Intermountain Irrigated Pastures and Mountain Meadows Series

University of California
Division of Agriculture
and Natural Resources

Intermountain Irrigated Pastures and Mountain Meadows

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Intermountain Workgroup
University of California Cooperative Extension

Foreword

Intermountain Irrigated Pastures and Mountain Meadows Series is a collection of independent articles. These types of natural resources are unique in California and represent an ecotype between Great Basin areas like Nevada and Utah, and Mediterranean regions more characteristic of California. Each article can be used by itself to learn more about irrigated pastures and mountain meadows in the Intermountain region of California. Collectively the Series represents a collaborative effort of Cooperative Extension workers from the Intermountain region, and valuable summary of their research and experience.

It was edited by Daniel J. Drake, Livestock and Range Advisor in Siskiyou County. The authors include: Glenn Nader, Livestock and Range Advisor Lassen County; Rick Delmas, Livestock and Range Advisor Modoc County; Don Lancaster, Crops Advisor Modoc County; Holly George, Livestock and Range Advisor Plumas and Sierra Counties; Larry Forero, Livestock and Range Advisor Shasta County; and Rodney Todd, Crops Agent Klamath County, Oregon.

Acknowledgements

We would like to acknowledge the people whose valuable assistance, advice and encouragement have lead to this contribution. Some of those providing assistance include: Harry Carlson, Director Intermountain Research and Extension Center, Tulelake; Ben B. Norman, Extension Veterinarian, UC Davis; Terrell Salmon, Regional Director, UC Davis; Rhonda Gildersleeve, Associate Professor, University of Wisconsin.

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Chapter 1

What are Intermountain Irrigated Pastures and Mountain Meadows?

Holly George, Cooperative Extension, University of California[1]

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Introduction

Most of the Intermountain area of northeastern California is forested and characterized by rugged mountain terrain with numerous high elevation valleys and meadows. Elevation ranges from 1000 to 8000 feet, causing extremes in temperature and precipitation. Annual precipitation varies from less than 10 inches on many eastern slopes to more than 80 inches on some western portions of the region. Much of the precipitation is in the form of snowfall which is quite heavy at higher elevations. The growing season varies. In many areas, a killing frost may occur any month of the year.

The United States Forest Service and Bureau of Land Management are the major landowners in this region. Irrigated pasture and mountain meadows cover over 552,000 acres of private land in Siskiyou, Modoc, Shasta, Lassen, Plumas, Sierra, Inyo and Mono counties, (1990 County Agricultural Reports). These pastures and meadows provide forage for sheep and cattle and habitat for various species of wildlife.

The irrigated pastures receive periodic cultivation and either border, wild, or sprinkler irrigation. They usually contain introduced (non-native) species of grasses and legumes. Many irrigated pastures are fertilized, either on a regular or irregular basis.

Irrigated pastures are often more level and receive water in a more controlled manner than meadows. Most mountain meadows have rough surfaces making water distribution difficult.

In the context of this publication, meadows are uncultivated high altitude grasslands that may be classified by elevation, range type, physical geography, vegetation, and/or wetness. The species composition varies depending upon the moisture, elevation and management; but mountain meadows usually contain native rushes, sedges, grasses and forbs.

In general, forage productivity and animal carrying capacity decrease as elevation increases. Lower production levels do not necessarily mean that a site is in poor condition (General Technical Report PSW-84).

Mountain meadows and irrigated pastures filter sediment from water flowing across them. This natural filtering system helps maintain clean water for humans, wildlife, fisheries and domestic animals.

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[1] Plumas/Sierra County 208 Fairgrounds Road, Quincy, CA 95971-9462; 530/283-6270

The Intermountain Irrigated Pastures and Mountain Meadows Series, summarizes information on irrigated pastures and meadows in northeastern California.

For Further Information

Managing Livestock Grazing on Meadows of California's Sierra Nevada, A Manager-User Guide, University of California Leaflet 21421. [1]208 Fairgrounds Road, Quincy, CA 95971; 916/283-6270.

Meadows in the Sierra Nevada of California: State of Knowledge, USDA, General Technical Report, PSW-84, Pacific Southwest Forest & Range Experiment Station.

Symposium Proceedings Management of Intermountain Meadows, June 1979, RJ 141, Second Edition, University of Wyoming Agricultural Experiment Station and Colorado State University Mountain Meadow Research Center.

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Chapter 2

Management Options for Utilizing Irrigated Pastures

Glenn Nader, Cooperative Extension, University of California [1,2]

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Many alternatives exist in harvesting irrigated pasture. The primary alternatives are haying and/or grazing. Hay and cattle market conditions and coordination with other ranch resources are important considerations in the selection of harvesting alternatives.

Haying

Conserving irrigated pasture as hay provides a forage product that will vary with plant species. Primary interest in irrigated pasture hay is for horse and cattle consumption. The degree of plant maturity also greatly influences hay quality, so the date or timing of hay- making largely determines hay quality. A dramatic drop in quality (protein and energy) occurs as plants become more mature. Pasture harvested before July 1 generally is higher quality, but yields somewhat less per acre than pasture cut later in the summer.

Multiple cuttings during the summer help maintain the quality of hay from pasture. Cutting about 30 days after the previous hay-making will provide reasonable yield and good quality.

Grazing

Traditional grazing practices utilize pastures in a set stock or continuous nature. Irrigated pastures in the Intermountain area grow rapidly during May and June, then slowly in summer. These growth patterns need to be incorporated in a grazing plan to properly schedule forage harvesting through livestock.

Rotational and short duration, high intensity grazing systems further enhance production and vigor of irrigated plants. Since each ranch is different, these systems are best designed with specific ranches in mind.

Haying and Grazing

A combination of haying and grazing can maximize production from irrigated pastures. Haying can be used to harvest rapid plant growth in June. The pastures can then be added to grazed paddocks to provide additional forage during the slowdown growth phase of July and August. A second strategy is to hay all irrigated pastures and use the aftermath for fall grazing. Both strategies diversify marketing and resource utilization.

Interrelation with Wildlife

Irrigated pastures can be an important habitat for nesting birds, especially waterfowl. In major waterfowl nesting areas harvesting after mid-July is recommended to allow for hatching and rearing of birds. Delayed harvesting decreases forage quality, but increases total yield.

In certain regions irrigated pastures are key fawning areas for deer and kidding areas for antelope. Deferring of harvesting patterns to

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[1] Sutter/Yuba County, 142-A Garden Highway, Yuba City, CA 95991-5512; 530/822-7515

[2] Commercial companies are mentioned in this publication solely for the purpose of providing specific information. Mention of a company does not constitute a guarantee or warranty of its products or an endorsement over products of other companies not mentioned.

mid-July allows for rearing of young wildlife to the proper stage when they can escape harvesting machinery.

The practice of haying followed by grazing into the fall provides excellent cover and feed for migrating geese. The open fields reduce predator impact on geese populations. Geese prefer these areas over areas that are only hayed without subsequent grazing. Rodent control can also be enhanced by removing excess forage before winter. Reduced stubble height reduces rodent habitat and increases predation.

Summary and conclusions

Haying and grazing irrigated pasture can be manipulated to meet the management goals and objectives for each ranch.

Pastures are important for wildlife habitat and aesthetics, but present economic incentives work against optimizing these resources.

When determining whether to hay or graze an irrigated pasture, not only are the ranch goals important considerations, but economic consequences are critical to sustainability. New intensive grazing strategies on irrigated pastures have increased the net return per acre. If water resources diminish and costs increase, cost studies will need careful analysis to determine the optimum use for pastures.

References

Shipley, M.A. and F.B. Headley. 1948. Nutritive Value of Wild Meadow Hay as Affected by Time of Cutting. Nev. Agric. Exp. Station Bulletin No. 181. pp.23.

For Further Information

See Chapter 3 (in this manual) Irrigated Pasture, Riparian Areas and the Environment.

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Chapter 3

Irrigated Pasture, Riparian Areas and the Environment

Rick Delmas, Cooperative Extension, University of California[1], *Rodney Todd, Cooperative Extension, OSU*[2]

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Pasture production is an environmentally sound, sustainable agricultural enterprise which converts the sun's energy into herbaceous material. Limited amounts of mechanical and chemical energy in the form of herbicides, fertilizers, tillage, and harvest equipment are required for efficient pasture production. When livestock are managed properly on irrigated pastures or on riparian areas, large quantities of plant material are converted into a product for human consumption while still protecting the land and biodiversity of wildlife and vegetation.

Wildlife

Wildlife is a valued product of the land, providing sports hunting and also aesthetic viewing. Pastures can provide the four basic needs of wildlife: food, water, cover, and space. Pastures with diversity of plant communities support a variety of wildlife. Irrigated pastures that are closely grazed and without shrubs and trees along fence rows provide a haven for open field loving birds, insects, grazing geese, deer and small rodents, which provide food for predatory birds. Pastures with ungrazed patches, trees and shrubs offer cover and nesting sites for birds. They also provide thermal cover, travel corridors, foraging, and cover for small mammals, birds, and in some cases larger ungulates such as deer and elk.

In range and forest ecosystems the majority of all wildlife species use riparian pastures for food, water, escape, and thermal cover. Areas with free flowing water, shrubs, trees and overhanging stream bank vegetation provide shade and habitat to support insects and fish populations. Proper grazing by livestock can control the vegetation and help maintain the diversity of plants for numerous wildlife species.

Pastures can be managed to enhance certain wildlife species. For example, close grazing of pasture in late summer or early fall results in desirable feed for geese, by stimulating clover a desired feed.

Water and Soil

Irrigated and riparian pastures provide a continuous ground cover that prevents soil erosion by wind and water. Well established irrigation and riparian pastures have extensive root systems that increase soil porosity which allows rapid infiltration and exchange of air, water, and nutrients. Riparian pastures with well-established root systems and at least 3 inches of plant material can filter sediments and reduce stream bank erosion during high rainfall and flooding. In this way, riparian pastures reduce nutrient loads in streams and lakes.

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[1] Inyo/Mono County, 207 West South Street, Bishop, CA 93514-3407; 760/873-7854
[2] 3328 Vandenberg Road, Klamath Falls, OR. 97603-3796; 541/883-7131

Nutrient loads entering a watershed are effected by the condition of the land and plant communities, human activities, and the parent materials of the watershed. Natural background levels of nutrients from parent materials need to be determined for each watershed before the affects of human or agricultural activities on nutrient loads in a stream or lake can be determined. Irrigated and riparian pastures in good condition should not increase net nutrient loads to streams and lakes, and may reduce nutrients entering a watershed system compared to other alternatives.

Summary

Pastures are dynamic functioning units. When goals are set and sound pasture management practices implemented, native, riparian and improved pastures will provide an ecologically sound, diverse habitat for many plant and wildlife species and support a sustainable livestock enterprise.

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Chapter 4

Site Evaluation: The First Step to Improved Pastures

Rhonda R. Gildersleeve, Cooperative Extension, University of Wisconsin[1]

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Developing or improving permanent irrigated pastures can be expensive and should be considered a long-term investment. Therefore, as with any investment, careful planning of pasture improvement deserves some research. Attention to details now will save time and money as you get into the establishment and management phases. Visualize WHAT you would like the pasture to look like once established, and determine what needs or expectations you have for that improvement. From that vision, you can develop a list of details which will help you outline a work plan for the project. To assist you in this portion of the planning stage, consider the questions in Table 1. As your pasture improvement plan takes shape, many of the decisions you make will be based on how some of these questions are answered.

Table 1. Questions to Consider When Developing a Pasture Improvement Plan.

Question	Some Options or Considerations	My Situation
What animal species and class of animal will utilize this pasture?	cow-calf pairs, stockers, market lambs, horses, bulls, dairy replacements, exotics (llamas, ostriches, etc.)	
What level of performance do I expect from livestock grazing on this pasture?	maximum gains, maintenance, exercise, other uses such as hay, and wildlife habitat.	
How will this pasture improvement fit in with the rest of my operation?	primary pasture for small acreage expansion of available pastures on farm or ranch, renovation of existing pasture, conversion of cropland into pasture.	

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[1] 222 North Iowa Street, Dodgeville, WI 53533; 608/935-0391

Question	Some Options or Considerations	My Situation
What are the soil and physical limitations and opportunities for pasture at this site?	Soil Considerations: a. drainage—well-drained, poorly drained. b. soil fertility—fertility, nutrient deficiencies, saline, alkaline. c. topographic limitations: steep, rocky, etc. d. what forage species are adapted to this soil? e. facilities: water, shelter, fencing, handling of livestock f. weed problems: poisonous plants, brush, etc. g. other considerations: wildlife habitat needs	
Is water available?	Irrigation Considerations: a. water availability—how much, how long, and how dependable is the supply of water? b. irrigation system options	
Are the tools and equipment available for accomplishing this project?	Establish pasture myself: Need tractor, land preparation and seeding equipment (rent or own); hire someone to establish pasture	
How will I manage this pasture once established?	Will I maximize site potential with appropriate fertilization, irrigation, weed control and grazing management? Do I need to produce hay as well as provide grazing? Does the pasture need to be a low input system with minimal management requirements?	
What economic returns do I expect or need from this investment?		

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Chapter 5

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Establishing Irrigated Pastures

Rhonda R. Gildersleeve, Cooperative Extension, University of Wisconsin [1]
Donald L. Lancaster Cooperative Extension, University of California [2, 3]

Introduction

Well established and managed irrigated pasture is potentially one of the highest producing forage crop options in the Intermountain Region. Irrigated pastures are adaptable to any size operation. Improved irrigated pasture production levels are influenced by proper establishment and subsequent management of the pasture. This chapter covers topics related to establishment of irrigated pastures. For information on the agronomic aspects of established pasture management, including soil fertility, irrigation, and weed control, see *Soil Fertility, Irrigation, and Management of Irrigated Pasture and Mountain Meadows.*

Assess Soil Fertility

Early in the work plan, take soil samples from the pasture site and have a soil test done to determine if any nutrients are deficient. Once the analysis is received, determine the appropriate type and amount of fertilizer to use. Intermountain soils are often deficient in sulfur (S) and phosphorus (P). For soils with sulfur deficiency, incorporate 200-300 pounds per acre of elemental S (or equivalent) into the top four to six inches of soil prior to planting. When soil phosphorus levels are below 10 ppm P2O5, incorporate 100 pounds of actual P2O5 per acre during seedbed preparation (see Seedbed Preparation below). Incorporate 50 pounds of actual P2O5 per acre when soil phosphorus levels are 10-20 ppm. These amounts are for maintenance and should provide adequate sulfur and phosphorus nutrition for 3 to 4 years for most pastures.

If soils are very low in S or P, additional annual applications may be necessary for a number of years. If the seeding drill used for establishment has fertilizer boxes attached, a starter P fertilizer can be placed near the seed as it is drilled.

If you have any questions about taking soil samples for analysis, or interpreting the results, contact your local Cooperative Extension office for assistance.

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[2] Modoc County, 202 West 4th Street, Alturas, CA 96101; 530/233-6400
[3] Commercial companies are mentioned in this publication solely for the purpose of providing specific information. Mention of a company does not constitute a guarantee or warranty of its products or an endorsement over products of other companies not mentioned.

Pasture Species Adapted to the Intermountain Region

An important requirement for developing productive irrigated pastures is to select species that are well adapted to your particular site. Extensive pasture species testing has been conducted at the Intermountain Research and Extension Center in Tulelake, California, and at the Klamath Research Station in Klamath Falls, Oregon.

Characteristics of the major grass species grown in the Intermountain Region are listed in Tables 1 and 1A. Tables 2 and 2A provide information on the most common pasture legumes. This information, along with the chapter on seed selection, should be used to select the best forage species for various pasture situations.

The species listed require full growing season irrigation or equivalent rainfall. If water is not available throughout the summer and fall, consult with your farm advisor to consider alternatives such as a perennial wheatgrass or other species which will respond well to irrigation, but are also drought resistant. Some forage species, such as alfalfa and smooth bromegrass will go dormant when water is scarce but return to normal production when water is available again.

Grass-Legume Mixtures

A mixture of one grass and one legume is used for most pastures. However, if your pasture has different soil types or drainage variations which might affect adaptability of the pasture species chosen, you may want to include two or more grasses and/or legumes in the mixture. In contrast, ranchers may choose a single species such as tall fescue or timothy on some sites, particularly if they are focusing on a specialty hay market as a primary use. Since a pasture is a long term investment, you should discuss the various species mixture options with your farm advisor before selecting the "best" mix for your conditions and intended uses.

Seeding Rates

Depending on the species or mixture of species chosen, a typical recommendation is for 8 to 20 pounds of grass seed and 2 to 5 pounds of legume seed per acre. The seeding rate recommendations may vary based on site conditions, method of seeding, and the number of seeds per pound for a particular forage species. Under marginal establishment conditions or when using broadcast seeding methods, it may be wise to increase the seeding rate by 10 to 20 percent. Also, the smaller the seed, the fewer pounds needed to achieve a full stand, so a lower seeding rate is used on small-seeded species. But small seed require careful seed placement.

To achieve a 50-75% grass and 50-25% legume mixture when planting tall fescue and Ladino clover, a typical seeding rate would be 16 pounds of grass seed and ½-2 pounds of clover seed per acre. Table 3 has information on the number of seeds per pound and seeding rate ranges for the grasses and legumes most commonly grown in the Intermountain Region.

Planting Times

For most of the Intermountain Region, the best time to plant pasture is in spring to take advantage of spring rains. Spring seeding may be easier to accomplish if the land preparation and fertilization are done in the fall. Then, in February or March, the area can be sprayed with *Roundup*® and the pasture seed planted with a drill. This method minimizes soil disturbance, conserves moisture and provides weed control.

If adequate irrigation is available for germination and seedling development, pastures can be planted in late summer or early fall. With fall seeding, it is important that the pasture seedlings establish an adequate root system before winter for

survival during cold winter conditions. In lower elevations of the Intermountain Region, mid-summer may be too hot for pasture establishment.

Seedbed Preparation

A firm seedbed which will allow precision placement and good soil contact of the small pasture seeds is necessary. The amount and type of land preparation vary with site and soil conditions. Compacted soils may require ripping. Ripping must be done when sub-soil is dry i.e. fall is best. Next, plow, disk, and/or harrow and pack as appropriate to eliminate clods and firm the seedbed.

If a sod-seeding drill is available, little or no tillage may be necessary. These drills open a furrow, place the seed in the opening, and press the soil back in place. Prior to using a sod-seeding drill, any previous vegetation should be cut or grazed closely and/or sprayed to decrease competition between the previous vegetation and the seedling pasture stand.

One or more irrigations between early seedbed preparation activities will increase moisture in the soil profile and germinate weed seedlings. Seedling weeds may then be cultivated or sprayed during further seedbed preparation.

Legume Inoculation

Legumes, in association with the appropriate nitrogen fixing bacteria (Rhizobia), can remove nitrogen from the air for their own needs, making some of this N available to the soil system through root decomposition for growth of the associated grass species. Inoculation places rhizobia with the legume seed. Legumes must be inoculated with the appropriate rhizobial strain before they can acquire nitrogen from the atmosphere. Legumes that do not develop a symbiotic partnership with the correct rhizobial bacteria have to compete with other pasture plants for soil nitrogen, increasing fertilizer requirements. Inoculation is especially important on problem soils and when introducing a new legume to a soil.

