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Ecology and Management of Annual Rangelands Series

Part 7: Livestock Production

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Ecology and Management of Annual Rangelands Series Technical Editor: Melvin George

Publications in this series:

Livestock production on California's annual rangelands has adapted to the seasonality of rangeland forage dominated by annual grasses and forbs growing in a Mediterranean-type climate (see the first publication in this series, "Mediterranean Climate"). Rangeland managers have learned to balance seasonal forage availability and quality with the changing physiological needs of their animals by feeding them hay and other supplements and by transporting them to other forage sources, including other vegetation types in cooler climates.

The main purpose of this publication is to provide the reader, especially staff from government and nongovernment organizations who are managing rangelands or interacting with rangeland managers, familiarity with the dominant range livestock production systems on annual rangelands and their dependence on other rangeland vegetation types. We will describe seasonal forage sources, nutrient requirements of grazing animals, seasonal forage quality, seasonal animal performance, supplemental feeding, water needs, livestock production systems, and animal health issues. Annual rangelands climate, grazing management, and vegetation management are discussed in other publications in this series (see "Mediterranean Climate," "Grazing Management," and "Vegetation Management").

SEASONAL FORAGE SOURCES

California's annual rangelands include the annual grasslands, oak woodlands, and

shrublands located in the foothills (generally below 3,000 feet elevation) of the Sierra Nevada, Cascade and Coast mountain ranges that encircle the Central Valley. Annual grasses and forbs dominate the grassland and the understory of the woodlands and shrublands. Livestock operations on these annual rangelands have adapted to the annual cycle of range forage production and nutritional quality that begins with germination following fall rains, followed by slow growth during the winter and accelerated growth in the spring until soil moisture is depleted (see the "Mediterranean Climate" publication).

While the annual rangelands may be the main source of forage for most of these livestock operations, livestock are commonly transported to other forage sources during the summer dry season. Around the time that annual rangelands begin to dry, often in May, many ranches headquartered in the Sierra Nevada foothills transport livestock (mostly

beef cattle) to higher-elevation federal lands managed by the Bureau of Land Management (BLM) and U.S. Forest Service (USFS) for summer grazing. These grazing areas include mountain meadows and Great Basin rangelands. Forage on mountain meadows, and in associated shrub and forestland, is provided in national forests through USFS permits. In the Great Basin, permits from the BLM allow livestock to graze on sagebrush-steppe and other ecosystems.

Forage in mountain meadows and on Great Basin rangelands begins to grow in the spring, as rising temperatures end winter dormancy. Forage growth is rapid for several weeks before slowing or ceasing during summer and fall. Timing of forage growth is dependent on temperature, elevation, soil moisture, slope aspect, and other factors. In some areas, plants go dormant again in early summer, while in other areas plants may not go dormant until late fall. On federal lands (BLM and USFS), leases are often at high-elevation locations, where for part of the year forage is dormant and covered with snow. Federal land permits control the start and end dates of the grazing season; typically, the grazing season is from May through October.

Every livestock operation is unique and has adapted to meet the needs of the livestock and the rancher. Ranch size and terrain, seasonally available forage, and family dynamics are just some of the factors that influence long-term planning and day-to-day operations on a ranch. The information that follows includes generalizations; it is important to understand that no two ranches are alike.

Some annual rangeland ranchers own or lease irrigated pasture in the Central Valley or the foothills, which provides another source of green forage for most of the year. Pastures are generally irrigated every 10 to 14 days, depending on the method of water delivery and the soil's available water storage. Cool-season (commonly clover, perennial rye grass, orchard grass, and tall fescue) and some warm-season (dallisgrass, bermudagrass) irrigated pastures provide high-quality feed during the summer and fall, when the quality of annual rangeland forage is poor.

Growth in irrigated pastures with cool-season plants is rapid in the spring, when temperatures are optimal for cool-season grasses and legumes, but is slowed by hot weather in the summer, a phenomenon sometimes called summer slump. Likewise, in the summer, yearling cattle weight gain is only marginal due to warm temperatures, regardless of standing forage. Stocker cattle may be expected to gain only 1 to 1.5 pounds per day during summer in Central Valley irrigated pasture, whereas gains in higher-elevation areas are normally over twice that rate. Cows nursing calves perform well in irrigated summer pasture, maintaining their weight. Growth of cool-season plants may increase with cooler fall temperatures but slows again in winter. Warm-season grasses, in areas that are suitable, provide a source of high-quality forage during the summer slump for cool-season grasses and legumes.

Because wet weather poses a risk of pasture damage, grazing may be precluded during winter, which is more suited timing for grazing animals on rangelands. Grazing of irrigated pasture during the wet winter season can open up the sod to weed invasion, disrupt irrigation borders, thereby decreasing irrigation efficiency, and cause soil compaction.

Spring growth of irrigated pasture is often higher than can be consumed, due to stocking rates being balanced for the entire summer season, so this growth is often captured in a single hay cutting prior to grazing. The forage cut for hay provides an added source of revenue or supplemental feed for cattle grazing rangelands. After the cut, the remaining forage is of higher quality and is less likely to cause eye damage to cattle, which can lead to pinkeye.

Some ranches, especially those on the central coast of California, are too far from high-elevation summer pasture and have developed supplemental feeding programs to maintain the herd through the annual rangeland dry season and winter slow growth period. Some Sierra foothill ranches have increased supplemental feeding to compensate for decreased federal land grazing in the Sierra Nevada mountains.

Ranches headquartered in northeastern California (Modoc County and parts of Siskiyou, Lassen, Plumas, and Sierra Counties) often own high-elevation pasture that they primarily cut for hay in the summer, to feed cattle during the winter. In the summer, livestock in these regions may graze on leased BLM and USFS allotments. Some ranches transport livestock to annual rangelands for winter and spring grazing to reduce feeding of hay. Some of these northeastern California ranches also move cattle into Oregon and Nevada for part of the year. Ranches in eastern California (Inyo and Mono Counties) operate in a similar fashion to those in northeastern California, though they are less likely to use annual rangelands for winter and spring grazing. Many of these ranches use grazing land in California and Nevada, and some use annual rangelands in the southern Sierra foothills.

The north coast of California features another set of forage sources. In this region, with its longer rainy season, annual rangelands have a longer green season. Perennial grasses can also be an important component of the forage. In addition, many ranches in this area have access to high-quality irrigated pasture in the lowlands along the Pacific coast. Many ranchers on the north coast are also timber producers who have opportunities for grazing private forestland following timber harvest.

The state's largest sheep operations are in the northern Sacramento Valley and the southern San Joaquin Valley. Sheep operations in California commonly graze their flocks on annual rangelands throughout the year, but may also transport them to other forage sources such as the desert in the spring or the mountains in the summer. Some operations graze alfalfa hayfields in the fall and winter; others use irrigated pastures in the Central Valley.

SEASONAL NUTRIENT REQUIREMENTS

Nutrient requirements of grazing animals change as the physiological needs of the animal change. Animal nutrient requirements can be determined from several published sources. The National Research Council publishes nutrient requirements for most common domestic livestock. Management guides for livestock commonly include nutrient requirements for the different physiological stages that occur during the reproductive cycle. Table 1, for example, shows the nutrient requirements (dry matter, protein, energy as TDN [total digestible nutrients], calcium, phosphorus, and vitamin A) of a 1,000-pound beef cow in five physiological stages. Stage 1 is the 45 days around calving. Stage 2 is the 45 days around breeding, when the cow is nursing the calf born during Stage 1, and is the time with the highest nutrient requirements. During Stages 3 to 5, nutrient requirements change as pregnancy progresses and the calf born in Stage 1 is weaned. The growing fetus places increasing nutrient requirements on the cow, and weaning the calf reduces cow nutrient requirements.

As a calf grows, its daily dry matter (DM) nutrient requirement increases. High protein and highly digestible forage are required to

Table 1. Nutrient requirements for a 1,000-pound beef cow

Nutrient	Stage of production				
	1 Calving (45 days)	2 Breeding (45 days)	3 Early gestation (90 days)	4 Mid gestation (90 days)	5 Late gestation (90 days)
Dry matter (lb/day)	20.6	21.0	19.5	18.1	19.6
Protein (lb/day)	2.5	2.6	2.0	1.3	1.6
TDN (lb/day)	13.8	14.0	11.5	8.8	10.5
Calcium (g/day)	36	38	25	15	23
Phosphorus (g/day)	25	27	20	15	18
Vitamin A (1,000 IU/day)	37	38	36	25	31

support high rates of growth. A 500-pound steer requires 12 pounds of DM that contains 8.5 percent crude protein (CP) to gain 0.5 pound per day. To gain 2 pounds per day, that same steer requires about 13.8 pounds of DM per day containing 11.4 percent CP. Similar requirements for ewes and growing lambs can be determined from nutritional references.

