IRRIGATED PASTURE PRODUCTION

in the Central Valley of California

Barbara Reed and Larry Forero

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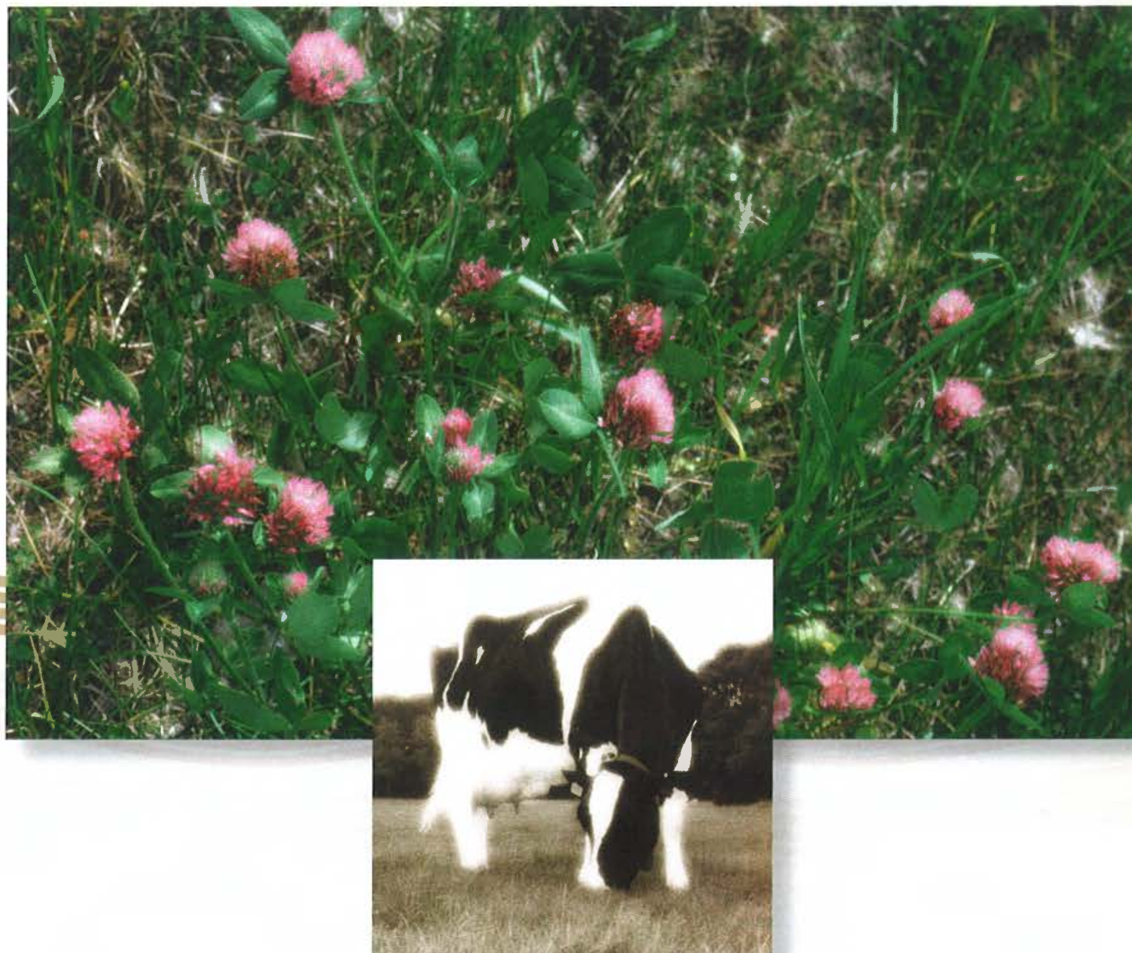

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FOREWORD

Irrigated Pasture Production in the Central Valley of California is intended to provide the residents of the region with current information on establishment, maintenance, and grazing management of irrigated forages. Irrigated pasture acreage in the state was just over 1.1 million acres in 2004. Agriculture Commissioner reports estimate the value of pasture between $100 and $120 per acre per year, and though it is not as high-profile as many other crops, the overall statewide value is around $100 million dollars. The forage provided by irrigated pasture supports the California beef and sheep industries, portions of the dairy industry (including heifer production), and the horse industry. Irrigated pasture provides between 5 and 6 million Animal Unit Months (AUMs*) of forage annually, including summer forage for California ranches, and is critical to their economic sustainability.

Barbara Reed

Larry Forero

**An Animal Unit Month (AUM) is the amount of forage needed to meet a beef cow's nutritional needs for one month, approximately 1,000 pounds of feed dry matter (DM).*

CHAPTER 1

PLANTING IRRIGATED PASTURE

Charles Raguse

INTRODUCTION

Irrigated pastures, which are a mixture of perennial grasses and legumes, can be grown successfully in practically all areas of the Sacramento and San Joaquin Valleys. Livestock utilization of irrigated pasture from November to February is limited because of lack of forage growth at that time of year and the potential for wet-weather grazing to cause permanent damage to the turf on certain types of soil. Special irrigation, fertilization, and weed control problems occur where soils are extremely shallow or have layers of hardpan or perched water tables that limit the rooting depth of the forage species. A water supply sufficient to meet crop demands is a definite prerequisite. Planning for a new irrigated pasture should not proceed unless this is ensured; otherwise, the long-term survival of the pasture is at risk.

PLANNING IN ADVANCE

Planning for the establishment of a new irrigated pasture or the renovation of an existing but degraded one ideally should begin two years in advance of planting. The reason is that you need to follow a proper sequence of seedbed preparation steps in order to ensure a vigorous, dense population of desirable plants in what will be a perennial crop.

SEEDBED PREPARATION: PHASE I

The first phase of seedbed preparation is a pre-planting sequence of annual crops, each of which should be economically justified in the overall farming system. The purpose of phase I is to guarantee the overall suitability of the seedbed for establishment of a long-term perennial crop, and will require at least one full calendar year. Any land leveling, alteration or repair of existing levees, control of noxious and troublesome weed populations, or cultivation must be done before you seed a winter cereal grain, oats for hay, or other desirable winter annual.

Following spring harvest of the winter annual and any additional cultivation, weed control, and other necessary operations, you plant a summer crop of sudangrass, forage sorghum, or corn. You have the option of grazing livestock on the summer crop, but this is not recommended because a primary purpose of the summer planting is to shade out summer-growing weeds. The preparation done before you plant the summer crop makes for easy "touching-up" in preparation for phase II.

Irrigated pasture forage plants do not have a deep root zone like alfalfa, so seedbed preparation for the annual crop that precedes pasture does not necessarily have to include deep ripping. Deep ripping is recommended, however, for sites with soil compaction or other soil structural problems (like a hardpan) that would interfere with water infiltration and drainage. For more details on ripping, refer to Intermountain Alfalfa Management (UC ANR Publication 3366). Information on field slopes for proper irrigation is in Chapter 4 of this book.

Before planting the summer annual crop, fields that do not require deep ripping (and those that have already been deep ripped) should be disced, harrowed, and then ringrolled or cultipacked to create a firm, fine-textured top layer of soil that is several inches deep. The goal is to have a field surface that will allow seeding at the proper depth, irrigation of the seedbed, and good soil-to-seed contact. Once this has been accomplished, you can plant a summer annual crop and then fine-tune the field to correct any remaining problems after that crop has been harvested.

Table 1. Weight of seed per pound varies widely for different forage species*

Forage	Seed per pound	Planting depth
Alfalfa	220,000	¼ to ½ inch
Bermudagrass	2,000,000	¼ inch
Birdsfoot trefoil	1,000,000	¼ to ½ inch
Ladino clover	860,000	¼ inch
Orchardgrass	590,000	¼ inch
Red clover	270,000	¼ inch
Rhodesgrass	3,800,000	¼ to ½ inch
Ryegrass, annual	224,000	¼ to ½ inch
Ryegrass, perennial	230,000	¼ to ½ inch
Strawberry clover	300,000	¼ inch
Sudangrass	50,000	½ inch
Tall fescue	226,800	¼ inch

* Seed weight will influence seeding rate to achieve the proper density of germinated seeds per square foot. Seeding depth of most irrigated pasture forage species is between ¼ and ½ inch.

SEEDBED PREPARATION: PHASE II

When phase I is complete, the field will have a uniform surface soil cultivation of 2 inches that will provide a seedbed appropriate for planting a mixture of grass and legume seed that are, in fact, very, very small (see table 1). The objective of seedbed preparation is to provide the right conditions for the seed embryo to germinate, establish a functional root system, and utilize its seed-energy reserve making photosynthetic (leaf) tissues. This is a high risk period in the growth of a perennial plant from seed, as compared to the regrowth of a mature plant from the base of its stem after grazing or mowing. The germinating seed will do best in an optimal environment, and that is why you want to do an excellent job in phase I. Photo 1 shows a land leveling operation to get the proper slope for irrigation.

CHOOSE A PLANTING SEASON

Spring. Planting a small-seeded grass-legume pasture in spring in California's Central Valley can only be justified when spring establishment is the only option and the need for seedbed preparation and control of existing and potential weed infestations are minimal. Soil surface crusting (which prevents optimal emergence) and root zone drying (which desiccates seedlings) can cause the complete failure of a spring seeding, and with it the total loss of the land preparation and seeding costs that

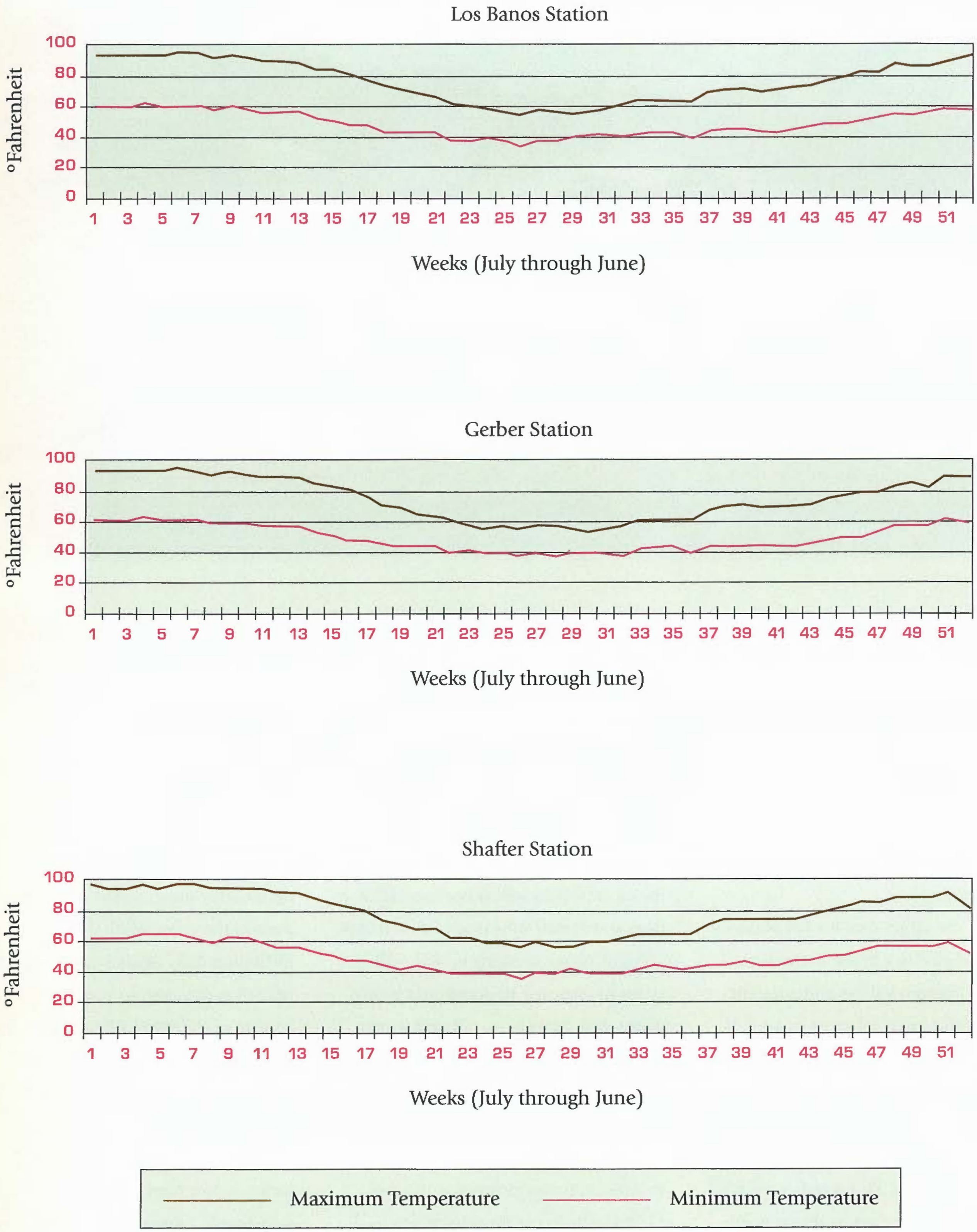
Photo 1. Land leveling to get the proper slope on a seedbed before planting.

preceded it. The decision to plant annual pasture in spring assumes (1) an accelerated need for re-establishment because of earlier-than-expected failure of another pasture and (2) the grower's capacity to closely control irrigation management, weeds, and forage utilization during planting and establishment.

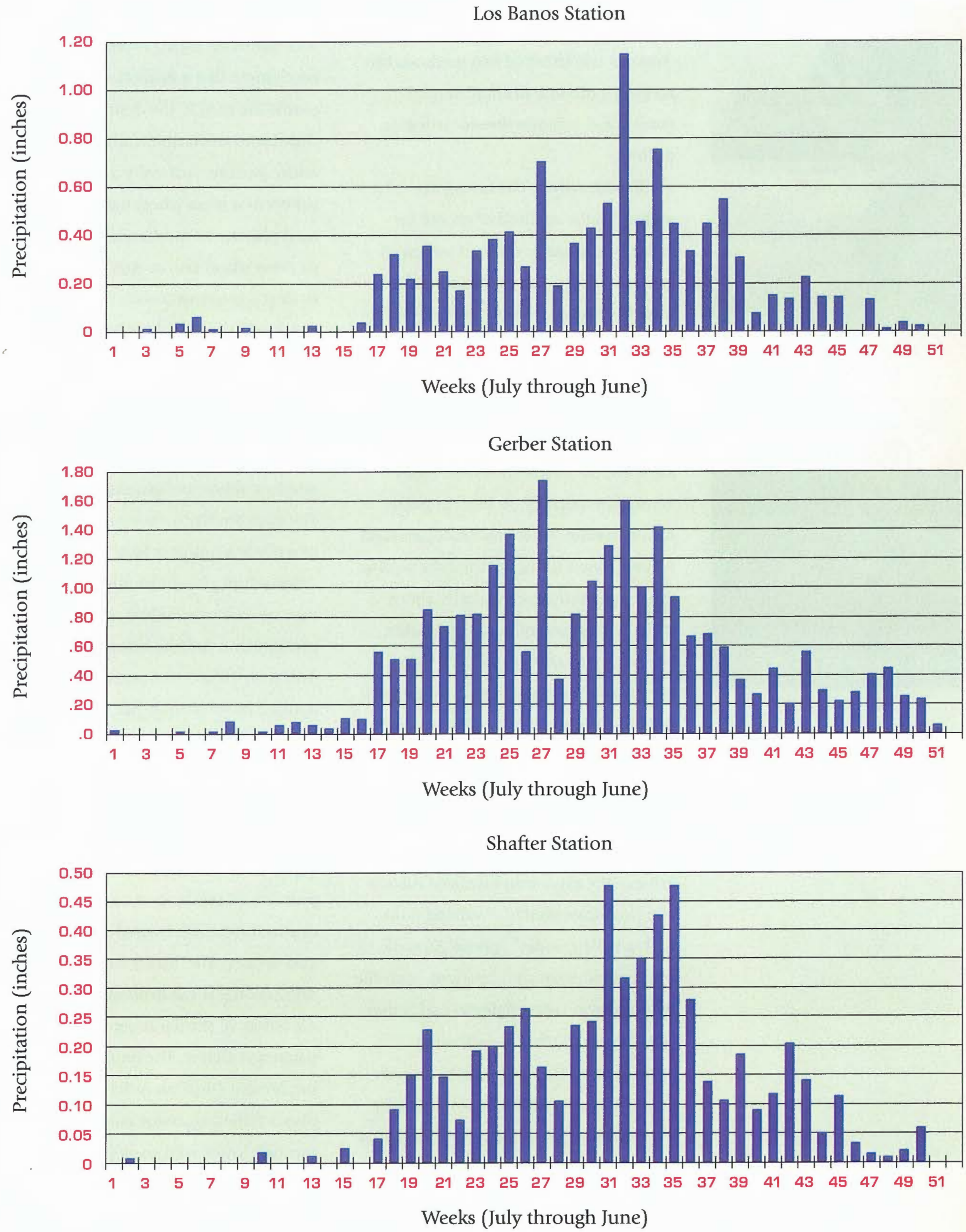
Fall. The target date for fall planting of annual pastures in the Sacramento and San Joaquin Valleys and adjacent areas should be October 15 or later. If you need to change your target date, it is better to shift to a planting date later than October 15 rather than earlier, since there may be delayed onset of fall germinating rains. Hot weather coupled with two or three days of strong north winds can desiccate seedlings. Late (or even mid) September and early October are tempting planting dates because of the potential for stronger seedling growth, but weeds take advantage of the same benefits. Furthermore, early fall plantings are subject to more insect predation and foliar diseases. The absolutely critical requirement for a good pasture is successful germination and early plant establishment. If this initial establishment is not successful, it does not matter how many other things go right. Some seedling growth will occur in response to occasional sunny, warm days during late fall and winter. Come spring, the established seedlings will be ready to continue growth.

Figures 1A, 1B, and 1C illustrate the average weekly maximum and minimum temperatures for 10 years (1995 to 2005) at three locations in the Central Valley: Los Banos (figure 1A), Gerber (figure 1B), and Shafter (figure 1C). Shafter minimums are higher than at the other two locations and Los Banos temperatures are moderated by coastal winds coming through the Pacheco Pass.

Figures 2A, 2B, and 2C show weekly total rainfall for the same locations over the same 10 years. Irrigated pastures in the northern Central Valley will have significantly more rainfall. Southernmost parts of the valley will have very high minimum daily temperatures and no rainfall at planting, so you may have to irrigate in order to initiate seed germination and growth. In general, enough water must be applied to keep the soil's surface moist. This will depend on the evapotranspiration (Eto) for the location. Northern valley locations have significantly more rainfall through the winter and spring than southern locations. The data for figures 1 and 2 were derived from CIMIS records.



Figures 1A, 1B and 1C. Weekly average maximum and minimum temperatures from 1995–2005 at Los Banos, Gerber and Shafter CIMIS stations.



Figures 2A, 2B and 2C. Ten-year average weekly precipitation from 1995–2005 at Los Banos, Gerber and Shafter CIMIS stations.

Photo 2. Hand seeder (belly grinder).

SEEDING

You can use either of two methods for seeding a mixture of small-seeded grasses and legumes: broadcasting or drilling.

