livestock must have free access to plenty of clean, fresh water at all times to be productive. This holds true for livestock on pasture as well as in the barn. This brief overview of livestock watering systems is appropriate for producers using continuous stocking, but it primarily addresses water system alternatives for producers practicing some form of rotation of animals among pasture paddocks.

As electric fence is usually more of a psychological barrier than a physical barrier, it is useful to introduce livestock to electric fence before turning them out into a pasture. Photo by Erika Lundy.

Stabilized crushed stone can be used to improve wet areas in lanes. Photo by James Russell.

Polyethylene webbing may be used to stabilize crushed rock on hills, streambanks, and in streams. Photo by Shawn Shouse.

Crushed stone commonly used in short sections of lanes that receive heavy, frequent use. Example: Rotational grazing systems for dairy herds that use the lane several times each day. Photo by Erika Lundy.

To minimize down-slope erosion, small diagonal berms can be formed in lanes to divert surface flow into adjacent pastures or buffers. Photo by James Russell.

Proper sizing of water system components is a function of herd size and the grazing system used. Photo by Denise Schwab.

Quantities and supply rates

Water requirements depend on temperature, stage of production, and water content of the diet. As a rule, animals will consume approximately two times their daily dry matter intake in water. At times, much of the water can be provided in forage; however, water supply should be designed for the worst case scenario – hot, dry weather (see Chapter 2, Table 2.5, for amounts of water required for different species). When developing a water system, consider the likelihood of possible expansion in the grazing area, or grazing intensity that will increase the number of animals to be watered. There are a number of important considerations and calculations necessary to determine the size of needed pumps, piping, and tanks. Consult with knowledgeable professionals when making design and materials choices.

Location of water tanks

Regardless of the grazing management system, it is preferable to deliver water to animals than to force them to walk long distances to satisfy their thirst. Therefore, the source of water is not always the best location for the water tank. Development of a water system that delivers water to each paddock, as opposed to one or two centralized drinking locations for the entire pasture area, should be a priority for all grazing systems. Individual paddock water devices increase livestock energy efficiency and reduce parasite loads that can occur in areas around centralized water tanks.

Animal behavior in the chosen grazing system will influence water system decisions. Livestock tend to drink individually where water is supplied to paddocks that are 10 acres or less in size. In this situation, small, movable tanks or tubs that hold between 25-35 gallons connected to a water supply are sufficient. Flow rates of 2-6 gallons per minute (gpm) are required to keep the tank full. Usually it is best to locate tanks along fence lines somewhat central to the paddock. Centralization of waterers is more critical for paddocks larger than 10 acres and when grazing high-producing dairy cows. Changing water location along the fence line from time to time will help reduce localized damage to forage if this is a problem.

The installation of water lines to get water to all paddocks can be a major hurdle. If water only can be supplied at locations central to the total grazing area, try to keep maximum travel distances for animals under a quarter of a mile.

When livestock must walk more than 800 feet to a centralized water supply, they tend to move to water and drink socially as a group. In this case, allow adequate tank size or trough length so that 10 percent of the herd or flock can drink at one time. Make sure there is adequate flow or tank reserve to provide enough water for the entire herd to drink within 20 minutes or less. Provide adequate open areas so the entire herd does not have to remain bunched up around the tank or in the lane leading to the tank waiting their turn to drink. Although water will remain a little cooler, it is not advisable to have the tank located under shade because this will encourage animals to rest in an area that will not be as dry or clean as the rest of the pasture.

Erosion problems in lanes leading to water, especially in high slope pastures, can have a negative impact on the grazing system.

Allowing livestock direct access to ponds, streams, or springs may result in bank deterioration, water pollution, and poor quality water. See Chapter 2, "Stream management in pastures" that addresses stream access and steam bank management.

Frequent lane use and poor layout design lead to excessive erosion problems. Photo by Samantha Jamison.

Water quality

Water quality influences how much water livestock drink. They will be more reluctant to drink bad-tasting, hot, or contaminated water and may allow themselves to become more stressed before drinking. If animals drink less they will consume less dry matter and production will be affected.

Clean out water tanks, troughs, and reservoirs periodically. Although water temperature is not critical, it will help reduce heat stress if water is a few degrees cooler than air temperatures during hot weather. Additional considerations about water quality recommendations are discussed in Chapter 2, "Water requirements."

Keep lane length and use to a minimum. If possible, fit lanes to the contour of the land. Photo by Samantha Jamison.

Water sources and pump alternatives

The easiest watering method is to allow direct livestock access to existing water resources such as ponds and streams. While this is a low capital and low maintenance option, it limits grazing system development flexibility, may lead to stream and pond bank erosion, and provides lower quality water for livestock.

The best watering systems incorporate well water or rural water piped under pressure to waterers at desired locations throughout the grazing system. These watering systems provide maximum grazing system design flexibility, good water quality, and minimize negative impacts on stream and pond bank stability. They do, however, have higher costs and maintenance. The following examples are alternative water delivery systems that can be considered. Some are site specific; all can be used with minor system-specific variations.

Water quality should be as much of a concern as water quantity. Photo by Erika Lundy.

Gravity flow from a pond. Water can flow by gravity to a waterer below the pond level with a pipe through the dam or a siphon tube over the dam. The float valve must be capable of high flow at very low pressure (large orifice). The Gallagher brass valve or the Kerick PVC valve work well. The siphon tube needs a valve at each end; be sure to fill it with water and place the suction end into the pond before it is opened. Existing ponds should be evaluated for location with respect to the planned grazing area and capacity to supply adequate quantities of water.

The simplest method to supply water is gravity flow water from a pond. Photo by Denise Schwab.

Nose pumps have been used for years with little trouble. Photo by Denise Schwab.

Tile water. Some sites may allow for the capture of tile flow for water. This can be done on a hillside with a retaining wall to allow access to the tile line and a small water trough. Many designs exist. The water quality and low maintenance make this option outstanding. On sites where excavating access to the tile line is problematic, a pump may be used to lift the tile water to the ground surface (electric or nose pump).

Well or pond water and electricity. If they are available, use them. Pressurized distribution pipe can be installed on top of the ground in fence rows to reduce installation cost. Black polyethylene pipe is about $0.30 per foot for one inch pipe and $0.60 per foot for 1.5 inch pipe. Trenching in can cost another $0.75 to 1.00 per foot. Use ***Private Water Systems Handbook*** (MWPS-14) (https://www-mwps.sws.iastate.edu/catalog/water-septic-systems/private-water-systems-handbook) or ISU Extension and Outreach publication ***Watering Systems for Grazing Livestock—Livestock Industry Facilities and Environment*** (PM 1604) (https://store.extension.iastate.edu/Product/5107) to help size pipelines. Quick couplers can make tank location easy to change. Black polyethylene pipe is fine if shaded by grass. There is no such thing as burst-proof pipe. Just use black polyethylene pipe available from any supply store (ASTM-2239 or 3408).

If shallow well water or surface water is available, but no electricity, consider accessing the water with one of the following alternative pumping methods.

Nose pump. Sometimes called a pasture pump, nose pumps are an animal-powered system. This pump uses a large diaphragm pump connected to a horizontal piston that cows operate with their nose. The pump is connected to a pond, stream, or shallow well with a suction hose. Water is located in a long narrow trough beneath the piston. As the cow tries to reach the water, she pushes the piston back, drawing about a quart of water into the diaphragm pump. When she releases the piston, the new charge of water is released into the trough. Nose pumps cost $300-500 and can lift water up to 20 feet above the supply elevation. Iowa producer experience suggests that 10 feet is a more reasonable limit on lift, and water can be delivered up to about 100 feet horizontally from the intake. One pump is recommended for every 20-25 cows if the herd is drinking as a group. If cows are in smaller paddocks and are drinking individually or in small groups, one pump may service a few more. Some training period is required for the cows, and calves cannot operate the pump by themselves. Producers report that a small percentage of cows, perhaps 1 in 50, will refuse to use a nose pump. Nose pumps are not suitable for winter use without significant modification.

Gas-powered transfer pumps. These pumps can be arranged to lift water to a supply tank. Automatic start can be accomplished at significant cost. Automatic shut-off can be accomplished with a kill switch operated by a float valve. More often, managers simply calibrate the amount of fuel required to fill the water tank, and supply the engine with only that amount of fuel. Pump and engine units cost $200-600 and deliver

2,000-10,000 gallons per hour at lifts of 5-50 feet. At least three days of water storage is recommended to minimize the need for daily pumping.

Water powered pumps. Water may be pumped from a stream or a pond using the energy of water flowing in the stream or pipe. The hydraulic ram pump uses the momentum of flowing water to create a water hammer effect that creates a small flow at higher pressure. At least four feet of drop and a way to discharge excess water are needed. Ram pumps cost $200-600 dollars and are very reliable if there is excess water available for use. They may take 4-8 gallons of waste water for every gallon pumped and can generate high pressures. Sling pumps require flowing streams at least 12-18 inches deep. The seasonality of stream or river flow rate affects the volume of water pumped. Since they operate 24 hours a day, excess water overflow at the delivery point must be controlled to prevent mud around the tank. Sling pumps cost $700-1,000.

Solar systems. These are available as commercial packages or can be assembled from components. Costs for complete systems can range from $1,000 to as much as $4,000. The variation in price comes from the electric capacity of the solar panel, the type of pump, and the height the water must be lifted.

Solar pumps are effective at providing water to grazing cattle in remote locations. Photo by Denise Schwab.

A solar panel(s) can be wired directly to the pump, or be installed to charge a battery that runs a DC pump. Electrical storage can be provided with batteries or water storage can be provided with extra tank size. A minimum storage capacity of three days is recommended for solar systems to carry through cloudy days.

The volume that can be pumped varies with system capacity, the hours of sunshine, and the height of lift. Solar systems can pump from 750 up to 1,500 gallons per day. While the initial cost of solar pump systems is high, they are well suited for use in remote locations. However, solar systems may be targets of vandalism.

Battery pumps. Simple pumping systems can be constructed using sump pumps that work off 12 or 24-volt batteries, a good rechargeable marine battery, an on/off tank fill switch, and miscellaneous wiring and piping. This battery system is portable, economical, uses locally available parts, and can move large volumes quickly if there is minimal pumping height. If large volumes of water are required, or more pumping height is needed, the battery life between recharging can be as short as one day. As new, more efficient pumps become available, battery life can be extended. Situations vary, but between 3,000 and 15,000 gallons can be pumped per battery charge. As with most livestock watering systems, the float switch must be protected from stock to prevent unnecessary pumping and damage.

Wind systems. Commercial windmills and piston pumps can cost around $4,000 and need to be positioned over a well for the supply. Piston pumps have been very common. Air pumps that inject bubbles to lift the water need a well water depth of at least 30 feet, do not need to be positioned directly over the well, and cost around $1,800.

A second wind-powered option is to use a wind generator to charge a battery that operates a DC pump. A 400-watt wind generator attached to a 12-volt deep cycle battery can power a diaphragm transfer pump similar to those used on a spot sprayer. Consult suppliers for the proper sizing combination of wind generator, battery, and pump. Wind systems should be installed with a minimum of three day storage capacity of water or electricity.

Hauling water. Long-term grazing systems should not be developed on the basis of hauling water to livestock in water wagons, although this might be considered as a temporary solution or in emergency situations. The cost of hauling water one mile is about $0.01 per gallon.

Water lines placed under the fence are better protected from livestock and machinery traffic. Photo by Denise Schwab.

Distribution systems for individual paddocks

In most cases, pumping water through a system of pipes and valves is required to provide water for all paddocks or pasture subdivisions. Such a distribution system also requires a pump that can develop sufficient pressure to push water through several hundred feet of piping and perhaps several elbows, junctions, and valves, to a tank that may be at an elevation many feet above the water supply, at a rate sufficient to satisfy the thirst of the animals. With relatively low flow rates (about 2-6 gpm), a 1/4-horsepower electric pump often is sufficient.

Small capacity, portable water tanks can be used in paddocks where only a few animals drink at a time. Tanks that provide for fast refill should be used. Photo by Mike Collins.

Pipes less than one-inch in diameter are seldom recommended, and 1.25 or 1.5-inch diameter pipe should be considered for distances of more than 1/4 mile. Refer to ISU Extension and Outreach publication ***Watering Systems for Grazing Livestock—Livestock Industry Facilities and Environment*** (PM 1604) (**https://store.extension.iastate.edu/Product/5107**) for pipe sizing.

Flexible polyethylene plastic pipe is readily available in coils of up to 500 feet. Common sizes range from 3/4- to 2-inch diameters. Always use pressure-rated piping, and select UV-stabilized pipe for above-ground use. One-inch black plastic pipe costs approximately $0.30 per foot, and 1.5-inch pipe is about $0.60 per foot. For above-ground use, white pipe will stay slightly cooler than black, but it costs approximately twice as much. If water lines are placed in the fence row, they will be less susceptible to livestock damage and will be quickly shaded by vegetation.

Buried lines are protected from animal damage and will stay cooler than above-ground lines. The cost of trenching in plastic water line is approximately $1.00-1.50 per foot. Some supply companies have developed new, more durable above-ground piping systems and quick coupler hydrants that reduce but do not eliminate the potential for winter freeze and rupture. UV-stable, polyethylene portable tanks (30-75 gallons) with float valves and quick coupling devices cost approximately $50-150 each. Small capacity, portable tanks require a fast refill valve and must be stabilized to prevent tipping.

A poorly designed or installed piping system can result in an inadequate water supply to animals, even though the source is adequate. When paddocks are developed, evaluate the layout for watering locations to minimize costs. Water supply equipment dealers may be able to provide additional assistance in water system design.

New ponds or wells for water supply and livestock water systems may be eligible for financial assistance through some USDA programs. Even with assistance, development expense may exceed the cost of piping water from existing water sources farther from the pasture. Pond locations are limited by topography and soil characteristics. Locations of new ponds with respect to the grazing area can significantly affect cost and complexity of the entire grazing system.

Designing a pasture system—an example

Once a paddock rotational plan is in place, it can be put into practice. Figures 3.10 through 3.13 show the steps of a farm that is switching from continuous grazing to an eight-paddock rotational grazing system. The water sources for this pasture are a good well and a shallow pond, both located at the building site. The buildings are in the lowest part of the site. There is a low, wet area northwest of the buildings, a south-facing slope along the northern property line, and a north-facing slope along the south property line.

The land with buildings and a perimeter fence is shown in Figure 3.10. The eight-paddock system can be implemented gradually over a period of years or all in one year.

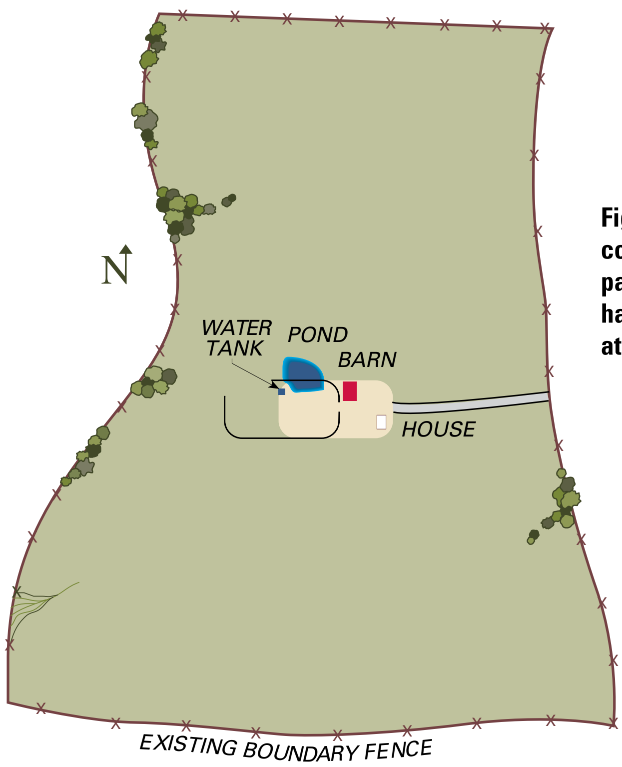


Figure 3.10. Existing continuously grazed pasture. Water and handling facilities are at the building site.