Dry Matter

Feedstuffs and forages can vary tremendously in their water content. Dry matter is the weight of forage after all water has been removed. It is common for laboratories to evaporate the water in forage before analyzing nutrient content. The nutrient content is then reported on a dry-matter basis. For example, the crude protein and crude fiber content reported in table 2 is reported as a percentage of dry matter. Animal nutrient requirements are also reported on a dry-matter basis. In table 1, the dry matter needs of a 1,000-pound cow are reported for five stages of production.

SEASONAL FORAGE QUALITY AND ANIMAL PERFORMANCE

Matching the nutrient demands of livestock with the nutrients supplied by range forage is a balancing act for most of each year. The nutritional quality of range forage varies with plant species, season, location, and range improvement practices and is optimal for livestock growth and production for only a short period of the year. Typically, four nutrients are of primary concern to managers of livestock on California's annual-dominated foothill and coastal rangelands: CP, energy, carotene (the precursor of vitamin A), and phosphorus (P) (George et al. 2001).

Energy is generally not deficient unless available forage is inadequate (see the "Grazing Management" publication in this series). Some minerals may be deficient, or toxic, at some times of the year or some locations within the state. Other minerals and vitamins may be of concern in certain areas of the state. Mineral and vitamin deficiencies are typically corrected with supplemental feeds or oral boluses.

Bentley and Talbot (1951) described forage quality in terms of three seasons (fig. 1), based on the adequacy of annual rangeland forage to support weight gains: inadequate-green, adequate-green, and inadequate-dry. Each of these

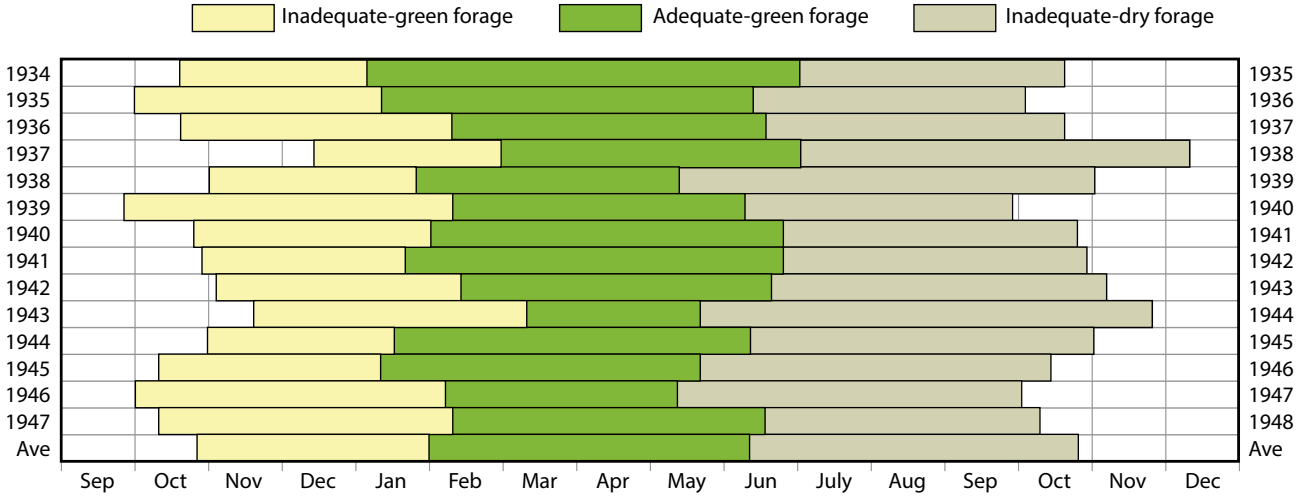

Figure 1. Record from 1934 to 1948 of the inadequate-green season, adequate-green season, and inadequate-dry season at the San Joaquin Experimental Range.

Figure 2. Annual rangeland forage during the inadequate-green season.

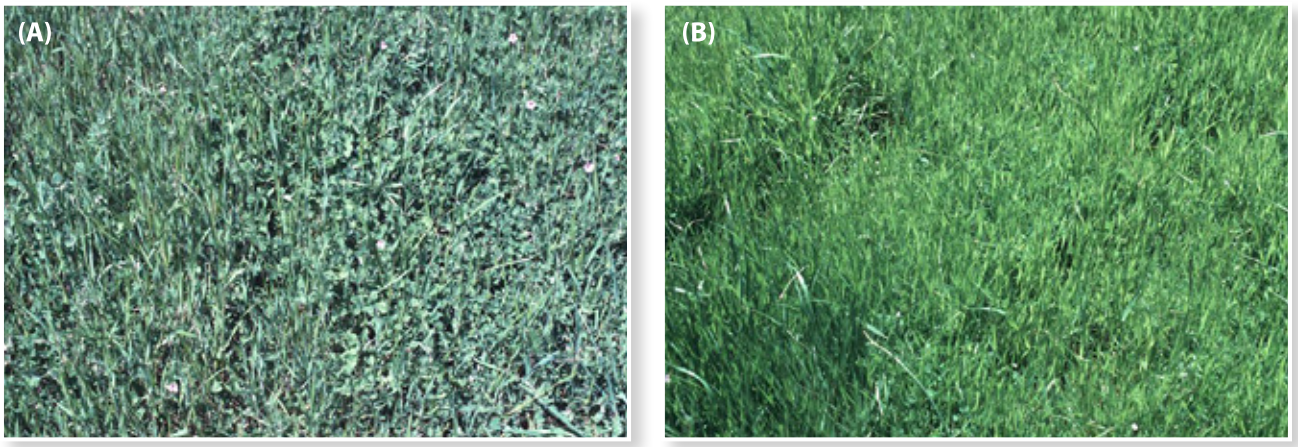

Figure 3. Annual rangeland forage with (A) and without (B) legumes during the adequate-green season's spring growth flush.

seasons varies in length and timing, depending on weather conditions. Early in the growing season, the nutrient content of forage is at its highest. Generally, forage nutritional quality decreases as plants progress toward maturity.

At any stage of maturity, forbs are usually higher in CP than grasses; legumes are usually higher in CP than other forbs; and forbs are often more digestible than grasses at the same stage of maturity. The leaves of shrubs are usually higher in CP than grasses but sometimes contain secondary compounds such as tannins that interfere with protein metabolism (see the "Secondary Compounds/Toxins" section of the "Range Plant Growth and Development" publication in this series). The fiber content of leaves and new stems of shrubs and trees increases with maturity; the stems eventually become woody, with much lower digestibility.

The inadequate-green season begins early in the growing season (fig. 2) with fall germination of stored seed. The nutrient content of forage is at its highest at this point; however, cattle grazing this forage may lose body weight, because sometimes the high-water content in young forage causes rapid passage through the rumen and results in incomplete digestion. The onset and length of the inadequate-green season varies based on precipitation and temperature. If the fall and winter are dry or cold, green forage production will be poor and cattle may require supplementation to maintain body condition. If warm weather in the fall coincides with adequate precipitation, forage production will be greater and animal performance will improve. Dry residual forage from the previous growing season is commonly available for grazing and provides energy but is low in CP and

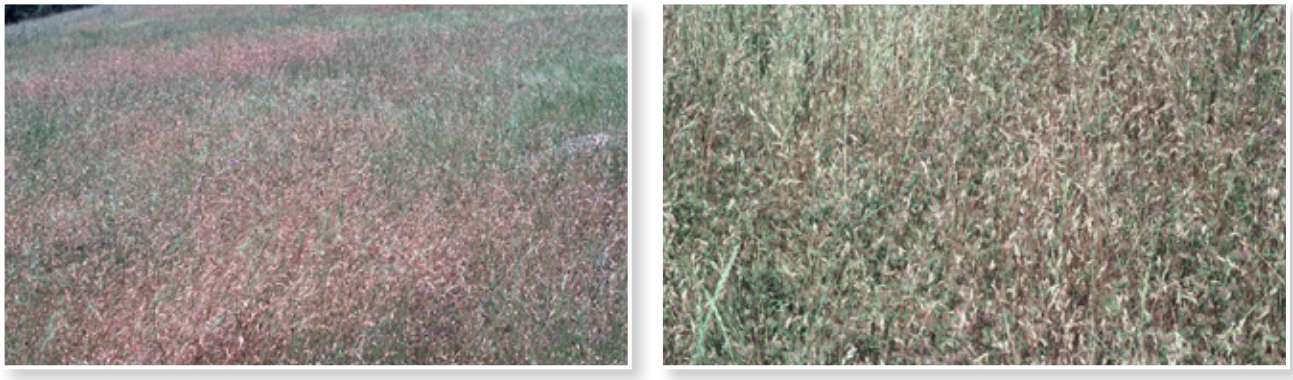

Figure 4. Annual rangeland forage during transition from the adequate-green season to the inadequate-dry season, when about half of the forage is green and half is dry.

