GRAZING SYSTEMS AND MANAGEMENT OF MEDITERRANEAN-TYPE PLANT COMMUNITIES

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Résumé

Depuis l'introduction de betail en Californie, il y a 220 ans la pratique du pâturage est devenue plus intensive. Au debut, l'elevage du betail ressemblait à la chasse au gibier et ses produits principaux etaient le cuir et le suif. Avec la croissance de la population, les produits de l'elevage sout derenus plus importants, en tant que source de nourriture et l'elevage est devenu une operation lucrative. Avec le developement de l'agriculture intensive daus la San Joaquin Valley, l'elevage s'est deplacé vers les collines du piemont de la Sierra Nevada et vers la Californie du nord et les clôtures sont apparves sur les etendues de paturage. Depuis les années 50, l'agriculture et l'urbanisation ont encore déplacé l'elevage. Aujourd'hui les pratiques de l'elevage se modifient en répouse aux interêts de l'environnement et pour reduire les coûts de production et accrôitre la production.

Summary

In the 220 years since the first livestock were brought to California grazing practices have become more intensive. In the beginning livestock production was little more than a "wildlife hunting operation" whose main products were hides and tallow. As population growth increased, livestock products became more important as a food source and livestock raising became a lucrative enterprise. As intensive agriculture developed in the San Joaquin Valley livestock raising was displaced to the foothills and northern California and fencing displaced the open range. Since the 1950s livestock raising has been further displaced by agriculture and urbanization. Today, livestock grazing practices are changing in response to environmental concerns and to reduce costs and increase production.

Introduction

California's Mediterranean rangelands (annual grasslands, oak-woodlands, and chaparral) constitute 26 million acres or about 25 percent of California's land surface area. These rangelands have played a central role in the development, history and legend of California. They have also, in the short span of 220 years, been irreversibly changed from a native perennial grassland to a non-native annual grassland. Cattle and sheep grazing was an important contributor to this change as well as the economic development of California.

Range Management History

California, long considered the "Land of Promise", was discovered, explored, and described by sea and land beginning in the mid-sixteenth century. The Cabrillo-Ferrelo

sea expedition of 1542-1543 made the first landing in what was described as "a very good closed port" on September 28, 1542, in the area of present-day San Diego (Rice et al. 1988). Continued exploration and description of the coastal areas of California ebbed and flowed for the remainder of the century. A special effort to chart the California coast accurately and to locate a sheltered port for permanent settlement occurred with the Vizcaino expedition of 1602-1603. This was the crowning achievement of early Spanish exploration of California (Rice et al. 1988). In 1606, a royal order forbid further exploration of California north of the Baja Peninsula. It would be another century and a half until the land expedition of Rivera-Portala-Fages of 1769 (also referred to as the Serra-Portola expedition) came to settle California with 300 colonists and to convert local Indians. The expedition established two presidios and missions at San Diego and Monterey (Rice et al. 1988). Thus, 1769 represents the year in which livestock, such as horses, mules, and cattle, were introduced into the California landscape (Burcham 1982).

The missions became the largest and most productive agricultural communities (Adams 1946). Father Junipero Serra founded nine missions between 1769 and 1784, the year that he died. Marginal agriculture and animal husbandry began during this period of settlement. The vast untapped grassland ranges of California were the first natural resource to be utilized by these new settlers (Burcham 1982). Ultimately, by the early 1820s, 21 missions spanned the distance of 500 miles between San Diego and Sonoma (Rice et al. 1988). At the height of activity, these missions and their associated pastoral-empire lands embraced about one-sixth of the total area of California (Burcham 1982).

The Spanish deemed that more specialized agricultural (including animal husbandry) towns were needed to support the military presidios and the increasingly populated missions. In 1777, the pueblo of San Jose was founded and in 1781 the pueblo Los Angeles was founded. To encourage immigration and development, the government supplied newly settled residents with food, clothing, tools, and livestock along with house lots, strips for farming, and grazing lands (Rice et al. 1988). Selected from the hardy stock of the Old World, these livestock were readily adaptable to the strikingly similar environment of the rangelands of the New World. The inherent vigor of these livestock, coupled with their relative freedom from disease, allowed them to adapt easily (Burcham 1982). Livestock now included horses, mules, cattle, sheep, goats, pigs, and poultry.

The colonist drew upon a heritage of Mediterranean and Mexican Indian agricultural techniques. Livestock raising was extensive and required only a small amount of unskilled labor. Neophyte labor of the converted California Indians, approximately 20,000 by the early part of the nineteenth century, allowed for the cultivation of larger tracts of land, development of more reliable irrigation systems, and more successful agricultural production (Rice et al. 1988).

