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Establishing and Managing Irrigated Pasture for Horses

JOSH DAVY, UC Cooperative Extension Advisor, livestock, range, and natural resources for Tehama, Glenn, and Colusa Counties; **THERESA BECCHETTI**, UCCE Advisor, livestock, range, and natural resources for Stanislaus and San Joaquin Counties; **DAVID LILE**, UCCE Advisor, livestock, range, and natural resources for Lassen County; **ALLAN FULTON**, UCCE Advisor, soils and irrigation for Tehama, Shasta, Glenn, and Colusa Counties; and **DEBORAH GIRAUD**, UCCE Farm Advisor, Humboldt and Del Norte Counties.

The establishment of irrigated pasture offers many advantages to the horse owner. Pastures bring together a high-quality forage resource and exercise space for the horse. However, irrigated pasture establishment requires careful planning. Preliminary considerations include the feasibility of irrigation, soil type in the proposed pasture, assurance that sufficient land is available to support your potential stocking needs, and the costs and availability of the equipment and materials you have to have if you mean to establish and maintain pasture. This publication is a guide to help you make horse pasture management decisions.

Pasture Establishment

Finding the right site

Thorough site evaluation is very important if you intend to establish a new irrigated pasture. Many sites are not practically suited to irrigated pasture production. Soil type and depth must be such that they do not limit root growth and that the soil has sufficient available water storage to make irrigation feasible and economical. A shallow soil with limited potential for water storage is a poor candidate for economical establishment of an irrigated pasture. You can find a good online tool to help you determine your site's soil type and associated information at the UC Davis California Soil Resource Lab website. To determine your soil type, click on the "online soil survey" tab at http://casoilresource.lawr.ucdavis.edu/drupal/.

The availability and cost of irrigation water are important factors in determining the economic prospects for establishing a pasture. Evapotransporation (ET) for a field is the combined amount of water lost to evaporation and used by the plants (transpiration). A reference evapotranspiration map (figure 1) has been developed by the California Department of Water Resources and the UC Davis Department of Land, Air, and Water Resources to help you determine a monthly average reference ET for your area. You can download an enlargeable PDF copy of the map at the CIMIS website (http://wwwcimis.water.ca.gov/cimis/cimiSatEtoZones.jsp), which also features a variety of other ET information.

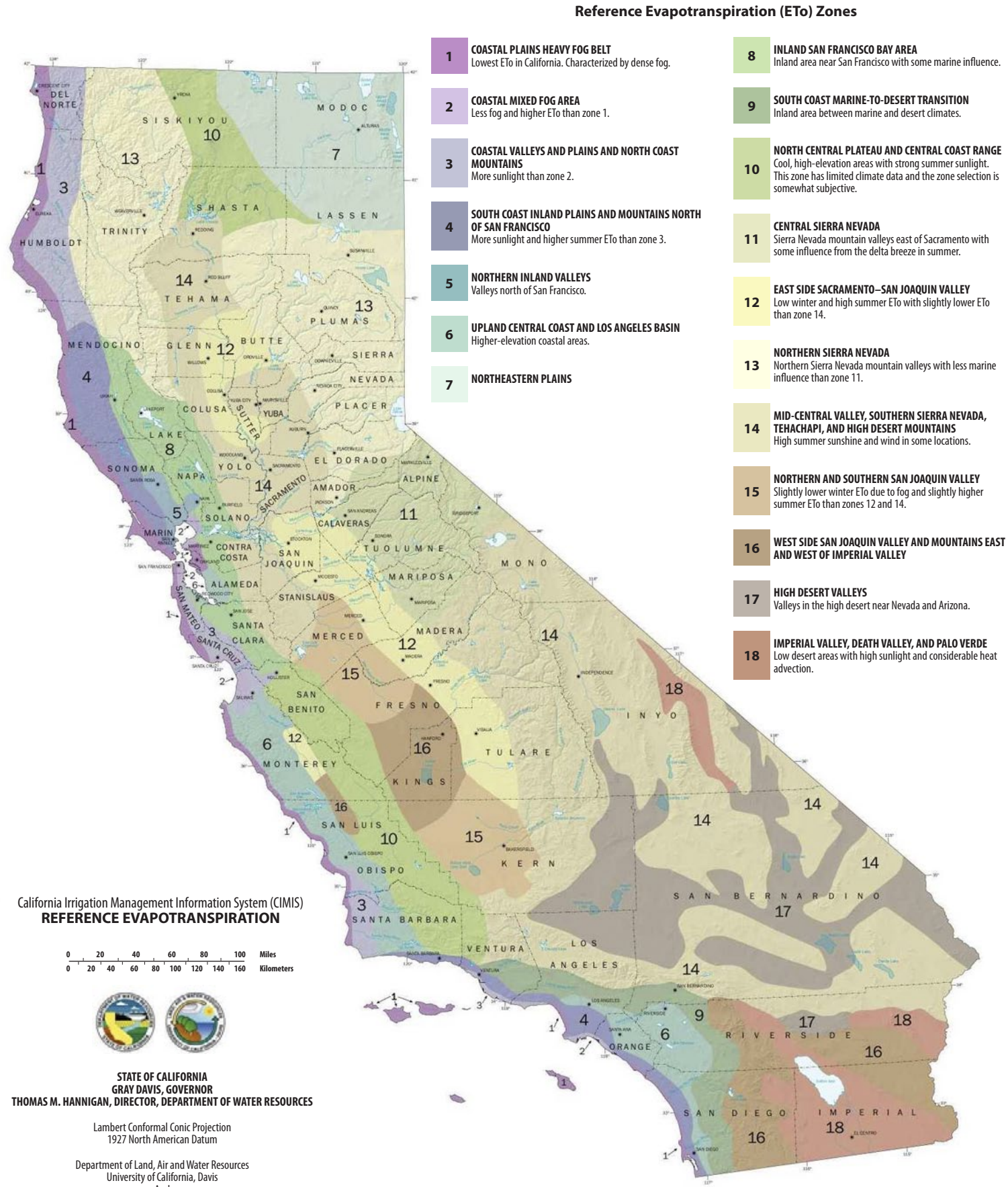

Figure 1. Reference evapotranspiration (ET_o) map for California. A higher-resolution version is available online at http://wwwcimis.water.ca.gov/cimis/cimiSatEtoZones.jsp. Reproduced here courtesy of California Irrigation Management System, Department of Water Resources, Office of Water Use Efficiency.

Monthly Average Reference Evapotranspiration by ETo Zone (inches/month)

Zone	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1	0.93	1.40	2.48	3.30	4.03	4.50	4.65	4.03	3.30	2.48	1.20	0.62	33.0
2	1.24	1.68	3.10	3.90	4.65	5.10	4.96	4.65	3.90	2.79	1.80	1.24	39.0
3	1.86	2.24	3.72	4.80	5.27	5.70	5.58	5.27	4.20	3.41	2.40	1.86	46.3
4	1.86	2.24	3.41	4.50	5.27	5.70	5.89	5.58	4.50	3.41	2.40	1.86	46.6
5	0.93	1.68	2.79	4.20	5.58	6.30	6.51	5.89	4.50	3.10	1.50	0.93	43.9
6	1.86	2.24	3.41	4.80	5.58	6.30	6.51	6.20	4.80	3.72	2.40	1.86	49.7
7	0.62	1.40	2.48	3.90	5.27	6.30	7.44	6.51	4.80	2.79	1.20	0.62	43.4
8	1.24	1.68	3.41	4.80	6.20	6.90	7.44	6.51	5.10	3.41	1.80	0.93	49.4
9	2.17	2.80	4.03	5.10	5.89	6.60	7.44	6.82	5.70	4.03	2.70	1.86	55.1
10	0.93	1.68	3.10	4.50	5.89	7.20	8.06	7.13	5.10	3.10	1.50	0.93	49.1
11	1.55	2.24	3.10	4.50	5.89	7.20	8.06	7.44	5.70	3.72	2.10	1.55	53.0
12	1.24	1.96	3.41	5.10	6.82	7.80	8.06	7.13	5.40	3.72	1.80	0.93	53.3
13	1.24	1.96	3.10	4.80	6.51	7.80	8.99	7.75	5.70	3.72	1.80	0.93	54.3
14	1.55	2.24	3.72	5.10	6.82	7.80	8.68	7.75	5.70	4.03	2.10	1.55	57.0
15	1.24	2.24	3.72	5.70	7.44	8.10	8.68	7.75	5.70	4.03	2.10	1.24	57.9
16	1.55	2.52	4.03	5.70	7.75	8.70	9.30	8.37	6.30	4.34	2.40	1.55	62.5
17	1.86	2.80	4.65	6.00	8.06	9.00	9.92	8.68	6.60	4.34	2.70	1.86	66.5
18	2.48	3.36	5.27	6.90	8.68	9.60	9.61	8.68	6.90	4.96	3.00	2.17	71.6

Variability between stations within single zones is as high as 0.02 inch per day for zone 1 and during winter months in zone 13. The average standard deviation of the ETo between estimation sites within a zone for all months is about 0.01 inch per day for all 200 sites.

