Pastures: Sustainable Management

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Well-managed forage systems contribute significantly to the sustainability of a farm/ranch operation. This publication addresses numerous aspects of sustainable pasture integration, grazing rotation strategies, and management options. It covers: grazing systems, pasture fertility, changes in the plant community through grazing, weed control, and pasture maintenance. It also discusses planning and goal-setting, and offers an appendix item on trees in pasture settings.

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NCAT photo.

Introduction

Management is the key to healthy, productive pastures. Controlled, rotational, or management-intensive grazing has increased forage production for many producers. Skillfully using livestock to harvest forages leads to improved soil fertility, a diverse, dense, and useful pasture ecology, and an extended grazing season. Fertile soil and productive pastures, in turn, support healthy animals.

Well-managed forage systems contribute to an operation's sustainability in several important ways:

- Lands most susceptible to erosion (or otherwise unsuitable for annual crops) can be maintained as permanent sod.
- Land used for row crops benefits from a year or more in pasture as part of a crop rotation plan. The life cycles of annual weeds and other crop pests are interrupted during the pasture years of the rotation.
- Soil health improves as the content of organic matter increases under good grazing management.
- Soil structure improves over time as compaction and hardpan is reduced.
- Ruminants (cattle, sheep, deer, goats) thrive in a better balanced agro-ecosystem and produce milk, meat, and fiber from grasses that cannot be digested by humans. Livestock eat excess plant materials while animal wastes contribute nutrients for plant growth.
- Marketing meat, milk, fiber, and other animal products can diversify producer income.

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The sun is the source of energy for the entire planet and much of this energy is captured and stored by plants. Plant fibers that are otherwise unusable by humans are eaten and converted into a new form of stored energy by domestic ruminants, such as cattle, sheep, and goats. Producers can then market this animal meat, milk, and fiber. In a very real sense, annual crop and livestock systems constitute a harvest of the sun and a new source of wealth. And the most efficient system to convert the sun's energy to money is likely to be the most profitable. A dense and diverse forage community offers an excellent opportunity for livestock managers who can harvest and market it.

In the not-too-distant past, farmers more fully integrated crop and livestock enterprises as a matter of course. Grain produced in field rotation was either sold or fed to livestock, depending on market conditions. Cropland was rotationally seeded to forages, usually for several years. Land not suitable for crop production was grazed. Animals also foraged after-harvest crop residues and the remains of failed crops. These time-honored strategies are not totally absent from today's agricultural landscape; however, a better integration of crop and livestock enterprises is a necessary step toward the goal of sustainable pasture lands.

Planning and Goal-Setting

In analyzing your pasture systems, think of yourself as a grass farmer, and the livestock as a means to market the forage. It doesn't matter whether the grass is produced on permanent pasture, on marginal land, or on crop land in the pasture years of a rotation. An excellent goal is to produce enough good-quality forage to sustain livestock over as much of the year as possible. Then choose the livestock that can best use it.

Of course, different livestock species and classes of livestock have different feed requirements and forage preferences. Most cow-calf operations, for instance, have lower forage nutrition and soil fertility requirements than do most dairies. Consistent production of high-quality forage under current management makes a dairy or stocker enterprise an option to consider. Otherwise, a different class of cattle, sheep, or other ruminant (either alone or in a multispecies system) may be more suitable to your specific site and management capability.

In setting production goals for any livestock enterprise, consider the economic return per acre rather than production per animal. This is a change from traditional thinking. Compare pounds produced per acre or per dollar invested rather than weaning weights or shipping weights. This type of analysis shows actual profitability more clearly. (See enclosed article by Doug Gunnink for tools to analyze profitability.)

Renovating Pastures vs. Establishing New Ones

Planting a new pasture offers the opportunity to choose forage species and varieties suited to the livestock type adapted to the soil and climate. Efficiency is further enhanced by matching the season of maximum forage production to the period when livestock can best use it or most need it. Further, planting a diverse mixture of forages with differing maturities provides a high-quality, longer grazing season.

County or state Extension personnel are often good sources of information about forage varieties adapted to an area or even to a specific site. The Natural Resources Conservation Service (NRCS) is another good source of information on forage production practices appropriate for particular grazing systems. This agency has been given specific responsibility for helping farmers improve the grazing lands of the United States. Most states have at least one NRCS Grazing Lands Specialist to carry out this mandate. You can find more information about this initiative at *www.glci.org/.*

On the other hand, improving management of an existing pasture is usually preferable to starting a new one. The cost to seed, till, and control weeds for a new pas-

ATTRA has developed several sustainability checksheets for educators and producers to use in evaluating any operation that includes a grazing system. Each is designed to make the producer think about how different parts of the pasture-based enterprise relate to each other. The checksheets were developed by teams of producers and educators and have been tested in several locations. Checksheets currently available include:

· Beef Farm Sustainability Checksheet
· Dairy Farm Sustainability Checksheet
· Small Ruminant Sustainability Checksheet

Call ATTRA to request a printed copy of any of these checksheets, or download them from our Web site at *www.attra.org/livestock.html.*

GOAL OF GOOD GRAZING MANAGEMENT:

The maximum number of animals has plenty of good quality forage to graze throughout as much of the year as possible. The needs of the soil, the plants, and the livestock are balanced to achieve this goal.

KEY TOOLS OF GRAZING MANAGEMENT:

- Stock density
- Frequency of moves
- Paddock rest

ture is expensive and must be considered. Additionally, a producer must consider the cost to keep livestock off the acreage during the establishment period. The risk of erosion during this transitional period must also be taken into account. In short, it may be more economical, and less disruptive to the soil ecology, to improve an existing pasture's forage by introducing desirable species using no-till seeding methods.

Many pasture problems—such as sparse plant cover, weed invasion, and slow growth—are caused by poor grazing management. If this is the case, establishing a new pasture will not solve the problem. Newman Turner, in *Fertility Pastures and Cover Crops*, observes that good grazing management can transform poor grazing land into healthy, productive pasture. On the other hand, newly reseeded pastures quickly become poor again under bad management. (1) Thus, a careful assessment of management practices is usually the best place to begin to make forage systems more profitable.

Choosing a Grazing System

Many managers use controlled grazing plans instead of continuous grazing to increase forage utilization and profits. In a system of controlled rotations, pastures are subdivided into paddocks—fenced acreage of any given size. Livestock is moved between paddocks at frequent intervals, giving animals access to a limited pasture area over a short period of time.

The animals do not return to a paddock until the plants have recovered and regrown to the desired height for grazing (usually six to eight inches). As a result, the plants have time to recover, the roots maintain energy reserves, and the livestock always have high quality forage.

Knowledge of forage plants and animal-pasture interaction is necessary to the success of this type of grazing plan—and frequent attention to both is essential. This is why these programs are often referred to as "management-intensive" grazing systems. Controlled, intensive, and rotational grazing are other terms loosely used for this type of grazing management. The subject of grazing management is covered more completely in the ATTRA publication *Rotational Grazing*.

Rotations can vary from once every couple of weeks to every 12 hours. Decisions about when to move livestock are based on the seasonal amount of forage available, the rate of forage growth, and the number and type of animals grazing the paddock. The number and size of paddocks is also considered. Typically, grazing animals are moved quickly through paddocks during periods of rapid plant growth. In the fall, quick rotations keep grasses from going to seed and preserve forage quality. This strategy can delay for several weeks harvesting of forage as hay, allowing for hay to be put up during a dryer time of the season. During other seasons, the grazed area is usually rested long enough for plants to replace carbohydrate reserves and to regrow.

