Forage Production Report

California Central Coast

2001-2019

Don Conestro (far right), at the UC Rancho Marino Reserve, explaining the forage production project to a group of UC Santa Barbara students

Royce Larsen, UC Cooperative Extension
Matthew Shapero, UC Cooperative Extension
Marc Horney, Cal Poly Rangeland Resources Program
LynneDee Althouse, Althouse and Meade, Inc.
Dan Meade, Althouse and Meade, Inc.
Katie Brown, Althouse and Meade, Inc.
Devii Rao, UC Cooperative Extension
Karl Striby, USDA Natural Resource Conservation Service
Craig Rigby, USDA ARS Forage & Range Research Lab
Kevin Jensen, USDA ARS Forage & Range Research Lab
[1]Don Conestro, UC Santa Barbara, Rancho Marino Reserve
Karl Lindsteadt, UC Cooperative Extension
Sarah Covello, UC Cooperative Extension

Thank you to all the landowners who have allowed us to come to their ranches to accomplish this project.
Thank you to: The San Luis Obispo County Agricultural Commissioner's Office, and the US Forest Service-Las Padres National Forest, the Russell L. Rustici Rangeland and Cattle Research Endowment and the Dahlgren Biogeochemical lab, UC Davis, for their support and help with labor and materials.

[1]The authors would like to posthumously thank and acknowledge Don Canestro for his work on this project, and for including the UC Santa Barbara Rancho Marino Reserve, which he loved, as one of the sampling sites.

Contact: Royce Larsen, (805) 434-4106, email: relarsen@ucanr.edu, website: http://cesanluisobispo.ucanr.edu/ direct link to report: http://cesanluisobispo.ucanr.edu/Custom_Program355/Forage_Production_Report/

Introduction

The purpose of this report is to discuss forage production in the California Central Coast from 2001 to 2019. These Rangelands are dominated by coastal prairies, annual grasslands, oak-woodlands and chaparral vegetation types (George et. al. 2014). Since California is at the confluence of several tectonic plates, there is a diverse geology leading to an assortment of soils that vary in their ability to support vegetation (O'Geen and Arroues 2014). In the Central Coast there are many (> 350) soil map units with elevation ranging from sea level to 5,000 feet. Average annual precipitation ranges from 42 inches to less than 6 inches. The coastal mountain range rises over 2500 feet, creating a rain shadow reducing precipitation east of the range. By 1993, range managers had divided San Luis Obispo County into three broad rainfall zones to facilitate range management decisions and general stocking densities (Weitkamp 1993), Figure 1. These precipitation zones are also used by the USDA Farm Service Agency in San Luis Obispo County. These three rainfall zones are defined as 1) the coastal precipitation zone (wet zone) with greater than 18 inches rainfall and a cooler coastal climate influence, this zone is rated at 8-15 acres per animal unit year (ac/AUY); 2) the central precipitation zone (moderate zone) with annual rainfall between 12 and 20 inches and without the cooler coastal climate influence, this zone is rated at 15-30 ac/AUY; and 3) the eastern precipitation zone (dry zone) with an average annual rainfall less than 12 inches, and no coastal climate influence, is rated at >30 ac/AUY (Figure 1). The variation in forage production is based on rainfall amount and timing, soil type, slope and aspect and temperature (Becchetti et al, 2016). Approximately 0.5 to 1.0 inch of rainfall during a 1-week period is needed to initiate germination and growth in annual rangelands. Annual range plants go through 4 different stages of growth including, germination or break of season, winter slow growth, rapid spring growth and finally peak forage production (Becchetti et al. 2016). Rainfall determines the beginning and end of the growing season while temperature determines the rate of forage productivity (Becchetti et al. 2016).