Pasture can consume large quantities of water. Every acre-inch applied to meet the pasture's ET is equal to 27,154 gallons of water. The CIMIS maps will give you a reference quantity for pasture water use, and you can then adapt it as needed to estimate how much water your pasture will actually need and how often you will have to irrigate.

For example, Sacramento Valley irrigated pastures can exceed 8 inches of ET a month during the irrigation season. If the available water storage of a proposed soil is 1.6 inches of water in an 18-inch root zone, it will require five irrigations in that month—that's at least one irrigation every 6 days. Any delay longer than this between irrigations during the warm season would make it impossible to maintain a productive pasture. The economics of constructing an irrigated pasture on this example site, then, would be determined based on the cost of delivering water every 6 days during the peak of the irrigation season. In many cases, delivering water on a 6-day schedule may not be feasible.

Irrigation type

Once you have found an appropriate site, you need to design the irrigation system. The two most common types of irrigation system are sprinkler and border flood. Both have advantages and disadvantages, and it is important that you understand them ahead of time.

Flood irrigation

Compared to sprinkler irrigation, flood irrigation requires a great deal of land preparation. The land must be leveled and then graded to a slope of 0.1 to 0.4 foot of drop per 100 feet of length. Borders must then be created to guide the water across the field. The length and width of the checks (irrigation runs) depend on soil type, head of the water (the inflow rate), and slope of the field. For more information, refer to *Irrigated Alfalfa Management* (ANR Publication 3512).

The advantage of flood irrigation is that once the preparatory phase is completed, investments of capital, maintenance, and labor in subsequent years are far less than for a sprinkler system. To irrigate with a flood system, you do not have to move sprinklers at each irrigation. Instead, an operator just opens a valve at one end of the field, the water follows gravity as it flows across the field, and the operator closes the valve when the water reaches the other end of the field. The downside of a flood system is that it uses more water than a sprinkler system. This may not be a big problem if your pasture is in an irrigation district, but if you have to pump your own water it might be expensive.

Sprinkler irrigation

A sprinkler irrigation system requires little or none of the surface grading required for flood irrigation, but it still can be more expensive because it requires capital investments in pipe and sprinklers. Types of sprinkler system include wheel lines, hand-moved lines, solid-set underground lines, and newer, hose-based systems that can be moved with a tractor or all-terrain vehicle (ATV). A sprinkler irrigation system has the advantage when water is limited or expensive, the soil is gravelly or sandy, or the terrain is not level—because it applies water more efficiently, most of the water is delivered directly to the root zone, where it will do the crop the most good.

A sprinkler system has its disadvantages, too, though. Sprinklers are difficult to manage in areas where there is strong wind. Unless you install a solid underground line system, most sprinkler systems must be moved manually for each irrigation, and that by itself requires more labor than a flood system does. Sprinklers also require more energy than flood irrigation since you have to pressurize the sprinkler pipes when applying water. Additionally, sprinklers may require protective barriers to prevent damage to the horses and also damage to the equipment from the animals. Occasional service may be necessary to keep the pipes and sprinkler heads in proper working order and free of debris.

Pasture species selection

Once you have chosen your irrigation system, you can select a seed mix. The desired level of management and quality of pasture forage are the primary factors that will guide you in choosing the type of seed mix to plant. In some cases, such as when you are planting a mountain pasture, soil type dictates the seed mix. The key features of the forage species described here (also see table 1) can help you select the right seeding mix for your pasture. Examples of seed mixes are shown in table 2.

Table 1. General characteristics of common pasture grasses

Grass variety	Turf hardiness	Winter/cold hardiness	Longevity	Production*	Palatability	Quality†
Cool-season grasses						
Fescue	High	High	High	High	Low to medium	Low to medium
Perennial ryegrass	Medium	Low to medium	Medium	Medium	High	High
Orchardgrass	Low to medium	Medium to high	Medium	Medium to high	High	Medium to high
Warm-season grasses‡						
Dallisgrass	High	N/A	High	Medium	High	Low to medium
Bermudagrass	High	N/A	High	Low to medium	Medium to high	Low to medium
Kikuyugrass	High	N/A	High	Medium	Medium to high	Low to medium

*Cool-season grasses will yield higher in fall, winter, and spring.
Warm-season grasses will yield higher in summer.

†Variables such as stage of maturity and use of fertilizers have a large influence on forage quality.

‡Warm-season grasses are dormant during the winter season.

Table 2. Example seed mixes for irrigated horse pastures

Forage*	Percent	Total seeding rate (lb/acre)†	Planting characteristics	Location
Tall fescue	100	20	Sod mix, high production, adapted to a wide range of soils from marginal to good	Intermountain area, Sacramento Valley, North Coast
Bermudagrass	100	5–10	Sod mix, medium production, exercise area	San Joaquin Valley south
Perennial ryegrass/ orchardgrass	30/70	20	High quality, intensive grazing management, good soils	All (less common in Intermountain area)
Orchardgrass	100	20	High quality, intensive grazing management, good soils	Intermountain area

* If a legume component is desired, add 1 to 2 lb/acre of birdsfoot trefoil.

† Increase seeding rate at least 10% for broadcast seeding.

Adjusting for pure live seed basis

It is important that you make sure that the seeding rates you use are based on a pure live seed basis and not on the bulk seed amount. If you do not base your seeding rate on pure live seed, you may significantly underseed your pasture. A pure live seed count takes into account the germination and purity of the seed as reported on the tag of the seed bag. For example, a seed tag that reports 90 percent germination and 85 percent purity would drop the pure live seed rate to 76.5 percent of the original bulk seed (90% × 85% = 76.5%). A 50 lb bag of that mix would actually contain 38.25 pounds of pure live seed (50 lb × 76.5% = 38.25 lb). All seeding rates in this publication refer to a pure live seed basis.

Warm-season versus cool-season grasses

The first consideration is warm- versus cool-season grasses. In foothill and valley regions, either type can be considered. In coastal areas and at elevations above 2,500 feet, cool-season grasses make the best choice for planting. Warm-season grasses grow best in the middle of summer but produce very little growth in fall, winter, and spring. In contrast, cool-season grasses have excellent fall and spring growth but are only moderately productive in the middle of summer. It is possible to plant both types together if you minimize the difference in palatability between grasses when you select the mix. A complete comparison of common warm- and cool-season grasses is available in the articles "Adaptability of Tropical Forages to California's Central Valley" and "Irrigated Warm- and Cool-Season Grasses Compared in Northern California Pastures" in California Agriculture journal, available online (http://californiaagriculture.ucanr.org/).

Cool-season perennial grasses: perennial ryegrass, orchardgrass, and tall fescue

Perennial ryegrass *(Lolium perenne)* and orchardgrass *(Dactylis glomerata)* are highly palatable to horses, whereas tall fescue *(Festuca arundinacea)* is only moderately palatable. This makes a mix of perennial ryegrass and orchardgrass desirable, but not if you add tall fescue to the mix. Horses can be very selective eaters. If you include the less-palatable tall fescue, ungrazed clumps of tall fescue and overgrazed areas of orchardgrass and perennial ryegrass can result, especially in a single-pasture grazing system. To eliminate this kind of selectivity, it is wise to plant either all tall fescue or no tall fescue at all. Although it has poorer forage quality and is less palatable than orchardgrass or perennial ryegrass, tall fescue does produce more forage than either of the other two.

