RANGELAND MANAGEMENT SERIES Publication 8022

Annual Rangeland Forage Quality

MELVIN GEORGE, Extension Range Specialist, Department of Agronomy and Range Science, University of California, Davis; **GLENN NADER,** UC Cooperative Extension Farm Advisor, Yuba-Sutter-Butte Counties; **NEIL MCDOUGALD,** UCCE Farm Advisor, Fresno-Madera Counties; **MIKE CONNOR,** Superintendent, UC Sierra Foothill Research and Extension Center; and **BILL FROST** UCCE Farm Advisor, Amador-Calaveras-El Dorado Counties.

UNIVERSITY OF CALIFORNIA
Agriculture
and Natural Resources
http://anrcatalog.ucdavis.edu

California Rangelands Research and Information Center
http://agronomy.ucdavis.edu/calrng/range1.htm

Matching the nutrient demands of livestock with the nutrients supplied by range forage is a balancing act for a considerable portion of each year. The quality of range forage varies with plant species, season, location, and range improvement practices. Range forage is optimal for livestock growth and production for only a short period of the year. Early in the growing season, forage may be of high nutrient content, but high water content in the forage may result in rapid passage through the rumen and incomplete nutrient extraction.

Indicators of high forage quality such as protein, energy, vitamins, and minerals decline as the growing season progresses (Figure 1). Conversely, indicators of low quality such as fiber and lignin increase as forage plants mature.

Typically, four nutrients are of primary concern to managers of animals on California's annual-dominated foothill and coastal rangelands: protein, energy, carotene (the precursor of vitamin A), and phosphorus. Additionally, certain minerals may be deficient or toxic at certain times or locations. Annual range forage may be deficient in copper. A high amount of molybdenum aggravates copper deficiency. Potassium and zinc may also be deficient in mature weathered forage. Other minerals such as selenium may be found in deficient or toxic levels in certain areas of the state.

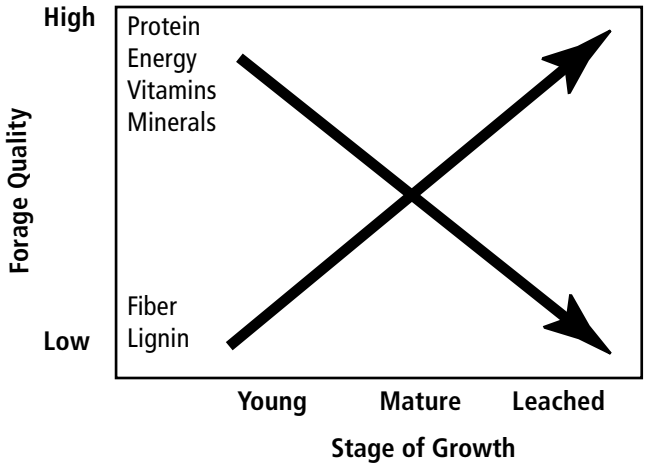

Figure 1.
Stages of growth and forage quality

UC PEER REVIEWED

PROTEIN

Hart, Guilbert, and Goss (1932) conducted a regional forage analysis of annual species on 17 ranches along a north-south transect of the Central Valley of California. Figure 2 shows seasonal and regional changes in crude protein (CP). Seasonal CP content of composite forage samples ranged from greater than 20 percent CP in late winter to less than 7 percent CP at the end of the dry season.

Early in the growing season, annual plants contain the highest protein content: over 15 percent in grasses, over 25 percent in filaree, and nearly 30 percent in bur clover (Table 1). This declines when plants flower, to about 10 percent protein in grasses and 15 to 20 percent in filaree and 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 lb steer gaining 2.5 lb per day is about 12.5 percent CP, showing that growing animals require substantial supplementation during the dry season (NRC 1984). 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) would require more than 9 percent CP. Depending on the legume and forb content of the forage, supplementation may be required.