Figure 5. Annual rangeland forage during the inadequate-dry season (midsummer), when seed have shattered and residual dry forage is brown.

Figure 6. Annual rangeland forage near the end of the inadequate-dry season, when the residual dry forage is gray and quality is at its lowest.

other nutrients. Leaching of nutrients from residual dry forage, by precipitation, further decreases its nutritional quality.

The warming conditions that prevail in late winter or early spring allow rapid forage growth, which improves animal performance. This is the adequate-green forage season (fig. 3), the period of rapid spring growth. At this time of year, forage usually is nutritionally adequate for animal maintenance, growth, and gestation. Rapid spring growth continues for a relatively short time, until soil moisture is depleted. Peak standing crop occurs when soil moisture limits growth or when plants are mature (fig. 4).

The inadequate-dry season is the summer dry season (figs. 5 and 6). Forage is an adequate energy source but is low in CP,

phosphorus, carotene, and other nutrients. Some classes of livestock can be maintained on such feed, while other classes may perform poorly if they receive no supplementation. During the summer, ranchers may provide supplements to cattle or transport them to green feed at higher elevations or to irrigated pasture.

California range and animal scientists conducted two exhaustive studies of seasonal range forage quality in the 1930s at a seasonal frequency and on a spatial scale that has not been repeated. They reported sampling date, stage of maturity, and levels of several nutrients that provide valuable insight into seasonal changes in forage quality. The results of these two landmark forage quality studies were analyzed together and are discussed here.

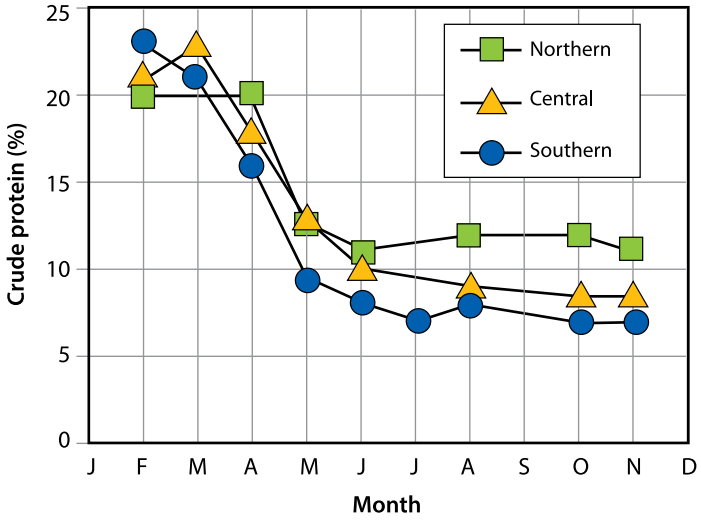

Figure 7. Seasonal crude protein (CP) content of composite samples taken from seventeen ranches along a north-south line from Red Bluff to Coalinga (Hart et al. 1932).

Table 2. Crude protein and crude fiber content of annual grasses, filaree, and bur clover at seven stages of maturity

	Crude protein (%)			Crude fiber (%)		
Stage of maturity	**Annual grasses**	**Filaree**	**Bur clover**	**Annual grasses**	**Filaree**	**Bur clover**
Early vegetative	18	27	28	24	12	16
Late vegetative	15	25	27	25	14	17
Early flowering	15	22	26	26	16	19
Late flowering	10	16	22	29	21	23
Mature	6	10	19	33	26	26
Dry	5	7	18	34	28	28
Dry, leached	3	5	17	35	30	29

Sources: Hart et al. 1932; Gordon and Sampson 1939.

Gordon and Sampson (1939) reported the nutrient composition of broadleaf filaree (*Erodium botrys*), redstem filaree (*E. cicutarium*), whitestem filaree (*E. moschatum*), wild oat (*Avena fatua*), soft chess (*Bromus hordeaceus*), ripgut brome (*B. diandrus*), red brome (*B. madritensis*), and annual fescue (*Vulpia* spp.) sampled seasonally at the San Joaquin Experimental Range in Madera County from 1934 to 1937.

Hart et al. (1932) published a report on seasonal forage quality in California's annual-dominated Mediterranean rangelands. In 1930 and 1931, they sampled soft chess, wild oat, whitestem filaree, redstem filaree, broadleaf filaree, and bur clover (*Medicago polymorpha*) on seventeen foothill ranches from Tehama County to Kern County. Beginning with early vegetative stages, a sample of each species was collected at monthly intervals until rains had ceased and the forage had matured and dried. During the remainder of the year, samples of the dry forage were collected at longer intervals.

Figure 7 shows the regional differences in seasonal CP content, which ranged from greater than 20 percent in late winter to less than 7 percent at the end of the dry season (Hart et al. 1932). Table 2 reports the CP and crude fiber (CF) content of annual grasses, filaree, and bur clover for seven stages of maturity (see "Stages of Forage Maturity" sidebar. Early in the growing season, CP in annual rangelands was greater than 15 percent in grasses and 25 percent in filaree, and nearly 30 percent in bur clover. By late flowering, CP was 10 percent in grasses and 16 and 22 percent, respectively, in filaree and bur clover. Once these annual plants dried, CP in annual grasses and filaree was less than 10 percent but higher in bur clover. Other annual legumes such as subterranean clover and rose clover follow the same seasonal trend as bur clover.

The minimum dietary CP requirement for a 500-pound steer gaining 2.5 pounds per day is about 12.5 percent CP, which indicates that

Stages of Forage Maturity

Standard stages of maturity of forage have been established by the National Research Council (NRC 1982) to facilitate feed composition comparisons. Estimates of crude protein, crude fiber, calcium, and phosphorus for seven stages of maturity are reported in tables 2 and 3.

Early vegetative: Early growth stage before stem elongation and flowering. For annual plants, this stage follows germination. For perennial plants, this is the new plant growth following dormancy or regrowth following harvest. New growth usually is high in nutrients and low in fiber. In annual rangelands, this stage occurs during the inadequate-green season (fig. 2).

Late vegetative: Stage at which stems are beginning to elongate, continuing to just before blooming. Nutrients usually are lower than at early vegetative stage. This stage occurs during the adequate-green season's spring flush of growth (fig. 3).

Early flowering: Stage between the initiation of bloom and when half of the plants are in bloom. Nutrients are beginning to accumulate in flowers. This stage occurs late in the adequate-green season.

Late flowering: Stage from last half of bloom to seed set. The dough stage in grass seed occurs during late flowering. Nutrients accumulate in flowers and seed, resulting in a loss of nutrients in leaves and stems. This stage occurs late in the adequate-green season.

Mature: Stage at which seed is ready to harvest or to be dispersed from the plant; plants are dry or drying. This is about the time when half of the forage is still green and half is dry (fig. 4). Forage quality has declined to such an extent that it does not meet the nutritional requirements of many classes of livestock.

Dry: Stage where plants are cured, seed has been dispersed, and weathering is in progress (fig. 5). Plant nutrients are low, and lignified fiber is high.

Dry, leached: Dry plants have weathered. Weathering has been accelerated by rainfall, which leaches nutrients from the dry residual forage (fig. 6).