Figure 3.11 shows an example of a first-year conversion to a four-pasture rotation. To maintain water quality, the pond has been fenced off. Well water will be pumped to a waterer in the barnyard. All pastures have a gate at the barnyard. This avoids the need to create lanes and makes livestock handling and rotation possible at a central handling facility. It also allows one water source to provide water for all pastures. This arrangement is not necessary for most pasturing systems but essential for milking herds that return to the barn daily. The pasture 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 these considerations. This first-year conversion to a four-pasture rotation will result in improvement in production over the continuously grazed system of Figure 3.11. The fencing can be either permanent or temporary and may be the final stage of setting up a four-pasture system or the first step to establishing the proposed eight-paddock rotational system. Fencing may be done with high tensile wire or some form of multi-stranded wire. However, barb wire should never be used for electric fencing.

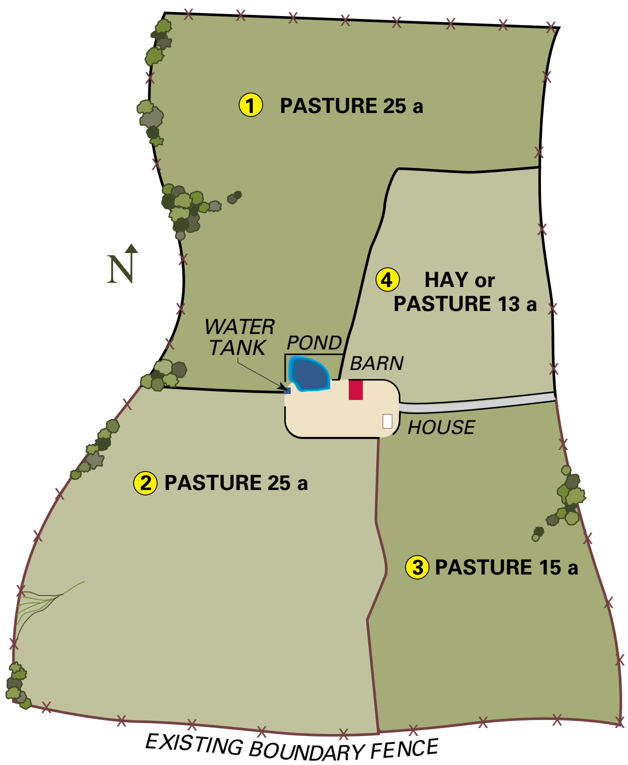


Figure 3.11. The site is divided into four pastures. All pastures are accessible to water at the building site. This may be the extent of the changes planned, or a partial installation of a more complex rotational system plan.

Figure 3.12 shows the next step of the process and the set of divisions needed to form the eight-paddock grazing system. The divisions have been made with portable fencing, which can be moved when harvesting hay or spreading fertilizer. In this refinement, the south-facing slopes were all fenced separately from other areas so that they can be grazed earlier than other paddocks in the spring. The low area northwest of the pond was fenced into a separate paddock because production would be much higher there than in 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 they have equal areas. (If paddocks are not equal in forage production, flexible rotations must be managed based on forage that is available.)

In Figure 3.12 access to water, handling facilities at the building site, and to other paddocks is through lanes. A water delivery system using pressurized water lines could easily be installed in this eight-paddock layout, which would provide water access in each paddock (Figure 3.13). Installing a water trough in each paddock would improve the uniformity of forage use and manure nutrient distribution in each paddock while reducing soil erosion in the lanes.

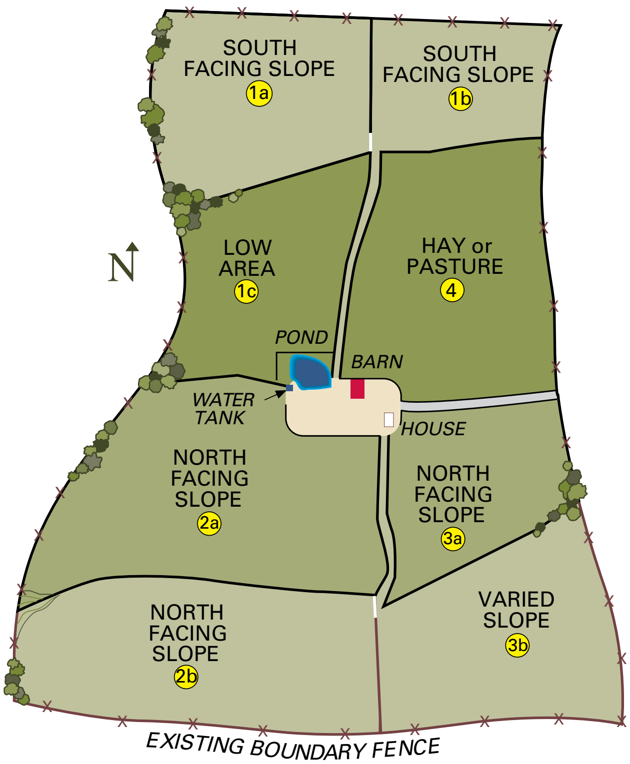


Figure 3.12. The site divided into eight paddocks with lanes providing access to other paddocks and to water at the building site. A water delivery system could be installed for this plan to provide water accessibility in each paddock.

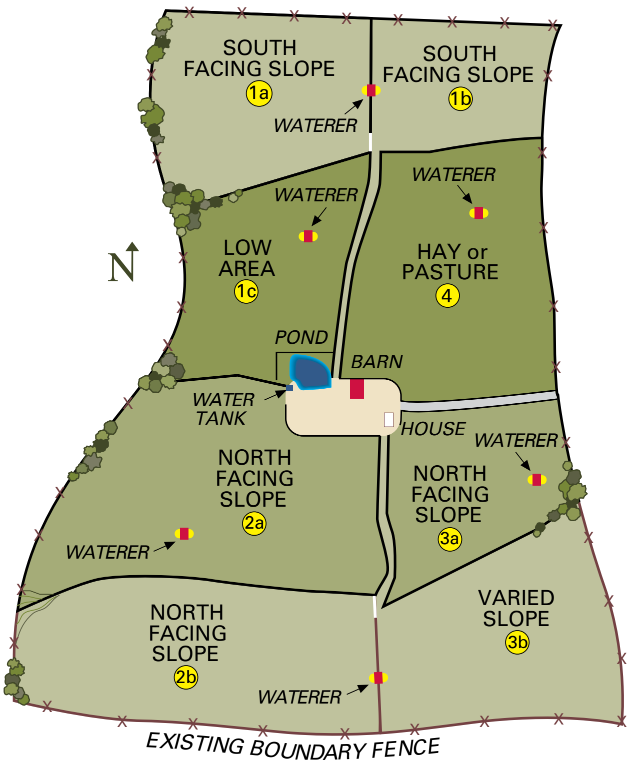
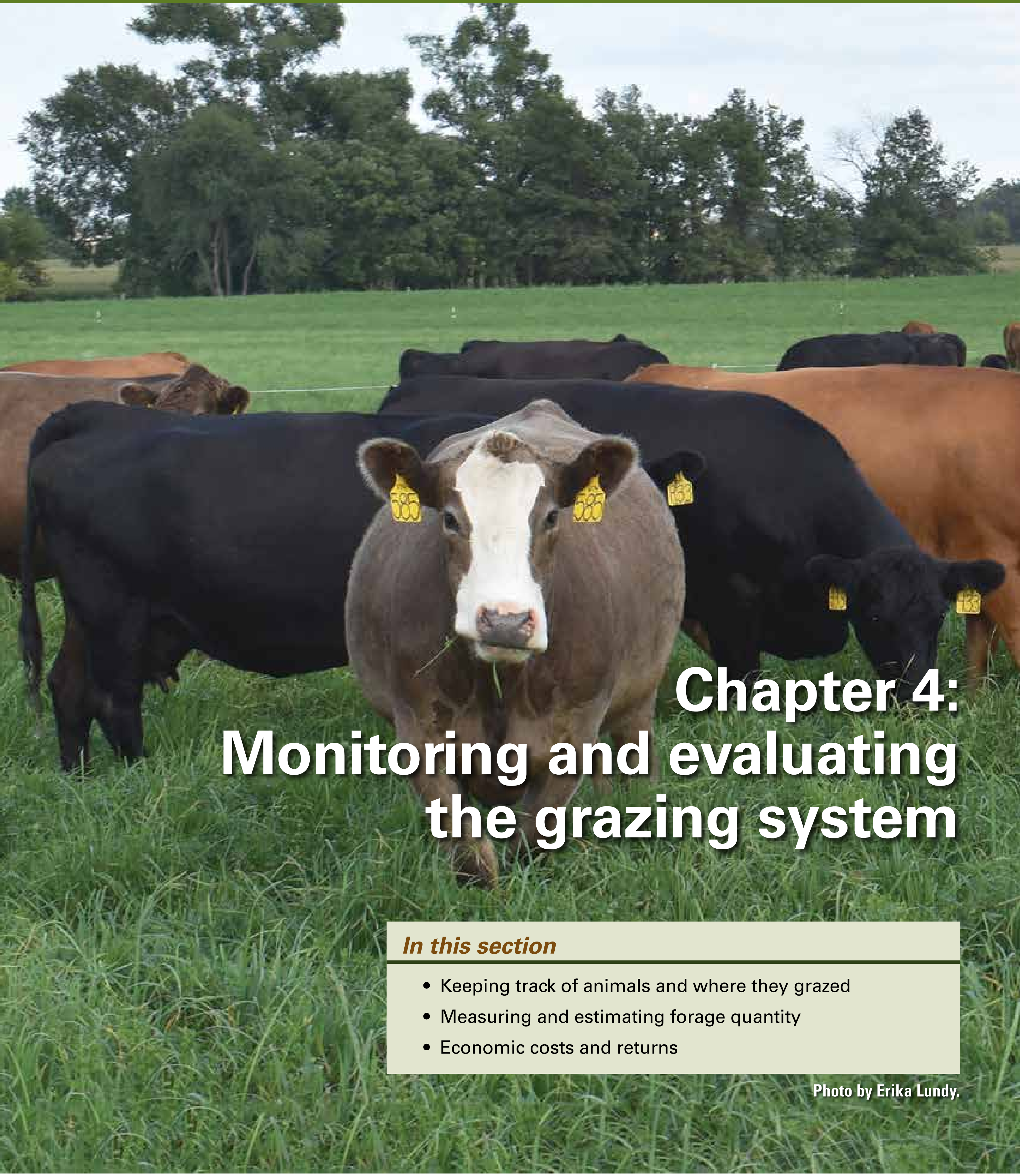


Figure 3.13. A waterer delivery system has been installed in each paddock to provide water accessibility.



Chapter 4: Monitoring and evaluating the grazing system

In this section

- Keeping track of animals and where they grazed
- Measuring and estimating forage quantity
- Economic costs and returns

Photo by Erika Lundy.

Records need not be complex

Record keeping is a management practice that provides a history of conditions and experiences as they occur. Producers may use this "as it really was" information to objectively evaluate, revise, and plan their grazing enterprise. Records for use in grazing management are not difficult, but they will help determine if management practices are on target to reach their goals. Some simple records that may be useful are discussed here.

Animal performance

Records are probably already kept on your livestock. Birth dates, breeding dates, calving and lambing dates, etc., are all useful in monitoring the reproductive efficiency and performance of individual animals and the herd.

Because production of animal product is the ultimate determinant of gross profit, performance records can be one indicator of management problems. However, net profits also are affected by production costs. High levels of production inputs and costs may produce a high level of animal performance but at unsatisfactory net profits.

Pasture productivity

Grazing days

Using a mobile device to record dates of grazing moves between pastures and numbers of animals is a simple pasture record keeping system. Photo by Samantha Jamison.

The simplest pasture records list how many animals were on a particular pasture or paddock and for how long. The record can be as simple as a notebook entry identifying what day the animals entered a pasture and what day they were removed. There are also programs that can used on a computer or mobile device to record information about the herd. In a season-long, continuously stocked system, the record is the total number of grazing days multiplied by the number of animals grazing. In rotational grazing systems, it is important to number or name each pasture or paddock because the turn in and the exit dates are identified for each location. (Figure 4.1 illustrates a simple method for tracking grazing days in a rotational system.) At the end of the season, the grazing days record provides interesting information such as how many times a particular paddock was grazed in the rotation and the amount of grazing days each paddock provided. This information can be interpreted as a measure of the paddock's seasonal productivity. If the records show that one paddock is more productive than another, the manager can use the information to consider dividing the paddock into two, increasing the flexibility of the system even more. Over time, information on the productivity of the pastures or paddocks can indicate problems with fertility or species composition that may need addressed in a long-term pasture management plan.

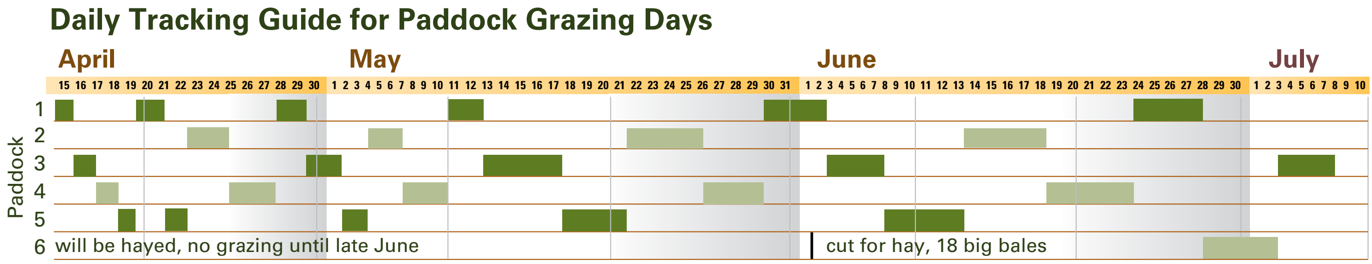


Figure 4.1. Example of daily tracking guide for paddock grazing days.

Measuring forage heights

Some rotational grazing managers use a management strategy of "take half, leave half," meaning they plan to graze only half of the forage present and leave about half of the residual leaf area for rapid recovery following grazing (Figure 4.2). To record this management strategy, the manager measures the plant height as animals enter the paddock (this is considered the in height). To determine the in height, measurements are taken of short and tall areas at 20-50 random locations throughout the pasture and an average height is calculated. A second measurement is taken one or more days later when approximately half the forage has been grazed to verify how much of the original height still remains. If, based on this measurement, the decision is made to move the animals to the next paddock, the second measurement is recorded as the out height. As the season progresses, these in and out heights often get progressively shorter, but producers are often surprised to learn just how much forage could be left for sod maintenance and plant vigor.

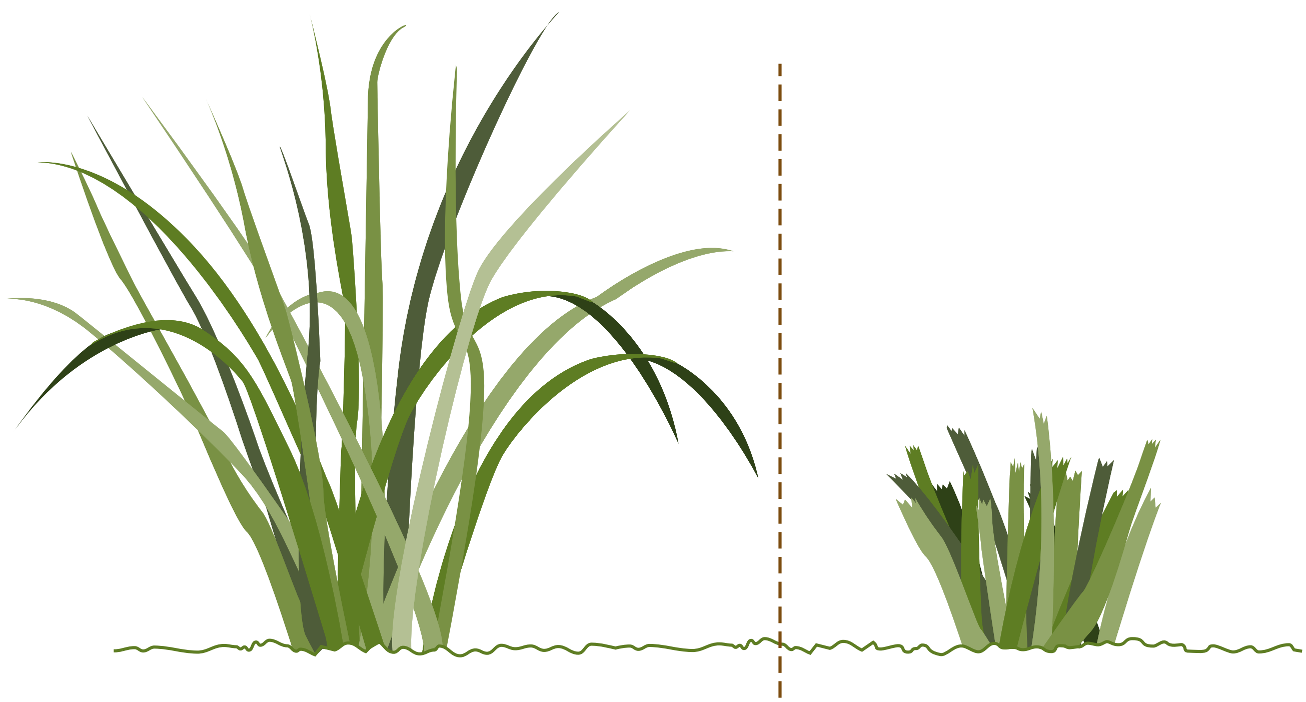


Figure 4.2. As a simple management guide, some producers check paddocks regularly until half of the initial measured growth is grazed, and then rotate the animals. This is commonly called the "take half, leave half" strategy.

