Pasture, Rangeland and Grazing Management

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Contents

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In a time of high-cost inputs, pasture-based livestock production systems can naturally maintain soil and plant integrity while growing healthy ruminants. This publication profiles the general types of pastures and rangelands and offers information about management and expected yields. Weed management strategies are also discussed and tips are offered to rehabilitate depleted land. Issues in grazing management, such as paddock development, plant selection, drought and plant toxicosis, are also discussed. Resources and references are also presented.

Sheep on native range in southwestern Montana.

Introduction

Pasture is the basis of any livestock operation that purports to be truly sustainable. It is especially important as the livestock sector continues to experience extraordinarily high fuel and other input costs. Pasture-based production systems offer farmers and ranchers the ability to let the ruminant's environment and immune system work together, thereby gaining an acceptable level of production while naturally maintaining the integrity of the ecological connections between ruminants, the soil and the pasture plants. Ruminants on pasture experience fewer health problems due partially to reduced stress, whereas ruminants that are subjected to confinement have their digestive physiology running at top speed with the use of high-grain rations. Grain-fed ruminants typically require treatment for maladies such as acidosis, mastitis and respiratory disease due to the fact that their immune systems have been seriously compromised. A singular focus on productivity often causes more problems than a systems approach. A well-planned and managed pasture-based operation can maintain reasonable production, reduce input costs and achieve a positive economic return, given a well-conceived marketing plan.

Much of the grazing land in the United States can be used more efficiently for livestock grazing. For instance, U.S. Department of Agriculture Agricultural Research Service scientists have utilized wheat pasture and old world bluestem perennial

grass pastures, such as those that occupy large sections in the Southern Great Plains, and stocked them with double the number of cattle they normally would when using intensively managed grazing techniques. Even on the arid rangelands of the western United States, increased stock density coupled with decreased time on a pasture has been successful in increasing livestock enterprise productivity while improving the condition of the rangeland.

The ecological processes that occur on temperate pastures and on arid rangelands are basically the same, but occur much slower on rangelands due mainly to temperature and moisture differences. The following section is an attempt to clarify the nature of both types of pasture ecology.

Temperate pasture

Temperate pastures are typically very productive. They are characterized by well-developed soils, medium to high precipitation and moderate to rapid nutrient cycling. They can be dominated by warm- or cool-season plants and occupy niches from Maine to Florida, from Texas to Minnesota and from Southern California to the Pacific Northwest coastal regions of Washington and Oregon. Many irrigated riverine pastures in the desert and Intermountain West also resemble temperate pastures due to deep soils, adequate moisture from irrigation or high water tables and the presence of high-yielding plant species such as bromegrass and alfalfa. Temperate pastures will on average yield anywhere from 2,000 pounds of dry matter per acre per year to more than 12,000 pounds per acre depending on the species, soil type, growing season, grazing management and other environmental factors.

Temperate pasture can be highly productive with proper grazing management.

Photo courtesy of USDA NRCS.

Rangeland

According to the Society for Range Management, rangelands are a type of land on which the natural vegetation is dominated by grasses, forbs and shrubs and the land is managed as a natural ecosystem (SRM). In North America, rangelands include the grasslands of the Great Plains stretching from Texas to Canada, from the prairie states of the Dakotas and Nebraska to the annual grasslands of California and forestlands and wetlands throughout North America. Included in this definition are arid shrublands throughout the western United States, the arctic tundra, and mountain meadows and deserts throughout the Southwest. Rangeland can also encompass pastures of introduced grasses, such as crested wheatgrass, that are managed as rangelands. Arid rangelands, which typify much of Arizona, New Mexico, Colorado, Utah, Nevada, Idaho, Montana, Oregon, California and Washington, can yield anywhere from 200 to 1,500 pounds or more of dry matter per acre per year.

Rangelands are typically characterized by low precipitation, shallow soils and slow nutrient cycling. They are usually dominated by grasses, forbs and shrubs efficient at water and nutrient utilization, so practices that are appropriate to temperate pastures, such as fertilization and plowing, are often inappropriate on rangelands. Regardless, rangelands can be very productive, providing sustainable income for ranch communities while protecting valuable natural resources through appropriate grazing strategies. Specific strategies for sustainable rangeland management are covered below in the sections **Prescribed grazing on rangeland** and **Developing a grazing management plan on rangeland**.

Native rangelands are more fragile than temperate pastures, and often require different approaches to management for sustainable production.

Managing soil and forage resources

Fertile soil is the foundation of sustainable production. Soil macro-organisms and microorganisms are the external digestive system that processes organic matter, delivering a smorgasbord of minerals, vitamins and other nutrients to the crop at a metered pace. This contrasts the conventional approach of flooding crops with a limited number of soluble fertilizer nutrients, leading to luxury consumption, imbalanced plant nutrition and a susceptibility to disease and attack by insect pests.

Pasture systems are maintained through grazing and animal impact on the land, which accomplish the following:

- nutrient cycling through feces and urine;
- timely defoliation and removal of plant material that encourages regrowth;
- root death through leaf removal, resulting in underground organic matter accumulation and nutrient cycling;
- increased water-holding capacity through accumulation of soil organic matter; and
- hoof action that breaks soil surface and compacts soil, thereby allowing greater germination of seeds and encouraging regeneration of pasture swards.

Rotational grazing is a proven method of increasing the efficiency of pasture systems. Intensively managed rotational grazing systems have the potential of maintaining pastures in a vegetative state for most of the growing season in many regions of the country. Coupled with the use of stockpiled pasture and stored forage, the possibility of year-round forage finishing of livestock becomes more feasible in more parts of the country. In addition, intensively managed grazing systems make it possible to feed livestock without concentrating wastes in manure pits and lagoons, thereby maintaining nutrients within the pasture ecosystem and preventing them from becoming pollutants.

An intensively managed pasture system is appropriate for maximizing gain per acre and maintaining soil and pasture stand health. But to take advantage of the beneficial qualities of an intensively managed pasture system, a grazier should pay careful attention to grass stubble height after grazing. A grazier should be aware of the direct correlation between after-grazing stubble heights and pasture health.

Livestock should be turned onto cool-season grass pastures such as orchardgrass, wheatgrasses, timothy, fescues and more when the grass is from 8 to 12 inches tall, and removed when the stubble height is from 3 to 4 inches tall. Cool-season grasses have the ability to regrow relatively quickly after grazing, given enough time and soil moisture. Cool-season grasses can regrow through tillering (new shoot growth from the crown) or through sprouting new plants by way of underground rhizomes, depending on the species.

Native warm-season grasses such as big bluestem, switchgrass and Indiangrass should not be grazed too short, as heavy

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Rotational Grazing

defoliation can seriously reduce the grass's ability to persist over time. Warm-season grasses will not take the kind of defoliation that cool-season grasses can without causing harm to the pasture. It is also advisable to leave from 6 to 8 inches of stubble after grazing during the growing season for native warm-season grasses. The extra leaf area is needed for the plant to photosynthesize plant sugars and prepare for later winter dormancy. A grazing system that leaves a 12-inch stubble at frost is appropriate for these grasses (Conservation Commission of the State of Missouri, 1984).