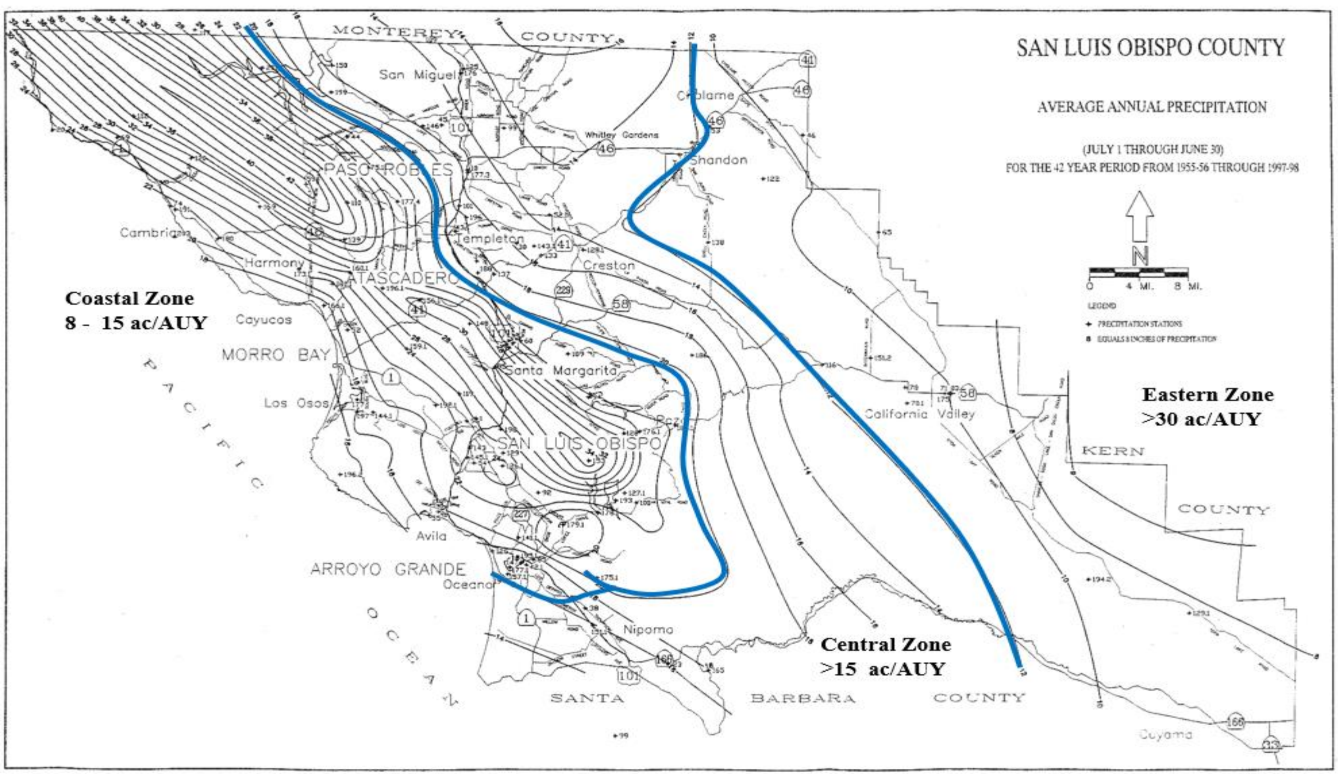

Figure 1. Precipitation Zones and Stocking Rates. Stocking rates (grazing capacity) and related precipitation zones in San Luis Obispo County (Information adapted from Weitkamp 1993). Grey isohyetal lines indicate precipitation averages per year. Blue lines divide the rainfall areas into three zones: Coastal, Central and Eastern with their average-animal unit year (AUY) stocking rate.

Methods and Site Locations

The three different precipitation zones previously described in reports for San Luis Obispo County, with their potential stocking densities, were expanded for Monterey, San Luis Obispo and Santa Barbara Counties. Results shown are based on the three general precipitation zones described in figure 1. To capture the variability of forage production there were 43 sites in the central coast representing a variety of precipitation zones, soil types, slopes and aspects and varying temperature regimes, Figure 2. Each site consists of 4 exclosures, see Appendix 1 for a description. Figure 2 shows the locations of the forage monitoring plots and Table 1 shows the year they were established. The averages from sites with greater than 3 years of data was used to compare the 2018-2019 growing season. For sites with less than 3 years of data, information from the USDA soil survey was used to estimate the normal, or "average" production.

Figure 2. **Monitoring Site Locations of the Central Coast.** The 43 forage monitoring sites for the cental coast. These sites were established between 2001 and 2019.

Table 1. Site Location by Year. The year data collection began from each site (left) is listed with site names and numbers.

Year	Site Name (The Name Describes the General Location of Each Site) and Site Number
2001	Adelaida (1), Cambria (3), Carrizo (4), Huasna (5), Morro Bay-S (6), Camatta Creek[1]
2003	Shandon (7)
2004	Bitterwater (8), Soda Lake (9)
2010	Creston (10), Pozo (11), Cal Poly-W6 (12)
2013	Morro Bay-N (13)
2014	Bitterwater-2 (14), Camatta Creek-N (15), Camatta Creek-S (16), Cayucos (17), Rock Pile Rd (18), San Miguel (19), Templeton (20), Topaz B3 (21), Topaz ST (22)
2015	Cal Poly-EU8-N (23), Cal Poly-EU8-S (24), Estrella (25), Shell Creek (27), Branch Mountain (28), Camatta Creek-T (29)
2016	Creston-2 (30), Cambria-2 (31), Gillam-FS1 (32), SLO (33)
2017	Zaca Station-1(35), King City (36), San Lorenzo Creek (37), Zaca Station-2 (42)
2018	Willow-FS2 (34), Los Alamos (38), HR-70 (39), HR-65 (40), River Rd (41)
2019	Office (2), Tepusquet Road (26), Bradley (43)
	[1]Camatta Creek was started as one site covering a south slope, north slope and top of the ridge, with one exclosure in each location. In 2014 and 2015 more exclosures were added, the sites were then relabled to better represent the South and North slopes, and the Top of Ridge.