The average height of the forage is related to how much forage is present. Knowing how much forage is available can help in budgeting feed, predicting gradual changes in regrowth rate, and making strategic management changes to minimize the effect of the changing forage supply before it becomes a crisis. The following section discusses several methods for using forage height to estimate forage quantity.

Although clipping, drying, and weighing the forage on a regular basis is the most accurate estimate of pasture productivity, it is time consuming and costly. Photo by Samantha Jamison.

Techniques for estimating forage quantity

Setting appropriate stocking rates for a pasture or paddock requires knowledge of the amount of forage available for grazing. The more intensively a pasture system is managed, the more important it becomes to be able to estimate the quantity of available forage. Many pasture managers develop an ability to estimate the amount of forage available or how long a pasture or paddock can be grazed by a given group of animals through their own experience which can take years to develop. For others, there are several methods to estimate the available forage, ranging from the very simple to the relatively complex.

Clip and weigh

The most accurate method to assess the amount of forage in a pasture or paddock is to clip 5-15 samples in a one or two square foot area. Once collected, dry the samples in an oven and weigh them. The average amount of forage available is equal to the dry weight divided by the total area sampled and calculated to pounds per acre. It is important to clip several samples and to be sure the samples represent the variation within the pasture. The number of samples necessary depends on the uniformity of the pasture or paddock. The more variable the forage growth, the greater the number of samples are necessary to get a good estimate. This principle applies to all the measurement methods discussed.

Estimating forage availability from pasture height measurements is probably the simplest method for most producers. Photo by Erika Lundy.

Using height to estimate pasture supply

Obviously, clipping is too time consuming to be a practical method to routinely estimate pasture quantity. Faster and easier methods for estimating forage quantity have been developed. Probably the simplest is to measure the height of the sward. This can be done easily with a yardstick. Record the height of the forage as it stands naturally at several locations within the pasture or paddock and averaging the measured heights. The amount of forage present is equal to approximately 200-500 lb per inch per acre of standing forage. Table 4.1 lists general guidelines for estimating the amount of forage. An alternative to using a yardstick is to use a grazing stick which are sometimes distributed by U.S. Department of Agriculture Natural Resources Conservation Service (NRCS) offices or organizations such as the Iowa Cattlemen's Association. The height measurement estimate can be verified by using the clip and weigh method on samples taken at the same sites where the measurements were taken and calculating the pounds per inch as measured. The biggest drawback with the sward height technique is that it fails to take plant density into account. It works best on dense, uniform pastures.

Table 4.1. Estimated lb dry matter per inch for forage type and pasture condition.

	Pasture condition		
Forage type	**Fair**	**Good**	**Excellent**
Smooth brome + legumes	150-250	250-350	350-450
Orchardgrass + alfalfa	100-200	200-300	300-400
Mixed pasture	150-250	250-350	350-450
Bluegrass + white clover	150-250	300-400	450--550
Tall fescue + legumes	200-300	300-400	400-500
Tall fescue + nitrogen	250-350	350-450	450-550

Note: Forage height is measured as natural plant position (leaves are not stretched or extended).

Estimating forage availability from pasture height measurements is probably the simplest method for most producers. This can be done using a density meter. Photo by Samantha Jamison.

Using a density meter

Researchers have developed other techniques that attempt to take the density of a sward into account. One of these techniques is the density meter, which is used at Iowa State University. The density meter consists of an 18 x 21.5 inch plexiglass plate attached to a PVC tube and weighs 2.6 pounds. The tube rides over a calibrated aluminum pole in the center of the plate. The pole is placed in the center of the area to be measured and the plate is allowed to settle under its own weight on top of the sward. The height of the plate is recorded and the amount of forage is determined using a calibration table (Table 4.2). Commercially available density meters record density values from a number of field positions and can immediately convert those values into yields. Using a density meter is a little more work than measuring simple sward height but it generally gives more accurate results, especially when sward density varies within a pasture. Various shapes and weights of density meters can be constructed but each must have its own calibration to be used effectively.

Table 4.2. Estimated lb live dry matter per inch using a density meter. Calibration for density meter covering 2.69 square feet with a compression of .98 lb/sq ft.

Compressed sward height inches	Live forage dry matter lb/acre	Compressed sward height inches	Live forage dry matter lb/acre
1	263	11	2793
2	516	12	3046
3	769	13	3299
4	1022	14	3552
5	1274	15	3805
6	1528	16	4058
7	1781	17	4311
8	2034	18	4564
9	2287	19	4817
10	2540	20	5070

Grazing sleds to measure forage quantity

The major limitation of using clipping, forage height, or disk meters is the limited number of locations that can be measured. To more accurately estimate forage quantity over a large area, grazing sleds have been developed. The sleds are pulled behind an all-terrain vehicle and measure forage quantity by displacement of a metal plate, obstruction of infrared light beams, or measurement of the intensity of green color. While forage yield may be estimated with the internal calibration of the instrument, it is likely that producers will need to calibrate the instruments using their own pasture conditions. These instruments are usually equipped with global positioning system (GPS) receivers to map forage yield across the pasture. At the time of this manual's publication, grazing sleds are being marketed and used in Australia and New Zealand, yet are still in the research and development phase in the United States.

Regular and systematic evaluation of pastures provides a basis for making management improvements. Photo by Erika Lundy.

Pasture condition scoring

A comprehensive evaluation of a pasture at any point in time reflects the impact of recent animal use and can alert the manager to actual or potential harm to forage productivity and environmental quality. Pasture condition scoring is a systematic way to check how well a pasture is being managed.

By rating key indicators common to all pastures, pasture condition can be evaluated and the primary reasons for a low condition score identified. Among the factors included in pasture condition scoring are plant composition, plant vigor, livestock use impacts, soil cover, and indicators of pasture problems such as weed and brush encroachment and active soil erosion.

The pasture condition scoring system most often used in the Midwest has been compiled and modified by several groups. ***The Guide to Pasture Condition Scoring*** and accompanying ***Pasture Condition Scoring Sheet*** are available from the NRCS. The guide uses visual evaluation of indicators (listed on next page) that rate pasture condition. Each indicator has five conditions, ranging from lowest (1) to highest (5). This objectively ranks the extent of any problem(s) and helps sort out the likely cause(s). When completing the process, evaluate each indicator separately. The plant vigor indicator can be analyzed further by rating six factors that cause plant vigor to be at its current level. Erosion also can be further evaluated by erosion type.

Pasture condition scoring should be done several times during the growing season. The same pasture, even a well-managed one, will look and score differently as the season progresses. Because it is a real-time evaluation, general indications of management practices that merit consideration or immediate attention can be identified. To be most useful, it is important to compare condition scores taken at the same time over several years. This kind of comparison provides a measure of change resulting from management and can indicate positive benefits from improved management. Deterioration of conditions can indicate areas for management improvements.

Factors included in pasture condition scoring

- Plant cover
- Plant residue
- Plant diversity
- Percent legume
- Plant vigor
  - Soil fertility (N, P, and K)
  - Severity of forage use
  - Forage species adaptation
  - Climatic stress
  - Soil pH
  - Insect and disease pressure
- Livestock concentration areas
- Uniformity of use
- Soil compaction
- Erosion
  - Sheet and rill
  - Streambank, shoreline, and gully
  - Wind

Pasture costs

How much does it cost to graze a cow or ewe for a day in a pasture? This amount isn't known unless records of pasture costs are kept. Some producers consider that they have little or no costs, but they often are not realistic in how they attribute costs and product values. Fence repair, weed management, fertilization, and labor are reasonable to charge to the pasture system, but the biggest cost of the pasture system is the value of the land. And this cost will only increase as the amount of pasture land decreases through conversion to crops and other uses. At a minimum, the pasture's rental value in the marketplace should be charged as a pasture cost. In some grazing systems, the rental value and pasture costs may be low per acre, but if it requires 3-5 acres to support one cow, the pasture cost per cow may be unreasonably high.

ISU Extension and Outreach beef cow enterprise records show that some pasture systems are very economical and some are quite costly. For example, the 10-year average for 1994-2003 SPA Beef Cow Business Record summaries showed an average daily grazing cost (economic) per animal unit was $0.40. When the farms enrolled in the program from 1995-2000 were divided into fourths for profitability, daily costs per animal unit were $0.216 for the "high profit" fourth and $0.411 cents for the "low profit" fourth. These translate into monthly costs of $6.47 and

$12.33, respectively, or a difference of more than $35 per cow-calf pair over a six-month grazing season. For the herds summarized during this 10-year period, the number of pasture acres per standard cow-calf pair averaged 2.5 acres for the producers enrolled. Average pasture cost per standard cow-calf pair on an economic basis was $111.69. These pasture costs accounted for 25.4 percent of the $439 per cow total cost. Pasture costs for individual producers varied greatly.

To learn more about pasture and livestock enterprise records, contact ISU Extension and Outreach for more information on how to get started. There are Livestock Enterprise Budget spreadsheets available on the Ag Decision Maker website for beef cow-calf herds and ewe flocks (**https://www.extension.iastate.edu/agdm/ldfirst.html**). An example of these spreadsheets can be seen in Figure 4.3. These tools are very useful for looking at alternative scenarios involving facilities, feed rations, or any other management change not only on a daily basis but also provide a way to evaluate annual animal production costs, including the significant costs of winter feeding. The Ag Decision Maker website also has spreadsheets to evaluate costs and returns to whole farm enterprises including a tool to compare land use alternatives which allows a comparison of the profitability of various crop production enterprises to grazing beef cattle or enrolling into the Conservation Reserve Program (CRP) on different soil classes.

Whatever record keeping system is used, it should be adequate to evaluate and monitor costs and returns over time. After all, one of the main objectives of any grazing enterprise is to constantly improve profitability by reducing input costs. The first step to profitability if good record keeping. Records give the information needed to make sound business decisions. Keeping records with the necessary level of detail requires both a system that works for the business and the motivation and discipline to maintain the records. The incentive is the ability to increase profitability and improve the profitability of long-run business success. Having good record systems in place will make record keeping much easier and analyzing records will allow informed business decisions. It is important to keep in mind that records are only useful if they are summarized to allow for comparisons and to provide values to identify when and where changes are needed. It is then up to the manager to implement changes and evaluate these changes and their impact on the enterprise.

Beef Cow-Calf (one cow unit)

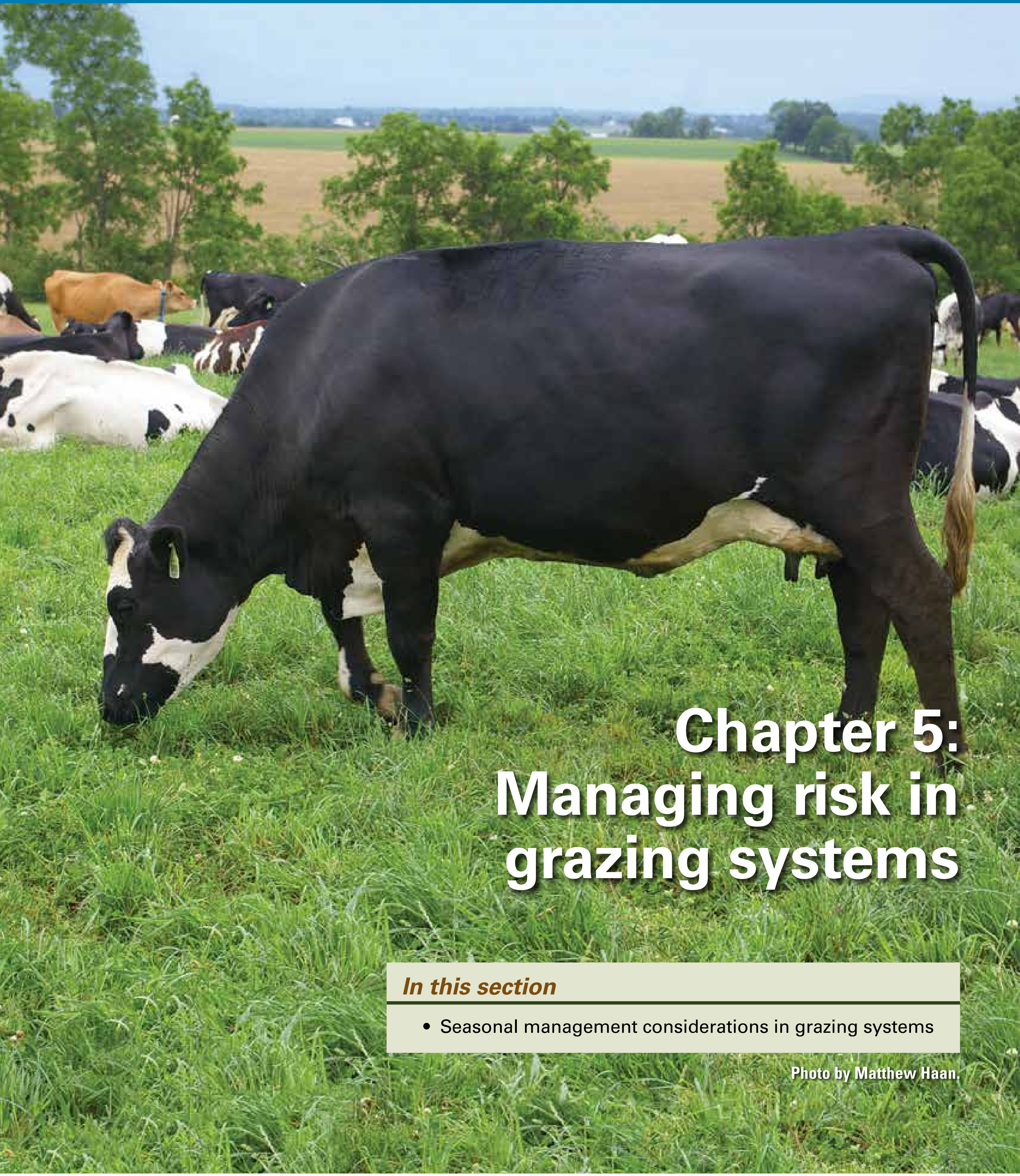
Ag Decision Maker -- Iowa State University Extension and Outreach
For more information see Information File B1-21 Livestock Enterprise Budgets.

Place the cursor over cells with red triangles to read comments.
Enter your input values in shaded cells.

