

Ecology and Management of Annual Rangelands Series **Part 8: Grazing Management**

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Grazing management is one of several tools available to land managers to manipulate vegetation, livestock performance, and ecosystem processes. The response of vegetation, livestock, and ecosystems to grazing is complex, and significant knowledge gaps exist because of this complexity. In the face of incomplete knowledge, grazing managers need to equip themselves with existing knowledge about grazing management effects, and they need a management process that allows them to assess the effectiveness of practices and adapt to changing conditions.

The main purpose of this publication is to provide government agencies and NGO personnel and private landowners with an overview of existing grazing management knowledge so that they can reach their goals through an adaptive management process. Adaptive management is a process of planning, implementing, and learning to progressively improve knowledge. It includes evaluating the success of management practices and strategies as well as the validity of assumptions underlying management direction (Boyd and Svejcar 2009). Monitoring provides feedback about the effects of management and the success of practices.

Grazing managers are confronted with a variety of grazing strategies or systems that are sometimes hard to compare or evaluate. These grazing systems can be better understood if they are described and compared in terms of four components or principles of grazing:

intensity, season, frequency, and duration of grazing. Grazing researchers have compared one or more of these four components of grazing in controlled experiments to understand their effects on vegetation and livestock production. The results of these controlled experiments sometimes conflict with the experiences of grazing managers. In this publication, we will review these four components of grazing and their effects on annual rangelands. We will discuss why grazing management research results sometimes conflict with experience. First we will discuss the adaptive management process of planning, implementation, and learning that grazing managers can use to help them cope with complexity and knowledge gaps.

ADAPTIVE MANAGEMENT AND PLANNING

Learning by trial and error has been around for eons. Some would say that adaptive management is a process of learning from this method. Adaptive management is a way for managers to do their jobs in the face of uncertainty and to learn by doing. Many descriptions of adaptive management exist and most describe a cyclic process that includes the following steps: problem assessment, design, implementation, monitoring, evaluation, and adjustment (Bush 2006; Reever Morghan et al. 2006; Boyd and Svejcar 2009). Grazing management is an adaptive process that begins with the development of a grazing management plan that provides for learning from monitoring based on measurable objectives.

The first step in the adaptive management process is development of management questions based on the site and management

concerns. Next is the synthesis of information about previous management successes and scientific literature relative to the site and management concerns. Then a plan is developed based on the findings of the first two steps. Once the plan is completed, it is implemented. Implementation is accompanied by monitoring that provides management with information about the effectiveness of the implemented practices and strategies. Finally, what is learned from monitoring is integrated back into the management plan.

The Adaptive Grazing Plan

No single outline for a grazing plan exists, but most include a statement of objectives, site description and resource inventory, land use description (historic, current, and future), grazing recommendations or prescriptions, other vegetation management practices, monitoring and evaluation, and an implementation schedule. The Sotoyome Resource Conservation District in Sonoma County has published an outline for a grazing plan that should be adequate for most situations (Bush 2006). Other plan outlines or templates can be found on the Internet.

Measurable Objectives

Management objectives need to be clear, meaningful, and attainable. Vague objectives lead to vague results. A statement of measurable objectives can help focus management on desired outcomes. Objectives such as improving the health of a riparian area or increasing biodiversity are vague unless stated with measurable endpoints. For example, increasing canopy cover in the riparian area from 40 to 70 percent and increasing the abundance or cover of desired species are measurable objectives. Meeting the residual dry matter (RDM) guideline set for the site is also a measurable objective. What to monitor should be obvious from the statement of measurable objectives.

Site Description and Resource Inventory

A description of the site and resources can be brief or quite long. The resource inventory may include legal descriptions, as well as descriptions of soils, vegetation, wildlife populations and habitat, and other characteristics that may be important to a specific situation. Online soil

surveys and ecological site descriptions from USDA Natural Resources Conservation Service (NRCS) often contain this information. Maps and aerial photographs showing soils, vegetation, and infrastructure (e.g., roads, fences, water developments, etc.) are an important part of the resource inventory. The aerial photography in Google Earth is a valuable planning resource.

Management Practices

This section of the plan should describe stocking rate, kind and class of animal, grazing units or pastures, animal distribution practices, and existing and needed infrastructure (fences, etc.). Other existing or proposed practices such as weed control and seeding should also be described. The selection of practices should be justified by connecting them to measurable objectives, and the timetable for implementation should be recorded. Management actions should be linked to biological processes. For example, if a practice is proposed to improve soil quality, the assumptions underlying this decision should be described in the plan and documented by science and experience. The effectiveness of rangeland management practices for reaching a variety of goals has been assessed by USDA's Natural Resources Conservation Service (NRCS) (Briske 2011).

Monitoring and Evaluation

Monitoring and evaluation provide a reference for gauging the success of planning and practice implementation (Boyd and Svejcar 2009). Monitoring involves recording observations and measurements for the purpose of detecting change. Stating measurable objectives early in the plan can tell the manager what to monitor. Recording observations and measurements in the resource inventory provides a benchmark for detecting change. Recording observations and measurements before and after practice implementation can provide an indication of practice effectiveness. Records of land use, ranch practices, weather, and disturbances can help the manager interpret monitoring information. Monitoring can be as simple as a photograph or notes written in a diary but can also include quantitative measures of vegetation or other variables. A

good set of measurable objectives can help minimize costs and time. Monitoring methods for measuring vegetation cover, production, and species composition are available in the *Targeted Grazing Handbook* (Launchbaugh and Walker 2006) and the *Monitoring Manual* (Herrick et al. 2005a, 2005b). Videos of vegetation measurement techniques, produced by U.S. range scientists and managers, can be found at www.youtube.com/playlist?list=PL7CD3CD7A9350A858.

PRINCIPLES OF GRAZING

Intensity of Grazing

Grazing managers can influence or control the four components of grazing: season, frequency, duration, and intensity. Intensity of grazing or stocking rate is the most important of the four. It is a fundamental variable determining the sustainability and profitability of rangeland livestock operations (Smith 1899; Sampson 1923). In determining stocking rate, grazing managers attempt to balance the forage demand of grazing animals with forage production over the changing seasons. In this section we will define some terms; discuss the estimation of carrying capacity and stocking rate; describe how stocking rate can be monitored; and review the effects of stocking rate on production and species composition.

Carrying Capacity and Stocking Rate

Carrying capacity, as defined by the Society for Range Management, is the average number of livestock and/or wildlife that may be sustained on a management unit compatible with management objectives for the unit (SRM 1998, Appendix A). It is based on average production over several years. *Stocking rate* is the relationship between the number of animals and the grazing management unit utilized over a specified time period. Stocking rate is often defined as the number of animals grazing an area of land for a specified period of time. It may be expressed as animal units per unit of land area over a described time period. *Light, moderate, and heavy grazing* are relative terms often used for comparative purposes but are often not well quantified. In the annual grasslands, moderate grazing

is around 50 to 60 percent utilization, but for many rangeland ecosystems moderate grazing is less than 50 percent utilization (Holechek et al. 2004). *Stock density* is the number of animals per acre at any point in time. This term is often used in intensive grazing management systems. *Overgrazing*, a popular term for heavy grazing, is more properly defined as continued heavy grazing that exceeds the recovery capacity of the community and creates a deteriorated range.

Overgrazing

In the view of most people, overgrazing is putting too many animals on the land. Promoters of intensive grazing management consider this definition to be misleading. In their view, overgrazing is the result of leaving animals in a pasture so long that they regaze forage regrowth before it has a chance to recover. While correct, this definition focuses on individual plants, whereas many other definitions also focus on pastures or entire plant communities or pastures. For example, according to A. W. Sampson (the “father of range management”), range and pasture vegetation is able to recover from the effects of a season’s overgrazing if given adequate time in which to recuperate. If, however, overgrazing is allowed for several successive years, complete barrenness is the inevitable result, and many years are required in which to build up the soil and restore its original forage yield (Sampson 1923). The Society for Range Management definition of overgrazing is continued heavy grazing that exceeds the recovery capacity of the community and creates a deteriorated range. An overgrazed range is a range that has experienced loss of plant cover and accelerated erosion as a result of heavy grazing or browsing pressure. For grazing management purposes, a definition that recognizes the effect of time as well as number of animals on individual plants, pastures, and plant communities (and even habitat) is preferred to those that focus only on number of animals and individual plants.

