

Long-term Residual Dry Matter Mapping for Monitoring California Hardwood Rangelands¹

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Abstract

Long-term residual dry matter mapping on the San Joaquin Experimental Range provides a working example of this monitoring technique for grazing management and research. Residual dry matter (RDM) is the amount of old plant material left on the ground at the beginning of a new growing season. RDM indicates the previous season's use and can be used to describe the health or condition of annual rangelands. An RDM evaluation is made before the first effective fall rains, usually in late September or early October. Direct clipping and weighing, comparative yields, or photo standards are used to obtain RDM estimates. Mapping of RDM provides a means of recording the total amount of herbage remaining, as well as its distribution on the landscape. RDM is mapped on three different range sites at low, moderate, and high amounts: 1) flat slopes and swales: <400, 600 and >800 lbs/acre; 2) gentle rolling slopes: <600, 800 and >1,000 lbs/acre; and 3) steep slopes: <800, 1,000, and >1,200 lbs/acre. Tracking this information assists management in adjusting stocking rates, selecting locations for livestock supplements and evaluating grazing systems. Researchers can evaluate different grazing impacts on sites, evaluate grazing models, and have a clear understanding of ambient grazing prior to experimentation.

Introduction

Many ranchers and range managers do not fully understand the importance of residual dry matter (RDM) on the California annual grasslands. RDM, sometimes referred to as mulch or plant litter, is the dry plant material on the ground left from previous seasons of growth (Clawson and others 1982, Frost and others 1988, Hedrick 1948). The exact terminology may vary among workers, but RDM consists of three classes or forms: 1) ungrazed mature vegetation still attached to the root system (forage residue), 2) vegetation residues detached from the roots laying on the ground (plant litter), and 3) decomposing residues partially or completely

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incorporated into the soil (humus) (Hedrick 1948, Molinar and others 2001). RDM estimation and mapping for management purposes deals primarily with the first two classes. The rancher's main tool for influencing soil surface conditions is by managing RDM (George and Menke 1996).

Annual plants respond each year to conditions that influence seed germination and early establishment, with fall weather having the greatest impact (Clawson and others 1982). RDM provides favorable microenvironments for early seedling growth, soil protection from erosion, soil organic matter, and it increases water infiltration and soil water holding capacity (Clawson and others 1982, George and Menke 1996, Molinar and others 2001, Rauzi 1960). Plant species composition on annual rangelands is also heavily influenced by RDM. High amounts of RDM favor the development of grass-dominated communities, while low amounts of RDM favor broadleaf-dominated communities (George and Menke 1996). Under normal climatic conditions, adequate amounts of RDM increase forage production on most sites (Bartolome and others 1980, Schwan and others 1949). Furthermore, RDM provides low-moisture fall forage for livestock feed (Clawson and others 1982).

Bentley and Talbot (1951) developed a system of site classification for rangelands typified by the San Joaquin Experimental Range. For the purposes of RDM estimation and mapping, the system consisting of ten site classes can be simplified by grouping sites into three slope categories: swales, open rolling, and steep brushy (Frost and others 1988). For range management, a rapid survey of rangelands can be done using visual estimation and comparative photos. RDM for the sites can be classed into light, medium and high categories using the class descriptions and comparative photos in the U.C. Cooperative Extension Leaflet 21327 (Clawson and others 1982). RDM classes can then be mapped using manual techniques or entered into a geographic information systems (GIS) database.

Mapping RDM periodically through the dry forage period can enhance livestock and rangeland management. RDM maps provide a record of residual dry forage amount and its distribution on a pasture, ranch or allotment. These records assist land managers in adjusting stocking rates (Clawson and others 1982) and selecting locations for water and supplemental feed to better utilize forage (Frost and others 1988). Long-term mapping and livestock use records provide accurate estimates of livestock carrying capacity for rangeland (Frost and others 1988). Researchers can use RDM records to evaluate grazing impacts on sites, evaluate grazing models, and evaluate treatment effects on grazing distribution.