The forage production results are shown as “usable forage”. Usable forage is that portion of the forage that can be grazed without damage to the basic resources (Society of Range Management, 2016) by depleting organic matter, increasing erosion and otherwise altering conditions necessary for sustaining forage production and ecological health. In the California annual rangelands, an important means of accomplishing this is leaving enough leftover plant litter to adequately cover the soil in the fall just prior to the beginning of rainy season. This old plant litter is referred to as residual dry matter (RDM). This RDM functions like a mulch that ensures maximal forage production in the coming season and helps protect soil from erosion at the onset of the fall rains. Recommended minimum levels of RDM in California annual rangelands are given in the publication “Guidelines for Residual Dry Matter on Coastal and Foothill Rangelands in California” (Bartolome et al. 2006). The current year’s total forage production, usable forage production and minimum recommended RDM values for each site are shown in Appendix 2.

Total forage production was measured each spring by clipping three, 1 ft^2 quadrats, within each of the four exclosures at every site at the time of peak growth stage. Samples were oven dried and weighed. Total forage production values are shown in Appendix 2 along with the calculations used to obtain “usable forage” values. Total forage production included all plants that were palatable to livestock. Plants not palatable, but were present and sampled, included fiddleneck (*Amsinckia* spp.), lupine (*Lupinus* spp.), doveweed (*Croton setiger*), locoweed (*Astragulus* spp.) and tarweed (*Hemizonia* spp.). These were excluded from the “total” and “usable” forage values. Rainfall was measured at each site using recording rain gauges starting in 2013. Prior to that, rainfall data was obtained from the nearest weather station operated by the County of San Luis Obispo, Bureau of Land Management’s Remote Automated Weather Stations (RAWS), or from the nearest ranch headquarters. A visual estimate of species composition was recorded for each site at the time of peak production. Starting in 2013, the dry-weight-rank method (See Appendix 3) was also used to determine species composition for each site (Ratliff, R.D., and W.E. Frost 1990), in addition to the visual estimate. See Appendix 3 for species composition for 2018–2019 growing season.

For the 2018–2019 growing season we added the analysis of forage samples for crude protein. Crude protein was estimated in the spring production samples using near infrared reflectance spectroscopy (NIRS). This compares the absorption of particular wavelengths of near infrared light beamed into a sample against the absorptance characteristics of nutrients from a library of similar reference samples. Samples were ground to pass through a 1 mm screen, then scanned using a model 6500, Pacific Scientific Instruments, scanner.

RAINFALL

Rainfall is reported by water year, which is defined as July 1st through June 30th (e.g. July 1, 2000 – June 30, 2001) for any given water year. A germinating rainfall occurred in November 2018. November was wetter than normal, while December was drier. January, February and March were above average rainfall. Overall 2018-2019 was a wet year when compared to a long-term rainfall record from the City of Paso Robles (Figure 3). Figure 4 shows average rainfall of all monitored sites for the project starting in 2001. Figure 5 shows the average monthly rainfall for 2018-2019. There was an unusual late season (after the annual forage plants had dried) rainfall event in May. That late season rain seemed to encourage growth of late season summer annuals, such as doveweed, tarweed, vinegar weed (*Trichostema lanceolatum)* and loco weed.

During 2001 to 2019, rainfall varied from the coastal to eastern sites and from year to year. The lowest rainfall recorded at any site, or year, was 1.70 inches while 40.65 inches was the highest. The years 2006-2007, and 2012 to 2015 were especially low rainfall years. However, as expected, the rainfall from 2001 through 2019 was consistently higher in the Coastal Zone than in the Central and Eastern Zones, Figure 6.