Many livestock operations base their stocking rate on carrying capacity estimates handed down from generation to generation; on the advice of their neighbors or local experts; and on trial and error. Stocking rate is usually documented in private and public land leases. Carrying capacity for annual grasslands is often in the range of 6 to 12 acres per animal unit (AU) per year (fig. 1). Sierra foothill and Coast Range oak woodland carrying capacity is commonly in the range of 10 to 30 acres per animal unit per year (fig. 2).

Animal Units and Animal Unit Months

Stocking rate and carrying capacity are often expressed as *animal unit months (AUMs)*. The original definition of an AUM was the amount of forage a cow and her calf would consume in 1 month. This definition worked reasonably well for several years, until cows started getting bigger and calf weaning weights increased. To accommodate bigger cows and calves, the definition of an AUM was put on a weight basis. Today, an *animal unit (AU)* is commonly defined as 1,000 pounds of body weight, and an AUM is the amount of forage that an animal unit will consume in 1 month. If the cow and her calf weigh 1,000 pounds, they are still 1 animal unit. More likely the cow weighs 1,200 pounds, and her calf grows to 400 or 500 pounds by weaning. So the cow without a calf is 1.2 animal units. However, by weaning time, the cow and her calf are around 1.6 or 1.7 animal units. The 1,000-pound animal unit can be applied to most large herbivores to get a rough estimate of stocking rate. However, tables of animal unit equivalents are often used to provide a more precise estimate that recognizes interspecies differences in metabolic and intake rate. For example, a mature sheep has an animal unit equivalent of 0.20. This means a sheep eats about 20 percent of the forage that a cow will eat in 1 month. Table 1 contains animal unit equivalents for several domestic and wild herbivores. Occasionally you will see the term *animal unit year (AUY)*. An AUY is 12 AUMs, or enough forage to feed an AU for 12 months.



Figure 1. Annual grassland carrying capacity often is in the range of 6 to 12 acres per animal unit per year.



Figure 2. Sierra foothill and Coast Range oak woodland carrying capacity is commonly in the range of 10 to 30 acres per animal unit per year.

Table 1. Animal unit equivalents for domestic and wild herbivores

Cattle	Animal unit
mature cow without a calf	1.0
cow with a calf	1.2
weaned calf to yearling	0.6
steers and heifers (1–2 years old)	1.0
mature bulls	1.3
Sheep	Animal unit
5 weaned lambs to yearlings	0.6
5 mature ewes with or without lambs	1.0
5 mature rams	1.3
Goats	Animal unit
6 weaned kids to yearlings	0.6
6 does with or without kids	1.0
6 mature bucks	1.3
Horses and mules	Animal unit
mature horse (1,200 lb)	1–1.25
mature mule	1–1.25
Wildlife	Animal unit
6 deer	1.0
antelope, mature	0.2
bison, mature	1.0

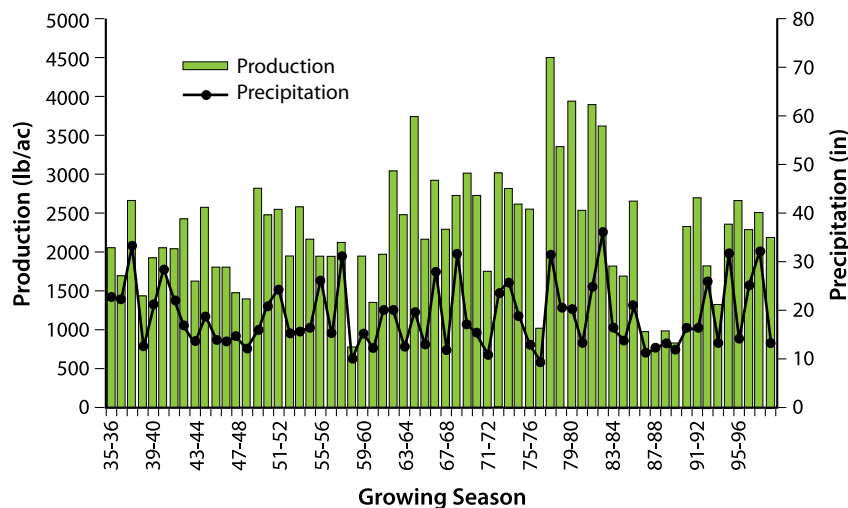


Figure 3. Annual range forage production and precipitation for San Joaquin Experimental Range in Madera County from 1935-36 to 1998-99 illustrates the potential variation in productivity. Annual rainfall has varied from about 9 inches to nearly 40 inches, and annual production has ranged from just under 1,000 pounds per acre to more than 4,000 pounds per acre. The average is about 2,000 pounds per acre. If we allocated half of that to grazing, it would take only 7 acres to support an animal unit for 1 year. In reality, the long-term carrying capacity is around 15 or 16 acres per animal unit. This avoids overstocking in most years and reduces the risk of running out of forage during dry years.

While the above carrying capacity ranges are based on long-term average productivity and experience, range forage productivity varies from year to year depending on prevailing weather conditions (fig. 3). Therefore, the stocking rate must be adjusted annually in response to these conditions. In a dry year it means that fewer AUs are put in the pasture, or the length of the grazing season is reduced. When forage is in short supply, ranchers purchase additional hay, rent additional pasture, or reduce herd size. High variability in rangeland forage production associated with seasonal and annual variation in weather makes estimation of proper stocking rate difficult. Therefore, it is common for stocking rates to be conservatively applied to minimize the consequences of low production years and prolonged drought. Three methods of estimating carrying capacity are presented in the following sidebar.

Estimating Carrying Capacity

To calculate carrying capacity you need to determine the *total available forage* in the pasture. Total production is adjusted by one of the following three methods to get total available forage. Estimates of total production can be found in “Ecological Site Descriptions” on the USDA’s NRCS website (<http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/technical/ecoscience/desc/>) or from Web Soil Survey (<http://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm>). Total production can also be estimated by clipping some quadrats to get an estimate of ungrazed standing crop at the end of the growing season. There are three ways to calculate total available forage. Method 1 is the take half, leave half method. Method 2 is the allowable use, or proper use, method commonly used on perennial rangelands throughout the western United States. Method 3 is the residual dry matter method often used on California’s annual rangelands.

Calculating Total Available Forage

1: Take Half, Leave Half Method

In the early days of range management, the utilization rule of thumb was “take half, leave half.” To determine total available forage, you multiply the total annual production by

Carrying Capacity (Take Half, Leave Half Method)

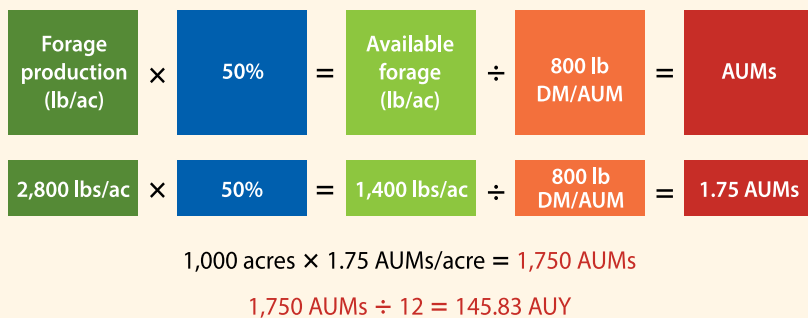


Figure 4. Calculation of carrying capacity using the take half, leave half method.

Carrying Capacity (Allowable Use Method)

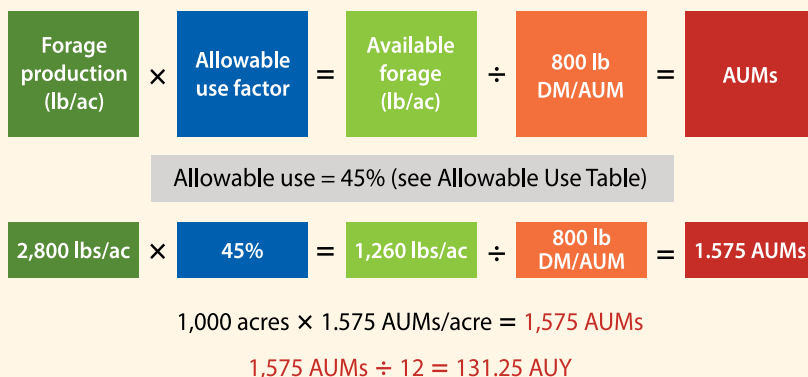


Figure 5. Calculation of carrying capacity using the allowable use, or proper use, method.