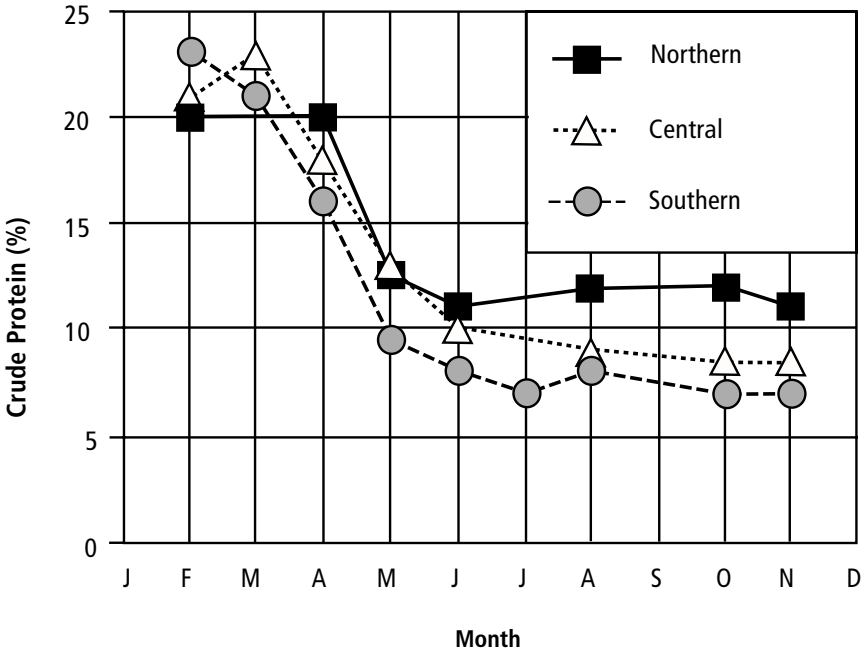

Figure 2. Seasonal crude protein content of composite samples taken from 17 ranches along a north-south line from Red Bluff to Coalinga, California (Hart, Guilbert, and Goss 1932).

Table 1. 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 grass**	**Filaree**	**Bur clover**	**Annual grass**	**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

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

CRUDE FIBER

Crude fiber is inversely related to digestibility, indicating declining forage quality from the adequate-green period (spring) to the dry-leached forage period (summer-fall) described by Bentley and Talbot in 1951. As shown in Table 1, crude fiber is less than 25 percent in annual grasses early in the growing season, increases to 25 to 30 percent during flowering and reaches 30 to 35 percent at maturity. Vegetative filaree contains less than 15 percent crude fiber, which increases to about 20 percent during flowering and reaches 25 to 30 percent at maturity. Crude fiber content of bur clover increases from about 15 percent early in the season to about 20 percent at flowering and 25 percent or more crude fiber at maturity.

ENERGY

Digestible energy (DE) is the gross energy of a food minus the energy lost in the feces.

Metabolizable energy (ME) is a measure of the dietary energy available for metabolism after energy losses that occur in the urine and in combustible gases (chiefly methane) are subtracted from digestible energy. According to NRC (1984), ME = 0.82 × DE.

Total digestible nutrients (TDN) is the sum of all the digestible organic nutrients including protein, fiber, nitrogen-free extract, and fat. TDN content of feeds is often reported as a percentage. TDN, DE, and ME all are measures of digestible energy. Conversion formulas between TDN, DE, and ME can be found in most animal nutrition textbooks. Energy converters are also available on the Internet (for example, http://animalscience.ucdavis.edu/java/LivestockSystemMgt/default.htm).

ENERGY

Metabolizable energy (ME) is digestible energy (DE) minus the energy losses in urine and combustible gases (see Energy sidebar). The ME content of annual grass as calculated from crude fiber analyses (Mertens 1989) is about 2.8 megacalories per kilogram or roughly 77 percent TDN during the early vegetative growth stage (Table 2). By the time grasses dry in early summer, ME is down to 2.2 Mcal/Kg and TDN is about 60 percent. The energy levels of filaree and bur clover are higher than for grasses at all stages of growth, declining to less than 70 percent TDN in the summer. Rangelands with high amounts of clover require less supplementation than grass-dominated rangelands as a result of higher energy and protein concentrations. While very high energy and protein contents may occur early in the growing season, this forage is often short enough to limit forage intake by grazing cattle. Consequently, grazing cattle may fail to consume adequate nutrients.

Table 2. Estimates of metabolizable energy (Mcal/kg) and total digestible nutrient (%) content of annual grasses, filaree, and bur clover at seven stages of maturity.

