Chapter 8 Grazing Management

Melvin R George, William Frost and Neil McDougald

Introduction

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 chapter is to provide agency and NGO personnel and private land owners 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 and evaluate 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 chapter 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 "trial and error." Adaptive management is a way for managers to do their jobs in the face of uncertainty and learn by doing. There are many descriptions of adaptive management and most describe a cyclic process that includes the following steps: problem assessment, design, implementation, monitoring, evaluation and adjustment (Bush 2006, Reever Morghan 2006, Boyd and Svejcar 2009). Grazing management is an adaptive process that begins with 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

There is no single outline for a grazing plan 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 increase canopy cover in the riparian area from 40 percent to 70 percent or increase the abundance or cover of desired species are measurable objectives. Meeting the residual dry matter (RDM) guideline set for the site is a measurable objective. What to monitor should be obvious from the statement of measurable objectives.

Site Description and Resource Inventory

Describing the site and resources can be brief or quite long. The resource inventory may include legal descriptions, 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 photos 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

In this section of the plan stocking rate, kind and class of animal, grazing units or pastures, animal distribution practices, and existing and needed infrastructure (fences, etc.) should be described. 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 NRCS (Briske 2011a).

Monitoring and Evaluation

Monitoring and evaluation provides 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 measureable 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 https://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 most important of the four. It is a fundamental variable determining the sustainability and profitability of rangelands (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 (Appendix A, SRM 1998). 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/area of land. **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 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 which exceeds the recovery capacity of the community and creates a deteriorated range.

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 year (Figure 8.1). Sierra foothill and coast range oak-woodland carrying capacity is commonly in the range of 10 to 30 acres per animal unit per year (Figure 8.2).

Figure 8.1. Annual grassland carrying capacity often is in the range of 6 to 12 acres per animal unit per year.

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 (Figure 8.3). Therefore stocking rate must be adjusted

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 regraze forage regrowth before it has a chance to recover. While correct, this definition focuses on individual plants while many definitions also focus on pastures or entire plant communities or pastures. For example, according to the “Father of Range Management,” range and pasture vegetation, if given adequate time in which to recuperate, is able to recover from the effects of a season’s overgrazing. If however, overgrazing is persisted in 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 which exceeds the recovery capacity of the community and creates a deteriorated range. An overgrazed range is a range which 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.

Figure 8.2. Sierra foothill and coast range oak-woodland carrying capacity is commonly in the range of 10 to 30 acres per animal unit per year.

annually in response to these conditions. In a dry year that 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.

Often carrying capacity is estimated from average annual forage production which is available from ecological site descriptions (formerly range site descriptions) for USDA NRCS

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 1000 lbs 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 1000 lbs then they are still 1 animal unit. More likely the cow weighs 1200 lbs and her calf grows to 400 or 500 lbs 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 1000 lb 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 a cow will eat in one month. Table 8.1 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.