Broadcasting. The broadcast method is the method of choice for small land areas or difficult terrain. A variety of tools that are available for broadcasting can simply be strapped to a person's body, and include both a reservoir for seed and some means of scattering the seed. Wheeled broadcast seeding implements can also be used: these are the better choice for larger acreages, especially on level to gently rolling terrain. After you broadcast seed you will want to incorporate the seed to the proper soil depth (usually about ¼ inch) with a ringroller or cultipacker. Sprinkler irrigation or rainfall then germinates the stand. Flood irrigation is possible, but must be applied carefully to avoid any displacement and burial of seeds due to water flow.

Broadcast seeding requires 25 to 35 percent more seed than drilling to achieve the same stand density. Also, if you broadcast seed by "walking it on with a belly grinder" (photo 2), walk the area twice on a grid pattern, with the two passes at right angles to each other (e.g., north/south and east/west), applying half the seeding rate on each pass. This grid pattern is not necessary when you use a tractor-drawn broadcast implement. It is not feasible to broadcast seed into sudangrass stubble. See the following section on drilling for how to seed into sudangrass stubble.

Drilling. Drill seeding is accomplished with a multipurpose implement like a Brillion seeder that plants the seed at the desired depth and distributes them uniformly over the entire pasture. Normally a seed drill has rollers or a press wheel that follows the seed placement mechanism. The rollers or press wheel ensure that the seed are in firm contact with soil. This promotes quick and successful seed germination once the seeds are provided with adequate moisture. Further, most commercial drills also provide for fertilizer application through an additional box and placement tubes. The opportunity for proper application of a needed fertilizer (e.g., a mono-ammonium phosphate like 11-52-0) may be well worthwhile on soils low in phosphorus. Adding nitrogen in the drill rows (like 5 to 6 pounds per acre, applied in 50 pounds per acre of 11-52-0) could be an economically justified benefit to rapid establishment of the seeded species. Some drills have separate boxes for grasses and for legumes. This feature minimizes the problem of seed separation in the mixes due to differences in seed size, shape, and density. The "Gold Standard" for drill seeding is the Brillion (photo 3). All others of similar design were patterned after it. The rental cost of the implement (Brillion or its equivalent) plus a skilled operator may be recovered through lower seed costs (lower seeding rates) and for the lower fertilizer application rate.

A no-till drill (photo 4) can be used if planting into a sod that has been grazed close to the ground or into sudangrass stubble and is preferred for the renovation process if the sod is to be disturbed as little as possible.

PLANT SPECIES SELECTION

The grasses and legumes typically used for pasture in the Central Valley are listed below. The list includes true perennials, "short-lived perennials," biennials, and annuals. Perhaps the most important economic consideration with regard to plant species selection is whether legumes will be included in grass plantings to provide the nitrogen necessary for high production or whether nitrogen fertilizers will be used instead. Forages that are 12.5 percent protein (equal to 2% nitrogen) or contain 40 pounds of nitrogen per ton of dry matter will require approximately 50 to 60 pounds of nitrogen for 1 ton of dry matter (or 2 AUMs), whether it takes the form of nitrogen fertilizer or legumes growing with the grasses.

The choice of which type of fertilizer to use also determines which plant species will benefit the most from the application. Nitrogen fertilizers favor the growth of grasses, whereas phosphorus, potassium, and sulfur fertilizers favor the growth of legumes, which will "fix" more nitrogen from the atmosphere and make it available to the grasses. Although you can produce slightly more total forage by applying high rates of nitrogen to grasses, it is far more economical to fertilize the legumes and let them provide the necessary nitrogen for the grasses. Growing the legume in association with grasses also keeps the forage's protein production level 2 to 5

Photo 3. Brillion seeders have long been used for planting irrigated pasture.

Photo 4. Using a no-till drill to plant an irrigated pasture.

percent higher throughout the year. Most ranchers use a mix of plant species, both to hedge against the possible failure of a monoculture and to get more consistent productivity through the growing season. The specific makeup of the mix will depend on local weather, soil type, livestock species to be grazed, and the management goals of the operation (photos 5 and 6).

Photo 5. Making a custom seed mix in a Brillion seeder.

Grasses

Advantages of grasses include their wide-spreading and moderately deep (18–24 inches), fibrous root systems. A well-established stand of grasses will hold a soil surface remarkably well against erosion and over time the turnover of its root system will contribute to the organic matter content of the soil and the enhancement and maintenance of tilth and good soil structure. As a group, the irrigated pasture grasses exhibit a larger range of vigor and robustness of growth than do the irrigated pasture legumes. Table 2 provides information on grass growth habits.

Grasses are erect in growth habit. Their regrowth is typically from buds at the base of the mature plant. Grasses, if grown by themselves, will not grow at optimum levels without nitrogen fertilization. For each ton of forage dry matter produced, grasses require 40 to 60 pounds of nitrogen. The cost of nitrogen fertilizer, more often than not, is offset by the combination of greater yield and higher forage quality, particularly in terms of higher protein content and greater digestibility. Some

Hawes Bloat Resistant Pasture Mix — Lot# 206HBRB-1

PURE	SEED	KIND	GERM	ORIGIN
28.55%	ORCA	Orchardgrass	90%	OR
28.07%	PRANA	Tetraploid Perennial Ryegrass	90%	OR
19.70%		Tetraploid Annual Ryegrass*	90%	OR
10.02%		Strawberry Clover*		CA
	Germination: 81.00% + Hard seed: 05.00% = 86.00% Total Germ			
09.64%	Birdsfoot Trefoil*		90%	OR
01.85%	Crop Seed			
02.12%	Inert Matter			
00.05%	Weed Seed			

*Variety not stated

Net wt: 50LBS., 22.68 KGS. Tested: 11/06, in CA sell by: 02/08 No noxious weeds

C&MS11
HAWES RANCH AND FARM
21923 DERSCH RD.
ANDERSON, CA 96007

Photo 6. Seed label

grass species produce an abundance of flowering stalks in early season. These grasses may require clipping, harvesting for hay, or increased grazing frequency to keep the grass in a vegetative (not flowering) state.

Irrigated pasture yields range from 8 to 12 tons of dry matter (DM) per growing season if adequately fertilized with manures or nitrogen fertilizers. A combination of warm- and cool-season grasses provides the majority of dry matter.

Orchardgrass is a perennial, bunch-type grass that is blue-green in color (photo 7). It has flattened stems and an extensive root system and an abundance of basal leaves, all of which helps it stand up to grazing. It is very palatable forage in its early stages of growth, but it becomes coarse and tough as it matures. Orchardgrass starts growth later in the spring than perennial ryegrass and goes dormant earlier in the fall. Optimum growth temperatures are around 70° to 75°F. It is less heat tolerant than tall fescue, although it produces somewhat better than perennial ryegrass during the warm season. Orchardgrass does not tolerate wet soils or flooding well.

Perennial ryegrass is a fine-stemmed plant that begins growth earlier in the spring than orchardgrass and continues later into the fall (photos 8 and 9). Perennial ryegrass is sensitive to temperature extremes. Even with irrigation, production decreases when daytime temperatures exceed 87°F (31°C) and nighttime temperatures exceed 77°F (25°C). Short periods of flooding do not generally reduce the stand of well-established ryegrass. A detailed discussion of perennial ryegrass is available online (go to http://forages.oregonstate.edu/index.cfm?PageID=33 and select "perennial ryegrass" from the Species menu).

Photo 7. Orchardgrass is a perennial bunchgrass.

Photo 8. Perennial ryegrass is a highly digestible, cool-season plant (entire plant).

Table 2. Attributes and management characteristics of major California irrigated pasture grass species

Species	Growth habit	Turf strength	Type of inflorescence
Bermudagrass	Very weakly erect, strongly rhizomatous, and strongly stoliniferous	Very strong in mature monoculture	Digitate array of spikes at stem tips
Dallisgrass	Erect bunchgrass, strongly tillering	Moderate to weak	Array of racemes
Orchardgrass	Erect bunchgrass	Moderate to weak	Stiff, spreading panicle
Rhodesgrass	Weakly erect, stoloniferous, creeping	Strong in mature monoculture	Dense, spikelike floral racemes, each 1½–6 inches long
Ryegrass (annual)	Erect bunchgrass	Weak	Slender spike with spikelets edgewise
Ryegrass (perennial)	Weakly erect, low-growing bunchgrass	Moderate to weak	Slender spike with spikelets edgewise
Smooth bromegrass	Erect sod-forming grass with underground rhizomes	Moderate to weak	Loose, narrow panicle
Tall fescue	Erect bunchgrass	Very strong in mature monoculture	Loose, narrow panicle

	Productivity	Stand life	Desirable features	Management problems
	Potentially high if well fertilized with N	Indefinite if well established	Suitable for use where heavy traffic and grazing pressure would occur; used almost exclusively in Imperial and Riverside Counties	If already in place, manage similarly to tall fescue and Dallisgrass; requires rigorous management; do not attempt to plant in a mixture that includes a legume; complete dormancy in the Central Valley below 50°F
	Very high if well fertilized with N	Indefinite if well established	Huge midsummer growth peak, which can be used to fill gaps caused by "summer slump" of other species	A species well known for taking over pastures; not suitable for inclusion in a mixture; an aggressive invader from irrigation ditchwater, as seed floats readily
	Moderate to high if fertilized with N	Moderate to short	Higher nutritional values than tall fescue and easier to manage in a mixed stand	Tendency to become a minor component of a grass-legume mixture
	High in humid, tropical areas	Long if good fertility	Suitable for use on saline soils in the southernmost parts of the Central Valley	Requires adequate soil fertility and will not compete in a mix with bermudagrass; same dormancy issues as bermudagrass
	Moderate to high, depending on N fertility	Annual, but reseeds itself effectively	Quick, strong establishment and fibrous root system make it a good addition to a planting mix for perennial grasses and legumes, especially on sloping terrain	No management problems, although annual grasses will disappear or become minor as perennials get established
	Low to moderate, but of high quality	Moderate to long if properly managed	Very high and seasonally consistent nutritional quality; not aggressive in mixed stands; responsive to N fertility	Tendency to become a minor component of grass-legume mixtures
	Moderate to high	Moderate	High productivity makes it a desirable hay crop elsewhere, so it is suitable for pastures where a hay cutting is taken before grazing	Less competitive than tall fescue and will tend to disappear from the stand over time; better suited to climates cooler than the Central Valley
	High if fertilized with N	Very long	Tough turf can hold up to heavy grazing	Highly aggressive; relatively low palatability in a mixture; strongly clumping; livestock avoid tall fescue when it is mature

Photo 9. Seedhead detail of perennial ryegrass.

Annual ryegrass is a vigorous, stemmy annual that is capable of early, heavy spring growth but does not persist into the summer (photos 10 and 11). Annual rye grass is tolerant of wet sites.

Dallisgrass is a warm-season perennial with a deeper root system than ryegrass (photo 12). It starts growth late in the spring and goes dormant in the fall. Dallisgrass will continue to grow even on the hottest days, producing heavily during the summer. If not intensively managed, it is not suitable for hay because it grows in clumps that tend to die out in the center and enlarge around the edge as the plant ages. These large clumps can be hard on harvesting equipment. Intensive grazing management can minimize this problem and keep clump development to a minimum. Dallisgrass will endure extremes of heat and moisture.

Tall fescue is among the most tolerant of both wet soil conditions and drought of any of the cool-season grasses (photos 13 and 14). If high plant densities are established, it forms a dense sod that is tolerant of trampling and winter grazing, a particularly desirable quality on heavy clay soils. Heavier soils will not drain as readily as loam or sandy loam soils. Animal traffic on soft, wet ground can tear the plants out by their roots and ruin a good leveling job by creating holes in the turf. At lower plant densities, tall fescue grows in clumps and is not very palatable for hay if

Photo 10. Annual ryegrass must be replanted each year unless it has gone to seed and established a seed reservoir in the soil.

Photo 11. Seedhead detail of annual ryegrass.

harvested when fully mature. Although it is more tolerant of mismanagement than orchardgrass or ryegrass, it requires more intensive management to maintain high forage quality.

Bermudagrass is a warm-season perennial species adapted to tropical and subtropical climates but is used in warmer areas of the Central Valley. It grows best under extended periods of high temperatures, mild winters, and moderate to high rainfall. When average temperatures drop below 50°F (10°C), growth stops. In warm, frost-free climates Bermudagrass remains green throughout the year, but growth is significantly reduced at the onset of cool nights. Optimum daytime temperature for Bermudagrass is between 95° and 100°F (35° and 38°C). Bermudagrass performs poorly on waterlogged soils.

Rhodesgrass is a perennial grass adapted to the humid tropics and subtropics. It is stoloniferous and creeping like Bermudagrass. It does not do well on heavy soils but can tolerate saline conditions. This grass does not compete well with Bermudagrass, so Bermudagrass should be eradicated if Rhodesgrass is to be planted. Neither Bermudagrass nor Rhodesgrass is suited to the northern end of the Central Valley because much of the growing season there is too cool for maximum productivity of tropical forages. Rhodesgrass is tolerant of wet sites.

Smooth brome does well in mountain pastures but is not adapted to lower elevations with their hot, dry summers. It is not recommended for valley locations.

Photo 12. Dalligrass produces forage in the Central Valley's hottest weather.

Photo 13. Tall fescue can become unpalatable if it matures into large clumps.

Table 3. Attributes and management characteristics of major California irrigated pasture broadleaf species

Species	Growth habit	Turf strength	Type of inflorescence	
Alfalfa	strongly upright	low to moderate in mature stands	raceme	
Alsike clover	upright	poor to moderate	head	
Birdsfoot trefoil, broadleaf	weakly upright	weak	umbel	
Birdsfoot trefoil, narrowleaf	prostrate to weakly upright	weak to moderate	umbel	
Crimson clover	upright	poor	head	
Ladino clover	stolons; moderately spreading	weak	head	
Red clover	upright	moderate	head†	
Strawberry clover ('Salina')	stolons; strongly spreading	good, if stand is dense	head	
Sweet clovers, yellow- and white-flowered	strongly upright	poor	raceme	

* May have a place as an oversown winter annual in perennial grass-legume pastures as the legume content decreases. Risk: Early spring rains and wet soil that prevent early grazing.

† Determinate inflorescence development.

‡ Coumarin, an aromatic compound responsible for the bitter taste of leaves and for the "sweet" smell after harvest, can convert to dicounarol, a blood-thinning agent, upon spoilage, and can then cause sickness or death of livestock that consume the feed. Breeding programs have sought to lower coumarin content.

	Productivity	Stand life	Desirable features	Management problems
	high	4 to 8 years under excellent management	high, long-season yields; very high nutritional quality, especially at early stages; well suited to intermittent harvest	The regrowth behavior and tolerance to cutting make alfalfa much better suited to mechanical harvesting. It is included here for sake of completeness.
	low to moderate	variable; considered a short-lived perennial	tolerant of cool, wet, and acid soils; a "niche" plant; when combined with timothy, was a premier horse hay in Midwest	Should not be considered in warm to hot climates or where favorable soil and water conditions permit growth of more productive species.
	moderate	moderate	not competitive in mixes with aggressive grasses	Reputation of being bloat-free. Once was the premiere sheep pasture in California. Best suited to deep soils.
	low	moderate to high	quality similar to broadleaf birdsfoot trefoil; a dependable "niche" species, especially where soils are highly variable	None.
	moderate to high	winter annual; very weakly reseeds	as a winter annual, provides a stand competitive to weeds and is palatable and nutritious; * heads are eaten readily	In its place, no major management problems known.
	high	moderate to short	excellent nutritional value, palatability, and digestibility	Can cause bloat; soil nutrition and grazing management are critical.
	moderate to high	ordinarily only 2 years	quite productive on good sites; a good choice for 2-year interim crop and alternate with hay	Stand life chancy; behaves as if it were a short-lived perennial. Susceptible to foliar diseases. Does better in cooler climates.
	moderate	moderate to perennial	spreads readily into open areas; tolerates close grazing well	Overshading will weaken and diminish stand. Hard seed content can cause it to be an invader in future crops. Less bloat-causing than Ladino clover.
	high	biennial	suitable as green manure crop	Because of its hardseeded nature, can volunteer in future years. Mature forage is coarsely stemmy. Coumarin to dicoumarol can be toxic.[‡]

Legumes

Photo 14. Detail of a tall fescue plant.

The advantages of legumes for perennial irrigated pasture lie in their greater nutrient content, their greater digestibility, and, most certainly, their ability to capture gaseous nitrogen from the atmosphere and convert it into plant protein. The nitrogen fixed by legumes also becomes available to grasses growing in association with the legumes. Research utilizing a stable, non-radioactive isotope of nitrogen ("labeled nitrogen") has demonstrated that "fixed nitrogen" may become available to grasses within two weeks of the time it was fixed by the legume. Most legumes are adapted to warm temperatures and are therefore more productive during summer than the cool-season grasses.

Pasture legume species can either be tap-rooted and erect in growth habit (such as alfalfa, which also produces its harvestable forage as upright "tillers" from its basal, or "crown" area) or stoloniferous, meaning that its true stems (in this case, "stolons") travel horizontally along the soil surface. In both instances, however, the meristems (specialized sections of plant tissue characterized by cell division and growth) that produce new vegetative growth are in protected locations. The root systems of stoloniferous legumes (e.g., Ladino and strawberry clovers) are much less extensive than are those of grasses and occupy a much smaller soil volume that is also closer to the soil surface. The roots can be damaged or dried out if not properly cared for. The roots of stoloniferous legumes arise from successive nodes along the stem; if plants are effectively nodulated, they will bear the nodules within a 2- to 4-inch depth and often at the soil surface.

The technical details just given illustrate that the critical management zone for continuity of soil moisture and fertility, prevention of soil surface compaction, and suitability of favorable soil surface temperature under hot and dry climatic conditions is very shallow for legumes, compared to that for well-established grasses. Table 3 provides information on legume growth habits.

Ladino clover is a large form of white clover (photo 15). It is a shallow-rooted clover ideally suited for use on shallow, hardpan soils. Its growing season is as long as those of other legumes. It is winter dormant in the northern Sacramento Valley, however, and has a production sag during midsummer.

Photo 15. Ladino clover is also called white clover.

Strawberry clover is a perennial legume similar to Ladino clover and is more tolerant of drought, salinity, and poor drainage (photo 16). In a mixture, it will become the dominant legume where adverse factors might limit the growth of Ladino. Salina, a popular variety of strawberry clover, is less likely than Ladino to cause bloat.

Alsike clover is a perennial legume used chiefly in the northern counties at higher elevations (photo 17). It is able to withstand wet, cold, and heavy soils better than many other legumes, but it is not suitable for areas with high summer temperatures.

Red clover is a short-lived perennial that grows like a biennial in most pastures and does not do well in excessively dry or wet conditions (photo 18). Under damp conditions, it is prone to foster the growth of powdery mildew. It is generally more productive than the other clovers mentioned above. Although it is a highly palatable, nutritious forage, its short stand life is a disadvantage.

Alfalfa is a deep-rooted, hardy perennial that produces high yields of quality feed under proper grazing management (photo 19). While there are many varieties available, non-grazing types are not suited to short-rotation or continuous grazing. When alfalfa is in the mix, the pasture needs to have short-duration grazing periods, adequate rest intervals, and at least a 3-foot depth of well-drained soil. It should be noted that although we mention alfalfa here, it is not considered as a serious contender for inclusion in a pasture mix since few grazing cultivars have dormancy ratings appropriate to the Central Valley. Seed dealers should have information about certified alfalfa varieties that are adapted to grazing and to California valley dormancy and climate conditions.