As the seedlings begin to grow after inoculation, the roots become infected with the rhizobia bacteria. Nodules on the roots are visual evidence of infection. However, not all nodules may be producing nitrogen for the plant. If the legume seedling was infected with the wrong strain of rhizobia, the nodules will be small and without the characteristic red or pink color when cut open. The red color indicates that nitrogen fixation is occurring. Some legumes associate with the same strains of rhizobia.

Soils that have never grown legumes will probably not contain the proper rhizobial strains for the legumes. Therefore, it is important to properly inoculate the legume seed with the appropriate bacteria. Once symbiosis develops the populations of rhizobia in the soil gradually increase and can remain in the soil for periods of time even if the legume is not present. Therefore, if the legume is successfully inoculated in the establishment year, rhizobia in the soil will colonize re-growth or new plants from reseeding during the next growing season. (See Appendix A for proper rhizobial inoculation procedures.)

Methods of Seeding Irrigated Pastures

Pastures can be established by drilling, broadcasting, or aerial seeding. While drilling seed is generally the preferred method, both broadcast and aerial seeding followed by harrowing and/or culti-packing the seedbed have been successful. Whichever method, the goal is to uniformly sow the seed into a firm seedbed at the correct depth and seeding rate. This is most easily accomplished with a drill. The optimum seeding depth for most forage species is ¼- to ¾- inch, with the soil packed firmly around the seed. It is usually necessary to use a cultipacker or similar device behind the drill to firm the soil around the seed. If the seedbed was prepared the previous fall, firming during

the winter may make packing behind the drill unnecessary. Avoid burying seeds too deep during packing.

Some soils are difficult to pack, and seedings may fail by drilling into a fluffy seed bed. A pre-planting irrigation often firms the soil enough to drill the seed (especially if using sprinkler irrigation). Seeding in two directions ensures uniform stands. Specific locations may preclude this. For sloped fields, machinery safety and potential for soil erosion need to be considered. If you have questions about seedbed suitability or the methods of seeding, contact your farm advisor before you plant.

Some drills are equipped to provide a starter fertilizer. Starter fertilizers are placed close to the drilled seed and provide extra nutrients which can be beneficial to new seedlings. When equipment permits starter fertilizer, phosphorus is the primary nutrient to supply, although small amounts of nitrogen can also be used. A good starter fertilizer providing only phosphorus would be Treble Super Phosphate (0-45-0) used at a rate of 80 to 100 pounds of product per acre. Another choice would be 11-52-0 or 16-20-0 used at a rate of 80 to 100 pounds of product per acre. Do not use urea, 18-46-0 or 16-48-0 as they may kill germinating seedlings.

Irrigation During Establishment

Sprinklers are excellent for pasture establishment. The key is to keep the soil surface moist. Once seeds germinate, allowing the surface to dry could result in severe loss of young seedlings. Try to keep the top 3 to 4 inches of soil moist until the seedlings are well established. With sprinkler systems, it is important to be able to irrigate the whole field every three to five days during establishment.

Establishment can be more difficult with flood irrigation. Sod-seeding (no tillage) works well with flood irrigation because the soil is not disturbed, moisture is conserved, and the seed is placed so it will not wash away. Growers often use portable sprinkler systems to establish seedlings before using flood irrigation.

A second option with flood irrigation is to prepare the land in the fall, spray spring weeds and drill pasture seed in early spring. Soil moisture in most years is adequate for germination and seedling development. Residue from the dead weeds helps protect seedlings during subsequent flood irrigation until the stand is established.

If sprinkler irrigation or sod-seeding are not possible, corrugations (shallow furrows) can prevent soil washing and crusting during germination and seedling establishment. Make corrugations after the seed is planted. Water moves laterally under the beds, keeping the soil surface loose so seedlings can push through, and do not wash away the seeds. Corrugations may be made between irrigation borders so flood irrigation can be used once the pasture is established. Corrugation shape varies: some are like the ripples on corrugated metal roofing, while others are 3-4 inches wide and 3-4 inches deep, with 24-30 inches between each furrow.

Timing of Initial Haying or Grazing

Do not graze or cut pasture for hay until seedlings are well established, usually late summer or fall for spring planting and late spring for fall planting. The key is to delay use until the plants start stem elongation and flowering. Haying or grazing before the stand is fully established reduces vigor, uproots plants, increases weed problems and may cause loss of the pasture.

Weed Control During Establishment

If weeds are overtaking the seedlings, clipping may be necessary to provide light and give the seedling grasses and legumes a chance to compete. If weeds are spotty, herbicide applications in problem areas may be effective. Broadleaf herbicides such as

2,4-D, dicamba, and trichlopyr should not be used on grass-legume mixtures, as they will damage seedling legumes.

Fertilization during Establishment

If major nutrient deficiencies are corrected by pre-plant applications of sulfur, phosphorus and potassium, it is seldom necessary to apply more than a starter fertilizer for initial seedling development in new pastures. Most perennial grass seedlings are inefficient at using additional nitrogen, thus additional fertilizer gives weeds a competitive advantage. Perennial grasses with a significant root system (6 to 8 inches of top growth) can use applied nitrogen efficiently if they have adequate irrigation and growing season left during the establishment period. Nitrogen applications in the 40 to 60 pounds per acre range should be adequate.

Summary

Improved irrigated pasture production levels are influenced by proper establishment and management. Establishment concerns include soil fertility, plant selection, land preparation, seeding, irrigation, and weed suppression. Soil fertility should be determined by taking soil samples, and the appropriate amounts of fertilizers should be applied before planting.

Select plant species that are well adapted to the site. A mixture of one grass and one legume species is used for most pastures, with the goal of 50 to 75 percent grass and 50 to 25 percent legume in the established stand.

The best time to plant a pasture is in the spring. Spring planting takes advantage of residual winter moisture, but pastures can also be established in the late summer or early fall with adequate irrigation. Prepare a firm seedbed for precision placement of seeds. One or more irrigations during land preparation encourages weed emergence. Weeds can then be tilled or controlled with herbicides before seeding the pasture. Seeds can be sown using drill, aerial, or broadcast applications. Legume seeds should be inoculated with the appropriate Rhizobia strain just before planting.

Sprinklers are excellent for pasture establishment. Try to keep the top 3 to 4 inches of soil moist until seedlings are well established. Sod-seeding is a no-till option that works well on areas that must be flood irrigated. New seedlings should not be grazed or cut for hay until plants are well established and have initiated stem elongation and flowering.

For Further Information

See Chapter 6 (in this manual), Soil Fertility, Irrigation, and Management of Irrigated Pastures and Mountain Meadows.

See Chapter 7 (in this manual), Selection of Plant Species for Intermountain Irrigated Pasture.

See Chapter 9 (in this manual), Renovating or Rejuvenating Irrigated Pastures and Mountain Meadows.

Table 1. Descriptive characteristics of selected grass species.

Species	Quality/Palatability	Yield Potential	Growth Habit	Means of Spread	Comments
Smooth bromegrass *Bromus inermis*	excellent	medium	sod	rhizomes	deep-rooted
Orchardgrass *Dactylis glomerata*	excellent	high	bunch	tillers	shade tolerant
Perennial ryegrass *Lolium perenne*	excellent	high	bunch	tillers	establishes quickly; most responsive in fertile soils
Reed canarygrass *Phalaris arundinacea*	medium Excellent for Palaton variety	high	sod	short rhizomes	use low alkaloid varieties
Meadow Foxtail *Alopecurus pratensis*	excellent	medium	sod	short rhizomes	hard to establish by machine sowing
Tall fescue *Festuca arundinacea*	good	high	bunch	short rhizomes	use endophyte-free seed to prevent fescue toxicosis
Timothy *Phleum pratense*	excellent	medium	bunch	corms	shallow roots; best suited for hay production
Kentucky bluegrass *Poa pratensis*	excellent	low	sod	tillers & rhizomes	not heat tolerant-goes dormant

Table 1A. Characteristics related to site potential of selected grass species.

Species	Longevity	Winter Hardiness	Drought Tolerance	Wet Soils/ Flooding Tolerance	Saline/Alkaline Soils Tolerance
Smooth brome grass	medium	excellent	good	fair	fair
Orchardgrass	medium	good	fair	poor	poor
Perennial ryegrass	medium	medium	medium	good	poor
Reed canarygrass	long	excellent	good	excellent	poor
Meadow foxtail	long	excellent	poor	excellent	poor
Tall fescue	long	excellent	good	exellent	medium
Timothy	long	excellent	poor	good	poor
Kentucky bluegrass	long	excellent	poor	good	poor

Table 2. Descriptive characteristics of selected legume species.

Species	Yield Potential	Growth Habit	Means of Spread	Flower Color	Comments
Alfalfa *Medicago sativa*	high	erect	tillers	purple	deep-rooted; hay or grazing types; bloat hazard
Alsike clover *Trifolium hybridum*	medium	erect	seed	white to pink	manage for natural reseeding; good for hay production; performs best in mixtures
Birdsfoot trefoil *Lotus corniculatus*	medium	erect	rhizomes	yellow	non-bloating legume; adapted to wide range of soil types & fertility conditions

White/Ladino clover *Trifolium repense*	high	prostrate	rhizomes and stolons	white	tolerates close grazing; bloat hazard; estrogenic
Red clover *Trifolium pratense*	high	erect to recumbent	seed	red to purple	manage for natural reseeding; shallow root system; estrogenic
Strawberry clover *Trifolium frageriferum*	low	prostrate	stolons	pink to white	Weak seedlings; well-adapted to wet & saline/alkaline soils & cold climates

Table 2A. Characteristics related to site potential for selected legume species.

Species	**Longevity**	**Winter Hardiness**	**Drought Tolerance**	**Wet Soils/Flooding Tolerance**	**Saline/Alkaline Soils**
Alfalfa	long	excellent	good	poor	good
Alsike clover	short	excellent	poor	good	fair
Birdsfoot trefoil	medium	good	fair	good	fair
White/Ladino clover	medium	good/fair	poor	fair	poor
Red clover	short	good	poor	fair	poor
Strawberry clover	medium	good	poor	excellent	medium

Table 3. Seed and seeding rates for selected grass and legume species.

Grasses		
Species	**Seeds/lbs. (in 1000's)**	**Seeding rate (lbs./A.)**
Smooth brome grass	137	12-20 (alone) 8-15 (mix)
Orchard grass	590	10-20 (alone) 5-10 (mix)
Perennial ryegrass	330	16-20 (alone) 5-10 (mix)
Reed canary grass	550	8-12
Meadow foxtail	540	15-25
Tall fescue	227	8-16
Timothy	1,230	8-12 (alone) 2-8 (mix)
Kentucky blue grass	2,200	5-10

Legumes		
Species	**Seeds/lb. (in 1000's)**	**Seeding rate (lbs./A.)**
Alfalfa	220	10-15 (alone) 6-8 (mix)
Red clover	260	8-12 (alone) 4-6 (mix)
Strawberry clover	290	3-6
Alsike clover	680	4-8
Birds-foot trefoil	375	6-12
White/Ladino clover	700/1000	3-5

APPENDIX A

PROPER RHIZOBIAL INOCULATION PROCEDURES FOR LEGUMES

Proper inoculation of legume seed is critical to successful establishment, nitrogen fixation and satisfactory pasture production. The inoculant is a LIVING bacteria. Heat and direct exposure to sunlight kill the bacteria immediately. Retail seed and inoculant suppliers and producers need to keep inoculants cool, dry and away from direct sunlight until planting time. Planting legume seed that has been inoculated with mishandled (i.e. dead) *Rhizobia* will likely result in complete stand failure, since the legume seedlings will be unable to develop adequate nitrogen fixation without the appropriate bacteria. Different legumes require different types or strains of rhizobial bacteria for inoculation. Table 1 lists several legumes used in the Intermountain Region and the strains of rhizobia that are compatible with those legumes.

Table 1. Strain of *Rhizobia* for Intermountain Pasture Legumes.

Legume	Inoculant Type
Alfalfa	A
Alsike Clover	B
Birdsfoot Trefoil	K
Ladino and White Clovers	B
Red Clover	B
Strawberry Clover	Trifolium Special 6

There are several ways to inoculate legume seed. The method used may depend on seed size, form of the inoculum, and planting method. In some cases, pelleted legume seed which has the inoculum included in a lime or clay coating around the seed may be available. Unless the pelleted seed is fresh, you may need to re-inoculate before planting into virgin soils, as the inoculum may have lost most of its effectiveness. For some legumes, a granular inoculum is available that can be mixed with the seed in the drill. Another choice (and this is most common for small-seed legume species) is inoculum packaged with a powdered peat base. For the powdered form, a "sticker" or adhesive gel is recommended to "glue" the bacteria to the seed, rather than simply mixing the powder with the seed in the drill box. The dry sticker powder is mixed with water and the inoculum to form a slurry, then combined with the seed. Do not simply mix powdered inoculants with seed in the planter box. The adhesive and instructions for inoculating the seed are usually available with the inoculum. Contact your farm advisor if you have questions about inoculation.

Important points about the inoculation process:

1. **DIFFERENT LEGUMES MAY REQUIRE DIFFERENT STRAINS OF RHIZOBIAL INOCULANT**. Buy your legume seed and the inoculum at the same time, checking to make sure the inoculum is the right strain for your legume.
2. Use a sticker.
3. Check the **EXPIRATION DATE** of the inoculum. Seed suppliers should keep inoculants refrigerated and away from sunlight. Once you buy the inoculum, store it in a cool, dry place away from sunlight.
4. Be sure to buy the recommended amount of inoculum for the quantity of seed you plan to plant. Buying an additional package or two may be wise in case you need to re-inoculate a batch of seed in the event bad weather prevents timely planting. For fields that have had few, if any, legumes growing previously, it is a

good idea to use double or even triple the recommended rate of inoculum.

5. **Rhizobia** die very quickly if placed on the seed and not planted immediately. Studies indicate that the inoculum may lose its effectiveness if the seed is not planted within 24 to 48 hours. **INOCULATE ONLY AS MUCH SEED AS YOU CAN PLANT IN A DAY.** If you are rained out and cannot get the inoculated seed planted, be sure to re-inoculate with a fresh package of inoculum.
6. **DO NOT USE CHLORINATED WATER** for mixing the sticker and inoculum. If chlorinated water is all that is available, let it stand uncovered overnight in a bucket to allow the chlorine to escape.
7. **DETERMINE NOW MUCH SEED YOU NEED TO INOCULATE FOR THAT DAY'S PLANTING.** Mixing seed and sticker/inoculum in 25-pound batches in a large washtub works well. Once the seed is inoculated, it can be returned to the seed bag until placed into the drill box.
8. **DO NOT MIX INOCULATED SEED WITH FERTILIZER.** Fertilizer can kill the bacteria on the seed surface within a few hours if placed in contact with inoculated seed.

Intermountain Irrigated Pastures and Mountain Meadows Series

Chapter 6

Soil Fertility, Irrigation, and Management of Irrigated Pastures and Mountain Meadows

Rhonda R. Gildersleeve, Cooperative Extension, University of Wisconsin[1], Donald L. Lancaster [2], Steve B. Orloff [3], and Roland D. Meyer [4, 5], Cooperative Extension, University of California

University of California
Division of Agriculture
and Natural Resources

Productivity of irrigated pastures is dependent on soil fertility, irrigation management, and proper utilization to maintain the vigor of the stand. Well managed irrigated pastures can produce four to eight tons of hay or equivalent grazable forage per year. Under good management, pastures planted with the recommended species do not decline with age and, thus, may not need to be renovated or replanted for 20 years or more.

Maintaining Balanced Soil Fertility

Highly productive pastures utilize significant amounts of nitrogen (N), phosphorus (P), potassium (K), and sulfur (S) (see Table 1). Fertilizers are applied to pastures to replenish the nutrients taken out of the soil by plants and removed with grazing or haying.

Table 1. Calculated annual removal of major nutrients, in pounds per acre, by cool season grasses.

Nutrient Removed	Percent of Dry Matter	Pasture Yield, Tons/Acre		
		4	6	8
		----------Lbs./acre----------		
Nitrogen	2.0	160	240	320
Phosphorus	0.32	26 (59)	38 (88)	51 (117)
Potassium	2.2	176 {212}	264 {318}	352 {425}
Sulfur	0.25	20	30	40

( ) indicates P_2O_5
{ } indicates K_2O

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[1] 222 North Iowa Street, Dodgeville, WI 53533; 608/935-0391
[2] Modoc County, 202 West 4th Street, Alturas, CA 96101; 530/233-6400
[3] Siskiyou County, 1655 South Main Street, Yreka, CA 96097; 530/842-2711
[4] One Shields Avenue, 2140 Plant and Environment Sciences Building, Davis, CA 95616; 530/752-2531
[5] Commercial companies are mentioned in this publication solely for the purpose of providing specific information. Mention of a company does not constitute a guarantee or warranty of its products or an endorsement over products of other companies not mentioned.

Periodic soil and plant tissue analysis are recommended to assess the fertility status of soil. Soil tests should be taken in the fall at three to four year intervals. Tissue samples taken at haying or in mid-season to check for nutrient deficiencies are also recommended in intensively managed irrigated pastures. Seek qualified advice and base fertilizer applications on soil and plant tissue tests, yield expectations and production experience for each field (see Appendix).

Desirable soil test levels for some of these nutrients for irrigated pastures are:

Phosphorus	>10 ppm for low N application rates
	>20 ppm for high N application rates
Potassium	>45 ppm

Most soils of the Intermountain Region have adequate K, unless they are sandy and have been intensively cropped for many years. In contrast, N, P, and S can limit forage growth due to widespread soil deficiencies of these nutrients in the Intermountain Region.

Nitrogen is almost universally deficient in soils, and in most cases, some N fertilizer will need to be added. If P and S levels are adequate, N is the key nutrient that determines yield levels. Depending on the production goals and utilization methods, ranchers should apply 60-200 pounds of N annually. The amount of N fertilizer needed depends on previous fertility management, yield expectations, composition of the forage mixture and site characteristics. Little or no N may be needed in a stand with a vigorous legume component. Legumes in symbiosis with Rhizobia contribute significant amounts of N during the fixation process. Well-nodulated legumes will fix 50-80% of the N found in their tissues.

Species	Nitrogen fixed, pounds/acre/year
Alfalfa	125-335
Red Clover	85-190

Table 2. Examples of legume nitrogen fixation amounts.

Studies in Northeastern California and Southeastern Oregon indicated that 50-60 pounds of N gave minimum responses, while 100-150 pounds of N optimized pasture responses based on the cost of fertilizer. For maximum yields, 200-300 pounds of N were required. Two or 3 split applications are preferred over a single application under intensive management utilizing high amounts of N fertilizer. Application of one-third to one-half of the total seasonal N required following each grazing or hay cut will increase utilization by the grasses and decrease loss of N through runoff or deep percolation.

If P and S have been applied according to soil test recommendations during establishment, you may not have to apply these nutrients again for 3-4 years unless soils were severely deficient (see discussion on soil fertility in establishment chapter). Once a pasture is established, ammonium sulfate (21-0-0-24S) is a good sulfur source for pastures, since it may also provide all or part of the N needed. Gypsum or elemental sulfur are also good sources of sulfur, and most elemental forms will last 4 to 6 years after a 200 pound per acre application. After establishment, common P sources are triple super phosphate (0-45-0) or one of the ammonium phosphate formulations (16-20-0 or 11-52-0). Adequate P fertilization will help maintain the legume component in a grass-legume mixture, while N fertilization maintains the grass. Therefore, it is important to balance application of these nutrients to maintain both components of the mixture.