To remain a major component of the pasture mix, orchardgrass and ryegrass usually need to be rotationally grazed so they can have a rest or recovery period between grazings. Without adequate rest periods, these grasses will not persist in the pasture. The longer livestock graze on them or the closer the animals crop them to the ground, the more rest they will require between grazings. Often, an adequate rest period for orchardgrass and ryegrass will be too long a period for tall fescue, which becomes less and less palatable as the time between grazings increases. Once established, tall fescue is better able to survive continuous grazing than either of the other two. If quality is your goal, then, and intensive management is an option for you, your best mix will be a combination of orchardgrass and perennial ryegrass. If, on the other hand, maximum production is your goal rather than quality and intensive grazing management is not feasible, tall fescue will be a more appropriate choice. Newer, thinner-bladed varieties of tall fescue are more palatable, but they still do not equal ryegrass in this respect. In coastal and mountain areas, soil type rather than management approach may dictate your selection of a seeding mix. Low-quality soils (poorly drained, alkaline, or acidic soils) may dictate that the pasture be planted to tall fescue rather than orchardgrass or other species.

If you choose a fescue variety, check with the seed vendor to make sure the seed is endophyte-free. Endophyte is a fungus that lives within the fescue plant. It does not affect the plant's outward appearance, but it can cause a variety of problems in grazing animals. In horses, it mainly affects the breeding mare. Fescue toxicosis can result in abortion, prolonged pregnancy, and foaling problems that can lead to the death of the foal or the mare (or both), a thick or retained placenta, and poor milk production. The endophyte can only be spread through the seed, so by ensuring your seed is endophyte-free at planting you will ensure the safety of the forage and your horses. Most fescue varieties, and particularly those sold in California, are currently sold as endophyte-free.

Seeding rates for cool-season grasses range from 15 to 20 lb per acre if seeded with a drill and 20 to 25 lb per acre if broadcast seeded. Perennial ryegrass has greater seedling vigor than orchardgrass, so if you select a combination of the two for planting, make sure to mix it one-third perennial ryegrass and two-thirds orchardgrass. This ratio should eventually result in equal representation of both species in the field. Trial data comparing varieties of cool-season grasses are available on the UC Alfalfa and Forages website (http://alfalfa.ucdavis.edu/).

Warm-season perennial grasses: dallisgrass, bermudagrass, and kikuyu

The most commonly planted warm-season grasses are bermudagrass (*Cynodon* spp.), dallisgrass *(Paspalum dilatatum),* and occasionally kikuyu *(Pennisetum clandestinum).* Judged on an annual basis, these grasses do not produce any more forage than the cool-season grasses, but they do excel at production in the middle of summer when hot daytime temperatures tend to slow the growth of cool-season grasses. All three of the grasses named above are palatable grasses. Kikuyu and bermudagrass are sod-forming (lateral-spreading) grasses that growers generally do not mix with other species. Bermudagrass produces well in the southern San Joaquin Valley from Stanislaus County south. If you plant bermudagrass, the desired seeding rates are 3 to 5 lb per acre if planted with a drill and 10 lb per acre if broadcast. Kikuyu should be planted at 1 to 2 lb per acre with a drill, 8 to 10 lb per acre if broadcast. In some situations either grass can be invasive; check with your county agriculture commissioner to determine whether county codes permit their use. Bermudagrass and kikuyu may need higher application rates of nitrogen fertilizer to maximize production because their sod-forming habit excludes legumes that could otherwise augment the soil with fixed nitrogen.

Dallisgrass does very well in the Sacramento Valley and northern San Joaquin Valley and is compatible with cool-season grasses. It does not require intensive management and is very palatable to livestock. In the north valley, it often does not need to be planted, as it will invade the pasture over time, especially if the pasture is irrigated from an open ditch. Dallisgrass seed is available, though it is sometimes relatively expensive and its germination can be staggered. Seeding rates are commonly 10 lb per acre if seed is drilled and 15 lb per acre if broadcast. It is not nearly as common in mountain areas or wet coastal areas, but ranchers occasionally do use warm-season grasses in inland Coast Range valleys.

Perennial grasses for exercise areas

If the main purpose of your pasture is to serve as an exercise area rather than a forage resource, a grass sod pasture is best. In the southern San Joaquin Valley and the southern desert regions of California, bermudagrass is commonly used for horse pasture. This type of planting produces a good sod that resists trampling. Bermudagrass is not nearly as productive in other parts of the state; northern Sacramento Valley counties and cooler mountain and coastal counties are better served by tall fescue as a sod-type pasture choice.

Cool-season annual grasses: annual ryegrass

Annual ryegrass *(Lolium multiflorum)* is a cool-season annual, meaning that it germinates rapidly in the fall (late winter in the mountains), grows until it makes seed in late spring, and then dies. Because it is so prolific, growers often include it in inland valley and coastal perennial mixes to provide quick cover. This practice is not recommended, however, since the annual ryegrass actually competes significantly with the perennial grasses in the mix, potentially reducing their establishment. It is better suited to seeding over established warm-season perennial grass pastures for winter and spring production.

Warm-season annual grasses: sorghum, sudan, sorghum/sudan hybrids, and tef

A common practice for livestock pastures in the warmer valley regions of California is to plant a sorghum (*Sorghum* spp.), sudan, or sorghum/sudan hybrid grass crop in late spring prior to a fall planting of a permanent pasture. The sorghums are summer annual grasses that germinate in late spring and die in the fall, at which time the permanent pasture can be drilled into the stubble. This method, commonly called a cleanup crop, provides summer hay or grazing forage and helps control weeds prior to planting of the permanent

pasture. This method should not be used in horse pastures, since sorghum forages can be toxic to horses, causing cystitis. Additionally, prussic acid and nitrate poisonings are possible with stressed sorghums. Whether grazed or hayed, sudan and sorghum forages should be harvested by cattle, not horses. An alternative nontoxic summer annual grass such as tef *(Eragrostis tef)* can be used in place of sorghum and achieve the same purpose without adversely affecting the health of grazing horses.

Cool-season perennial legumes: white clover, trefoil, and strawberry clover

Legumes are sometimes included in pasture seed mixes because they are palatable and high in protein and they have the ability to fix atmospheric nitrogen. The plant uses most of this converted nitrogen for itself, but some excess nitrogen does become available for use by surrounding plants such as grasses. Nitrogen fixation can help supplement a pasture's nitrogen needs, but the limited amount of legume cover in a horse pasture usually will not eliminate the need for other nitrogen applications. Plants in the legume family include clover (*Trifolium* spp.), peanuts *(Arachis hypogaea),* alfalfa *(Medicago sativa),* lupines (*Lupinus* spp.), peas (*Pisum* spp.), and soybeans *(Glycine max).* The forage legumes most often planted in pastures are clovers.

Horses generally prefer the grass component of the pasture. The horse's ration does not require the high forage quality of clover; this is in contrast to cattle, which prefer a combination of clovers and grasses. For pastures that provide grazing solely for horses, seed only sparingly with highly productive and stoloniferous spreading clovers such as white (ladino) clover *(Trifolium repens),* because of their ability to spread. The tendency of horses to select grasses over clover may lead to white clover dominance in the pasture. Less-prolific legumes such as trefoil *(Lotus corniculatus)* can be planted to help with nitrogen fixation. A third option, strawberry clover *(Trifolium fragiferum),* is intermediate between white clover and trefoil in its production potential, but as one of the hardiest clovers it can withstand moderate drought, waterlogged areas, and close grazing.

For planted clovers to develop nodules (figure 2) and fix nitrogen, they must be properly inoculated before planting. Clover seed often comes pre-inoculated; otherwise you can inoculate it just prior to seeding. Clover that is not inoculated or is fertilized with high rates of nitrogen generally does not fix nitrogen and is outcompeted by the grass component of the pasture.