Animal Husbandry was, at best, primitive and grazing management was non-existent. Poultry wandered freely throughout the communities, and the livestock were basically left to roam freely and unattended across the landscape. A few private land grants were made during the period of Spanish control. Most were sizable (75,000 acres) and granted to former soldiers. By 1820, only 20 such grants had been made. The first land grant (Spanish) occurred in 1784 with the approval of a petition to raise cattle. This first California land grant was the Rancho San Pedro covering nearly 75,000 acres and was located in the area bordered by present-day Manhattan Beach, Downey, and Long Beach. Mexican independence from Spain occurred in 1821. Under Mexican law, land grants were limited to approximately 50,000 acres, and by 1846 more than 800 private land grants totaling more than 26 million acres of land had been granted (Adams

1946). The Mexican land law revealed an understanding of the extent of land necessary to raise livestock. It required a grant to be not less than 1 square league (about 4,440 acres) or larger than 11 square leagues (about 50,000 acres).

Development of the "hide-and-tallow" trade after 1822 materially altered California's basic agrarian subsistence economy. Since cattle ran wild over millions of acres of the California rangelands, an annual roundup (rodeo) became a necessary way of life to sort out ownership and to brand. Vaqueros on horseback, called nuqueadores (Mora 1949), would dash through the herd of collected cattle, killing a third of the brood cattle that were over three years of age (Gates 1967) with a quick and deadly blow to the top of the neck with their sharp dagger-like knives. The base peons would then do the skinning to strip the hides. The meat would be stripped and dried into jerky, and the fat would be dried for tallow and then poured into large green hides called botas (Mora 1949). Sailors would then load the hides and botas aboard the ships for the voyage around the Horn (Coolidge 1985). One hide and tallow company storehouse could hold 40,000 hides (Rice et al. 1988).

The breeding livestock brought into California between 1769 and 1781 had by 1830 propagated into 2 million head of cattle, sheep, goats, horses, and mules (Rice et al. 1988). The hide-and-tallow industry was the primary source of revenue for the missions, pueblos, and the government. It took a long time, as much as one to two years, to gather a shipload of hides and botas of tallow so the trading ships generally worked in pairs. They would ply up and down various sectors of the coast month after month gathering the cargo. The Californio was not the prompt and thrifty type who had his hides cured and baled and botas of tallow stored for delivery (Mora 1949).

The idea of secularization of the missions had been a political issue for several decades in the early nineteenth century. When secularization did occur in the mid-1830s, it not only dramatically altered the Indian's role in society, but also the whole social structure of California. The missions had long been more agriculturally productive than the ranchos and pueblos because of their organizational structure and the availability of Indian labor. As with the pueblos and ranchos, the main industry of the mission was raising livestock, especially cattle for food and draft, and later for the hide-and-tallow industry. The coastal valleys afforded open-rangelands of plentiful and nutritious grasses and forbs. Perennial streams, seeps, and lakes provided water. The hospitable Mediterranean climate reduced the need to control and shelter the animals. The livestock reproduced in the wild and maintained themselves inexpensively (Rice et al. 1988). While cattle were the dominant product of the ranchos, sheep and horses were also abundant. Although they were of secondary importance to the missions and ranchos, there were as many as two million sheep in California by 1825 (Gates 1967). A few hogs were raised, mostly for lard. Poultry were more prevalent around the missions, pueblos, and small farms. Many vegetable crops were produced as well as corn and wheat, the latter becoming more prevalent with the advent of the iron-tipped wooden plows pulled by oxen or mules.

After the secularization of the missions and their subsequent decline as the primary source of agricultural products, the rancho society ascended to fill that position. The increased transference of mission and governmental lands through grants expanded the large landowner class and secured their influence in society, government, and commerce. The ranchos concentrated on the raising of cattle and along with the drought and secularization of the missions, sheep numbers dropped by at least three-fourths before the American period beginning around 1850 (Gates 1967). By 1860, there would be an estimated number of sheep of 1,088,002 (Gates 1967) or 1,099,002 (Burcham 1982).

Political turmoil was continually present in California, even after the establishment of Mexican independence from Spain in 1821. The secularization issue aggravated the situation as did the continued influx of foreigners, especially the Americans. Mountain men and marine vessels of commerce came and went, but the frontier settler population continued to grow such that by 1840, perhaps nearly 400 resided permanently in California (Rice et al. 1988). These land-hungry, manifest destiny farm families continued to arrive and strain the political fiber of California politics. In 1846-47, the Bear Flag Revolt, basically lead by John C. Fremont, wrested the political and military control away from Mexico. Also, the U.S. was at war with Mexico (1846-1848). The Americans did not plan to continue the dominance of the hide-and-tallow industry in the new state, nor did they wish to prolong the crude pastoral animal husbandry which had been the way of life of their Californio predecessors (Wickson 1923). "The future of this country lies in agriculture," was the common sentiment about California (Adams 1946).