Irrigation

Importance of Irrigation Management

Proper irrigation management is essential for a long-lived high yielding pasture. Pasture yields are probably more often limited by

inappropriate water management than any other single production factor. Plant species differ in their capability to withstand drought or deficit irrigation. For example, clovers are more susceptible to drought conditions than are many grass species. Therefore, deficit irrigation not only reduces pasture yields, but the nutritional pasture yields, but the nutritional quality of the forage may be reduced as well. Over-irrigation also detrimentally affects yields and quality. When too much water is applied, plants suffer from inadequate oxygen in the root zone and are susceptible to root diseases. Over-irrigation also leaches nitrogen out of the root zone, reducing yields and/or increasing fertilizer use.

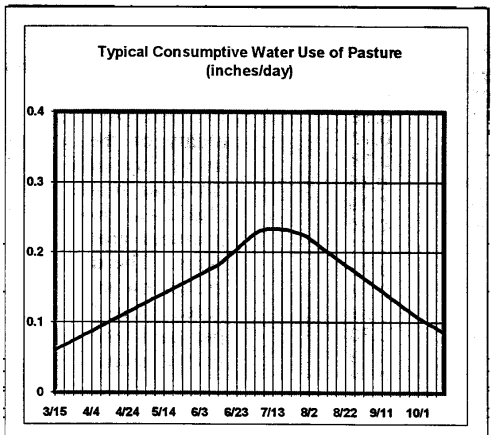

Figure 1. Daily water use of pasture. Actual data from Tulelake, CA but typical for pasture in Northeastern California. Irrigation (allowing for inefficiencies in irrigation) and rainfall should equal water use.

Proper irrigation management is simply applying adequate amounts of water at the appropriate time. The two basic questions that must be answered are "When should I irrigate?" and "How much water should I apply?". While these questions appear very simple and straightforward, their answer can be somewhat complicated. To answer these questions we must understand crop water use and soil moisture relations.

Water Use by Pastures

Crop water use is commonly referred to as evapotranspiration and is abbreviated as ET. It simply refers to the combination of transpiration from the plant and evaporation from the soil. Transpiration is the evaporation that occurs from plant leaves. Water vapor is lost from the plant through tiny pores (called stomata) on the leaf surface. This process of transpiration is essential and acts to cool the plant and aids in the uptake of nutrients. Water losses by evaporation are greatest when the soil is exposed either after a cutting or grazing. Amount of water lost from evaporation is minor in comparison to water used for transpiration.

The seasonal ET of pasture (expressed in inches per day) is illustrated in Figure 1. Note that crop water use peaks in mid-July when solar radiation and temperatures are high and relative humidity is low; therefore, more water should be applied in the summer than in Spring or Fall (i.e. more water per irrigation, more frequent irrigations, or both). For maximum yields, water should be supplied to meet the seasonal water needs of pasture. Table 3 shows weekly and daily water use of pasture in the Intermountain Region.

Table 3. Weekly total and daily average water use in inches by pasture in the Intermountain Area[1]

Week Beginning	Weekly Total (in)	Daily Average (in)
3/15	0.48	0.07
3/22	0.51	0.07
3/29	0.55	0.08
4/5	0.59	0.08
4/12	0.66	0.09
4/19	0.72	0.10
4/26	0.80	0.11
5/3	0.88	0.13
5/10	0.97	0.14
5/17	1.05	0.15
5/24	1.11	0.16
5/31	1.17	0.17
6/7	1.23	0.18
6/14	1.29	0.18
6/21	1.34	0.19
6/28	1.40	0.20
7/5	1.46	0.21
7/12	1.51	0.22
7/19	1.51	0.22
7/26	1.47	0.21
8/2	1.42	0.20
8/9	1.35	0.19
8/16	1.26	0.18
8/23	1.17	0.17
8/30	1.08	0.15
9/13	0.89	0.13
9/20	0.80	0.11
9/27	0.71	0.10
10/3	0.65	0.09

[1]Data for Yreka. Values for rest of Intermountain area would be similar.

These values represent evapotranspiration and do not account for inefficiencies including the non-uniformity of the irrigation system. Irrigation efficiency ranges from 50 to 80 percent for border-flood systems and 60 to 85 percent for sprinkler systems.

To determine how much water should be applied, simply divide the ET value from the table by the efficiency of the irrigation system. For example: Pasture uses 0.22 inches per day in mid July. Divide this value by an assumed irrigation efficiency of 80 percent, and we should apply 0.28 inches per day.

To supply the water needs of pasture in the summer, 2.5 inches of water should be applied every 9 days. In contrast, the same amount of water applied in 12 days is sufficient for late August. To meet the peak water demand in July, growers need a water supply of 6 gpm per acre of pasture.

The amount of water that should be applied per irrigation and the desired frequency of irrigation depends on the ability of the soil to hold water. A heavy clay soil can hold more than four times as much water as a sandy soil (Table 4). However, the water needs of pastures grown on both soil types is same. The difference is that pastures grown on sandy soils should be irrigated more frequently with less water per application than pastures grown on heavier soils.

Table 4. Available Water for Various Soils.

Type of Soil	Available Water Range in /ft	Available Water Average in /ft
Very coarse to coarse-textured sand (Sandy)	0.5 to 1.0	0.75
Moderately coarse-textured sandy loams and fine sandy loams	1.00 to 1.5	1.25
Medium texture-very fine sandy loams to silty clay loam	1.25 to 1.75	1.5
Fine and very fine texture-silty clay to clay (Heavy Clay)	1.5 to 2.5	2.0
Peats and mucks	2.0 to 3.0	2.5

Application Rates

In order to meet the water needs of the crop it is important to know the water application rate for the irrigation system. This can be determined using flow meters, pump tests, or by determining discharge rate for sprinkler systems. The following formula and conversion factors are helpful for determining water application rates.

A X D = Q X T
A= Area in acres
D= Depth of water applied in inches per hr.
Q= Flow rate in CFS Cubic Feet per Second
T= Time in hours
This basic equation can be rearranged to solve for any one value, if the other three are known.

A= (Q X T) ÷ D
D= (Q X T) ÷ A
Q= (A X D) ÷ T
T= (A X D) ÷ Q
Results from these equations can be converted to other units of measure.

Water Volume & Flow Conversions
27,154 gal.= 1 acre-inch
1 CFS = 449 gpm
1 CFS = 1 acre-inch per hour

Irrigation Systems

Pastures can be irrigated successfully with either flood or sprinkler irrigation; there is no "best" system. Flood systems work well on fairly level fields with medium to fine textured soils, while sprinklers are well adapted to medium to coarse textures (sandy) soils and unlevel terrain.

Flood Systems

Flood systems must have the proper slope, border width, length of run, and flow rate. A slope of 0.15 to 0.4 feet per 100 feet of length is recommended for most soils while greater slopes are needed for lighter soils. As slope increases, the width between borders should decrease to ensure sufficient lateral spread of the water. Short field lengths and high flow rate improve uniformity by minimizing deep percolation losses at the head of the field, but these practices usually necessitates a drainage ditch at the end of the runs with a tailwater recovery system. Slope and field lengths should be appropriate to prevent water from standing over 24 hours, as plants may die from oxygen depletion and mosquitoes may become a problem.

Sprinklers

Sprinklers can be used effectively in pastures, provided measures are taken to prevent livestock form damaging the sprinkler system. Slope is less critical with sprinkler systems than with flood systems. However, the mainline should be located up-slope or midway through the field to minimize pressure loss along the sprinkler lateral. Flow control nozzles should be used when pressure difference between first and end sprinklers exceeds 20 percent.

The uniformity of sprinkler systems is influenced by spacing, nozzle type and size, pressure, and wind speed and direction. A sprinkler spacing of 40 X 60 feet with a minimum pressure of 35 psi at the end sprinkler is usually adequate in the Intermountain Region. A catch-can test can be performed to evaluate the uniformity of a sprinkler system. A UC Cooperative Extension Advisor can provide further information on this test.

Irrigation Key Points- Summary

Crop water use is commonly referred to as evapotranspiration and is abbreviated as ET. Crop use of water varies throughout the growing season (Table 3).

Daily water applications can be calculated by dividing daily ET by irrigation system efficiency (typically 50 to 85 percent). The amount of water that should be applied per irrigation and the desired frequency of irrigation depends on the soils' ability to hold water. Pastures grown on sandy soils should be irrigated more frequently with less water per application than pastures grown on heavier soils.

Knowing the application rate for irrigation systems is important and can be determined with measurements and formulas.

Specific irrigation schedules need to incorporate the above concepts into a practical, flexible program adjusting for seasonal, and year-to-year variations.

Weed Control in Established Irrigated Pastures

Presence of weeds in an established pasture usually indicates a management problem that needs attention. Some weeds may be a problem in established pastures despite good establishment and management procedures. Weed identification is necessary to determine the method of control and is particularly important in case the weed is one that is poisonous to livestock. Identifying the seed source of the weed is also important. Often weeds growing along fence rows, roadsides, and other non-cropped or waste areas are a source of seed, and may require control to decrease contamination of the pasture. Livestock and equipment may move weed seeds from one end of the ranch into a clean field. Flowing water (streams or irrigation ditches) can also transport weed seeds.

After identifying the weed and seed source, one must determine the best control measure(s). One should consider economics, effectiveness, and possible side effects on desirable pasture plants and/or grazing management strategies. Depending on the type of weed and how it got into a pasture, a number of options, including chemical control may be available to remove or reduce the weed problem. Some examples of cultural control methods include clipping, adjusting grazing season or pressure to graze the weed off at a sensitive growth stage, mixed species grazing (sheep may graze one type of weed, cattle another), controlled burns, feeding livestock in holding areas for a few days before turnout so weed seeds don't pass through feces onto pasture, and machine or hand-digging out individual plants. Attention to soil fertility, irrigation, and grazing management will enhance the vigor of the pasture itself, and must be integrated into overall ranch management to decrease chances of weed invasion.

Chemical Weed Control Methods

The land owner or manager should familiarize himself with the proper use of herbicides prior to application. In California, applicants must take a written exam for a private applicator's permit and receive their User ID number from the local Agricultural Commissioner's Office prior to buying herbicides. All herbicide use must be reported. Materials are divided into non-restricted and restricted categories, and the designation affects the paperwork filed with the Agricultural Commissioner. Restricted use chemicals require a notice of intent filed

before the chemical is applied. All herbicides (restricted and non-restricted) used must be listed on follow-up reports turned into the Agricultural Commissioner's Office after application of the product (s).

Chemical application options on pastures include spot spraying, aerial or ground spraying, and wiper applications. Spot spraying problem areas with the appropriate herbicides is appropriate for pasture weeds that are restricted to certain areas of the field. Chemical application with a rope or sponge wick applicator or wiper is effective in pastures. Chemical is delivered to a rope or sponge as the wiper applicator moves across the pasture. Tall weeds are "wiped" with either selective or non-selective herbicides such as glyphosate (*Roundup*®) by the wiper, shorter pasture plants are spared. Wild iris is an example of a weed that can be effectively controlled in pastures with wiper applications.

Broadleaf weed control can be a challenge in a grass-legume mixture, since most herbicides effective on broadleaf weeds may also kill the legume component. Where effective on offending weeds, 2,4-DB can be used without damaging most legumes. Other broadleaf compounds such as 2,4-D and dicamba can be used judiciously in grass-legume mixtures by spot spraying or avoiding applications during periods of legume growth.

When deciding to use a herbicide, it is important to determine whether there are grazing or haying restrictions following application of the herbicide and how that will impact your operation. The restrictions will be listed on the herbicide label and may differ depending on the type of livestock. Be sure to follow all label directions, use recommended rates and abide by listed restrictions when applying herbicides to pastures.

Management for Natural Reseeding

Some species should be allowed to reseed themselves on occasion to maintain the vigor of the pasture. For example, red clover should be allowed to go to seed every two years to encourage natural reseeding of this short-lived perennial. Livestock should be removed once seedheads start to appear on the species that needs to reseed itself, and not be returned to the area until the seed has matured (usually at least 60 days or until hard frost). Once the seed has matured, livestock can actually be used to scatter the seed throughout the stand as they graze the aftermath. Species that should be allowed to reseed themselves include: red clover, alsike clover, birdsfoot trefoil and Matua prairiegrass.

Other Management Practices for Irrigated Pastures

Dragging pastures with chain harrows spreads and breaks up manure, reducing clumps of large decadent plants, rejected by the livestock. Dragging can be done either in late fall or early spring (or both). Clipping late in the growing season also minimizes clump formation and reduces weeds if done before they go to seed.

Overseeding with a grass or legume can be used to increase the vigor of the pasture and extend the grazing season. The reader is referred to the chapter on rejuvenating pastures.

For Further Information

See Chapter 5 (this manual), Establishing Irrigated Pastures.

See Chapter 7 (this manual), Selection of Plant Species for Intermountain Irrigated Pasture.

See Chapter 9 (this manual), Renovating or Rejuvenating Irrigated Pastures and Mountain Meadows.

Appendix

Guidelines for obtaining and interpreting plant tissue samples. A sample should consist of 40 to 50 stems or leaves from at least 25 to 30 different plants.

Plant and Growth Stage	Plant part	Nutrient	Nutrient Range			
			Deficient	**Critical**	**Adequate**	**Excess**
Grasses- Tall fescue, orchardgrass, and others	Top 4-6 leaves	N% P% K% S%	<2.0 <0.18 <1.5 <0.10	2.0–2.8 0.18–0.24 1.5-2.5 0.10-0.15	>2.8 >0.24 >2.5 >0.15	
Clovers- Ladino, white and alsike	Top 1/3 of plant-leaves and stems	P% K% S% Mo ppm B ppm	<0.15 <1.2 <0.10 <0.30 <15	0.15-0.20 1.2-1.5 0.10-0.15 0.3-0.9 15-20	>0.20 >1.5 >0.15 >0.9 >20	 5-10*
Clover- Red	Top 1/3 of plant-leaves and stems	P% K% S% Mo ppm B ppm	<0.12 <1.0 <0.10 <0.30 <15	0.12-0.18 1.0-1.5 0.10-0.15 0.3-0.9 15-20	>0.18 >1.5 >0.15 >0.9 >20	 5-10*
Alfalfa- Regrowth length of ½ to 1 inches or just prior to 1/10 bloom	Middle 1/3 of plant-stems only (strip leaves off)	P (PO4) ppm K%	<500 <0.65	500-800 0.65-0.8	>800 >0.8	
	Middle 1/3 of plant-leaves only	S (SO4) ppm	<400	400-800	>800	
	Top 1/3 of plant	Mo ppm B ppm	<0.3 <15	0.3-0.9 15-20	>0.9 >20	5-10*

* Forages containing more than 10 ppm molybdenum may produce “molybdenosis” in ruminant animals.
< Indicates less than
> Indicates greater than

Intermountain Irrigated Pastures and Mountain Meadows Series

Chapter 7

Selection of Plant Species for Intermountain Irrigated Pasture

Daniel J. Drake [1], Steve B. Orloff [1], and Don Lancaster [2, 3]
Cooperative Extension, University of California

University of California
Division of Agriculture
and Natural Resources

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Overview

Primary considerations when selecting species for planting in pastures are:

- Soil characteristics
- Availability of water for irrigation
- Whether the pasture is grazed, hayed, or grazed and hayed
- Class of livestock consuming hay or grazing
- Desired level of management

A mixture of a grass and legume, either clover or alfalfa, is highly recommended for most cases. Mixtures of grass and clover provide higher yields and superior quality than grass only. They also reduce risk of livestock bloat, winterkill, and dry better than legume-only pastures.

Back to the Basics

The safest, most durable and conservative pasture is a combination of Tall fescue and Ladino clover (Table 1).

Table 1. Suggested seeding rates for typical Intermountain irrigated pasture. Orchardgrass or perennial ryegrass could be substituted for fescue.

Seed	Pounds/Acre
Fawn Tall fescue	15
Ladino clover	2

Several new varieties of tall fescue produce about the same amount as Fawn, the standard variety (Table 2). Any of the varieties of tall fescue could be used although the fescue-ryegrass hybrids Johnstone and Kenhy yield slightly less.

The combination of tall fescue and clover produces a high yield of forage with reasonable quality and a strong sod. Most livestock operations need land for feeding in the winter and well-sodded tall fescue pastures can handle a remarkable amount of winter feeding without excessive damage.

Research at the Intermountain Research and Extension Center (IMREC) at Tulelake demonstrates that several new varieties of orchardgrass will produce about the same as tall fescue. Yields of hay from several years of research are shown in Table 2.

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[1] Siskiyou County, 1655 South Main Street, Yreka, CA 96097; 530/842-2711
[2] Modoc County, 202 West 4th Street, Alturas, CA 96101; 530/233-6400
[3] Commercial companies are mentioned in this publication solely for the purpose of providing specific information. Mention of a company does not constitute a guarantee or warranty of its products or an endorsement over products of other companies not mentioned.

Table 2. Yield comparisons of several tall fescue and orchardgrass varieties. Three cuttings per year.

Variety	Tons/Acre[1]
Tall Fescue	
Fawn	8.2
Alta	8.0
Kenhy	7.4
Tandem	8.0
Festorina	7.9
Johnstone	7.4
Forager	7.7
Phytor	7.6
Orchardgrass	
Latar	8.1
Kara	7.5
Able	7.7
Rancho	8.0
Hallmark	7.9
Comet	8.2
Orion	8.2
Crown	8.1

[1]Average from 1989, 1990, 1991 IMREC Project 44, Dr. Don Lancaster, Alturas, CA. LSD's were not siginificant, CVs were 7.6 for fescue and 5.7 for orchardgrass.

Perennial ryegrass is another possible alternative to tall fescue. However, in tests at the IMREC it has yielded 10 to 15 percent less than tall fescue. In addition, some varieties of perennial ryegrass have not persisted over multiple years. This is thought to be related to its susceptibility to periodic late spring frosts that are especially prone in the more moderate climatic areas of Northeastern California. Apparently, in the colder areas, perennial ryegrass does not break winter dormancy until the likelihood of late spring frosts is very small.

Orchardgrass and especially perennial ryegrass are believed to have somewhat better quality than tall fescue. Consequently, orchardgrass or perennial ryegrass could be used in place of tall fescue with Ladino clover. The pastures are somewhat less durable in terms of sod strength.

Mixtures of grass species, such as tall fescue and orchardgrass, for grazing are not recommended due to differences in palatability to livestock; livestock will usually detrimentally overgraze the more palatable species so that the less palatable species dominate after a few years.

Clover adds to quality and quantity of forage. Trials conducted at the W.C. Peters ranch in Montague indicated 50 percent more hay from grass and clover combinations than grass alone (6.7 vs. 4.4 tons/acre). Red clover is particularly high yielding (Table 3), however it has only lasted 2 to 4 years in commercial pastures. Thus, it might be worthwhile to include both red clover (seed at 2 pounds per acre) and Ladino clover at planting time, recognizing that the red clover will not persist in the pasture. Red clover is more difficult to dry for hay than other clovers.