Hay and Pasture Calves Sold

Production Efficiencies										
Calf weaning rate	92%									
Calf death loss	0%									
Cow death loss	2%									
Cow replacement rate	16%									
Income	**Price**	**Unit**		**Quantity**	**Unit**					**Total**
Heifer calves	$1.60	per lb	x	500	lbs	x	0.30	head	=	$237.39
Steer calves	$1.75	per lb	x	550	lbs	x	0.46	head	=	442.75
Cull cows	$0.64	per lb	x	1350	lbs	x	0.14	head	=	120.96
Gross Income										$801.10
Variable Costs										
Feed Costs	**Price**	**Unit**		**Quantity**	**Unit**					
Pasture	$50.00	per acre	x	2.5	acres				=	$125.00
Pasture fert. & misc. costs	$20.00	per acre	x	2.5	acres				=	50.00
Corn	$3.15	per bu	x	4	bu				=	12.60
Modified distiller grain	$50.00	per ton	x	0	tons				=	0.00
Salt and minerals	$0.09	per lb	x	60	lbs				=	5.40
Supplement & minerals	$0.16	per lb	x	0	lbs				=	0.00
Alfalfa - brome hay	$95.00	per ton	x	2.1	tons				=	199.50
Corn stalks	$3.00	per acre	x	4	acres				=	12.00
Other										0.00
Total Feed Costs										$404.50
Veterinary & health										$25.00
Machinery, equipment, fuel & repairs										30.00
Marketing & miscellaneous										20.00
Other										0.00
Interest on variable costs	5%		x	6	months				=	11.99
Labor	$14.00	per hr	x	8	hours				=	112.00
Total Variable Costs										$603.49
Income Over Variable Costs										$197.61
Fixed Costs										
Machinery, equipment, housing & fences										$65.00
Interest & insurance on breeding herd										110.00
Bull depreciation/replacement										20.00
Total Fixed Costs										$195.00
Total All Costs										$798.49
Income Over all Costs										$2.61
Breakeven selling price for variable costs (per lb)										$1.20
Breakeven selling price for all costs (per lb)										$1.69

Figure 4.3. Example of beef cow-calf spreadsheet from Ag Decision Maker.



Chapter 5: Managing risk in grazing systems

In this section

- Seasonal management considerations in grazing systems

Photo by Matthew Haan.

Managing risk in grazing systems

Throughout this publication, readers have been introduced to pasture plants, how they grow, and what they require to remain vigorous and productive. The animals grazing the pastures have changing nutritional needs that don't necessarily match the supply and nutritive values of the forage. Readers have probably already decided to either use continuous stocking for the grazing season or some form of rotational grazing. No matter what management system is chosen, decisions made about the animal or forage system come down to forage budgeting and the best way to keep the pasture growing.

When the proper balance between animal needs and forage supply has been achieved and the weather is average, management decisions are generally routine. Yet even with average weather in the Midwest, there will be a year or two that rainfall will be significantly above or below normal and adjustments will have to be made either in the number of animals, surplus forage harvested, or supplemental feed fed. This section addresses some of the most likely approaches to balance the forage supply over the grazing season and some specific strategies to consider in excessively wet or dry years.

Pastures shouldn't be grazed in the spring until forage is at least 3-4 inches tall. Photo by Erika Lundy.

Using several forages through the grazing season

Gaining the maximum amount of the year's nutrition from grazed forage is an important factor in the management of profitable grazing enterprises. The key to success in grazing-based animal production systems is to match the number of animals, genetics, and the management system with the types and amounts of forage available for grazing at different seasons of the year and to minimize the amount of expensive stored feeds needed.

Meshing these variables can be challenging. Iowa producer records show that feed costs make up about half the costs of producing livestock and that the amount of stored feed fed is the single largest factor separating high- and low-profit livestock producers. Optimal grazed forage use means sustaining animal performance on pasture with minimal use of stored feeds, without damaging the forage, soil, and water resources.

Growing season considerations

Early spring brings slow forage growth. (See Table 5.1 for a summary of management practices for the growing season for beef cow grazing systems.) Excessive early grazing of pastures may adversely affect forage growth for the rest of the summer. During early spring, animals shouldn't graze until forages are at least 3-4 inches tall and actively growing. This can be a difficult decision, particularly when winter feeding areas are muddy or stored feed supplies are low.

Table 5.1. Best management and risk management practices for a summer grazing system for beef cows.

Season	Best management	Risk(s)	Risk management
Mid-spring	Fertilize grass pastures with nitrogen.[1] Begin grazing when forage is 3-4 inches tall. Rotate animals to new paddocks every 1-2 days to synchronize with rapidly growing forage.	Poor forage growth caused by cool temperatures.	Graze an additional pasture of stockpiled perennial forage or a cold-tolerant small grain species. Feed stored feeds.
		Poor forage growth and soil compaction caused by grazing under muddy conditions.	Graze an additional sacrifice pasture that may be easily renovated.
Late spring	Rotate animals to new paddocks every 1-2 days until grasses begin to show seedheads.	Poor forage quality caused by excess forage growth.	Removal of excess forage as hay from 1/4 to 1/3 of the total pasture acres. Graze extra animals such as fall calves or replacement heifers with cows to remove excess forage.
Summer	Rotate animals to new paddocks when 1/2 of the forage is removed to synchronize rotation with slow-growing forage and to reduce grazing selectivity by cows. There should be an adequate number of paddocks to ensure a minimum rest period of 30 days between grazing episodes.[2,3]	Poor forage growth of cool-season species in midsummer heat.	Incorporate legume forage species into pasture with cool-season grass species. Plant warm-season grass species into several paddocks for midsummer grazing.
		Poor midsummer forage growth caused by drought.	Incorporate drought-tolerant legume forage species into pastures with cool-season grasses. Remove extra animals from the pasture. Creep feed calves. Early wean calves. Feed stored feed to cows in a sacrifice paddock.
		Low forage availability because of overgrazing in spring.	Feed stored feed to cows in a sacrifice paddock. Increase pasture acreage to stockpile for winter grazing.
		Fescue toxicosis	Prevent or cut seedheads, interseed legumes, or renovate with novel endophyte or endophyte-free varieties of tall fescue.
Early fall	Rotate animals to a new paddock every 1-2 days to synchronize rotation with rapid growth of cool-season species.[3]	Reduced persistence of legume forage species.	Move cows to paddocks containing only grass and allow legume pastures to rest for at least 30 days before a killing frost.
		Poor forage growth caused by overstocking.	Wean calves. Graze forage stockpiled on hay fields. Graze corn crop residues. Feed stored feeds.

[1] Application of nitrogen fertilizer to mixed grass-legume pastures will reduce persistence of desirable legume forage species.

[2] Increasing the number of paddocks up to eight significantly increases the length of the rest interval.

[3] Maintain minimum forage height at no less than four inches near streams to prevent water pollution.

Alternatives to placing animals on permanent pastures too early include:

- The use of a sacrifice pasture that easily can be renovated
- Stockpiled cool- or warm-season grass species with or without legumes
- Fall-seeded small grain cover crops such as rye

In mid to late spring, expect rapid forage growth and excess forage. An efficient rotational grazing system maintains forage in an immature vegetative state by frequent animal movement, in most situations only topping off the forage. It also includes some hay harvest and possibly temporary grazing by replacement heifers, stocker steers, or dry dairy cows or ewes to increase short-term stocking rates. Producers using continuous stocking will be unable to use the forage as rapidly as it grows and often cannot graze it before it reaches maturity.

Keeping the forage in an immature state during the spring has advantages; the forage continues to grow vegetatively throughout the remainder of the season and the negative effects that forage maturity has on digestibility in late summer are reduced.

Allowing animals to eat 50 percent of the forage in a paddock usually leaves adequate leaf area for rapid plant regrowth during the rest period. Photo by Denise Schwab.

As temperatures increase in early to midsummer, growth of cool-season forage species slows, leading to a decreased forage supply. Summer grazing strategies can include removing extra animals placed on pastures to use excess spring forage, and slowing the rate at which animals are rotated in the grazing system to allow for longer rest periods. A goal of summer grazing management is an adjustment of rotation and stocking to ensure adequate leaf area will remain to allow for timely regrowth. A simple management objective is to remove up to 50 percent of the vegetation present. A good approach to effectively implement the 50 percent removal strategy is to use one of several quick and easy measurement methods. (See Chapter 4, "Pasture productivity, measuring forage heights and techniques for estimating forage quantity.") In practice, if 50 percent is removed in each grazing cycle without adequate rest, overgrazing may result. Maintaining a minimum forage height of four inches in paddocks near streams is needed to prevent pollution of pasture streams.

In slow regrowth periods, the best way to maintain forage availability is to lengthen the rest period or reduce the number of animals. In rotational systems, the slower movement of animals between paddocks allows for lengthened rest periods for paddocks. When rotating animals to maintain forages, either increase the time animals are in a paddock if permanent fences are used, or decrease paddock size if temporary fences are used. Continuously stocked pastures may have adequate carryover forage from the spring excess, but frequently hay must be fed or the number of animals reduced in midsummer to meet the forage needs of the livestock.

During midsummer, the growth of cool-season grass species like Kentucky bluegrass or smooth bromegrass may be limited. Using forage species that grow well during warm weather (legumes, orchardgrass, and reed canarygrass) can help stabilize the forage supply during this period. Legumes are valuable as midsummer forage because of their nutritive value as well as more uniform growth. Many producers harvest a first cutting from hay fields and use the summer regrowth for summer grazing.

One or more pastures containing warm-season grasses may also be considered as a means to provide midsummer forage. Warm-season grass species may be difficult to establish and manage. When grazing them in a late vegetative stage, stem formation and maturity may be prevented and more rapid regrowth encouraged, but this management may impair persistence.

Endophyte-infected tall fescue may cause reproductive or health problems in grazing livestock, particularly in midsummer. The problems may be reduced by clipping seedheads, preventing seedheads with metasulfuron-based herbicides, increasing proportions of legumes, moving cattle to pastures that contain other forage species, or renovating pastures with tall fescue varieties that are endophyte-free or contain novel endophyte. More detailed information on prevention of fescue toxicosis is provided in Chapter 2, “Health considerations of grazing animals.”

Drought or wet years may be critical times. One option to manage during these adverse conditions is to stock pastures at a level 20 percent below the maximum for that pasture in a normal year. During a drought year, wean nursing animals early to decrease the number of animals in the pasture and decrease nutrient requirements of lactating beef cows or ewes. Feeding supplements such as hay or grain are essential for dairy cows and may be necessary for beef cows, stockers, and ewes. Under short forage situations, creep feed may be used as a supplement for calves. Maintain a sacrifice pasture for feeding stored feeds to allow other pastures to recover for later grazing or to improve winter survival.

In late summer to early fall, cool-season forages resume more rapid regrowth. The rate of growth and the amount of forage will be related to midsummer management and weather conditions. If forage has been kept in a vegetative state with adequate residual leaf area for photosynthesis, late summer forage growth will be good. If forage has been allowed to mature or has been overgrazed, late summer forage growth will be minimal.

Legumes are more productive than cool-season grasses during the warm summer months. Photo by Erika Lundy.

Warm-season paddocks also can be productive components of grazing systems during the warm summer months. Photo by Samantha Jamison.

The cost of stored feed to maintain livestock during the winter is often the single largest expense in cow-calf and sheep enterprises. Photo by Erika Lundy.

Grazing crop residues and stockpiled forages

Winter feed costs are the largest expenses in cow-calf and sheep production. Managing winter feed resources to minimize these costs is the key to profitable cow-calf production every year. At the same time, the nutritional contents of cow or ewe diets must be sufficient to maintain a condition score of five on a 9-point scale to maintain reproductive performance the following summer. More information on body condition scoring is available in the Beef Cattle Handbook (BCH-5405) ***Cow Body Condition Scoring Management Tool for Monitoring Nutritional Status of Beef Cows*** available on the Iowa Beef Center website at http://www.iowabeefcenter.org/bch/BodyConditionScoring.pdf.

The first step in developing a low-cost winter feeding program is to evaluate the feeds available and use management practices to best use those feeds. (See Table 5.2 for a summary of management practices during winter for beef cow grazing systems.)

Table 5.2. Best management and risk management practices for a winter grazing system for beef cows.

Season	Best management	Risk(s)	Risk management
Late fall	Graze corn crop residues.	Cows have a body condition score of less than 5 on a 9-point scale because body condition was inadequate at the end of summer grazing or because crop residue forage quality or quantity is inadequate.[1]	Adjust stocking rate to give desired performance.[2] Separate heifers and two-year-old cows from mature cows. Simultaneously graze stockpiled perennial forages or cover crops with corn crop residues. Feed hay, grain by-products, grains, and/or protein supplements, based on feed prices, only to maintain a condition score of 5.
		Decreasing forage quality because of excess precipitation.	Simultaneously graze stockpiled perennial forages with corn crop residues. Supplement with stored feeds to maintain a condition score of 5.
		Forage waste caused by grazing under muddy conditions	Strip graze corn crop residues. Temporarily move cows to pasture containing stockpiled perennial forages when muddy conditions exist.
Winter	Graze stockpiled perennial forages after corn crop residues supply is exhausted.	Inadequate forage quality because of excessive length of stockpiling.	Harvest forage as hay or by grazing before beginning stockpiling no earlier than Aug. 1.
		Stockpiled forage supply is rapidly depleted because of uncontrolled intake.	Strip-graze pastures to control access to maintain a condition score of 5.
		Cow body condition score drops below 5 because of inadequate forage amount and quality, snow cover is greater than 9 to 12 inches, or there is ice on top of snow cover.	Feed hay, grain by-products, grains, or protein supplements, based on feed prices, only to maintain a condition score of 5.
Early spring	Calve while continuing to strip-graze stockpiled perennial forages.	Poor subsequent forage growth and soil compaction caused by grazing under muddy conditions.	Graze an additional sacrifice paddock in which hay bales have been stored to prevent tractor traffic, if stored feeds are necessary.
		Inadequate amount of forage to graze.	Graze small grain (rye) cover crops fall-seeded in row crop fields.

1 To maintain adequate reproductive performance in the subsequent year, it is necessary that cows have a condition score of 5 on a 9-point scale at the time of calving. But, excessive body condition should be avoided.

2 Research has shown that cows supplemented with two lb of protein supplement (soybean meal, distillers grains etc.)/day will maintain body condition at grazing allowances as low as one-half acre/cow/month. But, in adverse weather, grazing allowances as high as two acres/cow/month might be needed to increase body condition.

Corn crop residues

Corn crop residues are the least expensive and most abundant winter feed resource on most Iowa farms. It is estimated that the cost of grazing corn crop residues is about $0.15 per cow per day. The amount of residues available for grazing are approximately equal to the weight of grain that was harvested. But grazing cows generally prefer to select wasted grain, leaves, and husks while consuming little stalk. For each bushel of corn produced, approximately 16 pounds of leaf and husk residues are created. Strip grazing will maximize stalk utilization, but a typical rule of thumb is for cows to only effectively graze about half of the leaf and husk material available. A field with a yield of 120 bushels of grain per acre will have 3-4 tons of total residues, but only one ton of leaves and husks. As a result, grazing corn crop residues at 2.5 acres per cow for the winter season reduced annual hay needs by about 1,800 lb per cow. This amount will vary with grain yield. The University of Nebraska's Department of Economics provides an Excel© spreadsheet, **"Corn Stalk Grazing Calculator"** that calculates the costs of matching livestock size and numbers with corn stalk acres (**http://beef.unl.edu/learning/cornstalkgrazingcalc.shtml**).

Grazing corn crop residues at 2.5 acres per cow can reduce annual hay needs by about 1,800 lb per cow. Photo by Denise Schwab.

The number of cows that can be grazed on corn residues depends on the condition of the cows. Cows can maintain bodyweight with access to as little as a half-acre of corn residue per cow per month with minimal supplementation, but may need as much as two acres per cow per month if weight gain on the cow is necessary or if the weather is severe.

Although a common belief is that grazing corn residues reduces soil tilth, research shows that soil compaction is an unfounded fear when cows graze on frozen soil and are removed from fields before the spring thaw. In addition, close to 90 percent of ground cover still remains in fields grazed at a half acre per cow per month.

The nutritive value of corn crop residues varies from year to year. Crop residue quality is highest in years with the lowest grain yields. Grazing cattle will select the portions of the corn residue with the highest digestibility and protein concentration such as the grain, husks, and leaves before consuming stalks. As a result, the need for supplemental feeds beyond trace mineral salt and vitamin A is likely to be minimal for the first month of grazing. As winter progresses and corn stalk residues lose quality because of selective grazing and weathering, protein and phosphorus supplementation may become necessary. Factors to consider include the cow's body condition, the cost of the supplement, and nutritional adequacy. A wide variety of protein sources ranging from high quality alfalfa, grain by-products like distillers grains or corn gluten feed, processed animal litters, or any other dry or liquid supplement can be used, but with a wide range in costs. The decision to use a protein supplement should be based on the cost per pound of protein as well as ease of feeding.

Corn crop residues are highest in nutritional value during the early winter months. Strip grazing is a method that can be used to preserve higher quality crop residues for grazing later in the winter. Photo by Patrick Wall.

Winter grazing of stockpiled grass and legume forages at two acres per cow can reduce the amount of hay needed to maintain cows during the winter by 1.25 tons per cow with minimal supplementation. Photo by James Russell.