Table 3. Calcium and phosphorus content of annual grasses, filaree, and bur clover at seven stages of maturity

Stage of maturity	Calcium (%)	Phosphorus (%)
Early vegetative	0.435	0.448
Late vegetative	0.414	0.422
Early flowering	0.393	0.396
Late flowering	0.330	0.318
Mature	0.267	0.240
Dry	0.246	0.214
Dry, leached	0.225	0.188

Sources: Hart et al. 1932; Gordon and Sampson 1939.

growing animals require substantial supplementation during the dry season (NRC 2000). Fall-calving cows require only 7.5 percent CP in their diet during the last third of pregnancy in summer, while a spring-calving cow (3 to 4 months postpartum) requires more than 9 percent CP. Depending on the legume and forb content of the forage, supplementation may be required. Since minimum protein levels are required for livestock to digest cellulose, protein supplementation is important during the dry season and early in the growing season.

As CF increases during the growing season, forage becomes less digestible and therefore of lower quality. In the forage quality studies (table 2), CF was less than 25 percent in annual grasses early in the growing season, increased to 25 to 30 percent during flowering and reached 30 to 35 percent at maturity. Vegetative filaree contained less than 15 percent CF, which increased to about 20 percent during flowering and reached 25 to 30 percent at maturity. CF content of bur clover increased from about 15 percent early in the season to about 20 percent at flowering and almost 30 percent at maturity.

Analysis of CF has been replaced by more modern methods that separate fiber into neutral detergent fiber (NDF) and acid detergent fiber (ADF). Total digestible nutrients (TDN) is calculated from ADF and is the most common method of evaluating energy in beef cattle rations. However, older reports of seasonal CF remain valuable as indicators of changing forage quality and digestibility.

Results from the landmark forage quality studies show calcium and phosphorus content decreased with increasing plant maturity (table 3). The calcium level is usually high enough for all classes of livestock during the vegetative and bloom stages of plant growth (see "Stages of Forage Maturity" sidebar). At the start of the dry summer period, calcium was down to about 0.25 percent (table 3). This is enough for a 1,000-pound dry pregnant cow (requiring about 0.18 percent), but lactating and growing animals usually require a higher calcium content in their diet, depending on body weight and rate of gain. Phosphorus content in forage changed from 0.45 percent at the early vegetative stage to a little less than 0.2 percent in the

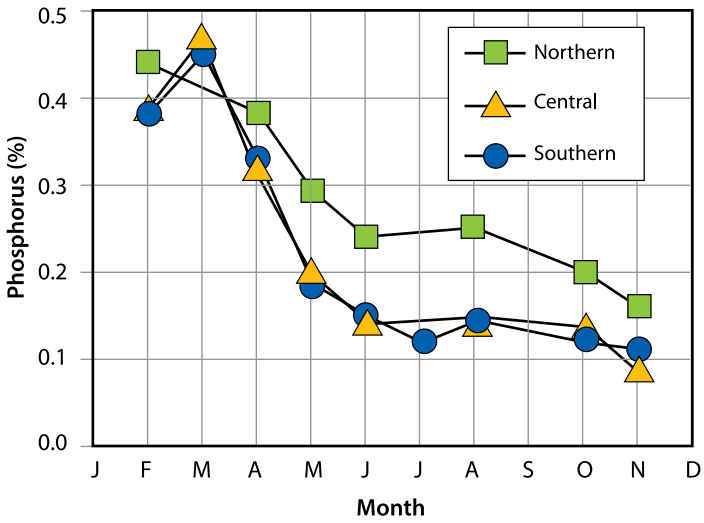

Figure 8. Seasonal phosphorus content of range forage dry matter from UC Sierra Foothill Research and Extension Center (Morris and Delmas 1980).

dry, leached stage, which is below the requirements for all classes of cattle. In studies decades later, the content of phosphorus and other minerals in forage followed a similar seasonal trend at the UC Sierra Foothill Research and Extension Center (fig. 8), between Marysville and Grass Valley (Morris and Delmas 1980).

While range livestock require several vitamins, only vitamin A is likely to become limiting since it is not available in plant tissue. Instead, it must be synthesized from beta carotene found in green plant tissue. The carotene content of grasses declines rapidly as plants begin to dry. A beef cow can store several months' supply of vitamin A in her liver during the growing season, but a lactating cow depletes her vitamin A storage rapidly. Green foliage from woody plants is a good year-round source of carotene, but it may not always be available. Vitamin A can be supplemented in loose salt mineral mixes, although most standard mixes may not be high enough for cattle grazing weathered or dry forage lacking carotene. Many ranchers use injectable vitamin A on the cow herd at weaning if cows are going to be placed on weathered forage for several months.

Mineral deficiencies vary depending on location (Davy et al. 2019). Supplementation of selenium, copper, zinc, magnesium, and manganese are likely necessary, except in Los Angeles, Inyo, Ventura, and Santa Barbara Counties, where the forage does not generally lack selenium. Where deficiencies exist, supplementation is necessary to prevent losses in immune response, weight gain, and reproduction. Supplementation can be carried out by oral bolus, injection, or specially formulated loose salt or molasses-based supplements (Davy et al. 2016).

SUPPLEMENTAL FEEDING

Because the nutrient value and quantity of forage varies seasonally, supplemental feeding is often necessary to provide adequate nutrients. During most of the year, salt and mineral supplements may be provided as either loose minerals or in block form and are often fed to provide phosphorus, calcium, and other minerals. Vitamin A may also be provided in the mineral supplements, or it can be injected.

After addressing mineral and vitamin needs, protein and energy deficiencies must be considered. On ranches with long adequate-green seasons, protein and energy supplementation may be minimal or even unnecessary. But many ranches provide protein and energy when they are inadequate. Many factors affect the type and amount of protein or energy supplement beef cows and sheep may require, including the amount and quality of forage available, animal size, age, body condition, and milking level. Daily feeding of alfalfa hay is often used to provide protein and energy, but less costly lower-protein grass hays may also be provided to meet energy needs. Protein may also be provided in the form of liquids, blocks, and tubs.

WATER

While water is not always considered when discussing nutrients, it is crucial to range animal nutrition and its availability strongly influences animal performance and distribution (see the "Grazing Management" publication in this series). Water is both a nutrient and a medium of metabolic functions in the body. It is an important milk and tissue constituent and provides the means of animal waste removal. Adequate consumption is necessary for animal health and production.

Table 4. Range animal daily water requirements

Species	Amount of water (gal)
Beef cattle	6–18
Sheep	1–4
Goat	1–4
Llama	2–5
Alpaca	2–5
Donkey	6
Horse	8–12

Source: USDA NRCS 2003.

Enough water must be available for the number and type of animals in a herd and for current and expected climatic conditions (table 4). The water requirements of cattle increase with increasing air temperature. Animal activity and lactation status also affect water requirements. In arid regions, the availability of water can limit seasonal use of pastures. In dry years, surface water sources may dry up early. During droughts, available forage may become unusable because wells that supply grazing animals' drinking water dry up. In early spring, however, the water content of forage in California's annual rangelands may be sufficiently high that cattle make little use of stock water sources.

Cattle's access to water can limit their use of forage within a pasture. On gentle or moderate terrain, cattle will generally travel up to 1 mile from water sources; areas of pasture more than 1 mile from water are generally underused (see the "Livestock Distribution" section in the "Grazing Management" publication in this series). On rougher terrain, cattle may further reduce the distance from water they are willing to travel, resulting in reduced use of available forage.

Water quality (e.g., temperature, sediment, and organic matter) can influence stock water use and animal performance. George et al. (2007) reviewed water quality effects on livestock production. Easy access to clean, cool water consistently supported the best animal performance.

LIVESTOCK PRODUCTION SYSTEMS

The following sections use operations calendars and animal inventory tables to describe production processes for fall- and spring-calving cow herds, beef stocker operations, and sheep operations.

The operations calendars describe the annual production process for the livestock enterprise and also reflect seasonal forage sources commonly used by California ranches. They cover the timing of breeding; calving or lambing; and nutrition and health practices. The calendar of operations is controlled by the need to balance the timing of forage availability with the timing of animal reproduction.

Animal inventory tables are a monthly inventory of each kind and class of animal on the ranch. They summarize births, deaths, sales, and purchases to explain changes in animal numbers throughout the year. These tables are useful for understanding how animal numbers rise and fall and why, for estimating monthly and yearly feed and forage demands, and for making plans about future marketing.