Narrowleaf or birdsfoot trefoil is a perennial legume that is not as productive as the clovers and alfalfa (photo 20). It is non-bloating and well-adapted to alkaline soils. It is a legume favored by many horse owners.

Photo 16. Strawberry clover

Photo 17. Alsike clover

This photograph is copyright Oregon State University, Forage Information System (http://forages.oregonstate.edu), and is used here by permission.

Photo 18. Red clover

Photo 19. Alfalfa

LEGUME-GRASS MIXTURES FOR IRRIGATED PASTURES

There are several reasons for planting a forage mixture instead of a single species. A few are listed below:

- To take advantage of the complementary benefits of a variety of different grasses and legumes. Legumes fix considerable nitrogen, which increases the protein content not only of the legumes but also the nearby grasses. Grasses grown alone require substantial amounts of nitrogen—50 to 60 pounds of N per ton of dry matter forage—to attain high yields, and legume-grass mixtures require less supplemental N.
- Different species' growth characteristics will help plants to fill different niches within a field and provide some assurance that the entire planting will not fail.
- Different patterns of seasonal growth will provide greater and more uniform overall yield as well as extend the season available for pasturing.
- In case of stand failure of one or more of the component species, other species in the mix will "take over" and maintain the productivity of the pasture.

Photo 20. Birdsfoot trefoil

During much of the growing season, temperatures are not optimal for forages, such as ryegrass, that originated in temperate zones. In such cases, plant growth will be slower than normal. The optimal production temperature range of cool-season grasses and legumes is compared to air temperature in figure 3.

It is important to recognize that the optimal production temperature range of cool-season grasses and legumes is very narrow compared to the summer temperature range derived from CIMIS data in Butte County (figure 3). Cool-season grasses and legumes will grow best in the spring and fall when daily temperature swings are more moderate and the maximum daily temperature is closer to the optimum temperature for the forages.

For pasture mixes, use from four to six well-adapted, palatable, nutritious species that do not compete strongly with each other. Many seed companies make pre-packaged pasture mixes, and it may be more convenient for someone with only a few acres to buy a ready-made mixture than to buy a few pounds of several different seeds. Check the seed tag to be sure that the pre-mix contains the grass and legume varieties you desire. Purchase certified seed to avoid introducing weeds or unknown forage species into your pastures. You can purchase custom mixes or create your own but the cost may be significantly higher than for pre-mixed seed. Use the germination rate and inert matter listings to calculate your final germination rate. See photo 6 for a typical seed label.

SEEDING RATES AS A BASIS FOR COMPOUNDING MIXTURES

Base your seeding rate on both the germination rate and the purity of the seed you have purchased. That way, you will account for seeds that will not germinate and inert matter in the bag. To calculate the Pure Live Seed (PLS), multiply germination rate times purity and divide by 100. You can find the germination rate and inert matter content on the seed tag.

PLS% = (% germination) x (% purity) ÷ 100

Next, use the PLS to calculate the seeding rate.

Seeding rate of bulk seed = (recommended PLS seeding rate) ÷ (PLS%) x 100

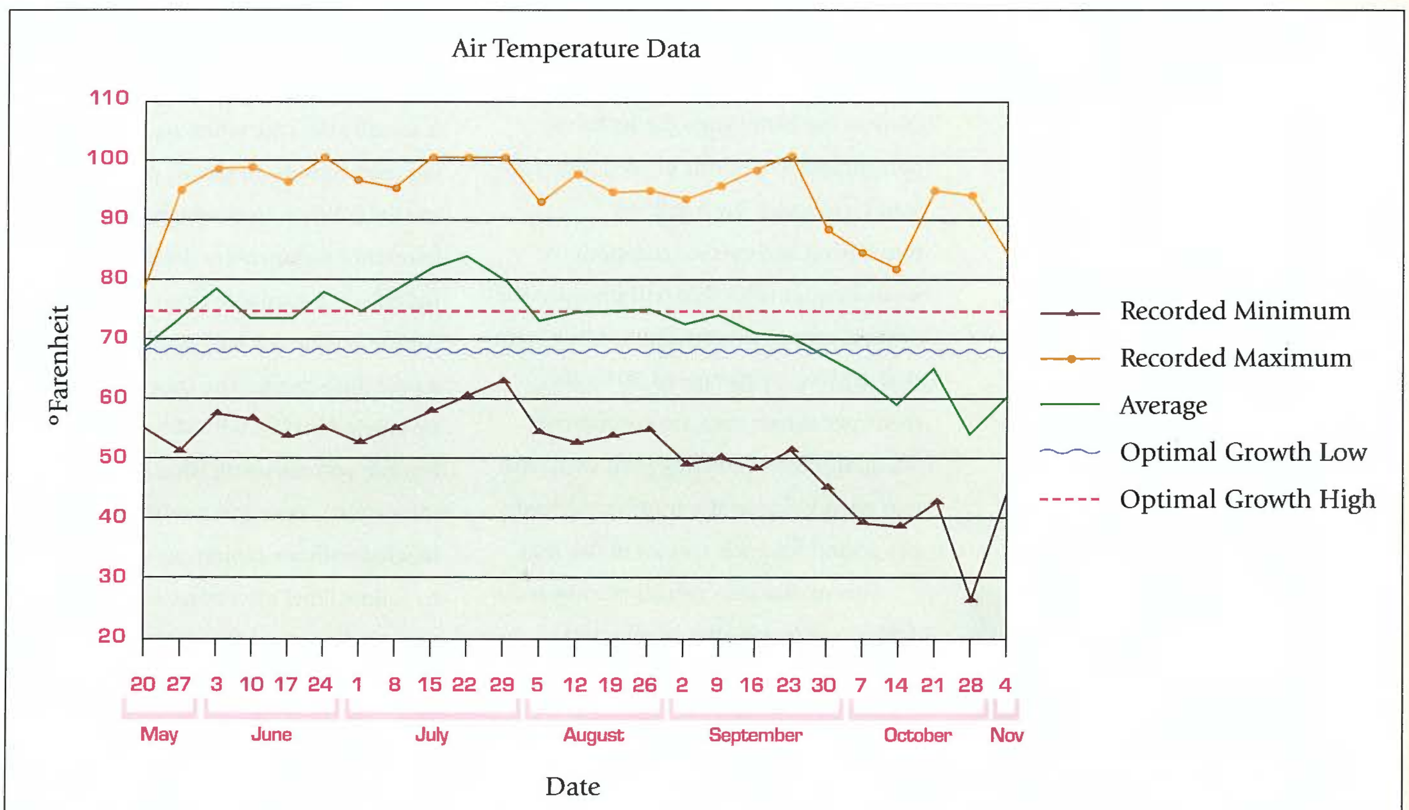


Figure 3. Optimal production temperature range of cool-season grasses and legumes compared to summer temperatures derived from CIMIS data in Butte County.

Transect Evaluation

You can do your own evaluation of plant density as follows. With stubble height at 4 to 6 inches, walk a straight-line transect of the pasture and stop at regular intervals. Look down and imagine a one-foot-square frame in front of your foot. How many of the sown species do you find? At least half of the time you should find at least 60 percent of the species sown, and plants should cover 80 to 85 percent of the ground. A good pasture would have all of the planted species in 90 percent of your observations. If your observations do not match these guidelines, your pasture may need renovation.

For more information on forage species, you can consult the Forage Identification CD-ROM available from Oregon State University's Forage Information Systems (FIS) Web site (http://forages.oregonstate.edu/).

A seeding rate of 16 to 20 lb of PLS per acre for a pasture forage mix is generally recommended. Satisfactory stands of irrigated pastures have been obtained with lower seeding rates of 12 to 14 lb per acre, but when seedbed preparation, seeding techniques, fertilization practices, and weather conditions are not ideal, an inadequate stand may result. It is better to seed at a rate that will overcome conditions that may be less than ideal in order to produce a more dense stand. If you are planting into an old pasture with a history of Ladino clover, do not add that to the seed mix or you will have an excess of clover.

MAKING YOUR OWN MIX

A good place to begin is with one of the mixtures listed in table 4. Then examine the tag on the commercial mixture and convert the list of ingredients from percentages to pounds of seed. You can build a mixture "by hand" by purchasing and mixing component seeds in quantities that will produce the desired species dispersion. Seeding rates that achieve a coverage of 50 to 100 seeds per square foot are considered adequate. When creating your own mix, you need to know the number of seeds per pound for each species in the mix.

This necessitates careful mixing and a decision as to whether grasses and legumes are to be sown separately or together. Separate sowing is feasible (and actually desirable) when you use a Brillion seeder or some other seeder with two seed boxes. When mixing by hand, mix the smallest component with the next largest until the mix is complete. Photo 5 shows a custom mix that was planted using a Brillion seeder. Consult table 1 for seed count per pound and then look at table 4 for a sample seed mix and table 5 for seed rate calculations.

SEED INOCULATION FOR LEGUMES

The legumes used in a pasture mix will fix nitrogen from the atmosphere and provide that nitrogen for growth of the legumes themselves as well as of grasses growing in association with the legumes. Rhizobium bacteria located in the nodules on the roots grow symbiotically with the legumes, providing them with food energy while they fix the nitrogen that forms the plants' proteins. If you suspect there is little or no indigenous Rhizobium in the soil, you should inoculate the seed before planting. This is usually the case when no similar legumes have been grown previously in the field. When in doubt, it is good insurance to inoculate the seed. The inoculant is available from most seed supply businesses and comes mixed on a peat dust carrier. The inoculant should be labeled for use with the particular legume you are using (this is important), stored in a refrigerator, and labeled with an expiration date. Be sure to follow label directions and avoid mixing the inoculant with the seed too far in advance of planting or mixing it with a fertilizer. Since the inoculant contains live bacteria, proper storage temperature and avoidance of contact with certain fertilizers is important to retain effectiveness.

Table 4. Percentage (by weight) and seeding rate of forage type typically found in commercial seed mixes for livestock

Mix type and constituents	Percentage (by weight)	Seed weight (at 20 lb/acre)
General livestock mix		
Ladino clover	3%	0.6 lb
Orchardgrass	43%	8.6 lb
Ryegrass, annual	11%	2.2 lb
Ryegrass, perennial	27%	5.4 lb
Strawberry (salina) clover	16%	3.2 lb
Horse mix		
Annual ryegrass	28%	5.6 lb
Orchardgrass	44%	8.8 lb
Perennial ryegrass	28%	5.6 lb
Sheep mix		
Perennial ryegrass	65%	13.0 lb
Strawberry (salina) clover	35%	7.0 lb

NOTE: The percentage (by weight) of legumes is smaller, but the number of legume seed per pound of mix will still be high because of the seed's small size.

Table 5. How to calculate an approximate final seeding rate (not including inert matter) for a hand-made seed mix using the general livestock mix in table 4

	Amount in mix			
General livestock mix	Percentage	Weight	No. seed per pound	No. seed in mix
Ladino clover	3%	0.6 lb	860,000	516,000
Orchardgrass	43%	8.6 lb	590,000	5,074,000
Ryegrass, annual	11%	2.2 lb	224,000	492,800
Ryegrass, perennial	27%	5.4 lb	230,000	1,242,000
Strawberry (salina) clover	16%	3.2 lb	300,000	960,000
TOTAL SEED	100%	20.0 lb		8,284,800
Seed per square foot*				190
Seed per square foot at 50% germination rate				95

*1 acre = 43,560 sq ft.

CHAPTER 2

FERTILIZATION

Roland Meyer and Larry Forero

PRIMARY NUTRIENTS FOR IRRIGATED PASTURE

The productivity of irrigated pasture depends on a variety of factors including climate, precipitation or applied water (amount and frequency of irrigation, etc.), soil type, soil fertility, and plant species. In this chapter we focus on soil fertility. The primary nutrients likely to elicit a growth response include nitrogen (N), phosphorus (P), potassium (K), and sulfur (S), a list that should also include molybdenum (Mo) and perhaps boron (B) for Sacramento Valley soils. The availability of N, P, K, and S from either fertilizers or the soil has a major influence on pasture production. Very low soil pH (< 5.0) may also influence pasture production, particularly for some legume species like alfalfa that require a pH higher than 6.3. A producer may fertilize with the same product year after year without knowing the actual current nutrient levels in the soil. Informed producers routinely test their soil and plant tissues to help determine which nutrients are lacking and then fertilize their crops accordingly.

N (Nitrogen). Nitrogen is taken up by the plant as nitrate (NO3-) or ammonium (NH4+) ions, but nitrate is the primary form found in most soils. Plants use nitrogen to make amino acids, the building blocks of proteins. All living cells contain protein. Plants also use nitrogen to make chlorophyll, nucleic acids, and enzymes. Most of the nitrogen in soils is unavailable to plants because it is tied up in organic matter.

P (Phosphorus). Soil pH (acid or basic conditions) will determine to some extent the availability of phosphorus to the plant, but in general phosphorus is released very slowly by the soil. Plants use phosphorus to make nucleic acids and to store and transfer plant energy, particularly from photosynthesis.

K (Potassium). Potassium is taken up by the plant as a cation (positively charged ion) and is not combined into other compounds. It is a catalyst in many plant reactions and remains in its ion (charged) form within cells and tissues. Potassium is important in plant carbohydrate metabolism, water use, root growth, and disease resistance.

S (Sulfur). Sulfur is taken up in the anion (negatively charged ion) form as sulfate. It is found in three amino acids and is essential for protein synthesis. It is also essential for nodule formation on legume roots.

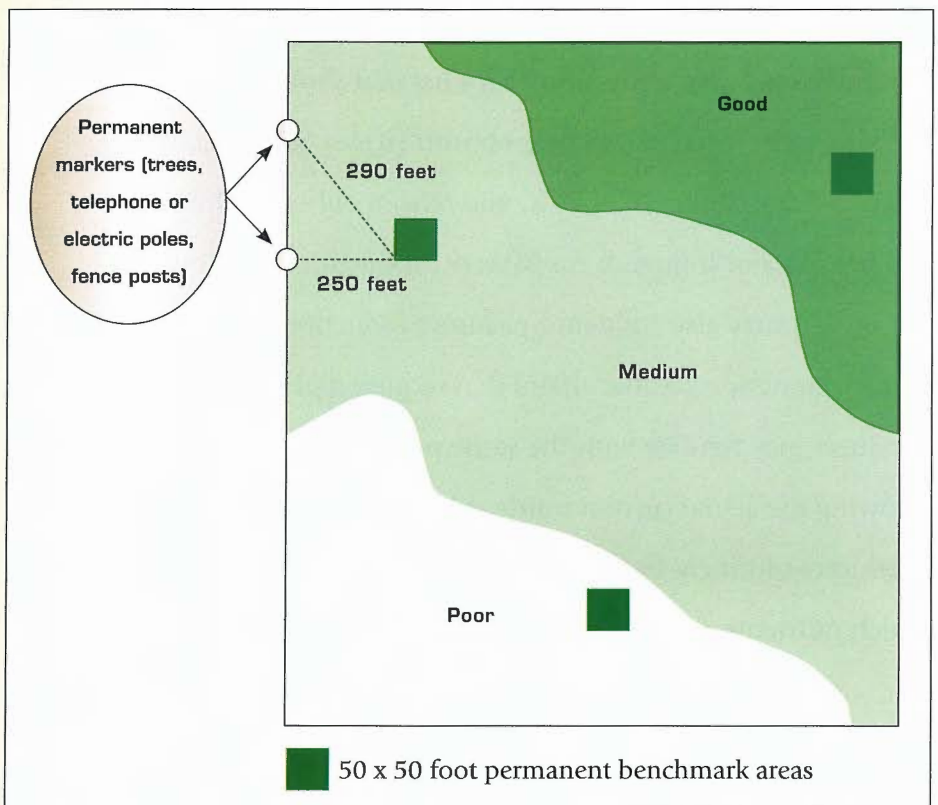


Figure 4. Sound soil and plant tissue sampling procedures involve establishing permanent benchmark sampling locations (50 x 50 feet in size) within areas of the field that support good, medium, and poor crop growth. Define these benchmark areas in relation to measured distances to specific landmarks on the edge of the field or use a global positioning system (GPS) device.

SOIL SAMPLING

Soil sampling should be done just prior to planting. Some nutrient tests should be done on plant tissues once the pasture is established, and these will be discussed later. Because a representative sample of an entire field gives an average of all the variations in that field, it is not the best approach if you want to develop recommendations for parts of the field that are less productive. The best technique is to divide each field into two or three areas representing good, medium, and poor pasture growth. Within each area, establish permanent benchmark locations for sampling that measure approximately 50 feet by 50 feet (figure 4). To ensure that you will be able to find each benchmark area again, describe it in relation to measured distances to specific landmarks on the edge of the field or use a global positioning system (GPS) device. By using this method to collect soil and plant tissue samples, you will be able to compare areas of the field with different production levels, develop appropriate management responses, and track changes over the years. In addition to testing soils for salts and pH, you should also analyze soil samples for phosphorus, potassium, and zinc (Zn) (DTPA extract). It is particularly important to test for zinc if you intend to establish a grass-only pasture. Once the pasture is established, soil tests should be taken at three- or four-year intervals.

Table 6. Interpreting the results of soil tests and rates of fertilizer required to amend deficient soils

Nutrient	If soil test is . . .*	Suggested fertilizer rate
Phosphorus (HCO3 extractable)	< 5 ppm 5–10 ppm 10–20 ppm > 20 ppm	100 lb P2O5/acre 50 lb P2O5/acre 25 lb P2O5/acre none
Potassium (ammonium acetate extractable)	< 40 ppm 40–60 ppm > 60 ppm	200 lb K2O/acre 100 lb K2O/acre 0–50 lb K2O/acre
Zinc (DTPA extractable)	< 0.5 ppm (soil pH < 7.0) < 0.5 ppm (soil pH > 7.0)	5 lb Zn as ZnSO4/acre 10 lb Zn as ZnSO4/acre

* Source: Soil and Plant Tissue Testing in California (UC ANR Bulletin 1879).

Table 7. Guidelines for obtaining plant tissues samples and interpreting test results

Plant and growth stage	Part of plant	Nutrient	Nutrient range*		
			Deficient	Critical	Adequate
Alfalfa (regrowth length of ½ to 1 inch or just prior to 1⁄10 bloom)*	middle ⅓ of plant; stems only (strip leaves off)	P (PO4) ppm K %	< 500 < 0.65	500 – 800 0.65 – 0.80	> 800 > 0.80†
	middle ⅓ of plant; leaves only	S (SO4) ppm	< 400	400 – 800	> 800‡
	top ⅓ of plant	B ppm Mo ppm	< 15 < 0.3	15 – 20 0.3 – 0.9	> 20§ > 0.9#
Clovers (ladino, strawberry, white, alsike, and red clover)*	top ⅓ of plant; leaves and stems	P % K % S % B ppm Mo ppm	< 0.15 < 1.2 < 0.10 < 15 < 0.3	0.15 – 0.20 1.2 – 1.5 0.10 – 0.15 15 – 20 0.3 – 0.9	> 0.20 > 1.5† > 0.15‡ > 20§ > 0.9#
Grasses (tall fescue, orchardgrass, and others)	top 4–6 leaves, no stems	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‡

* An economic yield response to fertilizer applications is very likely for values below the deficient level, somewhat likely for values in the critical level, and unlikely for values over the adequate level.