Carrying Capacity (RDM Method)

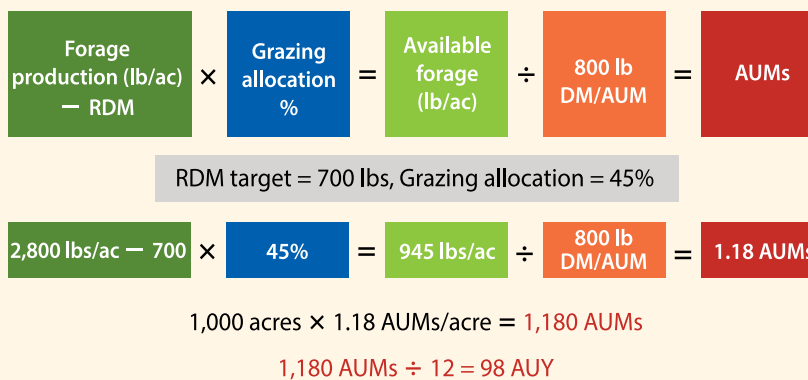


Figure 6. Calculation of carrying capacity using the RDM method.

50 percent (take half, leave half). To convert available forage in pounds per acre to AUMs, you divide by 800 pounds per acre (fig. 4). Some agencies use 1,000 pounds per acre.

2: Allowable Use Method

Now let us calculate total available forage using the allowable use method, which is often used on perennial-dominated rangeland. This method can also be used on annual rangelands. To calculate total available forage, you multiply forage production (lb/ac) by the allowable use factor, which can be found in most range management texts, or your work location may recommend a factor to use. See table 2, which lists allowable, or proper, use factors for several rangeland vegetation types. Just as in Method 1, you can convert available forage in pounds per acre to AUMs by dividing by 800 pounds per acre (fig. 5).

Table 2. Allowable use, or proper use, factors for U.S. rangeland vegetation types

Suggested proper use factor (%)	Ecosystem or type
30–40	northern desert shrublands
30–40	semidesert grass and shrublands
30–40	sagebrush grasslands
30–40	Palouse prairie
30–40	oak woodland
30–40	chaparral
40–50	shortgrass prairie
40–50	northern mixed prairie
40–50	southern mixed prairie
45–60	tallgrass prairie
45–60	southern pine forest
45–60	eastern deciduous forest
50–60	California annual grassland

3: Residual Dry Matter Method

On California’s annual grasslands and oak woodlands, carrying capacity is calculated by a method that ensures adequate residual dry matter (RDM) remains at the end of the grazing season (Bartolome et al. 2006). This method is usually more conservative than Methods

Table 3A. Minimum residual dry matter (RDM) guidelines for dry annual grassland

Woody cover (%)	Slope (%)			
	0–10	10–20	20–40	> 40
0–25	300	400	500	600
25–50	300	400	500	600
50–75	N/A	N/A	N/A	N/A
75–100	N/A	N/A	N/A	N/A

Table 3B. Minimum residual dry matter (RDM) guidelines for annual grassland/hardwood range

Woody cover (%)	Slope (%)			
	0–10	10–20	20–40	> 40
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 3C. Minimum residual dry matter (RDM) guidelines for coastal prairie

Woody cover (%)	Slope (%)			
	0–10	10–20	20–40	> 40
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

1 and 2. Just as in the first two methods, you need to calculate total available forage from the annual production. In the RDM method, the RDM target is subtracted from total annual production and the result is then multiplied by a utilization factor (fig. 6).

The RDM target is determined from tables 3A, 3B, and 3C or from UC ANR Publication 8092, *California Guidelines for Residual Dry Matter Management on Coastal and Foothill Annual Rangelands* (Bartolome et al. 2006). RDM is the amount of forage that managers have decided should be left to protect the soil surface and provide mulch for germinating seeds. The difference between the forage produced on the site and the RDM is the amount of forage that is available for use by livestock and wildlife, but it also includes forage that is lost to trampling, shatter, and decomposition. Thus, a domestic grazing animal will not consume all of that remaining forage. Grazing allocation, or harvest efficiency, is a term that has been used for the forage that is available for grazing by cows or other livestock. To maintain a conservative stocking rate, the grazing allocation, or harvest efficiency, should be 45 percent. Just as in the previous two methods, you convert available forage in pounds per acre to AUMs by dividing by 800 pounds per acre (see fig. 6).

Table 4. Approximate reductions in cattle grazing capacity for different slope percentages

Slope (%)	Reduction in grazing capacity (%)
0–10	0
11–30	30
31–60	60
> 60	100

Table 5. Approximate reductions in carrying capacity as distance from water increases

Distance from water (mi)	Distance from water (km)	Reduction in grazing capacity (%)
0–1	0–1.6	0
1–2	1.6–3.2	50
> 2	> 3.2	100

Carrying Capacity Adjustments

Carrying capacity and stocking rate are often adjusted for slope, distance to water, and canopy cover. Approximate adjustments for slope and distance to water are presented in tables 4 and 5. Carrying capacity must also be adjusted when productivity is reduced by weeds, brush, or trees that invade or encroach into pastures and range allotments. Canopy cover can also affect forage production and therefore carrying capacity. In oak woodlands, canopy cover and slope are important factors affecting carrying capacity.

McDougald et al. (1991) have developed a scorecard procedure for estimating carrying capacity that adjusts for canopy cover and slope within three rainfall zones (table 6). The scorecard method of estimating carrying capacity

is based on (1) the productivity of a site, expressed as the relationship between forage production and canopy cover; (2) grazing use, expressed as the relationship between slope and grazing pressure; and (3) a level of residual dry matter or litter, which indicates allowable grazing pressure and utilization. These variables are displayed as a field scorecard (see table 6) that the experienced range manager can use, along with actual livestock grazing use history, to estimate grazing capacity on annual rangeland. Poorly distributed watering facilities and conditions hampering livestock travel may lead to inaccurate grazing capacity estimates. Experienced range managers can make realistic adjustments to the scorecard to account for long distances to water and poor travel conditions in specific pastures or allotments.

Monitoring Stocking Rate

When estimating stocking rates, the values used in the calculations for daily or monthly intake or consumption rates, allowable use rates, residual dry matter (RDM), animal unit equivalents, methods of estimating total available forage, and adjustments made for distance to water and slope can result in different stocking rate estimates for the same pasture. These potentially different estimates should be fine-tuned based on end-of-season monitoring and experience. Selection of conservative values for stocking rate calculations leaves room for adjustment upward if a few years of experience show that the pasture is understocked.

To fine-tune stocking rates, grazing managers assess stocking rates throughout the grazing season, at the end of the grazing season, and over multiple years. Grazing managers regularly assess forage levels and animal body condition (see the seventh publication in this series, “Livestock Production”) during the grazing season. If forage levels are low and body condition is declining, animals are typically moved to new pasture or fed hay. If forage levels remain low for prolonged periods, as in a drought, animals may be sold to reduce the stocking rate.

The stocking rate should not exceed the carrying capacity, which is based on long-term average production. To determine if the

Table 6. Estimated carrying capacity scorecards for three rainfall zones

Southern California zone (less than 10” precipitation)

Canopy cover (%)	Slope class			
	< 10%	10–25%	25–40%	> 40%
	AUM/ac			
0–25	0.7	0.4	0.3	0.1
25–50	0.4	0.3	0.2	0.1
50–75	0.2	1.0	0	0
75–100	0.1	0	0	0
	RDM lb/ac			
	200	250	300	350

Central Coast and Central Valley foothills zone (10” to 40” precipitation)

Canopy cover (%)	Slope class			
	< 10%	10–25%	25–40%	> 40%
	AUM/ac			
0–25	2.0	0.8	0.5	0.3
25–50	1.5	0.6	0.4	0.2
50–75	1.0	0.4	0.3	0.1
75–100	0.5	0.2	0.2	0.1
	RDM lb/ac			
	400	600	800	800

Northern California zone (greater than 40” precipitation)

Canopy cover (%)	Slope class			
	< 10%	10–25%	25–40%	> 40%
	AUM/ac			
0–25	3.5	1.3	0.8	0.5
25–50	2.8	1.0	0.6	0.3
50–75	1.8	0.7	0.5	0.2
75–100	0.9	0.3	0.2	0.1
	RDM lb/ac			
	750	1,000	1,250	1,250

annual stocking rate is at or below carrying capacity, grazing managers estimate RDM at the end of the grazing season. If at the end of the grazing season (fall) RDM levels exceed the target RDM level for moderate grazing each year or for most years, then the stocking rate may be increased. If RDM levels are consistently low each fall, then the stocking rate should be reduced. If desired forage species

are declining in vigor or decreasing in number over multiple years, the stocking rate may be too high. Increasing amounts of bare ground or prevalence of soil disturbances could also be an indication of overstocking.

