

# Fourteen Years of Forage Monitoring on the California Central Coast Shows Tremendous Variation<sup>1</sup>

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## Abstract

To better understand forage production (above ground biomass) and precipitation patterns in the Central Coast region of California, the first in a growing network of primary production monitoring sites were established in 2001. The California Central Coast has a Mediterranean climate with cool, moist winters and hot, dry summers, and is dominated by annual grasslands and oak woodlands. By 2010, 12 sites were established across San Luis Obispo County, stratified by different rainfall zones, greater than 635 mm (coastal) to less than 200 mm (inland) for an average year. Forage production was measured each spring. The amount of rainfall varied from site to site, as well as from year to year. Annual rainfall ranged from less than 51 mm to over 1016 mm depending on the site and year. Both annual rainfall and its monthly distribution varied significantly. Total production ranged from a high of 11 201 kg/ha (coastal) to a low of 33 kg/ha (inland). Total annual rainfall and monthly distribution was a major driver of forage production. In addition, residual dry matter (RDM) seemed associated with plant species composition. The percentage of forbs observed at the sites was inversely related to RDM level. This data has helped local ranchers, agricultural commissioners, resource conservation districts and others in making management decisions for rangelands on the Central Coast, ranchers being particularly interested. This data set will also be useful for comparing changes in forage production that may occur due to variation in amount and timing of rainfall in the coming years.

*Key words:* California annual grasslands, forage production

## Introduction

Most of California has a Mediterranean-type climate which is characterized with cool moist winters and hot dry summers. Topographic variation yields a great many ecological sites and associated plant communities across California. One broad division is between the annual grassland type, which commonly exists below 365 m in elevation and consists mostly of naturalized species, and many introduced species from the Mediterranean region of southern Europe (George 2014). These annual grasslands are often co-dominant with oak woodlands or savannas, which in many areas are vestiges of their former extent (George 2014). In addition to climate and topographic variation, California is at the confluence of several tectonic plates which have a diverse geology leading to a mixed assortment of soils that vary in their ability to support vegetation (O'Gen and Arroues 2014).

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Annual forage productivity has been monitored at the San Joaquin Experimental Range since 1935, the Hopland Research and Extension Center since 1952, and the Sierra Foothill Research and Extension Center since 1978 (George and others 2014a). At these locations, total forage production varied greatly from year to year. George and others (2001) provided a summary of the data showing how annual rangelands grow, and the effects that rainfall and temperature have on forage production at these stations.

Though these long-term data sets are very important in understanding production of annual grasslands, they are limited to three locations around the state and have not illuminated much about variations among range sites within those experimental stations rangelands.

Our objective was to develop an additional long-term dataset, one which samples forage production by range sites on the Central Coast of California. This data will also be useful as ecological sites are completed in San Luis Obispo County.

## Methods

### Study area

San Luis Obispo County is dominated by coastal prairies, annual grasslands, oak-woodlands and chaparral vegetation types (George and others 2014b). Average annual precipitation ranges from 1,067 mm to less than 152 mm (fig. 1). Average annual rainfall is recorded on a water-year, July 1 through June 30, following San Luis Obispo County's format for recording annual precipitation. The coastal mountain range near the coast rises over 762 m creating a rain shadow effect significantly reducing precipitation east of the range.