A primary strategy of controlled grazing is to use fencing and livestock movement as tools to manage forage growth and protect it from overgrazing. If managed well, these systems produce more forage and the animals always have access to tender, high-quality vegetation that results from controlled grazing.

Knowledge of forage, plants, and animal-pasture interaction is necessary to the success of a controlled grazing plan.

Profit is the difference between the cost of production and the price received for a product. Most producers do not control the price they will receive for their livestock (though direct or cooperative marketing arrangements provide a measure of control). Lowering the cost of production is a clear means to increase profit. Costs go down as less feed is purchased and as animal health improves. The key to profitability is to emphasize a decrease in per-unit costs of production over a simple increase in production.

Many grazing managers—or graziers—claim that controlled rotational grazing improves pastures and the profits to be made from them. Forage utilization improves even under high stocking rates when the animals are moved at the right times. Livestock health improves because forage quality and quantity is better. Soil fertility is better because most nutrients cycle through the animals and remain in the paddocks. This can also reduce the need for purchased fertilizer. (See the ATTRA publication: *Nutrient Cycling in Pastures.*) More and better forage means more animal production, which should result in more profit per acre.

After three years of controlled rotational grazing, analyze the results.

A change to controlled grazing involves a modest capital investment. (See ATTRA's *Paddock Design, Fencing, and Water Systems for Controlled Grazing.*) This may include buying and installing electric fence chargers, high-tensile wire fencing, and systems to provide water to each pasture subdivision. A simple system of temporary electric fencing may suffice at the outset for many producers. Water can be delivered initially in above-ground, UV-stabilized pipe. With experience, most graziers will settle on how the permanent systems should be configured. For more information on controlled grazing call ATTRA at 800-346-9140 (toll-free), or visit the ATTRA Web site at *www.attra.ncat.org.*

Changes in the Plant Community

In a continuous-grazing system where animals are given free choice, they will eliminate the most nutritious or palatable plant species, because they graze them repeatedly. Root reserves of these preferred species are eventually exhausted, and the plants die out. Fescue, bermudagrass, and white clover persist under continuous grazing because their growing points remain, even when the plants are grazed heavily.

In a controlled-grazing system, animals don't have access to all the plants in the pasture at one time. Plants are allowed sufficient time to re-grow and restore their root reserves. Eventually, the plant community becomes more diverse under this type of grazing system. There is less competition for the same soil minerals, and plants thrive in the specific microclimates where they are best adapted. Producers report that native grass species and many legumes spontaneously appear in their pastures as rotational grazing systems are adopted. In fact, many advise new graziers to "plant only fence posts" in the first three years of intensive rotational grazing, because the plant ecology will change—for the better.

After three years of controlled rotational grazing, analyze the results. Should new forages be added to the pasture to meet specific production or management goals? If a goal is to extend the grazing season to reduce feed costs, new species might be added to existing pastures. Special-use paddocks might also be considered. For example, in southern pastures with cool-season grasses, the summer slump is a time of low forage production and potential health problems, especially from endophyte-infected fescue. Native grasses or plantings of summer annuals can fill this gap in the grazing season. In the Midwest, the grazing season may be extended into the winter by strip-grazing crop residue. Stockpiled fescue or other grasses, if carefully rationed, can support several extra months of winter grazing, even where there is some snow cover. Small grains offer options for fall, winter, and/or spring grazing, depending on regional climate conditions.

Managing Fertility

Grazed pastures need less fertilizer than those that are hayed. Animals actually use up very few of the nutrients from the plants they eat. Most minerals are returned in animal wastes as part of a natural cycling of nutrients. Phosphorus is excreted primarily in manure, and nitrogen and potassium return in urine and manure. As long as wastes are evenly distributed throughout the grazing area and biological agents such as earthworms, dung beetles, and soil bacteria are active, the system should be relatively stable.

Good fertility management includes a regular walk through the paddocks to monitor pasture production and to see where specific grasses and legumes thrive. Notice that certain plants tend to thrive under certain soil moisture and fertility conditions. The types and locations of weeds can also indicate how a fertility program is working and help identify special situations such as wet areas. (2)

Conscientious grazing managers record measurements or estimates of available pasture in each section. Using these figures, they budget resources for the future, taking into consideration the amount of rest needed before the next grazing period, as well as the animals' forage needs.

Various plants contribute to soil fertility. Legumes increase the total nitrogen content of the soil (see discussion below). Deeply rooted plants such as alfalfa, warm-season grasses, trees, and some weeds bring up other nutrients from deep in the subsoil. These nutrients remain in the top layers of the soil when the vegetation decays and then become available to other plants nearby. (See Trees in Pasture Systems in the **Appendix** for more about the benefits and potential problems related to trees in pastures.)

Periodic soil tests and forage analyses are tools to monitor a pasture's status. Soil test results indicate the levels of mineral nutrients in the soil. Forage analysis is a way to test whether nutrients present in the soil are actually being used by the plants. Many Extension offices offer forage analyses; when requesting this service be sure to specify whether test results will be used to balance a feed ration or for soil fertility decisions. Independent laboratories are available if your local Extension doesn't offer this service. The ATTRA publication *Alternative Soil Testing Laboratories* is available online or upon request.

Soil test results include fertilizer recommendations based on information the farmer provides about field history and planned use. Remember that these recommendations can vary depending on assumptions by the lab. For example, a recommendation may not be entirely accurate to produce grazing forage if the lab doesn't take into account recycled nutrients by the grazing animals. Lab fertilization recommendations may be over- or underestimated, depending on whether forage is harvested and removed or grazed on site. Use common sense to interpret soil tests, but keep them to monitor changes in soil chemistry and nutrient levels.

A special test to determine micronutrient levels may have to be requested. It is good to check these levels, since they can be critical to soil—and animal—health. When soils show deficiencies in essential micronutrients, supplement either the animals and/or the soil.

Soil organic matter (SOM) is monitored to determine the general health of the soil and its biological residents. You may have to request and pay extra to include SOM in your soil test. On the soil test report, SOM includes any living or partially decomposed materials, as well as humus, the final product of biological activity. When SOM is relatively high, it contributes nitrogen and helps make other mineral nutrients more available to plants. Adding composted animal manure is one way to increase SOM. Likewise, leaving a thin layer of organic residue on the soil surface contributes to SOM, and it shades the soil and feeds the soil organisms. (More about soil organic matter can be found in the section below.)

Some simple methods to assess soil characteristics require just a shovel and a few other widely available pieces of equipment. The ATTRA publication *Assessing the Pasture Soil Resource* describes several tests that can be used periodically for a quick assessment of the soil.

A simple pH adjustment can increase mineral availability in most soils.

Soil Amendments

Carefully consider whether purchased amendments are economically justified. If soils are the limiting factor, buying inputs to improve the soil is a wise, long-term investment. In such cases, improvement in soil fertility is key to building a dense,

lush, and healthy pasture. Such pasture provides good nutrition to grazing animals, and wastes contribute to further build the productivity of the land.