† Forages having greater than 3% potassium (K) may cause animal health problems, particularly if the magnesium (Mg) concentration is not greater than 0.25%.

‡ Forages having greater than 0.3% or 3,000 ppm SO4 sulfur (S) may intensify molybdenosis in ruminants.

§ A concentration over 200 ppm may cause reduced growth and vigor.

\# A concentration over 10 ppm may cause molybdenosis in ruminants.

Source: Adapted from Western Fertilizer Handbook, 9th Edition, and Intermountain Alfalfa Management (UC ANR Publication 3366).

The best time to sample soil is soon after an irrigation or rainfall when the probe can easily penetrate the moist soil. Soil samples can be taken using a shovel, but an Oakfield tube or similar sampling probe is preferred. The sample should be taken from the top 6 to 8 inches of soil. Take about 15 cores at random from each benchmark area and mix them thoroughly in a plastic bucket to produce a single 1-pint composite sample for the area. Deeper sampling can be done (6 to 12 and 12 to 24 inches deep) to assess possible salt problems. Data from nitrogen and sulfur soil tests are not useful for developing fertilizer recommendations. These elements should be evaluated in plant tissue instead.

Soil test reports indicate the general levels of pH, P, K, and perhaps Zn in a field. Although results for N and S are given on reports, these values are highly variable and are poor predictors of plant growth response. The levels indicated by a soil test provide an index as to whether or not a plant growth response can be expected from a fertilizer application of a specific nutrient. It provides the producer with a quick way to see if there are any major deficiencies. Table 6 indicates suggested fertilization rates for different soil P, K, and Zn levels. See table 8 (later in this chapter) for guidelines for lime applications to raise soil pH.

Photo 21. The yellow grass is nitrogen (N) deficient with adequate nitrogen where the cow flops appear.

Photo 22. Dark green 12- to 15-inch-high alfalfa on both sides of the sulfur deficient, 4- to 6-inch-high yellow alfalfa strip in the middle.

TISSUE TESTING

Tissue testing is an excellent method for determining the N, P, K, S, B, and Mo levels in plants. By actually measuring the nutrient levels in the plants themselves, this method provides producers with useful information on the plants' nutrient status. Table 7 gives guidelines for obtaining plant tissue samples and interpreting test results. A sample should consist of 40 to 60 stems or leaves from at least 25 to 30 different plants. Avoid urine and manure spots in the pasture when sampling. Plant tissue testing is especially valuable for identifying and comparing good and poor growth areas of a field.

DEFICIENCY SYMPTOMS

N Deficiency. In grasses, nitrogen deficiency will appear as stunted growth, pale yellowish color, and "firing" of tips, midrib, and the central portion of leaves, starting at the bottom of the plant. Plants will have a lower protein content.

P Deficiency. Phosphorus deficiency is characterized by stunted plants with small leaves, purplish discoloration on foliage, and poor root development. Purplish discoloration on foliage may also be the result of climatic or sharp temperature changes.

K Deficiency. In grasses, potassium deficiency may show as yellow areas turning to brown at leaf tips and edges, slow plant growth, and lowered resistance to disease.

S Deficiency. Stunted growth, pale yellowish color of the entire plant, small stem diameter, and roots that are well developed but smaller than normal in diameter all indicate sulfur deficiency.

FERTILIZER APPLICATION CONSIDERATIONS

Grasses. Nitrogen (N) is usually required by grasses at the rate of 30 to 50 lb of N per acre (N/A) every 30 to 45 days for every ton of dry forage you plan to produce per acre for the year. Higher amounts of nitrogen are necessary if you want to produce forage with a higher protein content. That often means 90 to 150 lb N/A at a cost of $30 to $50 or more per acre per year. The total amount of nitrogen should be split into two or even three applications. The greatest yield will usually result from early spring (February) applications of at least 60 to 100 lb N/A applied just before grass growth begins. In some fields, phosphorus, potassium, and sulfur may also be required to achieve optimum yields. Keep in mind that every ton of grass dry matter contains from 30 to 40 lb of N (30 lb N/ton if the grass contains 1.5% N or 9.4% protein and 40 lb N/ton if the grass has 2% N or 12.5% protein). The application of one-third to one-half of the total seasonal N requirement after each grazing or hay cut will increase utilization by the grasses and decrease the loss of N through runoff or deep percolation.

Grasses and Legumes. If legumes (like strawberry, white, alsike, or ladino clover or trefoil) are present in an adequate portion of the forage (usually 25 to 35%), then no nitrogen fertilizer application is necessary: the legumes will fix enough nitrogen to meet the need of the grasses. This can save the cost of the nitrogen, about $30 to $50 or more per acre per year. But phosphorus, potassium, and sulfur applications are more important to keeping the legumes growing. After establishment, apply 60 to 120 lb monoammonium phosphate (11–52–0) every 2 to 3 years and 100 to 150 lb elemental sulfur every 4 to 6 years. Nitrogen applications will favor the growth of the grasses, so if the clover or other legume populations become too high you can apply nitrogen to manage species competition. Fertilizer selection and application strategies should be chosen to match your grazing and haying management goals, the results of soil and tissue testing, and relative costs/benefits of fertilization. Remember, haying removes more nutrients from the soil unless the manure is returned to the same field.

Photo 23. Potassium (K) deficiency in alfalfa. Note the burned margins.

Photo 24. Nitrogen, phosphorus and potassium deficient orchardgrass on the left of red flag with much more alfalfa in the orchardgrass on the right as a result of phosphorus (P) and potassium (K) fertilization. The alfalfa responded to the P and K by fixing more nitrogen for both the alfalfa and the orchardgrass.

Soil pH. The acidity or alkalinity in the soil is expressed in terms of soil pH. The ideal pH for irrigated pasture should be around 6.0 to 6.5, with an acceptable range of 6 to 8. Clovers will seldom produce more forage unless the soil pH is below 5.5, but alfalfa will not produce well if the pH is less than 6.3. Table 8 describes the approximate amounts of fine-ground limestone needed to raise the pH of a 6-inch layer of soil. If available, sugarbeet lime is an excellent source of lime as it usually contains 20 to 40 lb P_2O_5 per ton as well as small amounts of other nutrients.

Table 8. Approximate amounts of finely ground limestone (100% CaCO3 equivalent) needed to raise the pH of a 6-inch layer of soil

Soil texture	Limestone needed to raise soil pH: from pH 4.5 to pH 6.5 (tons/acre)	Limestone needed to raise soil pH: from pH 5.5 to pH 6.5 (tons/acre)
Sand	1.1	0.6
Sandy loam	2.1	1.3
Loam	2.9	1.7
Silt loam	3.5	2.0
Clay loam	4.2	2.3
Muck	8.1	4.3

Source: Western Fertilizer Handbook, 9th Edition, Table 10-2, p 240.

MANURE AS A FERTILIZER

Manure can be highly variable in its nutrient content depending upon the source (cattle, chickens, etc.), method of storage, length of storage, and moisture content of the material. Composting the manure may be desirable if you want to reduce the number of weed seeds that can germinate and so avoid introducing any new weed species to the fertilized ground. Unfortunately, composting results in a loss of nitrogen from the manure that can range from 25 percent to as much as 50 percent.

Photo 25. Do not take soil or tissue samples directly from areas with manure on them.

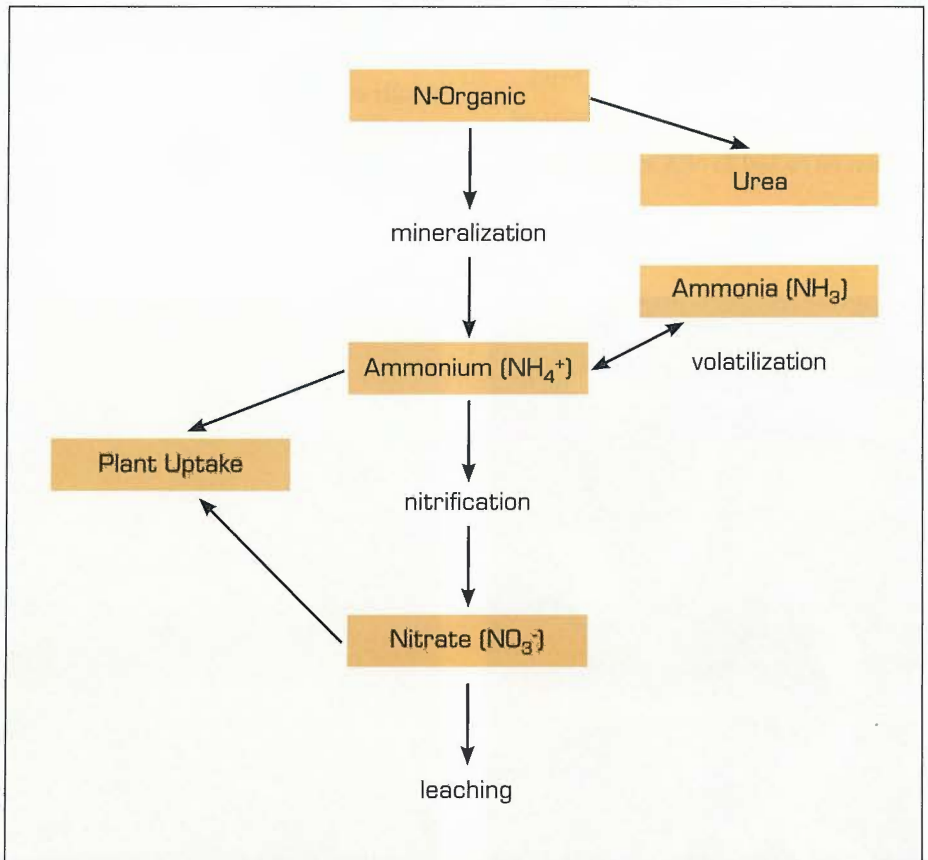


Figure 5. The fate of organic nitrogen (N) from manure as it decomposes in the pasture. Some N mineralizes right away and is taken up by the plant or lost to the atmosphere through volatilization. The rest decomposes over time through the action of soil microbes and exposure to weather. Then it is available for plant uptake or can pollute groundwater or surface water if there is more N available than the plants can use.

SUGGESTIONS FOR MANURE USE

1. Regardless of the source of the manure, it should be analyzed by a reliable commercial lab for N, P, K, and moisture no more than a week or two ahead of application. This becomes more important when the material is relatively fresh because nitrogen and moisture values can change rapidly.

2. Spread manure as uniformly and as accurately as possible. Experienced custom spreaders using calibrated equipment are able to do a much better job than someone with poorly maintained equipment or little experience.

3. On fallow ground, manure should be incorporated with a disc within hours after spreading, especially if it is relatively fresh and high in moisture or nitrogen content (>2 – 2.5% N). This will prevent the loss of N as ammonia gas. Nitrogen loss following surface application can amount to 15 percent or more per day for the first day or two after application. Losses of N as ammonia after spreading aged manure or compost are rather small.

4. When manure has been applied regularly in the past, the grower should assess the residual impact of the manure before deciding how much to apply to the next crop. As described in figure 5, each year a portion of the organic N will be broken down by soil microbes and become available to plants. Manure application rates should be based upon pasture growth needs for nitrogen, or perhaps phosphorus (use plant tissue testing) in the case of legume-grass pastures. Total nitrogen from manure should not be greater than three times the amounts of nitrogen suggested earlier (90 to 150 lb N/A), applied every other year, as amounts greater than this may result in groundwater pollution or salt accumulations. To assess the effect of residual manure N on soil fertility, use manure check strips where you do not apply fertilizer or manure, soil salinity monitoring, soil tests for P and K, and crop tissue N, P, and K monitoring.

Depending on the manure's nutrient value and its moisture level, the applied manure may have to be diluted to prevent salt burn of the plants or crusting over of plants with organic material from the manure. Remember, manures usually have a relatively high nitrogen concentration, so applications could favor grass production over legumes. For most agricultural uses of manure, the annualized value of the soil physical improvement will be quite small compared to improvements in nutrient value. There is no doubt that regular additions of manure over time may improve water infiltration and soil tilth, increase aggregate stability, reduce bulk density, improve water holding capacity, and inhibit the formation of crusts on the soil surface. However, allowing animals to graze on wet soils can destroy many of the improvements created by manure application.

Chapter 3

WEED CONTROL

Joe DiTomaso, Barbara Reed,
and Larry Forero

PASTURE ESTABLISHMENT

Weed control in pastures will be most successful if it is done before the pasture is established. This becomes even more important if weeds have not been controlled adequately in the previous crop(s) and a large reservoir of weeds seed is present. Because of the potential for weed seeds content in uncomposted manures, use only well-composted manure as a fertilizer on new pastures. High composting temperatures kill weed seeds. Weeds that become well established will out-compete young grasses and legumes, ruining the pasture's nutritional value and productive potential. Refer to Chapter 1 for information on establishing a pasture. Table 9 lists some of the most common pasture weeds and why they may appear.

It is easier to prevent weed establishment than to try to control weeds in irrigated pasture.

EXISTING PASTURE

Properly established and managed pastures rarely need weed control measures. Excessive weeds in existing pastures usually are symptomatic of some other management problem. Weeds grow and flourish in weak pasture stands. Die-off of grasses and legumes occurs if irrigation is poorly managed, fertilization is incorrect, or the grazing management is inadequate. Weed numbers can also increase if paddocks are under-utilized and weeds go to seed before they are controlled.

WEED PREVENTION

Follow these six steps:

1. **Proper pasture establishment** (see Chapter 1). This will include cultivation or tillage to damage the weeds' root systems, separate the plants' shoots from their roots, and bury plant parts. Once weeds have been destroyed mechanically, properly selected competitive grass and legume varieties can prevent re-infestation.

2. **Proper fertilization and irrigation** (see Chapters 2 and 5). High plant density and vigorous, rapid establishment of pasture will decrease light penetration for low-growing weeds.

3. **Correct animal management** (see Chapter 6). Some amount of animal management (to control grazing timing and duration) is necessary to maintaining weed control. Set stocking will contribute to weed problems. (*Set stocking* is the practice of allowing only a fixed number of animals on a fixed area of land during the time when grazing is allowed.)

4. **Hand weeding** (see more below). This weed control method can have excellent results when weed infestations are at low levels and the acreage needing treatment is small. This technique is most often used to prevent new infestations from expanding or to control the last remaining escaped plants following a successful control program.

5. **Mowing and clipping** (see below).

6. **Herbicide application** (see below).

Hand Weeding. In small pastures, hand weeding is an effective means of controlling weeds. This method prevents the weeds from going to seed. By hand weeding you avoid the use of chemical control methods, but determination, a shovel, a straw hat, and plenty of drinking water and time are usually required.

Mowing and Clipping. Periodic mowing of pastures prevents weeds from going to seed and can help balance forage species by increasing light for the lower legume canopy. This also keeps grasses growing vigorously and removes lower-quality growth, preventing the

Photo 26. Bull thistle can be removed with a shovel and some patience on small acreage.

Table 9. Some common weeds found in irrigated pastures and why they may appear*

Weed	Impact	Mode of infestation
Blackberry (Rubus spp.)	not grazed by livestock; can become significantly invasive; displaces desirable plants	spreads by seed and vegetatively; birds commonly serve as the mechanism of seed spread
Buckhorn plantain (Plantago lanceolata)	nuisance perennial plant that is generally not grazed; displaces more desirable forage plants	generally establishes on sites with high sunlight or in overgrazed areas
Bull thistle (Cirsium vulgare)	nuisance; can be grazed when young; mechanical injury to humans and animals	seed can come from neighboring pasture or can be brought in on equipment; tends to colonize open lands
Chicory (Cichorium intybus)	nuisance; can be grazed; accumulates nitrates	generally found in areas that are overgrazed and/or in less-fertile sites
Coastal or Menzies fiddleneck (Amsinckia menziesii)	annual plant; very toxic to all classes of livestock	commonly spread by seed from adjoining fields or pastures
Common groundsel (Senecio vulgaris)	highly toxic to livestock; late spring problem	generally found in poorly irrigated areas that lack plant cover
Dock (Rumex spp.)	perennial plant; considered a nuisance and generally unpalatable to livestock; can be toxic if livestock consume large amounts	generally inhabits wet areas; can spread vegetatively or by seed and usually disperses with water
Foxtails (Setaria spp.)	can cause mechanical injury when seedheads are present	source of seed may be livestock, equipment, or neighboring fields; tends to colonize open and disturbed areas
Nightshade (Solanum spp.)	several species, both annuals and perennials; not palatable and can be toxic to humans and livestock	not common in pastures and often found on disturbed sites
Smartweed (Polygonum spp.)	summer annual; not palatable and displaces more desirable species	colonizes wet areas
Wild mustard (Sinapis arvensis)	can cause off-flavor in milk of grazing dairy animals	generally colonizes disturbed open ground
Yellow starthistle (Centaurea solstitialis)	only grazed when young before spiny seedheads develop; very toxic to horses	seed source primarily from adjacent infested fields; occasionally brought in with equipment or soil; will colonize under-irrigated fields

* While this table includes only a partial list of weeds that can infest pastures, it illustrates the diversity of weeds that can become established if the pasture has not been properly established or well managed.

forage from becoming rank and unpalatable. Clipping, usually done after grazing, is not the same as haying a pasture. A mower with a high blade setting will cut the tops off of the weeds or ungrazed plants and prevent them from going to seed. Well-managed, intensive grazing may replace mowing if stock numbers are high enough.

Herbicides. Several postemergent herbicides can be used to control weeds in irrigated pastures. These include amine and ester formulations of 2,4-D, triclopyr, and dicamba, as well as clopyralid, aminopyralid, MCPA, chlorsulfuron, and glyphosate. Of these, clopyralid, aminopyralid, 2,4-D, triclopyr, dicamba, and MCPA are growth regulator herbicides that are selective on broadleaf species and have little activity on grasses. Clopyralid and aminopyralid also have excellent preemergence activity and are very effective against yellow starthistle and other members of the sunflower (Asteraceae) family. Chlorsulfuron is an amino acid inhibitor and is also very effective on most broadleaf species, particularly members of the mustard (Brassicaceae) and figwort (Scrophulariaceae) families. It also has both preemergence and postemergence activity on most species, but only preemergence activity on yellow starthistle. Like the growth regulator compounds, it is fairly safe on most grasses.

Photo 27. Mowing can help control weeds by preventing seed formation and keeping pasture plants from going to seed.

Glyphosate is non-selective and provides excellent control of annual and perennial grasses and broadleaf species.

All of these compounds injure legumes when applied during the growing season, but some can be used safely when treatments are made during the dormant phase of perennial legumes.

These herbicides can be targeted to weeds of interest if you use a wick-type applicator that can be boom-mounted. This technique is most effective on weeds that are taller than the desired plants and, thus, easy to see.

Most pastures cannot be grazed or harvested for hay during a specified waiting period following pasture-registered herbicide treatment, so you have to provide other feed during the waiting period. The exceptions are clopyralid and aminopyralid, which have no grazing restrictions.

Always read and follow label directions. Failure to do so is a violation of law and could result in animal illness, food contamination, or human illness.

TERMINOLOGY NECESSARY FOR SAFE AND EFFECTIVE USE OF CHEMICALS

REGISTERED USE: You must use a product according to label directions. Example: You cannot use a product on pasture if it is registered for use only in corn, even if the product kills the same weeds as are in your pasture.

WITHDRAWAL TIME: You must provide animals with another feed after removing them from a treated pasture and before sending them to slaughter.