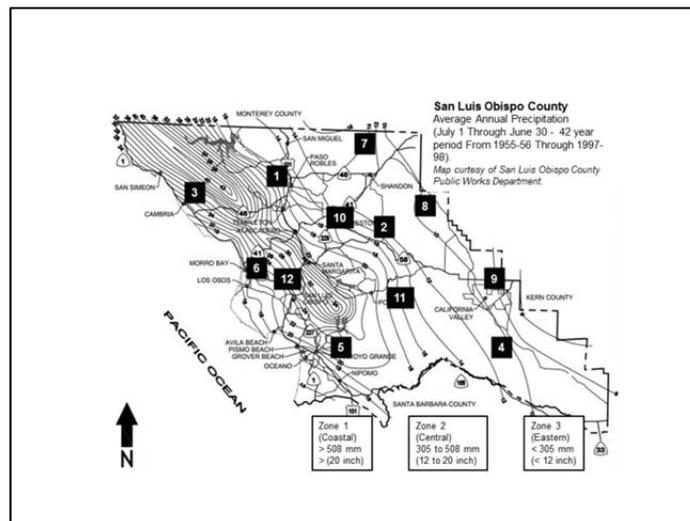


Figure 1—Average annual precipitation across San Luis Obispo County. The county is divided into three zones based on average annual rainfall. The locations of each site monitored, the zone they are in, and the year they were established are shown as follows: Adelaida (1), Camatta (2), Cambria (3), Carrizo (4), Huasna (5), and Morro Bay (6), were established in 2001; Shandon (7) was established in 2003; Bitter water (8) and Soda Lake (9) were established in 2004. Cal Poly (12), Creston (10), and Pozo (11) were established in 2010. The name corresponds to the number in the figure.

## Forage sampling

As early as 1975, range managers divided San Luis Obispo County into three rainfall zones, >508 mm, between 305 and 508 mm, and <305 mm, to facilitate range management (Weitkamp 1975). Twelve representative sites, between the years 2001 and 2010, were established across San Luis Obispo County in these different rainfall zones. Figure 1 shows the distribution of sampling sites and the average annual rainfall across the county. Sites representing the coastal zone included Cambria, Morro Bay, Huasna, and Cal Poly. Sites representing the central zone included Adelaida, Shandon, Creston, and Pozo. Sites representing the eastern zone included Camatta, Bitterwater, Soda Lake and Carrizo. The characteristics of each site, including soil type, range site, elevation, and distance from the coast are shown in table 1.

**Table 1—Information on the soil series, soil name, range site, elevation and distance from the coast for each site in San Luis Obispo County that was monitored**

Site name	Precipitation zone	Year started	Soil unit	Soil name	Range site	Elevation (m)	Distance from coast (km)
Cambria	Coastal	2001	191	Tierra	Course Loamy Claypan	134	4
CalPoly (W5)	Coastal	2010	127	Cropley Clay	Clayey	103	11
Huasna	Coastal	2001	165	Los Osos-Diablo Complex	Loamy Claypan	159	15
Morro Bay	Coastal	2001	128	Cropley Clay	Clayey	27	4
Adelaida	Central	2001	134	Dibble	Clay Loam	323	31
Creston	Central	2010	103	Arbuckle-Positas	Coarse Loamy	363	35
Pozo	Central	2010	50	Xerofluvents-Xerorthents	Not Available	482	37
Shandon	Central	2003	179	Nacimiento-Los Osos	Fine Loamy	585	61
Bitterwater	Eastern	2004	140	Choice Silty Clay	Clayer Hills	628	71
Camatta	Eastern	2001	101	Balcom-Nacimiento	Loamy	508	56
Carrizo	Eastern	2001	440	Belly Spring Panoza	Loamy	793	81
Soda Lake	Eastern	2004	240	Panoza-Beam Complex	Coarse Sandy Loam, Limy Upland	808	77

Since these sites were on private rangeland where grazing could not be controlled, three temporary exclosures were erected at each site. Total forage production was measured each spring by clipping vegetation from two 0.093 m<sup>2</sup> plots within each exclosure at the time of peak growth, for six samples per site. Total forage included plant species that were palatable, but excluded non-palatable species such as

fiddleneck (*Amsinckia* spp.), lupin (*Lupinus* spp.), turkey mullen (*Eremocarpus setigerus*), and tar weed (*Hemizonia* spp.). Samples were oven dried and weighed. Measurements were made at the time of peak growth. This usually occurred in late April, but there were yearly and site differences based on rainfall timing and amounts. Rainfall records were obtained from the ranch headquarters, or the nearest weather station operated by the County of San Luis Obispo or Bureau of Land Management's remote automated weather stations (RAWS). Each fall, the exclosures were moved in a random distance (between 7 to 21 m) and direction to a grazed location, but remained on the same soil type, slope and aspect. This was done to avoid affects from old residual dry matter (RDM) accumulations and to be representative of the current grazing levels. Old RDM influences both the amount of production and the species composition (Bartolome and others 2006). A visual estimation of species composition was recorded at each site at the time of peak growth.