Strip grazing may delay the need for supplemental protein and phosphorus longer than a month. Although strip grazing reduces wastage and limits grazing selectivity, strip grazing seems to primarily be effective under dry conditions. Under wet conditions, weathering losses in corn crop residues can be very high regardless of the grazing method. The wetter the year, the more rapidly nutrient digestibility will decrease. Nutrient losses from weathering have been confirmed at 14 percent in a dry year and 41 percent in a wet year over a 140-day winter period.

Harvesting corn crop residues is a more expensive alternative to grazing them. However, mechanical harvest allows use of the residues from fields without fences and in inclement weather. Because animals are less able to select the more nutritious plant parts from harvested residues, supplementation is likely to be more necessary when feeding harvested residues. Grinding forages and using total mixed rations may be desirable when feeding harvested corn residues. However, the overall operation size will dictate the practicality of investing in this feeding equipment.

Stockpiled forages

Many farms in the southern Midwest have inadequate acreages of corn residue to maximize the length of the grazing season. Here, regrowth from hay fields or pasture allowed to accumulate from early August to fall or winter may be used to extend the grazing season and can reduce the need for stored feeds in the winter. An allowance of two acres per cow reduces the amount of hay needed to maintain pregnant beef cows by 1.25 tons per cow compared with feeding all stored feeds in a drylot. Stockpiled fall-fertilized grass or grass and legume fields can provide the supplemental protein lacking in corn residues when fields are adjacent.

Essentially any cool-season grass can be used for stockpiling, but some species (Kentucky bluegrass, smooth bromegrass, reed canarygrass) are less productive and weather at a faster rate making them less useful. Because of its fall growth and persistence under grazing, tall fescue has been very useful in stockpiling systems. However, orchardgrass has proven to be a good alternative to tall fescue. If tall fescue is used, endophyte-free or novel fescue varieties are recommended. If endophyte-infected tall fescue is stockpiled, it is better to graze it in late winter as the concentration of toxic alkaloids decrease when exposed to winter weather. Although the nutritional value of tall fescue can be low during the growing season compared with other grasses, it holds its quality well in autumn and winter. Stockpiled legumes are only useful in late fall as they rapidly lose nutritional quality when exposed to winter weather. Warm-season grasses are not useful for stockpiling because they have poor growth in the fall and have very poor nutritional quality if stockpiling is initiated during their growth period in midsummer.

A maximum of 70 days in the late summer and autumn regrowth period is needed to build a high quality stockpiled forage supply. To achieve that 70-day growth period in Iowa, stockpiling can be initiated by mowing or grazing in early August. Stockpiling for periods longer than 70 days increases the amount of forage available, but considerably reduces its nutritional quality. In addition, stockpiling endophyte-infected tall fescue for longer than 70 days may increase the concentration of toxic alkaloids in the forage potentially causing hoof loss associated with fescue toxicosis (fescue foot) during winter.

Stockpiling forage for a maximum of 70-80 days in late summer and early fall will allow for the accumulation of one ton or more per acre of forage with a high nutritional value. Photo by Joe Sellers.

When grass pastures are stockpiled, they should be fertilized with nitrogen to maximize yield and improve quality. Fertilizer should be applied at 40-100 lb N/acre as early as possible in the stockpiling period. Fertilization will be less effective in drought years. Fertilizing endophyte-infected tall fescue at rates greater than 50 lb N/acre will increase concentrations of toxic alkaloids which in turn increases the risk of fescue foot.

Because grazing animals will selectively graze plant parts with the highest digestibility and protein concentration, forage quality will be severely reduced late in the season if continuous grazing is used for stockpiled forage. Strip grazing of stockpiled forage in weekly to monthly blocks is recommended to extend forage quality and supply.

Winter precipitation is an important factor in stockpiling. Although cows seem willing to graze through relatively deep snow (up to 18 inches) for high quality forage, as little as 1/4 inch of ice on top of snow makes grazing nearly impossible and short-term use of supplemental feed becomes necessary. Winter precipitation also reduces the nutritive value of stockpiled forages. As the nutritive value declines over time and supplemental feeding becomes necessary, consider the costs of various supplemental forage and feed alternatives to keep winter costs to a minimum.

Cows will graze through up to 18 inches of snow to consume high quality stockpiled forage. Photo by Samantha Jamison.

In stockpiled systems, as with the grazing of corn crop residues, moving cattle to a drylot or sacrifice pasture before the spring thaw to prevent damage to forage plants and prevent soil compaction is recommended.

Where both corn residues and stockpiled forages are used, nutritionists suggest that the corn residues should be grazed first and stockpiled pastures last based on the potential for protein and digestibility weathering losses (See Table 2.1, Chapter 2).

Integrating supplemental feeds

Even with excellent grazing management, some nutritional supplementation may be necessary. But because feed costs account for almost half of the costs associated with animal production, feeding stored feeds to grazing animals should be limited to periods when absolutely necessary.

Energy

Lactating dairy cows on spring pasture in early- to mid-lactation often require energy supplementation even if cow requirements are synchronized with forage availability. The general rule for grain supplementation of dairy cows is 1 lb of grain for every 3.5-4 lb of milk. Thus, cows producing 80 lb of milk per day should receive about 20 lb of grain. Although feeding confined dairy cows supplemental fat has become popular, feeding non-bypass fats to dairy cows in grazing systems should be avoided. Fats tend to reduce fiber digestion, which may already be reduced by the rapid rate of passage of lush forages. Feeding small amounts of a high quality hay may improve nutrient use by reducing the digesta passage rate. (Digesta is the total dietary material passing through the animal's digestive system.) High quality hay may increase the fiber content of the diet and thereby maintain a high ruminal pH and desirable ruminal fermentation.

Stocker steers generally have adequate forage availability and quality to meet their energy needs when grazing spring pasture. But by midsummer, their energy requirements increase with their increasing weights and supplemental energy may be needed to maintain daily gains. Supplemental energy should be offered when weight gains drop below two pounds per day. However, grain supplementation on pasture is not the most economical use of grain because the feed efficiency of supplemental grain on pasture is so low as cattle will substitute forage intake with grain intake. Thus, commonly, only one pound of extra gain occurs for each 10 lb of grain fed in a pasture compared with feed efficiencies of one pound of gain for every six pounds of grain fed in the feedlot. If an energy supplement is to be fed, animals should be removed from the pasture when daily gains are less than two pounds per day and transitioned to the feedlot.

Grain supplements are not efficiently used by cattle on pasture, but high fiber coproducts of the biofuel industry such as distillers grains or corn gluten feed are efficiently used by grazing cattle. Photo by Joe Sellers.

Energy requirements of mature beef cows and ewes can generally be met by pasture forage when requirements are synchronized with forage availability. However, if forage supply is inadequate because of midsummer drought or excessive winter snow, or if forage quality is low as with weathered corn crop residues, supplemental energy may be needed. Mature beef cows and ewes should be supplied extra energy only as necessary to maintain adequate body condition. However, heifers and cows with their first calves generally will require some supplemental energy because of the energy needed for growth.

Corn gluten feed, distillers grains, and soybean hulls, which are high fiber coproducts of the biofuel industry, have similar energy values to corn grain but perform better than corn grain if supplemental energy is needed by grazing cattle or sheep. Specifically, as these coproducts are nearly devoid of starch, they complement and maintain fiber digestion, and thus likely increase gains relative to corn grain when fed at increased amounts. In many instances, the cost of biofuel coproducts per unit of energy is competitive with corn grain, but as with all managerial considerations, economics should be scrutinized prior to determining a supplementation scheme.

Protein

The concentration of crude protein in most grass and legume forage is generally adequate to meet the needs of any grazing animal. However, the protein concentration and digestibility of corn crop residues may be low, particularly during late winter. Supplemental crude protein may be needed to ensure adequate use of corn crop residues. This crude protein may be supplied as high quality hay or haylage, oil seed meals, or corn-based coproducts. Nonprotein nitrogen sources such as urea require adequate levels of energy in the diet for proper use and therefore, are not typically recommended for use in grazing environments. Consult a nutritionist or extension livestock specialist to determine if this is likely to be of value.

An approach to improve the efficiency of protein supplementation for ruminant animals is the feeding of protein sources (sometimes referred to as rumen undegradable protein or bypass protein) that are not extensively degraded by the ruminal bacteria. Proteins in most forages are highly degradable in the rumen and not efficiently used by the animal in part due to high passage rates and lack of fermentable energy for rumen microbes to utilize all the nitrogen. As a result, even though forages contain a high protein concentration, animals with high protein requirements (such as lactating dairy cows or young, growing animals) may have improved performance when fed a bypass protein source which are typically heat treated such as corn-based coproducts or oilseed meals.

Minerals

Forages can often meet the calcium needs of all grazing species except lactating dairy cows and high producing beef cows. These cows may need additional calcium when receiving supplemental grain in their diet because grains are very low in calcium. Calcium levels in dry dairy cow diets are also important. If very high quality legume forages are fed during the dry period, the high levels of calcium and, more importantly, potassium present may lead to the metabolic disease milk fever during early lactation. To prevent this condition, feed grass forages containing lower concentrations of potassium during the dry period in a seasonal dairying system.

The phosphorus concentration of most grass and legume forage species grown in the Midwest is adequate for the majority of grazing species throughout the year, particularly if grown on soils containing adequate phosphorus and the forage is managed to remain immature. However, mature forages and crop residues are often very low in phosphorus concentrations. Because of the relationship of phosphorus with reproductive performance and the level of phosphorus in milk, phosphorus should be supplemented free-choice during lactation to dairy cows unless high phosphorus feeds such as corn coproducts are being supplemented. Similarly, supplemental phosphorus may be beneficial for

Costs of supplementing phosphorus in a mineral mix to beef cows may be avoided if pasture forage is kept in an immature state and contains 0.25 percent or more phosphorus. Photo by Erika Lundy.

lactating beef cows and ewes that are grazing mature forages or forages grown on low phosphorus soils, such as the sandy soils in western Nebraska, if not supplemented with corn grain or coproducts. But because of the high cost of supplemental phosphorus and lower phosphorus requirements of beef cows and ewes than dairy cows, testing pasture forage for phosphorus and using a low phosphorus mineral supplement (containing four percent or less phosphorus) if the forage phosphorus concentration is 0.25 percent of the dry matter or greater can be an effective strategy at significantly reducing supplement costs.

Magnesium concentration of forages will vary with plant species, soil magnesium levels, and seasonal weather. Magnesium deficiency called grass tetany (See Chapter 2, grass tetany), most commonly, occurs on lush grass pastures that have been heavily fertilized with nitrogen and potassium. Therefore, magnesium should be supplemented to grazing animals, especially in fall and spring when growth of cool-season forages is greatest. Supplementation should begin 30 days prior to initiation of grazing immature forages so cows can metabolically adjust to the supplement. However, reduced palatability of magnesium should be acknowledged. Therefore, it is prudent that free-choice intake of high-magnesium minerals be monitored. It may be necessary to incorporate magnesium into a more palatable carrier, such as a coproduct or corn, and force-feed to ensure proper intake.

Of the trace minerals, two of greatest concern in the Midwest are copper and selenium. Copper deficiencies may exist in some situations, but can be managed by supplementing trace mineral salt. As the levels of copper that are required by cattle are toxic to sheep, make sure that sheep do not have access to mineral supplements that are mixed for cattle. Selenium levels in Midwestern forages are marginally deficient and selenium should be supplemented either in the diet or by injection at critical production stages.

Vitamins

Because of the ability to synthesize many of the necessary vitamins, the only vitamins that need to be considered in the nutritional programs of grazing cattle, sheep, and horses are vitamins A and E. Vitamin A and E concentrations in fresh forages are quite high and more than adequate to meet animal needs. Similarly, the vitamin A and E concentration of well-preserved stored forages will remain high for a long period. However, the vitamin A and E concentration of crop residues or poorly stored hay is low and animals fed these forages should be supplemented with vitamins A and E, either free-choice or by occasional injections. It should be noted that vitamins are readily oxidized in the presence of other minerals. For this reason, a combined mineral and vitamin supplement should be fed within six months of production to ensure sufficient intake and bioavailability of vitamins.

Creep feeding

Feeding supplemental energy and protein to young calves and lambs in a separate feeder can increase their weight gains, but the economics of this added weight should be re-evaluated on an annual basis. Creep feeding for young animals is typically less efficient than might be anticipated. The feed-to-gain ratio in creep-fed calves can range between 7:1 and 15:1, whereas conversion in lambs and goats may be in excess of 5:1. In some markets, prolonged periods of creep feeding can lead to fleshier feeder animals that may be discounted in the marketplace. Furthermore, replacement heifers that become excessively fat likely have reduced milk and calf production when mature.

However, creep feeding may be of some value if

- Feeder animals are being retained by the owner for immediate finishing in the feedlot.
- Available pasture forage is limited by mid- to late-summer drought.
- Calves are weaned early to improve the rebreeding rate of cows under conditions of limited forage.

If creep feed is used, management approaches that limit creep feed intake such as adding four percent salt have sometimes improved the feed efficiency. Energy content of the creep feed should be inversely correlated to the period of time which creep will be fed as to avoid overconditioning. Common creep rations combine a variety of energy sources that maximize gains and complement forage-based diets such as coproducts, by-products such as beet pulp or cotton seed hulls, wheat middlings, corn, and oilseed meals.

Implants and ionophores

Technologies that improve rumen fermentation and cattle growth can enhance performance of the cattle while reducing resource use and cost of production in grazing systems. Growth stimulant implants work by improving lean growth of cattle. Most of these products are administered as compressed pellets in the middle third of the animal's ear and pay out over an 80-120 day period. Calfhood implants such as Ralgro, Synovex-C, or Component-EC will increase weaning weights of suckling calves by approximately 30 pounds. Estrogen based implants such as Ralgro, Synovex-S/Component TE-S, or Synovex-H/Component TE-H will improve growth rate on grass of stocker cattle by 8-12 percent. Implants that contain a combination of androgen (trenbolone acetate) and estrogen will improve growth rate by 15-20 percent. These implants, such as Component TE-G or Revalor-G are often the implants of choice for stocker cattle. Longer duration estrogen implants (Compudose and Encore) and combination implants (Syonvex ONE Grass) are also now available for stocker cattle.

Ionophores, such as Rumensin or Bovatec, work by shifting the rumen microbial population to improve efficiency. The net result is an improvement of 10-15 percent in daily gains of stocker cattle on pasture. This response is greater than when cattle are fed in a feedlot on higher levels of concentrate. Rumensin may also be used to improve growth in dairy heifers, milk production in dairy cows, and improve efficiency in beef cows. While Bovatec may be fed to improve gains and feed efficiency in sheep, Rumensin is toxic and should not be fed to sheep. Therefore, if raising both cattle and sheep, make sure the sheep do not have access to any supplements containing Rumensin. Ionophores are also coccidiostats and reduce methane production by grazing ruminants. Contact an ISU Extension and Outreach livestock specialist or a nutritional consultant if wishing to incorporate implants or ionophores into a grazing-based livestock enterprise.

Managing during drought and excess precipitation

Pasture management requires that flexibility be built into an operation to deal with both the expected and unexpected conditions that arise. In the upper Midwest, the normal climatic pattern leads to an erratic pasture growth response. No growth occurs during the winter months. Cool-season grass-based pastures have good to excellent growth in spring and autumn, but often grow slowly during midsummer. Warm-season grass-based pastures really only grow well during the summer months.

Managers of year-round livestock enterprises build their normal forage management around this expected forage growth pattern. They count on pasture forage during the 6-7 month growing season. They frequently need to supplement additional forage (grazed hay fields, hay, warm-season grass pasture) during a few months in midsummer. And they must conserve forage (hay, silage, stockpiled pasture, crop residue) for the winter.

Building flexibility for unexpected conditions also is a necessary part of planning. Drought and excessive rainfall are not easily predicted, but although common, are more likely with increased climate variability and must be planned for. Careful management during these stress conditions can go a long way to lessen the effect of the stress period on both the animals and the pasture.

Drought

Short-term dry periods are common. Drought is an extended period of lower-than-normal precipitation. Both can cause significant reductions in forage supply, but neither requires a panic management strategy. Dry weather and drought develop gradually and the manager needs to be aware of their development. The first plant response to dry weather and drought is a reduction of growth rate. In continuously stocked pastures (continuous grazing), drought detection may be the common sense observation in May or June that "There is less grass in the pasture than normal; what am I going to do for feed?" In rotational grazing systems where each pasture or paddock is routinely observed for regrowth rate, even a minor slowing in regrowth rate 6-10 days after grazing ends can be quickly detected.