WAITING PERIOD: After treating a pasture, you must WAIT for a specified period of time before you return animals to the pasture or harvest hay from the pasture.

The above terms are important for several reasons.

1. In California, only a few chemicals are registered for use on pastures.

2. Waiting periods can be as long as one year, depending on the amount of active ingredient used.

3. Waiting/withdrawal periods differ depending on the herbicide and the animal (dairy vs. meat).

4. Waiting periods can change depending on how much acreage is included in the treatment.

Table 10 gives an overview of herbicides that are registered for use on pasture in California.

Not all weeds are susceptible to all of the herbicides listed in above. Some herbicides are not recommended at all for certain soil types or certain growing conditions. Before purchasing any herbicide, contact your local Agricultural Commissioner to make sure you are complying with all current regulations and to obtain whatever permit(s) may be necessary. Depending on which herbicide you plan to use, you may need to hire someone with a Commercial Applicator License to do the weed control. For more information on pesticide licensing and certification, visit the California Department of Pesticide Regulation Web site,www.cdpr.ca.gov/docs/license/currlic.htm

APPLICATION METHODS

1. **Broadcast/spray application.** The entire field is treated (the most useful method for extensive weed infestations).

2. **Directed application.** This is also referred to as spot application, where only the target plant or patch is treated.

3. **Wick application.** Only the weeds are treated: application involves directly touching the target plant with an herbicide-saturated wick. This is more labor intensive than other methods, but it often uses less chemical material and it reduces the opportunity for herbicide drift.

BE SURE TO READ AND FOLLOW ALL LABEL DIRECTIONS.

Other useful weed publications are *Weeds of the West* (Whitson et al. 2004), *Poisonous Plants of California* (Fuller, et al. 1986) and *Weeds of California and Other Western States* (DiTomaso et al. 2007).

Photo 28. Always follow label directions exactly.

Table 10. Overview of herbicides registered for use on pasture

Herbicide (and brand names)	Uses
2,4-D Ester 2,4-D Amine (Weedone)	used to control annual, biennial and perennial broadleaf weeds (yellow starthistle, chicory, curly dock); do not apply to newly established pastures; will damage legumes
Aminopyralid (Milestone)	used for the control of broadleaf weeds, particularly yellow starthistle and some hard to control perennial thistles and knapweeds; registration established for California in late 2006
Chlosulfuron (Telar)	used to control many broadleaf weeds and some annual grass weeds
Clopyralid (Transline)	used for the control of broadleaf weeds, including starthistle and other troublesome thistles, some of them perennials
Dicamba (Banvel, Vanquish)	used to control annual and perennial broadleaf weeds and woody plants; do not apply to newly established pastures; may damage legumes (alfalfa, clovers)
Glyphosate (Roundup, Touchdown, etc.)	is not selective, so may kill everything it contacts, including grasses and legumes; best for spot treatments
MCPA (many names)	used for many broadleaf weeds, especially buttercup, hemp-nettle, field horsetail (top growth only), and seedling dock
Triclopyr (Garlon, Remedy)	used to control annual and perennial broadleaf weeds and woody plants (blackberry and poison oak); do not apply to newly established pastures; may damage legumes (alfalfa, clovers)

Chapter 4

IRRIGATION

Allan Fulton, Barbara Reed,
and Larry Forero

Sprinkler and flood irrigation are both used successfully on irrigated pasture throughout the region. In general, pasture should be irrigated once a week during the hot summer months, although 10-day intervals may be satisfactory in some areas if the soil and root zone are not too shallow. Pastures can use about 0.25 to 0.3 inches of water per day in mid-summer, so applying approximately 3 inches of water at each irrigation every 10 days should take care of the pasture requirements and account for any irrigation system losses. Figure 6 shows the relative drought tolerance of selected pasture legumes. Figure 7 shows typical water use due to evapotranspiration for Butte County.

Do not wait for the pasture plants to wilt before you start irrigation or permanent plant damage may occur. For most irrigated pasture, the effective rooting depth for irrigation scheduling purposes is only the top 12 to 18 inches of soil. Most pastures do not have significant root mass below that depth, so deep, infrequent irrigation scheduling typically used for alfalfa production is not appropriate for pasture. Figure 8 shows how you can use soil moisture sensors to monitor irrigation effectiveness and give you a way to compare sensor data with conventional visual and manual evaluation of soil characteristics to schedule irrigations.

Comprehensive information on this subject can be found in another University of California publication, *Soil Moisture Monitoring–A Simple Method to Improve Alfalfa and Pasture Management* (Orloff, Hanson, and Putnam 2001, online at http://alfalfa.ucdavis.edu/+resources/publications.html). Two other good references are *Irrigation Scheduling: A Guide for Efficient On-Farm Water Management* (Goldhamer and Snyder 1989) and *Scheduling Irrigations: When and How Much Water to Apply* (Hanson, Schwankl, and Fulton 1999).

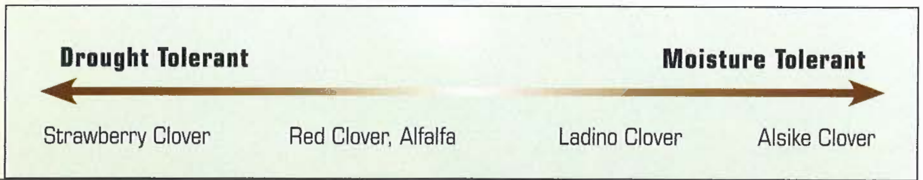


Figure 6. Relative moisture and drought tolerance of common pasture legumes.

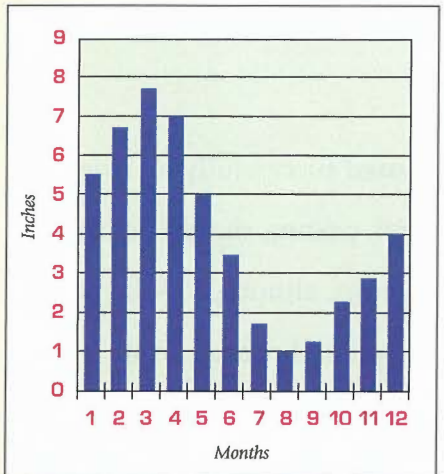


Figure 7. Average monthly evapotranspiration rate for irrigated pasture in Butte County. In July, nearly 8 inches of water is lost through plant transpiration and surface evaporation. Data obtained from Butte County CIMIS station for 2005-2006 irrigation season.

AMOUNT AND TIMING

The amount and timing of water applications are critical factors to consider when making plans for irrigated pasture production. Prior to planting it is essential that you know the cost and availability of irrigation water and the estimated water needs on a seasonal, per-acre basis. Factors to consider include whether there is a surface water or groundwater irrigation source. If groundwater is the source, find out about the well's design and the pump's capacity and power source, the cost of power and of standby charges, and about alternative energy sources for pumping groundwater. If it is a surface water supply, ask about water district charges per acre-foot, other assessments, the number of water users relying on the same source, the conveyance schedule, and the flow rate delivered to the pasture site.

Irrigated pasture in the Central Valley consumes from 4.5 to 5 acre-feet of water per acre per season for maximum forage productivity (see figure 7). Approximately 3.5 to 4 acre-feet will need to be provided as summertime irrigation; the balance is typically provided by rainfall in the winter, early spring, and late fall. An acre-foot of water is equivalent to 325,851 gallons of water, so an acre of irrigated pasture may require as many as 1.6 million gallons of water per year. How often a pasture needs to be irrigated will change with the season. Generally, the interval between irrigations is longer in the spring and fall than in the summer. About 3 inches of water should be applied at 7- to 14-day intervals in the summer, while in spring and fall the interval may be as long as 20 to 30 days. The interval between irrigations also depends on soil type and the soil's water-holding capacity in the root zone.

PUMP CAPACITY

Determining your pump capacity is important when you are supplying water to an irrigated pasture. A rule of thumb to start with is that you should have the capability to supply a minimum of 10 gallons per minute (gpm) for each acre irrigated by border flood.

This rule is based on how much flow it takes to meet maximum ET_0 on a daily basis, plus an allowance for "reasonable" efficiencies in applying the water uniformly across the pasture. This rule for minimum flow also assumes an ability to irrigate daily during the peak of the irrigation season in mid-summer to meet the pasture's high water demands, a condition that, in truth, is highly unlikely. Higher pump capacities of at least 20 to 30 gallons per minute per acre (gpm/A), and perhaps much higher for border flood irrigation, allow more management flexibility and convenience by using larger irrigation set sizes, less-frequent set changes, and periods of non-operation between irrigation cycles. A higher pumping capacity is likely to be more efficient, too, because it will allow more uniform water application across pastures. The trade-off is the higher capital costs for larger wells, larger pumps, and larger-diameter irrigation pipes and valves needed to convey higher flows. The ability to control or re-use tailwater is another factor affecting the desired flow rate. Higher flows are more appropriate when tailwater recovery and re-use are part of the irrigation system design. Lower flows are more appropriate when you want to minimize the need for tailwater management.

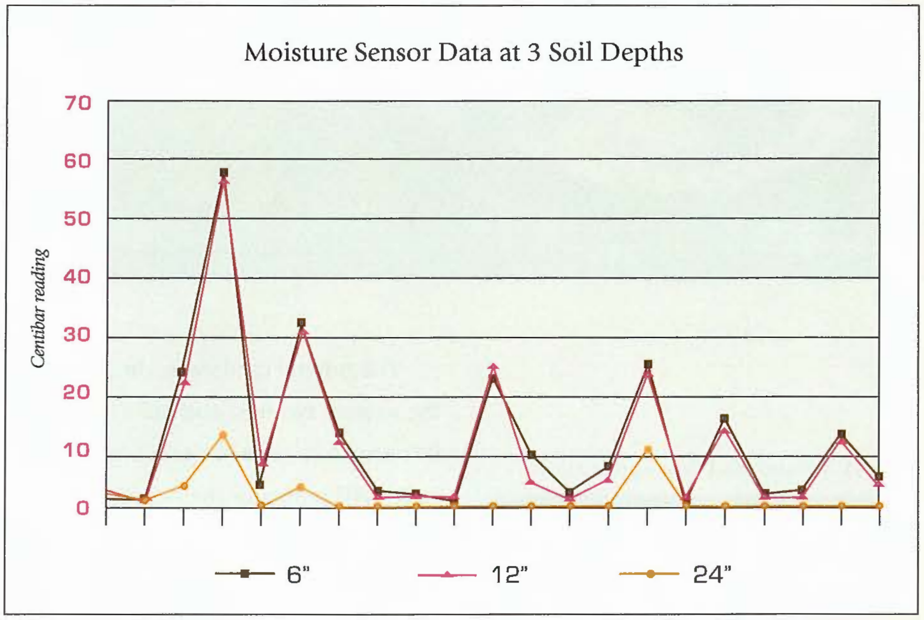
From the same perspective, a minimum of 6 gpm/A is needed for more efficient sprinkler systems where diesel or natural gas engines are used to pump the water continuously and for electric motors where their operation is not interrupted by time of use restrictions. If operation of electric motors is limited by time-of-use restrictions, a minimum flow of 8 gpm/A is needed for sprinkler irrigation. Like flood irrigation, these minimum flows for sprinkler irrigation require that you be willing to irrigate with small set sizes and irrigate daily during the peak of the irrigation season in mid-summer to meet pasture water demands. There are practical advantages to increasing the flow capacity considerably and increasing irrigation set sizes for sprinkler irrigation.

Now apply these rules for minimum flow: If you have a 20-acre field, your well and pump must be able to provide 200 gpm for flood, 120 gpm for sprinklers in operation 24 hours a day, or 160 gpm for sprinklers operating 18 hours per day according to time-of-use restrictions. In addition, you would need to irrigate daily during the summer when water demand is highest, a practice that is not likely to be feasible except on very small pastures. A more manageable minimum flow would be on the order of 600 gpm, 360 gpm, or 480 gpm for this hypothetical field example and the respective irrigation systems. Table 11 shows conversion factors for volume and flow units commonly used for measuring irrigation water.

IRRIGATION METHODS

Border Flood

For flood irrigation of pastures, water losses of 20 to 50 percent are typical and greater losses have been documented. That is, only 50 to 80 percent of the water you apply will actually be available to the pasture plants; the rest will be lost to deep percolation below the root system, runoff, and evaporation. On sandy soils where losses are highly likely to exceed 40 or 50 percent, sprinkler irrigation should be seriously considered as an alternative to flood irrigation.



Guide to centibar readings as compared to feel or appearance of soil

Centibar reading	Soil feel and appearance
0-10	Soil is dark and wet outline of soil can be seen on hand.
10-20	Sandy soils that need irrigation will appear dry; other soils will range from weak to strong ball when squeezed.
30-60	Sandy loam and silt loam soils will need irrigation and appear dry; heavier soils will form crumbly or slightly pliable ball.
60-100	Even clay soils need irrigation at this point; this soil will only form a ball under pressure.
100-200	Soil is light color, dry, and depending on type may be loose, powdery, or hard and cracked.

Figure 8. Water sensor data shows that the top 6 to 12 inches of soil loses moisture between irrigations. This can contribute to drought stress to pastures in which the majority of plant roots are 8 to 12 inches deep. The higher the centibar value, the lower the soil moisture. At 24 inches, the soil moisture remains fairly constant, but most pasture plant roots do not grow to that depth.

Photo 29. Water pumped into pipes for flood irrigation.

Table 11. Volume and flow conversions

Unit	Conversion factor
Volume	
1 acre foot (ac ft)	= 43,560 ft^3 = 325,851 gal
1 cubic foot (ft^3 or cu ft)	= 7.481 gal = 1,728 in^3
1 gallon (gal)	= 0.1337 ft^3 = 231 in^3
Flow	
1 cubic foot per second (ft^3/sec)	= 448.83 gal/min = 1 ac in/hr = 1 ac ft/12 hrs
1 gallon per minute (gal/min)	= 0.00223 ft^3/sec = 1 ac ft/226 days

The general landscape, the scale of the pasture systems, and the infrastructure supplying the irrigation water will influence the design of a border flood irrigation system. For example, common border flood irrigation systems in the southern Sacramento Valley and throughout the San Joaquin Valley usually are much different than those in the northern Sacramento Valley. More than 80 percent of the lands producing irrigated pasture and other forage crops in the southern Sacramento Valley and San Joaquin Valley use border flood irrigation with field lengths of about 1,300 feet and check widths ranging from about 80 to 120 feet. Flow rates into these larger border irrigation basins commonly range from 400 to 800 gpm or even higher. In contrast, border flood irrigation systems in the northern Sacramento Valley often consist of checks only 20 to 80 feet wide that are often no longer than 600 to 1000 feet with flows on the order of 150 to 300 gpm per check.

The design of a border flood system is site specific. The length and width of the irrigation runs (also called *checks*) depend on the soil type, head (flow rate) of water, and slope in the direction of water flow. In general, you should design the length and width of checks so irrigation and drainage can be completed within one or two days, since standing water provides conditions that favor mosquito breeding and increased weeds. This kind of design may require that a drainage ditch be included at the lower end of the field to drain excess water. The high water infiltration characteristics of sands and sandy loam soils may require some combination of narrower or shorter irrigation checks, higher flow rates, and steeper slopes to allow efficient irrigation. Conversely, loam, silt loam, clay loam, and clay soils are likely to irrigate more efficiently with wider checks and greater field lengths using similar or slightly lower flow rates. Field slopes may range from about 0.05 to 0.20 foot in rise per 100-foot length. In general, steeper field slopes are more appropriate for sandy soils but may require the use of narrower check widths to control the water and ensure that the water covers all of the pasture surface. Limit the lateral slope to no more than 0.1 foot rise per 100 feet within a check *(For additional technical information on border irrigation refer to the Natural Resource Conservation Service Border Irrigation Manual).*

Sprinklers

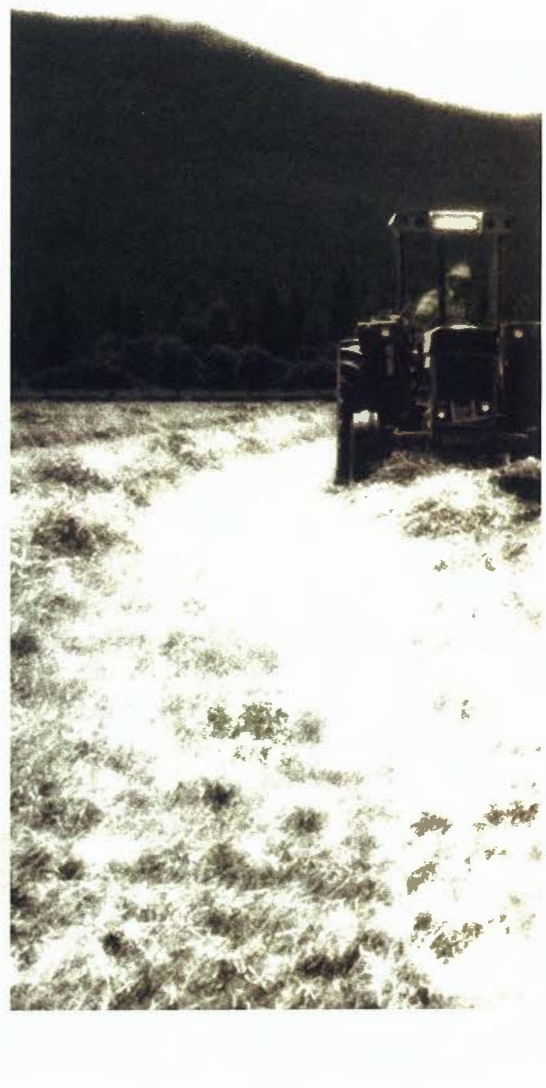
A sprinkler irrigation system requires little or no surface grading but is initially more expensive than border irrigation systems. Sprinkler irrigation is advantageous where the water supply is limited or expensive, the soil is shallow or sandy, or the terrain is rough or steep. However, sprinklers are difficult to manage in areas where the wind is strong. They may require protective barriers to keep them from being damaged by horses and cattle or to prevent injury to the animals. Some owners use old tires, PVC pipe, or cement pipes for this purpose. Newer sprinkler system designs use plastic pods to stabilize and protect the sprinklers and specific sprinkler designs to combat problems with wind. Sprinkler system losses are generally figured at 20 to 35 percent. That is, only 65 to 80 percent of the water you supply will be available to the pasture plants. Narrower sprinkler spacing that assures more overlap of the wetting pattern between sprinklers generally favors more uniform distribution of water and higher application efficiencies. You have to carefully consider the amortized capital cost of the irrigation system and the energy costs of pressurizing the water supply before you make any decision to use this approach on a relatively low-value commodity like irrigated pasture.

TIPS FOR DITCH USERS

Many irrigated pastures receive water via a common ditch. When more than one landowner depends upon the same ditch for irrigation water, conflicts can occur. To quote Mark Twain, "Whiskey is for drinking, water is for fighting." Here are a few ideas to help you manage common ditches successfully.

1. Make sure your fields are properly prepared for efficient irrigation.
2. Keep the water only as long as you need it.
3. Keep ditches clean and free of weeds.
4. Have your ditch tender's phone number handy.

Photos 30 and 31. Ditch boxes control water flow for flood irrigation.