Population growth after the discovery of gold in 1849 and the completion of the transcontinental railroad in 1869, ended California's isolation from the rest of the nation. Thus, began its transformation into an agricultural, industrial, economic, and political power. The Congressional Act of 1851 greatly altered the ownership pattern of land in California (Cleland 1962). The emerging railroad system of California became the driving force behind the transformation of the new state and especially that critical element to support the increasing population, food. California agriculture changed from a relaxed pastoral/nomadic style to one of a modern and diversified enterprise.

Cattle raising was the first industry to feel the effects of population increases initiated by the gold rush. Prices soared to as high as $500.00 per head (Rice et al. 1988). Herd sizes increased dramatically through more intensified breeding programs and cattle drives into the state from adjacent territories. This golden period of lucrative livestock raising and wide-open grazing of the hill and valley grassland ranges of California would come to and end by the late 1850s and early 1860s. The 1860 cattle population was at 999,836 head and the 1880 population was at 451,941 head (Burcham 1982). The gold rush peaked in value of gold extracted in 1854 (Rice et al. 1988), and many of the claims were worked-out by the late 1850s. Overgrazing by vast herds of livestock had depleted the productivity of the California Mediterranean rangelands. The great flood of 1861-62 and the even greater drought of 1862-1864 wiped out the struggling remnants of the livestock (cattle primarily) industry. During the years of drought, livestock were driven to distant rangelands to feed. Some were taken to the desert areas and some were taken to the mountains to take advantage of the seasonal forage (Burcham 1982). Those that remained were eaten for meat or killed for hides and tallow. In 1864 it was estimated that nearly a million head had perished (Wickson 1923). By the 1870s, livestock ranching had become a second business to the diversified agricultural production of crops, hays, and grains, especially wheat. Expansion of the local railroad service within the state unlocked virgin soils of remote fertile areas, connected farmers with local and distant markets and ports, encouraged settlement of newly opened regions of the state, and speeded the development of new crop varieties suited to California's climates as well as the development of specialized farming equipment and techniques. The railroads also saw that the future of the new state as well as the financial success of their respective companies was dependent upon farm and agricultural progress and success (Rice et al. 1988). A major limitation to the open grassland ranges of the Central Valley of California was the no-fence laws which required cattlemen to drive a herd between parallel lines of vaqueros to keep them off plowed ground or growing grains (Wickson 1923). This practically ended cheap or free

range and forced livestock producers to fence pastures or relocate to mountain or remote areas not suitable for crop and grain production.

The development of fruit and specialty-crop agriculture between 1870 and the early 1900s became the states major industry. The organization of farmer cooperatives insured good prices and success of the small land owner. Private businesses engaged in agricultural development and encouraged innovation with capital and organization (Rice et al. 1988). The increasing importance of state agricultural agencies and the University of California agricultural experiment station, education, and extension programs worked to modernize farming. By the beginning of the twentieth century, agriculture in California was an economically and politically important power dominated by complex, interlocking organizations and wealthy individuals.

The depleted and vanishing open ranges had given way to modernized, mechanized, and diversified agriculture. Livestock raising was relegated to fenced lands as part of the overall ranch/farm operation or relegated to the marginal rangelands of the foothills and remote regions of the state. A widespread demand for pasture improvement now arose as alfalfa, which had been known in California since 1851, and other irrigated forage crops began to be planted to replace or to supplement the depleted and botanically different natural vegetation (Burcham 1982).

Throughout the last decades of the nineteenth century, California, like the rest of the nation, endured cyclic depressions, socioeconomic dislocation, and labor strife. The urbanization process to find work accelerated the growth of San Francisco and spawned a new metropolis, Los Angeles (Rice et al. 1988). As consolidation, modernization, and mechanization occurred in the rural agricultural sector, less labor was needed and migration to the urban industrial arenas occurred. Immigration to California, promoted as the golden state, yielded unprecedented results. For example, Los Angeles had an 1890 population of 50,000. By 1900 the population was 100,000 and by 1910, more than 300,00 (Rice et al. 1988). This burgeoning population of the state needed to be fed.

Livestock numbers changed markedly to reflect the demand for meat products, hides, wool, etc. In 1880, cattle numbers reached a low of 815,004 head while sheep number reached an all-time high of 5,727,349 head.Hawkes (1956) suggested explanations as to the paradoxical trends in cattle and sheep numbers. These included: (1) competition from intensive agriculture, (2) changing economics for sheep production, (3) changing investment patterns in agriculture, (4) changing public land policies, and (5) changing role of wool and foreign supply. The population in 1910 was 1,609,693 head of cattle and 2,417,477 head of sheep. By 1950 there were 1,107,646 head of cattle and 2,056,663 head of sheep (Burcham 1982). Not only did the numbers change, but the demographics of livestock production shifted. Initial livestock production of the Californios was along the fertile coastal regions and later into the San Joaquin Valley (Adams 1946). With Americanization, secularization, farming and population growth, livestock production shifted to the valley foothills and into the Sacramento Valley. Final expansion of the industry would be into the coastal rangelands of northwestern California and into the northeastern part of the state (Burcham 1982). Wickson (1923) characterized the period of 1900 to 1910 as the "Decade of advancement of livestock industries" since it was a time of large capital investments in the meat-packing enterprises and operations. The general economic slowdown of the nation during the depression decade of the 1930s had an impact on the livestock industry in California. Some recovery occurred during the "war years" of the 1940s as the general economic conditions of the state and nation improved.