Stocking Rate Effects

Forage Production and Composition

In California, researchers have shown that annual rangeland productivity is most influenced by prevailing weather, but the amount of RDM in the fall also influences productivity (George, Nader, and Dunbar 2001; Bartolome et al. 2006). Fall RDM is the result of grazing intensity during the growing season and summer dry season. Moderate grazing should result in RDM levels near the guides in ANR Publication 8092 (Bartolome et al. 2006). Moderate grazing results in a patchy appearance, with an average residue about 2 inches tall, which equals or exceeds the recommended RDM level (fig. 7). Light grazing results in a less patchy appearance than moderate grazing, and unused forage averages 3 or more inches in height, exceeding the recommended RDM level. Heavy grazing produces a closely grazed appearance, with fall residue averaging less than 2 inches, which is below the minimum recommended RDM levels. With low RDM, small rocks, sticks, and manure are clearly visible.

Close grazing, resulting in low RDM, can delay fall growth and reduce winter growth of annual rangeland forage plants (Heady 1961). Moderately grazed pastures produce new plant growth 2 to 3 weeks earlier than those grazed closely. The residual vegetation left on the ground under moderate grazing protects young plants from drying winds and cold temperatures (Hormay 1944). Biswell (1956) reported that the botanical composition of vegetation is influenced by the intensity of grazing and the season of use. Moderate grazing usually produces the densest cover and more desirable species. Light grazing results in an increase in tall annual grasses. Heavy grazing at the correct stage of plant growth has been used to control weeds such as medusahead (*Taeniatherum asperum*) and yellow starthistle (*Centaurea solstitialis*) (Launchbaugh and



Figure 7. Appearance of light, moderate, and heavy grazing at the San Joaquin Experimental Range in Madera County, California.

Walker 2006; DiTomaso et al. 2008), but it may increase summer weeds (Biswell 1956).

Grasses can shade out other species, so grass often dominates when residue builds up due to favorable weather or light grazing pressure. Light to moderate grazing, resulting in higher RDM in the fall, encourages dominance by slender wild oats (*Avena barbata*), soft chess (*Bromus hordeaceus*), wild oats (*Avena fatua*), medusahead, ripgut brome (*Bromus diandrus*), and other tall species (Hormay 1944).

Grazing opens the canopy, increasing the occurrence of shorter species such as legumes and other forbs. Heavy grazing, resulting in low RDM in the fall, encourages higher

proportions of short or decumbent species such as silver European hairgrass (*Aira caryophylla*), turkey mullein (*Eremocarpus setigerus*), quakinggrass (*Briza minor*), nitgrass (*Gastridium ventricosum*), broadleaf filaree (*Erodium botrys*), burclover (*Medicago polymorpha*), redstem filaree (*Erodium cicutarium*), and clovers (*Trifolium* spp.). On a moderately utilized range, livestock do not graze heavily enough to make complete use of the available forage; thus, a patchwork of grasses and forbs is apparent (Hormay 1944).

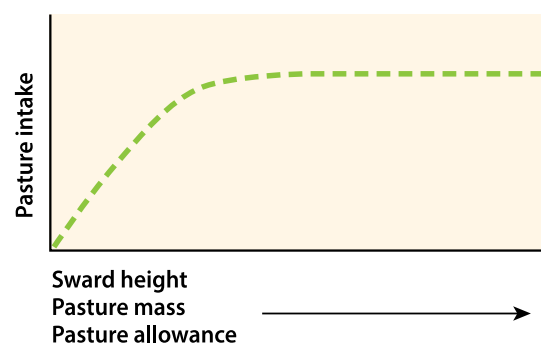
Using sheep, Rossiere (1987) evaluated the influence of grazing intensity on species composition and herbage production in an oak woodland and an improved grassland at the University of California's Hopland Research and Extension Center (UC HREC) over a 5-year period using three grazing treatments (100, 150, and 200% of moderate stocking). Plant species and production responses differed significantly between the oak woodland and improved grassland. On the woodland, ripgut brome (*Bromus diandrus*) and wild oats (*Avena barbata* and *A. fatua*) were most sensitive to increasing grazing intensity, while wild barley (*Hordeum leporinum* and *H. hystrix*) and annual fescue (*Festuca megalura*) were least sensitive. On improved grassland, subterranean clover (*Trifolium subterraneum*) increased and soft chess (*Bromus hordeaceus*) decreased with increasing grazing intensity. Soft chess remained most plentiful on woodland range under the heaviest grazing, and it continued to be a major species under heavy grazing of the grassland, demonstrating tolerance to grazing intensity. Filaree (*Erodium cicutarium* and *E. botrys*) declined on woodland but increased on grassland as grazing intensified. Peak standing crop was not significantly affected by

grazing intensity on woodland range, but it was greatest at 150 percent of moderate stocking and lowest at 200 percent of moderate stocking on the improved grassland. Decline in grassland herbage yield under the heaviest grazing treatment was due to reduction of soft chess, which was displaced by subterranean clover. Effects of grazing intensity on composition and productivity were impacted more by annual growing conditions (weather) than by grazing regimens.

Herbage Allowance and Intake

Stocking rate has a major effect on animal performance, but similar stocking rates may result in a wide range in performance across environments because of differences in forage mass or sward characteristics. Herbage, or forage, allowance is a function of both forage mass and stocking rate, and it can be a powerful tool for explaining differences in animal performance (Matches et al. 1981). A definition of herbage allowance is the weight of herbage per unit of animal live weight, but more refined definitions have been developed (Sollenberger et al. 2005). The amount of herbage available for grazing, its digestibility, and the amount of herbage remaining after grazing have been shown to influence animal performance. Higher animal gains can be expected with lower stocking rates than with higher stocking rates, and animal gains decrease as the stocking rate is increased. For example, Reardon (1977) reported that dry matter intake for steers was related to yield of pasture and to daily herbage allowance. Increasing stock density decreases the amount of herbage available per animal. With decreasing available forage, intake decreases. Animal performance usually increases with increasing forage intake. For example, dry matter intake of ryegrass increases with increasing herbage allowance up to about 1,500 to 3,000 kilograms of dry matter per hectare, where intake reaches a plateau (Hodgson 1977; Ellis et al. 1984; Telford 1980). Similar results have been found for winter wheat (Redmon et al. 1995).

Figure 8. Effect of forage standing crop on the relative forage dry matter intake (relative DMI) of lambs, calves, and dairy cows that are grazing pasture under continuous grazing management.



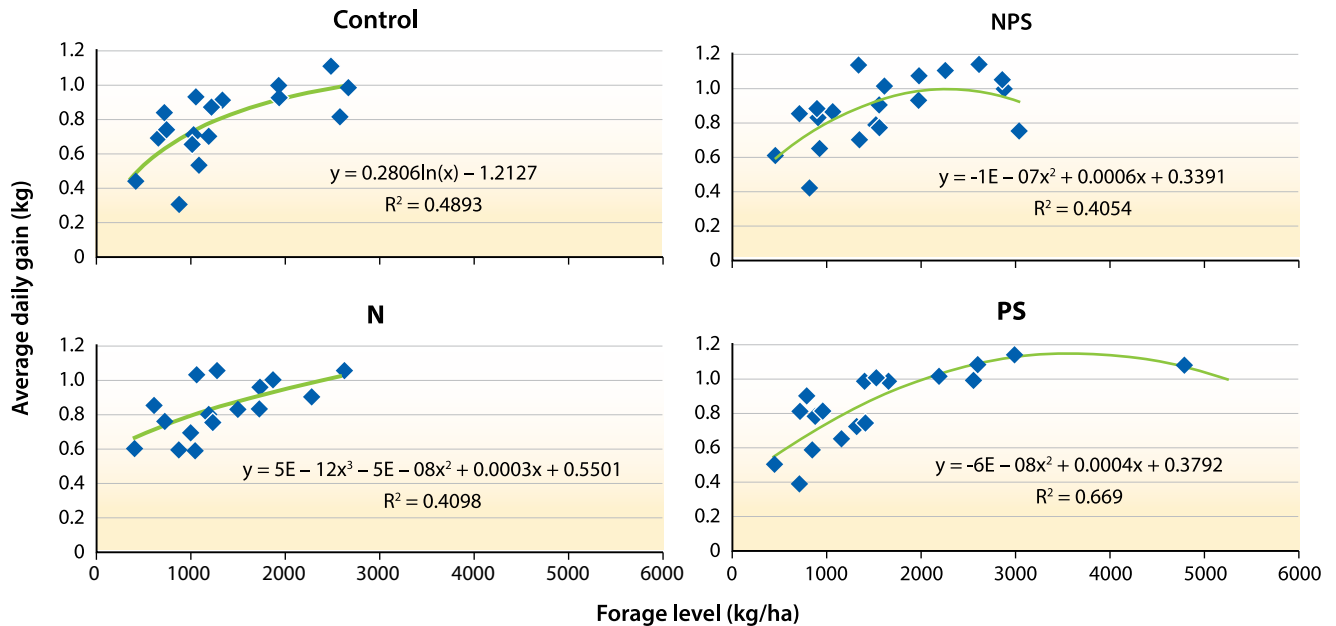


Figure 9. Regression of average daily gain of calves on forage levels in a study of nitrogen (N), nitrogen, phosphorus, and sulfur (NPS), and phosphorus and sulfur (PS) fertilization shows that gain increases with forage level until forage level reaches about 1,250 kilograms per hectare.