### **Data summary**

This case study is meant to provide descriptive data representing the first 14 years of a project to improve the representation of variability in rangeland forage production across the Central Coast. Subsequently, greater provision of funding and increased interest and participation by ranchers and range managers in the region has allowed the expansion of the monitoring network in ways which is beginning to allow replications of measurements across range sites (and ecological sites as they are developed), precipitation zones, slope/aspect, soil moisture and temperature gradients. It is our intention to make use of the sampling improvements to investigate how patterns in precipitation timing and amounts and temperature impact production/species composition across these areas.

### **Results**

The rainfall was highly variable by both year and site. The high was recorded at the Cambria site (coastal zone) at 1022 mm during the 2004-2005 growing season, and the low was 43 mm at the Soda Lake site (eastern zone) during 2013-2014. Figure 2 shows the distribution of rainfall by zones and year. Not only did the amount vary from year to year, and across precipitation zones, but the timing of that precipitation also varied. The average year consisted of rainfall beginning in October, with the heaviest rainfall during December, January, and February, then tapering off in March, April and May (fig. 3). Some years, like 2012-2013, water-year started when expected, but ended early (fig. 3). In contrast the 2013-2014 water-year did not start until very late (fig. 3), without a germinating rain until February, 4 months later than normal.

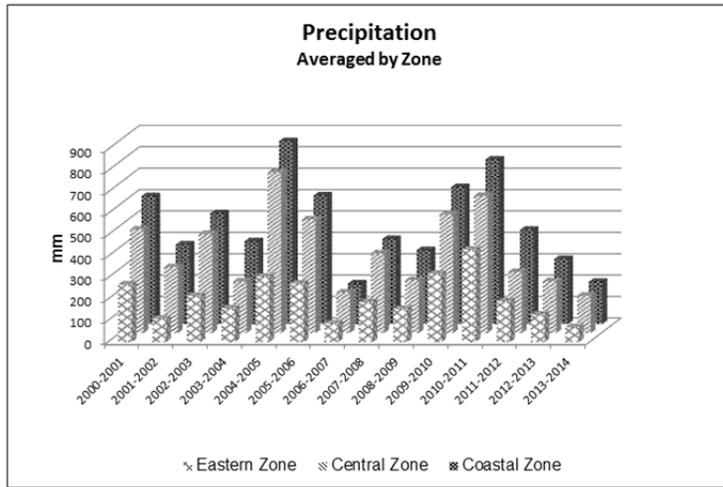


Figure 2—Annual precipitation shown by zone and year. Precipitation is shown for the water year, July-June.