Two notable developments occurred in the range livestock industry during the period of 1930-1950. First, there was a marked trend towards the specialization of production; and, second, the marketing of animals for slaughter occurred at a younger age (Burcham 1982). Specialization of production included a wide variety of production procedures, expressed by some of the following terms, that go beyond the use of traditional natural vegetation grazing. These include: dryland ranges, irrigated pastures, feed lots, feeder stocks, crop aftermath, soilage, byproducts, etc.

Modern Range Management (1950-1990)

Today, rangelands provide almost two-thirds of the total feed used to support a breeding herd of about 1 million cows. Rangelands also provide about 50 percent of the feed consumed by about 725,000 ewes. Most years each of these animals produces a calf or a lamb for market. In addition, 800,000 to 900,000 stocker or yearling cattle graze California rangelands for about six months each year before going to a feedlot. Range cattle populations have remained stable for the last 25 years, while sheep numbers have declined by 50 percent (FFRAP 1988).

Types of livestock operations vary regionally depending on seasonal forage sources (Oltjen et al. 1982). Fall calving allows grazing throughout the period of greatest forage production in winter and spring, coinciding with greatest nutritional requirements of the lactating cow and growing calf. This system has been widely used on California's foothill and valley rangelands in the Mediterranean climate zone. Calves are born September through November and usually weaned as the forage matures in May or June. Many cows are then maintained on the dry grassland through summer. In fall, they are fed some supplemental feed while utilizing aftermath forage left from the spring. Calving begins at this time, and supplemental feeding often continues throughout the breeding season (December to February) if new grass growth is not adequate for the cow and her calf.

This general description is modified in many ways. Ranches that have irrigated pasture or high elevation rangeland in northern California and Oregon may calve later (January-March) and then wean the calves as the summer feed source expires. Summer grazing ranges are often distant from the home ranch requiring shipping in the spring and fall. Some ranches headquartered at higher elevations in Oregon and northern California lease California's Mediterranean rangelands from late fall to spring to reduce winter feeding costs. Transportation costs are becoming a limiting factor to these practices. On the north coast where the dry season is shorter early spring calving is more prevalent. Some extensive operations, especially in the desert, calve over long periods during the year. Drought and lax management also contribute to long calving seasons.

At weaning time calves may be handled in several ways. Many of the calves weaned in May or June are sold, with most going to summer pastures in other states. Normally these calves command a high price at a time when the rest of the country needs young cattle for summer grazing, and calves may be in higher demand than the yearlings available from other regions. Some go to California summer rangeland or pastures, while others are backgrounded on low energy feeds such as grass hays, crop by-products, or dry grass. About half of the calves produced in the state are kept by the original owner for a second grazing season. The number of calves retained is subject to adjustment depending upon forage production conditions. To meet the fluctuations in the forage supply and obtain efficient utilization of annual plants, some adjustment in stocking is needed nearly every year.

For ranches keeping cattle on foothill range during all or most of the year, flexibility can be gained by operating a beef cow herd in which all or part of the calves are generally carried over and sold at the end of the next green forage season as long-yearlings (Bentley and Talbot 1951). Such an operation will carry enough cows and replacements to utilize most of the forage in the years when yields are well below average. Extra forage in favorable years can be utilized by yearlings. If there has been no extra forage the yearlings can be sold as weaners. If a change in livestock numbers is needed, it can be determined in late spring, after most plant growth has been completed and again at weaning time in the summer or fall. Experience at the San Joaquin Experimental Range in the Sierra Nevada foothills of central California has indicated that this type of operation is feasible and will allow necessary adjustment in livestock numbers in all but the poorest forage years.

Beef stocker operations are common on California's Mediterranean rangelands because cattle are bought at the beginning of the growing season and sold at the end of the growing season in late spring. This is a speculative venture, working to advantage if cattle are bought low and sold high. For this reason there are a variety of business arrangements including: cow-calf producers who keep a few stocker cattle, bona fide stocker operators, and groups of investors leasing land and hiring local managers. About half of California's rangelands are used to support stockers, and often the more productive or improved land fits this use pattern.

Stocker cattle are usually acquired from the south and midwestern U.S. or are spring or fall calves from California. In the fall and early winter, these cattle graze either dry residue from the previous growing season, grain stubble, or are fed hay. A supplemental source of protein is often required. Feeding is discontinued when the new grass growth is adequate. Stocker cattle are grown to feeder weights greater than 320 kg and then enter feedlots in California and other western states.