A simple pH adjustment can increase mineral availability in most soils. Legume growth in mixed pastures that tend toward acidity will benefit, and in turn increase available nitrogen and add more organic matter to the soil. Lime is used to raise the pH, but also is an important source of calcium. It is also less expensive than many other purchased fertilizers. The ratio of calcium to magnesium and potassium is important in itself. See the enclosure "Lime, the Forgotten Fertilizer" for more information on this subject.

Building Organic Matter

These items add organic matter:

- Plant roots
- Plant residues
- Green manures
- Animal manures
- Other organic "wastes"
- Hay and other feed brought in

These things destroy organic matter:

- Tillage and bare ground
- Some pesticides
- Compaction
- Continuous cropping

Composted animal manure might also be an excellent investment because it adds fertility and benefits soil microbes. However, if manure is applied to the same pastures over many years, phosphorus can build up. Excessive phosphorus levels in soils and the threat of phosphorus-saturated soils leaching soluble phosphorus are serious concerns in some parts of the country. See ATTRA's *Nutrient Cycling in Pastures* for details on the phosphorus cycle and how graziers can prevent phosphorus pollution of surface and ground water.

One situation where fertilizer purchases are often appropriate is in grass dairy operations. Because grass dairies compete with grain-fed systems, producers must provide continuous access to the highest feed value forage available. Likewise, grass-finished meat animals should have plenty of high-quality pasture to gain weight quickly and consistently during the finishing period. Both of these enterprises have potential for good profitability when well managed. Nevertheless, fertilizer inputs are justified only if existing pastures are under full use. The important point is to base decisions on an analysis that compares input costs to the profits or overall benefits that might be generated.

Another excellent resource to understand fertility in grazing systems is *Nutrient Cycling in Forage Systems*, the proceedings of a 1996 conference in Missouri. See **Additional Resources** (under Joost and Roberts) for ordering information. ATTRA also offers *Sustainable Soil Management* and *Assessing the Pasture Soil Resource* for more on pasture fertility and monitoring.

Organic Matter

Some recent research has focused on the many organisms that make up a healthy soil ecosystem. Plant root systems work together with tiny plants and animals underground in a complex, highly organized system very similar to the one above ground. The soil biological community includes large populations of many species of bacteria, fungi, nematodes, mites, and other microscopic animals. Balances among the populations are maintained by variations in the amount of food available for each part of the system. Elaine Ingham, Ph.D, a soil microbiologist, has named this system the Soil Foodweb.

Ingham offers a service to test soils for the presence of various organisms. (3) However, she says a grazier can monitor pasture soil health just by testing for soil organic matter (SOM) content, which includes carbon contained in living organisms, fresh plant and animal residues, and soil humus. This type of test measures the percentage of soil (by weight) that is SOM. Because organic matter levels are harder to maintain in warmer, more humid climates, what constitutes a "high" or "low" percentage varies in different parts of the country. Local Extension personnel or soil scientists can help define these relative values.

A single test establishes a beginning point, and subsequent tests show whether soil organic matter is increasing. See the box Building Organic Matter for ways to increase soil organic matter, along with practices that decrease it. Avoid practices that adversely affect the number of earthworms in the soil. In fact, counting earth-

worms in a shovelful of soil is an easy way for farmers to monitor soil health. Increasing worm numbers indicates progress toward the goal of a healthy, biologically active soil.

Legumes in the Pasture

Legumes increase soil fertility, improve overall feed value of available forage, and extend the grazing season. Bacteria that live in nodules on the legume roots convert nitrogen in the air to a form the plant can use. After the nodules separate from the roots or the plant dies, this nitrogen is available to nearby plants. Even during the growing season, dead leaves fall to the ground and provide extra nitrogen to the pasture system. Compared to grasses, legumes have higher digestibility and higher mineral and protein content.

When introducing legumes into an established grass pasture, first be sure that magnesium and potassium levels are suitable. Then graze the area heavily to set it back. Many producers use a sod-seeder or other no-till seed drill, but some have had luck with frost seeding. This is the practice of broadcast seeding in very early spring into areas where the ground alternately thaws and freezes. Timing must be good to take advantage of these temperature swings. These are conventional practices, and information is widely available about them.

For legumes to prosper in a pasture, the grass must be kept short enough that they are not shaded out. Nitrogen fertilizer favors the grass, and you can inadvertently reduce the percentage of legumes in the pasture mix by adding it. Each species of legume thrives in a particular pH range, but maintaining it between six and seven favors most legumes. Some legumes, such as lespedeza, tolerate more acid conditions.

Many annual clovers produce hard seed and will persist in a pasture if allowed to go to seed periodically. (It is this "hard seed" that accounts for the legumes that seem to appear from nowhere in pastures where management has changed, but no legumes have been planted.) Annual legumes that do not produce hard seed must be managed to allow some plants to go to seed every year to keep them in the forage mix. Beyond this, providing for the nutritional and light needs of legumes, along with adequate rest after harvest, should ensure their persistence.

If the legume is established and maintained at about a third of the total pasture, the plants won't need additional nitrogen fertilization. Research at Michigan State University shows that different combinations of four cool-season grasses with three clover species produce, on average, 14 percent more forage than the same grasses grown alone and fertilized with 200 pounds per acre of nitrogen. The conclusion is that it doesn't pay to apply nitrogen to pastures with 30 percent or greater mix of legumes. (4) However, it's hard to estimate legume percentage, because the leaf orientation makes it seem a higher percentage of total forage than it actually is. To better estimate overall percentage, sample and weigh plants in an area with a lot of legumes.

Remember, hungry animals introduced to highly leguminous or wet legume pastures may bloat. To prevent this problem, provide hay to animals before they access a legume pasture. Certain products on the market protect livestock from this potentially deadly physiological condition. Since bloating is inherited, if you cull susceptible animals, you may eventually reduce the problem in your herd.

Managing Weeds

In a controlled-grazing system, livestock can help control tall weeds that re-seed themselves. Because animals have access to a limited area for only a short period, they often become less selective in their grazing. They tend to eat the same weeds—in young, tender growth stages—that they reject as the weeds mature. Many weeds provide good nutrition during this period of palatability. Mowing before weeds flower and produce seed also helps to control them, although the cost is higher.

When introducing legumes into an established grass pasture, first be sure that magnesium and potassium levels are suitable.


Photo courtesy of USDA ARS.

Another weed management strategy is to graze different kinds of livestock together. Sheep will complement grass–eating cattle in the pasture by consuming broadleaves, blossoms, and seeds, while goats prefer brushy vegetation high in cellulose. Information about animals' nutritional requirements and the nutrient content of various forages is available from basic forage and animal science textbooks. For more information on the benefits and challenges of grazing mixed livestock, request the ATTRA publication *Multispecies Grazing*.

A growing number of beneficial insects is becoming commercially available to control thistles and some other perennial weeds. These weed-eating insects are especially adapted to a perennial pasture where habitat is not destroyed or disturbed by annual cultivation. If local sources are unable to help, ATTRA has information about biological management tools and where to get them.