Researchers have found that the intake rate initially increases with increasing herbage availability (fig. 8), becoming insensitive to herbage availability beyond a certain level (Willoughby 1959; Arnold and Dudzinski 1967; Arnold 1975; Mulholland et al. 1976). In a study at the UC Sierra Foothill Research and Extension Center (SFREC), researchers estimated forage level and average daily gain for steers during the growing season (February to May). The regression of gain on the forage level

reveals that the rate of gain increases to about 1,250 kilograms of forage per hectare and then tends to level off (Raguse et al. 1988) with further increases in forage level (fig. 9).

Livestock Production

A fundamental trade-off exists between the gain per animal and the gain per unit of area (fig. 10). At very low stocking rates, animals can selectively forage with little competition from each other. This promotes high gain or high body condition of individual animals but does not result in maximum productivity per acre. As the stocking rate increases, competition between animals for forage increases, resulting in a decrease in individual animal performance. At heavy stocking rates, individual animal performance also decreases because lower-quality plants make up a larger portion of the diet, and total intake can be reduced. Between the extremes of light and heavy grazing, there is an optimum stocking rate (see fig. 10) that maximizes productivity per acre (Mott 1960). Bement (1969) developed a stocking rate guide for short grass plains (fig. 11), showing animal gain per acre and animal daily gain in relation to ungrazed herbage remaining at the end of the grazing season and to the

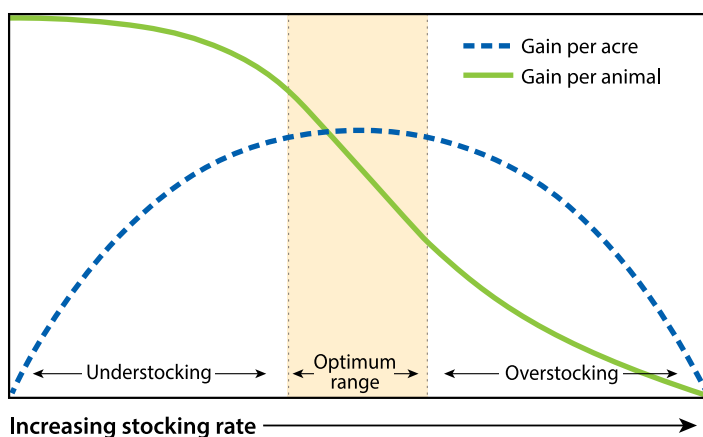


Figure 10. Response of gain per animal and gain per acre to increasing stocking rate.

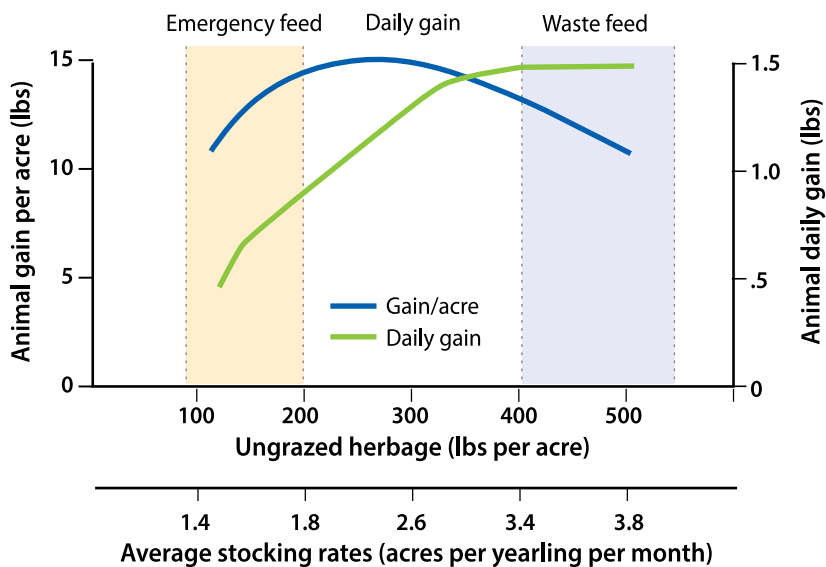


Figure 11. Stocking rate guide for beef production on upland blue grama range in Colorado grazed May through October 31 (Bement 1969).

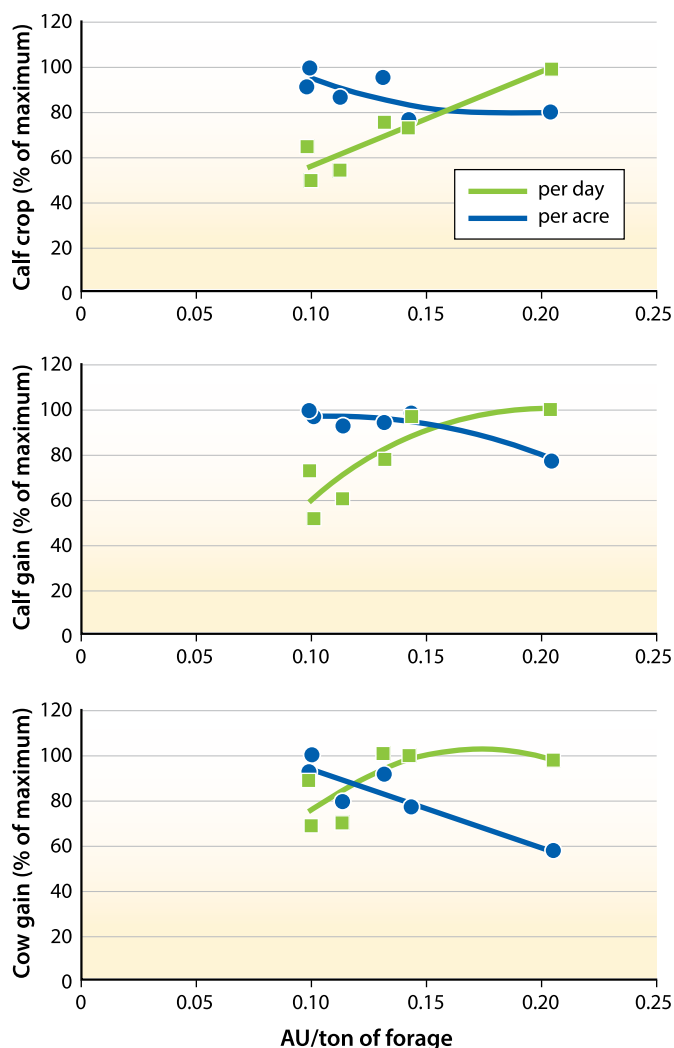


Figure 12. Optimal stocking rates for calf crop, calf gain, and cow gain at the San Joaquin Experimental Range.

approximate stocking rate. In figures 10 and 11, this optimum stocking rate is where the production per head and production per acre curves intersect.

Using production data reported by Wagnon et al. (1959), we plotted calf crop, calf gain, and cow gain against animal units per ton of forage to estimate the optimum stocking rate for annual rangelands at the San Joaquin Experimental Range (SJER). The results of this analysis show that the optimum stocking rate for calf crop and calf gains was at moderate to heavy stocking rates of about 8 acres per animal unit (AU), which is equivalent to a forage allowance of 0.15 to 0.20 animal unit per ton of forage (fig. 12). The optimum stocking rate for cow gain was at lighter stocking rates of about 12 to 16 acres per AU, which is equivalent to a forage allowance of 0.10 to 0.15 animal unit per ton of forage.

In 1944, Gus Hormay published *Moderate Grazing Pays on the California Annual Type*, where he reported studies at the SJER showing that moderate grazing of annual rangelands results in better gains than heavier stocking rates. He also reported that moderate grazing maintains the annual range type in a productive condition.