Pastures with a high clover content will often exceed the nutritional requirements for most classes of horses and can quickly cause a variety

Figure 2. Nitrogen-fixing nodules on roots of berseem clover *(Trifolium alexandrinum),* an annual legume. These nodules are formed by beneficial bacteria that enter the root hairs and cause rapid division of root cells. *Photo* by Jack Kelly Clark.

of adverse health effects. Any horse grazing on pastures with more than 10 to 15 percent clover content should be monitored closely for founder and gastrointestinal problems (colic). Founder is caused by a rotation of the coffin bone in the horse's hoof, which can lead to permanent lameness. Divergent growth rings on the hoof wall sometimes provide an initial sign of founder before lameness occurs. A horse that is kicking or biting at its stomach is likely showing signs of colic, and veterinary care may be necessary.

Clover seeds are much smaller than most grass seeds, so they should be planted at a lower seeding rate. If included in a horse pasture seed mix, the clover seeding rate should not exceed 1 to 2 lb per acre.

Ground preparation and seeding

Ground preparation

Once the irrigation and drainage system is completed and tested, you can begin to prepare a seedbed. It may be necessary to moisten the soil to a depth of 10 inches to make cultivation possible. Disking is generally adequate for preparing the seedbed. Avoid overcultivating the soil into a fine powder, as this can inhibit germination by allowing a crust to form at the soil surface. The seedbed is sufficiently worked when clods are less than 1 inch in diameter. You can use a harrow to help break up clods. Harrows are often dragged behind the disk. Where soil is highly compacted, it is often necessary to rip or chisel in order to break up the hardpan and allow roots to penetrate deep into the soil. A single pass over the field with a cultipacker after ground preparation helps produce a firm seedbed that will help control seed planting depth if you plan to use a drill. A light rain or irrigation followed by a dry period can have the same result.

Pastures that need reseeding but irrigate well and do not have compacted soil can be sprayed with a nonselective herbicide to kill weeds and then directly replanted, eliminating any need for the ground preparation procedures previously mentioned. Unless the soil is soft enough to allow easy penetration, though, this practice is only suitable if you plan to use a no-till drill to seed the pasture. Conventional cultivation of the ground is usually required for a grain drill.

Starter fertilizer

A soil test can provide information on phosphorus, potassium, and pH that will prove essential in pasture establishment. If a starter fertilizer (generally phosphorus or sulfur or a combination of the two) is to be applied, it is best to incorporate it near the end of seedbed preparation, before planting. If the pasture is drill seeded, a small amount of starter fertilizer can be placed with the seed by means of the fertilizer box on the drill, a technique that can help the emergence and establishment of the seeded grasses. If you are going to make a broadcast application of fertilizer—particularly nitrogen—it is often best to wait and apply it once the pasture is growing and weeds are under control. That way you know the pasture forage, not the weeds, will benefit from the fertilizer.

Selecting a pasture planting strategy and timing

In foothill and valley regions, fall (October) to early winter (January) seeding is recommended for cool-season grasses because a spring-seeded pasture often has weeds that are more difficult to combat, such as pigeon grass (*Setaria* spp.). A fall seeding lets the forage plants emerge and become competitive before the onslaught of summer annual weeds. Winter annual weeds tend to be far easier to control than summer annual weeds. The likelihood that the seedling pasture will successfully compete with winter annual weeds is high if you follow this four-step process:

1. Prepare a seedbed by disking in early fall.
2. Allow the weeds to germinate.
3. Spray with a nonselective herbicide or lightly disk.
4. Plant the pasture.

Mixtures that contain only warm-season grasses must be seeded in late spring when soil temperatures begin to warm after winter.

North coast pasture should be planted by late summer or early fall to ensure establishment of an adequate stand before winter, when rainy weather will bring problems involving cold temperatures, poor drainage, and erosion. Spring planting is also an option for coastal areas, but it is risky because wet weather there may create field conditions that will keep you from getting planting equipment into the field. Fall-planted pastures have the additional advantage of being ready to use the following spring.

In the higher-elevation Intermountain counties, seeding when growing conditions are getting warmer in April or May lets you take advantage of available soil moisture that has accumulated from winter precipitation. Late August to early September is another good time for seeding if adequate irrigation water is available. You do need to take care that you get the new pasture established early enough for it to be able to withstand the cold weather that will begin in late fall. Stands that have not had time to establish before freezing temperatures arrive may be lost.

If you use a sprinkler irrigation system, a September seeding followed by irrigation can help get the stand germinated and growing quickly while temperatures are still warm. If you use district irrigation water, this planting method may not be feasible, since the district may not supply water in the fall. A sprinkler system can be used if rainfall is inadequate during early establishment, so long as irrigations are timed to keep the soil surface wet without causing large puddles. Flood irrigation of newly seeded pastures should be avoided except in sites with sandy soil and enough of a slope to push a low flow of water across the field. Most pastures should not be flood irrigated regularly until there is complete germination and the seedlings have been growing for at least 2 weeks. With most flood irrigation systems, it is advisable to delay planting until you can count on fall rains, usually starting at the end of October or beginning of November. That way, the rainy season can take care of irrigation for crop establishment.

Planting the pasture

For rapid germination, seed must be in contact with the soil. You can accomplish this by slightly covering the seed with soil—approximately ¼ inch in depth, but no more than ½ inch—and packing it. Planting pasture seed any deeper than ½ inch can inhibit germination. Conversely, failure to cover the seed makes for poor contact between the seed and the soil and allows a substantial amount of seed to be lost to bird feeding.

Proper seed placement can be accomplished by drilling or broadcasting seed. A drill is the better choice because you can adjust seed placement to the correct depth and most drills follow placement with a packer wheel to ensure seed-to-soil contact. If no drill is available, broadcasting seed is the next best option. If you broadcast seed, take particular care to uniformly spread the seed. Spreading half the seed in one direction and half in the other direction usually ensures adequate coverage. Seeding in both directions is not necessary with a drill. Follow the broadcast seeding with a ring roller to cover and press the seed into the ground. If no ring roller is available, a less-effective alternative is to drag a harrow or a length of chain link fence to scratch the soil surface and cover the seed.

Seedling weed control

Grass seedlings in an irrigated pasture have good seedling vigor, but sometimes weed control is still necessary. If no legume is planted and there is a flush of broadleaf weeds, you can make a spring application of a selective broadleaf weed herbicide to help establish the grass pasture. Most broadleaf-specific herbicides require that the grasses develop up to six leaves before you spray in order to avoid herbicide injury to seedlings. If you plant a legume, weeds should be mowed rather than sprayed when they reach about 6 inches in height. Mowing will help open the newly planted stand to sunlight. Grazing should be delayed until the grass height reaches 12 to 15 inches.

Managing an Established Pasture

During a 6- to 8-month growing season, 1 acre of established (at least 1-year-old), well-managed irrigated pasture should supply enough feed for one 1,000 lb horse. Many horses weigh 1,200 lb, however, and so require 1.25 acres of pasture each. To maintain best production, it is far better to stock your pastures conservatively than to overstock them. Horses are physically hard on pasture because of their active behavior, their habit of congregating in one area of a pasture, and their ability to graze pasture plants closer than other classes of livestock. Because of this, the stand should be well sodded—meaning that the pasture mix should have complete ground cover and should dominate the plant community—before you allow grazing to begin.

Grazing

In general, the nutrient requirements for horses are not as great as those for growing or lactating cattle. Unlike a cattle pasture, a horse pasture is best allowed to mature before you graze it. Mature forage is lower in quality and can provide a large quantity of grazeable fiber with less of a potential to cause founder for the lightly worked horse.

Foaling mares and other horses with higher nutrient requirements need pasture that is in a high-quality vegetative state. Small, individual paddocks help to create uniform grazing across the pasture, as compared to large paddocks that give horses a chance to pick out the most desirable plant species. Interior electric fences are useful for management because they allow you to easily adjust paddock sizes until you determine the optimal size for a specific pasture. Another factor in some coastal area pastures is a tendency for rank growth to accumulate in underutilized forage. In such an instance, it may be necessary to concentrate your horses by fencing them in or to mow underutilized areas so the grasses will grow back in a higher-quality, more-productive vegetative state. If you do use fencing, proper maintenance is crucial to prevent horses from injuring themselves by getting caught in loose wire.