Tall perennial weeds that livestock do not eat can be controlled with the judicious application of a broad-spectrum herbicide, such as Round-Up®. Hand-held sprayers will work, but a wick-type applicator places the chemical on the targeted weed foliage only. Hand-held wicks are available as well as equipment designed to be pulled behind a tractor or four-wheeler. Also on the market are backpack flaming devices that actually burn the weeds and provide a non-toxic option to control difficult weeds. ATTRA publications *Flame Weeding for Agronomic Crops* and *Flame Weeding for Vegetable Crops* provide more detail about this option.

Conserved Forages vs. Grazing

Providing good-quality forage throughout the year saves considerably on feed costs. Year-round grazing is possible in some parts of the country and is a realistic goal in some regions. Many producers, even those in cold climates, report favorable experiences with attempts to "outwinter" their livestock. Adequate feed and shelter from wind and moisture are critical. Reports indicate that, under favorable conditions, animals seem to prefer being outside where they can forage at will.

A sustainable pasture plan should be based on animals harvesting quality forage for themselves as much as possible. Nevertheless, when spring pastures produce more than livestock can use, machine harvest is one strategy to ensure quality forage later in the grazing season.

Allan Nation, editor of The Stockman Grass Farmer, is fond of questioning the economics of owning "heavy metal." It is expensive to maintain equipment and to harvest forage for hay or silage, so it is sometimes more economical to buy hay or hire a custom baler. However, it can be difficult to find someone to custom harvest and process spring growth at the optimal time.

Another challenge to a spring hay harvest is the weather. A spell of good haying weather, if it comes at all, rarely arrives at the perfect time. One option in wet conditions is to harvest, pack, and seal the excess spring grass in bunkers for fermentation. Livestock, controlled by a single wire of electric fencing, can then have direct access to the silage bunkers.

Some producers advocate baling high-moisture hay and wrapping it so that it will ferment. Baleage, as the product is called, is a high-quality feed when properly harvested and protected from air spoilage. This is one way to harvest on time in wet springs. However, specialized equipment is expensive for one producer to own and operate, and rental may not be available. Several producers in an area with similar needs might recover

some costs through contractual arrangements among themselves. The amount of plastic used to seal cut forage is a concern for many farmers as well, since it must be disposed of after use. For more information on grass silage or baleage, contact a local Extension office or NRCS personnel.

In summary, conserving forages can help manage fast-growing spring pasture, and hay or silage is useful to carry livestock through some of the year in most parts of the country. However, the goal should be to directly graze as much as possible to avoid the costs to harvest and store forage. Custom harvesting or even buying good hay may be cheaper than maintaining a tractor and implements. (See the enclosed article by Jim Gerrish on the true cost of hay.)

Considerations for Irrigated Pasture Systems in the Western U.S.

Many regions in the western United States, including intermountain valleys of the Rocky Mountains, the prairies of the northern Great Plains, and certain arid regions of the desert Southwest, experience short grazing seasons due to high elevation, limited moisture, or a combination of both. Livestock producers in these regions find it particularly important to manage forage and pasture in the most efficient way possible. By integrating irrigated pasture with dryland pasture, range, and hay aftermath, the grazing season can be lengthened and livestock provided with high yields of quality forage.

The Essentials

Conventional wisdom holds that one acre of irrigated pasture in most intermountain valleys provides enough forage for twelve cow-calf pairs for one month. But unproductive irrigated pastures are more the norm, and few producers maintain pasture to its full potential. Productive irrigated pastures are usually the result of successful management of several production factors, including:

- fertility
- irrigation
- species selection
- grazing management

These factors can be managed.

Fertility

Attention to soil fertility is critically important in irrigated pastures. Pasture establishment is a key time to ensure soil is adequately fertile for the selected forage species to become established and remain productive. During secondary tillage, rock minerals, composted manure, or commercial fertilizers can be incorporated into the soil. In the intermountain regions, it is important to ensure adequate phosphorus and potassium before planting, but nitrogen should be applied early the second spring. Cool, dry springs are difficult on grass seedlings, and nitrogen applied at this time may be appropriated by weeds.

Some nutrients do leave the pasture system in the form of meat and milk.

Apply nitrogen only after the grass stand is successfully established. If the stand has a legume component, limit the use of synthetic nitrogen fertilizers. In general, nitrogen fertilization favors grass growth, and phosphorus fertilization favors legumes. Yearly applications of 20 to 50 pounds per acre of phosphorus can significantly increase alfalfa yields and stand persistence in areas deficient in phosphorus. Soil tests are fairly reliable to gauge phosphorus needs, but again, modern soil testing assumes the forage will be harvested and fed on site. Don't underestimate the utility of the mineral fraction of nutrients in the soil, and the natural nutrient cycle that supports pasture ecology.

Whereas most soil nutrients are cycled back to the soil in a grazing system, some nutrients do leave the pasture system in the form of meat and milk. More information on fertility and nutrient cycling can be found in the ATTRA publication *A Brief Overview of Nutrient Cycling in Pastures.*

Irrigation can also have an effect on nutrient cycling. Coarse, porous soils do not retain water as readily as heavier soils, and

heavy irrigation can leach nutrients into the groundwater. If the pasture has any slope to it, nutrients can leave in runoff. Ditches, dikes, and proper irrigation scheduling can alleviate this problem.

Grass-legume mixes provide good pasture productivity and animal nutrition and aid nutrient cycling and pasture fertility. Pastures with a heavy clover component can produce up to 200 pounds of nitrogen per acre per year, and can supply 6 to 12 percent of the nitrogen needs of companion grass plants during the growing year. Given these prospects, a producer can optimize the use of soluble and organic soil nutrients by relying on plant species diversity and nutrient cycling from manure, urine, and plant senescence to supply a large portion of pasture soil fertility. More detailed information on this subject can be found in the sections **Managing Fertility** and **Organic Matter**.

Never irrigate and graze at the same time.

Irrigation

Efficient water use is crucial for sustainable irrigated pasture management. Irrigated pastures require about 24 inches of water per growing season. What is not supplied by precipitation needs to be made up with efficient irrigation. Grasses and legumes require about 0.20 and 0.25 inches of water per day respectively throughout the growing season. So, frequency of irrigation depends on soil texture and, in turn, on water holding capacity of the soil.

Heavier (clay) soils hold more water, up to 2.5 inches per foot of rooting depth, and coarser (sandy) soils hold less water, around 0.75 inches per foot. Pastures have an effective moisture depletion allowance of about 65 percent, which means plants begin to suffer stress after 65 percent of the soil's water-holding capacity has been depleted. For example, pasture soil with a water holding capacity of 1.5 inches per foot, and a rooting depth of four feet, can hold a total of six inches of water. At a 65 percent depletion allowance, 3.9 inches remains available to the plants. If the plants use 0.25 inches per day, an irrigation event that saturates the soil will last about 15 days.

Understanding the basics of soil-water dynamics helps producers make decisions on when to irrigate, especially in areas where water is scarce or energy costs for pumping are high. The Agrimet system (see **Web Resources**) is an excellent resource for producers making irrigation scheduling decisions. In addition, the Natural Resource Conservation Service (USDA-NRCS) district offices have access to each county's soil information and can assist producers to determine the water holding capacity of soil types on area farms. *The Irrigator's Pocket Guide*, developed by NCAT for the NRCS, is an excellent resource with timely information on irrigation scheduling, system capacity, and general water management. It includes figures, forms, and tables to design and manage water systems more efficiently. The *Pocket Guide* has useful information for most areas. It can be ordered from ATTRA by calling 800-346-9140. Other ATTRA publications on irrigation include: *Soil Moisture Monitoring: Low-Cost Tools and Methods* and *Measuring and Conserving Irrigation Water.*

Always remember to irrigate a pasture immediately after the livestock have been moved, and never irrigate and graze at the same time. Hoof action on wet soil can destroy its structure, resulting in compaction and decreased soil productivity for years to come.