Table 3. Four year average yield of clover from the IMREC. At the end of four years, stands of red clover varieties were significantly poorer than Ladino clover.

Variety	Tons/ Acre
Redland red clover	9.6
Redland II red clover	9.9
Florex red clover	9.7
Arcadia Ladino clover	7.5
Spredor II Alfalfa	7.0
Alsike clover	6.0

Alkaline Soils

Fawn tall fescue is adapted to a wide range of soil pH. In either alkaline (greater than 7.2) or acidic (less than 6.9) soils, tall fescue is the recommended grass species. Addition of strawberry clover and trefoil is recommended in alkaline soils because both have more tolerance to alkaline conditions than Ladino clover (Table 4).

Table 4. Suggested seeding rate for alkaline Intermountain irrigated pasture.

Seed	Pounds/ Acre
Fawn tall fescue	15
Ladino clover	2
Strawberry clover	1
Trefoil	1

There does not appear to be large differences in total production for most of the trefoil varieties based on research at the IMREC (Table 5).

Table 5. Three year yield averages of trefoils indicating no significant differences in yield among varieties of trefoils tested.

Variety	Tons/ Acre
Furgus	5.6
Cascade	5.5
Granger	4.6
Norcen	4.4
Carroll	5.8
Empire	5.6
Macinaw	5.8
Dawn	5.3
Viking	5.0
ATP	5.3

Special Situations

Horses

Pastures accommodating horses typically need the extra protection of the strong sod formed by tall fescue. Orchardgrass is suitable for horses when superior nutritional quality is the primary concern, although the pasture may not last as long.

Limited Water for Irrigation

Consider using intermediate wheatgrass as the grass component of pastures when adequate water for irrigation season-long may not be available (generally mid-April to late September). Although Intermediate wheatgrass is thought of as a non-irrigated grass (dryland), it responds well to irrigation and survives during periods of inadequate water.

It may be wise to also substitute alfalfa for clover when water is limited. A recommended seeding mixture is shown in Table 6.

Table 6. Suggested varieties for marginal water supply for irrigating pastures.

Seed	Pounds/ Acre
Intermediate Wheat grass	12
Ladino clover	1-2
Alfalfa	1-2

If water supply is variable, a mixture of Ladino clover and alfalfa is recommended. With adequate water, Ladino clover does well, but, when water is limited the alfalfa survives and produces.

High Water Tables and Excessively Wet Soils

Frequently, soils above high water tables and excessively wet soils are also alkaline soils (see comments about alkaline soils). If tall fescue is not adaptable to the wet site consider using reed canarygrass. Palaton reed canarygrass has shown good yields and quality with low levels of alkaloids. Alkaloids can be a problem with reed canarygrass. However reed canarygrass is not as tolerant of alkaline conditions as tall fescue. Garrison Meadow Foxtail has also been used in wet sites with success.

Precautions

Only purchase endophyte-free tall fescue seed. Endophyte is a parasitic fungi that infect tall fescue plants. They do not harm the plant and may actually strengthen it, but they reduce performance of cattle grazing infected plants.

There is no method to visually determine if an existing field or seed is infected. However, the seed can be tested. Seed growers are aware of this problem and most of the tall fescue seed for forage is now endophyte free.

Since the endophyte is only spread through seed, a field that is established using clean seed, will remain clean.

Summary

Points to remember when selecting plant species for irrigated pastures:

- Mixtures of grasses and legumes are usually superior to grasses or legumes alone.
- Select from any tested variety of tall fescue or orchardgrass.
- Don't mix fescue with other grasses. Orchardgrass and perennial ryegrass can be mixed.
- Alkaline soils, soils with excessive moisture and pastures for horses need special consideration.

For further information contact your Cooperative Extension farm advisor or other professional agronomist.

For Futher Information

See Chapter 6 (in this manual), Soil Fertility, Irrigation, and Management of Irrigated Pastures and Mountain Meadows.

See Chapter 9 (in this manual), Renovating or Rejuvenating Irrigated Pastures and Mountain Meadows.

Intermountain Irrigated Pastures and Mountain Meadows Series

Chapter 8

Plant Growth Concepts for Intermountain Irrigated Pastures and Mountain Meadows

Rick Delmas, Cooperative Extension, University of California[1]

University of California
Division of Agriculture
and Natural Resources

Introduction

To be successful in a livestock grazing enterprise today a livestock producer must have a basic understanding of both plant and animal biology. Livestock producers are usually keenly aware of what it takes to produce healthy, fast gaining livestock, but much less aware of what it takes to produce large quantities of forage from pastures. It is important to realize that in a livestock grazing enterprise green plants are the raw materials which are converted by livestock into a salable product.

Plant Growth Overview

Most plants manufacture their own food through photosynthesis. When not utilized, grasses pass through successive growth stages:(1) leafy; (2) boot; (3) heading; (4) bloom; and (5) seed production. As grasses mature there is a dramatic increase in yield, fiber, and lignin and a decline in protein content of the plants. As leaves enlarge they product non-structural carbohydrates (sugar, starch, fructosan) which are largely coverted to the structural carbohydrates, cellulose, hemicellulose and lignin. Accumulation of dry matter declines as tillers mature, leaves senesce and new tillers cannot initiate due to shading.

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Roots

The root system in well-established pastures are very fibrous. Although roots of some species penetrate beyond six feet, the majority of roots occur in the top 12 inches of soil. The carbohydrates stored in the crowns and rhizomes of perennial grasses are transported from the leaves. In general, carbohydrate storage is low when the leaf area is small and plant growth rate is fast. This usually occurs during the initial spring growth and after harvesting. Carbohydrate storage is greatest when the plant's leaf area is large and the growth rate is slow. The carbohydrates stored in the roots and crowns furnish the necessary energy for plants to survive the winter, begin spring growth, and regrow after grazing or harvests.

Leaf and Stem Growth

The stem apex is one of the growing points of a grass. This growing point is situated at the very center of the tiller and starts close to soil level. Actively dividing cells make up the growing point of grasses; dividing cells differentiate new leaves. (Figure 1.)

[1] Inyo/Mono County, 207 West South Street, Bishop, CA 93514-3407; 760/873-7854

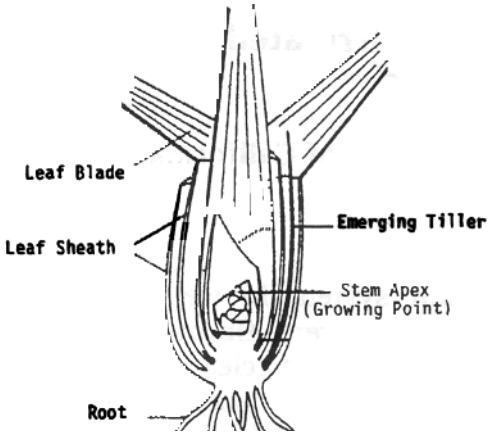

Figure 1. Illustration of grass plant and components

Before flowering for most grasses the stem remains contracted and the growing point remains close to the soil level where it produces a large number of elongated vegetative tillers. When flowering begins, stems elongate and new leaf production ceases since the growing point produces flowers instead of leaves.

New leaves depend on carbohydrate reserves elsewhere in the plant to supply them with nutrients until they can make it on their own. A rule of thumb is that when a leaf reaches about 1/4 to 1/3 of its mature size it can produce enough carbohydrates to sustain itself. As the leaf continues to grow to maturity excess carbohydrates are transported to new leaves, stem, reproductive structures and roots.

Plant Growth

The amount of production in a period of time depends on the amount of the sun's energy that plants can capture and convert to tissue. Maximum growth occurs when the leaves intercept 90% or more of the sun's radiation.

Grass growth is similar to the growth curve of other living organisms and can be broken down into 4 phases: (Figure 2.)

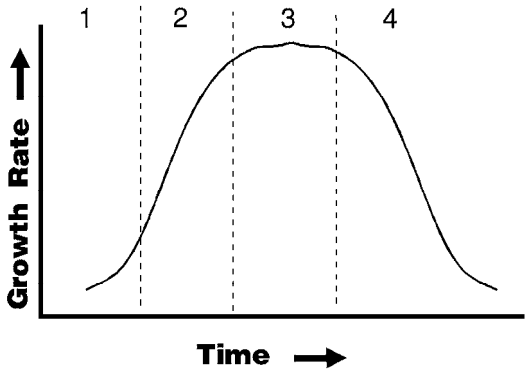

Figure 2. Theoretical depiction of grass regrowth rate after harvest or cutting.

- Phase I: This is at the beginning of the growing season or just after harvesting (haying or grazing). Plants are not capable of capturing much sunlight due to lack of leaf area and must use carbohydrate reserves in the roots for growth. Growth in this phase is slow.

- Phase II: Plants are rapidly growing, in a vegetative state, with maximum leaf area exposed to the sun for carbohydrate production.

- Phase III: Growth slows, stems elongate, and plants flower and go to seed. Yield is usually highest at this point. Nutrient value of the feed may be lower.

- Phase IV: Growth slows until more plant material is dying than is being produced.

All plants will go through the four phases of growth during a growing season if left unharvested. Length of the growing season depends upon frost, soil temperature and soil moisture. These factors will determine the seasonal growth patterns of a pasture and ultimate yield. It is the objective of a grazing management system to maintain a pasture in the Phase II vegetative state for as long as possible into the growing season. Pastures maintained in Phase II growth recover rapidly

after harvesting and furnish high quality forage for livestock.

Summary

Two factors need to be kept in mind when considering plant growth and livestock grazing. The first is that grasses are a renewable resource and grow with a predictable annual cycle. Secondly, as a pasture manager, you make the decisions of when to graze, how long to graze, and how many animals to stock.

By understanding how grasses grow, managers can better match grass growth with livestock nutritional needs to obtain optimum profitability, production, and forage utilization.

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For Further Information

See Chapter 10 (in this manual), Intensive Grazing Management Strategies for Intermountain Irrigated Pastures and Mountain Meadows.

See Chapter 11 (in this manual), Production and Management of Intensively Grazed Irrigated Pastures.

Intermountain Irrigated Pastures and Mountain Meadows Series

Chapter 9

Renovating or Rejuvenating Irrigated Pastures and Mountain Meadows

Daniel J. Drake[1], Steve B. Orloff[1], and Donald Lancaster[2, 3]

University of California
Division of Agriculture
and Natural Resources

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Introduction

Pastures may deteriorate for a variety of reasons. Pastures decline in productivity even with the best management, due to uncontrollable conditions, such as droughts. This article discusses methods for improving pastures that have deteriorated. Information on general management including irrigation and fertilization can be found in other chapters.

Therefore, the first step in renovating or rejuvenating pastures is to assess and correct the cause of the decline. If the cause is avoidable or controllable, further declines can be prevented. For example, inadequate irrigation can cause pasture deterioration and the irrigation system should be improved before renovation is attempted. Pastures that have deteriorated can often be improved through management practices without destroying the sward and establishing a new one. This rejuvenation is most appropriate for pastures that are satisfactory for most physical factors, such as slope, fencing, livestock water, drainage and irrigation systems, but need improvements in plant species or plant density.

The primary consideration for deteriorated pastures is whether desirable plant species are present. If adequate numbers of the preferred species are present, then reseeding is not necessary. When inadequate stands of desirable species are present, the grower will need to replant (see chapter on seed selection). Other factors necessitating improvement include: inadequate livestock water, poor fences, poor drainage and other factors.

The presence of weeds usually indicates an inadequate density of desirable type of plants. Few and scattered weeds can be tolerated but large blocks of weedy areas necessitate reseeding. Due to the wide variety of possible problems and causes it is important to assess and correct the problems in specific fields.

Assessing Pasture Problems

The physical layout of the pasture (or ranch) should be considered first.

[1] Siskiyou County, 1655 South Main Street, Yreka, CA 96094; 530/842-2711
[2] Modoc County, 202 W. 4th Street, Alturas, CA 96101; 530/233-6400
[3] Commercial companies are mentioned in this publication solely for the purpose of providing specific information. Mention of a company does not constitute a guarantee or warranty of its products or an endorsement over products of other companies not mentioned.

Items to evaluate include:

- Slope- how much can be tolerated, will the pasture be harvested for hay or grazed?
- Drainage- standing water, muddy spots, the presence of water-loving plants suggest drainage problems. Some drainage problems can be corrected; others must be accepted.
- Fencing- livestock grazing usually requires fencing.
- Poisonous plants- must be able to identify, possibly eradicate or control.
- Access- roads and trails are needed for transportation or movement of livestock or equipment.

The method of irrigation must also be considered. Wild meadow flooding normally allows for less control or frequency of irrigation than other methods, particularly sprinklers. Irrigation districts may provide water at long intervals which are less conducive to establishing new plants. This could restrict seeding opportunities to spring or fall.

Finally, plants must be targeted to the type of livestock, age, stage of production, and performance goals. If rapid rates of gain or high stocking rates are desired, pasture performance will need to be high. This calls for desirable plants species, few weeds and good management.

The following discussion assumes the pasture is physically adequate, (i.e. slope, drainage, irrigation, fences, livestock water and other physical factors are satisfactory). It concentrates on the plant species.

Typically, two scenarios exist:

1. Grass is adequate but populations of desirable legumes such as clovers, are inadequate, or the wrong species, or,
2. Both desirable grass and legume species are not present, are inadequate, or are the wrong species. Weeds may have replaced the desired plants.

Methods of Pasture Improvement

Fertilization: Nitrogen vs. Phosphorus

Applications of nitrogen to enhance grass or phosphorus to enhance legumes can be effective in stimulating or changing a pasture. If the pasture has some legume plants but they are small, fertilization can be effective in promoting legume production. In this case, reducing nitrogen fertilization and increasing phosphorus applications will often increase the legume component after 2 to 3 years. Response of legumes to phosphorus suggests pastures fertilized for many years with nitrogen (such as ammonium sulfate) but not phosphorus. Nitrogen fertilizer has encouraged the grass component at the expense of legumes, which are more responsible to phosphorus levels in the soil. Fertilizer test strips may be used to evaluate need for phosphorus.

When fertilization history is unknown, legumes can be observed to suggest phosphorus responsiveness. Clover plants that are phosphorus deficient may have small leaves (smaller than a dime), compared to the more typical leaves (the size of a quarter). Other factors can also contribute to small leaves, but this can be one piece of evidence. **Hay or pasture samples from the previous crop can be analyzed in the laboratory for phosphorus content. Levels below 0.2% (on a 100% dry matter basis) suggest that additional phosphorus might stimulate growth. Soil samples could also be taken.** Soil phosphorus levels below 10 ppm suggest that additional phosphorus might stimulate growth.

When populations of desired grasses are adequate but yields are low, nitrogen fertilizer can boost yield. A rate of 80 pounds of nitrogen per acre is a typical recommendation. This would be 380

pounds of ammonium sulfate per acre (80/0.21=380; ammonium sulfate is 21% nitrogen). Application rates of up to 150 pounds of nitrogen per acre could be used to stimulate grass growth.

A second application of 80 to 150 pounds per acre of N after harvest or in July could also be used to stimulate re-growth. High rates of N cause grasses to dominate over legumes.

Harrow and Broadcast Seed

Best seeding methods depend on the amount of plant cover at time of seeding. When bare soil exists, such as may occur due to loss of legumes during a drought, legumes may be broadcast onto the soil. "Roughing up" the soil surface with an implement such as a meadow harrow increases seed-soil contact, improving legume establishment. This should be done in early spring to benefit from rains. Seeding in early Spring is more likely to succeed, and reduces the risk of soil erosion from irrigation. It is difficult to flood irrigate bare soil without soil erosion.

Establishing legumes is difficult in areas where existing grass and weed stands are heavy. The existing plants compete for water and restrict sunlight, the resulting weak legume seedlings cannot survive hot summer temperatures. Early seeding can help, although cold soil temperatures retard seedling growth.

Broadcasting seed and fertilizer together, reduces the number of trips across the field. However, the competitive nature of the existing plants and poor seed-soil contact result in low germination and poor stand establishment. Seeding rates should be doubled, to about 4 pounds of legume seed per acre when seed is broadcast with fertilizer onto existing sod.

When the sod consists of broadleaf weeds and few desired legumes, a broadleaf herbicide, such as 2,4-D can be used, followed with broadcast seeding, with or without prior harrowing.

Another alternative is to delay broadcast seeding until after harvesting of a hay crop or very close grazing. These actions reduce the competition from existing plants and provide time for soil temperatures to warm, thereby enhancing germination. This alternative is limited to locations that could provide frequent summer irrigation for the seedlings.

When grass populations are low, seeds will need to be planted. If weed invasion has occurred over large areas of the pasture, the grower should consider starting over to re-establish the pasture. The reader is referred to the chapters on establishing pastures. Grass should be broadcast only when grass sod is not present and weeds are few.

Conventional and No-Till Drilling of Seed

Due to limited success of broadcasting grass seed into sod and low establishment rates for legumes, mechanically placing (drilling) seed into sod is frequently used. As with broadcast seeding, if major weed problems exist, consider re-establishing the pasture.

Conventional grain drills can be used to seed grass or legume seed directly into pasture when the ground and existing sod are relatively moist and soft. Avoid planting when it is too muddy and the drill creates a slick or glazed appearance to the furrows.

No-till drills can slice through sod and place seed in small furrows in direct contact with soil. Usually, small packer wheels or irrigation will cover the seed with soil for better germination. As with conventional drills, avoid muddy conditions. No-till drills can operate in dryer soils than conventional drills. They may also be used later in the summer after a hay crop is harvested or after some grazing. This permits some production from the pasture and provides time for soil temperatures to warm,

hastening seed germination. Summer seeding should be done only when frequent irrigation can be applied.

Competition between existing plants and new seedlings is also a problem when seed is drilled. Herbicides can be used to kill or suppress weeds or plants. During early spring when plants are just beginning to break winter dormancy, one pint of Roundup® per acre can be effective in suppressing existing pasture and permit new seedlings to become established. Use of herbicides will depend on the type of plant competition. Close cutting during haying or grazing and high air temperatures slow re-growth and reduce competition between seedlings and mature plants during summer plantings.

Timing (Season) of Seeding

Pastures can be reseeded in Spring, Summer and early Fall. Each season has particular advantages and disadvantages, but site specific conditions or management objectives may restrict renovation to only one season.

Early spring planting is safest. Early spring ranges from mid-February for the lower elevation areas of the Intermountain Region, to mid-April or even May at high elevation sites.

Early spring reseeding allows for an assessment of soil moisture accumulations over the winter and a projection for summer irrigation supplies. The probability of timely spring rains, however is highly variable. Damp soils permit the ready use of conventional grain drills for seeding of grasses, and cool temperatures with short days slows evaporation. Unfortunately, the window of opportunity between ground that is too muddy and sufficiently dry is usually small and too short to accomplish all desired renovation. In addition, cold soil temperatures in spring inhibit seed germination, while moist conditions encourage competing plants. Spring renovation also dictates delay in haying or grazing until establishment occurs so the resultant crop may be of lower quality.

Summer renovation does not interfere with spring harvest. It also provides more time to evaluate moisture and irrigation water supplies. However, frequent irrigation is not permitted in some irrigation districts and difficult to carry out with flood systems. Summer seeding is less expensive because the sward is suppressed by harvesting and high temperatures instead of herbicides. Summer reseeding should be accomplished in July.