	Metabolizable energy (Mcal/kg)			TDN (%)		
Stage of maturity	Annual grass	Filaree	Bur clover	Annual grass	Filaree	Bur clover
Early vegetative	2.8	3.5	3.3	77	97	91
Late vegetative	2.7	3.4	3.2	74	94	89
Early flowering	2.6	3.3	3.1	72	91	86
Late flowering	2.4	3.0	2.9	67	84	80
Mature	2.2	2.6	2.6	61	72	72
Dry	2.1	2.5	2.5	58	69	69
Dry, leached	2.1	2.4	2.4	58	67	67

STAGE OF MATURITY

Standard stages of maturity have been established by the National Research Council (1982) to facilitate feed composition comparisons. Estimates of crude protein, crude fiber, and energy for seven stages of maturity are reported in Tables 1, 2, and 3.

Seven stages of maturity are defined as follows:

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 rangeland this stage occurs during the inadequate-green season (Figures 5 and 6).

Late vegetative: Stage at which stems are beginning to elongate, continuing to just before blooming. Nutrients usually are lower than at early vegetative stage. Occurs during the adequate-green season's spring flush of growth (Figure 7).

Early flowering: Stage between the initiation of bloom and the stage at which 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 seeds, 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 green and half of it is dry (Figure 8). Forage quality has declined to such an extent that it does not meet the nutritional requirements of some kinds and classes of livestock.

Dry: Stage where plants are cured, seed has been dispersed, and weathering is in progress (Figure 9). Plant nutrients are low and fiber is high.

Dry, leached: Dry plants have weathered. Weathering has been accelerated by rainfall that leaches nutrients from the dry residual forage (Figure 10).

CALCIUM AND PHOSPHORUS

Calcium content decreases with increasing plant maturity. The calcium level is usually high enough for all classes of livestock during the vegetative and bloom stages of plant growth (see Stage of Maturity sidebar). When the dry summer period begins, Ca is down to about 0.23 percent (Table 3). This would be enough for a 1,000 lb dry pregnant cow (requiring about 0.18 percent), but lactating and growing animals usually require a higher Ca content in their diet depending on body weight and rate of gain.

Phosphorus content in forage changes from 0.45 percent in winter to a little less than 0.2 percent in the dry season (Table 3), which is below the requirements for all classes of cattle. The phosphorus content of Hart, Guilbert, and Goss's forage samples from 17 ranches along a north-south transect of the Central Valley were highest in late winter or early spring and declined to their lowest levels in late summer or fall (Figure 3). The content of phosphorus and other minerals followed a similar seasonal trend at the UC Sierra Foothill Research and Extension Center (Figure 4) between Marysville and Grass Valley (Morris and Delmas 1980).

Table 3. Calcium and phosphorus content of annual grasses 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	0.33	0.318
Mature	0.267	0.24
Dry	0.246	0.214
Dry, leached	0.225	0.188

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

VITAMIN A

Vitamin A deficiencies occur in California beef cow herds. The carotene content of grasses declines rapidly as plants begin to dry and turn brown, and carotene is the precursor to Vitamin A. A beef cow can store several months' supply of Vitamin A in her liver during the adequate-green season, but that supply can be depleted rapidly in a lactating cow. Green foliage from woody plants is a good year-round source of 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.