Livestock production systems include cow-calf, stocker, and sheep operations. A cow-calf operation maintains a cow herd all year for the purpose of producing calves to sell, and keeps some female calves each year to replace culled cows (cows removed from the herd and sold). Similarly, a sheep operation maintains a flock of ewes that produce lambs for sale and culled ewe replacement. Both operations maintain the herd or flock all year. A stocker operation grazes weaned calves on range or pasture to increase their weight before they enter a feedlot. In a grass-fed beef operation, the calves may stay on grass until they reach a slaughter weight of 1,000 pounds or more.

Cow-Calf Operations

Cow-calf operations can be separated into two types—those where calving takes place in the fall and those where calving occurs in the spring. On annual rangelands, where winters are mild, calving in the fall is common (though not universal) and allows cows and calves to take advantage of fresh forage growth that begins with the cooler months (table

Table 5. Operations calendar—fall-calving cow-calf herd

Timing*	Operations
Summer/fall	
May 1 to October 31	Cattle grazing—summer range, mountain pasture/dry grass
May	Trucking/trailing—moving cattle to summer pasture
May	Calves sold at auction
August	Precalving vaccines—cows and heifers
September 1 to October 31	Calving
Winter/spring	
November 1 to April 30	Cattle grazing—winter range
November	Trucking/trailing—moving cattle to winter pasture
November	Prebreeding vaccinations—cows/heifer calves
November 1 to 30	Finish calving
November	Bulls—breeding soundness exam, Trich† test, vaccinations
November	Yearling bulls purchased
December/January	Vaccination, marking/branding, and castration of calves
December 1 to February 28	Breeding
April	Pregnancy check and vaccination of cows and heifers; open cows, open heifers, and cull bulls sold at auction
April	Calves weaned, replacement heifers selected

* Dates are approximate; actual dates vary according to management and seasonal weather.

† *Tritrichomonas foetus*, a venereal disease of cattle.

Table 6. Operations calendar—spring-calving cow-calf herd

Timing*	Operations
Summer/fall	
May 1 to October 31	Cattle grazing—summer range/irrigated pasture/mountain pasture
May	Trucking/trailing—moving cattle to summer pasture
May 1 to May 31	Finish calving
June 1 to August 31	Breeding
June	Vaccination, marking/branding, and castration of calves
Winter/spring	
November 1 to April 30	Cattle grazing—winter range, some hay
November	Trucking/trailing—moving cattle to winter pasture
November	Pregnancy check and vaccination of cows and heifers
November	Calves (steers and heifers) sold at auction; open cows, open heifers, and cull bulls also sold
March/April	Yearling bulls purchased
March 1 to April 30	Calving
April	Bulls—breeding soundness exam, Trich† test, vaccinations

* Dates are approximate; actual dates vary according to management and seasonal weather.

† *Tritrichomonas foetus*, a venereal disease of cattle.

5). Like livestock operations in much of the western United States, ranches in the colder intermountain counties commonly calve in the spring (table 6) to take advantage of high-elevation range and pasture.

The annual calendar of operations is largely controlled by the reproductive cycle and is distinctly different for these two types of cow-calf operations. However, within each type of operation, there is a great deal of variation in the operations calendar. For example, the calving periods in tables 5 and 6 are approximate; calving can start earlier or end later than illustrated. Location and type of forage utilized are also highly variable from ranch to ranch.

Management activities that require handling cattle in corrals or chutes, such as vaccinating, branding, castrating, and pregnancy checking, are usually administered in conjunction with one another. This approach saves labor and decreases disturbance of the cattle. Other than when the animals are moved between winter and summer pasture, cattle are commonly worked twice each year, and activities on those two occasions may include, but are not limited to

- Time 1: branding, vaccinating, deworming, and castrating calves; vaccinating and/or deworming cows
- Time 2: weaning calves, selecting replacement heifers, vaccinating cows/replacement heifers (and possibly calves), selling steers and non-replacement heifers, testing for pregnancy, selling open (nonpregnant) cows and heifers

Table 7. Animal inventory per month—fall-calving herd (starts with 300 cows and bred heifers at the beginning of the breeding season in December)

Animals	Jun§	Jul	Aug	Sep	Oct	Nov	Dec*	Jan	Feb†	Mar	Apr‡	May
Cows	255	255	255	280	300	300	300	300	297	297	297	255
Steer calves	0	0	0	65	110	130	130	130	128	128	128	128
Heifer calves	0	0	0	65	110	129	129	129	128	128	128	128
Yearling heifers	50	50	50	50	50	50	50	5	5	5	5	0
Bred heifers	45	45	45	20	0§	0	0	45¶	45	45	45	45
Bulls	10	10	10	10	10	15	15	15	15	15	15	10

* Beginning of the breeding season; calves are born in September, October, and November.

† Inventory includes an approximate 1% annual death loss (3 cows; 3 calves).

‡ Open yearling heifers (5 = 10%) and open cows (42 = 14%) are sold after pregnancy checking; cull bulls are sold, and replacements are purchased in November.

§ Heifer calves become yearling heifers and 50 are carried over as potential replacements.

¶ Yearling heifers are bred during the winter at 14–16 months old; 90% become bred heifers and 10% stay open. Bred heifers become cows after calving in August/September.

Table 8. Animal inventory per month—spring-calving herd (starts with 300 cows and bred heifers at the beginning of the breeding season in June)

Animals	Dec	Jan	Feb	Mar	Apr	May	Jun*	Jul†	Aug‡	Sep	Oct	Nov§
Cows	255	255	255	280	300	300	300	300	297	297	297	255
Steer calves	0	0	0	65	110	130	130	130	128	128	128	128
Heifer calves	0	0	0	65	110	129	129	129	128	128	128	128
Yearling heifers	50	50	50	50	50	50	50	5	5	5	5	50
Bred heifers	45	45	45	20	0	0	0	45	45	45	45	45
Bulls	10	10	10	15	15	15	15	15	15	15	15	10

* Beginning of the breeding season; calves are born in March, April, and May.

† 90% of yearling heifers bred during the summer (at 14–16 months old) become bred heifers and 10% stay open. Bred heifers become cows after calving in February/March.

‡ Inventory includes an approximate 1% annual death loss (3 cows; 3 calves).

§ Open yearling heifers (5 = 10%) and open cows (42 = 14%) are sold after pregnancy checking; cull bulls are sold and replacement bulls are purchased in March/April; heifer calves become yearling heifers and 50 are carried over as potential replacements.

Table 9. Heifer development and stages of production

Stage of production	Description
Heifer calf	Female calf from birth to weaning
Yearling heifer	Weaning to first breeding
1st calf heifer	First breeding to weaning 1st calf
2nd calf heifer	2nd breeding to weaning 2nd calf
Cow	From 3rd breeding forward

In a cow-calf operation, animal inventory numbers change during the year due to selling, buying, births, and deaths (tables 7 and 8). Older animals may be culled due to their age, health problems, or because they are not pregnant. Tables 7 and 8 assume 90 percent of cows will produce a live calf, an annual 1 percent death loss across cows and calves, and an annual culling rate of 14 percent for cows and 33 percent for bulls. Heifer calves in the breeding herd are referred to as yearling heifers and bred heifers as they enter different stages of production (table 9). Replacement heifers may be managed separately from mature cows until their second breeding season for any combination of the following reasons:

- The bulls used to breed heifers may be different from those used for mature cows.
- Heifers require more management attention due to birthing inexperience and dystocia concerns.
- Heifers are usually placed on the better-quality pastures because they are still growing and require a higher plane of nutrition than mature cows.
- Calves from heifers may be considered terminal (that is, they will not enter the breeding herd) due to the genetic differences between sires used with heifers versus mature cows.
- Young heifers may be less competitive with larger, older cows for feed and water resources.
- Heifers are commonly bred earlier than the rest of the cow herd so they have additional time to cycle (enter estrus) before the next breeding season, when they will join the cow herd.
- The heifer breeding season may be limited to 2 months as a passive way of selecting for the most fertile individuals; the typical cow herd breeding season is 3 months.

Fall-Calving Operations

Fall calving is common on annual rangelands because of the high-quality winter and spring forage available when calves are growing and cows are lactating and rebreeding. Table 5 shows an example of a calendar of operations for a fall-calving cow-calf operation. Cows usually calve from September or October through December, about 9 months after the breeding season (average gestation period in cattle is 283 days). The calves are branded, vaccinated, and castrated during this period, or shortly afterward.