Species Selection

The importance of choosing the right plants to use in an irrigated pasture cannot be overstated. The high cost of irrigation, including initial equipment purchase, energy, and maintenance demand that a producer select the most productive plant species for the region. In some situations, short season problems and low yields can be addressed though proper species selection. Choose long-lived, winter-hardy forage plants adapted to your specific soil type. Plants should be capable of high yields and have the genetic potential to withstand grazing and regrow quickly.

Species diversity is also important, as was discussed in detail earlier. Greater productivity and increased biodiversity are fostered through grass-legume mixes. A grass component in a legume pasture can also minimize health problems associated with bloat. Some non-bloating legume species include cicer milkvetch, sainfoin, and birdsfoot trefoil. For the intermountain West, a mixture of two grasses and one legume provide as many, or more, benefits to pasture productivity as do more diverse pastures in higher rainfall areas.

Choose the right species for the mix, however, because species that mature at different times can result in low quality forage. Creeping foxtail and timothy are both excellent irrigated pasture grasses, but foxtail matures several weeks before timothy. Red clovers and vetches usually do not persist as well as alsike clover, white clover, and alfalfa in the intermountain regions. Some good substitutes for alfalfa in irrigated pastures are sainfoin and birdsfoot trefoil, which, unlike alfalfa, are tolerant of high water tables. A very common seed mix for irrigated pastures in the intermountain West is meadow brome, orchardgrass, and alfalfa.

Warm-season grasses are sometimes a good choice for the Southwest and Great Plains, and can result in substantial livestock gains and milk production when managed intensively. Warm-season annuals such as sorghum and sudangrass are good choices for rotational or strip grazing, and are very good if the pasture is used in a crop rotation. Cool-season grasses such as brome, ryegrasses, timothy, and cereals are often higher in digestibility and crude protein, and are more adapted to intermountain, inland Pacific Northwest, and Great Plains regions.

Check with your local county Extension office or conservation district for recommendations on forage species particular to your area. For general purposes, please refer to the Alberta Forage Manual and the Intermountain Planting Guide cited at the end of this publication. These two guides are excellent sources of information for anyone growing pastures and forages in the intermountain West or northern Great Plains. A list of forage species for Montana and Wyoming—widely adapted to irrigated pastures in many western states—is enclosed.

Forage Cropping Systems to Extend the Grazing Season

Many western ranchers grow alfalfa hay to provide high quality feed to late-gestation and calving cows in the winter. Most alfalfa fields remain productive for six to eight years in the intermountain West. As sward density diminishes, the stand is generally terminated and placed into small grains for a year or two. This rotation has its benefits. Tillage and crop differentiation allows the producer to break the pest cycle. And termination of an alfalfa field offers an opportunity to augment ranch forage assets with quality pasture while extending the grazing season as well.

For example, a producer might terminate the alfalfa and plant winter wheat in the fall, and then overseed the field with annual ryegrass in the spring. The wheat can be taken as grain, silage, or hay in the summer, allowing the ryegrass to grow for late summer and fall grazing. The same can be done with spring-planted barley. The result

Fertility and species selection are important. But the single most important factor to increase production on irrigated fields is a workable grazing management system that meets the nutritional needs of livestock and maintains the pasture sward in the vegetative stage throughout the grazing season.

of this cropping system is a high quality pasture that can be intensively managed with high stocking rates, thereby resting native pastures that might otherwise be grazed the same time each year.

Other systems that work well to extend the grazing season:

- Stockpiling perennial grass or legume forage for fall grazing.
- Early season grazing of winter wheat and subsequent grain harvest.
- Planting perennial grass pastures for use as winter standing forage, e.g., Altai wildrye, which maintains quality well when dormant and stands up under a snow load.

Grazing Management

Complementary grazing is a system in which livestock are grazed in annual or perennial seeded pastures in the spring and fall, and are taken to native range in the summer when the native grasses are in their prime. This system uses each pasture when it is at its peak in quality and quantity, and it is commonly used in western states to supplement range and extend the grazing season. Within this context, western producers are familiar with continuous grazing. The size and scope of grazing units, coupled with the use of public grazing allotments, often preclude fencing and other necessary infrastructure to support intensively managed rotaional grazing. In addition, most producers who graze irrigated meadows also hay them once or twice during the growing season, and only graze them for hay aftermath. For this reason, irrigated meadows tend not to be managed intensively for grazing, as they are seen to be more valuable for winter feed than for summer grazing. After all, that is what the mountain meadows are for.

Photo courtesy of USDA, NRCS

However, for the producer who wishes to scale back on hay production, the irrigated meadows can be used for grazing during the growing season, and upland meadows that consist of bunch grasses like Altai wildrye can be stockpiled for winter feed. Altai wildrye typically remains a high quality forage well into the dormant season, and large bunch grass type holds up well under a snowload.

Producers who choose to develop a rotational grazing system on their irrigated meadows can realize better animal gains per acre and reduced feed costs associated with feeding the cow herd in the winter. See the ATTRA publication *Rotational Grazing* for a general introduction to this type of grazing system. For most cool-season bunchgrass species, 18 to 27 days rest is adequate for substantial regrowth without allowing the plants to become too mature. A problem that can occur in short-season regions is forage maturing in the last pastures to be grazed before the livestock get to it. To deal adequately with this situation a producer might turn livestock in to the first pasture early, maintain a quick rotation, and then slow it down as the season progresses. A good formula to estimate an initial pasture stocking rate is:

$$\textit{number of animals} = \frac{\text{Pasture size (ac) x pasture yield (lb/ac)}}{0.036 \text{ x avg. animals wt(lbs) x grazing season (days)}}$$

For example, assume a producer has a 50-acre irrigated pasture of orchardgrass, meadow brome, and alsike clover. A reasonable expectation of dry matter yield in the intermountain West is 2.5 tons per acre, or 5000 pounds per acre. If the producer wants to graze 800-pound yearlings for 90 days, the calculations to figure the stocking rate on an early turn-out to maximize irrigated pasture use is:

$$\textit{number of animals} = \frac{50 \text{ acres x } 5{,}000 \text{ lb/ac}}{0.036 \text{ x } 800 \text{ lbs x } 90 \text{ days}}$$

Again, a rapid grazing rotation during the early season is important to consider. At higher elevations, spring temperatures can dip to freezing each night, slowing grass

growth. Hitting the pastures too hard too early can impede the system's ability to rebound and deliver good forage production later in the summer. Another approach is to decrease the stocking rate until nights become warmer and forage production begins in earnest. Like any rotational grazing system, controlled grazing in the West requires observation, observation, and more observation. The Chinese proverb holds true here: "The best fertilizer for the land is the footprint of the farmer."