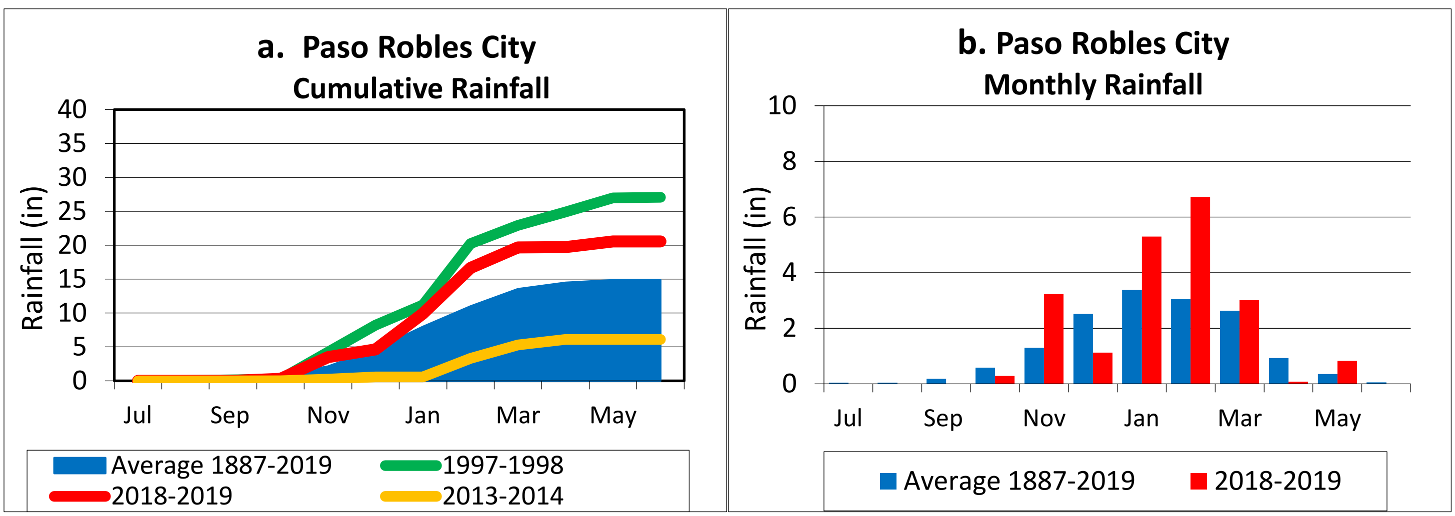

Figure 3. Paso Robles Precipitation. Graphs (a) and (b) show rainfall from 1887-2019, for the City of Paso Robles. Graph (a) is the cumulative long-term average (blue). The average is compared to rainfall totals for the wet 1997-1998 El Niño (green), the dry 2013-2014 (orange), and the current 2018-2019 (red) water years. Graph (b) shows the average monthly (blue) and the 2018-2019 water year (red). A water year is July through June. *(Data from City of Paso Robles)*

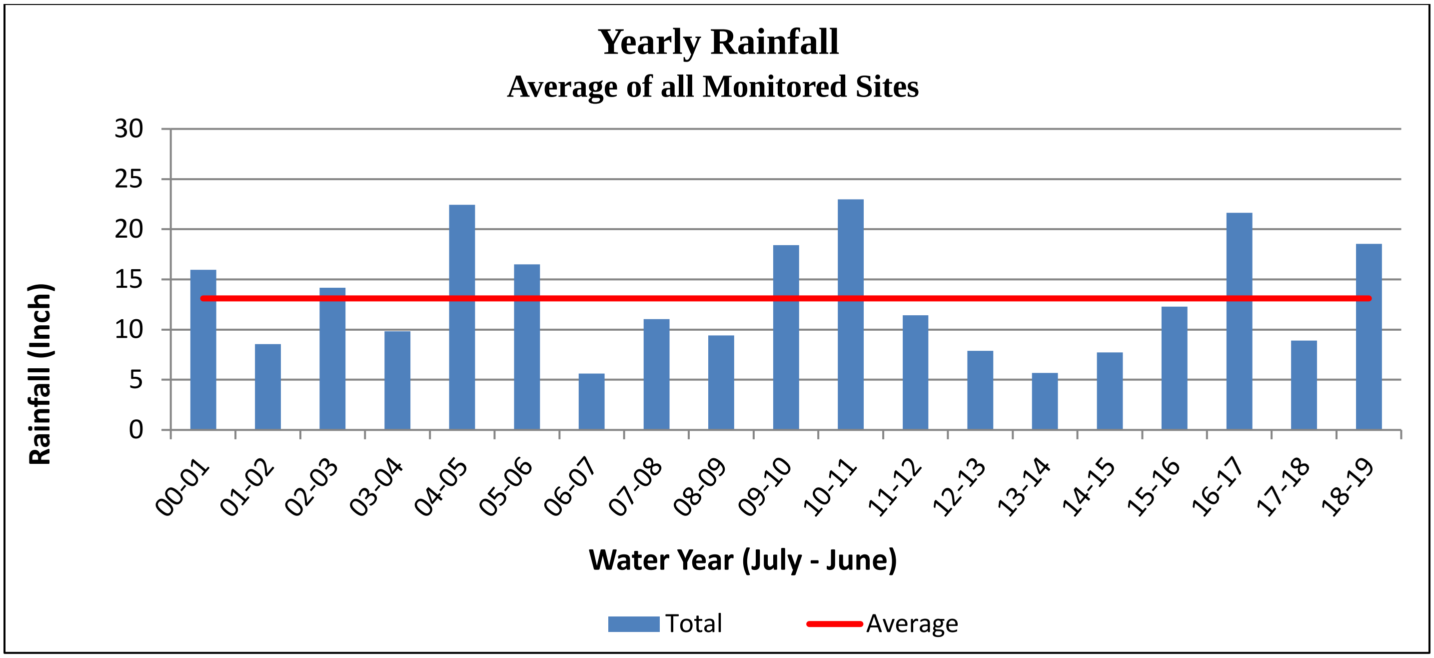

Figure 4. Average Precipitation All Years. Average rainfall of all monitored sites from 2001 to 2019. A water year is July through June.