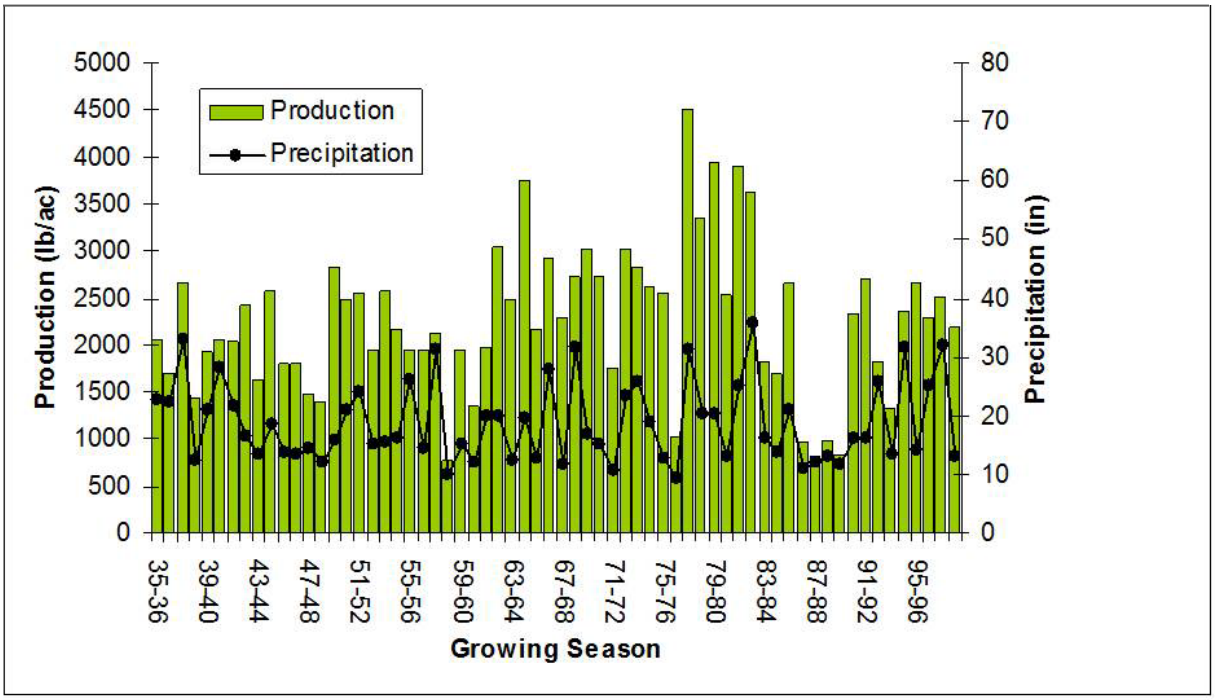


Figure 8.3. Annual range forage production and precipitation for San Joaquin Experimental Range in Madera County from 1935-36 to 1998-99 illustrates the potential variation in productivity. Annual rainfall has varied from about 9 inches to nearly 40 inches and annual production has ranged from just under 1000 lb/a to more 4000 lbs/a. The average is about 2000 lbs/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 risk of running out of forage during dry years.

Table 8.1. Animal Unit Equivalents for domestic and wild herbivores.

Cattle	**Animal Unit**	**Goats**	**Animal Unit**
Mature cows without a calf	1	6 weaned kids to yearlings	0.6
Cow with a calf	1.2	6 does with or without kids	1
Weaned calf to yearling	0.6	6 mature bucks	1.3
Steers and heifers (1-2 years)	1	**Horses and Mules**	
Mature bulls	1.3	Mature horse (1200 lbs)	1 to 1.25
Sheep		Mature mule	1 to 1.25
5 weaned lambs to yearlings	0.6	**Wildlife**	
5 ewes with or without lambs	1	6 deer	1
5 mature rams	1.3	Antelope, mature	0.2
		Bison, mature	1

(http://www.nrcs.usda.gov/wps/portal/nrcs/main/ national/ technical/ecoscience/desc/), or from the Web Soil Survey http://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm. To calculate carrying capacity you need to determine the ***total available forage*** in the pasture (See Appendix A, Estimating Carrying Capacity). Early range managers followed ***the "take half, leave half"*** approach to determining total available forage. The ***allowable use*** (sometimes called proper use) approach was instituted because taking 50 percent of the forage was too much or too little in some cases. The allowable use approach is a percentage of the total forage produced that can be removed by grazing. That percentage may range from 30 to 60 percent depending on the vegetation type and on the objectives of private or public range managers (Table 8.2). In California we often use the more conservative ***residual dry matter (RDM)*** approach to estimate total available forage. In this method RDM is subtracted from total annual production and the remainder is then multiplied by a utilization factor.

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 8.3 and 8.4. 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 effect forage production and therefore carrying capacity. In the oak-woodlands canopy cover and slope are important factors affecting carrying capacity.

McDougald et al. (1991) have developed a score card procedure for estimating carrying capacity that adjusts for canopy cover and

Table 8.2. Allowable or proper use factors for U.S. rangeland vegetation types.