Chapter 5

HAY MAKING

Larry Forero and Barbara Reed

Many owners of irrigated pastures have considered haying at one time or another. Haying is an excellent way to store excess forage for later use. Hay production may also provide the operator with another source of income. For some scenarios of hay and grazing you can refer to *Sample Costs to Establish and Produce Irrigated Pasture: Sacramento Valley, Flood Irrigation* (Forero et al. 2003), online at www.agecon.ucdavis.edu/uploads/cost_return_articles/pasturesv03.pdf.

YIELDS

Irrigated pasture can be cut for hay from one to three times during the growing season, depending on need. If there is excess pasture in spring but additional feed will be needed when the pastures go into a summer slump, make one cutting in early May. If pastures are not needed for grazing after the first cutting, a second cutting can be taken about 5 to 6 weeks later, and a third cutting would be ready by September. With adequate fertilization and irrigation, a harvest of 5 tons of grass hay should be possible. Haying may interfere with irrigation timing. Keep in mind that the effective root depth of most pastures is no more than 12 to 18 inches, so the timing of water applications in conjunction with hay harvests is critical.

QUALITY

Harvest of pasture for hay before grasses have set seed will provide the highest nutrient content, greatest palatability, and highest rate of consumption by livestock, but at the expense of yield.

Photo 32. A round baler bales wilted grass for haylage that will be wrapped in plastic. Round bale haylage is a good way to preserve forage to feed later.

Photo 33. Round bales wrapped and ready to store.

The feeding value of nutrients in a forage crop and the moisture content of the crop are highest at an early stage of growth. As the crop matures and enters the late bloom growth stage, plants contain more lignin and other structural carbohydrates, resulting in a level of nutritional quality that is less than that of less-mature plants. How you time your hay harvest and how mature your forage is at harvest will be influenced by the class of livestock you plan to feed and their nutritional needs.

TIMING

The correct time to harvest a grass and clover pasture is determined by the predominant plant species. For a mixed pasture of legumes and grasses, the correct stage of maturity for hay harvest is when the legumes are in the early bloom stage and the grasses have not yet bloomed. This recommendation represents a compromise, balancing quantity (yield) against quality (the palatability and digestibility of the forage).

The biggest problems associated with cutting hay for irrigated pasture are the cost and timing of harvest. Unless you have enough acreage to justify owning your own equipment, you may want to hire a custom harvester. There are other ways to store excess feed besides keeping it as hay, for instance to green-chop the forage and store it in plastic horizontal silage bags or place it in a pit or bunker silo. Saving the feed standing in the field is discussed in the next chapter.

Table 12 describes sample yields for pastures managed by haying only or a

Table 12. Forage produced for grazing only or a combination of grazing and haying

Month	Forage yield		Grazed only (20 acres): yield/acre	Graze and hay (20 acres): yield/acre		Average yield over 40 acres: yield/acre	
	lb/acre	*tons/acre*	*AUM*	*AUM*	*hay tons*	*AUM*	*hay tons*
May*	3,247	1.62	3.25	0	0	1.62	0
June	1,783	0.89	1.78	0	2.51	0.89	1.25
July	1,628	0.81	1.63	1.63	0	1.63	0
August	1,665	0.83	1.67	1.67	0	1.67	0
September	1,422	0.71	1.42	1.42	0	1.42	0
October	753	0.38	0.75	0.75	0	0.75	0
Annual Total	**10,498**	**5.25**	**10.50**	**5.47**	**2.51**	**7.98**	**1.25**

*Includes forage produced in the months preceding May.

combination of haying and grazing. To capitalize on excess forage production in the spring, 20 acres of the forage on the 40-acre ranch in table 12 is both grazed and harvested as hay while another 20 acres is only grazed. The result is an average forage base of almost 8 AUM and 1.25 tons per acre for the 40 acres. This is a more flexible management scheme than all-haying or all-grazing.

COSTS

Along with its benefits, there are some disadvantages to haying. The process of mechanically cutting pastures is labor and capital intensive. Tractors, swathers, balers, and rakes are required. Finished bales must be hauled from the field and stored. Haying equipment can cost in excess of $100,000. Used equipment can be purchased for less, but it may have higher repair costs and more frequent breakdowns.

Rather than owning equipment, another option is to hire a custom operator. Arrangements may involve a flat per-acre fee, a per-bale charge, or a percentage of the crop. One of the big drawbacks to hiring custom harvesting is the limited availability of the custom operator. The actual timing of your harvest may be less than ideal, and it may be difficult to find a custom operator who will do small jobs (under 20 acres).

Carefully consider the advantages and disadvantages of haying before you commit to the practice. Grazing additional animals during the times when forage is growing rapidly is an option well worth considering. Intensively managed grazing (see Chapter 6) may be sufficient to take care of excess forage production. The University of California publication *Acquiring Alfalfa Hay Harvest Equipment: A Financial Analysis of Alternatives* by Steve Blank (1992) discusses the economics of new or used equipment versus custom hiring for hay harvesting. See also *Sample Costs to Establish and Produce Irrigated Pasture: Sacramento Valley, Flood Irrigation* (Forero et al. 2003), online at www.agecon.ucdavis.edu/uploads/cost_return_articles/pasturesv03.pdf.

HAYLAGE

Another way to store excess feed is to cut the forage, wilt it in the field to approximately 45 percent dry matter, and then store it in round bales that are wrapped in plastic, or have it green-chopped and then ensiled. There are packing and covering costs for the haylage, and it has a defined shelf life once it is fed out. If you do not have the space or proper structures to store dry hay, haylage (especially in wrapped bales) may be a feasible alternative. Custom harvesting services for haylage production can be hired just as they are for hay harvesting. To determine the value of haylage, use the worksheet in table 13.

Table 13. Calculating the standing value of hay and using it to price hay silage (haylage)*

	Sample cost		Enter your actual cost here
Value of hay roadsided		$90.00	
Harvest costs			
Roadside	$4.00		
Bale	$11.00		
Rake	$3.00		
Swath	$8.00		
Total harvest costs		$26.00	
Value minus harvest costs *(A)*		$64.00	
Dry matter (DM) corrections			
Haylage DM *(B)*	45%	*Your* haylage DM:	
Hay DM *(C)*	88%	*Your* hay DM:	
Standing value *(A x [B/C])*	$64.00 x (45/88) = $32.73		
Your standing value	$____ x (____ / ____) = $____		

For the haylage buyer			
Add preparation costs (chopping, hauling, and packing [pit], or swathing, raking, baling, and wrapping costs [round bales]) to the standing value	$7.00 + $32.73= $39.73	*Your* costs plus standing value	$____ + $____ = $____
Adjust for shrink (shrinkage is less for round bales than for chopped or pit hay)	$39.73 x 0.15= $5.96	*Your* adjustment for shrink	$____ x 0.15 = $____
Cost per ton fed out (combined standing value and preparation costs divided by shrink adjustment)	$39.73 + $5.96 = $45.69	*Your* cost per ton fed out	$____ + $____ = $____

* Moisture content is the single largest factor in pricing hay silage (haylage). Always sample the haylage as it comes from the field and run a dry matter analysis at your local lab. As moisture decreases, so do harvest costs. Both the grower and the buyer can gain some advantages in making haylage. Yield for the next cutting may be higher than it would have been had the hay been baled, since water can be applied to the field sooner. Some losses occur in the ensiling process. A loss of 3% to 7% can be expected in bags.

CHAPTER 6

FORAGE AND GRAZING MANAGEMENT

Larry Forero, Melvin George, and Barbara Reed

Managing livestock on irrigated pasture is relatively simple once a few concepts are understood. First, pastures need to be managed to ensure both the appropriateness of the feed's nutritional quality for the type of stock and the survival of the plants they are consuming. Then you have to balance management for quality and persistence of the pasture against the timing of grazing. The best system matches feed availability and quality with animal requirements.

GRAZING

Grazing management covers a broad spectrum of methods. Continuous stocking (also called *set stocking*) does not require much management time or decision making. An intermediate level of management is needed for forage stockpiling (also called *feed banking*) and rotational grazing. At the other end of the management spectrum is intensive grazing management, which is often (and mistakenly) referred to as *rotational grazing.*

Set stocked pastures are just that—they are stocked with a set number of animals for the entire grazing period. The livestock have full run of the pasture and can select what they want to eat. *Rotational stocking* involves moving the stock periodically, based on such criteria as the condition of the pasture or the time of year, and can be as simple as moving stock between two paddocks. *Intensive grazing management,* however, is the practice of subdividing pastures and rotating livestock onto fresh feed, allowing other areas of the pasture the opportunity to "rest." Stock may be moved as often as 3 times each day to access fresh feed, but a schedule of moving them every 1 to 3 days is more common. Intensive grazing management decreases the livestock's ability to graze selectively because the number of head per acre usually is higher than for other grazing techniques and results in more uniform utilization of the pasture. The rotation of stock should not be done on a strict calendar basis, but should vary with feed growth, available forage mass, and animal condition.

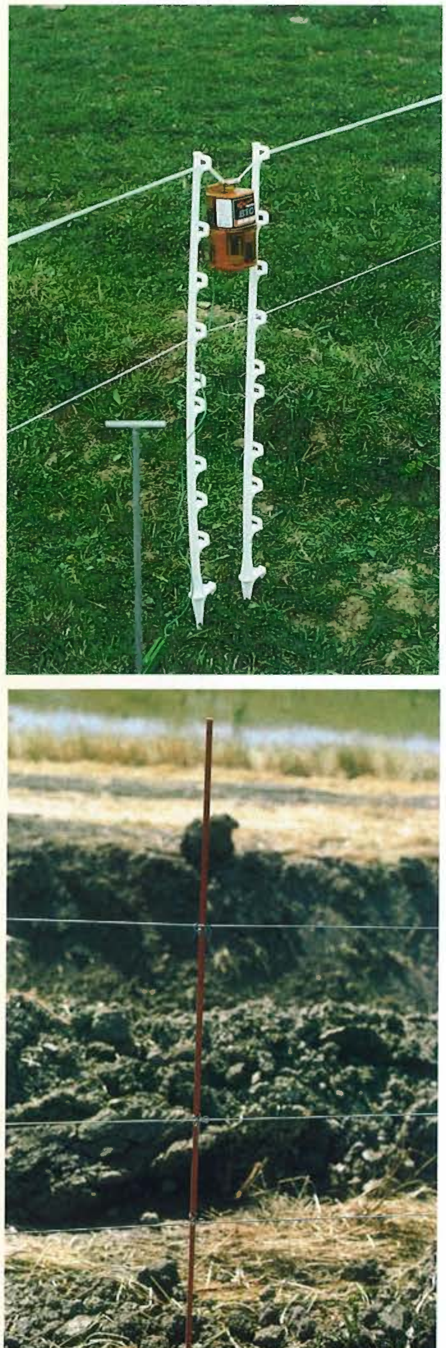


Photo 34A & 34B. Portable electric fencing provides a high degree of flexibility for paddock management. Plastic rods and electric tape or high tensile wire and plastic rods are easy to move and easily adapted to any size and shape paddock.

Stockpiling

When you stockpile forage, you have to make some decisions about both the timing and degree of utilization of forage growth, and you have to subdivide paddocks. The goal of stockpiling is to capture the forage growth as stored feed for grazing that will be deferred to a later date. The forage is left standing in place in the pasture for later use. The forage's feed value will not be as high as that of less-mature, fresh grown forage, but it usually is comparable in feed value to a grass hay and there are no purchase or harvest costs.

A skilled manager will use a combination of grazing methods in a forage operation. For example, it may be appropriate to practice set stocking at a high stocking rate and graze some paddocks down to the ground if a pasture is to be renovated, while the same manager may practice feed banking in other paddocks to anticipate future feed needs or shortages. Well-thought-out grazing management can result in lower purchased feed costs, better forage quality and production, and better animal performance. The marginal increase in labor is well worth the effort.

Table 14 compares the advantages and disadvantages of three stock management strategies. Management skill and local conditions play key roles in the overall success of any grazing scheme. Plant growth characteristics will be discussed later in this chapter. A clear understanding of how plants grow and the relationship between forage quality and plant maturity will help you make sound grazing management decisions.

STOCKING RATE

The carrying capacity of an irrigated pasture is usually based upon 70 percent utilization. This means that some feed residue will remain, some feed will be urinated and defecated on, and some will be trampled. In the northern Sacramento Valley, with grazing management, good irrigated pasture will support one animal unit per acre for 10 to 12 months. An animal unit (AU) is defined as the average amount of dry matter a 1,000 pound, non-lactating cow or its equivalent will consume in one day. Table 15 lists the animal unit equivalents of several classes of grazing livestock.

You should base your stocking rate calculation upon your best estimates of pasture production and quality. If your pasture is of good quality and totals 20 acres, how many yearling steers can you stock? You are dealing with two biological systems that are complex. Expect to make adjustments as you go along.

LIVESTOCK/PLANT INTERACTIONS

Animal production in the form of meat, milk, or calves requires adequate forage intake. Figure 9 describes the conceptual relationship between forage maturity and nutritional quality. Pasture plants between 4 and 8 inches tall generally result in high intake rates because bite size and biting rate are maximized. It is easier for livestock to graze short plants

Table 14. Comparing the advantages and disadvantages of stock management strategies

Management strategy	Potential advantages	Potential disadvantages	When to use
Intensive management	better forage utilization; more pounds milk/meat produced per acre; paddocks irrigated without stock present; lower chemical inputs (fertilizer, herbicide); potential for higher stocking rates	time and labor intensive; poorer individual performance	whenever trying to optimize pasture health and growth; when consistent animal performance is needed (lactating dairy cattle)
Set stocking	simple management approach; higher individual performance	paddocks damaged by stock during irrigation; higher chemical inputs (fertilizer, herbicide); patch grazing and poor forage utilization; lower total milk/meat/fiber produced	for intensive weed control; to prepare a pasture for overseeding without using herbicides or tillage
Stockpiling forage	decreased reliance on purchased forages; develop more strategic feed utilization plan; feed when you need it	if not managed properly, feed value could be too low; pastures still in the rotation may get too much use; more planning is required than for set stocking	late-season feed after growth has slowed or stopped

Table 15. Animal unit (AU) equivalents for different livestock

Animal	Weight	AUM equivalent
	lb	
Mature beef cow plus calf	1,000	1.00
Milking cow	1,250	1.25
Bull	1,500	1.25
Bred heifer	750	0.75
Weaned steer or heifer to yearling	600	0.60
Yearling steer or heifer	800	0.80
Goat	150	0.16
Horse*	1,000	1.25
Llama	400	0.40
Sheep	200	0.20

*The horse's AUM is greater than its weight because of lower feed efficiency.

How Many Yearling Steers?

A 20-acre ranch has an historic carrying capacity of 200 AUM.

1 AU per acre for 10 months × 20 acres = 200 AUM

The rancher has yearling steers that are 0.6 AU each and plans to keep them grazing for 10 months.

0.6 AU × 10 months = 6 AUM needed for each yearling steer

200 AUM ÷ 6 AUM = 33 yearlings for ten months

with many leaves than tall plants with a few leaves at the top of the stems. Pastures should be grazed as evenly as possible, while maintaining good plant vigor. If the stocking rate is too low, animals will graze in some spots and ignore taller, older, and lower-quality forage. Up to half of this high-quality forage is likely to be wasted if you under-graze the pasture. When cattle are rotated back onto such a pasture, they will go back to the previously grazed spots because they know they will find more tender leaves there. Young grasses and legumes are 75 to 80 percent digestible. After about 45 days, though, plant growth slows, and digestibility decreases. If you clip ungrazed spots to the same height as the closely grazed spots, that will help to maintain forage quality and uniform growth. You can also graze two livestock species with different grazing habits (say, cattle and sheep) to maximize forage utilization.

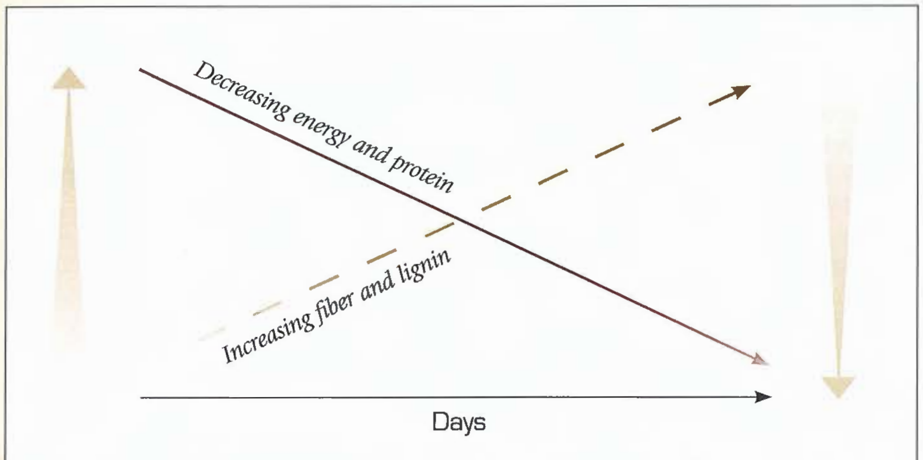


Figure 9. Conceptual relationship between forage maturity and nutritional value. As the plant structural carbohydrates (fiber and lignin) increase with plant maturity, the digestibility of the forage declines.

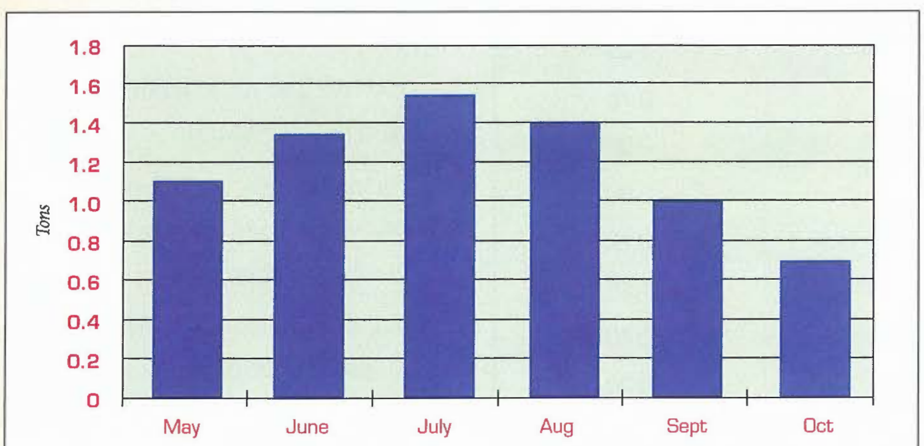


Figure 10. Average yield of irrigated pasture production on five foothill ranches in Shasta County, 2001–2003. The May harvest represents cumulative forage growth through the spring months.

Adjusting the stocking rate during the rapid forage growth period in spring is especially important. You may need to stock the pasture at twice the usual rate during April, May, and June just to keep up with pasture growth, and then drop back to the usual stocking rate for summer. This might mean buying additional animals at peak forage production time then selling them or moving them off the ranch later in the year. You can use surplus forage for hay or silage if no additional livestock are available (see Chapter 5). You can also move animals rapidly through the fields, giving them just enough time to consume the top of the forage and prevent it from going to seed.

The stocking rate can also affect the composition of grass-legume mixtures. If clovers are thinning, apply fertilizer that favors the legumes and graze the paddocks so the grass height will be equal to or slightly below the clover. If grasses are thinning, apply nitrogen and let them grow to 12 to 15 inches before grazing or cutting (see Chapter 2).