Early fall (late August to early September) reseeding shares many advantages and disadvantages with summer pasture renovation. In its favor are additional grazing or hay production, the chance of fall rains to reduce irrigation frequency problems and usually few summer annual weeds as competition. The major risk is the potential for early fall frosts, particularly for late reseedings and winterkill.

Summary

Rejuvenation of existing plants or renovation through seeding can improve forage yield. Fertilization, or selective seeding can improve pastures with less cost, less environmental disturbance and shorter restrictions on use compared to cultivating and reseeding.

Applications of nitrogen to encourage grasses or phosphorus to promote legumes can help adjust proportions of these plants. Seeding with no-till drills, conventional grain drills or by broadcasting may improve the sward without cultivation. Controlling competition, managing irrigation, and taking advantage of spring rain improves the changes of successful renovation.

For Further Information

See Chapter 5 (in this manual), Establishing Irrigated Pastures.

See Chapter 6 (in this manual), Soil Fertility, Irrigation, and Management of Irrigated Pastures and Mountain Meadows.

See Chapter 7 (in this manual) , Selection of Plant Species for Intermountain Irrigated Pasture.

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Chapter 10

Intensive Grazing Management Strategies for Intermountain Irrigated Pastures and Mountain Meadows

Daniel J. Drake, Cooperative Extension, University of California [1, 2]

University of California
Division of Agriculture
and Natural Resources

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Overview

A practical intensively grazed pasture system has several pastures or paddocks that are grazed for 1 to 4 days each, with some period of rest between grazing. The manager determines the number of livestock per paddock, the amount of grazing time on each paddock, the amount of time (rest) between grazings, and the height of grass before and after grazing.

Intensive grazing can be one of the most cost effective activities for pasture. However, successful pasture management requires that plant varieties, composition, fertility, and water management be considered.

Stocking Rates, Grazing Intensity and Duration

Intensive grazing encourages uniform removal of forage by using a relatively high number of livestock per unit area of pasture (i.e. high number of livestock per acre.) Ideally, livestock should remove the desired amount of pasture in 3 to 4 days. Grazing longer than 3 to 4 days can selectively discourage desirable plants and encourage undesirable plants.

Grazing should only remove a portion of the plant, leaving 2 to 4 inches to aid regrowth that will be removed in subsequent grazing (Figure 1).

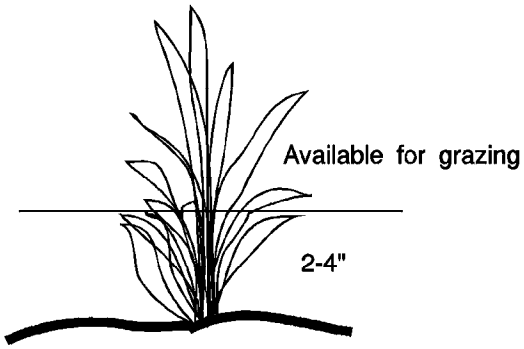

Figure 1. Grazing should harvest plant material leaving 2-4 inches. The residual serves as the basis for growth of new plant material for subsequent grazing.

The number of cattle for each acre is best estimated by adjusting for weight rather than number of animals (for cows and calves combine weight of cow and calf). For example, 15,000 (typical range is 15,000 to 25,000) pounds of livestock per acre is generally satisfactory when the duration of grazing is about 3 days. For cattle weighing 600 pounds each, 25 individuals (15,000 divided by 600) per acre would be satisfactory. If a pasture consisted of 5 acres then a total of 125 cattle (25 X 5), each weighing 600 pounds, could be grazed for 3 days. Similarly, if the cattle are cows with calves and their combined weight is 1350 pounds (cows 1,100 plus 250 pound calves), then each acre might be grazed with 11 cows (15,000 divided by 1100) and their calves.

[1] Siskiyou County, 1655 South Main Street, Yreka, CA 96097; 530/842-2711
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If the calves had been born in the fall and weighed perhaps 400 pounds by the start of the grazing season we might use 1,500 (1,100 plus 400) pounds as the weight of an individual unit (pair). Thus only about 10 pairs with larger fall-born calves could be grazed on each acre.

These examples are illustrated in Table 1, and your plans can be started in the space provided. This table provides information on management of one pasture or paddock that will be grazed for only 3 days at one time. We next need to consider additional pasture for the entire grazing system.

Table 1. The number of livestock for a single pasture or paddock of a grazing system (collection of pastures used in a rotational grazing plan) can be based on the desired weight of beef per acre rather than the number of head. Typical weight per acre is from 15,000 to 25,000 pounds of beef (column E). The "density" or number of livestock to be grazed in a single pasture is calculated in column F.

A Total acres available	B Number of pastures (paddocks) desired	C Size in acres of a single pasture or paddock (A÷B)	D Weight of Individual "Unit" Pair, Steer, etc.	E Desired weight per acre	F Total Number of "Units" (D's) on 1 acre (E÷D)	G Total Number of "Units" (D's) for a Single Pasture or Paddock (F X C)	H Total Number of "Units" (D's) for all land available (G)
40	8	5	600	15,000	25	125	125
40	8	5	600	25,000	41-42	205-210	205-210
40	8	5	1100	15,000	13-14	65-70	65-70
40	8	5	1100+400	15,000	10	50	50
Your Values							

A practical number of pastures to use in a grazing rotation system is eight. Fewer pastures will result in overgrazing or inadequate rest between grazings. More pastures can increase performance of the pasture, but they require considerably greater labor with smaller incremental returns. Even using only four pastures instead of eight is preferable to continuous grazing on a single pasture.

Figure 2 illustrates eight pastures that could be used in a rotational grazing scheme with 3 days of grazing on each pasture. This results in 21 days of rest for each pasture between grazings. Typically in the spring the rancher is anxious to start cattle on pasture as early as possible, but the grass may be a little shorter than desired. Grazing plans can be adjusted slightly by leaving the cattle for only 2 days in pastures 1, 2 and perhaps number 3. This will provide enough forage for the cattle and not overgraze the pasture. Then, with rapid spring growth, pastures 7, 8 and perhaps 6 will have more than enough forage for 4 days of grazing.

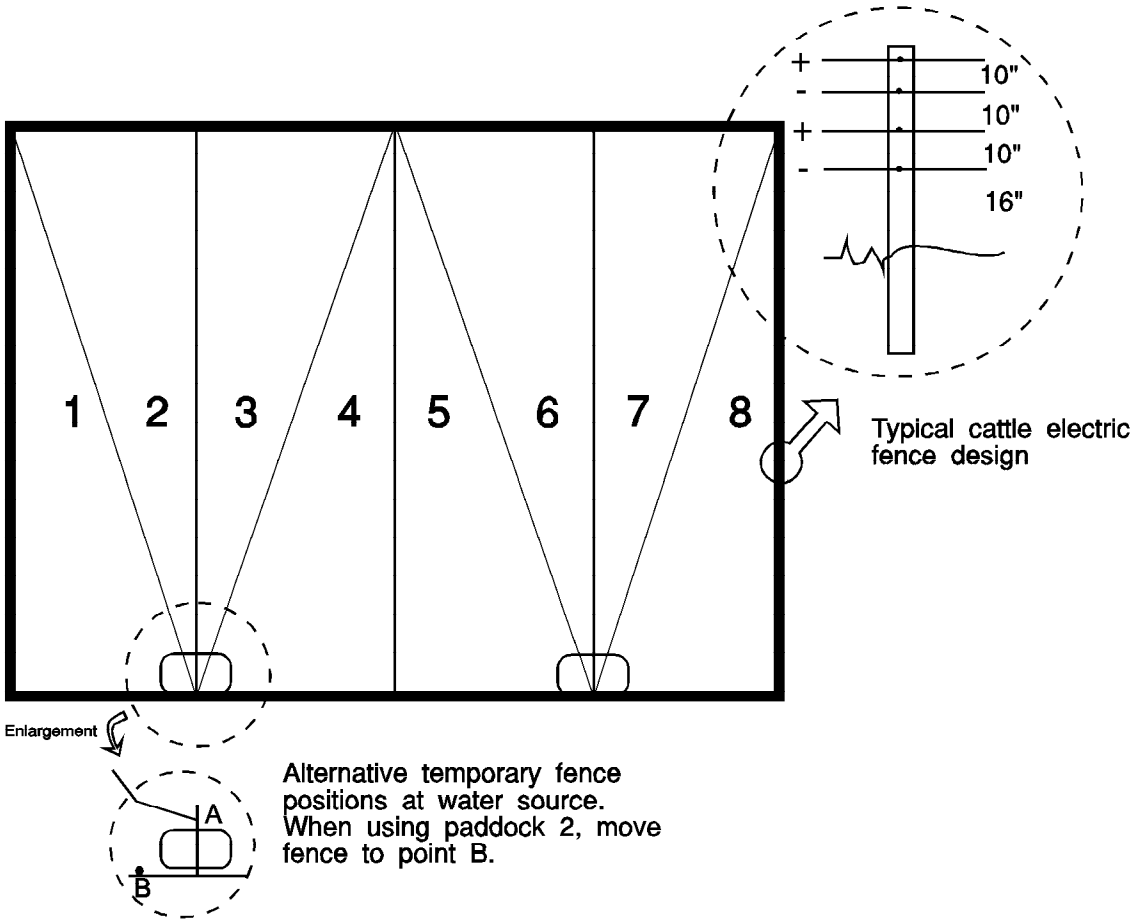

Figure 2. Aerial view of paddocks showing possible fencing arrangement and alternatives. Inset details electrification pattern for electric fence.

After about the Fourth of July, pastures in the Intermountain Region typically re-grow less rapidly. The grazing manager has several alternatives for adjusting to this change in plant growth.

1. Reduce the number of livestock.
2. Stock slightly low from the beginning so some "extra" feed builds up on the pasture to permit grazing periods of 4 days after the Fourth of July. This would result in rest periods of 28 days.
3. Provide supplemental feed.
4. During rapid Spring growth, do not graze or reduce grazing to create an extra "buffer" paddock that can be utilized during periods of slow plant growth. This “buffer” paddock might be hayed in June and allowed to regrow for a later grazing period.

Intensive grazing management plans should be flexible. The accumulation of hard, dry cow paddies is frequently a symptom of low stocking density. More livestock per acre will tend to break up or reduce the occurrence of dung paddies. Another alternative to reduce manure accumulation is to irrigate immediately after grazing, if feasible.

Another symptom of low stock density is the appearance of pastures that are "getting ahead" (phase III growth stage defined in a previous chapter) of the cattle. Forage is still tall after the prescribed three days of grazing, or the plants are beginning to mature as evidenced by developing seed heads. Solutions are to increase livestock density, increase grazing duration, or mechanically cut the excess forage. The excess might be baled, if practical. Increasing grazing duration is only a temporary solution since the result is more days of growth on the next pasture which will result in even more excess forage. If the excess is great enough, a hay cutting might be taken instead of grazing that pasture.

Facilities

Pastures of approximately the same size work much better than unequal sized pastures when used in a rotational system. Sometimes, instead of trying to divide our pastures into eight units, we need to consider what existing pastures can be grouped together to make eight units. Frequently 3 to 4 existing pastures can be easily split into two or three pastures each, making a total of eight units.

Figures 2 shows a typical layout. Two water troughs provide drinking water for all eight pastures. A single trough could be used but requires a lane or alley. A lane suffers from season-long trampling and has more non-rotated land than when a lane is not used. A lane for water assess would permit rectangular paddocks that might be important for irrigating, fertilizing, mowing or other practices. When livestock drinking water is shared by numerous pastures, as shown in figure 2, sacrifice areas or areas of heavier use occur near the water. In the illustration in Figure 2, sacrifice area could be minimized by placing troughs in the narrowest corner of each paddock. However, this would greatly increase the number of troughs needed. The illustration for paddocks 5, 6, 7 and 8, shows a compromise for sacrifice area and number of troughs. However, due to the small portion of the water trough available, adequate flow to quickly fill the tank should be ensured. The inset illustrates for paddocks 1 and 2 an alternative arrangement that increases trough space but suffers from a slightly larger sacrifice area. A single trough is shared by paddocks 1 and 2, with the fence being moved to permit wider access to the trough. The manager must weigh these considerations for each application.

Perimeter fencing can be barbed wire or high tensile smooth wire. Smooth wire fence should be built to provide for electrification if desired. It should have four strands, with alternating charged and non-charged (grounded) wires. Interior fencing can be multiple strands of smooth wire, or a single strand of smooth wire or woven plastic/metal wire, commonly marketed as Polywire. Limited experience suggests that the wider Polytape is more visible and less resistant to deterioration than Polywire.

Chargers should be high voltage (about 5,000 volts) but low amperage "New Zealand" type. These are very resistant to grounding out. The most important aspect of the energizer is adequate and proper grounding. If the fence does not work, always check the ground first.

Fence posts can be wooden or metal T-posts with insulators, or non-conducting plastic or special non-conducting wood such as ironwood. Single-wire interior fencing can use short, plastic tred-in posts that are easily moved. The posts are short and flexible enough for wheel lines to move over them.

A wide variety of specialty fence "posts" are now available such as pivoting types for center pivot irrigation systems, and tumble wheels, which facilitate moving.

After supply of drinking water, irrigating intensively grazed pastures is the greatest challenge. Fencing and grazing management strategies should be designed with existing irrigation systems in mind. With rapid cattle rotation and typically more fencing, irrigation can be difficult.

Irrigation while cattle are on a pasture leads to treading damage to the sward. However even if this is an established practice, adoption of intensive grazing would not be ruled out. Rotational grazing might confine damage to limited acreage compared to field-wide, unrestricted grazing. Rotational grazing management also would increase the chance for a specific paddock to receive irrigation without the presence of cattle.

Irrigation while livestock are on pasture is generally discouraged. However, grazing intensively need not alter existing irrigation schedules.

Cattle Selection and Management

No specific breed restrictions apply to intensive grazing programs. Breeds with Brahma influence can be used although they should be handled with care to avoid agitating them. As with set stocking, steers and heifers are typically not grazed together, nor animals with large differences in weight, but in both cases no more so than with other grazing management schemes.

Some grazing managers have found whistling or making some distinctive sound when moving cattle leads to a "learned" response. Cattle will be trained to move when the sound is repeated.

Ideally, cattle should be trained to an electric fence before putting them on pasture. The only reason for this is to avoid the possible labor involved in gathering cattle if they should break a fence. Cattle are most easily trained in a well-enclosed area. A short strip of electric fence can be erected, perhaps across a corner of a familiar corral. Then place a small amount of hay on the ground on the opposite side of the electric fence. As the cattle smell the hay they will learn to avoid the electric fence. This will not harm cattle and they will learn about electric fences in a controlled and safe manner.

Initially, cattle may not respond as desired to intensive grazing. However, the manager of intensively grazed cattle needs to decide who is making the decisions, the cattle or the manager. If an individual animal is causing significant problems, will management bend to the whims of that individual or will the manager put that problem somewhere else and get going with the program?

Summary

Intensively managed pastures can significantly increase carrying capacity or production of beef per acre. Intensive grazing maximizes pasture productivity by maintaining pasture plants at the stage which re-growth rate is optimum (i.e. the pasture is grazed rapidly down to 2 to 4 inches and then allowed a rest period for re-growth) and more of the pasture is consumed by the livestock. Pasture is uniformly grazed and desirable plant species thrive because cattle are not permitted to selectively graze.

Typically, intensive grazing is a cost effective management strategy, but it needs to be viewed as part of the total ranch system. Intensively grazed pastures may constitute only a portion of the total pastured lands. The effective manager will utilize livestock as "harvestors" of non-human edible forage and must understand both animal needs and plant requirements.

For Further Information

See Chapter 8 (in this manual), Plant Growth Concepts for Intermountain Irrigated Pastures and Mountain Meadows.

See Chapter 11 (in this manual), Production and Management of Intensively Grazed Irrigated Pastures.

See Chapter 12 (in this manual), Animal Health on Intermountain Irrigated Pastures and Mountain Meadows.

See Chapter 13 (in this manual), Fence Considerations for Intermountain Irrigated Pastures and Mountain Meadows.

Intermountain Irrigated Pastures and Mountain Meadows Series

Chapter 11

University of California
Division of Agriculture
and Natural Resources

Production and Management of Intensively Grazed Irrigated Pastures

Daniel J. Drake, Cooperative Extension, University of California[1,2]

Introduction

This article relates expected or typical production levels and economics of irrigated pastures to intensively grazed pastures. The discussion is limited to irrigated pasture and does not directly relate to mountain meadows. Meadows generally are less productive, less controlled and frequently have shorter growing seasons than irrigated pastures.

Throughout the Intermountain Region, irrigated pasture production varies due to length of growing season which is affected by elevation, quantity and frequency of irrigation water, fertility, pasture plant composition and other factors.

This article begins with a discussion of production and economics under traditional grazing schemes which employ set stocking or long-duration rotational grazing. The second part describes expected results of using more intensive grazing methods.

Typical Production

Grazing of Intermountain irrigated pastures usually starts in April to early May depending on aspect, elevation and local climate. Start of grazing is also influenced by spring temperatures.

The five month grazing season continues through September, when cold nights and frost slow plant growth. After the pasture plants have become dormant due to cold weather, the stubble may be grazed but quality and quantity is low.

During the five month growing season on irrigated pastures, calves with their dams[1] usually gain nearly 275 pounds, or about 1½ to 1¾ pounds per day. In addition, cows in good body condition will typically maintain or gain weight. During the growing season pastures support about 1 to 1¼ pairs per acre. Some ranchers rotate cattle into and out of the pastures, and at some points in time may have or or less cattle per acre.

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[1] Cows and their calves are referred to as pairs and for our purposes are the same as an animal unit. Thus pairs and animal unit will be used interchangeably.

[1] Siskiyou County, 1655 South Main Street, Yreka, CA 96097; 530/842-2711
[2] The author thanks Ken McCutcheon, Tom Hayden, Ernie Wilkinson and the Joe Benjamin Ranch for providing data on their grazing operations and observations.
[3] Commercial companies are mentioned in this publication soley for the purpose of providing specific information. Mention of a company does not constitute a guarantee or warranty of its products or an endorsement over products of other companies not mentioned.

However, when periods of time without cattle are combined with those when more than 1 to 1¼ pairs are present, the overall average is still about 1 to 1¼ pairs per acre.

Beef production by cow/calf pairs per acre is typically about 275 pounds, not counting gain by the cow. Weight gain by the cow is not considered because no income is generated from their weight gain. Obviously, there is value in adequately feeding the breeding herd. The pasture generates some feed and weight gain by utilization of the stubble, in addition. The stocking rate of irrigated pasture, as defined by the amount of land allocated to each animal unit for the entire grazing period, is about 1¼ pairs per acre. This could also be expressed as 0.8 acres per pair or animal unit (1 acre divided by 1.25 pair).

Another option for irrigated pasture is to graze weaned calves. In the industry these are called stockers and range from light calves of 250 pounds to heavy weight stockers of 800 pounds. Stockers will generally gain about 300 pounds during the growing season. Under traditional, season-long, set stock management the stocking rate is about 2 calves per acre. This results in 600 pounds of beef per acre.