California feedlots are principally located in the Imperial Valley, adjacent to Mexico, and in the San Joaquin Valley. This industry has suffered severe economic difficulties since 1974, and the number of feedlots has dramatically decreased. The feedlot industry has declined due to high transportation and labor costs associated with processing and marketing beef. Modern midwestern processing plants with lower labor costs are able to ship beef to California and compete with California packers resulting in decreased demand for California feedlot beef.

Many sheep operations make use of foothill rangelands throughout the year, while others supplement rangeland forage with crop residues and summer grazing on mountain ranges. California's sheep population has decreased dramatically since its peak in the 1930s. Restrictions on controlled burning of shrublands, reduction in grazing permits on pubic lands, and increased losses from predators and restrictions on predator controls have drastically reduced the area available for sheep grazing and contributed to the significant reduction in sheep numbers in California (Ellis 1983). Today sheep are raised throughout the state in small as well as large commercial flocks. In the early 1980s sheep numbers increased slightly.

Many purebred flocks and small flocks are managed to produce lambs in the late winter or early spring. The medium and large flocks are commonly managed to lamb in fall and early winter. Fat lambs are marketed at 45 to 55 kg. and may be finished in feedlots. Most fall born lambs can be finished on grass within six months. The decline of sheep slaughter and packing facilities in California has caused a great deal of concern among the state's sheep producers.

Seasonal Variation in Range Forage

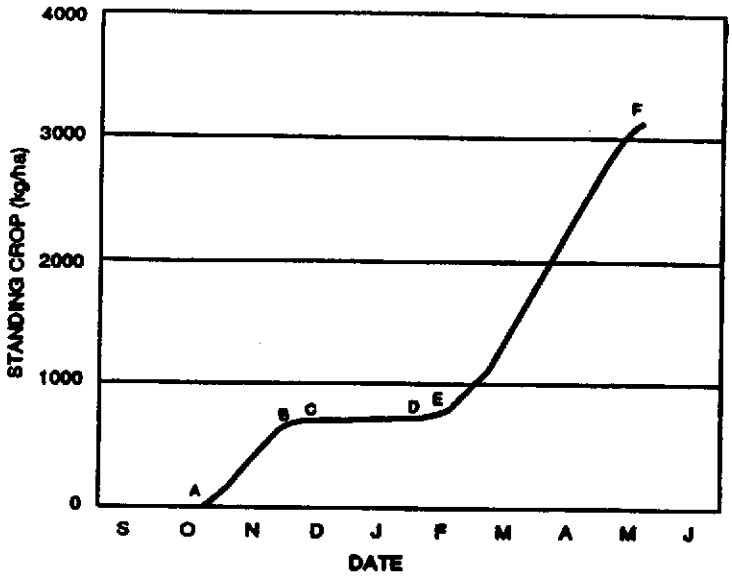
Range forage productivity is largely controlled by soil, aspect, topographic and climatic factors. California's rich geologic history has contributed to a great diversity in California's rangeland soils resulting in wide variations in forage potential. However, the Mediterranean climate has the greatest influence on yearly and seasonal forage productivity.

The annual grassland ecosystem is seasonal in its forage productivity and quality. The annual range forage year has been divided into seasons to reflect variations in productivity, quality, and animal performance. Bentley and Talbot (1951), using beef heifer gains segregated the seasons into the inadequate green season, adequate green season, and the inadequate dry season. George et al. (1988) defined four seasons that can be estimated from daily temperature and precipitation. The onset of growth (fall) begins with the emergence of new seedlings. As winter begins herbage production slows. With the end of winter comes a period of rapid spring growth that ends as soil moisture is depleted and annual plants mature and die. Figure 1 is a profile of the growing season that can be estimated by recording emergence date and estimating herbage standing crop in early winter, late winter and at the end of the growing season. Each of these seasons have characteristic productivity limitations.

The fall season is the period between the first germinating rains and the onset of cool winter temperatures. During this period, which can be quite short to several weeks long depending on the timing of fall precipitation and the onset of cool temperatures, dry residual forage produced during the previous growing season provides low quality dry matter for grazing. As germination and seedling establishment progresses, the amount of new green forage increases. This new forage is high in protein and energy, but the high water content may limit nutrient intake. During the winter new forage continues to grow slowly and the residual dry forage disappears due to grazing and decomposition. During the fall-winter period, low forage levels can limit intake of dry matter, energy, protein, and other nutrients. Supplementation, annual legume seedings, and nitrogen fertilization have been shown to improve animal performance during the fall and winter period (Menke 1989). Summer dormant perennial grasses and fall irrigation of annual legumes or annual ryegrass will increase forage production during the fall and winter seasons, but are not widely practiced due to either resource or economic limitations. Alfalfa stubble is often grazed during this period, especially by sheep.