A Word about Dragging and Harrowing Pastures

Avoid using irrigated pastures to winter feed hay unless you plan to renovate, drag, or harrow in the spring. Feeding grounds are subject to soil compaction because of the large numbers of animals that congregate there over the winter. Harrowing pastures to distribute manure, although not always cost-effective, is often recommended in short-season regions, at least once at the beginning of the growing season. In cold regions with short growing seasons, nutrients cycle in the soil at a much slower rate than in more temperate regions. Manure piles therefore tend to break down slower, and dragging can break them up, increasing surface area and, it is thought, aiding in decomposition.

Summary

Sustainable livestock production in the western U.S., as in all regions, requires ranches and farms to rely more on green growing forages as the primary feed for the operation. Careful attention to fertility, efficient irrigation, and grazing season extension through appropriate forage cropping systems are effective ways to lower production costs, reduce off-farm inputs, and build soil resources. In addition, paying attention to species selection and implementing a well-organized and suitable grazing management system fosters continued resource use in perpetuity, aids in the financial well-being of the operation, and ensures that ranching remains a viable livelihood for the next generation.

Sustaining Excellent Pastures

Maintaining a productive plant community that can profitably feed livestock requires attention to the soil, the plants, and the livestock. Each of these alone contributes to excellent pastures, but even more importantly, each affects the others. Too often, farmers attribute problems in a grazing system to the wrong forage species or inadequate fertility, when poor animal-plant-soil management is the real culprit. Bringing in a new species or adding fertilizer rarely solves problems caused by an inattentive manager. How you manage your grazing livestock, however, makes a big difference in pasture improvement. This improved pasture likewise contributes to better health of those same animals.

Can you identify the plants in your pastures?

If you don't already know your soil, get maps and learn about soil types. Use soil test results to decide what amendments to apply. Is your soil organic matter level high or low for your climate? Is it increasing under your management?

Can you identify the plants in your pastures? Are they perennial or annual? Do you know how best to graze these plants? What are their soil requirements? How tall should they be when you begin to graze and at what height should animals be removed?

How do your animals look and behave? Are they alert with bright eyes and smooth coats? Are they skittish or calm? Can you move them without a lot of stress?

Continually monitor your pastures. Are they lush and dense? Is there evidence of soil erosion? Are there many over-mature plants? Have certain areas been grazed too short? Is there some dead plant residue on the soil surface, but not too much? Is leaf color an even, strong green? Are there plenty of legumes in the species mix (about 30 percent by dry weight)? Does the soil feel soft and springy underfoot? Do you have plenty of feed for your animals throughout the grazing season, or are there times (mid-summer? late fall?) when you need more?

Good grazing management is different for each livestock operation. Stock density, fre-

quency of moves, forage residual, and plant resting periods are decisions that you make based on goals and preferences. Watch and record what happens as you change one of these factors. These observations will help you, as time goes by, to become a better grazier. Try to understand what causes changes that you see in the soil, plants, or the animals in your pastures. Each constantly affects the others, and the more you learn about how they interact, the more control you will have over your pasture system.

As an example, according to Jim Gerrish, stock density can be used to affect pasture quality, to cycle nutrients, and to regulate forage intake. One expected result of increasing the stock density is that after the animals leave a paddock, forage height will become more uniform.

Since many of the effects of individual decisions will not yield such obvious results, continually seek out more information about intensive grazing. Excellent books, some periodicals, many workshops, and even local field days can help you learn more. A list of written materials and electronic resources is found in **Resources**.

Consult with another rancher or join a producer group to learn more about grazing. Many such grazier groups provide information and support to improve members' systems. Typically, groups include beginners as well as those with years of experience. Activities range from gathering periodically and walking one another's pastures, to meetings with speakers, and seminars. See ATTRA's *Grazing Networks for Livestock Producers* for further information about these groups and how to start one. State forage specialists (either Extension or NRCS) should help you locate a nearby group, if there is one.

Putting it all together in a grazing system for your specific site is a challenge that may take years of observation and creative problem-solving. There is no one way to do it. Keep learning more about your forages and livestock. Seek ideas from other innovators and test them. Implement those that work. Keep fine-tuning the system. The result will be better pastures that better sustain your livestock and you.

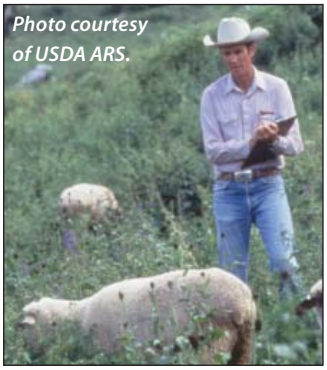

Photo courtesy of USDA ARS.

Keep records of grazing activities. Keep notes on how many and what types of animals graze each paddock. Write down when they enter and when they leave. Notes about forage heights at entry and removal, as well as estimates of the amount of forage consumed (pounds per acre or some other consistent measure), help determine overall forage production. Other comments about the soil, the animals, and the plants can be useful later as you analyze records. For instance, when a particular weed species becomes unpalatable or when clover begins to bloom may be valuable to know.

Financial records further help you understand and improve the overall grazing system. Keep track of how much fertilizer you use, when it was applied, and how much it cost. Are there application costs? What other expenses are there? Veterinarian bills, custom services, herbicides, and mowing or dragging expenses should be included in the record-keeping system. Were animals shipped or brought in? When? And for how much?

Whether you use a shirt-pocket notepad or a computer program, these records are central to understand and improve the efficiency and profitability of a grazing system. However, as the manager, you must take time periodically to analyze records. What have you done and when? How well has it worked? Were there unexpected outcomes? Try to figure out what happened. The best-laid plans will not be perfect—especially at first. Outside factors such as the weather and the markets further complicate situations.

As has often been said, there is never an average year. The most successful managers are constantly on the alert, ready to identify problems as they develop—such as thinning pastures or declining livestock health. Good managers are prepared with a plan for every contingency: years of drought or flood, selling or retaining stock during different parts of the price cycles, and the unexpected loss of labor. For example: When a drought sets in, will destocking or buying feed best serve your goals? Which animals should be culled first, and how can they be marketed most profitably? Are there steps you can take to reduce the negative impacts of the drought? Planning along these lines will be appreciated when the situation is at hand. See further information about drought management by searching on "drought" at the ATTRA Web site, *www.attra.ncat.org*.

Related ATTRA Publications

Rotational Grazing

Grass-Based and Seasonal Dairying

Dairy Farm Sustainability Checksheet

Sustainable Beef Production

Beef Farm Sustainability Checksheet

Sustainable Sheep Production

Goats: Sustainable Production Overview

Small Ruminant Sustainability Checksheet

Matching Livestock and Forage Resources in Controlled Grazing

Meeting the Nutritional Needs of Ruminants on Pasture

Multispecies Grazing

Sustainable Soil Management

Assessing the Pasture Soil Resource

Nutrient Cycling in Pastures

A Brief Overview of Nutrient Cycling in Pastures

Beef Marketing Alternatives

Paddock Design, Fencing, and Water Systems for Controlled Grazing

Grazing Networks for Livestock Producers

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2. Murphy, Bill. 1987. Greener Pastures On Your Side of the Fence. Arriba Publishing, Colchester, VT. p. 207-212.
3. Elaine Ingham
   Soil Foodweb, Inc.
   980 Northwest Circle Blvd.
   Corvallis, OR 97330
   541-752-5066
   www.soilfoodweb.com/
4. Leep, Rich, and Doo-Hong Min. 2005. Clovers beat commercial N in Michigan studies. The Forage Leader. Spring. p. 11.
5. Engle, Cindy. 2002. Wild Health: How Animals Keep Themselves Well and What We Can Learn From Them. Houghton Mifflin Company, New York, NY. 276 p.