Methods

Long-term mapping of RDM was implemented on the San Joaquin Experimental Range (SJER) in 1985 and is still continuing today. Only the RDM maps from 1985 to 1999 are presented here. The SJER (UTM zone 11N, Easting 257600, Northing 4109300) is located in the Sierra Nevada foothills 28 miles north of Fresno along state highway 41. The SJER (*fig. 1*) encompasses 4,539 acres and has been a USDA Forest Service research facility since 1934. The SJER is within the oak savanna region of the foothills and is characterized by grassy rolling hills with scattered trees and shrubs. Occasionally the stands of trees and shrubs become quite dense. The climate is Mediterranean with mild, rainy winters and hot, dry summers. Long-term average precipitation (65 years) is 19 inches. However, annual precipitation varies between 9 and 37 inches with most occurring as rain. Snowfall is rare at this location.

Rainfall usually occurs between the months of October and March, but may occur earlier or later. Forage production varies considerably with the amount and timing of storm events. Monthly mean air temperature ranges from 43°F in January to 81°F in July. The study site is better described in Bentley and Talbot (1951) or Frost and others (1988).

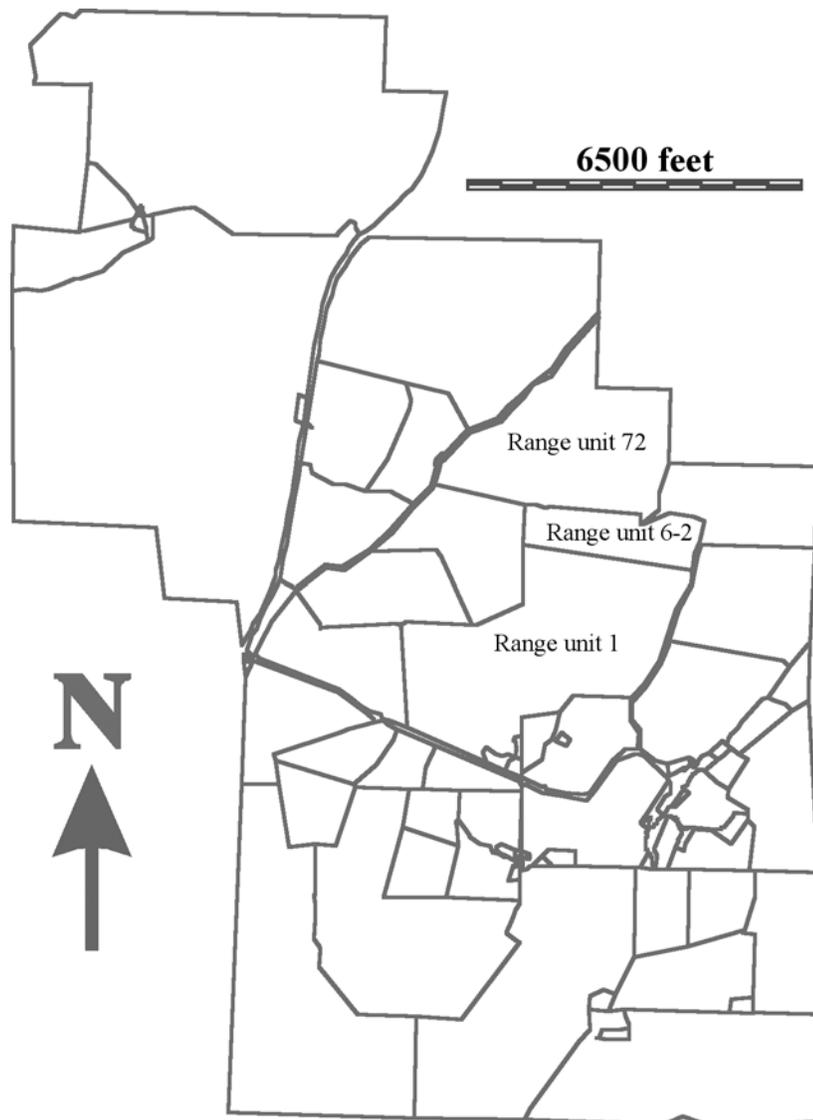


Figure 1—Fences on the San Joaquin Experimental Range showing the locations of range units used for the cattle distribution study.