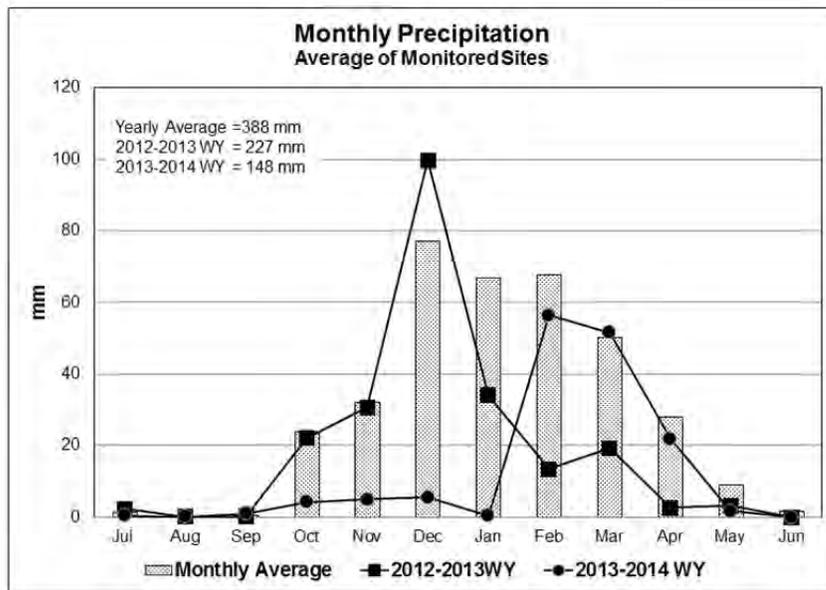


Figure 3—The average monthly distribution of rainfall at all monitored sites, 2000-2001 through 2013-2013 water year (WY). Also the distribution of 2012-2013 WY, and the 2013-2014 WY. A water year is July 1-June 30.

Rainfall, especially total amount, seemed to be the dominant factor in forage production. This pattern was clearly shown when averaged over all sites and years (fig. 4). Even though rainfall was the dominant factor, forage production still varied considerably from year to year and there were large differences from coastal, central to eastern zones during any given year (fig. 5). However, as expected the coastal zone

always had the highest forage production, and the eastern zone was always the lowest (fig. 6). During this study, the site with maximum production was at Cambria (2005-2006 growing season) and had 11 503 kg/ha while the site with the minimum production was at Soda Lake (2006-2007 growing season) and had 33 kg/ha. Overall the average was 3934 kg/ha across all years and sites.

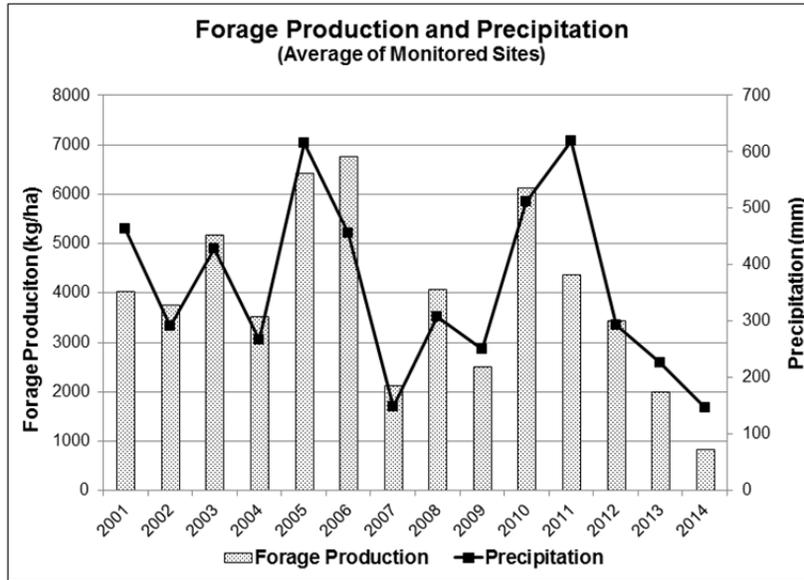


Figure 4—Average forage production and precipitation for all sites.

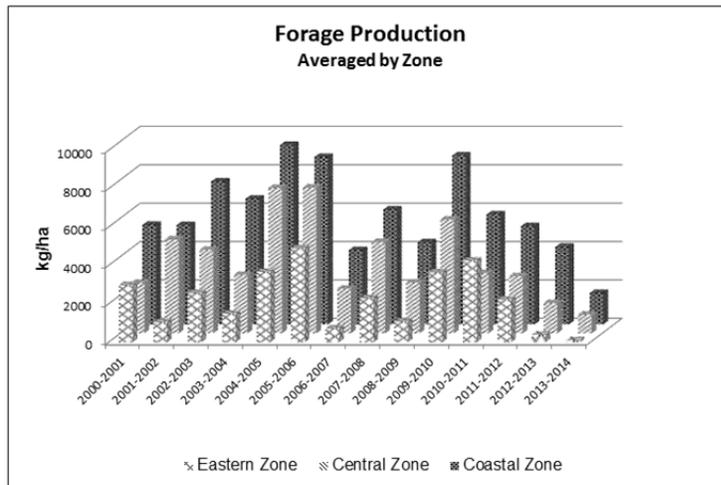


Figure 5—Total forage production for each site monitored in San Luis Obispo County. Production was measured at time of peak growth, late April or early May depending on the year.