Suggested proper use factor (%)	Ecosystem or Type
30 to 40	Northern desert shrublands
30 to 40	Semidesert grass and shrublands
30 to 40	Sagebrush - grasslands
30 to 40	Palouse prairie
30 to 40	Oak-Woodland
30 to 40	Chaparral
40 - 50	Short grass prairie
40 - 50	Northern mixed prairie
40 - 50	Southern mixed prairie
45 - 60	Tall grass Prairie
45 - 60	Southern pine forest
45 - 60	Eastern deciduous forest
50 - 60	California annual grassland

slope within three rainfall zones (Table 8.6). The scorecard method of estimating carrying capacity is based on: (1) the productivity of

Table 8.3. 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 8.4. Approximate reductions in carrying capacity as distance from water increases.

Distance from Water (mi)	Reduction in Grazing capacity (%)
0-1	0
1-2	50
>2	100

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 (Table 8.5) which the experienced range manager can use to estimate grazing capacity on annual rangeland along with actual livestock grazing use history. 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 rate the values used in the calculations for daily or monthly intake or consumption rates, allowable use rates, 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 potential differences support that these calculations are just estimates that 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 under stocked.

To fine tune stocking rate, grazing managers assess stocking rate throughout the grazing season, at the end of grazing season and over multiple years. Grazing managers regularly assess forage levels and animal body condition (see Livestock Production Chapter) 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 stocking rate.

Stocking rate should not exceed carrying capacity which is based on long-term average production. To determine if annual stocking rate is at or below carrying capacity grazing managers estimate RDM at the end of the grazing season. If end of the grazing season (fall) RDM levels exceed the target RDM level for moderate grazing each year or for most years then stocking rate may be increased. If RDM levels are consistently low each fall then stocking rate should be reduced. If desired forage species are declining in vigor or decreasing in number

Table 8.5. Estimated carrying capacity scorecards for three rainfall zones.

Southern California Zone (less than 10" precipitation)

	Slope Class			
Canopy Cover(%)	**<10%**	**10-25%**	**25-40%**	**>40%**
	AUM/acre			
0 - 25	0.7	0.4	0.3	0.1
25 - 50	0.4	0.3	0.2	0.1
50 - 75	0.2	0.1	0	0
75 - 100	0.1	0	0	0
	RDM lb/acre			
	200	250	300	350

Central Coast and Central Valley Foothills Zone (10" to 40 " precipitation)

	Slope Class			
Canopy Cover(%)	**<10%**	**10-25%**	**25-40%**	**>40%**
	AUM/acre			
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/acre			
	400	600	800	800

Northern California Zone (greater than 40" precipitation)

	Slope Class			
Canopy Cover(%)	**<10%**	**10-25%**	**25-40%**	**>40%**
	AUM/acre			
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/acre			
	750	1000	1250	1250

over multiple years, stocking rate may be too high. Increasing amounts of bare ground or prevalence of soil disturbances could also be an indication of over stocking.

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 et al. 2001a and 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 UC Leaflet No. 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 (Figure 8.4). Light grazing results in a less patchy appearance than moderately grazed areas 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 two to three 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 botanical composition of vegetation is influenced by intensity of grazing and by 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 Walker 2006, DiTomaso et al. 2008) but 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,

Figure 8.4. Appearance of light, moderate and heavy grazing at the San Joaquin Experimental Range in Madera County, California.

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 caryophyllea*), 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, Rosseire (1987) evaluated the influence of grazing intensity on species composition and herbage production of oak-woodland and improved grassland at UC HREC over a 5-year period using 3 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 (*F. 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 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 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 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 stocking rate is increased. For example

Reardon (1977) reported that dry mater 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 1500 to 3000 kg DM/ha where intake reaches a plateau (Hodgson 1977, Ellis et al. 1984, and Telford 1980). Similar results have been found for winter wheat (Redmon et al. 1995).