Obviously initial weight of calves influences stocking rate, since more total pounds of cattle are supported with heavier calves. The point is, even though initial weights, daily gains and stocking rates vary, the goal is to gain 600 pounds in beef per acre with stocker cattle under traditional management strategies.

Usually, stocker calves average about 650 pounds when grazing irrigated pasture. However, starting weights may be as light as 250 pounds, with final weights of 700 pounds or more. With stockers there is no weight gain of cows, since they are not present, but there could be some additional stubble grazing in late fall. Although it appears that stockers have a substantial advantage of nearly twice the beef production per acre over pairs, expenses must be considered. Comparisons need to include complete analysis of income, expenses, and risk for pairs versus stockers.

Production Economics

One method of deriving funds or estimating value from irrigated pasture is through rent. For the landowner, rent is income, while for the renter it is an expense. The worksheet included with this article helps in calculating rental charges. The information needed to calculate costs are the 1) size of the pasture, 2) number of and charges for cattle, and 3) duration of grazing. This information should be summarized annually for each pasture into

- total charges,
- total animal units,
- charges per acre,
- charges per animal unit.

This will permit evaluation of carrying capacity or stocking rate, plus costs.

In the Intermountain Region rental charges are generally on a pair basis. Since 1990, rates have varied between $14 and $20 per pair per month of the growing season. Availability (supply) of pasture, number of cattle (demand) and cattle prices will increase or decrease the "going rate".

An example will illustrate the procedure. A forty acre pasture could be stocked at 1.25 pairs per acre, for five months, with a charge of $16 per pair per month. Calculations indicate this pasture would carry 50 pairs (40 acres X 1.25 pairs). Total charges would be $4,000 (50 pairs X $16 X 5 months). On a per acre basis, charges would be $100 ($4,000/40 acres), and $80 ($16 X 5 months) per pair for five months.

Charges and calculations can be made for stocker cattle in the same manner, with an adjustment of the rental rate from a pair basis to a calf basis. This is usually a negotiated price based on the weight of the calf. Other factors that determine the final negotiated price are who irrigates, pays for fertilizer, manages the cattle and facilities. Since a pair is assumed to have a base weight of 1000 pounds, a calf is a smaller proportion based on its weight. For example, a 650 pound calf might be charged 65 percent (650/1000) of the pair rental rate. If the pair rental rate was $16 per month, then a 650 pound calf would be $10.40 per month ($16 X 0.65). When making these conversions from calves to

pair equivalents, it is important to use the average weight between entering and leaving the pasture, not the starting weight.

Cost of gain is less often, but increasingly being used as the rental basis. One method to assess or evaluate rent on a cost of gain basis is to convert charges from cost of gain to per head values. For example, if the cost of gain was 30 cents per pound, what is the cost per head per month? Assuming 300 pounds of gain over a five month period, the cost per head per month would be $18 (300 pounds X $0.30 cost per pound of gain/5 months). Rental on a "cost of gain" basis more accurately reflects quality of pasture and end product. However, the land owner may be at greater risk with payment based on cattle gain if cattle are inferior in quality, have health problems or other unforeseen problems not relating to the quality of the land and pasture.

The following example shows a more detailed analysis of stocker calves on irrigated pasture. Expenses and income are shown for a typical 40- acre pasture, with grazing by 80 head of 600-pound steer calves.

Stocker Cattle Profit or Loss and Risk Calculator by
Version 9.25.91 Daniel J. Drake

Name: Intermountain Example, Typical Stocker Cattle
Date: 11/11/92

		INFO SUPPLIED	CALCULATIONS Pessimistic	CALCULATIONS Optimistic	
GENERAL INPUTS AND ASSUMPTIONS					
Size of pasture, acres	:	40			
Number of cattle	:	80			
Days on feed, total	:	150			
Purchase weight, lbs.	:	500			
Expected purchase price, $/cwt	:	90			
Purchase price variability, %	:	10	99.00	81.00	
Expected selling price, $/cwt	:	83			
Selling price variability, %	:	15	70.55	95.45	
Daily gain, lbs/head	:	1.67			
Gain variability, %	:	10	1.50	1.84	
PASTURE INPUTS			Per Head	Per Acre	Total
Rent $/head/month	:	9	45.00	90.00	3600.00
Land, taxes, other $/acre	:	0	0.00	0.00	0.00
Land, taxes, other Total $	:	800	10.00	20.00	800.00
Irrigation Costs					
Water costs, $/acre foot	:	18	20.25	40.50	1620.00
Water amount, acre feet/acre	:	2.25			
Fertilizer Costs					
Amount, lbs/acre	:	300			
Cost, $/ton	:	125	9.38	18.75	750.00
Spread charge, $/acre	:	5	2.50	5.00	200.00
Labor cost, $/month	:	200	12.50	25.00	1000.00
MANAGEMENT INPUTS					
Vet & Medicine, $/head	:	5	5.00	10.00	400.00
Supplement					
Lbs./head/day	:	0.25			
Cost, $/ton	:	398	7.46	14.93	597.00
Days fed, all= 150	:	150			
Death loss, %	:	1	4.55	9.10	364.00
Yardage, $/head/day	:	0.05	7.50	15.00	600.00
Transportation, $/head	:	1	1.00	2.00	80.00
Brand insp., Beef pro., $/head	:	1.9	1.90	3.80	152.00
Insurance, Misc. $/head	:	0	0.00	0.00	0.00
Comm., % of buy cost	:	0.75	3.38	6.75	270.00
Comm., % of sell income	:	3	18.69	37.37	1495.00
FINANCIAL INPUTS					
Equity, $/head	:	75	75.00	150.00	6000.00
Cattle interest rate, %	:	12	18.49	36.99	1479.45
Op. Capital interest, %	:	11.25	3.44	6.88	275.37
CME Livestock Options					
Put Option strike price, $/cwt	:	0			
Option Cost cents/lb	:	1.2	0.00	0.00	0.00
Basis	:	-2.25			
Number of contracts 44,000# each	:	0			
Commission, total $	:	0	0.00	0.00	0.00
Critical Profit(1), $ total	:	30000			
Critical profit(2), $ total	:	-2000			

204	R E S U L T S		
205	**EXPECTED**	Per Head	Per Acre	Total
206				
207	Cattle cost, total	450.00	900.00	36000.00
208	Cattle equity, $	75.00	150.00	6000.00
209	Cattle interest, $	18.49	36.99	1479.45
210	Pasture cost	99.63	199.25	7970.00
211	Management cost	71.41	142.82	5712.82
212	Pasture & Management Cost	171.04	342.07	13682.82
213	Pasture, Manage. & Cattle Cost	621.04	1242.07	49682.82
214	Gain over total period, lbs.	250.50	501.00	20040.00
215	Total cost per lb. gain	0.68	1.37	
216	Selling weight, lbs	750.50	1501.00	60040.00
217	Total dollar receipts	622.92	1245.83	49833.20
218	Total receipt minus cattle cost	172.92	345.83	13833.20
219	Profit or loss	1.88	3.76	150.38
220	Breakeven sell price, $/cwt (cost of prod.)	82.75		
221	Return on equity, %	2.51		
222	Breakeven buy price, $/cwt	90.38		

Production and Economics of Intensively Grazed Irrigated Pastures

Production can increase 50 to 100 percent on intensively grazed pastures. This increase is in either stocking rate of pairs or beef produced per acre for stockers. Increases in expenses are difficult to account, but they are much less than the increased production.

A small scale demonstration has been conducted for five years in Scott Valley of Siskiyou County by Ken McCutcheon. This pasture of 6.8 acres was divided into 4 paddocks (each paddock about 1.7 acres) and rotationally grazed with 20 to 25 steers. Initial weights were about 550 pounds. The steers were Hereford or crosses with Shorthorn and/or Angus. Cattle grazed in each paddock for about 5 days, and then were moved to the next paddock. Grass height was 2 to 4 inches when cattle were moved. Rest between grazing was about 15 days. Pasture species composition remained approximately 65 percent tall fescue and 35 percent Ladino clover. ***Density*** of livestock for grazing was about 8,000 pounds per acre (cattle averaged about 700 pounds and each paddock was 1.7 acres; 700 lbs X 20 head/1.7 acres=8,235 pounds per acre). The calculated ***stocking rate*** was 2 animal units per acre (700 lbs/1000 lbs. per AUM X 20 head/6.8 acres) which is about 60 percent (2 vs. 1.25 animal units per acre) greater than expected. Average daily gains were about 1.75 pounds per day, resulting in total individual animal gains of about 260 pounds. Gains per acre were calculated at about 770 pounds. The highest observed gain per acre was 990 pounds, with the lowest at 700 pounds per acre indicating yearly variability of the pasture.

Detailed help in designing grazing management strategies can be obtained in the article *Intensive Grazing Management Strategies for Intermountain Irrigated Pastures and Mountain Meadows* or from a Cooperative Extension livestock Farm Advisor.

The principal additional costs incurred at the McCutcheon ranch, which are typical for more intensively grazed pastures, were fencing, labor to move cattle, and rent when utilizing rented land. With the need for more cattle due to higher stocking rates, there may be additional costs to purchase cattle and/or interest costs if cattle are financed.

The following example illustrates the increased costs of higher investment (equity) for cattle, increased interest, pasture rent and livestock management costs. It is the same budget as shown earlier except it reflects intensive grazing utilizing 3 steers per acre and other related changes in the budget. Higher total costs were more than offset by substantially higher returns.

	A	B	C	D	E	F	G	H	I
204				**R E S U L T S**					
205	**EXPECTED**					Per Head	Per Acre	Total	
206									
207	Cattle cost, total					450.00	1350.00	54000.00	
208	Cattle equity, $					75.00	225.00	9000.00	
209	Cattle interest, $					18.49	55.48	2219.18	
210	Pasture cost					81.42	244.25	9770.00	
211	Management cost					70.99	212.97	8518.72	
212	Pasture & Management Cost					152.41	457.22	18288.72	
213	Pasture, Manage. & Cattle Cost					602.41	1807.22	72288.72	
214	Gain over total period, lbs.					250.50	751.50	30060.00	
215	Total cost per lb. gain					0.61	1.83		
216	Selling weight, lbs					750.50	2251.50	90060.00	
217	Total dollar receipts					622.92	1868.75	74749.80	
218	Total receipt minus cattle cost					172.92	518.75	20749.80	
219	Profit or loss					20.51	61.53	2461.08	
220	Breakeven sell price, $/cwt (cost of prod.)					80.27			
221	Return on equity, %					27.35			
222	Breakeven buy price, $/cwt					94.10			

Observations and experience on a different ranch in Scott Valley suggests intensively grazed pairs may also be stocked at increased rates. One particular ranch, the Joe Benjamin ranch, utilized cow/calf pairs on 16 acres of irrigated pasture. Typically, a stocking rate of 1¼ pairs would be expected. Therefore, the 16 acres would be expected to carry about 20 pairs. Several years of experience have shown when 16 paddocks were used, the stocking rate can be 45 pairs, or 2.8 pairs per acre. The 16 acres were divided into one acre paddocks with a movable electric fence. Pairs were permitted to graze each paddock for two days. Cattle were moved when grass was 2 inches tall. This resulted in a rest period for the pasture of 30 days. The stocking rate increase was nearly 125 percent for the pasture. The value of this increase can be estimated by assessing the increase in rental value. The additional 25 pairs (45 compared to 20 pairs) would return a gross 2,000 additional dollars when rent is $16 per pair per month.

Conclusions

There is ample evidence that increased stocking rates from intensively grazed pastures using short duration, high intensity grazing lowers daily weight gain of cattle. But as stocking rates increase, the overall gain of beef per acre is larger. These trends are shown in Figure 1. It must be emphasized this is a theoretical representation and specific numbers and their relationships are not known. In addition those numbers will be dynamic, changing as the price of cattle and other economics change.

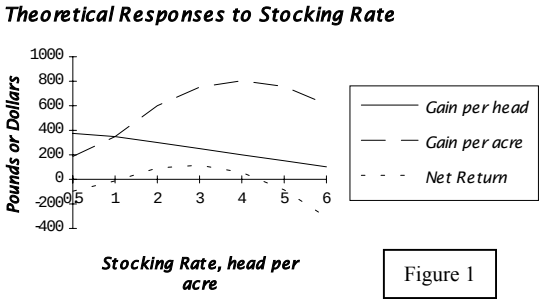

Figure 1

Gain per acre does decrease when stocking levels go beyond some high level. The graph also illustrates the relationship between stocking rate (grazing intensity) and net returns. This relationship is similar for gains per acre. There is an increase in net returns with increasing stocking rate, but, at some point, further increases result in lower net returns This downturn is more dramatic for land susceptible to weather extremes, such as dryland pasture. Irrigated pasture has a more reliable water supply and water application, and, thus the downturn in gain is less sharp.

The critical lesson is to understand the relationships between increasing stocking rate and weight gain, and gain per acre and net returns. Typically, we are far from maximum stocking rates. Keeping good records will assist in determining responses for specific pastures.

For Futher Information

See Chapter 2 (in this manual), Management Options for Utilizing Irrigated Pastures.

See Chapter 8 (in this manual), Plant Growth Concepts for Intermountain Irrigated Pastures and Mountain Meadows.

See Chapter 12 (in this manual), Animal Health on Intermountain Irrigated Pastures and Mountain Meadows.

See Chapter 13 (in this manual), Fence Considerations for Intermountain Irrigated Pastures and Mountain Meadows.

Intermountain Irrigated Pastures and Mountain Meadows Series

Chapter 12

Animal Health on Intermountain Irrigated Pastures and Mountain Meadows

Glenn Nader[1] and Larry Forero[2], Cooperative Extension, University of California[3,4]

University of California
Division of Agriculture
and Natural Resources

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Introduction

Disease management is an important part of a successful irrigated pasture and mountain meadow operation. It is best to work closely with your veterinarian to design a vaccination and management program that will minimize losses in your particular operation. This section provides information on animal health problems most common to Northeastern California pastures. Both parasites and poisonous plants can be serious health problems and may require special attention. Poisonous plants can especially create death loss the first year an intensive grazing system is implemented.

Internal Parasites

Worms(Gastro-intestinal parasites)

Description

Internal parasites on irrigated pasture reduce the performance and general health of livestock. Proper management of internal parasites can greatly increase profitability from grazing pastures in Northeastern California. Moist irrigated soils provide excellent habitat for internal parasites.

Stomach worms are a paramount problem, with their highest populations peaking in August. Nematodirus in calves and tapeworms are also problems with cattle grazing irrigated pasture, but to a lesser extent than stomach worms.

Prevention

The proper use of dewormers can effectively control parasites on irrigated pasture. In the past, we have looked at internal parasites as an animal sickness. New strategies have been to look at cleaning up the pastures through treatment of the animals to decrease infection rates within livestock. Dewormers are divided into two classes. Class I kills only adult worms while Class II kills adult worms and most inhibited worms. Strategic deworming with the Class II dewormers requires that the animals be treated in the fall after the first series of heavy frosts and a majority of eggs available in the pasture are destroyed by the extreme cold weather. The animals should be dewormed again within one month of placement on the irrigated pasture in the summer. Years with

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[1] Sutter/Yuba County, 142 A Garden Highway, Sutter County Ag Bldg, Yuba City, CA 95991-5593; 530/822-7515
[2] Shasta County, 1851 Hartnell Avenue, Redding, CA 96002; 530/224-4900
[3] The authors are grateful to Ben B. Norman, Extension Veterinarian for suggestions and review.
[4] Commercial companies are mentioned in this publication solely for the pupose of providing specific information. Mention of a company does not consitute a guarantee or warranty of its products or an endorsement over products of other companies not mentioned.

cooler or warmer temperatures than normal necessitate adjustments to this timing. This program should include a mid-summer treatment, when possible, that would again reduce the numbers of eggs being shed on the pasture for re-infection of the animals.

Treatment

To minimize potential infection levels of pasture, fecal eggs counts from livestock can be performed at regular intervals during the summer to determine when retreatment should occur. Generally, one to two treatments are required during the summer to keep parasite egg shedding minimized, which will reduce the number of eggs on the pasture for reinfection of livestock.

Treatment

Treatment with dewormers can be done by drenching, injection, pour-ons and feed or salt additives. When using feed or salt additives, carefully monitor consumption, as it will differ greatly according to the forage conditions. Dewormers are divided into two classes: Class I kills only adult worms while Class II kills most inhibited and adult worms.

Class I Dewormer	**Class II Dewormer**
●Thiabenzol (TBZ)	●Ivomectin
●Tramazol	●Safeguard/Panacure
●Totalon	●Valbazen
	●Synanthec
	●Dectomax
	●Cydectin
	●Eprinex

Liver Flukes

Description

Several new tests are available that monitor blood and feces for the presence of liver flukes. You should consult your local veterinarian about using these methods to determine whether you have liver flukes on your pasture. If any sheep die, an alternative method is to have your local veterinarian perform an autopsy. In cattle, liver flukes usually do not cause death, but examination of the livers at slaughter could confirm whether they have liver flukes.

Liver flukes are generally found in cattle or sheep grazing wet areas, especially those areas with standing water. Signs of the disease are anemia, unthriftiness, low milk production and, in sheep, death.

Fluke eggs are shed from cattle and sheep in the feces. When soil and water temperatures are above 50^{O}F (usually June), they hatch and will encyst in the snails (*Lymnaea spp*.). Snails can carry hundreds of immature liver flukes, with the immatures liver flukes staying in the snail from four to six weeks, depending on temperature. With adequate temperature immature flukes are shed from the snails and attach to grass. These are consumed by the grazing animals. Immature forms of flukes migrate through liver tissue for eight weeks before reaching the bile duct where their life cycle is completed.

Treatment

There are three products approved for treatment of liver flukes, Curatrem and Ivomec F (Clorsulon), and Valbazen (Albendazole). Ivomec F and Valbazen kill the adult stage of the fluke only. Curatrem drench is labeled to control immature (eight weeks and older) and mature flukes. These products should be used 4 to 8 weeks after killing frosts that have persisted for 18-21 days. For example, if hard freezes consistently start about November 1, then treatment would begin no sooner than early to mid December and should be completed by mid January. This procedure provides for killing of immature flukes on grass and in snails and development of immature flukes with the cattle to susceptible adult stages.

Some operators have been treating in early summer and have not been successful in cleaning flukes from their animals for the winter. This early treatment kills only the mature flukes and allows the immature flukes to re-infect. The rule in Northeastern California is to not treat for liver flukes prior to December 1.

You may want to work with your veterinarian as a part of your animal health program to ascertain whether flukes are a problem in your operation, and incorporate properly timed fluke treatment into your animal health program.

Fescue Endophyte (Fescue Foot)

Description

Fescue endophyte (Fescue Foot) describes a condition that occurs specifically in endophyte infected Tall Fescue pastures. The organism does not affect the growth or appearance of the grass, and it requires laboratory analysis (contact your livestock farm advisor for laboratory addresses) to detect its presence. It is seed transmitted. It is important to determine whether your fescue pastures contain high levels of toxic endophyte infection. The signs that can be seen in animals on fescue pastures with endophyte are:

1. lower feed intakes
2. lower weight gains
3. lower milk production
4. higher respiratory rates
5. higher body temperatures
6. more time spent in the water
7. more time spent in the shade
8. more time spent grazing
9. excessive salivation
10. rough hair coat
11. reduced reproductive performance.