Summary of High Stocking Rate Effects

- animal performance reduced
- intake and forage quality reduced
- desirable forage plants replaced by less desirable species
- overall forage productivity reduced
- bare soil increased and preferred grazing areas become degraded
- supplemental feed costs increased
- water quality potentially impacted due to increased bacteria, sediment, and nutrient loading

Summary of Low Stocking Rate Effects

- economic potential not fully realized; enterprise sustainability at risk
- mature animals maintain over-fat body condition, which can reduce reproductive capacity
- on perennial-dominated rangelands, patchy

grazing results in development of “wolfy” plants that are used little or not at all. (This reduces overall productivity. It occurs less in annual-dominated rangeland types, but underused patches of less desirable vegetation may occur.)

- some desirable forage species can be crowded out by taller-growing species
- reduced biodiversity of species that thrive under moderate grazing

Increasing Carrying Capacity

Changes in grazing management (season, frequency, duration, and intensity of use) generally will not change carrying capacity. Grazing capacity of some range allotments can be increased by improving livestock distribution with practices such as water development, supplement placement, herding, and fencing (George et al. 2007). Brush and weed control, seeding, and fertilization may also be options for increasing carrying capacity. On irrigated pasture, carrying capacity can also be improved with better fertility management and improved irrigation management.

Season of Grazing

Season of grazing refers to the portion of the year or growing season during which a particular area is grazed. On annual rangeland, grazing can occur throughout the year, but forage quality is poor during the dry season (George, Bartolome, et al. 2001). Historically, livestock producers have grazed annual rangelands during fall, winter, and spring and then moved livestock to public lands for high-elevation grazing from May to October (George, Nader, McDougald, et al. 2001). Irrigated pasture can also be a source of summer forage during this period. Many ranchers, especially those who are distant from high-elevation meadows, graze annual rangelands all year (see the seventh publication in this series, “Livestock Production”).

Frequency and Duration of Grazing

Frequency and duration of grazing have to do with how often a pasture is grazed, how long a pasture is grazed, and how long it is rested between grazing periods. Cross fencing to produce multiple pastures or paddocks

facilitates control of frequency and duration of grazing. Grazing system differences have to do with the frequency and duration of grazing. From yearlong continuous grazing with no manipulation of frequency and duration to the frequent moves associated with intensive rotational grazing, it is frequency and duration that account for the differences in these systems and are the basis for comparing them. Rotation frequencies can vary from seasonal to daily, resulting in a continuum of grazing methods (Holechek et al. 2004). In the following section, we will review grazing systems that apply to annual rangelands.

GRAZING SYSTEMS

Continuous and Seasonal Suitability Grazing

The duration of grazing under continuous grazing is all year or all season in a single pasture. Historically in California and the U.S., most pastures have been continuously grazed throughout the grazing season. While continuous grazing can be practiced if proper stocking rates are followed, preferred species may be more heavily used while less preferred species are lightly used. If a native species is preferred (not always the case), it could be grazed too heavily and frequently, leading to reduced vigor and competitive ability. With most rotational grazing, only one pasture is grazed at a time, while the other pastures rest. Resting grazed pastures allows native and non-native herbaceous vegetation to restore energy reserves, replace leaf area, rebuild vigor, and deepen root systems. Rotational grazing can be practiced in as few as two pastures or in many, sometimes 30 or more.

Continuous grazing and seasonal suitability grazing (Holechek et al. 2004) are commonly used on annual rangelands. These grazing systems are the result of research and adaptive management (trial and error) over several generations. Some have speculated that desirable plants, particularly grasses, will be grazed excessively under continuous grazing. However, research does not support this view when the proper stocking rate is implemented. With continuous grazing, the stocking rate

must be very light during the growing season because adequate forage must be left to carry animals through the dormant season. Under light stocking, animals are allowed maximum dietary selectivity throughout the year. For example, cattle and sheep preferentially select forbs (i.e., broad-leaved plants) during certain times of the year, which can greatly reduce grazing pressure on grasses. Rotation systems that restrict livestock from part of the range during the growing season can waste much of the forb crop because some forb species complete their life cycle quickly and become unpalatable after maturation. So, by the time some of the pastures are grazed in the rotational grazing system, the forbs have dried up and even shattered.

Seasonal suitability grazing (Holechek et al. 2004) describes a system that many ranchers use to manage grazing and forage. It has a flexible rotation schedule that fits the needs of the ranch operation. Often the ranch is subdivided into several pastures that are used in a flexible rotation that takes advantage of available forage, available water, shade, or other characteristics of a pasture. Sometimes the ranch is subdivided into different vegetation types (e.g., fencing meadows from uplands). It may include installation of riparian pastures so that riparian areas can be managed separately. A few ranchers accomplish rotation without internal fences. Instead they have several water troughs, and they rotate by alternately opening and closing (filling and emptying) the troughs, forcing the animals to move for water.

Rotational Grazing

Grazing systems are specialized grazing management practices that facilitate rest periods between grazing periods or deferment for two or more pastures (Heitschmidt and Taylor 1991). The principles of rotational grazing were first described near the end of the 18th century in Scotland (Voisin 1959), but implementation of rotational grazing systems on rangelands is a relatively recent phenomenon. Rangeland grazing has progressed from simple deferred systems (Sampson 1913) to more sophisticated rotational systems (Merrill 1954; Hormay and Evanko 1958; Vallentine 1967; Tainton 1999) and, most recently, to intensive

short-duration systems (Savory 1978, 1983; Savory and Parsons 1980). The goal of these grazing systems was to increase production by ensuring that key plant species captured sufficient resources (e.g., light, water, nutrients) to enhance growth and by enabling livestock to more efficiently harvest available forage. Production objectives for grazing systems include

- improved species composition or productivity by ensuring that key plant species receive a rest period during the growing season
- reduced animal selectivity by increasing stock density (i.e., animals to land area) to overcome small-scale heterogeneity (i.e., patch grazing)
- more uniform animal distribution within large heterogeneous management units by improving water distribution or cross fencing or both

A review (Briske et al. 2008) of studies that compared rotational and continuous grazing systems on rangeland determined that rotational grazing rarely results in increased plant or animal productivity. According to the review, studies showed that plant production was equal or greater in continuous compared with rotational grazing in 87 percent (20 out of 23) of the experiments that were reviewed. Animal production per head was equal or greater in continuous compared with rotational grazing in 92 percent (35 out of 38) of the studies. Animal production per acre was equal or greater in continuous compared with rotational grazing in 84 percent (27 out of 32) of the studies.

Some ranchers and scientists disagree with the findings of Briske et al. (2008), largely because grazing experiments follow fixed experimental protocols that exclude adaptive management decision making (Briske et al. 2011). This does not mean that the controlled experiments are invalid. But it does mean that these experiments do not reflect real conditions, where grazing management is an adaptive process involving goal setting, implementation, and learning from monitoring.

Additionally, ranchers have found that a rotational grazing system may allow for other benefits, such as reduced costs. Animals are

easier to find and round up when they are isolated to one segment of a pasture. Subdivision decreases distance to water and travel distances. Subdivision inherent in rotational grazing systems facilitates improved control over season, intensity, frequency, and duration of grazing. The infrastructure (fences, subdivision, water development, etc.) of rotational grazing and the rigorous planning and attention to detail inherent in intensive grazing systems may provide added value that makes rotational grazing more profitable or easier to manage. Initiating the grazing system may facilitate better management than was present before.

In rebuttal to Briske et al. (2008), Teague et al. (2013) present the case that multiple paddocks provide flexibility that facilitates adaptive management of grazing in heterogeneous and dynamic ecosystems. They postulate that without complete knowledge and with constantly changing conditions, management decision making is an imperfect process that requires continual modification as conditions change or new knowledge is gained. This debate has given rise to renewed attention to rotational grazing experiments and the efficacy of adaptive management for handling the complexity of rangeland resources (Briske et al. 2011; Teague et al. 2013).

Rotational Grazing Studies

There have been numerous annual rangeland studies comparing fertilizer and seeding treatment effects on livestock production (see the ninth publication in this series, “Vegetation Management”) but only a few studies where season, intensity, frequency, or duration of grazing were treatments. Two of these studies (Heady 1961 and Ratliff 1986) were reviewed by Briske et al. (2008). The earliest of these studies, from 1955 to 1960, compared continuous and deferred rotational grazing on two 40-acre pastures grazed by sheep at UC HREC (Heady 1961). The rotationally grazed pasture was divided into three paddocks. Each year, one paddock was grazed early in the growing season, one in the middle of the growing season, and one late in the growing season. There were no differences in herbage production or animal productivity between continuous and

rotational grazing. Differences in production between years were greater than differences due to grazing system.