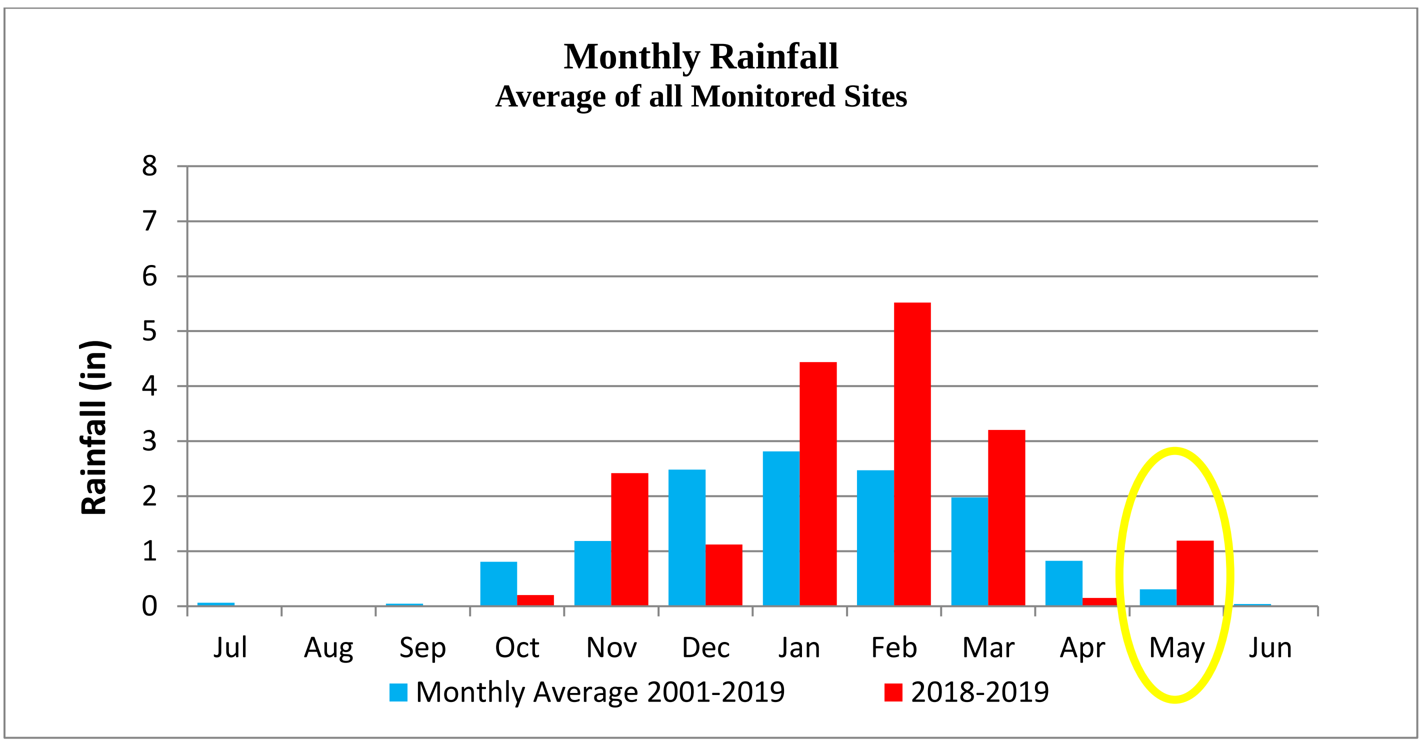

Figure 5. Average Precipitation 2001 – 2019. Average monthly rainfall for all monitored sites compared to the 2018-2019 water year. Note the late rain in May. A water year is July through June.