Livestock management prior to 1995 consisted of rotational management of small groups of cattle through the range units. In 1995, a system of high density-short duration grazing was implemented on the station. Cattle are moved as a large herd unit into each range unit for a short time, one to two weeks, to graze available forage.

RDM evaluation and mapping is made before the first effective fall rains, usually in late September or early October. A double sampling method is used for determining RDM amounts. The double sampling consists of both visual estimation

and weight determination. Clipping and weighing a few plots periodically calibrates the visual estimation in the field. Weights are estimated in pounds per acre. The three comparative photos shown in U.C. Cooperative Extension Leaflet 21327 (Clawson and others 1982) are used to provide a consistent reference for delineating RDM classes. The entire station is surveyed in a single day. RDM is mapped on the three different slope classes at low, medium, and high amounts: 1) flat slopes and swales: <400, 400-800, and >800 lbs/acre, 2) gentle slopes: <600, 600-1,000, and >1,000 lbs/acre, and 3) steep slopes: <800, 800-1,200, and >1,200 lbs/acre. An additional class is used to delineate areas burned by wildfires. RDM classes are delineated on a topographical base map using color-codes. The RDM map is then converted to digital format by digitizing it into a GIS database (*fig. 2*).

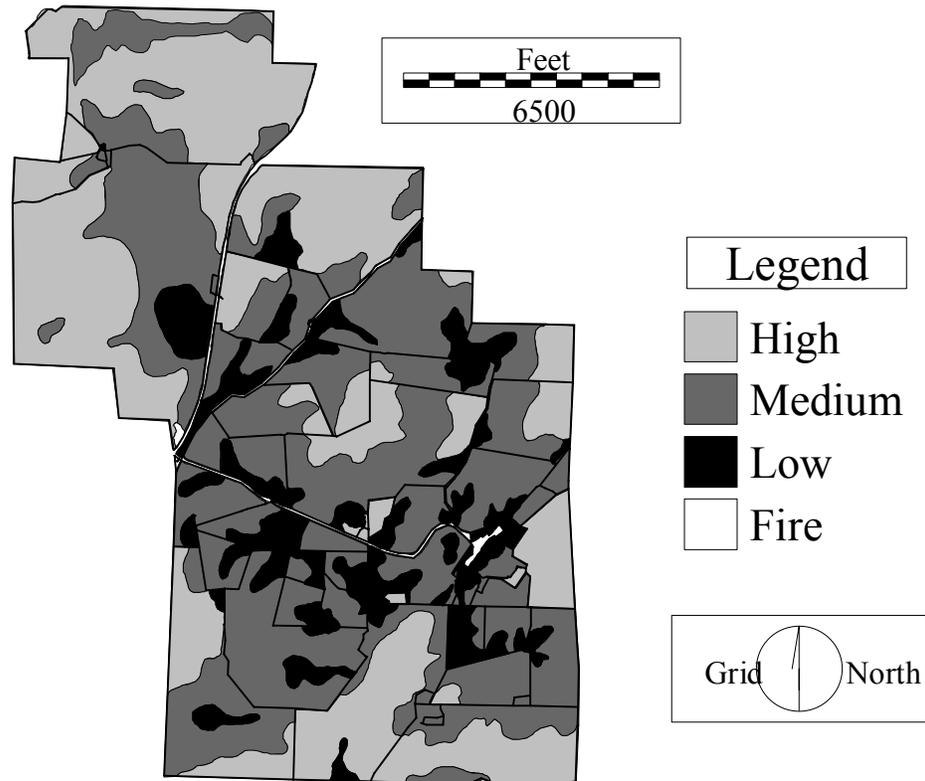


Figure 2—Residue map for 1996 shown with fences.