Plants growing in dry conditions with the added factor of high temperature will be more fibrous than normal and less digestible. There is sometimes concern that drought-stressed grass can accumulate excessive levels of nitrates. (See Chapter 2, "Health considerations of grazing animals, nitrate poisoning.") Although the nutritive value of drought-stressed forage is important, the short growth and inability of the animal to eat enough becomes an overriding factor.

Under drought conditions, producers who rotationally graze should slow the rotation to allow the paddock longer rest periods for recovery. Photo by Erika Lundy.

In continuously stocked pastures, grazing animals will find it more difficult to get enough forage with each passing day. The lack of adequate nutrition will limit animal performance. Frequent regrazing of short plant regrowth without adequate recovery, referred to as overgrazing, will stress the plant and decrease its vigor and ability to recover rapidly when soil moisture is again adequate.

Where pasture rotation is being practiced, a key drought management strategy is to slow the rotation in an attempt to allow more rest for all pastures. Besides allowing animals to spend slightly more time on each paddock, other ways to slow the rotation include supplementing feed or forage on the pasture, moving animals to a sacrifice area for feeding, and adding emergency paddock areas. These measures may help maintain adequate nutrition for the livestock and allow pasture plants to be in better condition to recover rapidly when better growing conditions resume. This "slow down the rotation when growth rate is slow" strategy also is appropriate for cool, cloudy springs when pasture recovery is slow.

Feeding supplemental feed in a sacrifice pasture or drylot will limit long-term damage to the entire pasture during periods of drought or excessive precipitation. Photo by Samantha Jamison.

In extreme conditions, such as during an extended drought when there is not enough forage in any pasture or paddock to continue grazing, moving animals to a sacrifice area for feeding is recommended. This is beneficial because it concentrates any further plant damage to a limited portion of the pasture. Sacrifice areas should be away from streams and on relatively flat land that can be easily renovated without erosion risk. Other strategies to reduce the pressure of animal use on pastures are to wean calves or lambs early, move stocker animals to the finishing lot early, or begin culling the herd or flock.

Drought through the winter can create problems with spring growth and grazing as well. Forage growing during cool, dry periods may actually have higher dry matter and energy content than that of the forage normally produced during the spring flush of growth. But the problem is that there simply may not be enough growth to sustain grazing. Livestock can quickly cause an overgrazed pasture condition if turned onto slow-growing spring pasture. The best spring drought management is to delay grazing until the forage begins to grow more rapidly. But obviously there are practical considerations and compromises when faced with a group of animals being fed hay in winter feeding lots that may be muddy.

Excess precipitation

During periods of excess rainfall, grazing animals can damage pastureland with continued hoof action. Grasses and legumes recover very slowly following damage during muddy grazing conditions. Legumes are often injured more severely than grasses. Trampling damage often is localized in continuously stocked pastures along travel zones and around water sources and mineral feeders. Excluding animals from these areas is difficult in a continuously stocked system.

With rotational grazing, trampling damage actually can be worse because relatively more animals are confined to smaller areas. A recommended management practice in muddy conditions is to move the herd or flock to a sacrifice paddock where supplemental forage can be fed, or move them to a drylot feeding area until the pastures are again suitable for grazing. Although damage to the sacrifice paddock can be severe, remember that its purpose is to provide for flexibility and damage control in the remainder of the grazing acreage.

Examples for cow-calf management

Forage budgeting is the easiest part of pasture management. There is a known group of animals whose daily nutritional needs can be calculated. Expected forage availability can be estimated from soil and plant productivity charts, and an appropriate stocking rate for average conditions can be determined. As discussed in Chapter 3, "Estimating pasture productivity from soil maps," the NRCS has online programs such as the Web Soil Survey and spreadsheets including the Forage - Livestock Balance worksheet that can be used to balance the number of animals with available forage from the current or an improved pasture management system. Some producers will stock to a level to use up their pasture forage during average and better growing seasons (the Risk family). They will probably be overstocked and short on forage 2-5 years out of 10. Other producers will be more cautious (the Conservative family), understock, and plan to have enough forage most years and some excess in the best growing seasons. To be successful, the Risk family must use a higher level of management but still may be disappointed in years when weather limits forage growth. Of course, each producer must decide the level of risk they are willing to take. Rotational grazing management often helps stabilize seasonal forage supply and use. In general, the more willing a producer is to accept risk, the more likely they are to be comfortable with an increased intensity of rotational grazing. In any grazing system, the incorporation of annual grass, legume, or brassica crops can be used to reduce risks of forage shortages in the spring, summer, or fall. However, as success in establishing annual crops is largely dependent on precipitation, reliance on these crops has its own risks.

Continuous grazing systems

If the Risk family and the Conservative family have chosen a continuously stocked grazing system, the first decisions for both in the spring are whether to fertilize the pasture and when to first turn animals out on pasture. To accumulate enough extra forage in the spring to get through the summer slump, the Risk family may fertilize with nitrogen. They must delay the start of grazing until the forage has begun to grow well (4-5 inches of growth), so the initial growth will not be slowed by spring grazing. The Conservative family may use the same basic strategy, but can actually begin grazing a little sooner (3-4 inches of growth) because the forage will be growing faster than their relatively smaller herd can eat it. Until early summer, management decisions for both types of producers are primarily animal care, fence maintenance, and weed management.

In early summer, some forward projection for forage budgeting is necessary. Both can use pasture measurements to estimate available forage and assess whether the summer weather is producing average, better, or worse summer growth rates. With average or better growth prospects, both are on track to have enough extra forage and new growth to get through until normal autumn production. If the summer is in a mild drought, the Risks will probably run short of forage and be required to supplement to meet animal needs. The Conservatives will probably be able to get through a mild drought without supplemental feeding. In a severe drought, both will probably need to use supplemental feeding, cull the herd, wean calves early, or graze an emergency pasture or hay field to get through the remainder of the season. If either the Risks or the Conservatives plan to use stockpiled forage for late autumn or early winter grazing, they must begin to stockpile the forage in August. Because their entire continuously stocked pasture is needed for August and September forage, any stockpiling must be done in a separate pasture area. As the forage growth slows in the late fall, the most important decisions for both families are whether to graze crop residue fields or stockpiled pasture, or to begin to feed supplemental hay either on pasture or in a winter feeding area.

A four-pasture rotational system

If the Risks and the Conservatives decide to graze in a simple rotational system, their first decisions in the spring are similar to those for continuously stocked management. They may choose to fertilize some or all pastures and begin grazing when their first pasture reaches 3-5 inches tall. In a normal or better spring growing season, the Risks, with relatively more cows, will be grazing through the first three pastures a day or two faster than the Conservatives. The Risks will probably be grazing pasture four as seed stems are forming and will waste a significant amount of its forage to trampling. While grazing pasture three, the Conservatives probably will have to decide whether pasture one has regrown enough for regrazing. If so, their pasture four can be cut for hay. If pasture one is not yet ready for regrazing, the Conservatives, too, will have to move the herd into their pasture four next.

Summer grazing decisions for both families will be based on pasture yield estimates and whether regrowth is ready in the next pasture. In normal and better seasons, both will have little trouble with forage shortages. In a mild drought season, the Risks may find they are moving faster through the pastures because regrowth is slow, and eventually may find that their herd is out of forage in all four pastures. They must then begin to supplement the herd or reduce the herd size or both. The Conservatives will likely get through a mild drought. When faced with severe drought and very slow regrowth, both families should slow their rotation, making longer graze periods, to give a few more days of rest to the remaining pastures. Feeding supplemental forage on pasture, in a drylot, or in a small sacrifice area of one pasture can help fulfill the forage needs for the livestock. If either type of manager plans to use stockpiled pasture in the late autumn or early winter, they should begin stockpiling in August. With a four-pasture rotational system, the Conservatives may be able to wean calves early, stockpile one of their four pastures, and rotate the cow herd through the other three pastures for the autumn months. The Risks, with their higher stocking rate, will likely not be able to set aside one of their four pastures for stockpiling, and thus must have an additional pasture area available for stockpiling. The decision for both families in autumn as to when to end the grazing season is again based on pasture regrowth rates. Possible autumn and winter feeding options include whether and when to move the herd to crop residue fields or stockpiled pasture, or whether to feed hay in a winter feeding area.

A 12-paddock MIG system

If the Risk family and the Conservative family have chosen to graze their herds in a management intensive grazing system, their early spring management decisions will include which and how many paddocks to fertilize to speed the growth of some paddocks and allow for an earlier start to grazing. Because they can provide some rest and recovery for the rapidly growing forage, both families can begin grazing when the pastures reach 2-3 inches tall and rotate relatively fast (1-2 days on each paddock), top grazing the high quality leaves only. Both types of producers can estimate forage supply and regrowth rate as they walk their paddocks, and both will have decisions to make about whether some paddocks can be temporarily dropped from the rotation for hay harvest.

With the flexibility that 12 paddocks allow, summer and autumn paddock rotation decisions are based on paddock forage height estimates and observed regrowth rates. The rotation can be slowed when pasture measurements show a declining regrowth rate in the summer. This strategy forces livestock to eat more of the older, lower quality forage and gives the recently grazed paddocks more time to recover. The flexibility and better recovery rates provided by the extra paddocks will probably allow both types of producers to manage through mild droughts without supplemental feeding. Only in severe drought will it be necessary for either family to feed supplement in a slowed rotation. In severe drought, both families may even decide to select one paddock as a sacrifice paddock for hay feeding, extending the rest period on the remaining paddocks. During most years, setting aside several paddocks in August for stockpiling is more feasible with a 12-paddock rotation. But in dry summers, stockpiling paddocks within the rotational system may result in overgrazing of the remaining paddocks unless some stock reduction strategy such as early weaning is practiced. In a well-run management intensive grazing system, both the Risks and the Conservatives can have good animal production (calf gain and cow condition), but the Risks' slightly higher stocking rate may enable them to market more animal product per acre from the system than can the Conservatives.

If producers use the increased forage productivity resulting from rotational grazing to increase the farm's stocking rate, they may increase the amount of product produced per acre. Photo by Matthew Haan.

Adjusting livestock production systems to better fit the forage supply

A forage/livestock production enterprise should be viewed as a production system. An important step in improving the efficiency of the system is to consider how well the pattern of animal needs is matched to the seasonal forage supply. Many livestock producers virtually ignore the efficiency of a good match of animal production and forage supply or try to alter the forage to fit the livestock system they have.

Beef cows

The familiar system of calving beef cows in February provides larger calves at weaning in November, minimizes the mud problems associated with spring calving, and finished calves tend to be sold at peak market prices in early summer. However, selling feeder calves at weaning in November is usually a time of low market prices. Furthermore, the high energy requirements associated with late gestation and early lactation occur during the period from midwinter to early spring when the amounts of forages available for grazing are minimal (Figure 5.1). Considerable

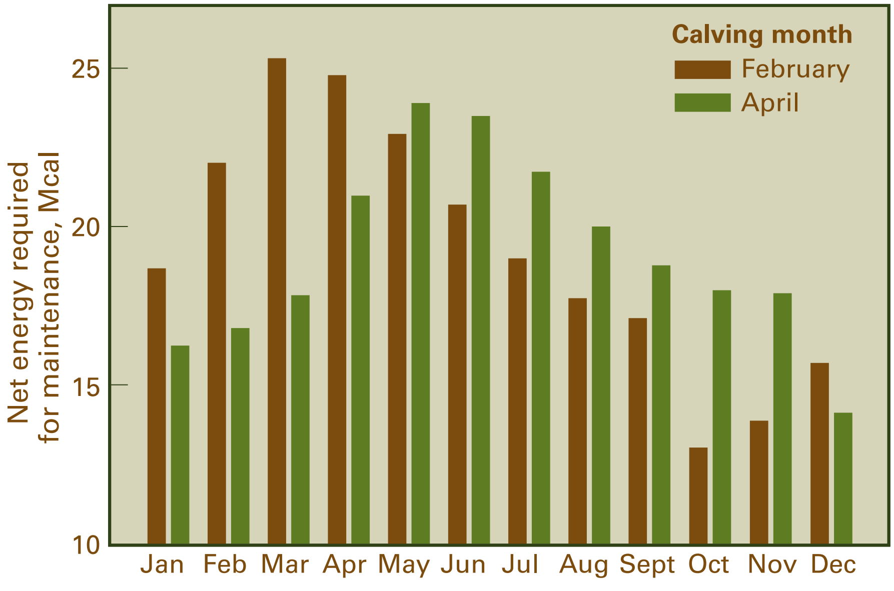


Figure 5.1. Daily energy requirements of beef cows calving in February and April.

Calving in April allows the high nutrient needs during early lactation to coincide with the peak forage supply and quality. Photo by Erika Lundy

Corn stalks can be effectively used in low-cost winter rations because the winter grazing period is when spring-calving cows have their lowest energy requirements. Photo by Denise Schwab.

amounts of stored feeds are necessary to maintain adequate body condition of cows calving in February. As a result, production costs of this system may be so high that even the better prices for the finished cattle cannot recover the increased costs.

In contrast to February calving, April calving matches the cow's maximum energy requirements with maximum forage supply in late spring. April calving also will match the cow's minimum energy requirements with the time that corn crop residues or stockpiled hay crop forages are most available. April calves may be sold at seasonally higher market prices if weaning is delayed. However, there may be limited forage available for grazing in late winter and early spring as energy requirements increase in late pregnancy. Some use of stored forages, grains, or grain by-products may be necessary to maintain body condition in late pregnancy. Small grain cover crops may supply high quality forage in April and May. Another limitation of April calving is there is often mud if calving occurs in drylots. Soil compaction and reduced forage production from pastures can also occur. Pasture damage can be reduced by using a sacrifice pasture containing stockpiled forages. It is important that a sacrifice calving pasture is suitable for regular renovation. Bales may be stored in the calving pasture to limit tractor traffic during this muddy period if supplementation is necessary. Another possible problem with April calving is that it can interfere with spring fieldwork if there is limited labor. A final limitation of April calving is that the calves may be difficult to finish at a time corresponding to the seasonally high prices in early summer.

Moving the calving season to May or June shifts the energy requirements so they are minimal when the availability of forages for grazing are the lowest. This change reduces the need for and cost of supplemental feeds and provides the opportunity to feed cows during the winter entirely on grazed forages. The maximum energy requirement associated with peak lactation, however, occurs after peak availability of summer forages. Furthermore, the breeding season of cows calving in April through June occurs in mid to late summer when heat stress may impair reproduction in the Midwest, particularly in cattle grazing endophyte-infected tall fescue pastures. Providing shade during this period is critical.

Fall calving, from August through October, places the maximum nutrient requirements of cows at a time when the highest quality corn crop residues and stockpiled forages should be plentiful. Because the lowest nutritional requirements of fall-calving cows is in early to midsummer, they work well in a leader-follower rotational grazing system, cleaning up the lower quality forage left after lactating spring-calving cows or stocker cattle graze the higher quality forage. Even in this system, it is necessary to observe body condition as cows may become excessively fat prior to calving. Because the breeding season of fall-calving cows occurs during the cooler conditions of late fall, greater reproductive success can occur, particularly in pastures containing endophyte-infected tall fescue. In addition, fall calves may be marketed at the traditionally highest market prices to graze as stocker cattle during the subsequent summer. However, the major limitation of fall calving is inclement winter weather limiting forage availability. In this case, cows may be supplemented with hay, grain, and coproducts and calves may be creep-fed or weaned early.

Because their breeding season occurs during cool conditions, fall-calving cows grazing endophyte-infected tall fescue may have higher reproductive efficiency than cows calving in the spring. Photo by Erika Lundy.

The protein, calcium, and phosphorus needs of beef cows generally will be met with fresh, growing pasture if adequate forage is being consumed to meet their energy needs. However, in crop residues, concentrations of protein and phosphorus as well as those of vitamin A, trace minerals, and salt may be limited, particularly during winter. Although the concentration of crude protein in stockpiled grass and legume forages changes little during winter, the digestibility of this protein decreases as weathering occurs.

Dairy cows

The nutrient requirements of dairy cows vary considerably depending on the lactation stage and physiological condition. Traditional year-round milking herds have cows calving throughout the year and cows within the herd have widely varying nutritional needs. These year-round herds can be managed to gain much of their nutrition from pasture during the growing season, but they also have significant supplemental feed needs and high winter feed costs.