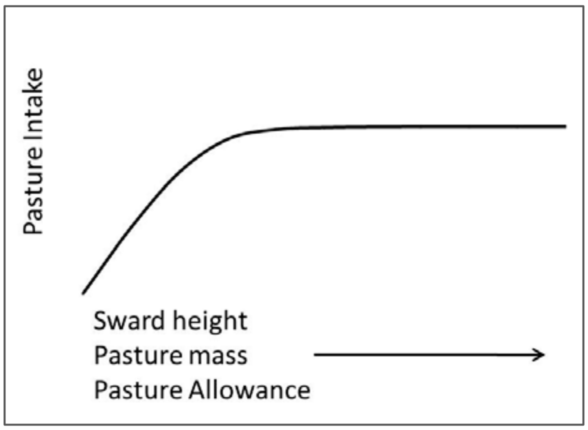
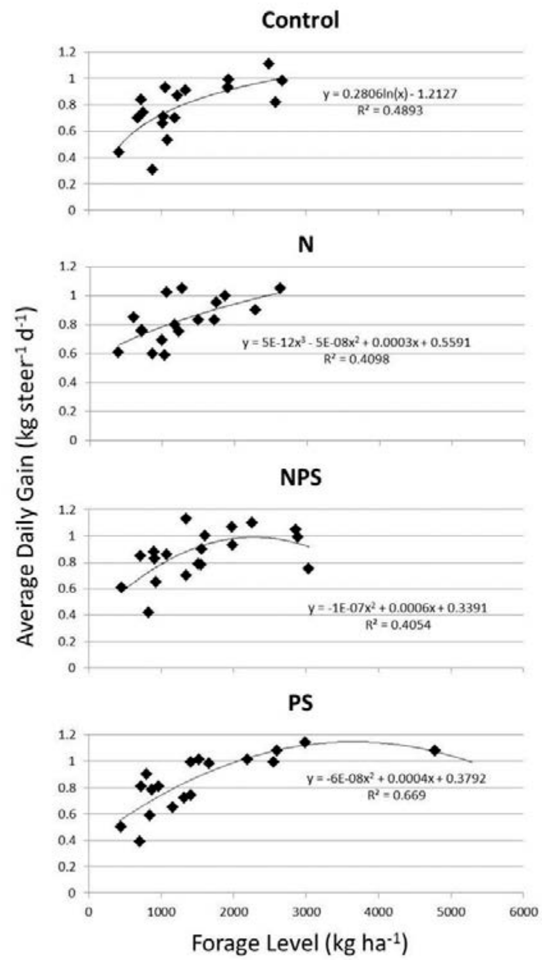


Figure 8.5. Effect of forage standing crop on the relative forage dry matter intake (relative DMI) of lambs, calves and dairy cows grazing pasture under continuous grazing management.

Researchers have found that intake rate initially increases with increasing herbage availability (Figure 8.5), becoming insensitive to herbage availability beyond a certain level (Willoughby 1959, Arnold & Dudzinski 1967, Arnold 1975, Mulholland et al. 1976). In a study at UC SFREC researchers estimated forage level and average daily gain for steers during the growing season (February – May). Regression of gain on forage level reveals that rate of gain increases to about 1250 kg of forage per ha and then tends to level off (Raguse et al. 1988) with further increases in forage level (Figure 8.6)

Figure 8.6. Regression of average daily gain



on forage levels shows that gain increases with forage level until forage level reaches about 1250 kg ha^{-1}.

Livestock Production

There is a fundamental trade-off between gain per animal and gain per unit of area (Figure 8.7). 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

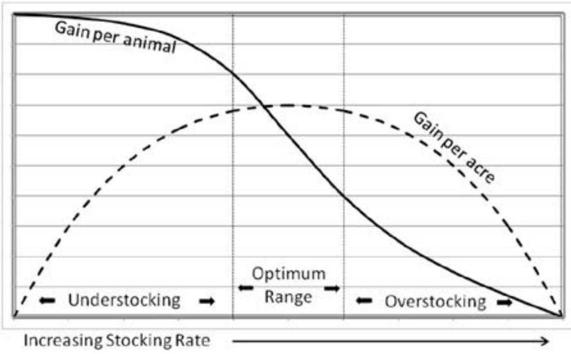


Figure 8.7. Response of gain per animal and gain per acres to increasing stocking rate.

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 that maximizes productivity per acre (Mott 1060). Bement et al.(1969) developed a stocking-rate guide for short grass plains (Figure 8.8) showing animal gain per acre and animal daily gain in relation to ungrazed herbage remaining at the end of the grazing season and approximate stocking rate. In Figures 8.7 and 8.8 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, Table 3 – pg. 27) 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 AU which is equivalent to a forage allowance of 0.15 to .2 AU/ton of forage (Figure 8.9).