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Resources

The Stockman Grass Farmer (see Periodicals, below) is an excellent monthly publication that covers alternative forages and innovative management. Many of the articles are written by producers and contain practical tested ideas. (Be warned: evaluate each new practice before committing resources to it.) The commercial and classified ads offer services and supplies that grass farmers need and that may be difficult to find locally. A free sample issue is available to those who call or write to request it.

Graze (see Periodicals, below) is another outstanding monthly that includes articles on all aspects of grazing, pasture management, and marketing. In a regular feature, five or more "grazing advisors" answer a question posed by the editor. These advisors, each an active grazing operation manager, represent a variety of livestock types and geographical locations.

Holistic Management® (formerly Holistic Resource Management or HRM) is a decision-making process that was originally developed for livestock management on range. Currently, many farmers and ranchers use this model as a monitoring tool to evaluate options when planning changes to their operations. Contact the Center for Holistic Management for information and referrals to state organizations and regional representatives. The Center also offers a quarterly newsletter.

The Allan Savory Center for Holistic Management
1010 Tijeras NW
Albuquerque, NM 87102
800-654-3619
www.holisticmanagement.org/

Many electronic resources are now available to those with access to a computer. Of particular interest are the interactive listserves used by various livestock ranchers. One that is not species-specific is the graze-l listserve. To subscribe, send a message containing the words "subscribe graze-l" and your e-mail address to listserv@taranaki.ac.nz. There are lists specific to many grazing species as well. Beef-l, dairy-l, and sheep-l sometimes address issues related to pasture–raised livestock. It is possible to ask questions and to network with other producers through these and other lists. However, because details on individuals and their specific situations may be lacking, advice received on electronic lists should be carefully evaluated.

Web sites also provide information useful to graziers. Although these sites are constantly changing, and there are more each week, several are listed below. Be sure to check the sites of nearby land-grant universities. Rotational grazing systems are becoming ever more accepted in the mainstream. Extension materials tailored to your state will contain information useful to both the beginner and the experienced grazier.

Additional Resources

Books: Irrigated pastures in the western U.S.

Alberta Forage Manual. 1992. Print Media Branch, Alberta Agriculture, 7000-113 Street, Edmonton, Alberta, Canada. 86 p.

Heitschmidt, Rodney K., and Jerry W. Stuth. 1991. Grazing Management: An Ecological Perspective. Timber Press, Portland, OR. 259 p.

Intermountain Planting Guide. USDA-ARS and Utah State University Extension. AG 510. Contact USU Extension for ordering information at 435-797-2251.

Books: General pasture management

Ball, Donald M., Carl S. Hoveland, and Gary D. Lacefield. 1996. Southern Forages. Potash and Phosphate Institute and the Foundation for Agronomic Research, Atlanta, GA. 264 p.

Barnes, Robert F., Darrell A. Miller, and C. Jerry Nelson (eds.). 1995. Forages: The Science of Grassland Agriculture. 5th ed. Vols. 1 and 2. Iowa State University Press, Ames, IA. 516 p. and 357 p., respectively.

Bingham, Sam, with Allan Savory. 1990. Holistic Resource Management Workbook. Island Press, Covelo, CA. 182 p.

Blaser, Roy E. 1986. Forage-Animal Management Systems. Virginia Agricultural Experiment Station Bulletin. Virginia Polytechnic University, Blacksburg, VA. 90 p. [This publication is out of print but is well worth the effort to locate at land-grant university libraries or through Interlibrary loan.]

Chessmore, Roy A. 1979. Profitable Pasture Management. The Interstate Printers & Publishers, Inc., Danville, IL. 424 p.

Gerrish, James R., and Craig Roberts. 1999. 1997 Missouri Grazing Manual. Forage Systems Research Center Agricultural Experiment Station, University of Missouri. 163 p.

Hodgson, John. 1990. Grazing Management: Science into Practice. Longman Handbooks in Agriculture. John Wiley & Sons, New York, NY. 203 p.

Hodgson, J., and A.W. Illius (eds.). 1996. The Ecology and Management of Grazing Systems. CAB International, Wallingford, UK. 466 p.

Joost, Richard E., and Craig A. Roberts. 1996. Nutrient Cycling in Forage Systems. Proceedings of a conference March 7-8, 1996, Columbia, MO. Potash and Phosphate Institute and Foundation for Agronomic Research, Manhattan, KS. 243 p.
Available for $15 from:
Potash and Phosphate Institute
772 22nd Avenue S.
Brookings, SD 57006
605-692-6280

Langer, R.H.M. 1990. Pastures: Their Ecology and Management. Oxford University Press, New York, NY. 499 p.

Murphy, Bill. 1998. Greener Pastures on Your Side of the Fence: Better Farming With Voisin Grazing Management (4th ed.). Arriba Publishing, Colchester, VT. 379 p.
Available for $30 from:
Arriba Publishing
213 Middle Rd.
Colchester, VT 05446

Nation, Allan. 1993. Grass Farmers. Green Park Press, Jackson, MS. 192 p.

Nation, Allan. 1992. Pa$ture Profit$ with $tocker Cattle. Green Park Press, Jackson, MS. 190 p.

Nation, Allan. 1995. Quality Pasture: How to Create It, Manage It, and Profit from It. Green Park Press, Jackson, MS. 285 p.

Ness, Julia Ahlers (ed.). 1998. The Monitoring Tool Box. The Land Stewardship Project, White Bear Lake, MN. 45 p.
Available for $45 from:
Land Stewardship Project
2200 Fourth St.
White Bear Lake, MN 55110
651-653-0618
www.landstewardshipproject.org

Nicol, A.M. (ed.). 1987. Livestock Feeding on Pasture. Occasional Publication No. 10. New Zealand Society of Animal Production. Private Bag, Hamilton, New Zealand. 145 p.

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Voisin, Andre. 1988. Grass Productivity (reprint). Island Press, Covelo, CA. 353 p.

Wilkinson, J.M. 1984. Milk and Meat From Grass. Granada, New York, NY. 149 p.

Periodicals

The Forage Leader
American Forage and Grassland Council
P.O. Box 891
Georgetown, TX 78627
800-944-2342

Graze
P.O. Box 48
Belleville, WI 53508
www.grazeonline.com
$30 for 1 year subscription (10 issues)

Hay and Forage Grower
Webb Division
Intertec Publishing Corp.
9800 Metcalf
Overland Park, KS 66212-2215

The Stockman Grass Farmer
282 Commerce Park Drive
Ridgeland, MS 39157
800-748-9808 (toll-free)
www.stockmangrassfarmer.com

Electronic Resources: General pasture management, southern and eastern pastures
[Note that these addresses change often.]