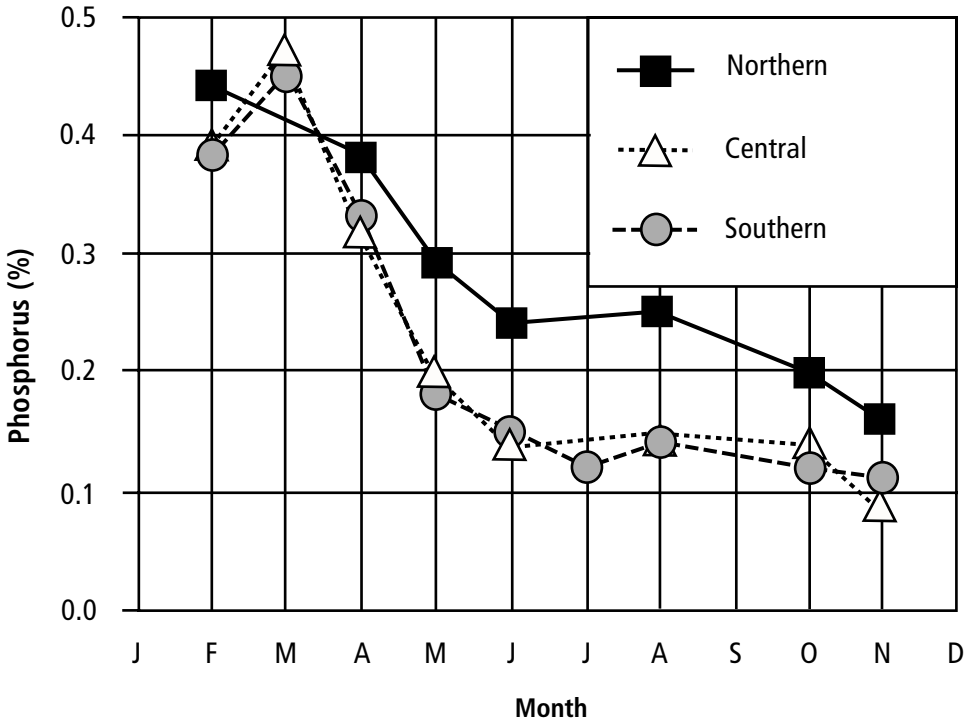

Figure 3.
Seasonal trends in phosphorus content of composite forage samples taken from 17 ranches along a north-south transect from Red Bluff to Coalinga, California (Hart, Guilbert, and Goss 1932).

SEASONAL ANIMAL PERFORMANCE

Bentley and Talbot (1951) described three seasons (Figure 5) based on the adequacy of annual range forage for weight gains. The inadequate-green season (Figure 6) begins with the fall germination of stored seed. Cattle grazing this forage may lose weight, hence the term *inadequate-green forage.* The onset and length of this period depend on prevailing weather conditions. If the fall and winter are dry or cold, green forage production will be poor and range supplementation may be necessary to maintain cattle performance. If warm weather 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 protein and other vital nutrients. The leaching of nutrients by precipitation further decreases the nutritional quality of this dry residual forage. For short periods during the green season, livestock may occasionally be unable to consume enough forage to meet their daily requirements for some nutrients because the high water content of the forage limits their dry matter intake.

Rapid spring growth begins with warming conditions in late winter or early spring. This also is the period when animal performance improves. The period is commonly called rapid spring growth or the adequate-green forage season (Figure 7). This forage usually is nutritionally adequate for maintenance, growth, and gestation. Rapid spring growth continues for a short time until soil moisture is exhausted. Peak standing crop occurs at the point when soil moisture limits growth or when plants are mature (Figure 8). This period is followed by the summer dry season (Figures 9 and 10) when the forage is a fair energy source but is low in protein, phosphorus, carotene, and other nutrients. Some classes of livestock can be maintained on dry feed while other classes may perform poorly if they receive no supplementation during the inadequate-dry season. During this summer period ranchers commonly provide supplements, transport their stock to green feed at higher elevations, or move their stock to irrigated pasture.