Calves are generally not weaned until close to the end of the annual range production season, often in May, typically when they are 6 to 9 months old. At this time, replacement heifers are selected, and the remaining calves are marketed. Weaning date may vary depending on ranch resources and the weather. In drought years, with low rainfall and poor forage production, some producers practice early weaning (when calves are 3 to 6 months old), which helps cows maintain body condition by reducing nutritional demands. Early weaning can also improve rebreeding during drought conditions (see the "Body Condition" sidebar).

Body Condition

Body condition scoring (BCS) of beef cows is a scoring system that ranks the degree of fatness of a cow on a scale of 1 to 9 (Selk 2010). Body condition scoring is done by visual assessment of appearance. During the assessment, areas of fat deposition and muscle deterioration along the back and spine, ribs, brisket, hooks and pins, and tail head are assessed taking into account fill, pregnancy, and age. BSC 1 is extremely thin, 9 is extremely fat, and 5 is moderate; 5 or 6 is considered ideal for beef cattle.

BCS can be used to identify animals that need supplemental nutrition and is also an important indicator of future calf vigor, rebreeding, milk yield, and calf-weaning body weight. Publications describing how to use BCS in cattle, horses, sheep, and goats are available on the internet.

Table 7 illustrates the shifting animal numbers in a 300-cow herd during the year. Note that a 300-cow operation will have more than 300 animals at any given time because replacement heifers, bulls, and calves are also part of the cow-calf production system. (In larger or smaller operations, the logistics are very similar.)

The fall-calving stock flow inventory shows the addition of calves born in the fall, removal of animals that are culled from the herd, and transfers of heifers from one group to the other as they mature and enter the breeding herd at the beginning of the breeding season (in this example, in January). Also recorded are death losses during the year, typically caused by disease or predators, especially among calves.

Spring-Calving Operations

Spring calving may occur on annual rangelands but is more common in regions of California with cold winters, mainly the intermountain regions east of the Cascade and Sierra Nevada mountains. The spring-calving schedule places the herd on high-quality forage when calves are growing and cows are lactating and rebreeding. Table 6 shows an example of a calendar of operations for a spring-calving beef cow-calf operation; calving generally starts in February or March since the breeding season is in late spring and summer. Calves are weaned from the cows in the fall and sold just prior to the winter season. Heifer calves that will enter the breeding herd to replace culled cows are selected at this time. Cows are also pregnancy checked in the fall and nonpregnant cows are culled. Bulls may also be culled from the herd in the fall or late summer.

As with a fall-calving herd, animal handling is minimized to reduce labor costs and animal disturbance. Cow herds on intermountain ranches during winter are usually fed hay in an accessible pasture or hayfield. Some of these ranches transport the cow herd to lower-elevation annual rangelands, which they own or lease, for the winter and early spring.

Table 8 shows an example of the livestock inventory for a spring-calving herd. It includes the addition of calves born in the spring and the removal of animals culled from the herd in the fall. It also shows the transfer of yearling heifers to mature cows when they give birth to their first calf. Death losses and purchases during the year are also recorded.

Parasite control is not included in either the fall-calving or spring-calving operations calendars because the most current research supports parasite management through the careful use of animal health assessments, administration of anthelmintics (dewormers) only on an as-needed basis to a portion of the herd (not all animals should be treated at the same time), and good pasture management. The deworming strategy maintains a refugia of parasites that are susceptible to anthelmintics and contributes to delaying anthelmintic resistance. More information on refugia and a more thorough explanation of this topic can be found on the internet by typing the terms *refugia* and *livestock* into a search engine. The website wormx.info, hosted by the Animal Consortium for Small Ruminant Parasite Control also has helpful resources.

Stocker Operations

Stocker cattle, commonly referred to as yearlings, are grazed on annual rangelands starting in the fall or winter (table 10). At that time, the calves typically weigh about 500 pounds,

Table 10. Operations calendar—stocker herd

Timing*	Operations
September to October	Cattle purchased
September to October	Vaccination, parasite control, and marking/branding
September 1 to May 15	Cattle grazing—winter range
April to May	Cattle sold at auction/video market/private treaty

* Dates are approximate; actual dates vary according to management and seasonal weather.

but starting weight can vary for a number of reasons. They can gain 200 pounds or more before they are sold in the spring, gaining 1 to 2 pounds per day, depending on the quality of the forage. Death losses are a risk in any livestock operation and a 1 to 2 percent death loss is average for most stocker operations. At the end of the annual range growing season, stocker cattle may be sold, sent to the feedlot, or moved to other forage sources such as federal land leases or irrigated pasture. Some stocker cattle may be finished on grass and marketed as grass-fed beef.

A stocker operation is a good option if high rates of gain can be achieved on the available annual rangeland. The annual range needs to be productive and of high nutritional quality during the growing season. Rangeland that can't support good stocker gains is better used to support a cow-calf operation. Because price per pound usually decreases with increasing animal weight, stocker weight gain needs to be inexpensive for a stocker operation to be profitable.

Sheep Operations

The commercial sheep production calendar is controlled by the reproductive cycle of ewes. Most sheep operations lamb in the fall and winter (table 11) to market spring lambs and capture the usually high spring lamb prices. However, some sheep operations lamb in the spring (table 12) to better utilize the high-quality summer forage available in their geographic region. This forage-availability approach mirrors that of cattle producers, as described in the fall-calving and spring-calving herd sections above.

For a fall-lambing flock, the breeding period for mature ewes starts in May (table 11), with most ewes bred by the end of July. Because extra management is needed for replacement yearling ewes, they are exposed to the rams in April or May, at least 2 weeks ahead of the mature ewes. Weaning may occur as early as January, but more typically occurs in March, April, or May and is partly dependent on available forage. Docking (tail removal), castration, ear marking, and weighing occur periodically throughout the lambing season. Sheep are sheared and wool is sold in March, April, or May. Replacement ewes are selected to enter the breeding herd in April and May, when the rest of the lambs are sold. Culling occurs in January (ewes) and February (rams).

Table 11. Operations calendar—fall-lambing flock

Timing*	Operations
Summer	
June to September	Grazing—high-elevation range or annual range/hay plus minerals
June to July	Breeding of yearling and mature ewes finished
September	Ewes tagged (shear hind end); vaccinations
Fall/winter	
October to January	Grazing—alfalfa stubble or annual range
October to December	Lambing
November to January	Docking tails, castration, and marking of lambs
January	Dry ewes culled
Winter/spring	
February to May	Grazing—desert/annual range
February	Vaccination of ewes and rams; rams culled
March to May	Shearing of flock
March to April	Lambs weaned, shipped/sold
March to April	Replacement rams bought
April to May	Breeding of yearling ewes
May	Breeding of mature ewes

* Dates are approximate; actual dates vary according to management and seasonal weather.

Table 12. Operations calendar—spring-lambing flock

Timing*	Operations
Summer/fall	
June to December	Grazing—feed hay/irrigated pasture/mountain pasture
June	Ewes culled
September	Vaccination of ewes and rams
September to October	Lambs weaned, shipped/sold
October to December	Breeding of yearling ewes
November to December	Breeding of mature ewes
Winter/spring	
January to May	Grazing—annual range
January	Breeding of mature ewes finished
February	Rams culled; ewes tagged (shear hind end); vaccinations
March to May	Lambing
March to April	Replacement rams bought
April to May	Docking tails, castration, and marking of lambs
April to May	Shearing of flock

* Dates are approximate; actual dates vary according to management and seasonal weather.

A spring-lambing flock follows a similar calendar to a fall-lambing flock, except that breeding and lambing shift forward 4 to 6 months, depending on the operation (table 12). Accordingly, lambs from a spring-lambing flock are marketed in the fall.

Two examples of animal inventory tables are provided to illustrate monthly changes in animal numbers for both a fall-lambing and spring-lambing flock (tables 13 and 14, respectively). An example of 1,000 ewes is used in both tables. Actual numbers of sheep per flock vary widely across the state with some profitable flocks maintaining as few as 200 ewes; more typically, commercial flocks may have 5,000 ewes or more. The animal inventory tables assume an annual death loss of 6 percent for lambs and 2 percent for ewes; a ratio of one ram per forty ewes; a cull rate of 20 percent annually for ewes and rams; and a 115 percent lambing rate.