The Great Lakes Grazing Network
www.glgn.org/

Cornell Forage-Livestock System
www.css.cornell.edu/forage/forage.html

Penn State College of Agricultural Sciences Publications
http://pubs.cas.psu.edu/Subject.html

American Farmland Trust's Grassfarmer Site
http://grassfarmer.com

University of Wisconsin Forage and Extension Links
www.uwex.edu/ces/forage/links.htm

Forage Systems Research Center
http://pubs.cas.psu.edu/Subject.htmlaes.missouri.edu/fsrc

Tom Trantham's Twelve Aprils Dairying
www.griffin.uga.edu/sare/twelve/trantham.html

Modern Forage Seeds
www.modernforage.com/clasroom.htm

Sustainable Farming Connection's Grazing Page
www.ibiblio.org/farming-connection/grazing/home.htm

Electronic Resources: Western irrigated pastures

Holzworth, L., and J. Lacey. 1991. Species Selection, Seeding Techniques, and Management of Irrigated Pastures in Montana and Wyoming. Montana State University Extension. EB 99. 17 p.
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Small Pasture Management Guide for Utah. USDA/NRCS, Utah State University Extension, and Utah State Conservation Districts. 11 p. *http://extension.usu.edu/files/agpubs/Pasture.pdf*

Interagency Forage and Conservation Planting Guide for Utah. Edited by Howard Horton, USDA/ARS. Utah State University Extension. AG-433. 79 p.
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http://forages.tamu.edu/PDF/scs-2003-07.pdf

Water Quality and Irrigation Management. Department of Land Resources and Environmental Sciences. Montana State University.
http://waterquality.montana.edu

The Great Plains Cooperative Agricultural Weather Network. U.S. Dept. of the Interior.
www.usbr.gov/gp/agrimet/index.cfm

AgriMet is a network of more than 90 automated weather stations that collect and telemeter site-specific weather data. This information is translated into crop-specific water use information. The primary emphasis is on irrigation management and applying the right amount of water at the optimal time.

Electronic Listservers

Graze-L
To subscribe send an e-mail to
majordomo@taranaki.ac.nz or *listserv@taranaki.ac.nz.*
In the body of the e-mail, type "subscribe graze-l"

The Grazer's Edge
To subscribe send an e-mail to
grazersedge-subscribe@onelist.com.
In the body of the e-mail, type "subscribe grazersedge."

APPENDIX: Trees in Pasture Systems

Trees in a pasture provide several services, but they can also be challenging. They affect soil fertility, hold surface soil in place, give livestock relief from the sun and the wind, and change water relations. They can supplement other feed sources, increase wildlife habitat, and become an additional source of income.

Trees gather nutrients from a large area to sustain both above- and below-ground parts and deposit those nutrients on the soil surface. Tree roots go deep into the soil and spread underground at least as far as the edge of the leaf canopy. When the leaves fall, the microorganisms in the top layer of the soil convert them into nutrient forms to be used again by the tree and by nearby forage plants. Tree roots continually grow and die. The dead roots are broken down in the soil and contribute directly to organic matter, increasing water retention and improving soil structure.

Shade trees in pastures can be a benefit, but they can also create problems. It is cooler under the trees, and livestock tend to congregate there. These areas become nutrient sinks. That is, nutrients gathered during grazing are later deposited under the trees as waste. This nutrient transfer from open pasture to under the trees reduces pasture productivity. These and other areas of high animal concentration or repeated use (like around water and minerals) also tend to accumulate parasites, which then reinfest the livestock. Livestock concentrating around a tree can also lead to compaction around the root zone and result in the loss of a tree.

Although no studies have shown that providing shade for livestock results in a production benefit, most producers like to make it available for the comfort of the animals. The "shademobile" is an innovative idea, promoted by Joel Salatin, designed to use shade to control where nutrients will be redeposited. It is an open-sided structure with a canvas or shade cloth cover that is towed by a tractor from paddock to paddock. Moving the shade around constantly changes the loafing area and controls where manure is deposited, while preventing parasite build-up.

Windbreaks in or around pastures should be planned to provide shelter from cold or hot, drying winds and to protect newborns from harsh weather. Windbreaks that include several species of shrubs and trees become valuable wildlife habitat. The resulting wildlife create an opportunity for spin-off enterprises such as lease hunting or bird-watching.

Plants and animals make their homes in all levels of tree canopies and understories. The birds help control insect pests, and some eat weed seeds. Larger predatory birds help control small-mammal populations. Birds roosting in trees even add their phosphorus-rich droppings to the nutrient cycle. This biological diversity increases the stability of the ecosystem and mediates against the disasters that monocultures are subject to.

To avoid the problems associated with shade, some farmers fence the tree area so that animals can't use the area at all. Or you can remove trees' lower limbs, so the shaded area moves across the pasture as the sun crosses the sky, and animals must move to follow it. The result is a more uniform pattern of waste distribution.

Trees can reduce erosion on hilly land. If planted in strips along the contour, they create a natural terracing effect. Over time, organic matter will accumulate along the line of trees, and the slope will become more productive and stable. As an added advantage in dry seasons, more water is stored underground in these terraced systems.

On the other hand, when they are planted in wet areas, trees collect water in their extensive root systems and "pump" it out through the leaves by transpiration. Poplars and eucalyptus have been used to reduce surface salinity in areas where water lies too close to the surface.

Agroforestry is a term applied to farm systems that intentionally integrate trees as an additional enterprise or for their environmental services. Nut trees or high-value timber are especially popular in pastures.

Although trees require additional care and management, they can provide a long-term source of additional income. With good management–particularly attention to marketing–both nuts and thinnings provide sources of income before the final timber harvest.

While the trees are still young, row crops may be grown between them. When the canopy begins to close, and light is inadequate for row crops, forage crops can be grown for hay. When the trees are large enough that they can't be damaged by livestock, the area can be directly grazed. This reduces mowing costs while contributing to fertility for tree and forage growth.

Small trees need protection from livestock and deer. Deer, like domestic livestock, browse on young tree growth and will eat any parts that they can reach, threatening the survival of young trees. An alleyway with electric fencing on either side of seedling rows will provide protection. You can buy plastic tubes that fit around each sapling and guard the young tree from grazing and wind. New tube designs with ventilating holes to allow for air circulation prevent the increased pest and disease problems encountered with earlier designs.

Information on all types of agroforestry practices is available in the ATTRA publication *Agroforestry Overview.*

Many trees and shrubs produce seeds, leaves, or nuts that supplement existing forages and provide valuable feed during certain times of the year. Because trees and shrubs are perennials with long life expectancies, few annual costs are associated with their continued productivity. Fodder trees—such as locusts, willows, some poplars, leucaena, and tagaste—have potential for either seasonal or year-round browsing. In some

cases, seasonal cutting back to the trunk will produce tender shoots that are more palatable and easily accessible to the animals that browse them directly, but if animals have continuous access, they may exhaust root reserves and kill the trees. In some regions, tree fodder is considered an emergency feed for unusually dry seasons.

Like forage legumes, leguminous trees such as black locust and honey locust fix nitrogen. Rhizobial bacteria live closely with their roots, converting nitrogen from the air into a form that the trees can use. The nitrogen is used by the tree, but when the leaves die, they add to the total nitrogen in the pasture system.

Traditional beliefs hold that animals will select a diet according to their needs, if they have access to a wide variety of plants, including shrubs and trees in the pasture or hedgerow. When appropriate species are available, livestock may select them to self-medicate for their health problems. Cindy Engel in *Wild Health: How Animals Keep Themselves Well and What We Can Learn From Them* (5) explores this idea in some detail.

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