Rapid spring growth begins with rising spring temperatures. During this portion of the growing season, forage levels and forage quality are usually adequate for rapid livestock gains. Forage level increases rapidly and frequently out produces the livestock's ability to consume it. Unused forage at the end of this season remains as low quality dry residue. Forage production and quality during this period is increased by seeding annual legumes and nitrogen fertilization. Excess forage may be cut for hay and fed in the field through the summer.

Forage maturity and moisture loss is the harbinger of the summer dry season. Standing dry forage continues to decline in quality, shatter, and decompose throughout the summer season. This forage provides energy to grazing stock but frequently is of inadequate quality to meet other nutrient requirements. Therefore, intake of this forage is limited by its quality. It is common practice to move stock to higher elevations, irrigated pasture, or provide protein and mineral supplements during this season. Annual legumes, such as rose clover and lana vetch, that do not shatter when dry can increase the quality of this dry forage. Crop residues, especially grain stubble, may be grazed during the summer.



A. Emergence of new seedlings
B. Beginning of winter
C. Early winter herbage yield estimate
D. late winter herbage yield estimate
E. End of winter
F. End of growing season (peak standing crop) herbage yield estimate

Figure 1. Seasonal herbage production profile for annual rangelands.

Grazing Management Practices

Seasonal or year-long continuous grazing of foothill grasslands has been the traditional practice. However, it has been common practice to graze different pastures seasonally. Research at the San Joaquin Experimental Range (Bentley and Talbot 1951) suggested that moderate grazing gave the most efficient cattle production, while maintaining satisfactory herbage production. Close grazing reduced range forage production as well as efficiency of cattle production. The effects of grazing intensity were apparent in winter growth of forage and in the yield of mature herbage. The effects of grazing intensity on plant vigor were less apparent during the spring. Differences in grazing during the current season partially obscured the effects of past grazing use. However, differences in forage yield and composition were still apparent in the spring. Currently, grazing management of annual grasslands emphasizes maintenance of adequate residue and efficient utilization of forage to encourage desired forage species and to ensure adequate soil protection (Clawson et al. 1982).

Although annual plants do not survive from one growing season to the next, their management in one year can influence productivity the following year. Light to moderate grazing intensities that leave high amounts of dry forage residue in the fall, tend to result in more desired forage species during the following growing season. Research has shown that heavy grazing left low amounts of dry residue which tended to produce undesirable species (Heady 1956, Heady 1961, Hooper and Heady 1970, Evans and Young 1970, Bartolome et al. 1980). As grazing intensity increased, dry forage residue transferred to the following growing season decreased. As dry forage residues from the previous season increased, forage levels in January increased (Bentley and Talbot 1951).

Specialized grazing management systems adapted to the annual grasslands generally have not been used nor have they been the subject of extensive research. Heady (1961) provided extensive circumstantial evidence from the literature to support yearlong grazing as the way to manage annual range. He also showed lamb weaning weights from continuously grazed pastures to be better than those from deferred rotation. However, this was a comparison of continuous grazing to a three pasture deferred rotation where a different pasture was used during each third of the grazing season. In the 1980s the results of this study have been cited as evidence that time controlled rotational grazing (Voisin 1959) would have no production advantage over continuous grazing. However, time controlled grazing is very different from the deferred grazing used in Heady's study.

During the 1980s a small number of ranchers began to subdivide their annual grassland pastures and rotate following the concepts developed by Voisin (1959). His rotation principles are based on two simple rules: a) rest periods should vary with pasture growth rate; and, b) individual paddocks should be grazed for no longer than six days. During periods of slow pasture growth rests are long (60-90 days), and during periods of rapid growth rests are shorter (20 to 30 days).

Inexpensive New Zealand fencing techniques have allowed the time controlled grazing manager to subdivide and conduct a planned, but flexible pasture rotation. As part of the fencing and rotation plan, the manager can limit the use of critical areas to meet environmental quality objectives such as erosion control, agroforestry and reforestation, wildlife habitat enhancement, and riparian area improvement. Time controlled grazing also facilitates the management of pasture legumes and development of complementary forages to fill gaps in the forage system. California ranchers have achieved the following benefits from controlled grazing systems:

Increased carrying capacity
Increased productivity per hectare
Improved animal performance
Reduced winter feeding
Increased legume density and cover
Reduction in weed populations
Improved management planning
Improved predator control
Improved wildlife habitat
Protection of critical areas

Increased gross income, reduced variable costs, reduced overhead costs, and improved efficiency are also associated with each of these benefits.

Preliminary Ranch Monitoring Results

Because time controlled grazing systems (TCGS) can have multiple pervasive effects on the ranch system, its full influence can not be determined from short-term studies involving single factor contrasts (Sheath and Bryant 1984). Instead its effect on several components of the whole ranch system must be determined. Because it is impractical to replicate entire ranches, case study and on-farm monitoring approaches must be taken. The following are some examples of how TCGS influences ranch operations and profitability.