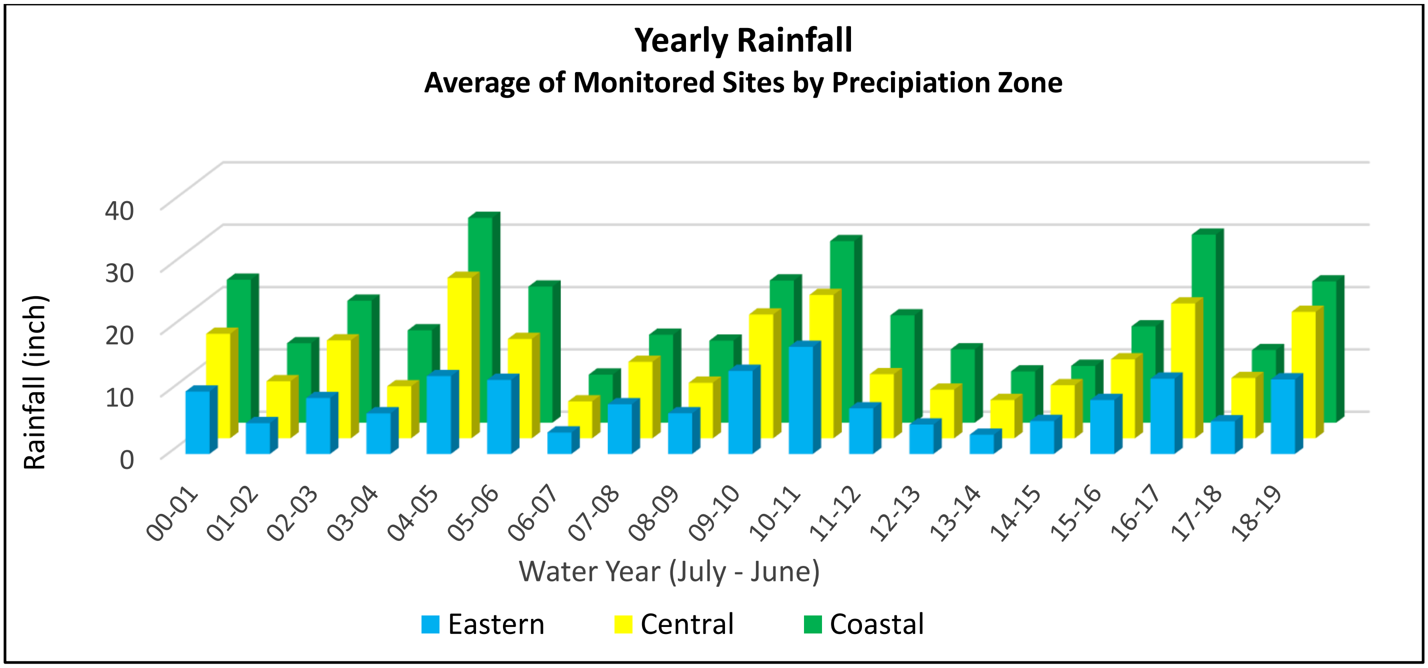

Figure 6. Precipitation Compared Between Zones Among Years. Average yearly rainfall for the Eastern, Central, and Coastal Precipitation Zones 2001 to 2019. A water year is July through June.

Usable Forage Production

The growing season corresponds to the water year, but growth only starts when rainfall begins and ends when the rainfall quits. Even though we had a slow start this year, with widespread germination occurring in November (germination usually occurs mid-late October), the average usable forage produced across all sites was about 120% of the average. This we think was due to the unusually wet January, February and March which likely made more moisture available into the rapid growth period of March and April. Average rainfall for all precipitation zones during 2018–2019 growing season was 157% above average, Figure 7.

However, when looking at forage production within each precipitation zone, the higher rainfall did not relate to higher usable forage production. The results showed that rainfall for the eastern precipitation zone was 142%, with usable forage production at 155% of average. The rainfall for the central precipitation zone was 159%, with usable forage production at 105% of average. The rainfall for the coastal zone was 170%, while usable forage production was slightly below average at 98%.

There was also usable forage variation from site to site within each precipitation zone. During the 2018-2019 growing season, the coastal zone had production between 5968 and 1842 lb/ac with an average of 4079 lb/ac. The central precipitation zone had production between 5647 and 842 lb/ac, with an average of 2675 lb/ac. The eastern precipitation zone had production between of 4125 and 195 lb/ac, with an average of 1478 lb/ac.

Figure 8 shows the variation in forage production by precipitation zone since the project began in 2001. There were large variations in usable forage production from year to year, and from the coastal (wetter) sites, to the eastern (drier) sites. The drought years, especially 2012 through 2016, had high forage losses and were excessively difficult for the livestock industry. During the 2013-2014 growing season, there was a 95% overall forage loss. There were a lot of cattle moved or sold due to that drought, so much that the lowest number of cattle sold since 1928 occurred in 2016 (San Luis Obispo County Annual Crop Report, 2016). The livestock industry is still trying to recover from that drought.