FORAGE GROWTH, REST, AND RECOVERY

Intensively managed grazing is the best method for maintaining high-quality forage. The interplay of forage growth and grazing affects the forage's nutritional quality. The pasture should be divided into paddocks based upon the land type, forage production, animals (species, age, and numbers), and grazing management. During the spring, you may want to rotate livestock between only a portion of your paddocks and keep the other paddocks to be cut for hay. You can rotate livestock through all of the paddocks during the rest of the grazing season. Figure 10 shows average irrigated pasture forage yields in Shasta County.

Rotate the livestock according to their condition and the pasture's growth rate, not according to calendar date. Pasture fertility and grazing intensity also affect the length of the rotation period. Typical rest (non-grazed) periods of 15 to 30 days are recommended for irrigated pasture during periods of rapid forage growth. During late spring and summer, if soil water and nutrients are not limiting, rest periods of 20 to 30 days are recommended. If the rest period is too short, the plants will not have time to recover (i.e., to rebuild carbohydrate reserves and photosynthetic area) before the next grazing. If the rest period is too long, palatability and nutritive value will drop. When forage is growing rapidly and is not grazed, fiber content accumulates and protein content drops as a percentage of total plant dry matter (DM). Total digestible nutrients (TDN) is a calculated value based on analysis of the fiber content of the forage. In winter, paddocks may need 100 days or more of rest because the plant growth rate is so slow.

Table 16 demonstrates the relationship between paddock numbers and rest/graze periods. In summer, most irrigated pastures will take 20 to 30 days to recover from close grazing. If you rotate between 16 paddocks, this means that you will stock at a rate that will require 1.3 days for each grazing period. It will take 15 days to return to the first paddock. In most conditions, pasture needs more than 15 days rest unless grazing stock is just taking the tops off of plants as the animals move through. If you have 28 paddocks, you could change paddocks daily for 27 days before returning the animals to the first paddock. If you subdivide larger paddocks with temporary fences, you can increase paddock numbers as needed. Subdividing paddocks and increasing stock density will slow your rotation down. Caution! When you increase stock density on smaller paddocks, the stock may need to move as often as every 12 hours to prevent permanent damage to the pasture. This is especially important in wet weather. In this case, increasing stock density means moving the existing stock to a smaller acreage rather than adding new animals to your total inventory.

Photo 35. Grass in phase I is highly palatable and usually no more than 8 inches high.

Photo 36. Grass in phase II is storing nutrients in the root system and is growing most rapidly.

Proper grazing management will increase your total livestock production per acre, help prevent spot grazing, and control many types of pasture weeds. Livestock will get a continuous supply of high-quality, young forage and the plants will have a chance to recover between grazing periods. This is especially important when livestock are grazing tall-growing grasses and legumes.

PLANT GROWTH

Figures 11 and 12 conceptually describe the growth curve and three phases of growth and illustrate the difference in growth rate and accumulation of dry matter in the summer versus the winter.

Forage quality is optimal in phase II. Figure 13 compares the crude protein and total digestible nutrients (TDN) of alfalfa, corn silage, grass (boot stage), and irrigated pasture. Pasture in phase II contains as much crude protein as alfalfa and boot-stage grass and a similar calculated TDN. Figure 14 shows average crude protein values for pastures sampled prior to grazing (phase II) in Glenn and Tehama Counties.

Photo 37. Grass in phase III is very fibrous and not very palatable; growth has slowed.

Table 16. Relationship of paddock rest to number of paddocks and grazing period

Number of paddocks	Grazing period	Rest period
1	continuous grazing	no rest period
2	1–3 days	1–3 days
8	1–3 days	7–21 days
16	1–3 days	15–45 days
28	1–3 days	27–81 days

Growth phase I occurs after plants have been severely grazed (see figures 11 and 12). Most of the leaf area has been eaten, leaving less photosynthetic area to intercept sunlight, and the forage canopy will be only a few inches high. Plants require more energy than they are able to produce through photosynthesis, so energy is mobilized from the roots. The roots become smaller and weaker as energy is transferred to growing leaf area. Growth during phase I is very slow, but the re-growth material is extremely palatable and nutritious (high in protein and energy).

Growth phase II is the period of the most rapid growth. This occurs when re-growth reaches one-quarter to one-third of the plant's mature size. Enough energy is captured through photosynthesis to support and replenish root carbohydrate reserves. The forage canopy may be 4 to 16 inches high. This growth contains sufficient protein and energy to meet the nutritional requirements of most livestock.

Growth phase III is the period when the growth rate of plants slows as plant height increases and leaves become more shaded. Lower leaves begin to die and decompose. Leaves use more energy for respiration than they produce through photosynthesis. Nutrient content, palatability, and digestibility of this material are poor. The forage canopy may reach heights of 24 to 36 inches and may have fully developed seed heads. (Adapted from instructional materials from the 1998 California Grazing Academy.)

Grazing Dictionary *Adapted from* Journal of Production Agriculture, *5:191–201.*

Listed below are some selected definitions for grazing lands and grazing animals. For a more extensive discussion of grazing terminology you can refer to http://forages.oregonstate.edu/topics/description.cfm?TopID=604

Carrying capacity

The maximum stocking rate that will achieve a target level of animal performance, in a specified grazing method, that can be applied over a defined time period without deterioration of the ecosystem. Carrying capacity is not static from season-to-season or year-to-year and may be defined over fractional parts of years. The average carrying capacity refers to the long-term carrying capacity averaged over years, whereas the annual carrying capacity refers to a specific year.

Continuous stocking

A method of grazing livestock on a specific unit of land where animals have unrestricted and uninterrupted access throughout the time period when grazing is allowed. The length of the grazing period should be defined.

Grazing method

A defined procedure or technique of grazing management designed to achieve a specific objective(s). One or more grazing methods can be utilized within a grazing system.

Intensive grazing management

Grazing management that attempts to increase production or utilization per unit area or production per animal through a relative increase in stocking rates, forage utilization, labor, resources, or capital. Intensive grazing management is not synonymous with rotational grazing. Grazing management can be intensified by substituting any one of a number of grazing methods that utilize a relatively greater amount of labor or capital resources.

Paddock

A grazing area that is a subdivision of a grazing management unit, and is enclosed and separated from other areas by a fence or barrier.

Rest

To leave an area of grazing land ungrazed or unharvested for a specific time, such as a year, a growing season, or a specified period required within a particular management practice.

Rotational stocking

A grazing method that utilizes recurring periods of grazing and rest among two or more paddocks in a grazing management unit throughout the period when grazing is allowed. The lengths of the grazing and of the rest periods should be defined.

Set stocking

The practice of allowing a fixed number of animals on a fixed area of land during the time when grazing is allowed.

Stocking density

The relationship between the number of animals and the specific unit of land being grazed at any one point in time. May be expressed as animal units or forage intake units per unit of land area (animal units at a specific time/area of land).

Stocking rate

The relationship between the number of animals and the grazing management unit utilized over a specified time period. May be expressed as animal units or forage intake units per unit of land area (animal units over a described time period/area of land).

Stockpiling forage

To allow forage to accumulate for grazing at a later period. Forage is often stockpiled for autumn and winter grazing, after or during dormancy or semi-dormancy, but stockpiling may occur at any time during the year as a part of a management plan. Stockpiling can be described in terms of deferment and forage accumulation.

Strip grazing

Confining animals to an area of grazing land to be grazed in a relatively short period of time, where the paddock size is varied to allow access to a specific land area. Strip grazing may or may not be a form of rotational stocking, depending on whether or not specific paddocks are utilized for recurring periods of grazing and rest.

GRAZING CONSIDERATIONS

Livestock grazing irrigated pasture generally have few health issues related to grazing. Producers should be aware of the following three situations that have the potential to create problems for their livestock.

Bloat Control

Livestock producers are often concerned with bloat. Bloat is rarely a problem with properly managed livestock and pastures. Watch livestock carefully for bloating and distress after you turn them out onto pastures. Some producers feed their livestock with hay before allowing them to graze new pasture. Simply limiting the animals' initial grazing time has been demonstrated as a successful way to reduce the incidence of bloat. Do not make sudden management changes once the animals are put on the pasture.

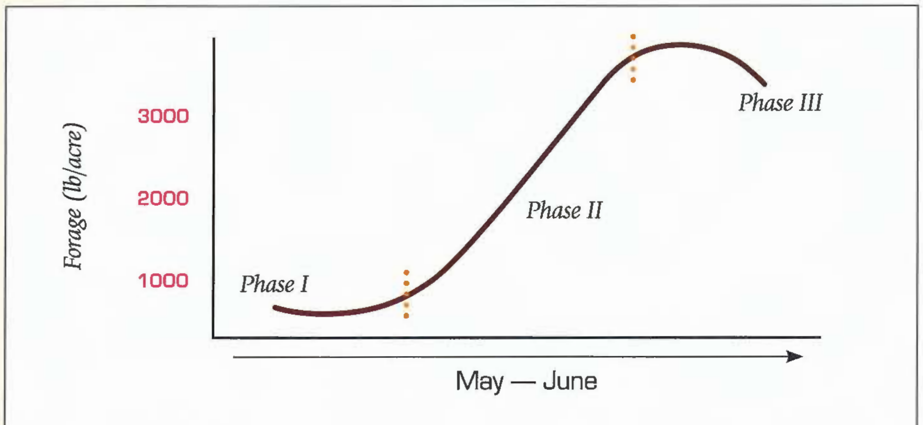


Figure 11. This curve is typical for summer growth. It is best to graze plants in the middle of phase II even if the maximum dry matter will not be harvested from the pasture. The nutritional quality of the forage is excellent, and if sufficient time is allowed for re-growth to bring the plant back to phase II again, the energy reserves in the roots of the plant will be restored.

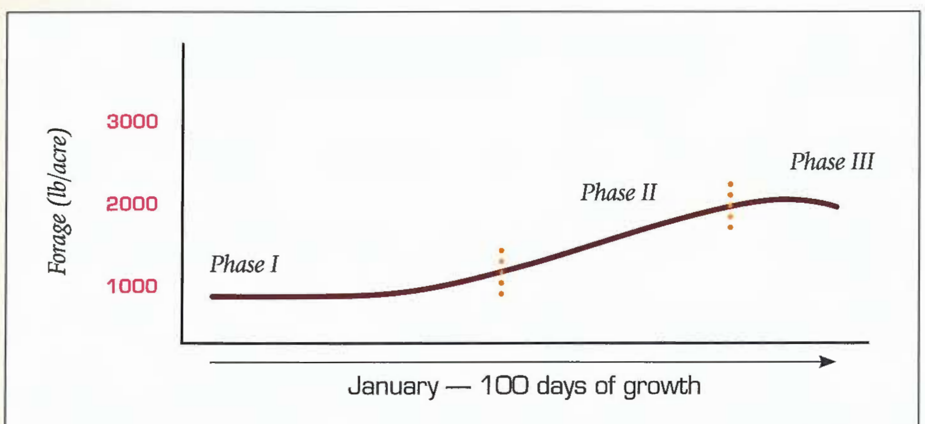


Figure 12. The growth curve is flatter in fall and winter. The growth rate is much slower and the total accumulation of plant dry matter is less than in the summer months.

Bloat-control products can be given as anti-foaming agents added to water, as an oral drench, top dressed onto feed, or in salt/molasses blocks. The ultimate aim in bloat control should be the development of a pasture that permits high production yet results in a low incidence of bloat. On a practical basis, the use of pastures made up of clover and grasses in equal amounts comes closest to achieving this goal. Most pastures have less than 50 percent clover, and this will help prevent bloat. Photo 38 shows a typical bloat control product.

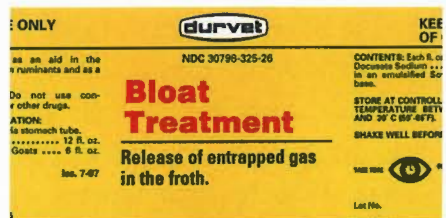


Photo 38. Label indications for a bloat-preventive product.

Grass Tetany

A metabolic disease, grass tetany is caused by a shortage of magnesium (Mg) both in grazing animals and in their diets. High levels of potassium (K) interfere with Mg absorption by the animal. Fertilization with K of soils having extremely low Mg levels relative to the calcium (Ca) levels may increase the plants' uptake of K and decrease their uptake of Mg, increasing the risk of grass tetany. Milk production can deplete both Mg and Ca in the animal, but the reduction in Mg in particular causes clinical signs of this disease. Grazing animals that consume low levels of Ca, phosphorus (P), and salt (NaCl) are at a greater risk of developing grass tetany. A well-formulated supplement should be prepared and made available to livestock when they are pastured on lush feed. Measures that help prevent grass tetany include (1) extra Mg in the diet, (2) extra Ca in the diet along with Mg, and (3) additional NaCl intake. For more detailed information on grass tetany, refer to the Merck Manual online (www.merckvetmanual.com/mvm/index.jsp?cfile=htm/bc/80400.htm).

Endophyte Toxicocis

Tall fescue may harbor an internal plant fungus known as an endophyte (meaning "inside the plant") that makes the plant more tolerant of environmental stresses but can be toxic to pregnant mares and their foals. Cattle generally are less sensitive to endophyte toxicosis than horses. In California, endophyte toxicosis is not frequently reported to the California Animal Health and Food Safety Laboratory.

High levels of endophyte may result in the following symptoms and behaviors in dairy and beef cattle as well as in sheep:

- low forage intake
- low weight gain
- low milk production
- high respiration rates
- high body temperatures (with water and shade used to cool body temperature)
- rough hair coats
- excessive salivation
- reduced blood serum prolactin (required for milk production)
- reduced reproductive performance

Cattle grazing on fungus-infected tall fescue occasionally develop lameness and may lose portions of their feet or tails in winter. This condition is referred to as "fescue foot." Horses have experienced problems after eating fungus-infected tall fescue. Mares have experienced abortions, prolonged gestation, difficult birth, poor milk production, and foal deaths. If endophyte toxicosis is of concern to you, ask for certified Endophyte-free fescue seed or sample the existing pasture fescue for endophytes.

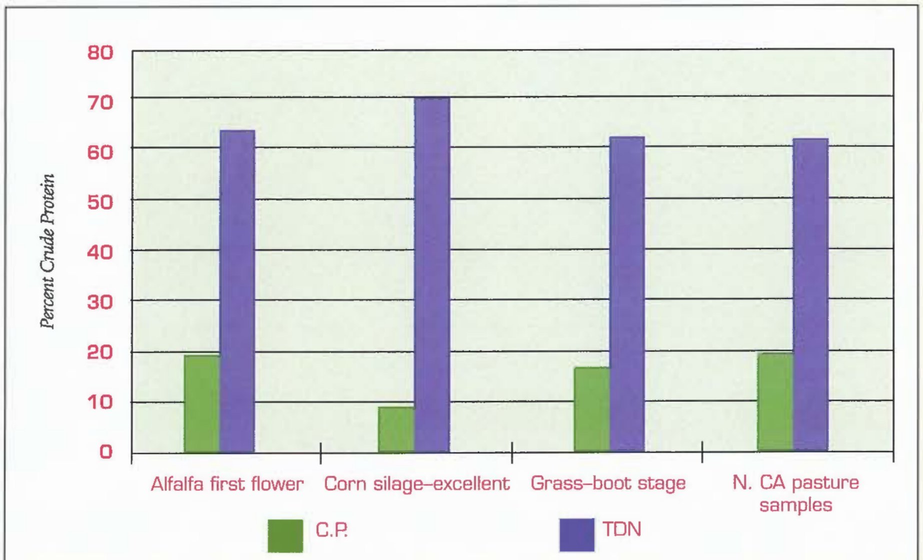


Figure 13. A comparison of percent total digestible nutrients (TDN) and percent crude protein (CP) in alfalfa, corn silage, grass (boot stage), and Northern California pasture samples. Data for alfalfa, corn silage, and grass derived from *FEEDVAL: Comparative Values Calculated from Crude Protein, TDN, Ca and P: REferee Feeds Used To Calculate Value Of Nutrients* (W.T. Howard and Randy K. Shaver, University of Wisconsin–Madison, November 1997).

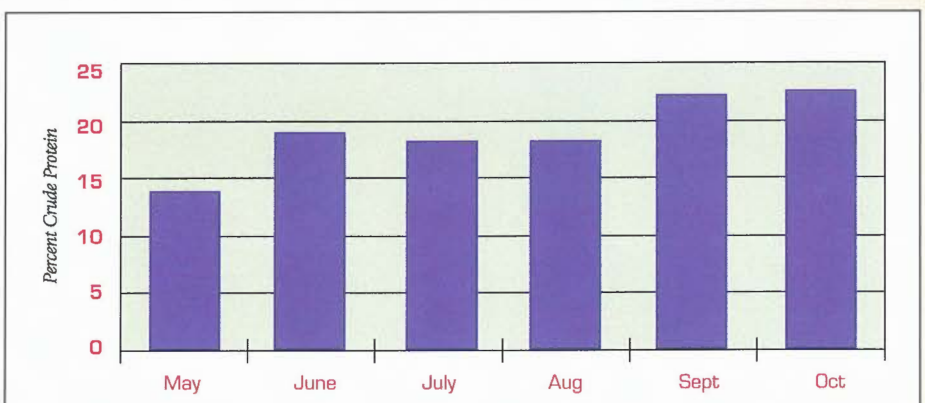
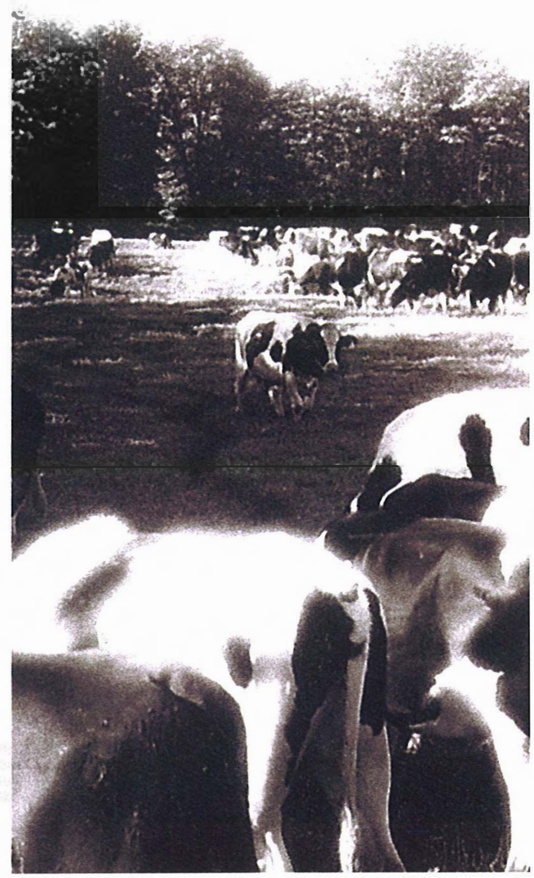


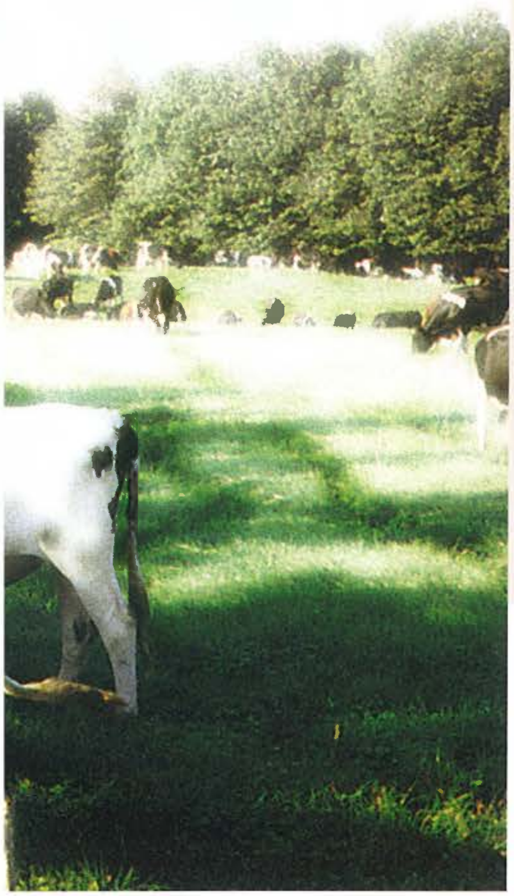
Figure 14. Average crude protein of pastures in Glenn and Tehama Counties sampled prior to grazing (phase II growth) between April and September from 1993 to 1996. As in Figure 13, the crude protein of pasture is more than adequate for most livestock.