As mentioned above, the most current research supports parasite management through the careful use of animal health assessments, administration of anthelmintics (dewormers) on an as-needed basis to a portion of the flock (not all animals should be treated at the same time), and good pasture management. As such, parasite control is not included in the operations calendar for a fall-lambing or spring-lambing flock. Anthelmintic resistance is a serious concern in sheep and other small ruminants, underscoring the importance of refugia and the role they play in delaying anthelmintic resistance. More information on refugia and a more thorough explanation of this topic can be found on the internet by typing the terms *refugia* and *livestock* into a search engine. The website wormx.info, hosted by the Animal Consortium for Small Ruminant Parasite Control also has helpful resources.

ANIMAL HEALTH

This section focuses on animal health problems related to forage, such as nutrient deficiencies and toxicities, and those related to the pathogens found on rangelands or pastures. Vaccination, parasite control, proper nutrition, and animal management are standard practices for preventing disease and avoiding health issues. The University of California School of Veterinary Medicine has published reports for California livestock producers that address many of these health problems. Many of these reports can be accessed at https://ucanr.edu/sites/UCCE_LR/.

Table 13. Animal inventory per month—fall-lambing flock (starts with 1,000 ewes at the beginning of the lambing season in October)

Animals	Jun	Jul¶	Aug	Sep	Oct*	Nov	Dec	Jan†	Feb	Mar‡	Apr§	May
Ewes	800	784	784	784	1,000	1,000	1,000	800	800	800	800	800
Yearling ewes	216	216	216	216	216	216	216	216	216	216	216	216
Ewe lambs	216	216	216	216	230	460	575	552	552	276	216	216
Ram/wether lambs	0	0	0	0	230	460	575	552	552	276	0	0
Rams#	25	25	25	25	25	25	25	25	25	20	25	25

* Lambing season is October, November, and December; lambing rate is 115%. Ewe lambs become yearling ewes, and yearling ewes become mature ewes when they lamb.

† Inventory includes an approximate 6% annual death loss for lambs. Culled ewes are sold.

‡ Culled rams are sold. Lambs are marketed in March and April.

§ Replacement rams are purchased.

¶ Inventory includes an approximate 2% annual death loss for ewes.

Rams are stocked at about 1 ram per 40 ewes.

Table 14. Animal inventory per month—spring-lambing flock (starts with 1,000 ewes at the beginning of the lambing season in March)

Animals	Jun†	Jul	Aug	Sep‡	Oct	Nov	Dec§	Jan	Feb¶	Mar*	Apr	May
Ewes	800	800	800	800	800	800	784	784	784	1,000	1,000	1,000
Yearling ewes	216	216	216	216	216	216	216	216	216	216	216	216
Ewe lambs	552	552	276	216	216	216	216	216	216	230	460	575
Ram/wether lambs	552	552	276	0	0	0	0	0	0	230	460	575
Rams#	25	25	25	25	25	25	25	25	20	25	25	25

* Lambing season is March, April, and May; lambing rate is 115%. Ewe lambs become yearling ewes and yearling ewes become mature ewes when they lamb. Replacement rams are purchased in March and April.

† Inventory includes an approximate 6% annual death loss in lambs. Culled ewes are sold.

‡ Lambs are marketed in September and October.

§ Inventory includes an approximate 2% annual death loss in ewes.

¶ Culled rams are sold.

Rams are stocked at about 1 ram per 40 ewes.

Forage-Related Health Issues

Nutrient Deficiencies and Toxicities

Protein, energy, minerals, vitamins, and water are the main nutrients of concern to livestock managers. Several nutrients in these categories may be deficient, or toxic, at some times of the year or locations within the state. Vitamin A, magnesium, copper, and selenium deficiencies are important during part of the year and in some locations. Supplemental feeding can replace most of the nutrients deficient in annual rangeland forage. Selenium may be found in toxic levels in certain areas of the state.

Vitamin A

Signs of vitamin A deficiency in cattle include reduced feed intake and growth, rough hair coat, night blindness, edema, diarrhea, seizures, increased susceptibility to infection, abnormal sperm, abnormal bone growth, low conception rates, abortion, stillbirths, and weak calves. As mentioned above, vitamin A must be synthesized from beta carotene found in green plant tissue. Green foliage from woody plants is a good year-round source of carotene, but it may not always be available. Ranchers can provide vitamin A in a mineral supplement or with an injection if cows are going to be placed on weathered forage for several months.

Grass Tetany

Grass tetany, a condition associated with low magnesium levels in the blood serum, causes affected animals first to display an

uncoordinated gait and ultimately to experience convulsions, coma, and death. Low magnesium levels are caused when high levels of potassium and ammonium in forage interfere with absorption of magnesium (Maas 1999).

Grass tetany is usually confined to lactating cows (though it can also occur in other cattle classes and in sheep). Because lactation increases a cow's calcium and magnesium requirements, heavier milking cows are at a higher risk of magnesium deficiency.

Because rapidly growing grasses are often high in potassium and low in magnesium, grass tetany is more severe and frequent when cattle graze young forage. The risk of magnesium deficiency is reduced when cattle are provided early supplementation in the form of mineral blocks or mineral mixes high in magnesium.

Copper Deficiency

Copper deficiency in cattle is complicated because it can be the result of very low copper in the diet, which is a primary copper deficiency, or an interference with copper absorption in the animal due to molybdenum and/or sulfates in the feed or water, which constitutes a secondary copper deficiency. Whether the copper deficiency is primary or secondary, the common symptoms in cattle include diarrhea, unthrifty appearance, poor weight gain, light hair coat (Angus are brown, orange, or gray; Herefords are yellow), swollen and painful joints, broken bones, rear leg weakness or paralysis in calves, infertility, anemia, and decreased resistance to disease.

The main symptoms vary from herd to herd and are not easily predictable. However, when copper deficiency does occur, it invariably causes losses in production, health, and profits. Copper deficiency is best managed with supplemental mineral mixes, boluses, or blocks. Sheep must have very small amounts of copper in their diet, but they are extremely sensitive to too much copper. If sheep are allowed access to copper supplements formulated for cattle, in most circumstances the flock will experience significant death losses.

Selenium Deficiency

Selenium deficiency, sometimes called white muscle disease, is a degenerative muscle disease found in cattle and sheep (Maas 2007). Selenium deficiency is concentrated in northern, and especially northeastern, California, and is frequently observed on soils of volcanic origin. In animals suffering from selenium deficiency, white sections appear in heart muscle.

White muscle disease most commonly affects young calves and results in stiffness, lameness, or sudden death from cardiac failure. Other clinical signs may include retained placenta, reduced weight gain, poor feed conversion, diarrhea, reduced reproduction, lowered immune response, rough hair coat, general ill-thrift, and death. Effective diagnostic methods are available, and selenium deficiency can be corrected economically through boluses. Supplementation in the form of loose minerals or injectables is also available.

Selenium Toxicity

Another threat to livestock in the western United States, including California, is selenium toxicity. Selenium toxicity can occur with acute or chronic ingestion of excess selenium from supplementation or plants with a high selenium content, for example, *Astragalus* species (locoweed). Symptoms of selenium toxicity include lameness, anorexia, emaciation, hair loss from the tail, and cracked, deformed, and elongated hoofs. Toxicity can be either acute or chronic. Acute poisoning is caused by consumption, usually in a single feeding, of a sufficient quantity of highly seleniferous plants to produce severe symptoms. Chronic poisoning, sometimes called alkali disease, is caused by sustained feeding on seleniferous plants. The most obvious clinical signs of alkali disease are defects to the horn and hoof structure, lameness, and a rough hair coat or hair loss. Animals with chronic selenium toxicity are unlikely to return to full productivity even after exposure stops.

A neurological condition called blind staggers used to be attributed to selenium toxicity. However, newer evidence suggests that high levels of selenium in feed do not cause

this disease and that it is most likely due to polioencephalomalacia, which is a vitamin B1 deficiency.

Bloat

Bloat is a forage-related condition of both cattle and sheep in which an animal produces more gas in the rumen than it can expel. In a healthy animal, gas separates from the rumen's solid and liquid contents and collects as a free bubble at the top of the rumen. Increased gas pressure in the rumen leads to eructation, or belching. Bloat occurs when the eructation mechanism is impaired or inhibited.

Livestock can develop bloat for several reasons, but the most important is consumption of bloat-causing forage, especially legumes such as grazed clover and alfalfa (Meerdink 2003). Frothy bloat, the most common form, occurs on pastures containing clover or alfalfa and affects multiple animals. The chance that cattle will develop frothy bloat can be reduced through various management practices. These include feeding animals dry roughage before moving them to high-legume pasture and feeding them 48 hours prior to turnout with an antifoaming agent (Duren and Miller 2009), which can be mixed with grain or provided in molasses-salt blocks.