Direct visual observations were made on two small herds of cattle for 2 years (1997-1998 and 1998-1999), summer and winter. The cattle were observed in range units 1, 6-2, and 72 (*fig. 1*). For six 24-hour periods, scan sampling observations were made every 15 minutes using video cameras combined with global positioning system (GPS) technology. Observations were mapped spatially and entered into the GIS database. Livestock trails in these units were also mapped using a differentially corrected GPS. These data were used to validate that the RDM spatial patterns were related to animal use patterns.

RDM maps were quantified using the GIS database to calculate the coverage of each RDM class. A composite image of all RDM maps was created using GIS map algebra techniques.

Results and Discussion

RDM mapping proved to be a quick, efficient and accurate method for monitoring livestock use. A team of two people was able to map residue across the entire research facility in one day. The double sampling technique, combined with the comparative photos, provided accurate and consistent results. Calibration clippings at periodic intervals showed estimates to be within 10 percent of actual weights.

In general, RDM mapping revealed the same use pattern for the fifteen-year period. Cattle showed a grazing preference for the swales and shallow, flat slopes. Residue was reduced to medium or low levels before reduction below the high level was detected on the gentle rolling slopes. Reduction of residue on the steep slopes was seldom detected until the residue on the gentle rolling slopes was at the medium level. The other major influence on residue levels was the location of water sources. Areas near water had lower residue weights than areas farther away. Slope and distance to water were the two most cited factors influencing cattle distribution and RDM levels. This was the same use pattern described in Wagnon (1968) and Frost and others (1988). These findings also correspond to conclusions reached in our cattle observation study (Harris 2001). The composite image (*fig. 3*) for the fifteen-year period clearly showed these patterns.

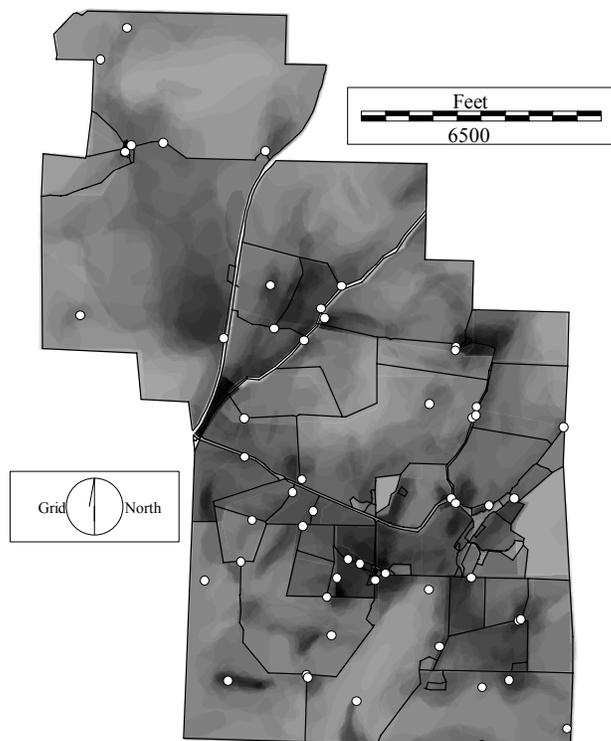


Figure 3—Composite image of 15 years of RDM maps. Light gray shows high residue levels (low animal use) and dark gray shows low residue levels (high animal use). Water sources are shown as white points and fences are in black.