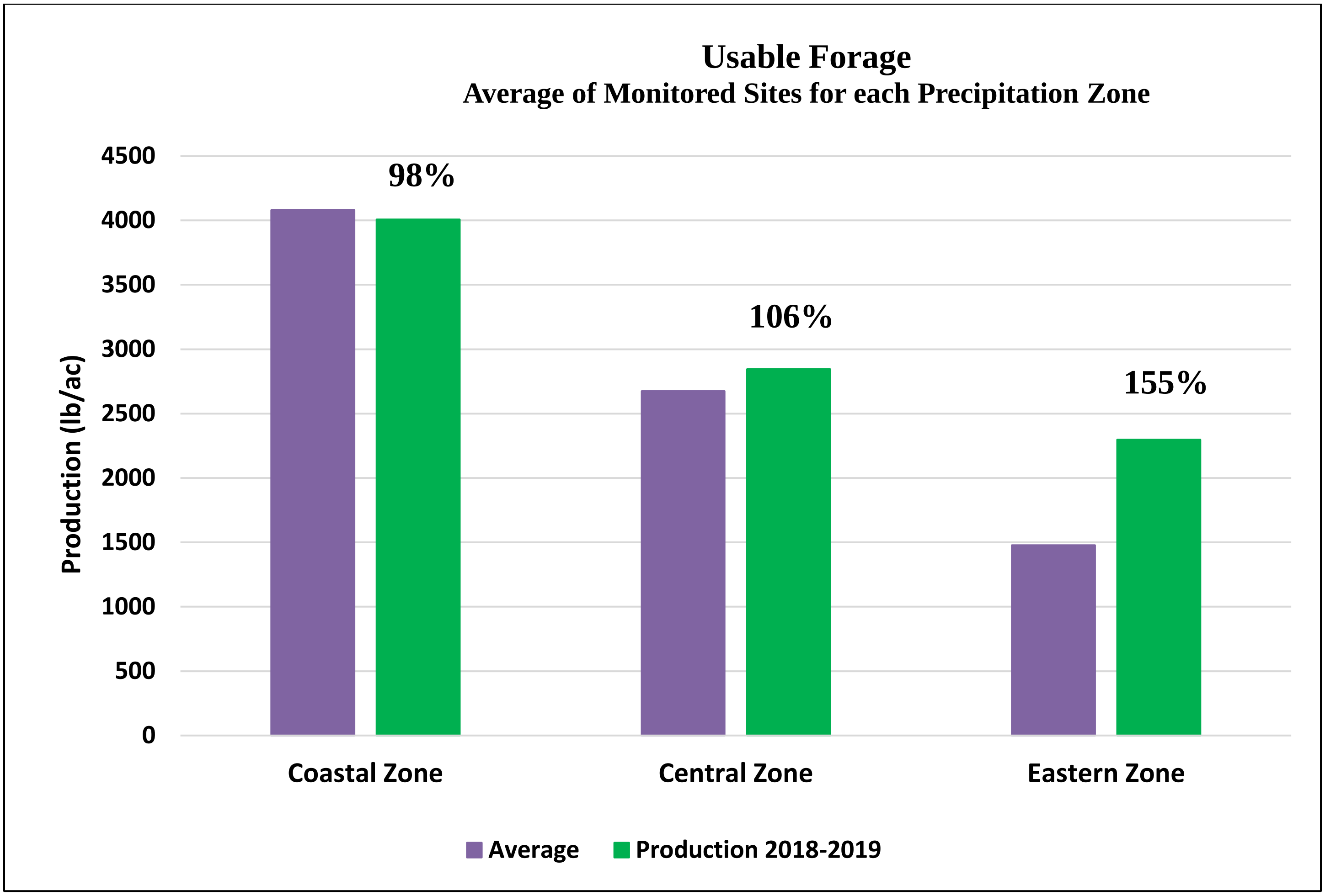

Figure 7. Usable Forage in 2018-2019. Usable forage production values showing the long-term average of each site, compared to the 2018-2019 growing season.