Poisonous Plants

Each year, ingestion of poisonous plants results in significant losses of livestock. Preventing such losses is a key problem in range and livestock management. Under normal conditions, some poisonous plants form an important part of livestock diets and do not present negative effects. However, when animals are excessively hungry or otherwise stressed, they may eat too much too fast, resulting in plant poisonings. Successful ranchers are familiar with the poisonous plants on their rangelands and know how to control or avoid them; examination of a pasture or range each year before use is crucial to preventing plant poisonings.

Among cattle, sheep, and horses in California, oleander is the most commonly diagnosed source of plant poisoning (Forero et al. 2011). Plants that accumulate nitrate or nitrite, such as Johnson grass (*Sorghum halepense*), sudangrass (*Sorghum bicolor*), goosefoot (*Chenopodium* spp.), and pigweed (*Amaranthus* spp.), are also a major source of plant poisonings.

Animal poisonings involving ingestion of acorns or oak leaves are infrequent—so infrequent that each generation of ranchers must be alerted to the danger by an older generation—but they can be catastrophic, for example in 1985 in a few northern California counties when about 2,700 cattle died due to oak toxicity (Forero et al. 2011; Maas 2008a). Tannins and phenols occur naturally in all of California's more than fifty species of oak trees. These substances can be toxic to cattle, with symptoms sometimes culminating in kidney failure. The risk of oak toxicity increases when forage is scarce and large numbers of acorns are present, or when storms knock down tree limbs, making leaves and buds easily accessible to cattle.

Oak toxicity can be prevented by providing supplemental hay or other feed during high-risk periods. Successful treatment of affected animals usually requires fluid therapy and antibiotics. Access to water and high-quality grass hay are very important parts of providing adequate nursing care.

A distinct condition called acorn calf syndrome results in the birth of calves with very short legs, abnormal hooves, and misshapen heads. The syndrome is associated with feed of poor nutritional quality during the second trimester of pregnancy (that is, in the 3rd through 7th months of pregnancy) (Hart et al. 1947). The exact cause is not known, but acorn calf syndrome seems to occur more often following autumns with high numbers of acorns.

Pathogen-Related Health Issues

There are many routes by which animals are exposed to or infected by disease, for example, by direct contact with an infected individual, which includes respiratory and venereal diseases such as IBR and trichomoniasis; by the fecal-oral route, which includes enteric diseases, such as salmonellosis and Johne's disease; by exposure to vectors, which includes tickborne diseases like foothill abortion and anaplasmosis; and by exposure to soil- or waterborne pathogens, which includes

clostridial diseases and leptospirosis. Infection with intestinal parasites typically occurs by ingestion of the infectious stage of the parasite on pasture.

Parasites

Liver Flukes

Liver flukes (*Fasciola hepatica*) are parasites that cattle ingest when grazing on grass that harbors the fluke in its encysted stage. Liver flukes are found in the livers of almost all beef cattle slaughtered in California (Maas 2006a), but primarily in animals that have grazed on irrigated pasture. (Liver flukes also occur in sheep.) Low rates of liver fluke infestation normally do not harm cattle, but high rates can cause serious damage to the liver, resulting in diarrhea, weight loss, and jaundice. Controlling liver flukes can be difficult and treatment is dependent on the exposure level and timing within each individual ranch operation; treatment options are best discussed with the herd veterinarian.

Liver flukes can also play an indirect role in cases of bacillary hemoglobinuria, better known as redwater. Redwater is caused by the bacterium *Clostridium hemolyticum*, which colonizes in the liver of susceptible cattle and produces protein toxins that destroy the body's red blood cells, damage other organ systems, and rapidly cause death. Redwater bacteria grow rapidly in areas in the liver damaged by migrating liver flukes. The disease has a short incubation period; most affected cattle are found dead and bloated.

Anaplasmosis

Anaplasmosis is a disease that attacks the red blood cells of infected cattle, causing anemia and often death (Maas 2006b). The disease is caused by a tick-transmitted rickettsia parasite called *Anaplasma marginale*. All cattle are susceptible to infection by *A. marginale*.

Herd location is important in determining whether problems will occur. The presence of cattle and deer that might be reservoirs and ticks that naturally transmit the disease are the primary factors. For example, with herds raised in the Central Valley of California on permanent pasture, with no ticks, no deer, and no carrier cattle, there is little risk of anaplasmosis. These cattle are free of the disease, have no immunity (unless vaccinated), and are totally susceptible to infection and disease. If these cattle are introduced to oak foothill pastures, especially during a bad tick year, they will become infected, get sick, and 50 percent will die if not treated.

When cattle are raised in the coastal foothills, Sierra foothills, and many mountain areas of California, they become infected early in life, have no clinical disease when infected (because they are young), and are immune carriers. If susceptible cattle are moved into these areas, they are at risk. If the carrier cattle are moved to Central Valley pastures, they may act as sources of infection, especially infection via blood transfer (dehorning instruments, ear taggers, and biting insects, etc.). Many cattle herds have some immune individuals and some susceptible individuals, and it is common for a percentage of the adult animals to become infected and sick every year. These are herds that need to be vaccinated routinely to prevent losses.

Bacterial and Viral Infections

Pinkeye

Pinkeye is an eye infection caused by the bacteria *Moraxella bovis*. Other species of bacteria, *Moraxella bovoculi* and *Mycoplasma bovoculi,* also play a role in infection. Pinkeye results in oozing, discolored, and bulging eyes in cattle (Maas 2008b). Factors that contribute to the spread of pinkeye include flies, tall vegetation, dust, pollen, foxtail awns, and humans. Practices that reduce the spread of pinkeye in a herd include reducing flies, cutting tall pasture before cattle are turned out, and wearing disposable gloves when treating animals. Vaccination against pinkeye with commercially available *M. bovis* vaccines can be effective; vaccination failures are often the result of using an incorrect strain of the vaccine or vaccinating too late in the season, after flies become abundant. Autogenous vaccines tailored to the specific strains found in the herd are another tool that can be effective in controlling the disease. When using fly tags impregnated with insecticides, it is important to remove them at the end of fly season to reduce the chance that flies develop resistance.

Not all cases of weepy, discolored eyes are caused by pinkeye. Exposure to foxtail—a grass—can cause similar effects. Foxtail, however, affects areas to the side of the eye, while pinkeye affects the center of the eye.

Foothill Abortion

Foothill abortion (Maas 1995), a bacterial disease of rangeland cattle also known as epizootic bovine abortion (EBA), is transmitted by bites from the pajaroello tick (*Ornithodoros coriaceus*). This tick lives in the soil around trees, in dry brush areas, and around rock outcroppings in foothill rangelands on the east and west side of California's Central Valley.

Infected pregnant cows show no obvious clinical symptoms, but they usually abort their calves 6 to 9 months into pregnancy. Some infected cows carry the pregnancy to term, but their calves are born weak and fail to thrive. If cows or sexually mature heifers are exposed to the ticks and the EBA agent prior to breeding, they tend to develop immunity and are not susceptible to abortion for a considerable time (Maas 1996).

The University of California Davis School of Veterinary Medicine has produced a vaccine with 90 percent effectiveness. Immunity conferred by the vaccine persists for several years, even if cows are not exposed to the pajaroello tick over that time. The vaccine is not yet commercially available, though commercial availability appears to be on the horizon.

Bluetongue

Bluetongue disease is a recurring, noncontagious, insect-borne, viral disease of sheep and sometimes other ruminants. It is endemic in California and a common problem of unvaccinated sheep in the San Joaquin Valley. It is caused by the bluetongue virus, which is transmitted by the midge *Culicoides sonorensis* and other *Culicoides* species. The virus causes an acute disease whose major signs are high fever, excessive salivation, swelling of the face and tongue, and cyanosis of the tongue. Nasal symptoms may be prominent, with nasal discharge and noisy and labored respiration. Mortality is high.

There is no efficient treatment, but simple husbandry changes and practical midge control measures may help break the livestock infection cycle. Housing livestock during times of maximum midge activity (from dusk to dawn) may lead to significantly reduced biting rates. The *Culicoides* midges that carry the virus usually breed on animal dung and moist soils; treating these sites with insecticide can reduce the midge population but typically is not practical on a large scale. Range flocks should be bedded on high ground away from these breeding sites.

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