Fencing Costs: Permanent electric fencing has become popular because it requires fewer posts, less wire, and less installation labor, it is easier to maintain, and it reduces predation. Portable electric fencing increases land use flexibility. Table 1 compares material costs of traditional fencing and high tensile fencing using a wagon wheel cell (Figure 2) and supplemental fencing to subdivide existing pastures (Figure 3). Permanent and portable electric fencing makes pasture subdivision easy and inexpensive.

Increased production: Livestock production (kg/ha) can be increased in two basic ways: 1) increased animal performance, or 2) increased carrying capacity. Table 2 shows the increased levels of production that have been documented on two ranches in northern California following the implementation of TCGS. Table 3 compares pasture subdivision costs and production changes on rangelands with those of traditional range improvements.

Winter Feeding: Preliminary ranch analyses and observations have suggested that winter feeding can be reduced under a TCGS. Winter feed costs are one of the larger variable costs on annual grassland livestock systems. Willoughby (1958 and 1959) showed that animal performance increased as forage level increased to 1250 kg/ha. Therefore, increases in forage level due to grazing management may improve animal performance and decrease winter supplemental feeding. Winter forage on offer usually increases as grazing intensity decreases. Bentley and Talbot (1951) showed that winter cow weight gain increased as grazing intensity decreased (Table 4). Over a nine year period the average starting date of the winter grazing season was January 29 and the average ending date was March 21. Observation and measurement of winter forage levels indicated that stock in a rotation usually move to a higher forage level than that found in their current pasture. This would suggest that there may be an opportunity to reduce winter supplemental feed with TCGS. Limited information from one ranch indicated that winter hay feeding decreased from 450 kg/cow to 91 kg/cow after implementation of TCGS.

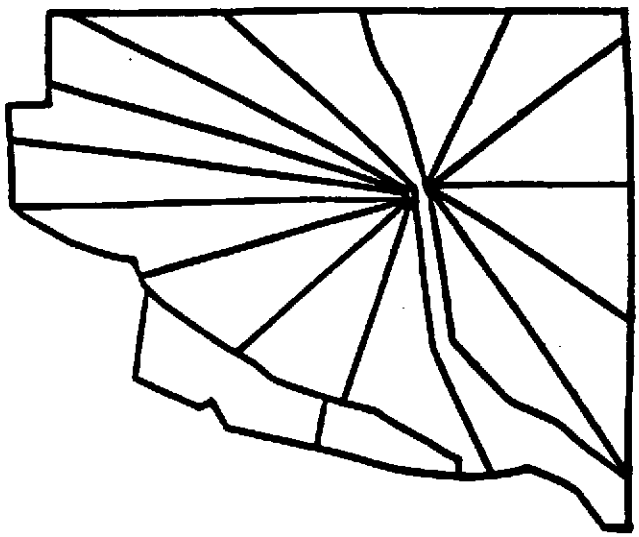


Figure 2. Wagon wheel pasture cell configuration with stockwater at the center.

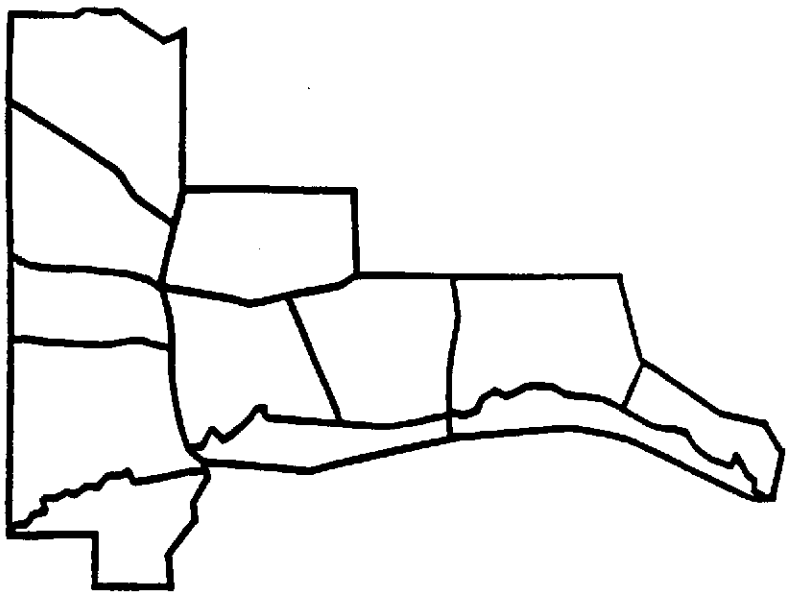


Figure 3. Block pasture cell developed from existing fencing.

Table 1. Material costs of electric fencing for two grazing cells and estimated cost if traditional barbed wire were used.

Grazing Cell	Area (Ha)	Distance (km)	Cost ($/km)	Cost ($/Ha)
	Single strand electric high tensile wire			
Wagon Wheel	424	21	240	11.80
Block	444	15	240	8.10
	4-strand barbed wire			
Wagon Wheel	424	21	1200	58.95
Block	444	15	1200	40.55

Table 2. Estimated material costs for fence and water development, and production improvements for annual range determined from ranch records.