We did not have access to livestock use records and were not able to relate RDM patterns to actual animal use across the SJER. However, for the summer of 1997 we had GIS layers that showed animal distribution for range units 1, 6-2, and 72 (*fig. 4*). While the total animal use in these range units was not exclusively by the cows in our observations, they were the major influence on the RDM pattern (*fig. 5*). The two figures showed good agreement between observed animal use and residue levels. An additional influence on RDM levels was shown by the low pattern (*fig. 5*) surrounding the supplement site in range unit 72 (the upper range unit). This low pattern on a ridge was not shown in the previous 12 years of RDM mapping and only occurred in years (1997 and 1998) when supplement was placed on the ridge.

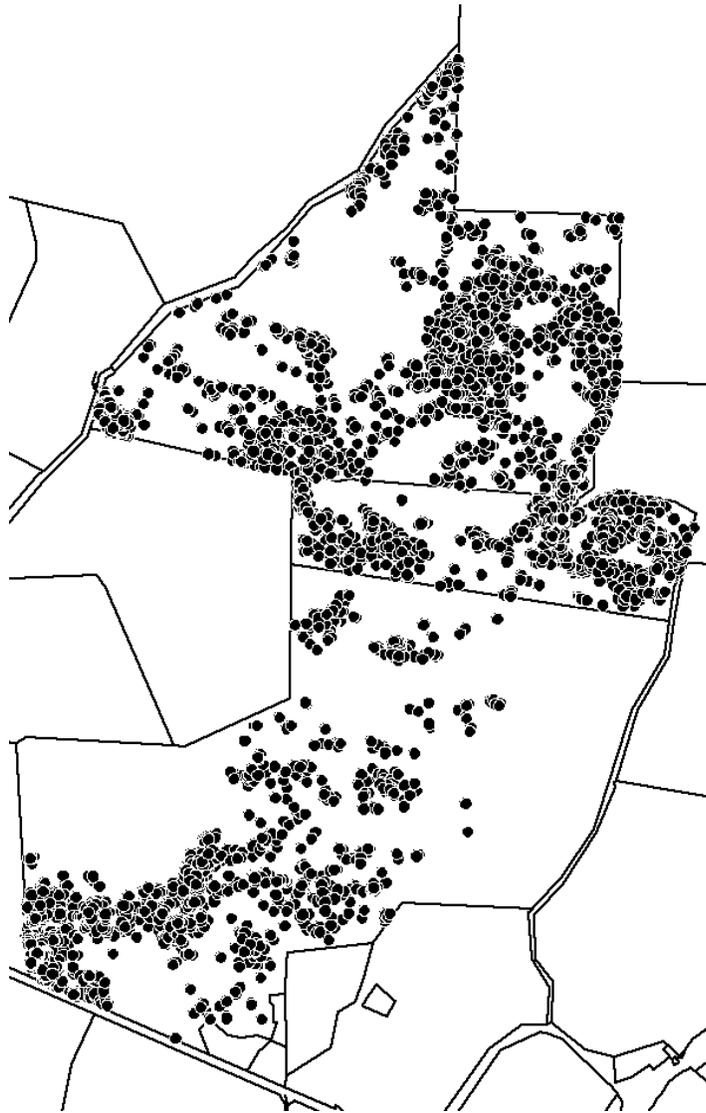


Figure 4—Cattle distribution for the summer of 1997 during daylight hours. Positions show individual cows at fifteen-minute intervals during six observation days.