Dairy cows, like beef cows, can be synchronized with the forage availability by controlling the calving date. Dairy producers practicing a seasonal dairying schedule attempt to have their cows calve in April so that the maximum nutrient requirements of the cows occur at the time of peak forage growth in late May (Figure 5.2). Although spring

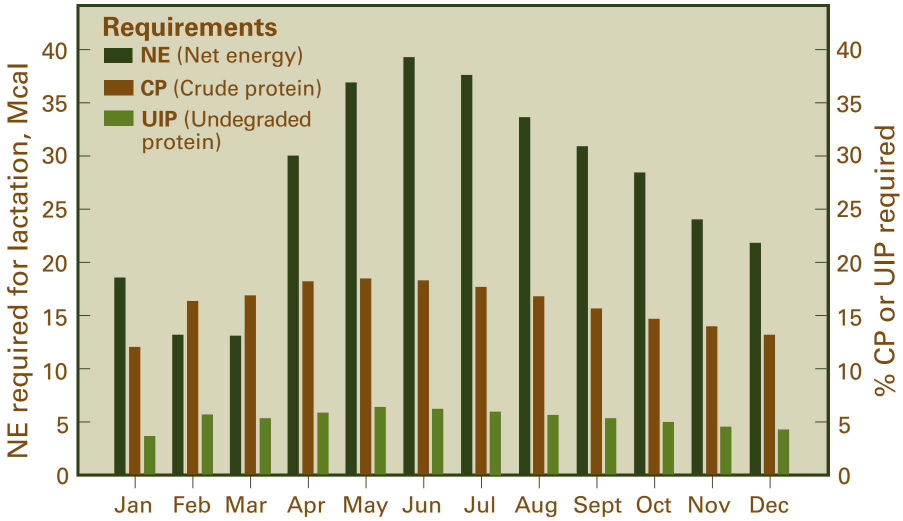


Figure 5.2. Daily energy and protein requirements of a Holstein cow producing 18,000 lb of milk and freshening in April.

Use of pasture nutrients by dairy cows may be improved by feeding small amounts of hay, silage, or grain and also encourages cows to come to milking parlors or sheds. Photo by Scott Bauer.

forage production is ample, energy intake by cows may be limited by the consumption capacity of the animals and by the moisture concentration of lush forage. Lush forage often has a high rate of passage that may reduce digestibility. Some supplementation of energy in the form of grain or grain by-products may be desirable. In addition, feeding small amounts of dry hay may increase dietary fiber content and reduce the rate of digesta passage, thereby improving ruminal fermentation characteristics and nutrient utilization. The protein requirements of lactating dairy cows and the high degradability of proteins in lush forage are likely to result in a protein deficiency in early lactation as well. A less degradable true protein source such as heat-treated soybean meal or corn gluten meal may need to be supplemented during this period.

After peak lactation of April calving cows, milk production and forage production both decrease. Depending on forage species and weather conditions, forage yield and nutritive quality may decrease more rapidly than the change in nutrient requirements of the cows, particularly where grazing management is not optimal. As forage production declines, supplemental nutrients may be supplied as necessary. In the fall, stockpiled grass and legume forages and corn crop residues may supply sufficient high quality forage at the end of lactation to meet cattle needs to replace body fat reserves.

The April calving cows in seasonal dairy herds are dry during January through March. Lower quantities and qualities of stored feeds may be fed during most of this dry period. If cows are in adequate condition at the start of the dry period, excessive energy should not be fed during the dry period. To prevent milk fever in early lactation, the amounts of legume forages fed during the dry period should be restricted to limit calcium and potassium intake. Therefore, a moderate-quality grass hay may be more desirable during this period. In the last 2-3 weeks of the dry period, cows should be introduced to the supplemental feeds that they will receive during lactation.

If grazing is used in either a seasonal or year-round dairy enterprise, it is essential that pasture forage be managed to maintain a high nutritive quality. Management techniques that may be used to maintain high quality vegetative forage include harvesting excess forage in late spring, using clean-up grazing with dry cows or heifers, and clipping of seedheads.

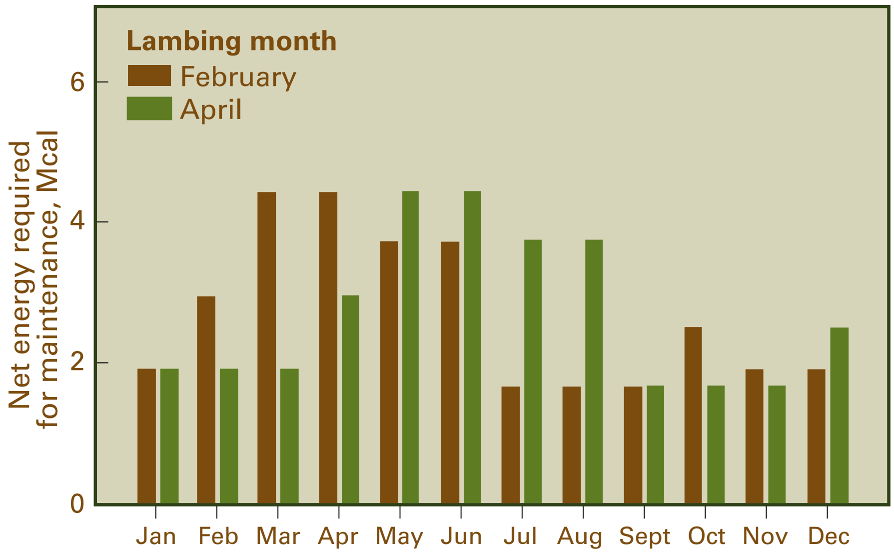


Figure 5.3. Daily energy requirements of ewes with twins lambing in February and April.

Ewes

Similar to beef cows, the nutrient requirements of ewes lambing in February are not well synchronized with forages available for grazing (Figure 5.3). Peak lactation and nutrient requirements occur in March when pasture forage availability is low. In addition, the period when flushing (energy supplementation with high quality forages, grains, or coproducts prior to breeding) should be practiced occurs in late summer when forage availability may again be low. In contrast, the minimum nutrient needs of ewes occur in early summer when the quantity and quality of available forage are highest.

Lambing in late April or early May results in the highest nutrient requirements of ewes occurring when forage availability is highest. In this system, flushing and breeding occur in November and December and when high quality crop residues and stockpiled grass and legume forages will be available. Moreover, the dry period and early gestation occur during periods when forage availability is low in late summer. In a rotational stocking system, ewes may be particularly useful during the dry period for removal of lower-quality excess forage remaining after removing growing lambs from a paddock.

Pasture lambing can pose some specific production problems. Predators have been a major limitation to lambing on pasture in the past. Electric predator fencing and guard animals, however, can reduce this problem. Internal parasites also present problems with grazing lactating ewes and young lambs, but a well-managed rotational grazing system and rotation between uses so pasture lambing does not occur on the same piece of ground every year can help mitigate those risks.

Stockers

Stocker cattle usually are purchased in early spring for summer grazing. The amount of energy required for gain by stocker steers increases as the steers gain weight (Figure 5.4). As a result, the energy requirement of individual animals will be lowest when forage availability is greatest. Therefore, in the early summer, additional animals such as cows, replacement heifers, or larger steers may be added to increase the stocking rate to make optimal use of excess forage. This management practice will not only increase animal production per acre, but also will maintain the forage in an immature stage. For optimum gain on pasture, some supplementation of a ruminally undegradable protein source such as distillers grains may be desirable.

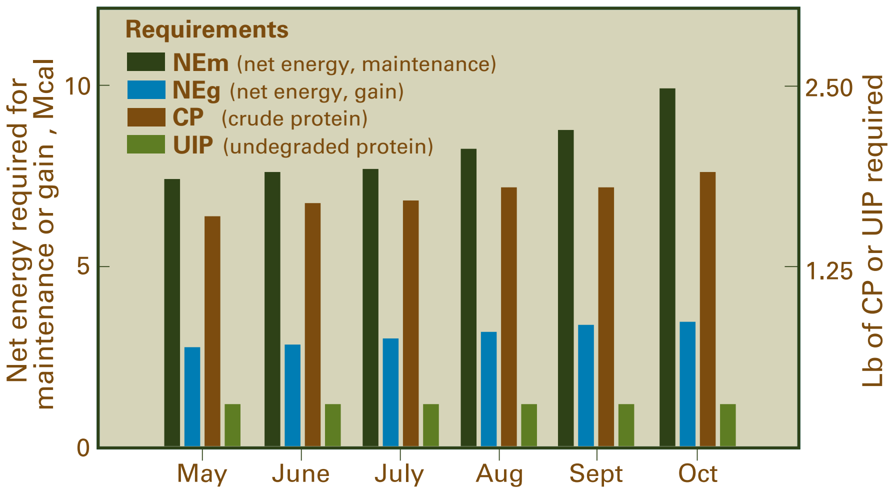


Figure 5.4. Daily energy and protein requirements of a steer with an initial weight of 600 lb and gaining 2 lb per day.

Stocker steers can be a seasonal grazing enterprise or used by producers with beef cow herds or sheep flocks to harvest extra forage not otherwise used at peak spring forage production. Photo by Erika Lundy.

As the grazing season proceeds, forage availability and nutritive value will decrease at the same time that the steer's energy requirements are increasing. Extra animals added earlier in the season or some of the heaviest steers should be removed from the pasture. Energy supplementation from grains or grain coproducts like corn gluten feed, soybean hulls, or distillers grains also can be considered. As the bodyweight of stocker steers increases, their protein requirement relative to their energy requirements decreases, making protein supplementation less essential.


Photo by Matthew Haan.

Concluding thoughts: Challenges and opportunities for grazing livestock in the 21st century

This publication has presented information integrating plant growth, composition, and ecology; livestock nutrition, behavior, and management; and tools to develop, implement, monitor, and improve grazing systems. These management concepts facilitate the long-term productivity of the forage stand and quality of soil, water, and air resources while optimizing profitability of grazing livestock production. Many of the principles discussed date back to the book "Grass Productivity," written in 1959 by French biochemist Andre Voisin, and have been applied across a range of environmental and economic conditions experienced in the last half of the 20th century. While the biological principles of forage production remain true regardless of economic conditions, several factors are creating challenges to grazing in the 21st century.

A major challenge to grazing systems is presented by the conversion of grazing lands to row crop production, government conservation programs, commercial or residential real estate, recreation, and other land uses. The amount of grazing land in the United States has decreased at a rate of 0.46 percent per year since 1945, for a total loss of 31 percent, according to the United States Department of Agriculture-National Agricultural Statistics Service. This loss of grazing land was even greater in the Midwest with a total reduction of 58 percent since 1945, of which about a third of the loss occurred during the decade prior to 2017. With this loss, the value of grazing land in Iowa increased by 363 percent from 2001 through 2017. Similarly, costs of other inputs have continued to

Photo by Trey Jackson.

increase. From 1960-2017, the price of urea fertilizer increased by 406 percent while the price of superphosphate increased by nearly 800 percent as stocks of fuels and mineral deposits required to produce these resources become increasingly limited. These trends will be expected to continue in the future.

While all agricultural enterprises will be influenced by predicted changes in climatic conditions during the 21st century, grazing enterprises will be particularly susceptible. Variable precipitation and temperatures will influence forage production and quality, as well as grazing animal nutrient requirements and behavior. For much of the mid-to-lower Midwest and southern plains, more frequent and longer periods of drought are predicted, interspersed with periods of high precipitation. As the frequency of heavy rainfall events has doubled over the last century in the Midwest, the frequency of flooding is increasing in this region as well as throughout the United States. Obviously, either of these events may have adverse effects on the long-term composition and productivity of the pasture plant community, as well as on the quality of soil and water resources. With increasing climate variability, temperatures in the Midwest are predicted to increase by 4-6°F by the middle of the 21st century and by 5-10°F by the end of the century. This change will increase the probability of heat stress resulting in reduced breeding and growth rates of grazing livestock, particularly as endophyte-infected tall fescue continues its northern migration. Furthermore, with these changes in climate, additional problems with invasive species common in the southern United States like sericea lespedeza in grasslands and blue-green algae (cyanobacteria) in ponds or low-flowing streams will increase.

Fortunately, many of the challenges to grazing may be addressed through the management practices discussed in this publication. Implementing a grazing system that incorporates practices providing sufficient rest periods between grazing for optimal forage growth and quality should provide the opportunity to increase pasture stocking rates by 25 percent or more while reducing fertilizer and supplemental feed costs. Installation of paddocks should also improve the forage plant community either through management of plants already present or by allowing isolation of areas for pasture improvements through seeding and post-seeding management. In addition, a rotational grazing system is ideal for stockpiling winter forage to reduce stored feed costs. Rotational grazing may protect water resources by managing the grazing period of riparian and upland paddocks to maintain adequate forage height to increase water infiltration and reduce precipitation runoff. During droughts, rotational grazing management may maintain forage production if the drought is moderate or provide paddocks that may be sacrificed for supplemental feeding if the drought is extreme.

Beyond improving the utilization efficiency of traditional pastures through the improved pasture and grazing management practices described in this publication, graziers may address many of the challenges presented in the

21st century through grazing of underutilized or novel forage resources. With approximately 14 million acres of corn harvested annually in Iowa, grazing corn crop residues could sustain a herd of 1.4 million beef cows over winter with little supplemental stored feed needed. Crop residues provide similar opportunities in other states with considerable row crop production. Although some grain producers might be concerned with the effects of grazing corn crop residues on subsequent corn grain or soybean yields, research at Iowa State University and the University of Nebraska has shown minimal or positive effects in a corn-soybean rotation. Incorporating cover crops or perennial forage border strips into a corn residue grazing system will supply additional forage for grazing while protecting soil and water resources. A third potential source of grazing land would be grasslands set aside for conservation and recreational uses either in government programs or by private land owners. Without management, such grasslands become dominated by dense stands of cool season grasses infested with invasive weed and brush species. A disturbance like grazing can optimize a grassland's ecological services like wildlife habitat, carbon sequestration, and maintenance of water quality provided by grasslands. Thus, grazing can provide a win-win situation for livestock production and environmental quality.

Photo by Erika Lundy.

If the owner of grazing livestock wants to increase available grazing land, but does not own extra crop land or land set aside for conservation or recreational purposes, then such land may have to be leased, presenting several obstacles. First, a landowner who is willing to allow grazing must be identified. While this may be done by contacting neighboring farmers or landowners, some Midwest extension programs have developed exchange programs to match beef cow-calf producers with row crop producers willing to lease land for grazing of crop residues with or without cover crops. Contact a state or area extension specialist regarding the availability of such an exchange in your area. After a landowner willing to allow grazing has been identified, then a lease agreement covering the rental charge, the length and timing of grazing, and the responsibilities for fencing, the water system, animal care, and liability must be prepared. If land enrolled in a government program is available, information on whether the enrolled land is eligible for grazing and, if so, the length and timing of grazing and any government payment reduction must be considered.

While information in this publication provides opportunities to improve both livestock productivity and environmental quality, it is unlikely to maximize all potential outcomes. For example, grazing management that would maximize wildlife habitat would likely result in reducing the amount and quality of forage, thus limiting livestock production particularly from livestock enterprises requiring high quality forage. But this is not a zero-sum game. Even lower quality forage from grasslands primarily managed for wildlife habitat can provide some grazing by livestock with lower nutritional requirements while the grazing provides disturbance that enhances the ecosystem services provided by the grassland. Complementary stocking systems can be used to develop flexible systems in which different pastures or paddocks can be managed primarily to meet specific goals while still providing some enhancement of others.

Therefore, the first step in developing a grazing system is to prioritize goals. When preparing a management program to meet these goals, producers should not only use information in this publication, but also utilize the expertise and experience provided by extension and National Resource Conservation Service specialists, service providers from farm and commodity organizations, local grazing groups, and other experts. However, under economic constraints occurring in the 21st century, graziers must be particularly aware that not all grazing management practices advertised to improve their system will work due to any number of reasons. When implementing recommended practices to improve pastures and/or grazing management, producers should be aware that response of grassland plants, grazing livestock, and natural resources like soil and water cannot be beyond the biological limits of a given site under the constraints imposed by weather conditions. While the information in this publication or other information sources can improve livestock production through improved forage production and quality, the response of forages and livestock to improved grazing will depend on the soil, forage, and livestock characteristics on the farm and the weather conditions in a given year. Keep in mind that what works on a neighbor's pastures and livestock or, more importantly, what works in a different region of the country or world will not necessarily work to the same extent, if at all, on your farm. Therefore, a grazier should always keep in mind that the optimal grazing system for their operation will depend on the land, forage, cattle, economic, and labor resources available to them and their willingness to dedicate those resources to a grazing enterprise.