Rest or rotational grazing

If you rotate pastures, midsummer rest periods of approximately 3 to possibly 4 weeks are desirable for orchardgrass and perennial ryegrass pastures. Two to three weeks' rest may be adequate during periods of peak growth, such as spring for cool-season grasses. A rest period long enough to allow grasses to reach a height of 12 to 15 inches can be considered sufficient for cool-season grasses. If pastures are grazed heavily, however, you may need to provide rest periods two or even three times as long as has been specified here. Dallisgrass and tall fescue are productive after a slightly shorter rest period.

Cool-season grass pastures can be considered ready for a rest period when they have been grazed to a height of 4 to 6 inches above the ground. By resting the pasture at this height, you will ensure that there will be enough leaf area for regrowth during the rest period. Most warm-season grasses and tall fescue can be grazed to a slightly lower plant height.

Continuous grazing or set stocking

It is possible to graze a pasture without rest periods, so long as the stocking rate is moderate and enough water and nitrogen are present to sustain growth. This grazing method is known as either continuous grazing or set stocking. Stand maintenance is only possible with continuous grazing if you graze moderately, by not allowing forage levels to be grazed to a height of less than 6 to 8 inches. Forage use is usually less efficient and the stocking rate is lower on a pasture that is continuously grazed than on a pasture that provides adequate rest for perennial plant regrowth between grazings. Continuous stocking has the advantage of requiring less labor time and interior fencing than other grazing strategies.

Corral or sacrifice area

In many cases, the acreage available for pasture is not sufficient to provide enough feed to maintain a horse without supplementation. When this is the case, it is better to practice a normal pasture rotation on the planted pasture and to maintain a separate pen or corral as a sacrifice area that is not planted in pasture. Horses in the sacrifice area can be fed supplemental hay while the irrigated

pasture has time to rest and recover from grazing and to optimize production. This area may also be used during periods of irrigation or heavy rainfall to keep horses from damaging wet pastures.

Irrigation

Irrigated pastures in the Sacramento Valley generally require 3 to 4 acre-feet of irrigation water per acre over the summer growing season to supplement rainfall. In the San Joaquin Valley, irrigated pastures may need a minimum of 4 acre-feet of water per acre in a summer growing season. Pastures in mountain counties can be expected to use about 3 acre-feet of water per acre to maintain optimal soil moisture. Coastal pastures will use less.

Necessary flow rate or pump output

On a hot summer day in the Sacramento Valley an irrigated pasture can consume about 9,000 gallons of water per acre, which works out to 0.3 inch per day. An irrigation system with a capacity to deliver an inflow of at least 7 gallons of water per minute is required to meet this maximum rate of daily water consumption. Because irrigated pasture is rarely irrigated on a daily basis and because sprinkler and flood irrigation systems are designed to irrigate the pasture in sets, a higher actual flow rate of 10 to 30 gallons per minute per irrigated acre is a more realistic requirement. Lower flow rates are generally required for sprinkler irrigation than for flood irrigation. A greater rate of flow helps to efficiently flood-irrigate a longer field, and a sandier soil with a higher water intake rate can be difficult to cover with water. Higher flow rates also provide more flexibility in the timing of sprinkler and flood irrigations.

Irrigation scheduling

Irrigation scheduling is one of the most important factors influencing irrigated pasture production: it is the decision-making process by which you determine when to irrigate a pasture and how much water to apply during the irrigation in order to optimize pasture growth and irrigation costs while minimizing the growth of weeds that reduce the feed quality of the pasture. Ideally, irrigation scheduling requires that the irrigation water supply be available on demand and that it not be restricted by a set delivery schedule, as can be the case when the water supply is shared by multiple users (i.e., rotating deliveries administered by a water district or by watermasters on an adjudicated stream).

Common methods used for scheduling irrigations in pastures include use of a water budget and monitoring of soil moisture in the pasture root zone. These two methods used together can achieve better results than either one can on its own. The water budget approach seeks to match the amount of water consumed by the pasture to the amount of water applied by an irrigation system in order to prevent undesirable plant water stress. Real-time estimates of crop water consumption are available online at www.cimis.water.ca.gov. These estimates are based on real-time weather data and are available for many regions of California.

The water budget method. The water budget method is better suited to sprinkler systems. Because the water flow is confined within pipelines and delivered through nozzles, it is easier to accurately measure the actual rate of water application. Sprinklers generally allow greater control over the water application rate and the uniformity of application, making it easier to evaluate the effectiveness of a water budget. Application rates are easily measured: you just place catch cans under the sprinklers and use them to collect the water applied over a measured amount of time.

The water budget method can also be used in flood-irrigated pastures, but it is harder to implement and less reliable. The water application rate is much more difficult to measure for a flood system because the soil's infiltration and water-holding properties play such a large part in determining how much water you need to apply in order to flood an entire pasture with water. It is easily possible for you to have to apply much more water with a flood system than was consumed by the pasture prior to irrigation. A significant fraction of the applied water can percolate below the root zone of the pasture or run off the end of the irrigation check, contributing nothing toward matching the pasture's actual water consumption. Consequently, the water budget method may have limited benefit in determining how much water to apply via a flood irrigation system.

You can, however, realistically assume that in most instances a flood irrigation will apply water

throughout the entire root zone of the crop. Thus, a more helpful use of the water budget method for flood irrigation is to use it to determine the proper interval to allow between irrigations rather than the amount of water to apply. To do this, you match the crop's water use with the available water storage of the pasture soil type. Available water storage is the difference between the soil's full-field water-holding capacity and its dry wilting point. The value is different for different soils, depending mostly on their particle analysis. Clay type soils have the highest available water storage level, loam soils have a moderate level, and gravelly and sandy soils have the lowest level. The available water storage for most irrigated soils is equivalent to between 9 and 15 percent of the top 39 inches of soil. Thus, a pasture with a 2-foot root depth will likely have between 2.16 and 3.6 inches of water available for crop use. The depth of the pasture root zone is easy to determine using a shovel or soil auger. The depth can vary from 1 to 4 feet, depending on a variety of factors such as grazing management, soil limitations, and pasture forage species. Information on most California soil types and available water storage values are available online at the California Soil Resource Lab website (http://casoilresource.lawr.ucdavis.edu/drupal).

Soil moisture monitoring method. A second method used for irrigation scheduling is to actually monitor soil moisture. You can use inexpensive soil moisture sensors to gauge how dry the soil is in the pasture root zone, and those data can help you determine the best time to irrigate. Soil moisture monitoring is especially useful for

- determining how deep water percolates into the soil profile after rainfall or irrigation
- understanding the distribution of the pasture root zone and the depth of soil from which the pasture extracts water
- determining seasonal water extraction trends in the root zone

Perhaps the least complicated method for soil moisture monitoring is to use a shovel or soil auger to retrieve soil samples at different depths in the root zone and then handle the samples to get a general sense of soil moisture (figure 3). Samples that are lighter in color and that crumble are drier than samples that are darker and roll into a firm ball or form a ribbon when you pinch the soil between thumb and index finger.

Without the use of one or the other of these methods, it can be difficult to schedule irrigations. Every pasture has its own unique water requirements. Simply waiting for the forage to turn brown before irrigating is not an option: it will reduce the pasture's production and can permanently damage the pasture. Depending on conditions, the necessary frequency of irrigations can vary from every 7 days for one pasture to every 20 days for another. Irrigation frequency can even vary for a single pasture depending on the time of year.

Grazing during irrigation

Stock should be excluded from the pasture during irrigation and high rainfall events and kept out until the surface dries. Wet soils are compacted by trampling, and compaction retards root growth and water infiltration. In addition, pocked-up pastures from wet-season grazing have bare soil that is open to weed seed germination. This major source of pasture abuse is easy to avoid if you simply corral your animals or move them to a drier pasture during the wet season or irrigation events. Besides protecting the pasture's health, it is also healthier for the animals to be kept off of wet pastures. Many hoof problems can be avoided if you keep your horses on dry ground. In parts of the north coast where seasonally wet pastures can be the norm, you may want to take extra measures such as providing covered areas with gravel and cement pads in order to maintain the animals' hoof health and prevent degradation of the pasture.