Some studies have indicated an 82 percent increase in average daily gains when cattle on uninfected pastures are compared with those on endophyte infected fescue pastures. Also, infected pastures, in one case, decreased pregnancy rate by 34 percent.

Prevention

Since the fungus is carried in on the seed, the best way to protect against infestation is to buy endophyte-free fescue seed. Generally, forage type tall fescue seed from Oregon is endophyte free and is tagged accordingly.

Treatment

Limited pasture surveys in the Intermountain Region suggest low incidence of endophyte infection. If you have a stand that has endophyte, you may want to 1) change the pasture species from fescue to possibly orchardgrass, 2) establish endophyte-free fescue after completely tilling or rotating out the infected pasture.

Grass Tetany

Description

Grass tetany usually occurs in the spring when plants are growing rapidly. During this rapid growth phase, the amount of magnesium available in the plant is limited. Soils in areas with low magnesium and calcium extend the potential for grass tetany. Limited magnesium causes the animal to be in-coordinated, have staggers, and, usually, die. Periods of cloudy or foggy and cooler than normal temperatures increase the potential for grass tetany. In addition, increases in potassium or nitrogen fertilizer increase the risk of grass tetany. Cows in their last trimester of pregnancy are most susceptible.

Prevention

Supplement magnesium by using a salt mix 30 days before to the susceptible period. The one limitation of this method is that not all animals will consume salt daily, and some animals may not receive adequate supplement. Delaying grazing until the plants are more mature and have more magnesium available is another option. Generally, operators are interested in getting animals off costly hay or other conserved feed as soon as possible. An increase in legumes decreases the potential for tetany. You may want to increase legumes early in the season by using of phosphorus fertilizers. Cattle that survive tetany are prone to do so again, so culling of selected individuals may be considered. Supplementing fresh, fast growing irrigated pasture with alfalfa hay may decrease the threat of grass tetany. If you have a controlled water source, the addition of soluble magnesium to the water may be used to control tetany. Magnesium sulfate (Epsom salts) is one of the most readily available forms of magnesium sulfate.

Treatment

Grass tetany is an acute disease with rapid death. In most cases there is insufficient time for a vet to travel to your ranch to treat the animals. Grass tetany animals can be treated with intra-venous (in the blood stream) calcium magnesium gluconate. Caution should be used when with intra-venous administration of any product, particularly one with calcium and magnesium. Rapid intra-venous administration of certain mineral products can stop the heart and be fatal. Another complicating factor is handling of cattle for treatment frequently precipitates death. When handling grass tetany cattle, minimize the amount of stress by moving the animals slowly.

Poisonous Plants

Several plants contain toxins which are lethal to livestock. Generally, these plants are of lower palatability and are not consumed until feed is limited. The likelihood of poisoning may increase in intensive grazing systems where the animals do not have the selectivity that they had in large pastures. Prior to implementing an intensive grazing system, check for poisonous plants.

Symptoms

Illness symptoms and animal behavior help identify poisonous plant problems. The following categories can help focus attention to specific poisonous plants.

❑ Gastrointestinal

1. Vomiting	cocklebur, death camas, fiddleneck, milk weed, nightshade, senecio, veratrum, wild tobacco
2. Diarrhea or abdominal pain	cocklebur, death camas, fiddleneck, milkweed, nightshade, senecio, veratrum, wild tobacco
3. Constipation	fiddleneck, larkspur, nightshade, wild tobacco
4. Excessive salivation	death camas, milkweed, nightshade, star thistle, veratrum, water hemlock, wild tobacco

❑ Reproductive

1. Abortion or deformed offspring	locoweed, lupine, tobacco, poison hemlock, veratrum

❑ Nervous System

1. Convulsions	cocklebur, lupine, milk weed, veratrum, water hemlock, wild tobacco
2. Coma	death camas, greasewood, lupine, poison hemlock, water hemlock
3. Muscular incoordination	greasewood, locoweed, lupine, poison and water hemlock
4. Dilation of pupils	locoweed, milkweed, nightshade, poison and water hemlock
5. Nervousness, excitability	arrowgrass, bracken fern, choke cherry, larkspur, locoweed, lupine, poison hemlock

❑ Respiratory

1. Slow respiration, labored breathing	choke cherry, locoweed, nightshade, veratrum
2. Rapid respiration	choke cherry, arrowgrass

❑ Skin (cutaneous)

1. Photosensitization	St. Johnswort

Prevention

Prevent weed encroachment into meadows and pastures. Prior to grazing leased or newly acquired irrigated pastures or meadows check for toxic plants. This is critical in intensive grazing systems because when sufficient alternative forage is available animals usually will not select toxic plants. When intensive grazing pressure is applied, the ability to alternative forage is reduced.

Take care when collecting samples of poisonous plants for identification. Prevent the suspected poisonous plants from contacting skin by using gloves. If utensils, such as knives, are used for dissecting or collecting, thoroughly clean them to prevent possible contamination of humans or animals. Human deaths have occurred when utensils were not cleaned after slicing Death Camas and Water Hemlock.

Partial List of Poisonous Plants in the Intermountain Area

NAME	DESCRIPTION	PREVENTION
Bracken Fern *Pteridium aquilinum*	This fern is found in burned areas, under open forests, (especially ponderosa pine), and abandoned or overgrazed fields. Symptoms usually occur in the fall when other forage is depleted. Symptoms may develop 2 to 3 weeks after removal from infestation. Symptoms occur suddenly as high temperature and bloody nasal and fecal discharges. Death occurs in 1-10 days.	Bracken fern is avoided when adequate alternative forage is present. Eradicate by mowing or cultivation for 2 to 3 years.
Choke cherry *Prunus virginiana var. melanocarpa or demissa*	This is a shrub or small tree found along damp places in woods and brushy areas. Leaves contain the poisonous component, hydrocyanic acid. A toxic dose must be taken at once but can be as small as .25 percent of the animal's body weight. Death is usually rapid.	Wilted leaves are most toxic. Hungry or thirsty animals should not be trailed through choke cherry areas. Eradication is impractical but near watering holes appropriate herbicides can be helpful.
Cocklebur *Xantheum spp.*	Annual herb containing seeds covered with spines. It is usually found in ditches, streams, and rivers. Only the seedling are poisonous, as the plant matures the toxicity will decrease rapidly. Consumption of cocklebur will cause depression, weakness, convulsions, and vomiting.	Spray herbicides on infested areas and provide sufficient feed.
Death Camas *Zigadenus spp*	Perennial bulbous with basal, flat, grasslike leaves; flowers greenish, yellow, or pink. Similar to wild onion but has no onion odor. Seeds are most toxic. Leaves and stems lose toxicity as the plant matures. Relatively small amounts (6 percent of body weight) can result in death.	Spray the area with herbicides.
Greasewood *Sarcobatus vermiculatus*	A shrub-like plant generally limited from Inyo County northward to Lassen and Modoc counties. Poisoning usually occurs in the Spring, when greasewood may be the major feedstuff. Oxalic acid is the toxic component. Symptoms occur within 5 hours of consumption. Death may follow.	In some locations greasewood is the predominant plant and control is impractical. When little alternative forage is available, supplements are useful.
Horsetail *Equisetum spp.*	The stems are round, hollow, and in jointed sections. Sometimes called joint grass. Consumption causes a lack of coordination. The neck of the affected animals is usually arched back. To counteract the action of thiaminase in this plant, treat animals showing signs with thiamine or B complex with high thiamine content. Consumption of the plant affects horses and cattle.	Do not graze with horses or cows with new born calves. Herbicide control is difficult
Larkspur *Delpheninium spp.*	Annual or perennial erect herbs. Flowers each with 1 spur. Either cultivated or wild. Usually in open foothills or meadows and among aspen. Young plants and seeds are more toxic. Toxicity decreases with maturity. Lethal dose is .5 lbs.\100 lbs. of body weight. Sheep are four times more resistent than cows.	Withhold livestock until the plant begins to dry up. Spray the area with herbicides.

Partial List of Poisonous Plants in the Intermountain Area, Continued…

NAME	DESCRIPTION	PREVENTION
Lupine *Lupinus spp.*	Perennial. Leaves simple or palmately divided; flowers blue, white, red, or yellow in terminal raceme. Impacts sheep, cattle, goats, horses, and swine. Seeds have the most concentrated poisonous compounds. Seeds in the pods consumed as 1.5 percent of the body weight have been lethal. Remove the animals from the source, don't otherwise disturb sick animals. There is no effective treatment, but survivors recover completely.	Avoid grazing from the fruiting period on. Supplemental feeding may be beneficial.
Milk Weed *Ascelepias spp.*	A perennial that often bears blossoms and fruit at the same time. The plant may be one to three feet high. Greenish white flowers are born in an umbrella-like cluster. Leaves may be narrow or broad. Two to three ounces of the most poisonous species will kill an average size sheep	Animals usually do not eat milk weed unless good forage is scarce. Provide sufficient amounts of forages and survey pastures prior to implementing any intensive grazing system.
Poisonous Hemlock *Conium maculatum*	The leaves look like parsley. Purple spots on stems. White flower. When crushed, it has a parsnip smell. Often confused with water hemlock and wild carrot. Consumption causes a staggering gate, dilated pupils, slow irregular breathing, and death from respiratory failure. The plant looses toxicity as it dries, so poison hemlock properly cured in hays will not cause problems. Sheep may be poisoned by as little as 4 to 8 ounces of green leaves. Cattle that eat 10 to 16 ounces may be affected. Smaller amounts consumed by cows during the second to fourth month of pregnancy can cause crooked calf disease.	Spray infested areas with herbicides.
Sneezeweed *Helgnium hoopesii*	A perennial plant that grows 1.5 to 3 feet tall from a woody tap root. Long, narrow, pale green leaves grow alternately on the stem. Flowers are orange - yellow. Grows on moist slopes and well-drained mountain meadows. Approximately 2 pounds of sneezeweed daily for 20 days can cause vomiting, bloating, and frothing at the mouth.	Graze for less than 20 days on infested pastures. Spray the area with herbicides.
Water Hemlock *Cicuta douglasii*	A bi-annual that grows in wet and swampy areas. Hollow stem, white flowers, and tuberous roots. Resembles poisonous hemlock and wild carrot. Very small portions of the root (walnut size) have been reported to kill a cow. Causes rapid death (15 to 30 minutes), with other symptoms being salivation, convulsions, and coma.	Spray herbicides on ditches and waterways

Partial List of Poisonous Plants in the Intermountain Area, Continued…

NAME	DESCRIPTION	PREVENTION
Western False Hellebore *Veratum californicum*	Grows in wet seepage areas in meadows and on hillsides. Reaches a height of four to six feet and is a robust perennial of the lily family. Leaves may reach nine to twelve inches long and three to six inches wide. Cream colored flowers grow in cluster at the top of a single unbranched stalk in a way that resembles corn. Seed pods turn black as they ripen.	Prevent grazing during early gestation. Eliminate by digging or spraying.
Yellow Star Thistle *Centaurea spp.*	Annual with leaves densely covered with cottony hair. Terminal-spreading cluster of bright yellow flowers with spines below. Known to affect horses only. Unidentified alkaloid. Causes involuntary chewing movements, twitching of lips, flicking of tongue. Mouth commonly held open. Unable to eat; death from dehydration, starvation, aspiration pneumonia. Requires consumption of 300 to 600 pounds over a 3-month period.	Provide adequate feed to horses. Control infested areas with herbicides.

Bloat

Description

Bloat kills an estimated 0.5 percent of all cattle dying from natural causes in the United States. Bloat usually occurs when cattle or sheep graze green succulent clover in the pre-bloom stage of growth. Gases, which are the natural by-products of digestion, accumulate in the rumen. If enough accumulate, the animal becomes visibly distressed and may even die unless treated.

Prevention

Watch livestock carefully after they are turned out onto pastures. Some producers fill livestock with dry stemmy hay prior to allowing them to graze. Limiting initial grazing time on pasture has been successful in limiting the incidence of bloat.

Commercial bloat guards fed free choice, soap, *Rumensin*® and *Bovatec*® also lessen the incidence of bloat.

The ultimate control is pasture that permits high production, yet results in a low incidence of bloat. Research in this area centers on developing strains of legumes that have low bloat potential. On a practical basis, pastures with equal amounts of clover and grasses come closest to achieving this goal.

Treatment

When the animal's life is not immediately threatened, the passage of a stomach tube is recommended. In the case of frothy bloat, the administration of an anti-foaming agent may be a consideration (vegetable oils, i.e. peanut, corn, soybean). In life threatening cases, an emergency rumenotomy may be necessary. The incision will result in an explosive release of rumen contents. Some animals seem to be more susceptible to bloat than others. Chronic bloaters should be removed from the herd.

Footrot

Description

is the result of a bacterial agent and is the major cause of lameness in beef and dairy cattle of all ages. It is most prevalent during wet weather but also occurs during dry weather when the ground is firm and cattle have access to stagnant water and mud or have been forced to cross newly broken ground. The hard dry ground probably bruises the heels and the tissue between the digits. Once a break occurs in the skin, the organisms in the mud readily infect the wound. One or more feet may be affected at any given time.

Animals may be suspected of contracting foot rot when inflammation between the digits occurs and limping is severe. Eventually necrosis and longitudinal fissures appear, revealing a purulent discharge and central mass of necrotic tissue. When the central mass of necrotic tissue is removed or sloughs healing usually progresses rapidly.

Prevention

Remove stones, trash and other articles from the pasture. Walking cattle through a 3 percent formalin foot bath, a 5 percent copper sulfate foot bath or mixed powdered copper sulfate and lime twice a day decreases the incidence of foot rot. Oral iodides have been beneficial as preventatives in some cases.

Treatment

Systemic and local treatment with antibiotics and sulfur drugs appears to shorten the course of the disease. Other procedures which may speed recovery are cleaning the foot, or applying a protective dressing.

Pinkeye

Description

Pinkeye has been reported worldwide since 1889. It is still one of the most difficult cattle diseases to prevent or treat in a practical manner. The disease may occur in any season of the year although it is most prevalent in the summer. Pinkeye is caused by the bacteria *Moraxella bovis*.

Researchers attribute higher incidence of pinkeye in the summer to higher plant pollen levels, increased levels of ultra-violet light, and greater numbers of flies. The clinical signs of pinkeye include (in the early stages) photophobic (animals seeking shade), and excessive tearing and blinking, and the eye is often kept closed. After 5 to 7 days, ulcers from 1/8 to 3/4 inches across may be seen on the surface of the eye. There is edema of the cornea and reddening of the conjunctiva (white part of the eyeball). Fiery red rings with white or yellow opaque centers may be seen. Healing can occur at any stage of the disease. By 14 to 16 days, blood vessels grow to ulcers in the center of the eye. The eye may rupture causing permanent blindness (this is infrequent).

Prevention

Because face flies are partially responsible for the spread of pinkeye, fly control with ear tags (where they still work) or reducing fly numbers with sprays or dust bags can reduce the spread of the disease. Injection of a long-acting oxytetracycline has reduced the severity of pinkeye in experimental animals and has eliminated the pinkeye carrier state in apparently normal animals. Some commercial pinkeye vaccines exist, however, there have been problems with adverse vaccine reactions and, in some cases, adequate protection.

Treatment

There is a wide range of antibiotics available with good efficacy against *M. bovis*. Normal eyes produce about one ounce of tears daily, washing out most applied local medication. Powders cause even more tearing and are not preferred. High pressure sprays may also be irritating. Because the disease may be spread between animals, removing infected animals may reduce overall incidence of the disease. Eye patches reduce the pain from exposure to sun and flies.

Your veterinarian may prescribe treating pinkeye through the injection of kanamycin or ammoxicillion (an extra-label, prescription basis) under the membrane of the eyelid. If you have never treated an animal in this fashion, it is imperative to learn the proper technique prior to attempting to administer the vaccine. If you are considering this technique, it is important to remember that good head restraint is necessary. Treat both eyes. Remember that as you are wrestling calves and get tears on your clothes that you are effectively transmitting the micro-organism from animal to animal. A plastic apron and heavy "dishwashing" gloves, both disinfected between calves may be the best way to prevent spreading the disease between eyes and calves.

Anthrax

Description

Anthrax is a peracute disease of virtually all warm blooded animals and man. It is caused by a bacteria known as Bacillus anthracis and occurs worldwide. Anthrax is known to occur in the Surprise Valley area in Northeastern California and in portions of Inyo and Mono counties. Outbreaks of anthrax commonly are associated with neutral or alkaline, calcareous soils that have become "incubator" areas for the

organisms. In these areas the spores apparently revert to the vegetative form and multiply under optimal soil, moisture, temperature, and nutritional conditions. Cattle, horses, mules, sheep and goats may readily become infected when grazing such areas. Outbreaks originating from soil-borne infection are common after a major climatic change (i.e., drought) and always during warm weather.

Prevention

If you do not live in an anthrax area, it is not generally recommended that you vaccinate against anthrax. If your operation is in an anthrax area, consult with veterinarian about a prevention program. Anthrax can be prevented through the herd health program.

Treatment

A diagnosis based on clinical signs may be difficult, especially when the disease occurs in a new area. Therefore, a confirmatory laboratory examination should be done. If you suspect an anthrax death, call your veterinarian to assist with the analysis of the problem. There are human health factors to consider when dealing with anthrax infected livestock. Animals suspected of contracting anthrax should be confined and treated with penicillin. The anthrax organism is extremely sensitive to the antibiotic. Administrating penicillin to infected animals can result in rapid recovery.

Clostridial Group

Clostridial diseases account for many of the sudden deaths of cattle and, until recent years, were not incriminated.

This group of diseases are caused by spore forming bacteria that grow where there is virtually no air. The natural habitat for the majority of these species is the soil and the intestinal tract of animals. The organisms, as resistant spores, live for long periods in the soil and may be acquired by susceptible animals from the soil, from ingestion, or by wound contamination. The diseases are a constant threat to the success of a livestock producer and result in tremendous loss to the industry.

The following diseases are caused by Clostridial organisms:

1. Blackleg caused by *Clostridium chauvoii*
2. Malignant edema caused by *Clostridium septicum*
3. Enterotoxemia caused by *Clostridium perfringens*
4. Internal Blackleg caused by *Clostridium sordellii*
5. Blacks Disease caused by *Clostridium novyi*
6. Red water caused by *Clostridium hemolyticum*
7. Tetanus caused by *Clostridium tetani*
8. Botulism caused by *Clostridium botulinism*

The clostridial disease group is probably one of the most frequently vaccinated against. Good protection from these diseases is possible through a good vaccination schedule. Clostridial diseases are caused by bacteria. The Clostridial organisms most likely to cause a problem on irrigated pasture in the Intermountain Region includes Blackleg, Malignant Edema, Overeating and Tetanus. Red water may be a problem in some areas.

Blackleg

Description

Clostridial chauvoii causes Blackleg. The organism is found in soil and intestinal contents of animals and man world wide. Commonly, the cattle that contract the disease are in excellent health, gaining weight and the best animals in the group. Cattle aged 6 to 18 months are most commonly affected, but all ages are susceptible. The disease usually occurs during the summer and fall.