	Costs ($/Ha)				Livestock Production (kg/Ha)			
Pasture Type	Fence	Water	Total	Total Amortized*	Before TCGS	After TCGS	Difference	Stock Type
Annual Range	12.5	0	12.5	2.30	28	54	26	Calves
Annual Range	12.5	0	12.5	2.30	56	84	28	Stocker

*Costs amortized over 10 years @ 13%.

Table 3. Comparison of pasture subdivision to other common range improvements using conservative estimates of improvement life, costs and production increases.

Practice	Life (yrs)	Cost ($/Ha)	Amortized Cost ($/Ha/yr)	Production Increase (%)	Return (kg/Ha)
None	--	--	--	--	56
Subdivision	10	25	4.60	30 - 100	84
Legume Seeding	20	125	17.80	50 - 100	84
Nitrogen Fertilization	2	62	37.50	50 - 100	84

Table 4. Nine year average winter beef cow gains on foothill rangeland grazed for an average of 51 days ending on March 21.

Grazing Intensity	Grazable Hectares	Grazable Hectares per A.U.	Gain (kg)		
			Supplemented	Unsupplemented	Mean
Close	42	2.2	1.1	20.7	10.9
Moderate to close	54	2.3	12.2	29.8	21.0
Moderate	65	3.3	30.5	53.3	41.9
Light to moderate	82	4.2	29.0	48.2	38.6
Light	103	5.2	23.2	45.7	34.5
Light	73	3.7	31.0	50.3	39.5

Table 5. Change in species composition (%) from 1984 to 1986 for four transects in medusahead infestations and one transect in a small ungrazed exclosure.

Composition	Medusahead 1984	Medusahead 1986		Exclosure 1984	Exclosure 1986
Bare Ground	1	8		0	0
Litter	16	25		16	18
Medusahead	45	10	**	08	10
Soft Chess	17	23		16	
Wild Oats	4	0		34	22
Annual Ryegrass	2	5			
Annual Fescue	1	2			
Ripgut Brome	0	0		22	44
Annual Legumes	4	4			
Filaree	10	13			
Other Forbs	2	6	*	4	6
Sample size (n)	4	4		1	1

* ($p<0.05$)
** ($p<0.01$)

Table 6. Sheep (no.) and financial ($) losses due to coyote predation before and after installation of electric fencing in 1985 (Pratt 1987).

	1984-85	1985-86	1986-87
Ewes*	50	0	0
Lambs**	200	40	0
Estimated Cost	($15,050)	($2,660)	($0)

*$35.00 each
**Avg. 43 kg. @ $1.54/kg.

Weed Control: Pasture weeds are the number one complaint of many pasture owners. Several ranchers have witnessed decreases in pasture weeds following implementation of TCGS. Unfortunately, we have not documented these apparent declines in plants such as sour dock, foxtail, and even thistles; however, we have documented a decline in medusahead (*Taeniatherum asperum*) on annual range two years after implementation of TCGS (Table 5). Medusahead declined from 45 percent of the species composition to ten percent, and the heavy litter associated with medusahead patches was reduced.

Protection of Critical Areas: The livestock industry is increasingly perceived by environmentalists as using grazing practices that reduce wildlife habitat, degrade riparian areas, and accelerate erosion. TCGS provides a tremendous livestock control tool, which when properly planned and applied, can reduce or mitigate environmental concerns associated with livestock grazing. Erosion from grazing is largely the result of poor livestock distribution resulting in overgrazing and poor vegetative cover in some areas while other areas that are less accessible remain ungrazed. TCGS allow the manager to achieve proper livestock distribution resulting in much improved soil cover. Additionally, TCGS have been used to limit livestock access to riparian areas allowing natural vegetation to stabilize stream banks. Wildlife habitat has been improved when selected pastures are left out of the rotation, allowing grass to provide cover and food. These improvements are the result of planning that targeted special management to meet wildlife habitat goals.

Reduced Predation: One sheep ranch in Solano County, several in Mendocino County,and one in Humboldt County have reduced coyote predation through the use of electric fencing. Table 6 shows sufficient decline in lamb losses following addition of three offset electrified wires to an existing fence to pay for the fence in one year. Another sheep producer uses a Great Pyrennes guard dog to supplement the electric fences. The concentration of the sheep that occurs in a TCGS prevented the dog and sheep from being separated and thus less effective.

Conclusion

California's range livestock industry has adjusted to external pressures throughout its history. Now and in the coming decades grazing management will become more intensive in response to environmental and economic concerns. Changes in grazing and ranch management practices to increase production efficiency will be essential as California's red meat products compete for world markets. Likewise, producers will adjust their grazing and related range operational practices to reduce environmental impacts voluntarily or in response to local, state, and federal regulations.

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