Pasture fertilization

Fertilizer applications can vastly improve pasture productivity. However, fertilization is no replacement for grazing and irrigation management. An adequate amount of grass must already be present in the pasture to put the fertilizer nutrients to use. Fertilizer applications to a highly overgrazed pasture provide only limited benefits and certainly are not cost effective.

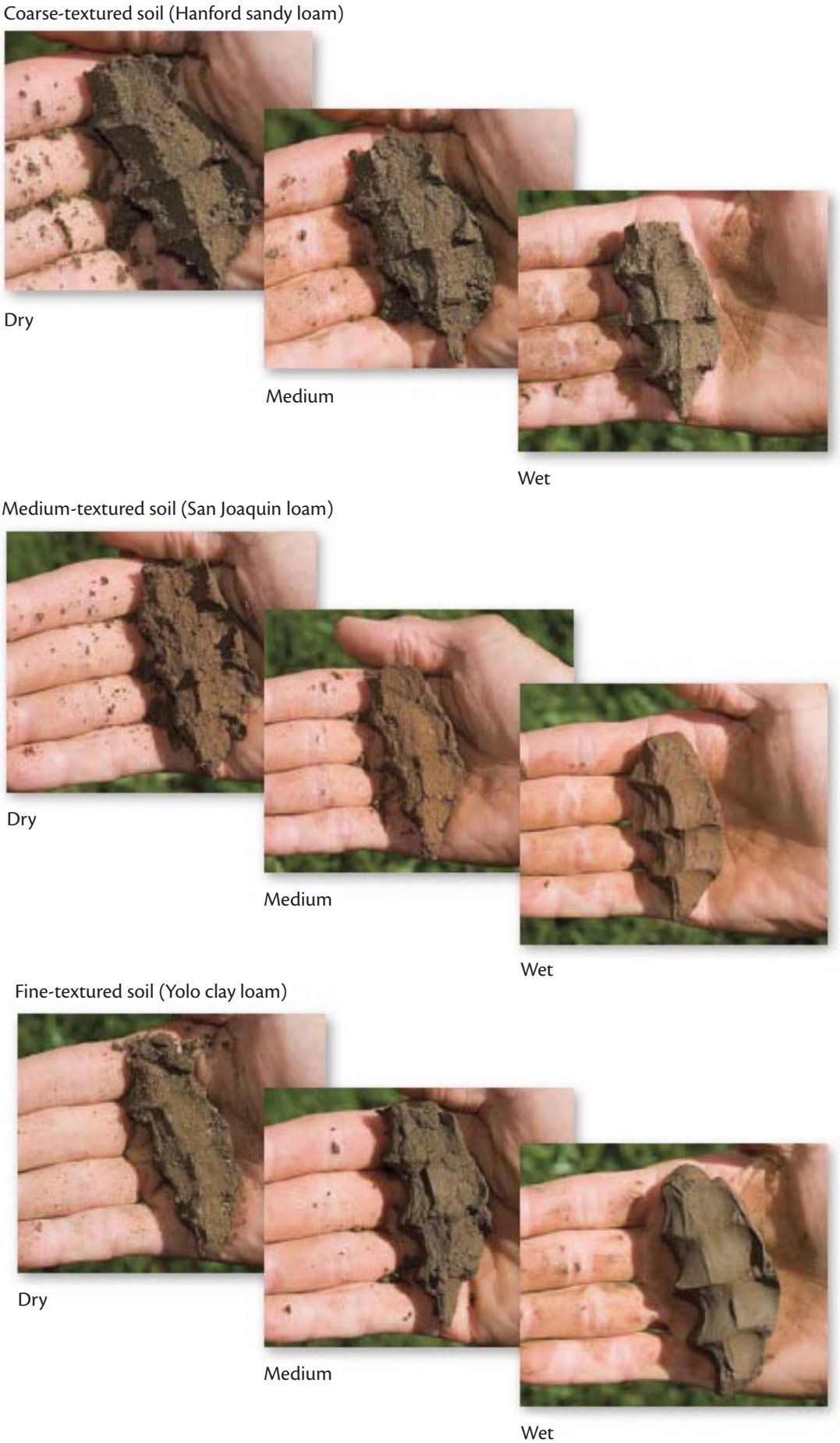

Figure 3. Determining soil texture and moisture by the feel method. *Photos* by Jack Kelly Clark.

Determining nutrient deficiencies

The most common nutrient deficiencies on irrigated pastures are nitrogen and phosphorus. In the Intermountain region and some valley areas, sulfur deficiency is common as well. Pastures in northern California coastal areas often have low soil pH and require applications of lime for optimal pasture establishment. A few also require potassium applications.

The first postseeding fertilizer application should be delayed until the seeded pasture species are growing vigorously and can compete with weeds. Fertilizer applications before this time benefit only the weeds. A soil test for phosphorus, potassium, and pH and a plant test for nitrogen and sulfur can help you determine the best way to address pasture deficiencies.

Although commonly reported data, nitrogen and sulfur results from soil samples are only moderately reliable bases for making fertilizer decisions. A test for nitrate nitrogen (nitrogen in a form that is readily available to plants) can be of value for estimating the amount of nitrogen that is available for plant use in the soil at the current time.

Nitrogen is a highly mobile nutrient. Content in the soil can easily change in a short period of time due to factors such as leaching and denitrification. Soil test results are only valid at the time the samples are collected; they have little value when planning for the distant future. We also need to remember that other forms of nitrogen, such as organic nitrogen, can mineralize and become available for plant use. These forms do not show up in the nitrate nitrogen test and can be significant if manure has been applied to the pasture or if the pasture was previously in alfalfa.

Sulfur soil analysis is of limited value because plants can obtain sulfur from other sources besides the soil, such as rainfall. Outside sources contribute only small amounts of sulfur, but the plant requirement for sulfur is low compared to nitrogen so it is easier to satisfy. A plant analysis will capture data on sulfur uptake from the soil and from alternative sources.

Table 3. Critical levels and fertilizer correction per acre for fertility lab analysis

Plant analysis			
Nutrient	**Low level**	**Marginal level**	**Adequate level**
Nitrogen (N)	< 2.0%	2.0 – 2.8%	> 2.8%
Sulfur (S)*	< 0.10%	0.10 – 0.15%	> 0.15%
Soil analysis			
Nutrient or soil characteristic	**Low level (and correction)**	**Marginal level (and correction)**	**Adequate level**
Phosphorus (P)	< 5 ppm (100 lb P) 5 – 10 ppm (50 lb P)	10 – 20 ppm (25 lb P)†	> 20 ppm
Potassium (K)	< 40 ppm (200 lb K)	40 – 60 ppm (100 lb K)	> 60 ppm
pH‡	< 4.5 (2.9 tons sugarbeet lime)	< 5.5 (1.7 tons sugarbeet lime)	6 – 6.5

* If both sulfur and nitrogen are low, consider an amendment such as ammonium sulfate (21-0-0-24) that contains both nutrients.

† Correction of marginal level may have minimal benefit for grasses but will likely enhance clover growth. Horse pasture managers may want to carefully evaluate the economics of correction.

‡ Correction levels are based on loam soils.

SOURCE: *Irrigated Pasture Production in the Central Valley of California* (UC ANR Publication 21628).

Soil sampling involves augering at least 10 subsamples to a depth of 6 inches from a representative section of the field. These subsamples can be combined to make one overall sample for laboratory analysis. One to two cups of soil is enough for lab analysis. Avoid including debris and plant material in your soil samples.

You can collect plant tissue samples at the same time as you collect soil samples. To collect plant tissue samples, pull the top four to six leaves from only vegetative grass plants. Do not allow any clover leaves or grass stems into the sample. Many soil analytical laboratories are available to test your samples, and you can find most of them online. Call the lab in advance of sampling to obtain submission sheets and further information. Table 3 shows low, marginal, and adequate test results and how much fertilizer you should apply to correct any deficiencies.