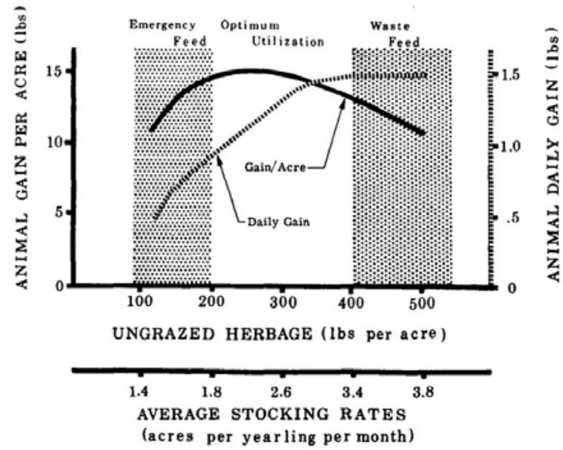


Figure 8.8. Stocking rate guide for beef production on upland blue grama range in Colorado grazed May through October 31 (Bement 1969).

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 0.1 and 0.15 AU/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 reports 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.
- Increase in bare soil and preferred grazing areas become degraded.
- Increased supplemental feed costs.
- Potential for water quality impacts due to increased bacteria, sediment, and nutrient loading.

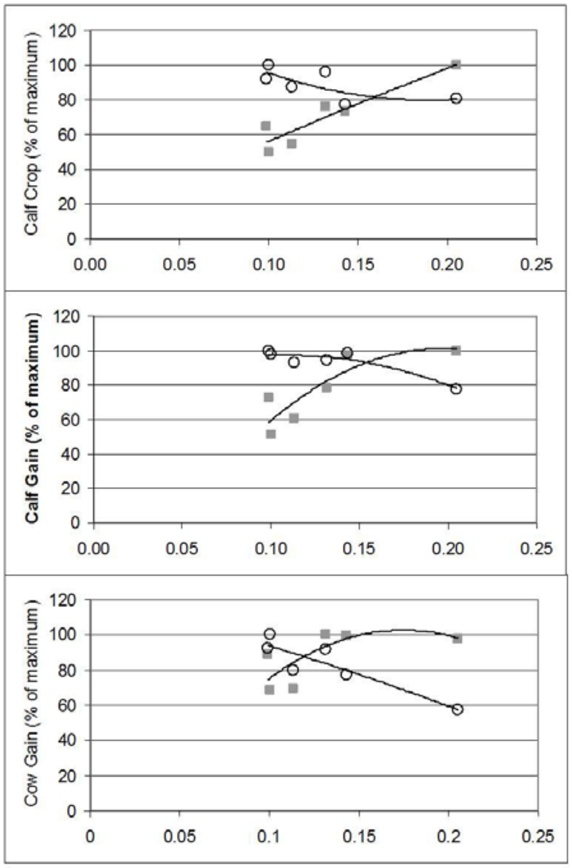


Figure 8.9. Optimum stocking rates for calf crop, calf gain and cow gain at the San Joaquin Experimental Range.

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. This occurs less in annual dominated rangeland types but under used 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 such practices 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 et al. 2001b). 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 et al. 2001c). Irrigated pasture can also be a source of summer forage during this period. Many ranchers, especially those that are distant from high elevation meadows, graze annual rangelands all year (see the Livestock Production Chapter).

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 facilitate 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 2004). In the following section we will review grazing systems that apply to the 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 are 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 allow native and non-native herbaceous vegetation to restore energy reserves, replace leaf area, rebuild vigor, and deepen their 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 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 proper stocking rate is implemented. With continuous grazing, 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 the forbs have dried up and even shattered by the time some of the pastures are grazed in the rotational grazing system.

Seasonal suitability grazing (Holechek 2004) is a system that describes how many ranchers 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 such as 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 et al. 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 1) improved species composition or productivity by ensuring key plant species a rest period during the growing season, 2) reduced animal selectivity by increasing stock density (i.e., animals/land area) to overcome small scale heterogeneity (i.e., patch grazing), and 3) ensure more uniform animal distribution within large heterogeneous management units by improving water distribution and/or cross-fencing.