Graze warm-season annual grasses such as sorghum-sudan just before heading when the plants are 2 feet tall. Livestock should be removed when these grasses have from 4 to 6 inches of stubble. Take care when grazing sorghum-sudan and related grasses, as prussic acid poisoning can be a problem if grazed too early. See **Plant toxicity** below for more detailed information.

Grazing can begin when grass is shorter on warm-season bermudagrass, bahaigrass and buffalograss pastures because these grasses have a more prostrate growth pattern and can generally handle heavier defoliation. From 2 to 3 inches of stubble on these grasses is not too short.

Cool-season grass yields range from 4 to 6.5 tons per acre, and warm-season pastures can typically yield from 2.5 to 4 tons per acre. In addition, pastures with grasses and legumes grown together typically yield from 10 to 15 percent more forage than monoculture pastures. Producers should determine the annual pasture productivity, as this will provide a baseline of information to make management decisions.

Determining forage yield

Forage yield can be determined with a pasture ruler or a rising plate meter. A pasture ruler is just that: a ruler calibrated in inches placed on end at ground level, with forage height measured in inches. A rising plate meter measures density as well as height. A 20-inch by 20-inch plate weighing 2.6 pounds is dropped on a rule at waist height.

Clip and weigh method

Construct a 2-square-foot quadrant frame from PVC or copper pipe. Each straight edge should measure 17 inches. Randomly throw the frame on the ground and clip all the plants inside the hoop at ground level. Place the clipped forage into a paper sack and repeat the procedure at least nine more times, placing samples in separate paper bags.

1. To determine percent dry matter, weigh one sample in grams (453.6 grams per pound, 28.47 grams per ounce), and place in a microwave for two minutes on a high setting. Weigh the sample in grams and repeat until no change in weight occurs. Place a small dish of water in the microwave to prevent damage.
2. Calculate the dry matter percentage of the sample by dividing the dry weight by the fresh weight and multiplying by 100.
3. Multiply the percent dry matter by the fresh weights of the remaining samples.
4. Average the weights of all samples and multiply the dry matter weight in grams by 50 to get pounds per acre.
5. Remember to adjust this figure for allowable use. If you wish to use only half the forage in the pasture, multiply the result by 0.50 to get pounds per acre for grazing.

For this measure in Iowa and Missouri, each inch of forage height equals 263 pounds per acre of dry matter and has been verified by numerous clip and weigh field studies. This measure should be calibrated for local conditions by clip and weigh method to obtain accuracy.

A good rough estimate is 300 pounds of dry matter per acre per inch on a ruler. This measure is likely to have from 50 to 80 percent accuracy depending on if you have calibrated your measurement procedure. Jim Gerrish's values range from 150 pounds per acre per inch in a fair stand to 600 pounds per acre per inch in an excellent stand as determined by clipping and weighing numerous quadrants and comparing them to sward heights (Gerrish, 2004). The vast differences in the above estimates reflect differences in pasture types. For example, bermudagrass will most likely be different from

bromegrass when measuring stand density with a ruler or rising plate meter.

Consideration must be given to forage quality and the species of livestock grazing the pasture. The higher the forage quality (vegetative, growing grass and clover), the greater the intake. Please refer to the accompanying box for information on animal intake by species. Understanding how much an animal will eat each day can assist producers in estimating forage demand.

Intake, sward density and grazing period

Forage intake is directly related to the density of the pasture sward. Ruminants can take only a limited number of bites per minute while grazing, and cattle in particular will only graze for about eight hours per day. It is important to ensure that each bite taken by the grazing animal is the largest bite possible. Cattle graze by wrapping their tongue around and ripping up forage. Large bites of forage are therefore ensured by maintaining dense pastures.

Dense pastures are pastures with actively growing and tillering forage plants. Tillering occurs in grasses that are grazed or mowed while vegetative, resulting in the activation of basal growing points and the initiation and growth of new stems and leaves. Tillering results in a plant covering more basal area, therefore helping make a pasture denser.

The length of the grazing period, or time in a paddock, also has a direct effect on pasture intake. An animal's intake decreases the longer it remains in a given paddock. This happens due to plant disappearance as plants are grazed and cattle search for their next bite. The decrease in crude protein content begins roughly two days after the animals have been turned into the paddock. Jim Gerrish has shown that as an animal remains in a paddock, intake and liveweight gains decrease (2004). It is for this reason that most dairy graziers move high-producing cattle to new paddocks after each milking.

Table 1. Animal intake by species

Species	Intake (% of body weight) per day	Intake in pounds per day
Mature cattle	2 to 3	20 to 30
Sheep	2.5 to 3.5	5 to 10
Goats	4 to 5	3 to 5

Legumes and soil fertility

Legumes like clover, alfalfa, birdsfoot trefoil, sainfoin and vetch have the ability to convert atmospheric nitrogen to the plant-available form of nitrogen through the symbiotic work of rhizobium bacteria, which occur naturally in a healthy soil. In a natural ecosystem, legumes can fix nitrogen at rates ranging from 25 to 75 pounds of nitrogen per acre per year. In cropping systems, the amount is several hundred pounds (Lindemann and Glover, 2003). For well-managed diverse pastures, supplemental nitrogen fertilization can be eliminated altogether. For pastures under high-density grazing systems, from 70 to 85 percent of the nitrogen taken in by the animals is returned and cycled back to the soil in the form of feces and urine. A diverse pasture with a significant legume component that is managed intensively with heavy stocking and frequent moves has the potential to become a stable, closed system.

An animal's intake decreases the longer it remains in a given paddock.

Stocking rate

Determining the initial stocking rate for a given pasture is relatively simple, but not necessarily easy. It is simple because the calculations are relatively straightforward. It is not easy because you must familiarize yourself with basic forage growth principles and apply those principles to what you observe on your own pasture.

There are several key issues to consider when thinking about how many animals a pasture will support. Consideration must be given to forage production potential; utilization patterns by livestock; the nutrient content of the forage and forage growth patterns; the plant species that comprise the pasture; species diversity of the pasture

plant community; and seasonal variations in temperature and moisture.