Ratliff (1986) reported on an 8-year (1961 to 1968) comparison of continuous and seasonal rotational grazing at the SJER in the Sierra Nevada foothills in Madera County, California. Cow and calf weight responses showed continuous grazing of annual rangeland to be most productive for cow-calf production. At weaning, calves under continuous grazing treatments averaged 55 pounds heavier than calves under seasonal grazing treatments. No advantage of one grazing treatment over another was found for mature cow weights.

Seasonal grazing has been studied by several researchers on California’s annual rangelands. In each case, seasonal grazing offered no forage or livestock production advantage over continuous grazing. Heady and Pitt (1979) found that ewe and lamb performance at the University of California’s Hopland Research and Extension Center (UC HREC) was better in one pasture grazed continuously yearlong than in a similar pasture that was divided into three paddocks and grazed in March, April, or May and then continuously the rest of the year. June ground cover and botanical composition in those pastures grazed on a repeated seasonal basis showed the same yearly differences as the pasture grazed continuously. Total standing crop in June also responded similarly to both grazing treatments over the 3-year period.

Bartolome and McClaran (1992) concluded that seasonal grazing at moderate utilization levels offers little potential for changing forage production or composition on unimproved annual grasslands and oak savannas and the differences between years were due to weather and stocking rate, not the seasonal grazing treatments. In this study at UC HREC, the sheep (generally dry ewes) grazed the two study pastures each year during the dormant season (May to October). Stocking rates were adjusted to produce residue levels in October within moderate stocking guidelines for annual grassland and oak woodland (Clawson et al. 1982). In mid-October of each year, the sheep were moved into the fall-winter grazing treatment, where stocking was adjusted to achieve

the 50 percent utilization typical of moderate grazing pressure. On February 15, animals were moved into the adjacent spring treatment pasture, which had not been grazed since October. Seasonal use of pastures was constant over the study period.

In annual rangelands, season or time of grazing can be used to suppress one species while increasing another. Predating the concept of prescribed or targeted grazing, Laude et al. (1957) found that after herbage removal, soft chess (*Bromus hordeaceus*) was found to continue tillering and flowering much longer than foxtail fescue (*Festuca megalura* and now *Vulpia myuros*). They concluded that early grazing could be continued to the growth termination stage of the foxtail fescue, resulting in reduced foxtail fescue seed production while allowing soft chess to tiller and produce abundant seed. When comparing early clipping responses of soft chess and red brome (*Bromus madritensis*), they found increased flowering in the regrowth of soft chess relative to red brome that persisted to mid-April, after which the flowering in both species decreased. They concluded that if grazing continued until the late season decline in flowering, soft chess would be favored over red brome.

Love (1944, 1952) and Love and Williams (1956) reported some of the earliest studies where annual plant competition to seeded native perennials was reduced by targeted grazing. Grazing from April 2 to April 20 has been shown to improve stand establishment of purple needlegrass (*Nassella* or *Stipa pulchra*) and nodding needlegrass (*N.* or *S. cernua*) when compared with deferment of grazing until April 20 and then grazing until May 21. The early grazing treatment plant counts of seeded purple needlegrass were 111 plants but only 23 plants under deferred grazing. Plant counts for nodding needlegrass were 228 with early grazing but only 24 with deferred grazing. Additionally, the plants in the deferred grazing treatments had weak root systems that barely held the crowns in contact with the soil.

In another study reported by Love and Williams (1956), continuous grazing was compared with seasonal rest during the 63-day flush of flowering and seed set by bur clover (*Medicago polymorpha*). They found that

lamb production per acre was greater with continuous grazing than with the rotational grazing that resulted in rest during bur clover flowering and seed set. However, bur harvest from the pasture that was rested during flowering was more than three-fold greater than with continuous grazing.

Grazing Native Perennial Grasses

Grazing effects on native perennial grasses in California's annual-dominated rangelands have received little attention because these grasses were not the dominant or key species for management. Some native perennial grasses increase with protection from grazing (Pacific hairgrass, *Deschampsia holciformis*) and others decrease (California oatgrass, *Danthonia californica*). And some, like purple needlegrass (*Nassella pulchra*), increase when protected from grazing according to some studies and not to others (Jackson and Bartolome 2007). Although intense continuous grazing is one of the disturbances that contributed to the loss of native perennial grasses and their replacement by non-native annual grasses and forbs, little is known about the growth response of these native grasses to intensity, season, frequency, and duration of defoliation. In a review of grazing effects on purple needlegrass, George et al. (2013) concluded that early spring and summer grazing, along with rest during flowering and seed set, are important components of seasonal grazing. Providing for rest following grazing and avoiding prolonged close grazing are also important. Following are some guidelines for managing purple needlegrass:

- First, do no harm! Avoid grazing closely and continuously over many months and years.
- Apply early spring grazing to reduce competition from invasive annuals.
 - On productive soils, use heavy spring grazing to reduce invasive species and follow with rest during flowering and hard summer-fall grazing. This is to reduce litter and produce a harsh microclimate for germination and seedling establishment of annuals the following growing season.
 - On less-productive soils, limit heavy spring grazing to high-production years and follow with rest during flowering

and hard summer-fall grazing. This is to reduce litter and produce a harsh microclimate for germination and seedling establishment of annuals the following growing season.

- Graze during the dry season to create a harsh soil surface microclimate during germination and seedling establishment the following year.
- Rest for at least 4 weeks following spring grazing to allow regrowth and tillering. Rotational grazing can facilitate application of this rest treatment.
- Rest during flowering to allow for seed set before soil moisture is depleted. Depending on the timing of spring grazing, the guideline immediately above could accomplish this objective.
- Avoid close grazing during the growing season. Minimum stubble height of 5 to 10 centimeters will ensure regrowth and tillering. Growing season-long, with close grazing (less than 2.5 cm) for two growing seasons in a row, can result in plant mortality.
- It might be logistically difficult to apply all of these guidelines in a timely manner to all pastures. If rest cannot be applied to all pastures during flowering and seed set annually, then this rest treatment should be rotated annually so that purple needlegrass has a chance to flower and set seed in each pasture every few years.
- Rotational grazing can facilitate application of most of these practices. Rotational grazing that (1) provides for at least 4 weeks of rest following grazing during the growing season, (2) avoids grazing the same pasture during flowering each year, (3) avoids grazing below a stubble height of 5 centimeters during the growing season, and (4) removes standing litter during the dry season should maintain the vigor and competitive ability of purple needlegrass.

Although these guidelines should be generally applicable to most sites, intra- and interannual weather differences and site differences will influence tillering and regrowth. Consequently, grazing management must be an adaptive process that responds to prevailing

conditions by adjusting the season, intensity, and frequency of grazing to prevailing regrowth conditions. If it is a dry year or the site has a low production potential, then intensity and frequency of grazing should be reduced. Likewise, if the potential for regrowth is higher, then purple needlegrass might tolerate more frequent and intense grazing.

TARGETED GRAZING

Targeted grazing is the application of a specific kind of livestock at a determined season, duration, frequency, and intensity to accomplish defined vegetation or landscape goals. While many of the practices and objectives of targeted grazing have been around for many years, the focus on grazing as a vegetation management tool is timely and holds great promise for manipulating the quantity and quality of ecosystem services provided by grazed plant communities. For example, Derner et al. (2009) have reported that grazing can be applied to engineer grassland bird habitat in the western Great Plains.

There are several examples where grazing has proven useful for manipulating plant species composition. Strategic application of increased stock density has been used to reduce weed populations (Launchbaugh and Walker 2006; DiTomaso et al. 2008) such as medusahead, goatgrass and yellow starthistle (see the ninth publication in this series, “Vegetation Management”). Grazing has been used to reduce standing crop that competes with native forbs (Hayes and Holl 2003; Kimball and Schiffman 2003) and habitat of threatened or endangered species (Weiss 1999; Marty 2005). Barry et al. (2011) recently assembled these and other examples where grazing can be managed to reduce weeds, reduce fire hazard, change species composition, and provide habitat for several wildlife species. Finding additional applications of targeted grazing to manipulate ecosystem services will be a fruitful area of continuing research.

LIVESTOCK DISTRIBUTION

Reducing livestock impacts on water quality, aquatic and riparian habitat, and biodiversity

are continuing goals for livestock producers, natural resource managers, and conservation groups. While reducing heavy stocking rates may help protect water quality and riparian areas, reducing residence time in streams and associated riparian areas using traditional livestock distribution practices (George et al. 2007) is often more effective. While fences are usually an effective tool for controlling livestock distribution and reducing impacts on riparian zones or other critical areas, manipulation of grazing patterns can also effectively reduce adverse impacts from livestock. Studies have shown that riparian health is related to time invested in management by the landowner/manager (Ehrhart and Hansen 1997; Ward et al. 2003; George et al. 2011).