Photo by Matthew Haan.

Appendix

In this section

- Pasture and grazing terms
- Planning worksheets
- Resources

Photo by Erika Lundy.

Appendix A—Pasture and grazing terms

Terms for describing vegetation

Forage. Vegetative parts of plants (leaves and stems) that are consumed by grazing livestock for feed.

Available forage. Amount (dry weight) of forage that is available for grazing by grazing animals.

Forage mass. Total dry weight of forage per unit area of land.

Aftermath. Forage regrowth following a harvest, typically hay.

Residue. Forage remaining after harvest of a grain crop. For example, corn crop residue.

Residual forage. Forage remaining in a pasture at the end of a grazing period.

Stockpiled forage. Forage that is allowed to accumulate for later grazing, typically late fall and winter grazing.

Sward. General term to include all of the aboveground plant growth in the pasture.

Monoculture. A sward, or area of grass, that consists of a single plant species. For example, pure bromegrass.

Mixed sward. A sward, or area of grass, that contains two or more plant species. For example, two or more grass species or a grass and a legume.

Terms for describing land used for grazing

Pastureland. Land that is used exclusively for forage production for the purpose of grazing livestock.

Rangeland. Land in which native vegetation is used as forage for grazing livestock.

Cropland pasture. Tillable land that is used for pasture production in rotation with cultivated crops.

Terms related to grazing land units

Pasture. Grazing area that is enclosed and separated from other areas by fences and other barriers.

Paddock. Grazing area that is a subdivision of a larger grazing area and that is generally separated by fencing. For example, a pasture can be divided into several paddocks.

Carrying capacity. Ability of a grazing land unit to support the production of livestock. Generally measured in terms of animal units. More specifically defined as the maximum stocking rate that a pasture will support without damaging the pasture ecosystem. The ideal varies from year to year on the same area because of environmental conditions affecting forage production.

Terms related to the grazing animal

Animal unit (AU). Defined as a 1,000 lb cow, dry or with calf less than six months old, who eats about 26 lb of dry matter per day.

Animal unit month (AUM). Amount of dry forage that one animal unit will consume in a month.

Animal unit equivalent (AUE). Proportionate fraction or multiple of a standard animal unit used to describe forage demand by other classes of livestock. Based upon forage consumption relative to the standard animal unit. See Table 3.2.

Grazing pressure. Number of grazing animal units per unit of forage mass (AU/lb of forage).

Forage allowance. Amount of forage weight available for each grazing animal unit at a point in time (lb of forage/AU). The reciprocal of grazing pressure. For example, 450 lb of dry matter per animal unit.

Stocking density. Number of animal units per grazing land unit at any one specific time (AU/acre). For example, the stocking density of 30 cow/calf pairs in a 90-acre pasture is one-third animal unit per acre. If the same 30 cow/calf pairs are in one of nine 10-acre paddocks within the 90-acre pasture, the stocking density at any point in time in now three animal units per acre.

Stocking rate. Number of animals grazing a land unit for a specified period of time (animals/acre). For example, 30 cow/calf pairs in a 90-acre pasture for the 150-day summer grazing season.

Terms related to grazing management

Continuous stocking. Allowing animals unrestricted access to an area of land for an extended period of time or throughout the entire grazing season.

Fixed (set) stocking. Allowing a fixed number of animals unrestricted access to an area of land for an extended period of time or throughout the entire grazing season.

Rotational grazing. Grazing system in which animals are rotated among two or more paddocks with recurring periods of grazing and rest during the grazing season.

Leader-follower grazing. Method of rotational grazing utilizing two or more groups of animals, usually with different nutrient requirements, to graze sequentially on the same land area.

Management intensive grazing (MIG). Any grazing system in which forage utilization is managed to control forage availability and quality. Sometimes called controlled grazing.

Mixed grazing. Grazing two or more species of animals on the same land unit during a grazing season.

Mob grazing. Method of stocking at a high grazing pressure for a short time to remove forage rapidly as a management strategy.

Seasonal grazing. Grazing that is restricted to specific seasons of the year.

Strip grazing. Method that confines animals to an area of grazing land to be grazed in a relatively short time, where the paddock size is varied to allow access to a specific land area.

Grazing period. Length of time for which a unit of land is grazed.

Rest period. Length of time for which a unit of land is ungrazed following a grazing period or harvest.

Utilization rate. Percentage of available forage consumed by animals during one grazing period on a pasture or paddock.

Appendix B—Worksheets

Guidelines to worksheets 1 and 2

Utilization rate guidelines

Rotation schedule	Utilization rate (full season)	Average*	Utilization rate (spring growth)	Average*
Continuous grazing (1 pasture)	30-35%	32.5%	30-35%	32.5%
14 days or greater (2-4 paddocks)	35-40%	37.5%	40-50%	45.0%
6-8 days (3-7 paddocks)	45-55%	50.0%	50-55%	52.5%
2-3 days (6-15 paddocks)	55-60%	57.5%	55-60%	57.5%
Daily (25-35 paddocks)	60-70%	65.0%	55-60%	57.5%
2 times per day (45-60 paddocks)	70-75%	72.5%	55-60%	57.5%

Utilization rate should follow these general rules

During rapid spring growth:
For 4 paddocks or fewer, utilization rates can be higher in the spring than during the rest of the season because of rapid forage growth.

For 5 or more paddocks, utilization rates should be lower in the spring than during the rest of the season to keep the rapidly growing forage from getting ahead.

Season long:
With short grazing periods and long rest periods, higher utilization rates are possible.

With long grazing periods and less rest, more leaf area should be left so lower utilization rates are necessary.

Rest period guidelines

During rapid growth:
20 days may provide adequate rest for plant recovery.

During summer growth:
40+ days may be needed for adequate plant recovery.

Season-long rest interval:
30-35 days is the basic recommendation for planning purposes.

Estimating forage availability

Estimated lb dry matter per inch per acre for forage type and pasture condition.

	Pasture condition		
Forage type	Fair	Good	Excellent
Smooth brome + legumes	150-250	250-350	350-450
Orchardgrass + alfalfa	100-200	200-300	300-400
Mixed pasture	150-250	250-350	350-450
Bluegrass + white clover	150-250	300-400	450-550
Tall fescue + legumes	200-300	300-400	400-500
Tall fescue + nitrogen	250-350	350-450	450-550

Note: Forage height is measured as natural plant position (leaves are not stretched or extended).

* Use the average in worksheets 1 and 2 when asked for utilization rates

Worksheet 1: Determining paddock number and size and total acres needed for a specific number of grazing animals

Step 1. Daily feed consumed by the grazing herd

			Weight		Total Weight		Intake (%)		Daily feed consumed
No. of beef cows, ave. milk		x		=		x	3.0	=	
No. of beef cows, high milk		x		=		x	3.5	=	
No. of calves		x		=		x	3.0	=	
No. of bulls		x		=		x	2.5	=	
No. of stockers, repl. heifers		x		=		x	3.0	=	
No. of ewes, dry		x		=		x	3.0	=	
No. of ewes, lactating		x		=		x	4.0	=	
No. of nursing lambs		x		=		x	3.0	=	
No. of rams		x		=		x	3.0	=	

Total lb. daily forage dry matter (DM) intake ________

Step 2: Determine amount of forage required adjusting for utilization rate (see Worksheet Guidelines)

lb. daily forage DM intake (Step 1) ________

Utilization rate* ________ %

= #DIV/0! lb. standing forage DM needed daily

**use the average of given rate on Worksheet Guidelines*

Step 3: Determine lb. DM per acre

Estimated lb. DM/inch/acre* ________ x Height in inches ________ = ________ Total lb. DM per acre

**See Worksheet Guidelines*

Step 4: Determine acres needed daily

lb. standing forage DM needed daily (Step 2) #DIV/0!

Total lb. DM per acre (Step 3) ________

= #DIV/0! Acres needed per day

Step 5: Determine paddock size

Acres needed per day (Step 4)		Number of days on paddock (per cycle)		Acres per paddock
#DIV/0!	x		=	#DIV/0!

Step 6: Determine number of paddocks

Rest period (21-42 days) ________ + No. of days on paddock ________

No. of days on paddock ________

= No. of paddocks #DIV/0!

Step 7: Total acres required for a specific number of grazing animals

Number of paddocks (st. 6)		Acres per paddock (st. 5)		Total acres needed
#DIV/0!	x	#DIV/0!	=	#DIV/0!

Example of Worksheet 1

Worksheet 1: Determining paddock number and size and total acres needed for a specific number of grazing animals

Step 1. Daily feed consumed by the grazing herd

			Weight		Total Weight		Intake (%)		Daily feed consumed
No. of beef cows, ave. milk	20	x	1,200	=	24,000	x	3.0	=	720
No. of beef cows, high milk		x		=		x	3.5	=	
No. of calves	19	x	300	=	5,700	x	3.0	=	171
No. of bulls	1	x	2,000	=	2,000	x	2.5	=	50
No. of stockers, repl. heifers		x		=		x	3.0	=	
No. of ewes, dry		x		=		x	3.0	=	
No. of ewes, lactating		x		=		x	4.0	=	
No. of nursing lambs		x		=		x	3.0	=	
No. of rams		x		=		x	3.0	=	

Total lb. daily forage dry matter (DM) intake 941

Step 2: Determine amount of forage required adjusting for utilization rate (see Worksheet Guidelines)

lb. daily forage DM intake (Step 1) 941

Utilization rate* 50 %

= 1,882 lb. standing forage DM needed daily

use the average of given rate on Worksheet Guidelines

Step 3: Determine lb. DM per acre

Estimated lb. DM/inch/acre* 350 x Height in inches 10 = 3,500 Total lb. DM per acre

**See Worksheet Guidelines*

Step 4: Determine acres needed daily

lb. standing forage DM needed daily (Step 2) 1,882

Total lb. DM per acre (Step 3) 3,500

= .54 Acres needed per day

Step 5: Determine paddock size

Acres needed per day (Step 4)		Number of days on paddock (per cycle)		Acres per paddock
.54	x	7	=	3.8

Step 6: Determine number of paddocks

Rest period (21-42 days) 35 + No. of days on paddock 7

No. of days on paddock 7

= No. of paddocks 6

Step 7: Total acres required for a specific number of grazing animals

Number of paddocks (st. 6)		Acres per paddock (st. 5)		Total acres needed
6	x	3.8	=	22.8

Worksheet 2: Determining the number of animals for a specific size of grazing system

Step 1: Determine number of paddocks

Rest period (21-42 days, see guidelines) ____ + No. of days on paddock ____
divided by
No. of days on paddock ____
= No. of paddocks #DIV/0!

(This should be consistent with the value used for utilization rate from the worksheet guidelines)

Step 2: Determine paddock size

Pasture size ____ acres
divided by
No. of paddocks (step 1) #DIV/0!
= Acres per paddock #DIV/0!

Step 3: Determine acres available per day

Acres per paddock #DIV/0!
divided by
No. of days on paddock ____
= Acres per day #DIV/0!

Step 4: Determine lb. dry matter per acre

Estimated lb DM per inch per acre		Height in inches		Total lb. DM per acre
	x		=	

Step 5: Determine lb. dryy matter available per day

Lb. per acre (step 4)		Acres per day (step 3)		Lb. DM available per day
	x	#DIV/0!	=	#DIV/0!

Step 6: Determine lb. dry matter consumable per day

Lb. DM available per day		Utilization rate (guidelines)		Lb. DM consumable per day
#DIV/0!	x		=	#DIV/0!

Step 7: Daily feed consumed by the grazing herd

			Weight		Total Weight		Intake (%)		Daily feed consumed
No. of beef cows, ave. milk		x		=		x	3.0	=	
No. of beef cows, high milk		x		=		x	3.5	=	
No. of calves		x		=		x	3.0	=	
No. of bulls		x		=		x	2.5	=	
No. of stockers, repl. heifers		x		=		x	3.0	=	
No. of ewes, dry		x		=		x	3.0	=	
No. of ewes, lactating		x		=		x	4.0	=	
No. of nursing lambs		x		=		x	3.0	=	
No. of rams		x		=		x	3.0	=	

Total lb. daily forage dry matter (DM) intake ____

Step 8: Determine adjustment ratio for grazing herd in step 7

Lb. DM consumable per day (step 6) #DIV/0!
divided by
Total lb. daily DM intake (step 7) ____
= Adjustment ratio for herd #DIV/0!

Step 9: The adjustment ratio provides a basis on which to make changes in animal numbers for stocking the system.

A ratio less than 1 indicates a need to consider reducing animal numbers proportionately.

A ratio greater than 1 indicates an opportunity to increase animal numbers to better use the forage.

Example of Worksheet 2

Worksheet 2: Determining the number of animals for a specific size of grazing system

Step 1: Determine number of paddocks

Rest period (21-42 days, see guidelines) **35** + No. of days on paddock **7**
———————————————— = No. of paddocks **6**
No. of days on paddock **7**

(This should be consistent with the value used for utilization rate from the worksheet guidelines)

Step 2: Determine paddock size

Pasture size **54** acres
———————————————— = Acres per paddock **9**
No. of paddocks (step 1) **6**

Step 3: Determine acres available per day

Acres per paddock **9**
———————————————— = Acres per day **1.28**
No. of days on paddock **7**

Step 4: Determine lb. dry matter per acre

Estimated lb DM per inch per acre		Height in inches		Total lb. DM per acre
200	x	10	=	2,000

Step 5: Determine lb. dryy matter available per day

Lb. per acre (step 4)		Acres per day (step 3)		Lb. DM available per day
2,000	x	1.28	=	2,560

Step 6: Determine lb. dry matter consumable per day

Lb. DM available per day		Utilization rate (guidelines)		Lb. DM consumable per day
2,560	x	50	=	1,280

Step 7: Daily feed consumed by the grazing herd

			Weight		Total Weight		Intake (%)		Daily feed consumed
No. of beef cows, ave. milk	20	x	1,200	=	24,000	x	3.0	=	720
No. of beef cows, high milk		x		=		x	3.5	=	
No. of calves	19	x	300	=	5,700	x	3.0	=	171
No. of bulls	1	x	2,000	=	2,000	x	2.5	=	50
No. of stockers, repl. heifers		x		=		x	3.0	=	
No. of ewes, dry		x		=		x	3.0	=	
No. of ewes, lactating		x		=		x	4.0	=	
No. of nursing lambs		x		=		x	3.0	=	
No. of rams		x		=		x	3.0	=	

Total lb. daily forage dry matter (DM) intake 941

Step 8: Determine adjustment ratio for grazing herd in step 7

Lb. DM consumable per day (step 6) **1,280**
———————————————— = Adjustment ratio for herd **1.36**
Total lb. daily DM intake (step 7) **941**

Step 9: The adjustment ratio provides a basis on which to make changes in animal numbers for stocking the system.

A ratio less than 1 indicates a need to consider reducing animal numbers proportionately.

A ratio greater than 1 indicates an opportunity to increase animal numbers to better use the forage.

Resources

For more information on pasture management and grazing management topics, refer to these resources.

ISU Extension Store
https://store.extension.iastate.edu

Iowa Beef Center
www.iowabeefcenter.org

Integrated Crop Management
https://crops.extension.iastate.edu

Ag Decision Maker
https://www.extension.iastate.edu/agdm

USDA-Natural Resources Conservation Service, Iowa
www.nrcs.usda.gov/wps/portal/nrcs/detail/ia/technical/landuse/pasture

In Iowa, opportunities for more grazing information include grazing meetings and conferences; forage, conservation, and livestock organizations such as the Iowa Forage and Grassland Council and the Iowa Cattlemen's Association; and producer grazing groups such as the Practical Farmers of Iowa. Iowa State University Extension and Outreach and the Natural Resources Conservation Service provide local and statewide opportunities. Producer grazing groups hold pasture walks during the growing season. These may be particularly helpful for producers considering a more management intensive grazing system, since attendees will be able to view such systems and visit with both the host and other graziers. Iowa State University Research and Demonstration Farms regularly have field days and also host other educational events.

This, and related publications are available on the ISU Extension Store at https://store.extension.iastate.edu and the Iowa Beef Center at www.iowabeefcenter.org.

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