Stocking rate can be determined using the following formula:

$$\text{Number of animals} = \frac{\text{pasture size X pasture yield per acre}}{\text{daily intake X average animal weight X days of grazing}}$$

The formula is completed with the following:

1. pasture size in acres
2. pasture yield in pounds per acres of dry matter
3. daily intake as a percent of body weight (2 to 3 percent for cattle, see ***Table 1*** for other species)
4. average animal weight in pounds for the grazing herd
5. length of the grazing season in days

Example: Determine the number of 1,000-pound cows a 50-acre pasture will support for 100 days, given a pasture yield of 3,000 pounds of dry matter per acre.

$$\text{Number of animals} = \frac{\text{50 acres X 3,000 pounds per acre}}{\text{0.02 X 1,000 pounds X 100 days}}$$

Number of animals = 75

For very high-quality pasture, the intake rate used in the calculation could be increased to 3 percent for cows. The intake rate may also be increased to account for forage that is trampled or otherwise wasted. If the calculations are for sheep or goats, the daily intake and the average animal weight would be different. See ***Table 1*** for values.

More information on stocking rate is covered below in the section entitled **Rotational grazing and paddock size**.

Ecological weed management in pastures

Agricultural systems are very complex biological systems that operate in a particular ecological balance. Each region of the country, indeed each watershed and field, might behave in very different ways because of differences in soil type and depth; indigenous or local plant cover; cropping systems; and temperature and water availability, not to mention field cropping history. By developing a cropping system or perennial pasture that utilizes nature's own defenses and achieves ecological balance, a sustainable, pest-limited crop can be grown.

Do you really have a weed problem?

Many plants that are considered pasture weeds are highly palatable and nutritious during the vegetative stage. Take, for instance, dandelion and plantain. Both are plentiful in many pastures, and producers can spend thousands of dollars spraying them with herbicides. They are, however, valuable plants that occupy different root zones and deliver nutrients from different soil depths. They are also very nutritious and palatable when young. These and many other so-called weeds can be a valuable contribution to sustainable pastures. Even our so-called noxious weeds like knapweed and kochia can be grazed by sheep, goats and cattle with skilled management.

Weeds are often a result of soil disturbance and human interference in nature. Weeds are plants that occupy space that humans do not want them to occupy, and farmers have many very good reasons for not wanting weeds to occupy certain spaces. Some are non-native, invasive plants that have the capacity to crowd out or compromise the health of other plants and animals. Those types of weeds may need concerted control strategies. In agriculture we have become very accustomed to taking reactive measures such as pesticide application or mechanical approaches such as cultivation in order to eliminate unwanted plants and establish a favorable environment for the kinds of plants we choose to be there. But if we can look at crop production and pasture as systems and begin to understand how plants, animals and humans interact on a given landscape, weeds will become much less of a problem. By managing croplands and pastures according to natural principles,

we can significantly reduce weed problems. For more information see ATTRA's ***Principles of Sustainable Weed Management for Croplands***.

Techniques for dealing with problem weeds in pastures

Keeping weeds out of a pasture is much easier than trying to get rid of a bad infestation. Some management practices for keeping pastures weed-free include:

- terminate low-producing, weedy fields;
- rotate perennial pastures with annuals;
- integrate a high-density rotational grazing system;
- know your pastures; and
- consider multispecies grazing.

The aforementioned methods, used singly or in combination, can easily be incorporated into a pasture management system, setting up a situation in which weeds find it hard to get ground. When pasture stands such as alfalfa get too old, they often begin to decline and allow other plants to take over. Many times the grass component of the field will increase as alfalfa decreases, but in instances of low fertility or drought, weeds can take advantage of the open niche and become established. In these cases, terminating and reseeding the fields is sometimes recommended. Some producers refer to this as farming the pasture. For some pastures that are terminated, you might consider planting to winter wheat or oats and winter peas for a season. These are valuable forage crops and they help to break pest cycles while building soil.

High-density grazing systems also diminish weed invasion by reducing grazing selectivity. As an animal is forced to consume all the plants in a given area, no one plant is favored. This gives grass an advantage. Grass, because of the lowered position of its growing point when vegetative, tolerates leaf removal better than broadleaf plants, which often elevate their growing points much earlier in the season. Very intensive systems can even favor grass over legume growth, so pay careful attention to the legume component of intensively grazed paddocks. Reseed annual legumes by frost-seeding, feeding seed to cattle, broadcasting in the fall or allowing legumes to go to seed to maintain legumes in these systems. See the section **Pasture renovation and establishment** for more information.

Most of all, know your pastures. Make it a point to understand soil types and how they change with the aspect and slope of the land. Obtain some reference guides that will assist you in identifying the plants on your farm or ranch. Your Cooperative Extension Service is a great place to find these. The more you know about what your pastures will produce, the better position you will be in to make appropriate management decisions.

Many plants considered pasture weeds are highly palatable and nutritious during the vegetative stage.

Remember the principal concerns in managing unwanted pasture plants are:

- encouraging forage growth over weed growth through selection of appropriate livestock species and proper timing of grazing;
- ensuring adequate soil fertility through nutrient cycling, species diversity and inclusion of legumes; and
- rotating non-erodible fields, especially monoculture perennial fields, to break weed cycles.

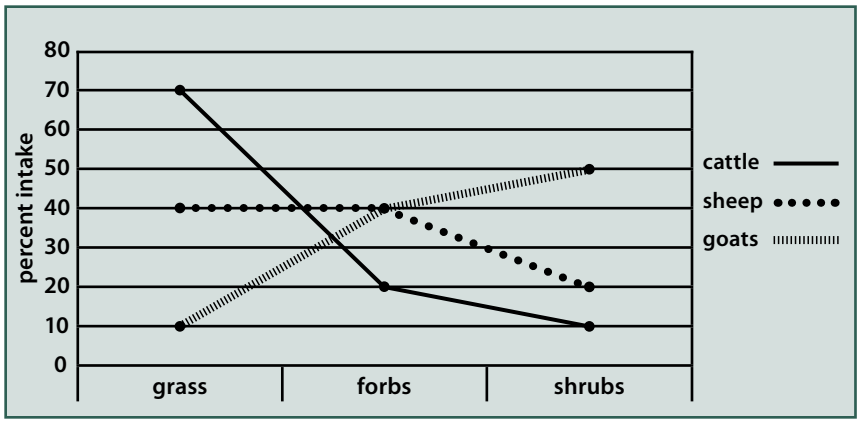
Perennial pastures on non-erodible land can be rotated with cereals, summer annuals or even vegetables to interrupt weeds, diseases and problem insects.

Multispecies grazing

Multispecies grazing refers to the practice of utilizing different livestock species to:

- diversify farm income;
- utilize pastures of different ecological types on the farm;
- manipulate the plant community to meet the production goals of the farm; and
- interrupt parasite life cycles.

Figure 1. Plant preferences for grazing livestock



Cattle, sheep and goats evolved eating different plant types. Cattle typically consume, in order of preference, grasses, forbs and shrubs. Sheep will consume, also in order of preference, forbs, grasses and shrubs and goats will seek shrubs, forbs and grasses.

Sheep have been effectively utilized on Western native ranges to control invasive species such as spotted knapweed, leafy spurge and yellow starthistle. Cattle that are grazing in conventional rotations often remain on Western ranges for weeks at a time during the summer and are moved when a set stubble height of key grass species like bluebunch wheatgrass or rough fescue is attained.