Fertilization strategies to correct nutrient deficiencies

Fertilizer strategies can affect a pasture's plant composition. If legumes are present and if water, phosphorus, and sulfur are adequate, then nitrogen fixation by the legumes can supply some of the pasture's nitrogen requirement. In fact, adding high rates of nitrogen in that situation would increase the production of grass and reduce clover. Where phosphorus or sulfur is deficient, the addition of phosphorus or sulfur will cause legume production to increase. Unlike with nitrogen, a single application of phosphorus or sulfur fertilizer should be enough to last several years.

Pasture plants can get some nitrogen from legumes but generally still need a fertilizer application to achieve optimum production, especially in a horse pasture with a limited legume component. The proportion of clover in a horse pasture, unlike in a pasture for cattle, is not likely to produce enough nitrogen to meet the pasture's need for optimal growth. If a pasture is made up entirely of grass and you want it to produce more forage, applications of nitrogen fertilizer will generally increase growth. During periods of rapid growth, a grass pasture will use up a single nitrogen application in about 30 to 40 days, so it is common to apply 30 to 40 lb of nitrogen per acre several times during the growing season to maximize productivity. Growers do not generally fertilize pastures with nitrogen more than two or three times a year. Because nitrogen is a highly mobile nutrient, excessive or overly frequent applications can actually waste the excess nitrogen, which can even be detrimental to local water quality.

Purchasing fertilizer

Fertilizer packages are labeled to show their content as N-P-K-S (nitrogen-phosphorus-potassium-sulfur); the numbers represent the percentage by weight for each of the nutrients. Below are common examples of granular fertilizers and their corresponding nutrient contents:

Urea (46-0-0-0)

Ammonium sulfate (21-0-0-24)

Monoammonium phosphate (11-52-0-0)

Monoammonium phosphate sulfate (16-20-0-13)

Triple 15 (15-15-15-10)

Purchase your fertilizer based on cost per pound for the nutrient you are correcting. For example, urea (46-0-0-0, or 46% nitrogen) is usually cheaper per pound of nitrogen than ammonium sulfate (21-0-0-24, or 21% nitrogen), even though a 50 lb bag of urea is more expensive than a 50 lb bag of ammonium sulfate. This is because the 50 lb bag of urea contains more than twice as much actual nitrogen fertilizer (23 lb) as a 50 lb bag of ammonium sulfate (10.5 lb).

Fertilizer application

Fertilize your pastures at a time when the fertilizer granules can be dissolved into the soil by water soon after application. This lessens the chance that nitrogen will be lost through volatilization (i.e., lost into the air) in warm weather. With a sprinkler irrigation system, the proper timing for

application is directly before an irrigation. Flood irrigation may push some of the material off the field, so for that method a better time to apply is as soon as an irrigation set is being shut off, when the field still has enough water on the surface to incorporate the fertilizer into the soil but not enough to cause it to run off in the tailwater. Urea forms of nitrogen fertilizer are far more volatile than any other form, which means if you do apply them, you need to incorporate them or dissolve them into the soil within several days.

Manure

Manure contains multiple forms of the common nutrients necessary for maximum pasture production. On a well-established pasture with a firm sod, you can drag manure with a chain harrow or a section of chain link fence to help spread the piles out and make the nutrients more widely available to the pasture. Dragging the pasture also helps speed the breakdown of manure, leaving fewer areas that are bare of forage as a result of standing manure piles. Drag the pastures only when they are dry so as not to open up the soil surface for weed invasion. Dragging a pasture can be very beneficial, but you must take care to evaluate each pasture and make sure that dragging is necessary and is not causing excessive damage.

Weed control

The best way to accomplish effective weed control in an irrigated pasture is to establish a strong, competitive stand of pasture forage. A vigorous pasture stand competes for light, nutrients, and water, and that keeps weed seeds from germinating and growing. Some weeds provide you with clues that can help you with your management decisions. For example, smart weed (*Polygonum* spp.), rushes (*Juncas* spp.), dock (*Rumex* spp.), and sedges (*Cyperus* spp.) are water-loving weeds, which can hint at the presence of standing water, poor drainage from winter rains, or excessive irrigation. Conversely, weeds like spiny clotbur or cocklebur *(Xanthium spinosum)* and yellow starthistle *(Centaurea solstitialis)* can indicate dry patches in a pasture.

Other weeds such as milk thistle *(Silybum marianum),* bull thistle *(Cirsium vulgare),* and pigeon grass (*Setaria* spp.) can be considered opportunists. These are biennial and annual weeds that must be propagated by seed, so their emergence indicates an area of the pasture where the forage plants are less competitive. This can be the result of various factors, such as grazing during the wet season, grazing during irrigation, or grazing a pasture too low, thereby opening the soil surface to sunlight.

Chemical control

Some invasion of weeds, and the resulting necessity to control them, is an inevitable occurrence in pasture management. In many instances, herbicide applications can be very effective for weed control. For example, if broadleaf weeds are present in a field with no legumes, you can cheaply apply a broadleaf selective herbicide without damaging the pasture grasses. In a pasture that includes clover, chemicals are best used to spot-treat concentrations of weeds rather than to treat the entire pasture. Besides sprayers, wicks and rotary wipers are effective tools for applying nonselective herbicides to weeds without harming desirable forage plants.

Table 4 provides examples and descriptions of common herbicides registered for pasture use. Before you apply any herbicide, make sure to read the label carefully to determine the application rate, planting interval, and grazing withhold time. Many herbicides require a private applicator's license, operator identification, and/or a use report to the county agricultural commissioner's office. Make sure to contact your county agricultural commissioner for specific regulatory details. For more information on herbicides and specific weed control, see the University of California's Integrated Pest Management website (www.ipm.ucdavis.edu).

Mowing

Mowing is another tool for weed management, but it will not eradicate most weed species. Mowing can help combat weeds in two ways.

- First, properly timed mowing can help prevent weed seed production and dispersal for nonpalatable weeds. Proper timing is essential to the success of mowing if you want to hinder seed production. Mow too frequently or too early and you will cause the weeds to set seed below the mower height, making control even more difficult. The optimal time for mowing is when the weed seed heads are appearing but before the seed is fully developed and viable.
- Second, since horses graze palatable forage plants and avoid weeds, the weeds get a competitive advantage and grow taller, putting them in range of the mower's blades. Mowing erases the competitive advantage of weeds by cutting them back to the same height as the desirable forage plants.

Overseeding an established pasture

The life span for planted pasture species differs according to species, growing conditions, and pasture location. For example, many perennial

Table 4. Common herbicides registered either for pasture or for irrigation ditch use

Herbicide	Common brand names	Restricted material?*	Comments
2,4-D Dicamba MCPA	Many product names, some of which include combinations of these chemicals	Yes	Broadleaf weed herbicides having little residual effect. Will not harm established grasses. Good for control of most broadleaf weeds until weeds begin to reach maturity. Do not apply to newly seeded pastures (<5 leaves).
Triclopyr	Element 3A, Remedy	No	Similar to 2,4-D, dicamba, and MCPA but better for control of woody plants such as blackberries and poison oak. Not as good on other broadleaf weeds. Will not harm established grasses. Do not apply to newly seeded pastures.
Clopyralid	Singer, Transline, Star Thistle Killer, Spur	No	Broadleaf herbicides with residual control of germinating broadleaf weeds. These herbicides can have lasting effects on clover and broadleaf weeds due to soil residual times. Not as good as 2,4-D, dicamba, or MCPA on large broadleaf weeds. Aminopyralid has a broader weed spectrum than clopyralid but should not be used around desirable trees.
Aminopyralid	Milestone	No	Will not harm established grasses.
Glyphosate	Roundup, Glyphomax, Gly Star	No	Nonselective herbicide; will harm all plants that are sprayed.
Combination herbicides			
Aminopyralid + 2,4-D	ForeFront R&P	No	Works better than aminopyralid alone on larger broadleaf weeds but still provides residual control of germinating broadleaf weeds.
2,4-D + Triclopyr	Crossbow	Yes	Commonly used for both woody and broadleaf weeds, with no residual effects.
Aminopyralid + triclopyr	Milestone VM Plus	No	Works on woody plants and small broadleaf weeds with residual control of germinating broadleaf weeds.

