RANGELAND MONITORING SERIES Publication 8092

California Guidelines for Residual Dry Matter (RDM) Management on Coastal and Foothill Annual Rangelands

James W. Bartolome is Professor in the Division of Ecosystem Sciences, UC Berkeley; **William E. Frost** is UC Cooperative Extension Natural Resource Advisor, El Dorado County; **Neil K. McDougald** is UCCE Livestock and Natural Resource Advisor, Madera County; and **Michael Connor** is Superintendent, UC ANR Sierra Foothill Research and Extension Center.

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

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

BACKGROUND

Residual Dry Matter (RDM) is a standard used by land management agencies for assessing the level of grazing use on annual rangelands and associated savannas and woodlands (George et al. 1996). Residual dry matter is the old plant material left standing or on the ground at the beginning of a new growing season. It indicates the combined effects of the previous season's forage production and its consumption by grazing animals of all types. The standard assumes that the amount of RDM remaining in the fall, subject to site conditions and variations in weather, will influence subsequent species composition and forage production.

Properly managed RDM can be expected to provide a high degree of protection from soil erosion and nutrient losses. Applications of specific RDM standards based on a limited research base and experience have demonstrated the effectiveness of this approach to grazing management. Because of the limited amount of research information available, standards and score cards normally have to be developed based on local experience and general guidelines such as those that appear in this publication. Numerous agencies have successfully applied the RDM-based method for managing grazing intensity over the past 20 years. Some examples are the Bureau of Land Management and the Natural Resources Conservation Service (BLM 1999), the National Park Service (Shook 1990), the US Forest Service (USDA 1985), and the University of California's San Joaquin Experimental Range (Frost et al. 1988).

REGIONAL GUIDELINES

A series of experiments conducted by H. F. Heady and dating from the 1950s showed that the amount of fall RDM (what Heady termed *natural mulch*) dramatically influenced forage productivity and composition at the high-rainfall (35 inches/year) Hopland Field Station site (Heady 1956). To determine the effects of RDM that would be representative of heavy to moderate grazing on annual range at different sites, Heady established nine experimental plots in the late 1960s and early 1970s and maintained them for three to five years. They were arranged along a rainfall gradient from the North Coast (rainfall >40 inches/year) along the west side of Central Valley, to the driest annual range in the western San Joaquin Valley (rainfall <7 inches/year) (Bartolome et al. 1980).

This study showed that RDM had a significant influence on range productivity in areas with average annual rainfall in excess of 15 inches, subject to the overriding controls of site conditions and yearly weather variations. Maximum productivity within the 15- to 40-inch annual precipitation zone occurred with 750 lb/acre of RDM in

UC PEER REVIEWED

SEASONAL AND YEARLY VARIATIONS IN ANNUAL RANGE FORAGE

California has a Mediterranean-type climate: a cool, wet winter and a warm, dry summer. Plant growth is limited by the lack of soil moisture in summer and by cold temperatures in the winter. This leads to a characteristic growth curve with rapid growth in fall after the first rains, slow winter growth, and rapid growth again in spring, ending as plants die or go dormant in summer. The basic shape of the curve is similar from year to year, but the timing and amounts of growth vary (George et al. 2001a).

Annual range livestock producers have adapted to large variations in forage quantity and quality between and even within years. Scientists describe spring as the *adequate green forage season,* when livestock nutritional needs are met. In summer, protein may become a limiting factor, while in fall and winter, energy and protein may both be limiting to animal performance (George et al. 2001b). Production and composition of annual-dominated ranges are controlled primarily by weather and site conditions, and do not respond significantly to intensive grazing management systems (Bartolome 1993). Seeding with annual legumes has enhanced the profitablility of production in some areas (Frost et al. 1989), but the opportunities for increasing forage productivity are limited.

Starting in the 1930s, California range researchers determined that the variation in quality and quantity of forage on annual range is primarily controlled by a few environmental factors: precipitation, temperature, soil characteristics, and residual dry matter (RDM) (Bentley and Talbot 1951). Forage production is higher in regions with greater average rainfall, and productivity in a given year also varies with the timing and amount of precipitation. The amount and type of woody overstory also influences understory forage (Frost et al. 1997). Scattered oaks may enhance forage production, while denser stands, especially of live oaks or brush, suppress production.

fall. The effects on composition in Heady's experiment were mixed (Jackson and Bartolome, In Press 2002). However, the experimental sites constituted an incomplete representation of the annual range region and were limited to flat ground without any woody plant cover. An ongoing experiment in the Sierra Foothills suggests that the range of 600 to 1,200 lb/acre of RDM maximizes both forage production and species richness (Bartolome and Betts 2001).

