

Annual Grassland Forage Productivity

Mel George, Jim Clawson, John Menke, and James Bartolome

Ranchers and range managers in California depend heavily on annual production of natural forage, or herbage, from grasslands—but to best utilize this forage they must understand the seasonal productivity of the annual grassland ecosystem. Intensive studies carried out on the San Joaquin Experimental Range in the 1970's led to the development of models which provide much new insight into seasonal forage productivity. Thus, we can now describe typical patterns of forage production (grasses and forbs) which, while not all-inclusive, are correct in a general sense and are of great value in range management.

Four factors—precipitation, temperature, soil characteristics, and residue—largely control forage productivity and seasonal species composition. These factors also change the timing and characteristics of the four distinct growth phases: break of season, winter growth, rapid spring growth, and peak forage production. Many of these patterns can be used to guide management decisions. As the season progresses, the patterns become set and the outcome more predictable.

Weather Influences

The new growing season begins in fall with rains which start the germination of stored seed (see Table 1). The young annual plants then grow rapidly if temperatures are warm but

slowly if cooler temperatures prevail. There is little growth during low winter temperatures. Rapid spring growth commences with warming conditions in late winter or early spring. Rapid growth continues for a short time until soil moisture has been exhausted. Peak standing crop occurs at the point where soil moisture becomes limiting or when plants mature.

Break of season begins following the first fall rains which exceed 1 inch during a 1-week period. This may occur at any time from September 15 until January 1. Early false breaks may occur in summer but the emerged plants may not survive until the true break. Taprooted filaree (*Erodium* spp.) is one of the few exceptions that often survives a false break. Timing of the break dramatically affects forage production (Figure 1, A-D).

Forage species composition is usually established by December 1, and is largely determined by dates of autumn rains as well as by autumn temperatures. In drier years or in years of adequate but poorly distributed rainfall, filaree usually dominates. High rainfall years and years with late spring rains result in grass dominance. Early rains coupled with evenly spaced adequate rainfall usually result in clover years.

Winter growth period occurs at the end of the fall break of season and is the result of cooling temperatures, shorter days, and lower light levels. There may be little or no forage growth during this period, and dry-matter losses may occur (Figure 1, E). Forage production is greater in mild winters (Figure 1, F). A short or no winter-growth period may occur if

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Table 1. Influence of eight normal weather variations of timing of seasonal dry matter (DM) forage productivity in California's annual grassland ecosystem. Data is representative of granitic range site at the San Joaquin Experiment Range with an average annual rainfall of 15 to 20 inches.

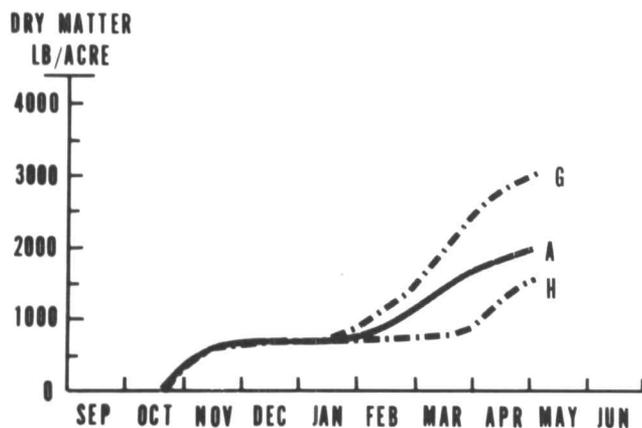
Curve in Figure 1	Break of season	Onset of winter growth		Onset of rapid spring growth		Peak standing crop		Weather pattern
	Date	Date	DM (lb/A)	Date	DM (lb/A)	Date	DM (lb/A)	
A	Oct 23	Nov 7	600*	Feb 1	700†	May 1	2000‡	Average fall, winter and spring
B	Oct 1	Nov 7	1000	Feb 1	1100	May 1	3000	Warm, wet fall, average winter and spring
C	Oct 23	Oct 23	—	Feb 1	300	May 1	1000	Cold, wet fall, average winter and spring
D	Nov 15	Nov 15	—	Feb 1	300	May 1	1000	Dry fall, average winter and spring
E	Oct 23	Nov 7	600	Feb 1	300	May 1	1500	Average fall, cold winter, average spring
F	Oct 23	Nov 7	600	Feb 1	1000	May 1	3000	Average fall, mild winter, average spring
G	Oct 23	Nov 7	600	Jan 15	700	May 1	3000	Average fall, short winter, early spring
H	Oct 23	Nov 7	600	Apr 1	700	May 1	1500	Average fall, long winter, late spring

*Forage production from break of season to onset of winter growth (Oct. 23-Nov. 7 in this example).