When cattle, being primarily grass eaters, remain in a pasture for long periods of time, they tend to exhibit grazing selectivity and choose vegetative grasses and young forbs over knapweed and other noxious weeds. Ranchers who have allowed a band of 800 or more sheep to graze for several days before or immediately after the cattle have seen significant knapweed usage by the sheep, with moderate grass utilization. See ***Figure 1*** for a comparison of plant preferences for grazing livestock.

Applying pressure with diversified livestock to knapweed, other forbs and grasses in equal amounts will increase range biodiversity significantly over time. Sheep can be used as an alternative enterprise by taking value from wool, lambs or by contract grazing on other parcels to control noxious weeds. Goats have a similar utility in areas with shrub infestation and have been successfully used to control kudzu, English ivy, scotchbroom, Chinese tallowtree, juniper and mesquite in many parts of the country. Small ruminants can also add value to a farm by providing meat and milk products to growing ethnic groups that seek these traditional foods. Refer to the ATTRA publication ***Multispecies Grazing*** for more information.

Using small ruminants on cattle operations will necessitate a change in farm and ranch infrastructure. Fencing, lambing sheds and secure paddocks in areas with predators such as wolves, coyotes or bears are often necessary, but costs can add up and drain profitability.

Other methods of maintaining small ruminants on ranches include employing a competent herder who will ensure the sheep or goats graze the necessary places and placing guardian animals such as guard dogs, donkeys or llamas with the livestock for predator control.

For more information see ATTRA's ***Predator Control for Sustainable and Organic Livestock Production***. Small ruminants are excellent additions to diversified farms and ranches because they have the ability to remove weed problems by shifting plant succession towards a more complex, balanced stage.

Pasture renovation and establishment

When is it appropriate to renovate pastures? Renovation often isn't necessary. Many farmers and ranchers have noticed increased productivity and decreased weed problems merely by working out a high-density rotational grazing system. Pastures are very resilient and, when maintained in the vegetative stage for most of the grazing season, ecologically appropriate grasses and forbs often begin to dominate where weeds and other unpalatable plants once proliferated. This happens due to the ecological principle called succession.

Nature tends toward the stability that comes with species complexity. Complex systems

occupy all available space both above and below ground, and therefore utilize nutrients and water more efficiently. Complex systems are more resilient from year to year, as some species will thrive during wet times and others will proliferate during dryer times. Simple systems, on the other hand, are less resilient and are prone to disease and insect attack due to the absence of diversity. In simple systems, one or two species prevail and there are fewer niches for beneficial organisms to occupy. Simple systems also exploit only a single soil layer, and therefore many soil nutrients will remain isolated from the system.

Ecological succession and grazing management

In nature, ecosystems evolve from simplicity to complexity. Consider a field that is plowed and abandoned. Usually the first plants to show up are annual grasses and forbs, followed by perennial forbs and grasses. As the years progress, the grasses begin to occupy more of the space and some shrubs will establish. If left alone and provided adequate precipitation, the shrubs will dominate. Trees will show up next, and woodland will appear at the height of succession. Managed grazing can hold succession to perennial forbs and grasses by maintaining the pasture in the vegetative, or growing, stage.

For those fields that have been cropped with annuals for the past several decades, renovation and reseeding might be appropriate, especially if high-yielding dairy cattle or growing lambs graze them. What follows is a short discussion on pasture renovation. For more information on field renovation and reseeding, including budgets for pasture establishment on a per-acre basis, see ATTRA's *Converting Cropland to Perennial Grassland*.

Pasture establishment

Establishing a new pasture is a time-consuming and expensive process. Careful attention should be paid to proper plant material selection; soil tilth and seedbed preparation; soil fertility and the addition of compost or manures; green manure plow-down; and amendments with rock powders. Plant materials should be adapted to the native soil pH and water-holding characteristics; annual precipitation; temperature; seasonality; and grazing system. This is a good time to incorporate rock phosphate and adjust the soil pH by adding lime according to soil test recommendations.

No-till grass seeders ensure proper seed placement and result in better germination.

Proper seedbed preparation is very important for establishing a productive pasture. There are essentially three ways to plant pasture grasses and legumes: planting into a prepared seedbed, no-till planting into the stubble of a prior crop or interseeding into an existing stand.

Seed-to-soil contact is of extreme importance when planting by any method. The seed must remain in contact with moist soil for the first month after germination or the seedling will whither. There are various methods for achieving seed-to-soil contact while planting. Drilling with a grass drill is the most effective, as it allows for better control of seed placement. Many times packer wheels follow the drill to firm the seedbed and ensure seed-to-soil contact. Broadcasting seed can be effective for some species, especially if the soil is packed after planting. Pulling a roller or dragging a harrow behind a tractor or four-wheeler is an effective tool to increase the germination of broadcast plantings, especially for ryegrass and clover seeds. Other grass seeds such

Seed-to-soil contact is of extreme importance when planting by any method.

as timothy, orchardgrass and most warm-season native grasses do not establish well by broadcasting and should be drilled. Be careful not to plant too deep or the seeds might not germinate. Follow local Cooperative Extension Service recommendations for seeding rate and depth.

Another method of planting new pastures is frost seeding. Frost seeding works well in areas that experience a freeze-thaw pattern in the spring before green-up. Broadcast seeds after snowmelt and allow the natural freeze-thaw action that occurs each day to work the seed into the ground. If the timing is right, this can be an effective way to achieve seed-to-soil contact and incorporate legumes into a grass pasture. For the humid areas of the South or drier areas of the West, fall-seeding of legumes is more appropriate so that seeds can establish during the winter rainy season.

Rotational grazing and paddock size

If given a choice, livestock will only eat the highest-quality, most palatable plants in a pasture. In order to ensure that plant biodiversity is maintained in the pasture, it is necessary to set up a grazing management system to better control livestock grazing. The elements of grazing to control are the timing and the intensity. This means controlling the number of animals and how long they are in a pasture.

Paddocks divided by a single electric wire increase options for managing pasture throughout the grazing season.

Photo by Linda Coffey, NCAT, taken at Nichols Dairy, Westphalia, KS.

Rotational grazing systems take full advantage of the benefits of nutrient cycling as well as the ecological balance that comes from the relationships between pastures and grazing animals. High-density stocking for short periods helps build soil organic matter and develops highly productive, dense, resilient pastures. For more information see ATTRA's ***Rotational Grazing*** and ***Paddock Design, Fencing and Water Systems for Controlled Grazing***.

A rotational grazing management plan need not be complex. It merely has to direct the grazing animal to eat when and where you want them to in order to keep the plants in their growing, or vegetative, stage. Rotational grazing allows for more effective forage utilization by increasing herd size on smaller paddocks for a shorter time, thereby decreasing grazing selectivity and giving the farmer more control of what and when the livestock eat. The basic principles of rotational grazing management include:

- proper timing of grazing corresponding to plant physiological stage;
- proper intensity of grazing, or duration on the pasture;
- residue or plant height after grazing; and
- duration of rest.