Clawson et al. (1982) developed regional guidelines for minimum allowable RDM based on the best research information available at the time of their writing. Subsequent experience and limited research suggest that those guidelines for RDM were probably too low for grasslands with more than about 12 inches of average annual precipitation. McDougald et al. (1991) developed a scorecard that can be used to quickly estimate an area's grazing capacity. The scorecard was developed by combining site characteristics (rainfall, canopy cover, and slope) that affect animal use to quickly estimate grazing capacity. The scorecard approach can yield useful estimates of grazing capacity from a pasture or an entire landscape and is easily coupled to geographic information systems (GIS) to allow mapping of forage availability (Standiford et al. 1999).

For RDM management purposes, California grasslands and associated oak woodlands and savannahs can be divided into three types. (Recommended minimum RDM guidelines for each type are listed in scorecard form in Tables 1 through 3.)

Dry annual grassland. Annual plant dominated, average annual rainfall less than 12 inches (see Table 1).

Annual grassland/hardwood range. Annual understory with variable oak or shrub canopy, average annual rainfall between 12 and 40 inches (see Table 2).

Coastal prairie. Perennial grasses common, variable woody overstory, rainfall variable (see Table 3).

The purpose of these guidelines is to provide livestock producers and other rangeland managers with useful information for managing rangelands. They were developed to help managers assess the proper level of herbaceous forage use, and for this reason they do not include measurements of other vegetation such as oak leaves and summer annuals. Included in the category of summer annuals would be such species as yellow starthistle, turkey mullein, and tarweed. While these plants and

Table 1. Minimum residual dry matter (RDM) guidelines for dry annual grassland.

Percent	Percent slope			
woody cover	**0–10%**	**10–20%**	**20–40%**	**>40%**
	(lb RDM per acre)			
0–25	300	400	500	600
25–50	300	400	500	600
50–75	NA	NA	NA	NA
75–100	NA	NA	NA	NA

Table 2. Minimum residual dry matter (RDM) guidelines for annual grassland/hardwood range.

Percent	Percent slope			
woody cover	**0–10%**	**10–20%**	**20–40%**	**>40%**
	(lb RDM per acre)			
0–25	500	600	700	800
25–50	400	500	600	700
50–75	200	300	400	500
75–100	100	200	250	300

Table 3. Minimum residual dry matter (RDM) guidelines for the costal prairie.

Percent	Percent slope			
woody cover	**0–10%**	**10–20%**	**20–40%**	**>40%**
	(lb RDM per acre)			
0–25	1,200	1,500	1,800	2,100
25–50	800	1,000	1,200	1,400
50–75	400	500	600	700
75–100	200	250	300	350

plant parts do provide soil protection, they do not figure into current livestock management and so are not included in these guidelines. If the goal were to assess site protection regardless of the type of land use, then RDM guidelines could be developed to include oak leaves and summer annuals.

ESTIMATING RESIDUAL DRY MATTER

A variety of means are available for the estimation of residual dry matter. An easy and quick method is to visually compare photo standards (Figures 1 through 3) with conditions on the landscape prior to the first effective fall rains, usually in late September or early October. Reference photos of grazing intensity standards have been developed for the Central Valley foothills using photos from the UC San Joaquin Experimental Range (SJER). The *moderate* level of grazing has been recommended for the best livestock performance and range protection for this region of California. Moderate grazing also provides more residual dry matter than listed in the minimum guidelines described in Tables 1 and 2. The other grazing intensities, described as *light* and *heavy,* are examples of too much and too little utilization. Residual dry matter levels corresponding to the photographed examples were collected for several years at SJER.

Figure 1. Light grazing results in high RDM levels.

Figure 2. Moderate grazing results in the recommended moderate level of RDM.

Figure 3. Heavy grazing results in low RDM levels.

CLIPPING A PLOT

The technique for clipping a plot for RDM measurement varies between agencies and individuals. The following procedure, recommended by the University of California, is the method that was used in the research on which these guidelines are based.

1. Place the quadrat (usually 1 square foot) on the ground surface.
2. Remove from the area within the quadrat all summer annuals such as tarweed, yellow starthistle, and turkey mullein.
3. Remove tree leaves.
4. Clip the remaining plant material within the quadrat as close to the ground as you can without disturbing the soil surface.
5. Rapidly collect as much of the clipped plant material as is practical without inadvertently including bits of soil.
6. Weigh the plant material (1 gram per square foot = 96 pound per acre). The plant material should be dry in September or early October unless there has been unusually early rain.

The primary means for measuring residual dry matter is by clipping plots. The guidelines in this publication were developed based on research that involved clipping all standing dry matter in early fall as close to ground level as possible without undue disturbance to the soil surface. Experience with clipping to the 0.5-inch standard commonly applied in areas populated primarily with annual grass shows that practice to leave behind approximately 25 percent of the total vegetation, by weight.

More common is the use of a combination of clipping and estimating residual dry matter. This may take the form of a formal process, such as the comparative yield method (Haydock and Shaw 1975), or it may be a less-formal process whereby an evaluator first clips plots and gradually learns to estimate the RDM by eye. These estimates are commonly recorded on maps and used to develop visual depictions of residual dry matter across a pasture or landscape (Frost et al 1988).