While basic livestock distribution practices have changed little in the last 50 years, new research suggests ways to fine-tune and combine these practices that will improve their effectiveness. The practices are based on basic and applied research in animal behavior and landscape ecology, and they involve changes in pasture management or changes in livestock management. George et al. (2007, 2011) have reviewed practices that attract livestock to underused areas and away from riparian habitats. George et al. (2011) concluded that stocking rate reductions were not the universal solution to riparian grazing impacts. Instead, they found that the key to reducing livestock density in the riparian zone is to implement distribution practices (e.g., drinking water developments, herding, and strategic placement of supplement feeds) that attract livestock away from critical areas and reduce grazing use and the time spent grazing in a riparian area.

MANAGEMENT SUMMARY

- Seasonal grazing has been studied by several researchers on California's annual rangelands. In each of these controlled studies, seasonal grazing offered no forage or livestock production advantage over continuous grazing.
- In annual rangelands, season or time of grazing may be used to suppress one species while increasing another.
- Plant production and animal production per

head increases with decreasing stocking rate (grazing intensity).

- Herbage allowance is a more precise predictor of animal performance than stocking rate but can be difficult to apply on pastures that are heterogeneous.
- Animal production per land area first increases with increasing stocking rate and then decreases. Peak production per acre is at or near the optimal stocking rate.
- Over the long run, moderate stocking rates balance production per animal and production per acre at or near the economic optimum.
- Residual dry matter in the fall provides an indicator of grazing intensity that should influence the decision to change stocking rate.
- In controlled studies on annual rangelands and rangelands in general, plant and animal productivity are not improved by rotational grazing systems when compared with continuous grazing. However, many ranchers have found that rotational grazing and the accompanying planning are beneficial economically and often facilitate attainment of other ranch objectives.
- While rotational grazing does not improve productivity, it may facilitate control of season, frequency, duration, or intensity of grazing, which meets other ecosystem management goals.
- Targeted grazing prescriptions can be applied to manage rangeland weeds, reduce competition with desirable vegetation, and help reduce fuel loads associated with wildland fires.
- Livestock distribution practices can effectively reduce the impact of grazing livestock on riparian areas and other critical areas.

GLOSSARY

Following are definitions of some terms, extracted from the Society for Range Management's longer glossary (SRM 1998). This is now available online at the Global Rangelands website (<https://globalrangelands.org>), and it is regularly updated.

allowable use: (1) The degree of utilization considered desirable and attainable on various parts of a ranch or allotment, considering the present nature and condition of the resource, management objectives, and levels of management. (2) The amount of forage planned to be used to accelerate range improvement.

animal unit (AU): Considered to be one mature cow of approximately 1,000 pounds, either dry or with calf up to 6 months of age, or their equivalent, based on a standardized amount of forage consumed.

animal unit month (AUM): The amount of dry forage required by one animal unit for 1 month, based on a forage allowance of 26 pounds per day. The term AUM is commonly used in three ways: (a) stocking rate, as in “X acres per AUM”; (b) forage allocations, as in “X AUMs in Allotment A”; and (c) utilization, as in “X AUMs taken from Unit B.”

available forage: That portion of the forage production that is accessible for use by a specified kind or class of grazing animal.

carrying capacity: The average number of livestock or wildlife that may be sustained on a management unit compatible with management objectives for the unit. In addition to site characteristics, it is a function of management goals and management intensity. The amount of forage produced annually in a management unit is only one attribute used to determine carrying capacity. The forage also has to be available to the animals. On many rangelands, the carrying capacity may be less than forage production would indicate because parts of the management unit are inaccessible to grazing animals. In essence, forage is present but unavailable.

continuous grazing: The grazing of a specific unit by livestock throughout a year or for that part of the year during which grazing is feasible. The term is not necessarily synonymous with *yearlong grazing*, since seasonal grazing may be involved.

deferment: Delay of livestock grazing on an area for an adequate period of time to provide for plant reproduction, establishment

of new plants, or restoration of vigor of existing plants.

deferred grazing: The use of deferment in grazing management of a management unit, but not in a systematic rotation including other units.

deferred rotation: Any grazing system that provides for a systematic rotation of the deferment among pastures.

forage allocation: The planning process or act of apportioning available forage among various kinds of animals (e.g., elk and cattle).

grazing distribution: Dispersion of livestock grazing within a management unit or area.

grazing management plan: A program of action designed to secure the best practicable use of the forage resources with grazing or browsing animals.

grazing period: The length of time that animals are allowed to graze on a specific area.

grazing pressure: An animal-to-forage relationship measured in terms of animal units per unit weight of forage at any instant.

grazing season: (1) On public lands, an established period for which grazing permits are issued. May be established on private land in a *grazing management plan*. (2) The time interval when animals are allowed to utilize a certain area.

grazing system: A specialization of grazing management that defines the periods of grazing and nongrazing. Descriptive common names may be used; however, the first usage of a grazing system name in a publication should be followed by a description using a standard format. This format should consist of at least the following: the number of pastures (or units), number of herds, length of grazing periods, length of nongrazing periods for any given unit in the system, followed by an abbreviation of the unit of time used. *See deferred grazing, deferred rotation, and short-duration grazing.*

heavy grazing: A comparative term indicating that the stocking rate of a pasture is relatively greater than that of other pastures. Often erroneously used to mean overuse.

- herbage allowance:** Weight of forage available per unit animal on the land at any instant.
- holistic resource management (HRM):** A goal-oriented approach to the management of the ecosystem, including the human, financial, and biological resources on farms, ranches, public and tribal lands, as well as national parks, vital water catchments, and other areas. HRM entails the use of a management model that incorporates a holistic view of land, people, and dollars.
- light grazing:** A comparative term indicating that the stocking rate of one pasture is relatively less than that of other pastures. Often erroneously used to mean underuse.
- moderate grazing:** A comparative term which indicates that the stocking rate of a pasture is between the rates of other pastures. Often erroneously used to mean *proper use*.
- overgrazing:** Continued heavy grazing that exceeds the recovery capacity of the community and creates a deteriorated range.
- overstocking:** Placing a number of animals on a given area that will result in overuse if continued to the end of the planned grazing period.
- overuse:** Utilizing an excessive amount of the current year's growth, which, if continued, will result in range deterioration.
- proper use:** A degree of utilization of the current year's growth, which, if continued, will achieve management objectives and maintain or improve the long-term productivity of the site. Proper use varies with time and systems of grazing.
- range readiness:** The defined stage of plant growth at which grazing may begin under a specific management plan without permanent damage to vegetation or soil. Usually applied to seasonal range.
- rest:** Leaving an area ungrazed, thereby foregoing grazing of one forage crop. Normally *rest* implies absence of grazing for a full growing season or during a critical portion of plant development (e.g., seed production).
- rest period:** A time period of no grazing included as part of a *grazing system*.
- rest rotation:** A grazing management scheme in which rest periods for individual pastures, paddocks, or grazing units, generally for the full growing season, are incorporated into a grazing rotation.
- rotational grazing:** A grazing scheme where animals are moved from one grazing unit (paddock) in the same group of grazing units to another, without regard to specific graze/rest periods or levels of plant defoliation.
- sacrifice area:** A portion of the range, irrespective of site, that is unavoidably overgrazed to obtain efficient overall use of the management area.
- seasonal grazing:** Grazing restricted to a specific season.
- short-duration grazing:** Grazing management whereby relatively short periods (days) of grazing and associated nongrazing are applied to range or pasture units. Periods of grazing and nongrazing are based on plant growth characteristics. Short-duration grazing has nothing to do with intensity of grazing use.
- stocking density:** The relationship between number of animals and area of land at any instant of time. It may be expressed as animal units per acre, animal units per section, or animal units per hectare (AU/ha).
- stocking rate:** The number of specific kinds and classes of animals grazing or utilizing a unit of land for a specified time period. May be expressed as animal unit months or animal unit days per acre, hectare, or section, or the reciprocal (area of land/animal unit month or day). When dual use is practiced (e.g., cattle and sheep), stocking rate is often expressed as animal unit months/unit of land or the reciprocal.
- use/utilization:** (1) The proportion of the current year's forage production that is consumed or destroyed by grazing animals. May refer either to a single species or to the vegetation as a whole.
- yearlong grazing:** Continuous grazing for a calendar year.

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