Onset of the disease is usually sudden and cattle may be found dead without early symptoms. Acute lameness and marked depression are common. Initially, there is a fever, but by the time that clinical signs are obvious, the temperature may be normal or subnormal. Characteristic swellings develop in the hip, shoulder, chest, back or neck. At first, the swelling is small. As the disease progresses, the swelling enlarges.

Treatment

Animals may be treated with some success under the intense supervision of a veterinarian and the use of appropriate antibiotics.

Prevention

Vaccinate with an appropriate clostridial vaccine at the appropriate time.

Malignant Edema

Description

Malignant edema is caused by the bacteria *Clostridium septicum*. Infection generally occurs through the contamination of wounds. Wounds caused by accident, castration, docking, unsanitary vaccination and parturition may become infected.

Infected animals lose weight and run a high fever. Local signs may develop within a few hours to a few days. The local lesions are soft swellings that pit on pressure and extend rapidly because of large quantities of exudate that infiltrate the subcutaneous and intermuscular connective tissue of the affected areas. The muscle in such areas is dark brown to black. Accumulations of gas are uncommon.

Treatment

Treatment with high doses of penicillin or broad spectrum antibiotics is effective early in the disease. The injection of penicillin directly into the periphery of the lesion may minimize spread of the lesion, but the affected tissues will usually slough.

Prevention

Vaccinate with an appropriate clostridial vaccine at the appropriate time.

Enterotoxemia

Description

Enterotoxemia, or overeating disease, is a clostridial disease that generally affects sheep and young calves on "rich" food. It is caused by *Clostridium prefringens*, types C or D. However, predisposing factors are essential. The most common being the consumption of high-energy feeds, an abundant milk supply or lush pasture. Under these conditions, the bacteria grow rapidly and produce a powerful toxin.

The symptoms are difficult to see, as sudden death is the result of the disease. Frequently, lambs are found dead in the field without having shown any signs of illness. Quite often, lambs with the biggest appetite are affected. The disease develops rapidly, and the animal becomes weaker and weaker and shows nervous disturbance (circling, butting, etc.). Calves look like they are bloated.

Prevention

Along with proper feeding, vaccinate with type C and D toxoid. Lambs should be vaccinated with type D only.

Treatment

None

Tetanus

Description

Tetanus is caused by *Clostridium tetani*, infection of wounded tissue. It is often characterized by spasmodic contraction of voluntary muscles. Cattle, sheep, and horses are affected by the disease. Spores in soil and fecal material are introduced through wound openings. Death usually results from

disturbance of circulatory and respiratory efficacy. Symptoms are increased heart action, rapid breathing, erect ears, stiff gait and congested mucus membranes. Mortality averages about 80 percent.

Prevention

Vaccinate annually with clostridial bacterin that includes protection against *Clostridium tetani*.

Treatment

If an animal that has not been previously immunized suffers a wound, tetanus antitoxin can be administered successfully. When symptoms are present, antitoxin and large doses of penicillin coupled with good nursing has resulted in recovery.

Red Water

Description

Red water is caused by liver damage followed by *Clostridium hemolyticum* infection. Liver flukes commonly predispose the disease. It is associated with wet meadow environments throughout the Pacific Coast states. The disease occurs in cattle and is uncommon in sheep and swine. Animals over six months of age are more susceptible than calves. The disease appears to spread by direct contact with sick animals. Typical symptoms include high fever, red urine, anemia, lethargy and death within 24 to 36 hours.

Prevention

Incorporate a clostridial bacterin that includes protection against Red water into your herd's health program. Treating livestock against liver flukes (in fluke areas) can limit susceptibility to the disease.

Treatment

Penicillin has been used to treat Red water in the early stages. It is nearly impossible, however, to recognize the symptoms and treat successfully prior to death.

Comments

Be sure to vaccinate all your calves at the proper times at least against blackleg and malignant edema. Before you purchase vaccine, discuss the protection you need with your veterinarian.

Progressive producers have recognized the importance of using proper vaccination techniques and using all pharmaceuticals in accordance with the label. The recently initiated Cow-Calf Quality Assurance program is a proactive approach to improve the overall management of livestock to ensure the consumer enjoys a safe, wholesome product.

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Intermountain Irrigated Pastures and Mountain Meadows Series

Chapter 13

Fence Considerations for Intermountain Irrigated Pastures and Mountain Meadows

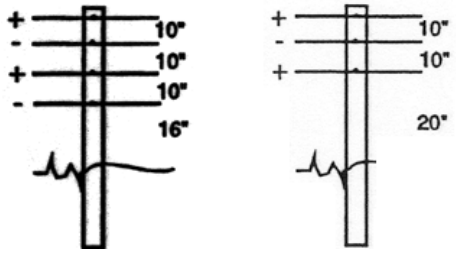
Glenn Nader[1] and Daniel J. Drake[2], Cooperative Extension, University of California[3]

University of California
Division of Agriculture and
Natural Resources

Fencing can greatly increase management alternatives for livestock. In the West, traditional fencing has been barbed wire and, more recently, woven wire. With the introduction of high tensile fence wire and high-power, low-impedance electric fence chargers provides an effective and lower cost fence. When considering new fences or maintenance of older fences, use of electric fences should be seriously evaluated. Modifications of these fences include "polywire" units of plastic thread and wire. The wire conducts electric current and the plastic thread provides for ease of handling. This article discusses some of the important items to consider with the electric fences.

Perimeter Fences

Perimeter fences usually consist of barb wire, but can also be constructed with multiple strands of high tensile wire. It is not necessary for the fences to be electrified, although livestock control will be improved with charging.



Typical 4 and 3 wire cattle electric fences.

In electric fences, wires are alternately charged, providing the fence its own ground. (If the fence installation includes an adequate ground rod, see "Grounding of the power unit.") In pastures with abundant soil moisture, grounded wires on the fence may not be necessary as the livestock will be adequately grounded with the moist soil. Modifications of this type of perimeter fence can include more wires to help repel deer, coyotes, dogs and other animals.

A primary reduction in cost for high tensile, multiple strand perimeter fencing is from the use of fewer fence posts. Fence posts need not be spaced closer than 20 feet apart for perimeter fences. If droppers (short "posts" that keep wires apart but do not touch the ground) are used, posts can be spaced up to 150 feet apart.

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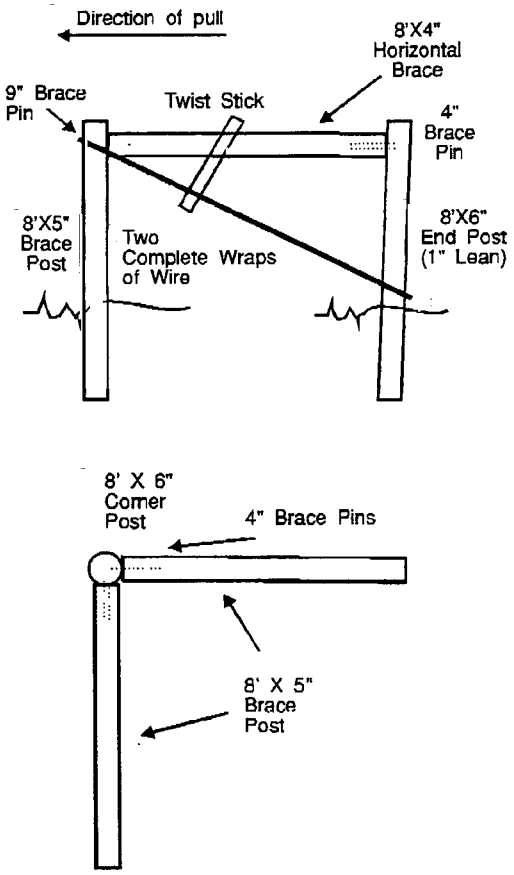
[1] Sutter/Yuba County, 142-A Garden Highway, Sutter County Ag Bldg, Yuba City, CA 95991-5593; 530/822-7515
[2] Siskiyou County, 1655 South Main Street, Yreka, CA 96097; 530/842-2711
[3] Commercial companies are mentioned in this publication solely for the purpose of providing specific information. Mention of a company does not constitute a guarantee or warranty of its products or an endorsement over products of other companies not mentioned.

These types of fences exert substantial forces on end or corner posts. Suggested construction shown should be adequate for six or fewer high tensile wires. Additional wires would necessitate double brace posts of similar construction. Wood posts should be of high quality. Materials adequately used with more traditional barbed wire, may be unsuitable for smooth wire fences due to greater tension. This may become more evident with time and deterioration of materials, particularly inadequately treated posts. (See "*For Further Information*" about treatment of wood posts.)



Upper diagram illustrates (in side view) typical end post construction for six or fewer high tensile wires. Lower diagram (plan or top view) shows typical corner post.

Brace posts are used at the end of runs (straight lengths of fence), changes in direction or at gates.

Interior Fences

Interior fencing on irrigated pasture or mountain meadows can be adequate with a single electric wire. Wire can be either high tensile 12.5 gauge galvanized metal wire, Polywire, or tape. Post spacing can be up to 125 feet or more. Depending on personal preferences, posts and wire for interior fencing can be permanent, temporary or a combination, such as permanent posts and Polywire. Interior fences should be easy to change.

Interior fences, when used with wheel line irrigation systems, can be either parallel or perpendicular to the wheel lines. Perpendicular fences usually are not satisfactory because the wheel line creates a barrier in the paddock. Interior fences parallel to wheel lines usually require posts lower than the wheel line. In addition, when high tensile wire is used, posts should be of the break over design. An alternative would be use of Polywire. However, when Polywire is used in fences parallel to wheel lines, it will usually have to be loosened (slack provided) due to a tendency to become snagged or caught in the cleats of the wheel on the wheel lines.

Some special features to keep in mind:

1. Electric fences are psychological, not physical barriers to livestock. Some training period may be needed and the fence will not always be 100 percent effective.
2. Avoid the tendency to over-build the fence and under-power the charger. Instead, insure adequate power through use of an appropriate charger.
3. Most field problems relate to inadequate grounding. Check and re-check the grounding system.

Posts

Several types of posts are used with Polywire:

1. Fiberglass, tread-in types. Place where desired and step or tread them into the ground. Spacings from 30 to 70 feet have been effective. When working with fiberglass, wear leather gloves to protect your hands from injury by fiberglass slivers.
2. Fiberglass rod. These can easily be driven with a small 1/2" galvanized plumbing pipe nipple 4" long with a cap on the end. Effective spacing has been 50 to 75 feet.
3. Fiberglass Sucker rod that has pre-drilled holes. These types of posts have been spaced 75 to 125 feet.
4. Traditional steel post with plastic clip on insulators, spaced at 75 to 100 feet.
5. Steel rods with plastic insulators. These are used with a single Polywire fence. Spacing is similar to fiberglass rods, about 50 to 75 feet.
6. Texas Tumblewheels. These are really not posts but rolling wheels which support wire and allow two or more people to move the fence by rolling it. Wheels are needed about every 100 feet.
7. Breakover or pivoting type posts. Use with irrigation systems. Spacing depends on stiffness of the spring and height but may vary from 50 to 200 feet. For pivot irrigation systems, the fence on the breakover posts should be offset 30 degrees or more so no more than two drive units of the pivot irrigation system are on the fence at one time. Breakover posts should be 10 to 20 feet away from the drive over point. For systems with towers more than 180 feet apart, an insulated line post should be used in the middle. Tension springs located with the in-line strainers should also be used to provide extra stretch as the fence is forced down by the wheels of the drive unit. To keep the wires together at the crossover point by the wheels, a piece of wire should be used to connect them together.
8. Irrigation break through gates. While not really posts, irrigation break through gates can be used with pivot irrigation systems instead of break over posts. These gates consist of flexible whips attached to solid posts where the drive units will pass through the fence. This permits the drive units to pass through the flexible whips.

TYPES OF WIRE

High-tensile wire:	12.5 gauge, galvanized metal wire
Polywire:	6 strands of interwoven plastic and metal threads 9 strands of interwoven plastic and metal threads
Polytape:	Highly visible wide plastic and metal combination and is used for cattle gates and horse pastures. It comes in varying widths

The plastic wires, Polywire and Polytape, are available in many colors. White Polytape and Polywire are the most visible.

Observations suggest electric tape is more effective than wire in areas where deer are present.

Types of power units

Adequate power in the charger is critical for electric fences. Whenever possible select 110 volt power over battery operation. The tendency is to under-power. Remember, a fence one mile long with two charged wires is really a two mile long fence. While site specific circumstances prohibit specific recommendations, one joule of charger power will supply 6 miles of wire. Conditions such as the type of fence, climate, vegetation and ground moisture may increase the recommendation.

- 110 volt powered unit:
  1. Can easily be plugged into a 110 volt wall outlet
  2. Limited portability
  3. Works well in corrals or paddocks near facilities
  4. Most powerful

- 12 volt battery operated systems:
  1. Will last 2 to 6 weeks, depending on amount of fence being charged, resistance in the fence (weeds, grass), and proper grounding of the power unit
  2. Very portable

- Six D-cell battery power unit:
  1. Will last about 1 to 6 weeks, depending on amount of fence charged, resistance in the fence (weeds and grass), and proper ground of the power unit
  2. Very portable

- Solar power assisted unit:
  1. Solar panel decreases the need to recharge or replace the batteries
  2. Cost is from $150 to $600, depending on quality of unit

All units are rated for the miles of fence they will charge. Some companies may overrate their chargers. One should carefully choose between power units to have a successful electric fence. Most fence power units are rated for the amount of electrical output. It is given in units of amps, volts, or joules. A joule is equal to a current of 1 watt passed through a resistance of 1 ohm for 1 second. The higher the joules, the more electrical output in each pulse of the fence power unit. A power unit is needed that will charge your fence with 4,000 to 6,000 volts to successfully hold cattle.

Grounding of the power unit

For the fence to work effectively, the power unit must be properly grounded. Improper grounding is the number one cause of power fence failure. Several grounding methods are:

Place three six-feet-long ground rods (galvanized plumbing pipe can be used with a pipe clamp for grounding) 10 feet apart link them with a single wire and connect to your power unit.

In desert or dry environments place ground rods in a Bentonite pit, which will hold moisture and provide a more effective ground.

In dry environments, you may also want to provide a ground wire on your fence to facilitate completing a circuit when an animal contacts a charged wire and the grounded wire.

To check your power unit for proper grounding, use a fence voltmeter while the fence power unit is on. Push one clip end of the meter into the ground and then clamp the other lead on the ground rod. If the meter reads 300 volts or more, you need to place another ground rod 10 feet from the first. Wire the rods together to increase the surface area used to ground the system. Repeat this process until the meter reads below 300 volts. A properly grounded fence power unit will increase the electrical charge on your fence and the battery units will stay charged longer.

Place electric fence power unit ground rods at least 30 feet away from power or phone ground rods.

Lightning protection

Lightning can cause major damage to the power unit. Protect the power unit by using lightning arresters between the fence and power unit.

Either a wire lightning choke or porcelain lightning arrester can be purchased from fencing supply companies. These devices direct electrical charges from lightning away from the charger unit and fence to a ground, thereby protecting the system.

Maintenance

Electric fence needs more maintenance than traditional barbed wire. Check the fence

periodically with a voltmeter to ensure that it is working effectively and has not been grounded out. Voltmeters range from simple illuminated light types ("idiot" lights) to more sophisticated digital display types. To be effective, the fence should be operating at 4,000 to 6,000 volts. *A good voltmeter is an essential component of the fencing system.* By checking the voltage from the charger outward along the fence, shorts can be located. Some illuminated light testers may be damaged when used on high voltage charger systems.

Training livestock to electric fences

Cattle - For highest control of livestock with an electric fence, cattle should be trained. This is not difficult. If proper training of animals is not done, the fence is likely to be unsatisfactory. Because of the limited number of wires that is generally used in an electric fence, there is no visual barrier, but a psychological barrier. If the animals do not see the fence or do not know that it is there, they will go through it. Cloth or tape can be placed on the fence for visibility. Training of the animals prior to turning them out can easily be done by placing hay on the ground near a charged wire in a corral or field. As the livestock investigate the hay, they will become acquainted with the charged wire. This will reduce the number of animals getting through the fence during the start of the grazing period.

Horses - Walk the boundary of the fence, calmly without touching it, with the horse(s) prior to releasing them in new pasture. This walk will prevent the horse charging through the hot wire in the process of exploring the new pen.

Sheep - Sheep should be trained before they have a full coat of wool. It is very hard to train sheep when they have a lot of wool. However, if attempted, wires should be close together and the voltage should be maintained near 6,000 volts.

Buried Cable

Burying electric fence insulated cable at gates is highly recommended. Electric wires stretched in the air above gates frequently are not high enough, especially after sagging occurs. Electrified gates that carry current across the gate connecting the fence on each side of the gate results in portions of the fence without charge when the gates are open.

When electric cable is buried directly into the ground, frequent traffic over the wire such as at gates, may result in loss of voltage over time. It is recommended to place the cable inside plastic electrical conduit pipe to protect it from traffic.

It is recommended to put the cable inside plastic electrical conduit pipe to protect it from traffic through the gate. It is also advisable to seal the ends of the pipe with electrical putty to prevent water and dirt from entering or lying in the pipe. The pipe will also allow easier cable replacement if a short ever develops. The use of standard electrical wire is not recommended with electric fence chargers, due to low voltage ratings. The 12 ¾ gauge buried cable should last longer as well as conduct better than the 16 gauge.

Using electric fence wire connector nuts to attach the cable to the fence on both sides of the gate is highly recommended. Just wrapping the buried cable wire around the high tensile wire may cause a loss in voltage. It also is more difficult to disconnect when trouble shooting voltage loss in a section of the fence.

Safety Precautions

Proper warning signs

Use proper signs with an electric fence to protect people and reduce liability. Signs placed every quarter mile on an electric fence would be spaced the same as legal "No Trespass" signs. Frequently, manufacturers recommend signs every 300 feet.

Most new fence chargers are the pulsating type which allow the person or animal to remove themselves from the fence. Use of old continuous charging units should be avoided.

Also, avoid using barbed wire for an electric fence. A person or animal can become lodged on a barb and shocked several times. Barbs on the wire can pierce the skin, permitting the charge to enter the blood system. If this occurs,

electrical impulses from the fence charges could stop the heart. It is illegal to electrify barb wire in Australia and New Zealand, and it is highly discouraged in the United States.

Fence Costs

Table 1. Example of relative fencing costs, costs will vary.

	Fence Cost, $/100 feet		
Fence Type	Materials	Labor	Total
4 woven wire + 1 barb	70	25	95
10 wire high-tensile	55	20	75
5 wire barb	44	27	71
8 wire high-tensile	46	11	57
3 wire high-tensile electric	20	4	24
3 wire portable electric	16		16
1 wire portable electric	6		6

Source - University of Kentucky, 1989

For Further Information

Video Tapes

Temporary Electric Fences by Dave Pratt, University of California, Cooperative Extension, Napa/Solano County Livestock Advisor.

Books

Fence System Design Handbook by HTF System, 851 Richards Blvd., Sacramento, CA 95814.

Gallagher Power Fencing Manual, PO Box 708900, San Antonio, TX 78270.

The New Fencing System Made Simple, by Premier Fence Systems, Box 89, Washington, IA 52353.

Fences, Society of Range Management, 1839 York Street, Denver, CO 80206.