Measurement is conducted in the late fall (October through November) prior to the first significant rain. While the timing of the fall germinating rain is a moving target, the amount of residual dry matter at the time of that rain is the critical factor that ensures soil protection and a favorable microenvironment for the coming year's herbaceous plant community. Preliminary results from field trials indicate that from the time of peak standing crop (measured when plants have completely matured), the subsequent late-fall RDM will fall by a factor of 10 to 15 percent per month until the fall germinating rain (without livestock grazing). One way to estimate losses to grazing is to convert stocking rates into approximate amounts for daily or monthly intake of forage. Clipping done before or after the ideal October-November window will produce less accurate but still useful results.

LITERATURE CITED

Bartolome, J. W. 1993. Application of herbivore optimization theory to rangelands of the western United States. Ecological Applications 3(1):27–29.

Bartolome, J. W., and A. D. K. Betts. 2001. Residual dry matter impacts on water quality and biomass production. University of California Sierra Foothill Research and Extension Center Field Day, April 18, 2001.

Bartolome, J. W., and M. P. McClaran. 1992. Composition and productivity of California oak savanna seasonally grazed by sheep. J. Range Manage. 45:103-107.

Bartolome, J. W., M. C. Stroud, and H. F. Heady. 1980. Influence of natural mulch on forage production at differing California annual range sites. J. Range Manage. 33:4–8.

Bentley, J. R., and M. W. Talbot 1951. Efficient use of annual plants on cattle ranges in the California foothills. USDA Circ. 870. 52p.

BLM. 1999. Utilization studies and residual measurements. Bureau of Land Management National Business Center, Denver, Interagency Technical Reference 1734–3.

Clawson, W. J. (tech. ed.). 1980. Monitoring California's annual rangeland vegetation. University of California Division of Agriculture and Natural Resources, Leaflet 21486.

Clawson, W. J., N. K. McDougald, and D. A. Duncan. 1982. Guidelines for residue management on annual range. University of California Division of Agriculture and Natural Resources, Leaflet 21327.

Frost, W. E., J. W. Bartolome, and J. M. Connor. 1997. Understory-canopy relationships in oak woodlands and savannas. In: Pillsbury, N. H., J. Verner, and W.D. Tietje (tech. coord.), Proceedings of a symposium on oak Woodlands: Ecology, management, and urban interface issues, March 19–22, 1996, San Luis Obispo, CA. U.S. Forest Service General Tech. Rept. PSW-GTR-160. pp. 183–190.

Frost, W. E., N. K. McDougald, and W. J. Clawson. 1988. Residue mapping and pasture use records for monitoring Calfiornia annual rangelands. UC Davis Range Science Report 17.

Frost, W. E., N. K. McDougald, W. J. Clawson, and D. A. Duncan. 1989. Annual clover establishment for increased cattle production on annual rangeland in the central Sierra foothills. CATI Tech. Bull. 880603.

George, M., J. W. Bartolome, N. McDougald, M. Connor, C. Vaughn, and G. Markegard. 2001a. Annual range forage production. University of California Division of Agriculture and Natural Resources, Publication 8018.

George, M. R., W. E. Frost, N. K. McDougald, J. M. Connor, J. W. Bartolome, R. B. Standiford, J. Maas, and R. Timm. 1996. Livestock and grazing management. In: Standiford, R. B. (tech. coord.), Guidelines for managing California's hardwood rangelands. University of California Division of Agriculture and Natural Resources, Publication 3368: 51–67.

George, M., G. Nader, N. McDougald, M. Connor, and W. Frost. 2001b. Annual rangeland forage quality. University of California Division of Agriculture and Natural Resources, Publication 8022.

Heady, H. F. 1956. Changes in a California annual plant community induced by manipulation of natural mulch. Ecology 37:798–812.

Jackson, R. D., and J. W. Bartolome. 2002. A state-transition approach to understanding nonequilibrium plant community dynamics of California grasslands. Plant Ecology. 162:49–65.

McDougald, N. K., W. J. Clawson, J. W. Bartolome, and W. E. Frost. 1991. Estimating livestock grazing capacity on California annual rangeland. U.C. Davis Range Science Report 29.

Shook, W. W. 1990. Range Management Guidelines, Point Reyes National Seashore. USDI NPS.

Standiford, R. B., J. W. Bartolome, W. E. Frost, and N. K. McDougald. 1999. Using GIS in agricultural land assessment for property taxes. Geographic Information Sciences 5(1):47–51.

USDA Forest Service 1985. Range Analysis Handbook, Region 5.

FOR MORE INFORMATION

You'll find detailed information on many aspects of field crop production and resource conservation in these titles and in other publications, slide sets, CD ROMs, and videos from UC ANR:

California Range Brushlands and Browse Plants, publication 4010

Determining the Value of Leases for Annual Rangeland, publication 21456

Estimating the Cost of Replacing Forage Losses on Annual Rangeland, publication 21494

To order these products, 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, CD ROMs, and videos from

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

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

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

Publication 8092

pr-11/02-WJC/VFG

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.