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 when compared to continuous grazing. During this review it was learned that plant production was equal or greater in continuous compared to rotational grazing in 87 percent (20 of 23) of the experiments that were reviewed. Animal production per head was equal or greater in continuous compared to rotational grazing in 92 percent (35 of 38) of studies. Animal production per acre was equal or greater in continuous compared to rotational grazing in 84 percent (27 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. 2011b). 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 processing 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 gazing 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. Initiation of the grazing system may be facilitating better management than was present before.
In rebuttal to Briske et al. (2008), Teague et al. (2013) presents 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 managing 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 Vegetation Management Chapter) 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 (1961-1968) 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 lbs (25 kg) 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 year-long 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 McClaren (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 those differences between years were due to weather and stocking rate, not the seasonal grazing treatments. In this study at UC HREC sheep, generally dry ewes, grazed the 2 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. Pre-dating 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*). He 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 that soft chess would be favored over red brome.

One of the earliest studies where annual plant competition to seeded native perennials was reduced by targeted grazing was reported by Love (1944, 1952) and by Love and Williams (1956). 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 to 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 to 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 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 they were not the dominant or key species for management. Some native perennial grasses increase (Pacific hairgrass, *Deschampsia holciformis*) with protection from grazing and others decrease (California oatgrass, *Danthonia californica*) and some, like purple needlegrass (*Nassella pulchra*) increase when protected from grazing in some studies and not in 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 nonnative 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 and 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 for purple needlegrass:

1) First, do no harm! Avoid grazing closely and continuously over many months and years.
2) Apply early spring grazing to reduce competition from invasive annuals.
    a) On productive soils, use heavy spring grazing to reduce invasive species and follow with rest during flowering and hard summer–fall grazing to reduce litter and produce a harsh microclimate for germination and seedling establishment of annuals the following growing season.
    b) On less-productive soils, limit heavy spring grazing to high-production years and follow with rest during flowering and hard summer–fall grazing to reduce litter and produce a harsh microclimate for germination and seedling establishment of annuals the following growing season.
3) Graze during the dry season to create a harsh soil surface microclimate during germination and seedling establishment the following year.
4) Rest for at least 4 weeks following spring grazing to allow regrowth and tillering. Rotational grazing can facilitate application of this rest treatment.
5) Rest during flowering to allow for seed set before soil moisture is depleted. Depending on the timing of spring grazing, Guideline 4 could accomplish this objective.
6) Avoid close grazing during the growing season. Minimum stubble height of 5–10 cm (2–4 inches) 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.
7) 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.
8) 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 cm 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 inter-annual 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 Vegetation Management chapter). 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. (2006) 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 land owner/manager (Ehrhart and Hansen 1997, Ward 2002, 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 involve changes in pasture management or changes in livestock management. Bailey (2004, 2005) and 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 optimum 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 to continuous grazing. However, many ranchers have found that rotational grazing and the accompanying planning to be 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 that meets other ecosystem management goals.
- Targeted grazing prescriptions can be applied to manage rangeland weeds and to reduce competition to 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.

Appendix A. 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 (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 U.S. Method 3 is the residual dry matter method often used on California's annual rangelands.

Calculating Total Available Forage

Method 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 50 % (take half, leave half). To convert available forage in lb/a to AUMs you divide by 800 lb/a. Some agencies use 1000 lb/a (Figure 8.10).

Figure 8.10. Calculation of carrying capacity using the "take half, leave half " method.

Method 2: Allowable Use Method

Now let's calculate total available forage using the allowable use method that 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 (lbs/a) by the allowable use factor which can be found in most range management texts, or your work location may recommend a factor to use. Table 8.2 lists allowable or proper use factors for several rangeland vegetation types. Just as in Method 1 you can convert available forage in lb/a to AUMs you divide by 800 lb/a (Figure 8.11).