Allow the pasture plants to get to sufficient height prior to turning the cattle onto the pasture. By waiting until the grass is from 8 to 12 inches high, depending on species, the roots have become well developed and the plants can handle defoliation. Grazing intensity, or duration, can be taken care of by designing a suitable rotational grazing system. Rotational grazing, as the name implies, involves moving the cattle periodically from pasture to pasture or paddock to paddock. For instance, a good rule of thumb is to split a pasture into 10 or more paddocks with electric wire or electric tape and stock each paddock heavily for a short amount of time. See ***Table 2*** for

determining the number of paddocks and paddock size. By doing this you are forcing the animals to eat all that's there, including weedy plants they might otherwise not eat. However, before the animals eat the plants to the ground, move them to the next pasture. This takes into account the third principle. It's important to leave several inches of grass to allow adequate leaf area for subsequent regrowth.

Depending on the species, you will need to leave from 2 to 6 inches of plant stubble at moving time. An 11-paddock rotational grazing system that allows animals to graze each pasture for three days will give each paddock 30 days of rest. These figures are for planning purposes, and it is recommended to move according to forage height rather than by the number of days on pasture.

Table 2. Rest periods for selected plants

	Cool weather	Hot weather
Species	**(Days)**	
Cool-season grasses	14	35-50
Warm-season grasses	35-40	21
Legumes	21-28	21-28

Blanchet et al. ,2003

Grasses need from 15 to 50 days of rest between grazing events to allow adequate regrowth, depending on season, moisture and plant type. The accompanying chart shows typical rest times for various pasture plants, realizing that water and moisture will have a large effect on plant regrowth.

Calculating paddock size and number

Two questions that will immediately come up for someone contemplating a rotational grazing system are:

- How many paddocks should I have?
- How big should the paddocks be?

The University of Minnesota Extension gives details for calculating paddock numbers in their *Grazing Systems Planning Guide* (Blanchet et al., 2003). See the **Further resources** section for more information. Essentially, answers to these two questions can be easily acquired by utilizing the following formulas:

To calculate the number of paddocks needed, use the following formula:

$$\text{Paddock number} = \frac{\text{Rest period (days)}}{\text{Grazing period (days)}} + \text{number of animal groups}$$

Example:

$$\text{Paddock number} = \frac{30 \text{ days}}{2 \text{ days}} + 1 \text{ animal group} = 16 \text{ paddocks}$$

Then, to calculate the size of each paddock in acres, use this formula:

$$\text{Paddock size} = \frac{\text{Daily herd forage requirement (pounds) X grazing period (days)}}{\text{available forage per acre (pounds)}}$$

Example:
Considering that growing steers will generally consume around 2.5 percent of their body weight, we will estimate the intake of 100 700-pound steers to be 17.5 pounds per animal per day, times 100 animals equals 1,750 pounds daily herd forage requirement. If the animals will be in each paddock for two days, and the available forage in the paddock is 2,000 pounds per acre, then,

Paddock size = 1,750 pounds X 2 days/ 2,000 pounds per acre = **1.75 acres**

Therefore, for a herd of 100 700-pound steers and grass availability of 2,000 pounds per acre, you would need 16 paddocks of 1.75 acres each, allowing for two days of grazing in each paddock before moving the herd to the next paddock. It is very important to realize, however, that 2,000 pounds per acre is not the total productivity of the paddock, but reflects only the amount of forage the animals will be allowed to consume. A dense orchardgrass-timothy pasture in good condition can produce approximately 400 pounds of forage for each inch of plant height. So if you plan to begin grazing when the grass is 10 inches tall, and move the cattle when the grass is 5 inches tall, you should only calculate the 5-inch difference in height in your paddock size calculations. In our example, 400 pounds per inch times 5 inches equals 2,000 pounds per acre of available forage.

The figures and interpretations in this example are highly variable, and your situation will likely be different from this or any other grazing plan. This example is intended to familiarize producers with the basics of developing a rotational grazing system.

Overgrazing

Overgrazing occurs when the grazing pressure exceeds the carrying capacity of the pasture. This condition is not really a function of how many animals are on a pasture, but how long they remain there. In grazing management, time is the most important factor to consider in establishing a grazing system for sustained forage production. Continuous grazing allows livestock to selectively graze the most palatable plants over and over. The problem with this isn't necessarily in the selective grazing activity, but in the fact that the grazed plant does not get the time to regrow before it is grazed again. New growth is more palatable and contains more nutrients than older growth, so animals will come back for a second and third bite as long as they are in the pasture, resulting in the most palatable forages being killed out.

Divide pastures into enough paddocks to ensure that all plants have ample time to regrow after grazing.

Divide pastures into enough paddocks to ensure that all plants have ample time to regrow after grazing. In addition, for pastures with adequate water during the growing season, a very high stock density encourages animals to graze the pasture more uniformly than if the pasture was lightly stocked. In this situation the so-called weedy species are being grazed at the same intensity as the so-called good species.

Plant species and systems for extending the grazing season

Species used to extend the grazing season include cool-season annual grasses such as ryegrass and cereal grains; forage brassicas such as kale, rape and turnips; warm-season annual grasses such as sorghum-sudan hybrids, pearl millet and corn; and legumes such as Austrian winter pea (cool-season) and forage soybeans (warm-season). These annual crops can be incorporated in a perennial pasture by several methods.

Annual ryegrass and cereal grains such as oats, wheat and rye can be overseeded into warm-season pastures in the fall. These pastures will be ready to graze in December to January in the Deep South, and early spring for parts farther north. Ryegrass establishes well when broadcasted into perennial sod, but small grains typically establish better when drilled into sod.

Brassicas can be spring or summer planted into corn or other annual crops to provide late summer or fall forage for livestock. These crops produce as much as 12,000 pounds per acre and are well suited to strip-grazing.

Warm-season annuals like pearl millet, corn and sorghum-sudan are highly nutritious and provide quality forage during the summer when cool-season pastures such as orchardgrass, fescue and bromegrass slow down. Summer annuals fit nicely in rotational grazing systems. Careful attention to drought-stressed plants is warranted as these are susceptible to excessive nitrate accumulation, prussic acid accumulation or a combination of the two and subsequent livestock poisoning. Contact your local Cooperative Extension Service office for information on testing for these compounds.

Other species that can be used successfully to extend the grazing season are Austrian winter pea and forage soybeans. Winter pea, a cool-season legume, is often used as a cover crop in cereal rotations. Spring grazing of winter pea allows ranchers to rest more sensitive pastures and graze them when the soil is drier and the vegetation better established. Forage soybeans likewise have a place in summer cropping systems where farmers are rotating crops such as corn or grain sorghum with legumes to build soil organic matter. Grazing these crops for several months before plowing down the green plants is an added bonus to building soil organic matter and tilth.