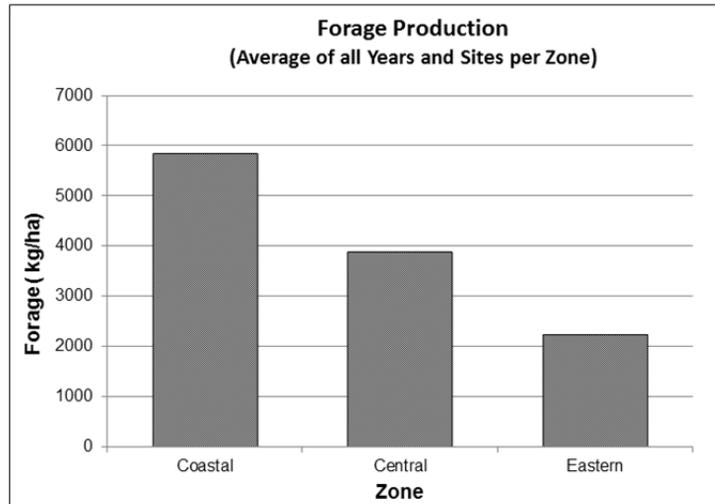


Figure 6—Total production stratified by rainfall regions of San Luis Obispo County. Coastal zone includes Cambria, Morro Bay, Cal Poly, and Huasna sites. Central zone includes Adelaida, Shandon, Creston, and Pozo sites. Eastern zone includes Bitterwater, Carrizo, Soda Lake, and Camatta sites.

Our data suggests a pattern of grass dominance over forbs when RDM was highest (fig. 7). Forbs seemed to increase, and sometimes even exceed grass cover, for a couple of years when RDM was low (fig. 7). This pattern was observed more so in the eastern side of the county where low productivity generally resulted in lower RDM levels.

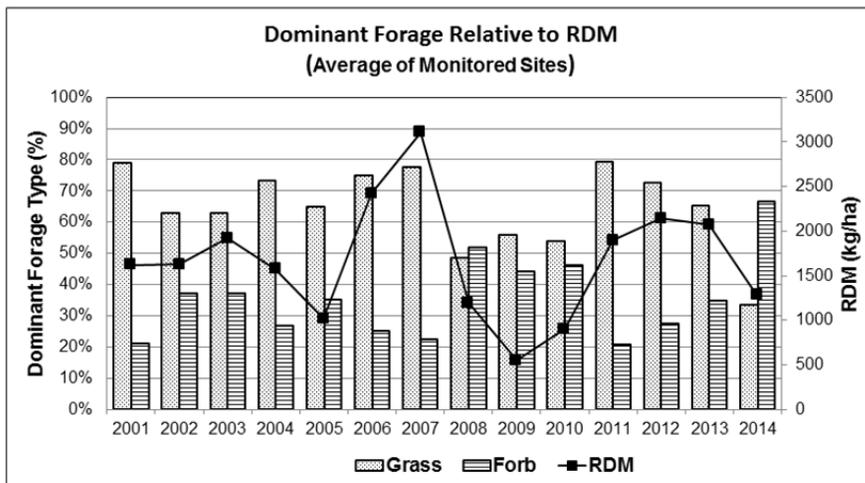


Figure 7—Dominate forage type, grass versus forb, relative to residual dry matter (RDM). RDM was measured during the fall prior to germination and growth of forage.