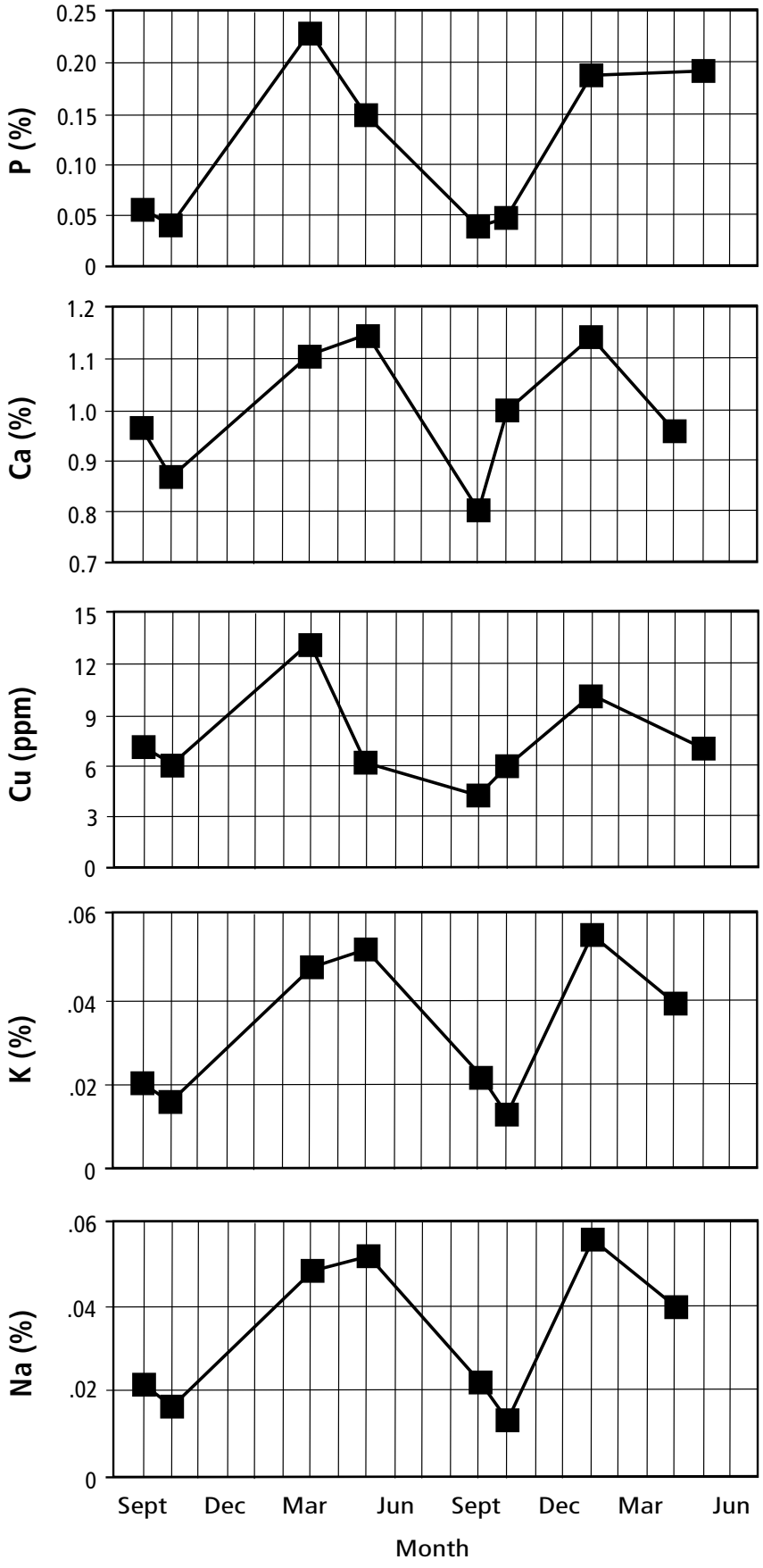

Figure 4.
Seasonal mineral content of range forage dry matter from UC Sierra Foothill Research and Extension Center (Morris and Delmas 1980).