Annual forage crops can be an excellent addition to a farm since they extend the grazing season several weeks or even months. However, annual cropping systems often come with environmental costs such as erosion, loss of organic matter and destruction of soil structure, most notably when soils are heavily tilled. Consider rotating annual crops to different fields each year

to minimize environmental impacts such as water or wind erosion.

Stockpiling forages

Stockpiling is defined as letting forage grow during summer and deferring grazing to the fall or winter. This is an effective way of providing winter forage in some areas and can reduce the need for harvested forage. If it reduces hay use at all, significant savings can be realized. This system works well for early winter when spring-calving cows are in mid pregnancy. Stockpiled grazing can be followed with meadow feeding of high-quality alfalfa hay prior to calving.

Stockpiling has been shown to work well given appropriate pasture management and efficient allocation of dormant pasture during the winter. Many grass species will maintain a relatively high nutrient content and palatability for several months after dormancy begins. Two extra months of grazing can significantly reduce the costs associated with producing and feeding hay. In some cases, producers have been able to utilize stockpiled forage and eliminate the need for hay feeding completely. This usually works better in climates where the dormant grass can be preserved longer under adequate snow cover or because of reduced microbial decomposition caused by low temperatures and limited moisture.

Stockpiled forages can be fed by either limit-feeding (allowing only so many hours of grazing per day) or by strip-grazing with a movable electric wire or tape. Another option for feeding stockpiled forages is to swath them with a hay mower and then rake them into windrows. Cattle can graze directly off the windrow during the winter by using an electric wire or electric tape to ration hay on a daily basis. This is similar to strip-grazing in that the wire is moved each day to expose a predetermined amount of forage for grazing. This method, while still relying on a tractor to cut and windrow the hay, reduces the amount of fuel, materials and hay equipment needed for bale-and feed-hay by eliminating the baling process altogether. This method works best in dryer regions where weathering is less likely to reduce the nutritional quality and palatability of the hay.

Table 3. Forage species for stockpiling

In the North and West	In the South and East
Altai Wildrye	Bermudagrass
Orchardgrass	Tall Fescue
Reed Canarygrass	Reed Canarygrass
Timothy	
Alfalfa	

For more information on grazing season extension call ATTRA at 1-800-346-9140.

Prescribed grazing on rangeland

Prescribed grazing can be thought of as a process of developing a grazing system that seeks to integrate the economic and ecological realities that ranchers are faced with on the Western range. The USDA defines prescribed grazing as "the controlled harvest of vegetation with grazing or browsing animals, managed with the intent to achieve a specified objective" (USDA, 1997).

Management objectives addressed by prescribed grazing include:

- Improve or maintain the health and vigor of selected plants and maintain a stable and desired plant community;
- Provide or maintain food, cover and shelter for animals of concern;
- Improve or maintain animal health and productivity;
- Maintain or improve water quality and quantity; and
- Reduce accelerated soil erosion and maintain or improve soil condition for susceptibility of the resource (USDA, 1997).

A very crucial aspect of a prescribed grazing regime is the development of a workable and ecologically appropriate grazing management plan.

Developing a grazing management plan on rangeland

Designing an effective grazing plan isn't as daunting as it seems. Mostly it is applying observation to management, observing some more and then adjusting as needed. There are five steps in developing a grazing plan. They are:

1) Create an inventory
2) Define goals
3) Determine grazing units
4) Develop a grazing schedule
5) Develop a monitoring and evaluation plan (Montana DNRC, 1999)

Remember that livestock should always be within a two-hour walk from water.

Create an inventory

This is for gathering baseline information to allow you to make appropriate decisions about land and pasture use. Obtain soil maps from your Natural Resources Conservation Service office and mark appropriate land forms, soil types and fences and paddocks. Find out what plants are in each pasture and evaluate the pastures based on a condition score. Utilize features such as key species, percent canopy cover, amount of bare ground, presence of noxious weeds, annual forage production in pounds per acre and amount of residue to determine pasture condition and productivity.

Define goals

Make a list of what you want to accomplish. This will be a list of your expectations and will guide you in making plans and decisions. Do you want to improve the economic value of the ranch? Maintain wildlife habitat? Improve water quality and quantity? Reduce noxious weeds? Also consider available acreage and the amount of time you have to put into this project.

Determine grazing units

Divide the pastures into units that you can rotate animals through. This will allow you to rest pastures and allow for regrowth following grazing. It will also allow you to rotate grazing on a seasonal basis. Determine how much forage is available in each grazing unit and map it out. Note key species, percent cover, water availability, facilities and other aspects important to you. Remember that livestock should always be within a two-hour walk from water. This will help you to determine grazing unit size for large parcels.

Develop a grazing schedule

This will be a graphic illustration of your plans for grazing each unit during the grazing season. Develop the schedule based on your total animal units and available animal unit months in each unit. If you have a 100-acre pasture with two animal unit months per acre, you have 200 animal unit months of forage available. At 50-percent allowable use, cut it in half to 100 animal unit months. This means you have enough forage available to feed 100 animals for one month. Or, said another way, 50 animal units for two months, 33 for three months and so on. For more detailed information on calculating animal unit months, see the Montana Grazingland Animal Unit Month Estimator located at ***www.mt.nrcs.usda.gov/technical/ecs/range/technotes/rangetechnoteMT32.html***

Important concepts here are duration of grazing and time for regrowth. Some range ecologists and managers believe that grazing intensity is also important, and it is. A plant needs to have green leaves left after grazing for photosynthesis and subsequent regrowth. However, others feel that grazing severity isn't as important as regrowth time. Whichever you choose, it is important to remember to allow plenty of time for adequate regrowth before the animal gets to bite a plant a second time. Take a look at the native plants on an upland range site if you have the opportunity. Some, like bluebunch wheatgrass and little bluestem, are large-statured and can handle several bites from an animal in one grazing event. Some, like Sandburg bluegrass, Idaho fescue and black grama, are smaller and one bite is all it takes to reduce the plant to stubble.

Cattle especially tend to graze severely, so don't get too caught up in how much they take off. Strive for 50-percent use and allow for regrowth. For some sites on dry ranges, this will mean one grazing event per year. For areas with more moisture, you might be able to return every 15 to 30 days for another grazing event.

Develop a monitoring and evaluation plan

This is the most neglected part of range management, and the most important. A good monitoring system will allow you to check how your management decisions are working on the ground. It will allow you to determine, for instance, if a particular grazing plan is having the desired effect over time. A monitoring plan will often involve a few important evaluation criteria, such as plant species composition, percent cover and frequency of species. By comparing these measurements over time, you can start to see trends and can alter and adjust your grazing system in order to arrive at your goals.

Recordkeeping is a very important part of pasture monitoring. In addition to recording the aforementioned physical measurements, keep track of when livestock enter and leave a pasture; what materials or chemicals are used; revegetation or weed control treatments; and observations on cattle health while in the pasture. This information will be extremely useful in refining your grazing plans.