* Restricted materials require a Private Applicator's License for purchase. In addition, an operator identification number, notice of intent, and use report may be required before you can apply an herbicide to a pasture. Contact the county agricultural commissioner prior to herbicide purchase for additional regulatory information.

ryegrass varieties live less than 5 years, whereas many tall fescue varieties have a very long life span. Occasionally it may be necessary to overseed an established pasture to ensure a continued stand. For overseeding, you can drop the planting rate by one-third to one-half of what would have been an initial planting rate. If a no-till drill is available, the pasture can be grazed down and planted according to the same method and timing described earlier under "Pasture Establishment." If you overseed using the broadcast method, you will have to find some means for incorporating the seed into the soil. This is best done by lightly harrowing the field, then seeding, and then covering the seed, either through use of a ring roller or a very light second harrowing. It is important that care be taken to prevent excessive harm to the established pasture. If you use an adjustable harrow, set the teeth at a 45° angle to cover the seed. In many cases a single pass over the field with a harrow is sufficient for seedbed preparation. Seed that is broadcast and not incorporated into the soil has very little chance of successful establishment. For more information, see *Overseeding and Companion Cropping in Alfalfa* (UC ANR Publication 21594).

Water quality

Unfortunately, horse paddocks are sometimes expansive areas of nearly bare soil that are of little ecological value and may even have a negative impact on water quality. Poor management of a horse pasture can result in soil compaction, higher rates of runoff, less-efficient use of nutrients, and increased concentrations of suspended solids and pathogens in tailwater or storm water runoff. Mismanagement can eliminate any potential ecological benefits from irrigated pastures by actually making the pasture detrimental to the environment.

The management practices described in this publication can help you optimize the productivity of your pastures while providing environmental benefits, particularly protection of downstream water quality. A productive and vigorous irrigated pasture with proper irrigation, grazing management, and fertilization can provide a number of environmental benefits as it prevents soil erosion, helps recycle nutrients, and acts as a giant buffer strip, filtering water pollution from other sources.

Supplemental Feeding

Supplemental feeding is unavoidable for horses kept on pasture during cold or wet seasons and when the horses' nutritional requirements exceed what pasture forage can supply. Forage quality changes throughout the grazing season. Spring growth is highly nutritious and may have a laxative effect on grazing animals. During this time, animals grazed on pasture must be closely monitored to avoid the development of founder. You may have to limit spring grazing and supplement the animals' feed with dry hay. Cereal grain and pasture hay usually are adequate to meet their needs at this time. For horses with insulin resistance, a low-glycemic grass hay such as orchardgrass should be used as the supplement. Depending on its workload, a horse will consume from 1.6 to 2.0 percent of its body weight daily. A 1,100 lb idle horse or one used only for light or occasional work needs 18 to 22 lb of hay daily, which works out to one 120 lb bale every 5 to 7 days.

Mares that are nursing foals and horses that are used for hard work may need supplementation in addition to pasture forage during certain times of the year. This can be especially true for animals pastured on lower-quality tall fescue that is mature or on warm-season grasses. Increasing the clover content of pastures may be a good idea if you have horses like these that require higher nutrient levels. However, pastures that are high in clover content need to be grazed with caution if you have idle horses that only require a maintenance diet. If grazing management does not allow you to increase clover content in specific pastures, you can use supplement tools such as a creep feeder to help meet the higher nutrient needs of growing foals. Economical premixed, nutritionally balanced rations are available for all classes of horses that have high nutrient requirements.

A commonly overlooked aspect of the horse diet is salt and mineral supplementation. Salt is required in all pastures and should be fed free-choice, either as a block or in a loose mineral mix. Besides this general mineral requirement, mineral deficiencies are common in specific areas of California. For example, many California pastures are

extremely deficient in selenium, and that can have a detrimental effect on horse performance. Your local UC Cooperative Extension farm advisor or veterinarian can help you identify areas that are typically deficient. Data from cattle research can indicate whether a particular county is deficient in a mineral. The University of California's Trace Minerals for Beef Cattle website (http://animalscience.ucdavis.edu/MineralProject/) offers additional useful information on mineral supplementation. Blood and serum samples can be collected by a veterinarian to determine the general mineral status of your horses. This is a practical, economical means of determining specific animals' needs for mineral supplementation.

Animal Health

Irrigated pastures provide a valuable forage resource for the horse owner, but the high-quality feed they produce can be dangerous to some horses—particularly those with lower requirements for maintenance nutrition. Make your horses' transition to pasture a gradual one. You also need to watch for seasonal transitions in the pasture itself, such as in late winter to spring, when the dry matter content of forage increases sharply, causing greater availability of nutrients. A safe transition to pasture feeding may require that you initially limit the animals' grazing exposure to pasture to periods of only an hour or two at a time. Monitor your horses closely to prevent possible long-term adverse health effects that can result from overconsumption of pasture plants that exceed the horses' nutrient requirements. If necessary, you can help alleviate this problem by managing your pastures to keep the grasses in a mature growth stage, decreasing the quality of the forage.

Proper vaccination and worming are essential when you keep horses on irrigated pastures. Moist areas and warm summer temperatures combine with the congregation of multiple animals in a confined area to create perfect opportunities for parasites to flourish. Follow regular worming schedules and rotate dewormer ingredients to keep the parasites from developing resistance to any particular product.

The same conditions that cause parasites to flourish can also result in large fly populations. Many tools are available to you for fly management. You can introduce natural fly predators around key areas such as sacrifice pens and barns. Some products are fed to horses and help keep fly larvae from forming in manure. These products are usually combined with molasses into a block, making them highly palatable to encourage consumption. The success or failure of this type of treatment hinges on whether the manure of the supplemented horses is the actual source of the fly problem. If one small property owner uses the products but a nearby neighbor does not, the first owner is likely to get very limited benefit from this type of control measure. Fly sprays and face masks can help keep flies from annoying horses on pasture, but the sprays usually require frequent re-application.

Areas of ponding in irrigated pastures encourage mosquito breeding. Besides being a general annoyance, mosquitoes are vectors of West Nile Virus, a serious disease. All horses should be vaccinated for West Nile Virus prior to the mosquito season. You can develop a vaccination and worming regime tailored to your local area and other potential exposures in consultation with a veterinarian. Further information on horse health is available online at the UC Davis Center for Equine Health website (www.vetmed.ucdavis.edu/ceh/).

Common Poisonous Plants

As you go about your daily management of horse pastures, it is wise to seek out and identify plants that are not part of the seed mix that you planted. Horses avoid most of these weeds and most are not toxic, but some weeds can pose a serious toxicity threat to horses. The California Animal Health and Food Safety Lab at UC Davis can help horse owners identify potentially toxic plants from samples. Check online for information: http://cahfs.ucdavis.edu.

Oleander is the most common toxicity problem for horses in California (see *Livestock-Poisoning Plants of California,* UC ANR Publication 8398).

Never plant oleander in any area that has the potential to have horses present. Do not graze horses on sorghum forages. Most horses usually avoid most poisonous plants or eat too little to cause problems unless they are forced to eat them for lack of other feed, but this is not the case for all horses. Some horses acquire a taste for certain toxic plants, such as yellow starthistle and locoweed, and will readily seek them out. In such a case, you need to aggressively control potentially harmful plants in order to protect the health of your horses. *Livestock-Poisoning Plants of California* features a list of problem plants with photos that will help you identify the most common toxic plants in California.

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Confine chemicals to the property being treated. Avoid drift onto neighboring properties, especially gardens containing fruits or vegetables ready to be picked.

Do not place containers containing pesticide in the trash nor pour pesticides down sink or toilet. Either use the pesticide according to the label or take unwanted pesticides to a Household Hazardous Waste Collection site. Contact your county agricultural commissioner for additional information on safe container disposal and for the location of the Hazardous Waste Collection site nearest you.

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