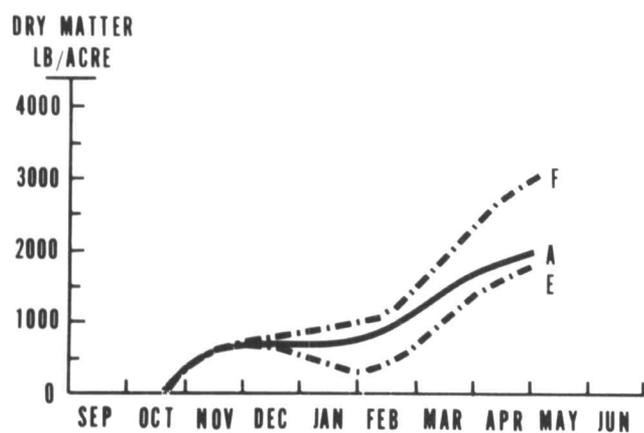
†Forage production from break of season to onset of rapid spring growth (Oct. 23-Feb. 1 in this example).

‡Forage production from break of season to standing crop (Oct. 23-May 1 in this example).

SAN JOAQUIN EXPERIMENTAL RANGE



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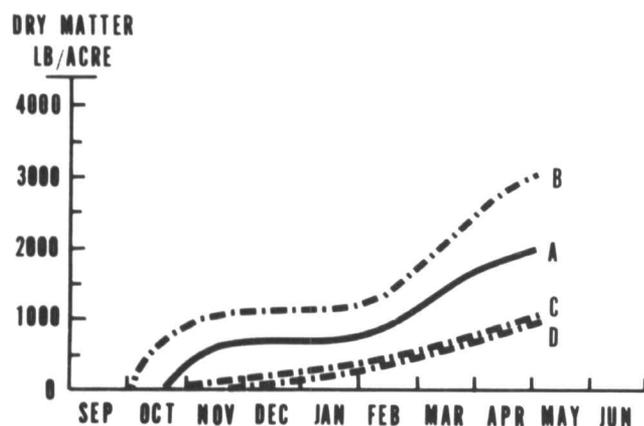


Fig. 1. Range forage production curves (A-G in table) showing influence of eight different weather patterns on a granitic range site at San Joaquin Experimental Range.

there are late breaks of season—under those circumstances, little new growth is apparent in the fall.

Rapid spring growth period begins with the onset of warming spring temperatures, longer days and higher light inten-

sities (Figure 1, G.H). This normally occurs between February 15 and March 15 when average weekly temperatures exceed 45° F. The length of rapid spring growth varies considerably in California, from a month in dry southern regions to more than 3 months in wetter coastal regions.

Peak forage production occurs at the end of the rapid spring-growth period (peak standing crop). This can be as early as April 1 in southern San Joaquin Valley to as late as May 25 on the north coast. Late arrival of peak standing crop requires adequate rains in April or early May. The date of peak standing crop on the same site may also differ widely among years and according to species composition. In years of filaree dominance, peak standing crop will be earlier than in years of grass dominance.

Moisture from summer thunder storms, although not important for plant growth, may speed decomposition and always leaches nutrients from standing forage. Standing residue is frequently shattered into ground litter.

Soil Characteristics

Available water for plants, although mainly dependent on rainfall, also depends on soil depth, soil texture, aspect and topography. Annual plants depend primarily on moisture available in the top 1 foot of soil, although taprooted filaree and summer annual forbs may make considerable use of water at greater depths.

Heavy clay soils hold more moisture and provide a buffering effect when rains are widely spaced; thus, the rapid-growth period may be longer. These soils typically occur in swale areas which naturally receive more moisture from runoff. Upland slopes tend to be dryer because of high runoff and lighter-texture soils. South-facing slopes dry faster than do north-facing slopes. Thus, the production curves in Figure 1 may be different on adjacent sites and on south-facing and north-facing slopes.

California soils vary tremendously in fertility, although nitrogen is generally the most limiting nutrient in California's annual grassland soils. Phosphorus and sulfur may become secondary limiting factors. Where deficient, these nutrients can be added to substantially improve range productivity.

Species composition of legumes is influenced by pH, and annual grassland soil pH's range from alkaline to acidic. Acidic soils generally tend to occur in high rainfall areas, while alkaline soils tend to occur in drier southern areas; pH may vary from 4.5 in high rainfall zones to 8.5 in lower rainfall areas.

Residue

Apart from fertility, residue is the major manageable factor governing productivity and composition. Residue is the dry component of forage left at the end of the dry season. Residue, acting as a mulch, influences germinating plants and soil organic matter. To maintain desired forage production, therefore, it is useful to set minimum residue standards (Clawson et al. 1982). These standards vary from 200 pounds of dry matter per acre in the south to 1,250 pounds per acre on steep slopes on the north coast. Leaving greater amounts does not enhance total forage productivity but may encourage grass dominance.