To obtain more detailed information on rangeland monitoring contact ATTRA at 1-800-346-9140.

Managing for drought

Drought is a natural ecosystem process. The concept of an average or normal precipitation or temperature is a fabrication that humans use to try to understand complex systems and attempt to predict behaviors and outcomes. Whether in a humid zone or an arid environment, a producer will experience relative wet and dry years. Dealing with the dry years is a real challenge to livestock operations that rely on water to grow the plants and recharge the aquifers and streams that feed the animals. Having a drought plan is a very important component of a well-thought-out farm or ranch management plan.

A drought-management option that deserves serious consideration is for a producer to maintain livestock numbers at 75 percent of carrying capacity for normal years and utilize the extra forage in wet years for high-value animals such as stockers (Ruechel, 2006). In dry years the pastures will be better able to accommodate current livestock numbers. Another option is to slow down rotations during dry years, thereby allowing more paddock or pasture rest time. This option can be effective especially when the herd is split between different pastures to minimize the impact on drought-stressed plants.

If you must de-stock during drought, consider which animals should be the first to go. Do you have low-producing females? Do you have older calves that can be sold as stockers? Whichever you do, be sure not to de-stock too late. Pasture that is overstocked and drought-stressed is hard to repair, whereas a cow herd can be bought when rains return.

A rangeland monitoring photo of a transect in southwestern Montana. Photo points such as this help range managers evaluate changes in vegetation due to grazing management.

Plant toxicity

Graziers must pay careful attention to the negative health effects that certain plants can cause in livestock. Plant toxicosis occurs either through the ingestion of poisonous plants or forage plants that contain toxic substances due to environmental or physiological conditions. Plant poisoning from water hemlock, nightshade or astragalus can be significantly reduced by proper grazing management. These poisonous plants contain resins, alkaloids and organic acids that render them unpalatable. If the pasture contains enough good forage, there is little reason for the animals to select bad-tasting plants. Contact your local Cooperative Extension Service office for information on poisonous plants in your area.

Your local Cooperative Extension Service office

Contact your local Cooperative Extension Service office for information on poisonous plants, forage nitrate testing and locally adapted forages. The USDA maintains an online database of local Cooperative Extension Service offices on its Web site at www.csrees.usda.gov/Extension/index.html. You will also find the phone number for your Cooperative Extension Service office in the county government section of your telephone directory.

The following section illustrates some of the more common and economically important environmentally or physiologically caused disorders.

Bloat

Livestock can bloat when they consume vegetative legume pastures such as clovers and alfalfa. Bloat is a condition manifested by the distention of the rumen, noticed as a severe protrusion on the animal's left side caused by fermentation gasses that are not able to escape. Legumes are high in protein and the more immature the plant, the higher the concentration of proteins it contains. These proteins are very rapidly digestible and produce gas very quickly, faster than the animal can expel. Control is accomplished one of four ways:

- ensuring the legume component is less than 50 percent of the pasture stand composition;
- feeding one-third of the daily dry matter requirement as long-stem grass hay before grazing lush pastures that contain greater than 50 percent alfalfa or clovers;
- planting a non-bloating legume like Cicer milkvetch, sainfoin or birdsfoot trefoil; and
- feeding an anti-foaming agent, usually composed of fats, oils or synthetic surfactants.

Organic producers should make sure that they do not feed prohibited materials. Any treatments they use or plan to use must be listed in their organic system plan and approved by the organic certifier before use.

Grass tetany

Grass tetany is caused by low blood levels of magnesium (Mg). When succulent cool-season grasses are grazed early in the spring, the condition can have a rapid onset. Symptoms include lack of coordination, staggering and eventually death. Grass tetany is prevented by:

- delaying spring grazing;
- feeding a legume hay with spring grass pastures since legumes are higher in magnesium than grasses;
- providing a mineral supplement; and
- grazing early spring pastures with less tetany-prone animal such as steers, heifers and cows with older calves, since pre- and post-partum cows are most susceptible to grass tetany.

Prussic acid

Prussic acid, or hydrocyanic acid, is a toxin that occurs in annual grasses such as Johnsongrass, sorghum and sorghum-sudan hybrids. When these grasses are stressed due to drought or frost, prussic acid levels accumulate and, if grazed by livestock, will cause salivation, labored breathing and muscle spasms. Death can occur very

quickly after consumption. Prussic acid does not persist like nitrates do. Forage that has been ensiled or harvested as hay and dried to a less than 20-percent moisture content is safe for consumption. Prussic acid poisoning can be prevented by:

- testing for prussic acid if conditions are right;
- avoiding grazing for a week after the end of a drought since young plant tissue after a drought-ending rain will be high in prussic acid;
- avoiding grazing for a week after a killing frost;
- considering pearl millet as a warm-season annual forage since pearl millet does not produce prussic acid; and
- avoiding turning hungry livestock into a suspect pasture.

Testing for prussic acid requires timely delivery to the lab, as cyanide levels decline after the plant is harvested. Refrigerate but do not freeze samples if you cannot get them to the lab right away. If mailing samples to the lab, mail them on a Monday to reduce shipping time.

Contact your local Cooperative Extension Service office for information on forage prussic acid testing.

Nitrates

All plants contain nitrates, which are the precursor to plant proteins. Excess nitrates will accumulate in the lower stems of some plants when plants are stressed. This can occur during a drought, heavy rain or long period of cloudy weather. In effect, nitrate accumulation occurs when photosynthesis slows down. During this time the plant may not be metabolizing nitrates, but it will still be taking nitrates from the soil. The result is a backlog of poisonous nitrates in the plant stems. Concentrations of 1.5 percent or more in plant tissue can be toxic to livestock, and concentrations of less than 0.25 percent are considered safe. Excess nitrates can be deadly to livestock, and the most commonly affected plants are annual grasses such as the cereal grains including oats, wheat and barley; warm-season annual grasses such as sorghum, pearl millet and corn; and broadleaf plants such as pigweed, thistles, goldenrod and lambsquarters. In contrast to prussic acid, nitrate toxicity in forage does not decrease with time. Nitrate poisoning can be prevented by:

- testing of suspected plant tissue prior to feeding;
- harvesting or grazing suspected forages several days to a week after the end of a drought;
- beginning harvest or grazing of suspected forages in the afternoon after the plants have had several hours of sunlight since this helps the plants metabolize nitrates;
- chopping forage and diluting with clean hay; and
- minimizing nitrogen fertilization.

Contact your local Cooperative Extension Service office for information on forage nitrate testing.

Excess nitrates can be deadly to livestock and the most commonly affected plants are annual grasses.