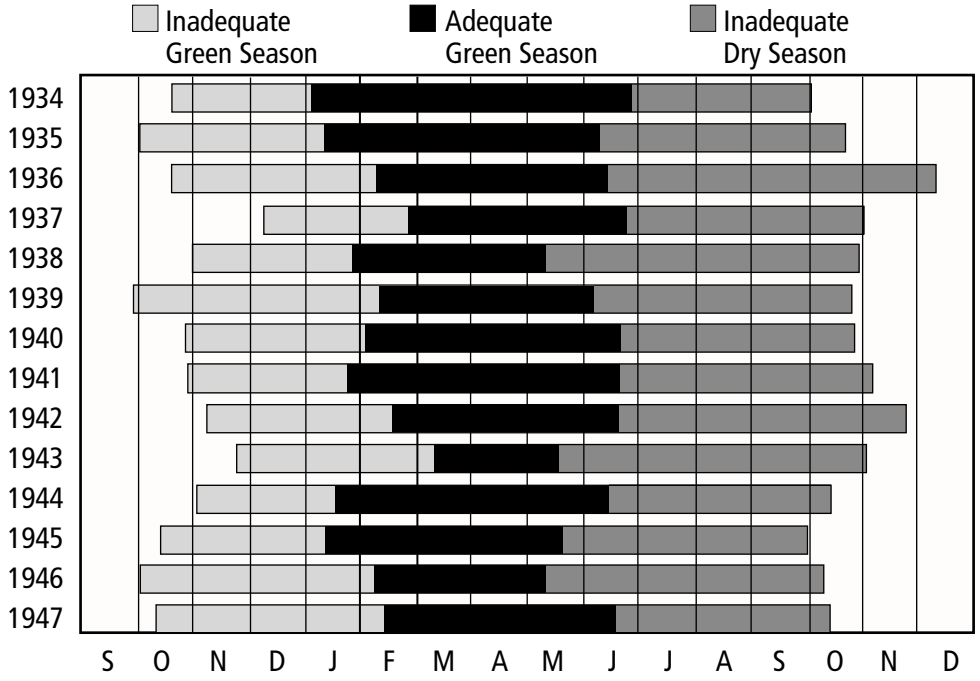

Figure 5.
Variations in length of time of the inadequate-green season, adequate-green season, and inadequate-dry season at the San Joaquin Experimental Range (Bentley and Talbot 1951).

Figure 6.
Landscape (A) and close-up photographs (B) of annual range forage during the inadequate-green season.

Figure 7.
Close-up photos of annual range forage with (A) and without (B) legumes during the adequate-green season's spring growth flush.

Figure 8.
Landscape (A) and close-up photos (B) of annual range 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 9.
Landscape (A) and close-up photos (B) of annual range forage during the inadequate-dry season (midsummer), when seeds have shattered and residual dry forage is brown.

Figure 10.
Landscape (A) and closeup photos (B) of annual range forage near the end of the inadequate-dry season, when residual-dry forage is gray and quality is at its lowest.

LITERATURE CITED

Bentley, J. R., and M. W. Talbot. 1951. Efficient use of annual plants on cattle ranges in the California foothills. Circular 870. Washington DC: USDA.

Gordon, A., and A. W. Sampson. 1939. Composition of common California foothill plants as a factor in range management. Bulletin 627. Berkeley: University of California, Agricultural Experiment Station.

Hart, G. H., H. R. Guilbert, and H. Goss. 1932. Seasonal changes in the chemical composition of range forage and their relation to the nutrition of animals. Bulletin 543. Berkeley: University of California, Agricultural Experiment Station.

Mertens, D. 1989. Conversion equations for ADF to ME (personal communication).

Morris, J. G., and R. E. Delmas 1980. Seasonal variation in the nutritive nature of Californian range forage for cattle. In Beef cattle day. Browns Valley: University of California Sierra Foothill Range Field Station. pp. 16–20.

National Research Council. 1982. United States-Canadian tables of feed composition. Washington DC: National Academy Press. p. 144.

National Research Council. 1984. Nutrient requirements of beef cattle. Washington DC: National Academy of Sciences.

ADDITIONAL READING

Adams, J. R., and M. W. Stellmon. 1999. Cow-calf management guide, second edition. Moscow, ID: University of Idaho, College of Agriculture.

Bruce, B., R. Torell, and B. Kvasnicka. 1999. Nutritional management of beef cows in the Great Basin. Reno: University of Nevada.

FOR MORE INFORMATION

You'll find detailed information on many aspects of livestock and range management in these titles and in other publications, slide sets, and videos from UC ANR:

Beef Rancher's Software Package, publication 21460

California Range Brushlands and Browse Plants, publication 4010

Monitoring California's Annual Rangeland Vegetation, publication 21486

To order these publications, visit our online catalog at http://anrcatalog.ucdavis.edu. You can also place orders by mail, phone, or FAX, or request a printed catalog of publications, slide sets, and videos from

University of California
Agriculture and Natural Resources
Communication Services
6701 San Pablo Avenue, 2nd Floor
Oakland, CA 94608-1239

Telephone: 1-800-994-8849 or (510) 642-2431, FAX: (530) 643-5470
e-mail inquiries: danrcs@ucdavis.edu

An electronic version of this publication is available on the ANR Communication Services website at http://anrcatalog.ucdavis.edu.

This publication was funded in part with a grant from the Cling Peach Advisory Board of California.

Publication 8022

6/01-WJC/WFS/VFG ISBN 978-1-60107-202-3

This publication has been anonymously peer reviewed for technical accuracy by University of California scientists and other qualified professionals. This review process was managed by the ANR Associate Editor for Natural Resources.