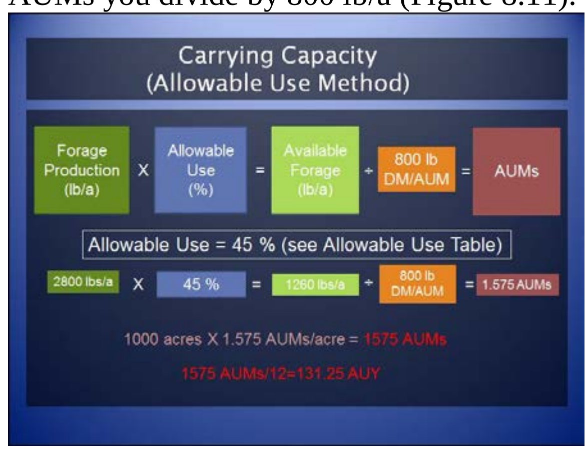


Figure 8.11. Calculation of carrying capacity using the allowable use or proper use method.

Method 3: Residual Dry Matter Method

On California's annual grasslands and oak-woodlands stocking rate is calculated by another method that insures that 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 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 (Figure 8.12).

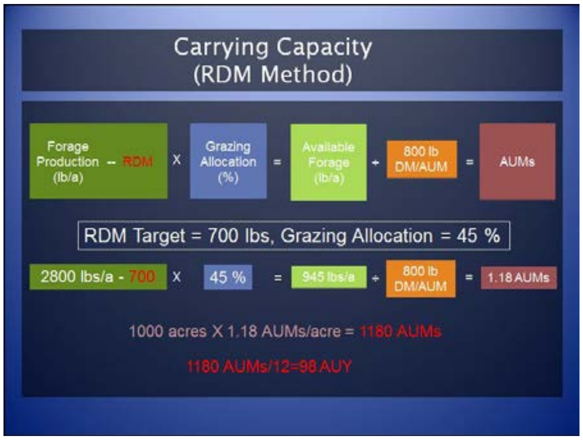


Figure 8.12. Calculation of carrying capacity using the RDM Method.

The RDM target is determined from Table 8.6 or from UC Leaflet No. 8092 entitled "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. Harvest efficiency or grazing allocation is a term that has been used for the forage that is available for grazing by cows or other livestock. Too maintain a conservative stocking rate the grazing allocation or harvest efficiency should be 50 %. Just as in the previous two methods you convert available forage in lb/a to AUMs by dividing by 800 lb/a (Figure 8.12).

Table 8.6a. Minimum residual dry matter (RDM) guidelines for dry annual grassland.

Woody Cover	**Slope (%)**			
	0 -10	10-20	20 - 40	> 40
	RDM (lb/a)			
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 8.6b. Minimum residual dry matter (RDM) guidelines for annual grassland/hardwood range.

Woody Cover	**Slope (%)**			
	0 -10	10-20	20 - 40	> 40
	RDM (lb/a)			
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 8.6c. Minimum residual dry matter (RDM) guidelines for coastal prairie.

Woody Cover	**Slope (%)**			
	0 -10	10-20	20 - 40	> 40
	RDM (lb/a)			
0-25	1200	1500	1800	2100
25-50	800	1000	1200	1400
50–75	400	500	600	700
75–100	200	250	300	350

Appendix B. Terminology

Following are definitions of some terms extracted from the Society for Range Management 's longer glossary (SRM 1989) which is now available online and is regularly updated (https://globalrangelands.org/rangelandswest/glossary).

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 one 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"; (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 and/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 which 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, heavy. A comparative term which indicates that the stocking rate of a pasture is relatively greater than that of other pastures. Often erroneously used to mean overuse.

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* which defines the periods of grazing and non-grazing. 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 non-grazing periods for any given unit in the system followed by an abbreviation of the unit of time used. *See deferred grazing, deferred-rotation, rotation, restoration, and short duration grazing*.

Heavy grazing. A comparative term which indicates 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. Holistic Resource Management (HRM) is 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 which incorporates a holistic view of land, people, and dollars.

Light grazing. A comparative term which indicates 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 which 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 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, i.e., seed production.

Rest period. A time period of no grazing included as port 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 in to 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 non-grazing are applied to range or pasture units. Periods of grazing and nongrazing are based upon 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 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 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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