## Discussion

The interannual variability in total forage production makes land-use planning difficult. What is worse is that in many years, it may not be clear how productive a year it will be until most of the growing season has passed. Our data indicates a

larger interannual variation than George and others (2014a) reported for the three experimental ranges in Northern and Central California. The Central Coast often receives less precipitation than Northern California making management much more difficult for ranchers or range managers (George and others 2010). Such variation makes it difficult to maintain persistent numbers of breeding females in livestock herds. Since mother cows in a cow/calf operation have to be kept for the whole year, stocking should be kept light to moderate in order to ensure adequate feed during the leaner years. Stocker cattle are a good option for many to utilize extra feed during the wetter years. This can be helpful because the stockers can be removed (sold, or grazing leases closed) when the feed runs out.

We hope that by continuing to record fall RDM levels and subsequent peak production on the same sites, we may learn more about whether, or how much, low RDM levels impact recovery of production levels following periods of drought. We also anticipate learning about the magnitude of real drought impacts, and how best to express them to government policy makers.

## Acknowledgments

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## References

- Bartolome, J.; Frost, W.; McDougald, N. 2006. **Guidelines for residual dry matter of coastal and foothill rangelands in California**. Rangeland Monitoring Series. Publication 8092. Oakland, CA: University of California, Davis, Division of Agriculture and Natural Resources. <http://anrcatalog.ucdavis.edu/pdf/8092.pdf>. (11 February 2015).
- George, M.R. 2014. **Mediterranean climate**. Chapter 1. In: Annual rangeland handbook. Davis, CA: University of California, Davis, Division of Agriculture and Natural Resources. [http://californiarangeland.ucdavis.edu/Annual\\_Rangeland\\_Handbook/](http://californiarangeland.ucdavis.edu/Annual_Rangeland_Handbook/). (11 February 2015).
- George, M.R.; Becchetti, T.A.; McDougald, N.M.; Vahghn, C.E.; Flavel, D.K.; Forero, L.C.; Dudley, D.M.; Larsen, R.E.; Striby, K.D.; Frost, W.E.; Oneto, S.R. 2014a. **Monitoring annual rangeland forage production**. Davis, CA: University of California, Davis, Division of Agriculture and Natural Resources. [http://californiarangeland.ucdavis.edu/Monitoring\\_Annual\\_Rangeland\\_Forage\\_Production/](http://californiarangeland.ucdavis.edu/Monitoring_Annual_Rangeland_Forage_Production/). (11 February 2015).
- George, M.R.; Roche, L.M.; Eastburn, D.J. 2014b. **Ecology**. Chapter 6. In: Annual rangeland handbook. Davis, CA: University of California, Davis, Division of Agriculture and Natural Resources. [http://californiarangeland.ucdavis.edu/Annual\\_Rangeland\\_Handbook/](http://californiarangeland.ucdavis.edu/Annual_Rangeland_Handbook/). (11 February 2015).
- George, M.R.; Larsen, R.E.; McDougald, N.M.; Vaughn, C.E.; Flavel, D.K.; Dudley, D.M.; Frost, W.E.; Striby, K.D.; Forero, L.C. 2010. **Determining drought on California's Mediterranean-type rangelands: the noninsured crop disaster assistance program**. Rangelands 32(3): 16–20.
- George, M.R.; Bartolome, J.; McDougald, N.; Connor, M.; Vaughn, C.; Markegard, G. 2001. **Annual range forage production**. Rangeland Management Series. Publication 8018. Oakland, CA: University of California, Davis, Division of Agriculture and Natural Resources. <https://ucanr.edu/repositoryfiles/8018-54092.pdf>. (11 February 2015).
- O'Geen, A.T.; Arroues, K. 2014. **Soils**. Chapter 3. In: Annual rangeland handbook. Davis, CA: University of California, Davis, Division of Agriculture and Natural Resources.

[http://californiarangeland.ucdavis.edu/Annual\\_Rangeland\\_Handbook/](http://californiarangeland.ucdavis.edu/Annual_Rangeland_Handbook/). (11 February 2015).

Weitkamp, B. 1975. **The influence of climate on range forage production in San Luis Obispo County.** Farm Advisor Facts #16. San Luis Obispo, CA: University of California Cooperative Extension, San Luis Obispo County.