Low amounts of residue in fall encourage higher propor-

tions of the following species: silver hairgrass (*Aira caryophyllaea*); turkey mullein (*Eremocarpus setigerus*); little quakinggrass (*Briza minor*); nitgrass (*Gastridium ventricosum*); broadleaf filaree (*Erodium botrys*); burclover (*Medicago polymorpha*); cutleaf filaree (*Erodium cicutarium*); clover (*Trifolium* spp.).

High amounts of residue in fall encourage dominance by the following: slender wildoats (*Avena barbata*); softchess (*Bromus mollis*); wildoats (*Avena fatua*); medusahead (*Taeniatherum asperum*); riggut brome (*Bromus diandrus*).

Grass dominates California's annual grassland ecosystems largely by shading understory forbs, thus giving grass a competitive advantage. Grazing lessens this advantage by opening the canopy for greater forb or legume dominance. On a moderately utilized range, livestock do not graze heavily enough to make complete use of available forage, therefore, a patchwork of grasses and forbs will be apparent.

Literature Cited

Clawson, W.J., N.K. McDougald, and D.A. Duncan. 1982. Guidelines for residue management on annual range. Univ. of Calif. Div. of Agr. Sci. Leaflet 21327.

Vegetation Changes on Arid Rangelands of the Southwest

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Change, an inherent characteristic of ecosystems, is a recognized feature of vegetation in the arid and semiarid portions of the southwestern United States. Territorial surveys in the 19th century and terrestrial photography in the 19th century and early 20th century have been used to establish a base for vegetation conditions and then for recording variations from this base. All evidence indicates a dramatic shift from land with a high proportion of grassy vegetation to one dominated by shrubs. Most of these changes have occurred in the last 50-100 years. Following are some of the reasons and possible solutions to problems resulting from these changes that would be applicable to parts of Arizona, New Mexico, and Texas, with possible use in other arid and semiarid regions of the world.

Changes

There is little doubt that shrubs were invading grasslands slowly before man's influence, as evidenced by small pockets of shrubs. With the increase of ranching and farming activities in the late 19th and 20th centuries, there has been a rapid increase of shrubs. Woody plants were present under pristine conditions but they rarely migrated from very specific sites into grassland communities. Formerly restricted primarily to the waterways and drainages or occurring as scattered individuals, woody plants now form an almost continuous cover over large parts of the arid and semiarid rangelands of the Southwest. Figures 1 and 2 show the rapid increase of shrubs from 1858 (livestock water was developed about 1900) to 1963 on 144,000 acres of the Jornada Experimental Range in southern New Mexico.

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Editor's Note: Another paper on this subject appeared in the June 1984 issue of *Rangelands*, entitled "Vegetation Restoration in the Chihuahuan and Sonoran Deserts of North America" by Jerry R. Cox, Howard L. Morton, Thomas N. Johnsen Jr., Gilbert L. Jordan, S. Clark Martin, and Louis C. Fierro.

Vegetational history would indicate a slow drying of the Southwest since the Tertiary period with some intervening wet periods. P.V. Wells (1977) showed that some of the more xerophytic species, such as creosotebush, either entered or reentered the Chihuahuan Desert Region during the Holocene period, after having survived the Wisconsin glacials

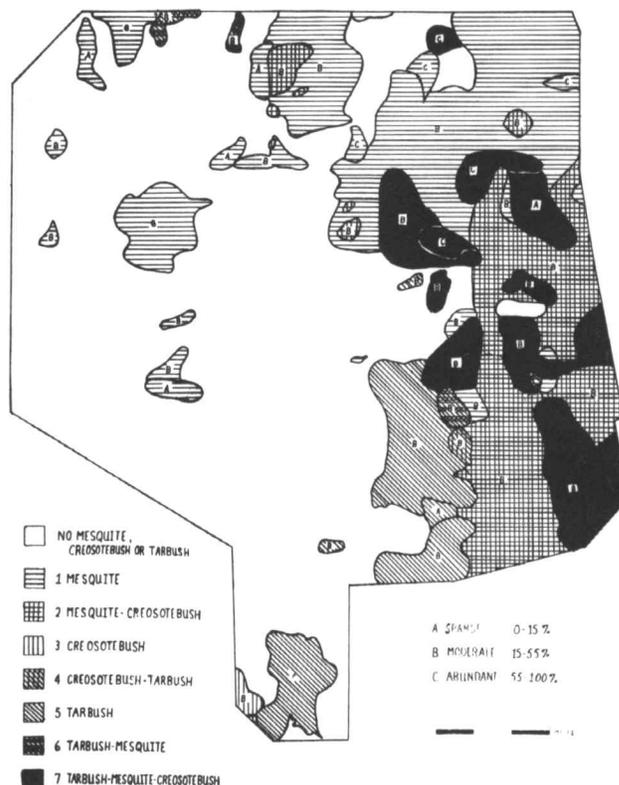


Fig. 1. Major brush species by abundance classes in 1858 on the Jornada Experimental Range.