Fescue toxicosis

Another important condition to consider in the South and Midwest is fescue toxicosis, which is caused by fungi growing symbiotically with the plant. Three distinct ailments can occur when livestock consume infected tall fescue. Fescue foot results in fever, loss of weight, rough hair coat and loss of hooves or tail switch. Bovine fat necrosis is a syndrome characterized by hard fat deposits in the abdominal cavity. Summer slump is evidenced by fever, reduced weight gain, intolerance to heat, nervousness and reduced conception. Fescue toxicosis can be reduced by:

- seeding of legumes to dilute fescue intake;
- early close grazing of fescue to reduce seed development;
- restricting nitrogen fertilization to the summer when warm-season grasses are actively growing; and

- replanting with endophyte-free seed or another grass species such as orchardgrass.

Southern Forages, a book listed in the **Further resources** section, has an excellent entry on fescue toxicity in its Common Forage-Livestock Disorders chapter.

Summary

When a livestock farmer relies on pasture or rangeland to supply the protein and energy requirements of livestock, it benefits the farm, the watershed and the community in significant ways. The management practices that foster a more sustainable agriculture system are founded on a management philosophy that values health in people, animals, plants and soil.

Pasture-based animal agriculture promotes environmental stewardship and community development through certain key management practices, including limiting the use of off-farm inputs such as diesel, fertilizer and purchased feed; and toxic substances such as pesticides. Soil conservation practices, such as limited tillage and use of perennial pastures, store carbon in the soil while building soil organic matter.

The biological diversity of the pasture is enhanced through grazing management, especially through planned grazing systems that provide adequate rest and regrowth. Conserving water and energy resources through irrigation monitoring; solar and wind technologies; and biofuel development can enhance farm sustainability. The selection of adapted plant and animal genetics to local conditions can enhance the health and resilience of the whole farm community.

Marketing food to local communities tends to reduce the distance food travels from farm to plate and provisions the community with better, fresher food. Local processing plants add value to local animal products while providing employment and economic development.

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Further Resources

ATTRA publications

Assessing the Pasture Soil Resource
Dairy Resource List: Organic and Pasture-Based
Managed Grazing in Riparian Areas
Multispecies Grazing
Nutrient Cycling in Pastures
Pastures: Sustainable Management
Pastures: Going Organic
Paddock Design, Fencing, and Water Systems for Controlled Grazing
Rotational Grazing

Grazing behavior and livestock handling

Foraging Behavior: Managing to Survive in a World of Change; Behavioral Principles for Human, Animal, Vegetation, and Ecosystem Management
Fred Provenza, PhD
Utah State University
www.behave.net/products/booklet.html

Stockmanship: Improving rangeland health through appropriate livestock handling
Steve Cote
Order from the Natural Resources Conservation Service and the Butte Soil and Water Conservation District
P.O. Box 819
125 S. Water St.
Arco, ID 83213
(208) 527-8557
www.grandin.com/behaviour/principles/Steve-Cote.book.html

Grazing systems: Planning and management

A Guide for Planning, Analyzing, and Balancing Forage Supplies with Livestock Demand
Lacey, J., E. Williams, J. Rolleri, and C. Marlow. 1994. Bozeman, MT: Montana State University Extension.
http://animalrangeextension.montana.edu/Articles/Forage/grazing/guide_planning.pdf

Grazing management: an ecological perspective
Rodney K. Heitschmidt and Jerry W. Stuth
http://cnrit.tamu.edu/rlem/textbook/textbookfr.html

According to its foreword, this book was written to help resource managers broaden their perspective relative to management of grazing animals and heighten their awareness of the role they play in maintaining the integrity of ecological systems. Published by Timber Press in Portland, Ore.

Grazing Systems Planning Guide
Kevin Blanchet, University of Minnesota Extension Service
Howard Moechnig, Natural Resources Conservation Service
Minnesota Board of Water and Soil Resources,
Jodi DeJong-Hughes, University of Minnesota Extension Service
University of Minnesota Extension Service Distribution Center
405 Coffey Hall
1420 Eckles Ave.
St. Paul, MN 55108-6068
order@extension.umn.edu
www.extension.umn.edu/distribution/livestocksystems/DI7606.html

Delineates the components of a grazing system by taking the farmer through the grazing management planning process.

Management-intensive Grazing: The Grassroots of Grassfarming
Jim Gerrish, Green Park Publishing
This book can be obtained through The Stockman Grassfarmer's Bookshelf at 1-800-748-9808.

The industry standard for growing and managing pastures for sustained livestock production.

Pastures for profit: A guide to rotational grazing
Cooperative Extension Publications
45 N. Charter St.
Madison, WI 53715
http://learningstore.uwex.edu/pdf/A3529.pdf

Grazing ecology and setting up a rotational grazing system.

Pasture for Dairy Cattle: Challenges and Opportunities
Donna M. Amaral-Phillips, Roger W. Hemken, Jimmy C. Henning, and Larry W. Turner. University of Kentucky Cooperative Extension.
www.ca.uky.edu/agc/pubs/asc/asc151/asc151.pdf

Southern Forages
Donald M Ball; C S Hoveland; Garry Lacefield
Altanta, Ga.: Potash & Phosphate Institute: Foundation for Agronomic Research, 1991. Fourth Edition 2007.
http://ppi-store.stores.yahoo.net/soutfor.html

The book Southern Forages ***was first introduced in 1991 and has since gained wide recognition as a practical and reliable source of information on modern forage crop management.***

Selecting forages

Fertility Pastures
Newman Turner
Faber and Faber, 24 Russell Square, London
Classic text on herbal lays, soil health and profitable livestock production on pasture. Out of print. Used bookstores and interlibrary loan might yield good results obtaining this worthwhile book.

Forage Information System
http://forages.oregonstate.edu/index.cfm
A comprehensive Web site for forage-related topics, including publications, educational opportunities and professional resources. Maintained by Oregon State University.

Intermountain Planting Guide
USDA Agricultural research Service, Utah State University, Logan, Utah
Order from USU Extension Publications
(435) 797-2251
http://extension.usu.edu/cooperative/publications/

Organizations

Holistic Management International
1010 Tijeras Ave. NW
Albuquerque, NM 87102
(505) 842-5252
hmi@holisticmanagement.org
www.holisticmanagement.org/
HMI is a goal-oriented, decision-making system for ecological management of resources, people and capital.

Rangelands West
Western Rangelands Partnership, Agriculture Network Information Center,
University of Arizona
http://rangelandswest.org/
Web-based educational tools and information to assist resource managers improve rangelands and maintain sustainability.

Quivira Coalition
1413 Second Street, Suite 1
Santa Fe, NM 87505
(505) 820-2544
www.quiviracoalition.org/index.html
Publications on ecological resource management including range management, grazing, road construction, monitoring and managing resources at the urban-rural interface.

Pasture, Rangeland and Grazing Management
By Lee Rinehart
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Amy Smith and Robyn Metzger, Production

This publication is available on the Web at:
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or
www.attra.ncat.org/attra-pub/PDF/past_range_graze.pdf

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