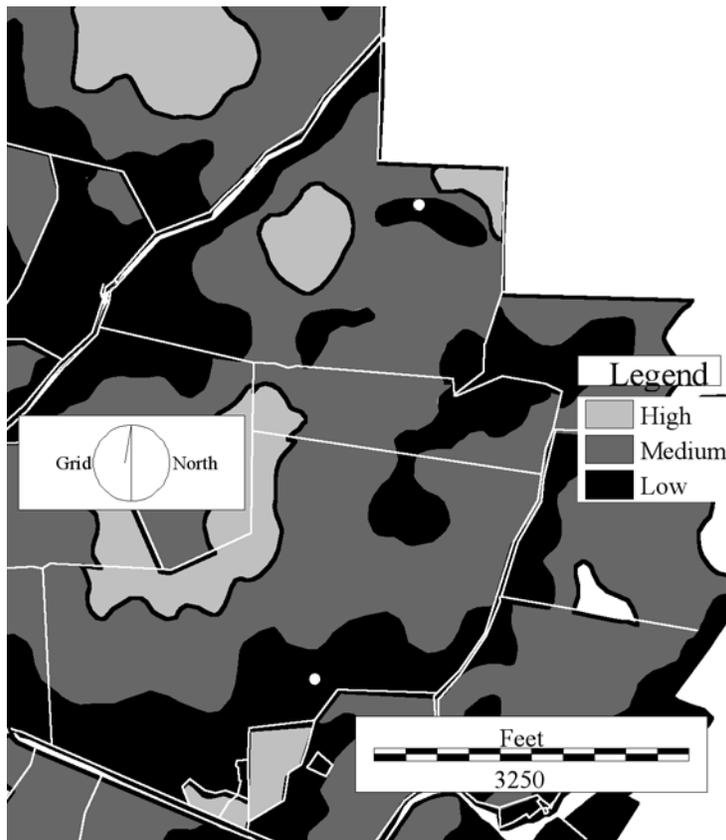


Figure 5—Residue map for range units 1, 6-2, and 72 during the summer of 1997. Supplement sites are shown as white points and fences are shown as white lines.

Livestock trails are the result of animal travel to preferred areas (Walker and Heitschmidt 1986, Ganskopp and others 2000). As such, they are another indicator of animal use. Walker and Heitschmidt (1986) indicate that trail density is a good predictor of animal use, with a high density of trails indicating highly preferred sites. Harris (2001) states that trails proved to identify preferred grazing sites; over 75 percent of all grazing in these range units occurred within 30 meters of a major trail. The trail systems in range units 1, 6-2, and 72 were mapped using DGPS units to within 2 meters. Comparison of the trail systems to the composite image for these range units (*fig. 6*) shows that most trails were associated with areas of lower RDM (darker areas).