CHAPTER 7

LEASES

Larry Forero, Glenn Nader,
and Barbara Reed



Many people in California who want to lease irrigated pasture for grazing have little or no experience in negotiating a lease. This chapter will serve as a general outline for how to develop a livestock grazing lease on irrigated pasture. Our recommendations are based on good pasture management and should help the lessor (landlord) and lessee (tenant) develop a lease that will satisfy their unique circumstances. Both parties should clearly understand the terms of the lease before they sign the document. In all cases, the lease should be a written document developed in consultation with an attorney experienced in this area. Remember, a lease is a legally binding contractual agreement.

When a livestock lease is negotiated, it is important that both the tenant and landlord have a clear understanding of the lease arrangement. Many pasture owners have no interest in taking on any of the responsibilities necessary to produce pasture and graze livestock. The tenant needs to carefully consider his exact responsibilities and factor them into the value of the lease.

TYPICAL PASTURE LEASE ARRANGEMENTS

Several types of lease are used for pasture. There are several payment schemes based on charges per acre, per whole tract, per head of livestock, per animal unit month (AUM), and per pound of gain (for growing cattle). Some of these leases can include a variable component that adjusts the dollar value of the lease based on livestock market conditions.

Lease Charges Based on Animal Weight Gain

Here is an example of how to calculate the lease charge when it is based on livestock weight gain. The price for gain in this example is set at 30 cents per pound.

Final weight and price (October)
700 lb

Initial weight and price (April)
450 lb

Net gain
250 lb

250 lb net gain x \$0.30 per pound = \$75.00 charge

Lease Charges Based on Animal Price

Along with the base rent, a variable lease might be indexed on the price of steer calves, yearling steers, or lambs in October, or on an average beef cattle or replacement heifer price.

For example, assume a base rental rate of \$11 per acre, a 10-year average value for a 600-pound steer calf of \$0.85 per lb (for the month of October), and a current October 2004 value of \$1.19 per lb. The lease would cost (\$1.19/\$0.85) × 11 = \$15.40 per acre.

A lease that is indexed to cattle prices will produce higher than average lease costs (found in Agricultural Commissioner Crop reports) when market demand for cattle is high.

Per-acre charges vary with the productivity of the pasture and conditions of the lease. This method is recommended for smaller land parcels and simple leases. The number and type of livestock, the time of year, and the length of the lease need to be established to prevent abuse. In this arrangement, the lessor receives a set return per year and the lessee assumes the risk of any fluctuations in the pasture's forage production.

Per whole tract refers to renting a block of land or ranch for one fee. This is normally used when leasing an entire ranch for a period of years or when mixtures of land types are leased as a unit (e.g., pasture, cropland, range, and forest).

Per head charges for a month or season vary depending on whether the stock are cows and calves, stocker cattle, replacement heifers, sheep, or horses (also see AUM Equivalent). In this case, the lessor takes some of the risk of changes in annual forage production rates but has more direct control of stocking rates. This method, too, is suitable for smaller parcels.

Per animal unit month (AUM) charges provide flexibility in that they allow for different types of livestock and seasons of use without their being specifically indicated in the lease. A field rated at 100 AUMs per year could support 10 cows for 10 months, 50 cows for 2 months, or 125 sheep for 4 months. The AUM is defined as the amount of forage required by a mature beef cow (and calf) for 1 month, with equivalents calculated for other animals. The AUM is often used when describing stocking rates in soil surveys and other forage production analyses. This method is used by government agencies and professional range managers. For conservative estimates and ease of calculation, you can figure that 1 AUM = 1000 pounds of forage.

Although some people consider a cow-calf pair to be 1 AUM, some landowners will charge more for cows with calves than for cows whose calves have been weaned. A cow-calf pair requires more feed and management than a cow does on its own.

Share of gain applies to seasonally grazed weight-gaining animals such as stocker cattle, replacement heifers, and lambs. These charges may consist of a pre-established charge per pound of gain (e.g., \$0.30/lb of gain). Animals are weighed before and after grazing to determine the charges (see sidebar). When rent is based on weight gain, proper weighing, working, and loading facilities should be provided by the lessor. The conditions of weighing should be spelled out in the lease agreement. This type of lease is more common where livestock or truck scales are available.

Variable leases have two parts: a base rate that is fixed for the term of the lease and a variable rate that is modified each year by a livestock price index. This lease allows the rental rate to go up or down as the price of livestock varies, reflecting the market. Local livestock auctions or USDA market reports can be used as a basis for a price index. The index can be developed using a long-term average for a set month as compared to the most current market price (see sidebar).

DETERMINING RENTAL RATES

Setting the rental rate is a major factor in the process of developing a lease agreement. You should have an idea of what local rental rates are before you begin any lease discussion. The Agricultural Commissioner's Crop Report for your county is one good starting place for finding this information.

After you establish a forage or base rental value for the pasture, you need to consider additional items before you settle on the final rental rate. Along with the lease terms described below, the most important items to agree upon are the type and weights of livestock, numbers of animals (the stocking rate), and the grazing season.

LEASE TERMS

Liability Insurance

Both the landowner and the tenant should carry liability insurance to protect both parties against unforeseen problems such as third-party injury or property damage. It is important to have proof of this insurance. The landlord should be named as an additional insured on the tenant's farm/ranch insurance policy. Coverages of $1,000,000 per occurrence and $2,000,000 per year are typical policy minimums.

General Terms of the Lease

A lease must include the following:

1. names of the involved parties
2. description of the location
3. number of acres involved
4. type, number, and weights of livestock
5. type of lease (continuing, annual, or seasonal)
6. starting and ending dates
7. who is the paying and responsible party for
    a. water (including the power bill if the water is pumped)
    b. fertilizer costs
    c. irrigation
    d. animal health
8. method of payment
9. legal terms as necessary (reviews, amendments, transfer of property, right of entry, etc.)
10. the maintenance and repair of improvements (fences, corrals, buildings, etc.)

Length of Lease

Long-term leases are usually contracted for a minimum of 3 to 5 years and can be advantageous to both parties. The advantage to the lessor is economic incentive for the lessee to practice good pasture management that will provide a maximum sustained rental income and protect the forage resource in the long term. The advantage to the lessee is opportunity to focus on long-range management rather than short-term financial problems. However, long-term leases impart a certain degree of inflexibility to both parties. Quick changes in economic conditions may be hard on a lessor or lessee who is locked into an inappropriate lease price.

Short-term leases are usually contracted for a period of 1 to 3 years. The advantage of a short-term lease is that it allows the lessor or lessee to terminate the lease quickly if the situation is not suitable. The main disadvantage is that the lease provides little, if any, incentive for the lessee to maintain or improve the facilities and pasture.

Landowner Services

Landowner services range from rent collection only to irrigation, pasture fertilization, and complete responsibility for the stock during the grazing period. Some of the services commonly negotiated include counting stock, checking animal health and treating the sick with an acceptable death loss agreed upon, providing and checking stock water, providing salt and minerals, pasture movement of stock, and maintaining fences. The nature and scope of these services and commensurate compensation for these additional duties must be clearly understood by both the tenant and landlord. All management responsibilities for pasture and stock should be specified in the lease agreement.

Water

Adequate irrigation water is essential for productive pasture. Properly located, clean drinking water for stock is important for livestock performance and pasture utilization. Water quality and availability should be described in the agreement along with assignment of responsibility for maintenance and repair of the stock water and irrigation systems.

Reasonable Use

Maintaining the long-term productivity of the pasture and facilities is an important consideration in grazing leases. Refer to Chapter 8 on grazing economics for guidelines. Protection of the land from overgrazing is the purpose of grazing-use guidelines. Effective control of where livestock graze and how they are distributed on the pasture land are important for both livestock production efficiency and resource protection. The least costly and most accessible information for estimating a pasture's carrying capacity is found in historical livestock numbers and time of use. When you use this information, you assume that the number of livestock run in the past on the land (or on a similar piece of land), with acceptable levels of use, is an accurate estimate of its grazing capacity. Ranchers who have been on their land many years have a "feel" for the number of cattle or sheep that can graze an area. The best place to start in estimating the livestock production capacity of a management unit is with local ranchers or other knowledgeable people, asking them about their experience and knowledge in the area. After you establish an initial stocking rate, intensive management requires that you closely monitor forage use throughout the grazing season. This will influence your decisions about whether to reduce stocking rates when forage is short or to increase stocking rates if surplus feed is available. If the estimated capacity of the land does not match actual use, you can work with the landlord to adjust the lease terms accordingly.

Special Clauses

Each lease should contain a means for modifying the terms to handle emergency situations such as drought or flood. There should also be a way to change or terminate the lease when both parties agree to do so. Restrictions on hunting or fishing privileges and tree cutting and selling should be stated in the lease.

Biosecurity. Some lessors have had problems determining who actually owns the livestock being grazed on their pastures. If the lessor wants to be sure of the animals' ownership, a requirement of proof of ownership can be included in the lease language. If the lessor has concerns about the health of the livestock, a health certificate can be required. Both parties need to decide how to dispose of the carcasses of animals that die on pasture.

Weighing Conditions. When rent is based on weight gain, it is the lessor's responsibility to provide proper weighing, working, and loading facilities. The conditions of weighing should be spelled out in the agreement.

Maintenance and Improvements. It is essential to provide for maintenance of facilities in a lease so that the structures do not deteriorate and the pasture is not degraded. Similarly, if pasture improvements are needed or desired, they can be incorporated into the lease agreement as a part of the fee or a condition of lease renewal. Provisions for maintenance and improvements can be worked into a lease so that they benefit both the landlord and the tenant. The more certain a rancher is that a lease renewal will be granted, the more incentive he or she has to pay attention to the long-term productivity of the land and upkeep of the facilities. Under a long-term lease (3 to 5 years minimum), the lessee may assume the major responsibility for maintenance and repair on all buildings, interior fences, gates, corrals, ditches, and water facilities to the satisfaction of the lessor. For short-term leases, the lessor may assume major maintenance responsibilities. Similar conditions can be specified for improvements. Some improvements can be viewed as maintenance, including weed and poisonous plant control, cross fencing, and minor water developments, while others such as reseeding and fertilization require a greater capital investment that may be shared by both parties.

Inventory

The pasture conditions, water sources, and infrastructure should be inventoried at the initiation of the lease. Evaluate only those facilities necessary for a livestock grazing operation, such as fences, corrals, and barns. The productivity of forage and the availability and distribution of water will determine the number of stock that can be run on the land (its carrying capacity). Additionally, at the time of the inventory it will be beneficial to note any deficiencies that need to be corrected and any opportunities for improvement that would increase production. To do a deficiency and improvement analysis, the landowner needs to understand the productive capacity of the pasture and maintenance and improvement practices or must have access to people who can supply this information.

ADDITIONAL RESOURCES

Information on all aspects of pasture and livestock production is available through your local University of California Cooperative Extension County Office (located in most counties throughout California). Local Natural Resources Conservation Service (NRCS) offices can also provide information relating to the development of ranch management plans. Contact agricultural lenders, real estate brokers, or lawyers who have experience in agricultural/grazing leases. One excellent source for current market values of pasture land is the California Chapter of the American Society of Farm Managers and Rural Appraisers:

American Society of Farm Managers and Rural Appraisers
California Chapter Office
P. O. Box 838
Woodbridge, CA 95258
Tel: (209) 368-3672 Fax: (209) 368-3602
www.calasfmra.com

CHAPTER 8

GRAZING ECONOMICS

Larry Forero, Glenn Nader,
and Barbara Reed

All farming enterprises have costs (and hopefully returns) associated with them. When planting and managing irrigated pasture it is important that you know what the costs are before you begin. Once involved in pasture production, a landowner should have the tools to determine whether or not the ongoing operation is profitable and what opportunity costs are associated with the pasture enterprise. *Opportunity costs* are generally considered to be the non-cash costs associated with forgoing the opportunity to do something different with a given resource. When a producer chooses to graze a pasture rather than rent the pasture to someone else, he or she has forgone that rental income.

IRRIGATED PASTURE PRODUCTION COSTS

For a detailed discussion of irrigated pasture costs refer to *Sample Costs to Establish and Produce Pasture: Sacramento Valley, Flood Irrigation* by Forero, Reed, Klonsky, and DeMoura (2003) , online at www.agecon.ucdavis.edu/uploads/cost_return_articles/pasturesv03.pdf.

COMPARING PASTURE RENTAL TO HAY PURCHASE

Table 17 compares the costs of irrigated pasture rental to the costs of hay purchase. In this example, feeding a horse on hay at $100/ton is cheaper than managing an irrigated pasture for the pasture's 7-month growing season. However, you may consider other factors in your analysis that do not have well-defined costs, such as the benefit of exercise for the horse or the aesthetics of a green, lush pasture. Purchased forage can be more expensive

Table 17. Comparing the cost of renting irrigated pasture to the cost of purchasing hay

Factor	Pasture rental (measured in AUM)	Hay purchase (measured in tons)
Pasture productivity (feeding period April-October)	8 AUM/acre	—
Cost per unit	$346/acre or $43.25/AUM	$100.00/ton
Horse feed demand for the feeding period	1,000 lb horse = 1.25 AU 7 months x 1.25 AU = 8.75 AUM (1.09 acres)	2.5% of body weight per day 0.025 x 1,000 lb = 25 lb per day 25 lb hay per day x 210 days = 5,250 lb or 2.63 tons
Cost for the feeding period	8.75 AUM x $43.25 = $378.43	2.63 tons x $100.00 = $263.00

Table 18. Gross returns for grazing steers for 5 months

Expense		
Purchase 33 steers (500 lb per steer @ $0.93/lb)	$15,345	
Pasture rental bill (20 acres x $21/acre/month x 5 months)	$2,100	
Vet/medical ($10/head x 33 head)	$330	
Shipping (40 miles x $4/mile)	$160	
TOTAL EXPENSE		$17,935
Livestock gain: 2 lb/day (300 lb in 5 months)		
Gross income		
33 steers x 800 lb x sale price of $0.77/lb	$20,328	
TOTAL INCOME		$20,328
– Total expense		$17,935
= Net profit		**$2,393**
Net per-acre profit (20 acres of pasture)		$120/acre

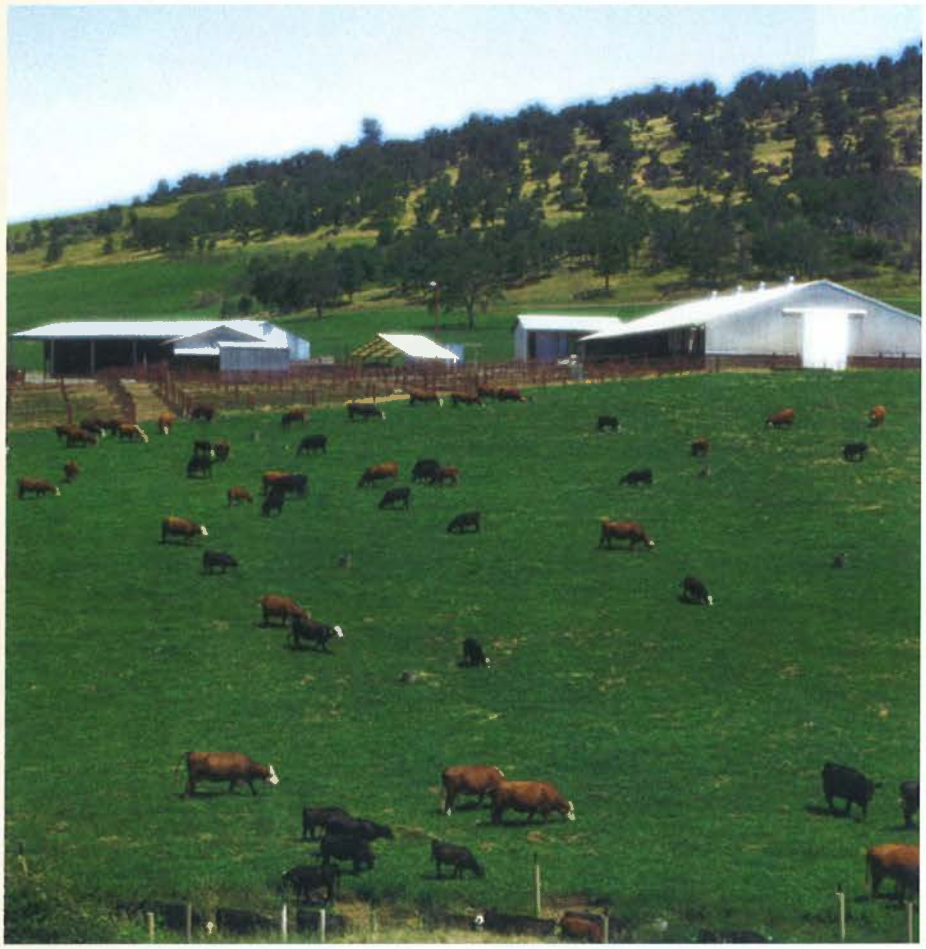
than pasture production if hay prices go up or if you have to move, cover, and store hay, or the carrying capacity of the acreage is higher than average. Table 17 only compares these costs for the growing season. In both cases (hay and pasture), supplemental feed would have to be stored or purchased for the winter months.

GROWING CATTLE ENTERPRISE

In Chapter 6 we discussed the concept of stocking rate and the Animal Unit (AU) method of estimating a pasture's carrying capacity. Using an example that describes 20 acres of irrigated pasture stocked with steers, we can calculate potential gross returns. Table 18 demonstrates one method of calculation.

The figures used above are examples and do not necessarily represent your actual costs. Capital improvements for animal handling (corrals, squeeze chute, etc.) are not included. For current information in your area, consult your local Farm Advisor, Auction Yard or commodity trade publication. Productive irrigated pasture that is well-managed can yield higher returns than the $120/acre discussed in the above example. The season, type of cattle, market conditions, condition of the pasture and management capabilities of the operator all influence the financial return that can be expected from irrigated pasture.

APPENDIX:
SUGGESTED ADDITIONAL READING



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For more information on forage testing and forage laboratories in California, refer to the California Alfalfa and Forages Web site on forage quality (http://alfalfa.ucdavis.edu/quality/).

http://anrcatalog.ucdavis.edu

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