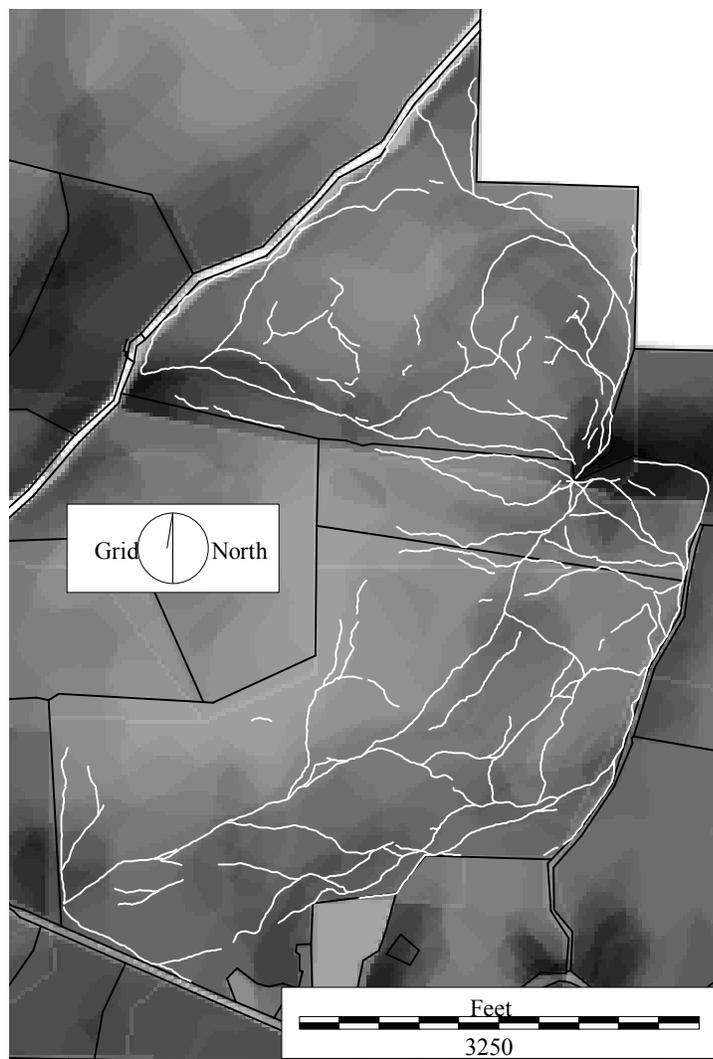


Figure 6—Comparison of composite RDM image (15 years) with livestock trail systems for range unit 1, 6-2, and 72. Light gray shows high residue levels (low animal use) and dark gray shows low residue levels (high animal use). Livestock trails are shown as white lines and fences are in black.

The percentages of area with low, medium and high levels of RDM were not related to forage production and rainfall (*table 1*). Peak production was the highest in 1992 at 2,699 lbs/acre. This was 468 lbs/acre higher than the 65-year average of 2,261 lbs/acre. High RDM covered 75.5 percent of the area, while low RDM levels covered 2.4 percent. Production was the lowest in 1988 at 807 lbs/acre, or 1454 lbs/acre below the average. Medium RDM covered over half (53.2 percent) of the SJER. High RDM covered 33.6 percent and low RDM covered 13.2 percent of the area. The greatest coverage for high RDM was in 1986 (94.1) when peak production was high (2,653 lbs/acre). The greatest coverage for medium RDM was in 1998 (56.0 percent) and peak production was 2,508 lbs/acre. The greatest coverage for low RDM was in 1990 (40.8) when peak production was far below the average at 845 lbs/acre. Clawson and others (1982) stated that the “moderate” (medium RDM) level of

grazing had been recommended for the best livestock performance and range protection in this zone. Using this criterion, the best matches between animal use and forage production occurred in years 1988, 1990, 1997, and 1998 when medium RDM levels were over 50 percent of the area of the station. However, the high percentage of low RDM (40.8 percent) in 1990 might indicate overuse of forage resources for that year.

Table 1—Percent cover of RDM, peak forage production and annual rainfall for the 15-year period (1985-1999).

Year	High (percent)	Medium (percent)	Low (percent)	Fire (percent)	Peak production (lbs/ac)	Rainfall (inches)
1985	86.6	11.7	1.3	0.3	1,690	13.6
1986	94.1	4.4	1.5	0.0	2,653	20.8
1987	85.5	6.8	7.7	0.0	968	11.1
1988	33.6	53.2	13.2	0.0	807	12.1
1989	62.8	32.3	4.8	0.0	988	13.0
1990	9.2	50.0	40.8	0.0	845	11.6
1991	78.8	19.4	1.9	0.0	2,338	16.1
1992	75.5	22.1	2.4	0.0	2,699	16.2
1993	76.0	22.8	0.9	0.3	1,829	25.7
1994	51.2	44.6	4.1	0.1	1,328	13.3
1995	64.8	32.4	2.8	0.0	2,355	31.7
1996	39.6	48.4	11.9	0.1	2,651	14.1
1997	28.2	51.5	20.3	0.0	2,286	24.9
1998	30.3	56.0	13.7	0.0	2,508	31.8
1999	33.9	41.0	25.1	0.0	2,191	13.1

Conclusion

RDM mapping can provide an important tool for ranchers and resource managers. It is quickly accomplished and does not require specialized equipment. Mapping of RDM allows managers to identify areas of heavy use and possible erosion sites. Using long-term RDM mapping, prevalent grazing patterns can be identified and sites suggested for water or supplement to modify undesirable use by cattle. Mapping can then aid in evaluating the effectiveness of management actions to correct problems. RDM mapping, combined with livestock use records, assists in evaluating grazing systems and in adjusting stocking rates.

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