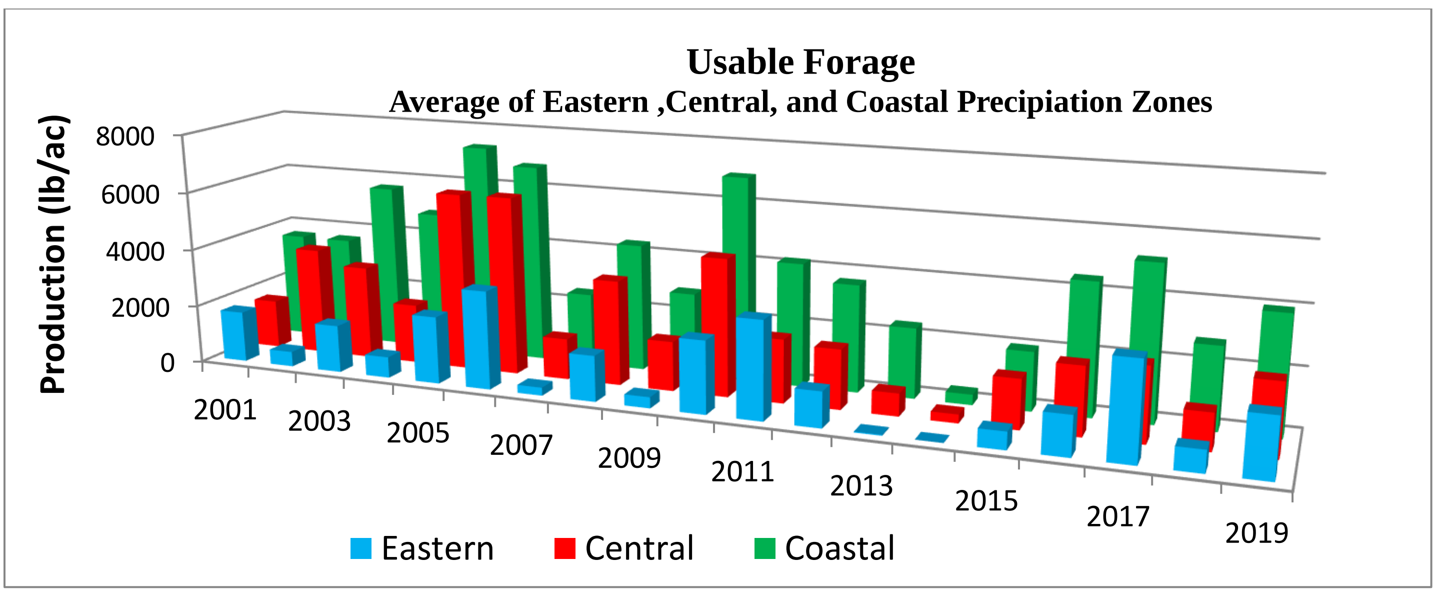

Figure 8. Usable forage production by Precipitation zone from 2001 through 2019. Note, production during the 2012 through the 2016 growing seasons' drought were very low, especially the 2013-2014 growing season.

Forage Species Composition

We measured two major classes of herbaceous (non-woody) forages: grasses and forbs. Forbs are the broad-leaved flowering plants like filaree, clovers, and the many species of wildflowers. Grasses have been the more dominant herbaceous forages on rangelands in the Central Coast, especially in the coastal precipitation zone.

Common forages by precipitation zone (Nomenclature via Jepson eFlora: http://ucjeps.berkeley.edu/eflora/ December 2019)

Eastern Precipitation Zone:

Grasses soft chess (*Bromus hordeaceus*), wild oat (*Avena spp.*), foxtail (*Hordeum spp.*), annual fescue (*Festuca spp.*), ripgut grass (*Bromus diandrus*), and red brome (*Bromus rubens*).

Forbs filaree (*Erodium* spp.), bur clover (*Medicago polymorpha*), and fiddleneck (*Amsinckia spp.*), annual clover (*Trifolium spp.*), deervetch (*Acmispon spp.*), and morning glory (*Convolvulus arvensis),* Mustard *(Hirschfeldia incana)*.

Central Precipitation Zone:

Grasses soft chess, wild oat, annual fescue, foxtail, red brome, and rye grass (*Festuca perennis*).

Forbs filaree, purple vetch (*Vicia americana*), deervetch, bur clover, fiddleneck, and owl's clover (*Castilleja spp.*).

Coastal Precipitation Zone:

Grasses rye grass, soft chess, wild oat, California oat grass (*Danthonia californica*), California brome (*Bromus carinatus*), annual fescue, purple needle grass (*Stipa pulchra*), and false brome (*Brachypodium sylvaticum*).

Forbs filaree, bur clover, plantain (*Plantago spp.*), lupine (*Lupinus spp.*), black mustard (*Brassica nigra*), pepper grass (*Lepidium spp.*), owl's clover and coast morning glory (*Calystegia macrostegia),* common vetch *(Vicia sativa ssp. nigra).*

From 2001 to 2019, the most dominant grasses in the coastal zone have been rye grass and wild oats, while soft chess brome, annual fescue, and red brome were most common in the central and eastern zones. Filaree has been the most common forb found in all three zones, but bur clover was also common.

Grasses and forbs, two classes of herbaceous forages, competed with each other for dominance through the years 2001 to 2019. Rainfall amount and timing, along with temperature, were the major factors contributing to the dominance of either type. Grasses tend to dominate during higher rainfall years while forbs tend to dominate during drier years. During the 2018-2019 growing season, grass was the dominate forage type in the coastal and central precipitation zones, but forbs slightly dominated in the eastern precipitation zone.

Grazing management is another factor that influences grass vs. forb domination (Bartolome et al. 2007). High amounts of RDM favors grasses, while low amounts of RDM favors forbs. Grasses usually dominated in the coastal and central precipitation zones each year (e.g., the higher rainfall areas), but in the eastern precipitation zone grasses and forbs changed dominance frequently depending on rainfall amount for any given year, Figure 9. The composition of each species for the 3 different precipitation zones during 2018-2019 are shown Appendix 3, Table 1.

CRUDE PROTEIN OF FORAGE

The nutritional value of forage for livestock depends on the species growing and season of use. Central Coast annual forage species generally germinate in mid-late October. They then remain in a slow growth phase, perhaps growing two to four inches, throughout the colder months of November, December, January and February in a pre-peak or early vegetative state. The rapid growth phase typically begins after warming starts in March, with the onset of seed production and plants reaching maturity, or peak production. For annual species, late vegetative stage is followed by senescence (drying period, or post-peak). The few perennial species usually green up in October, stay green longer into the spring, then go dormant during the long hot summer period.

Generally, forbs have more leaf area, and therefore a higher nutrient content, especially crude protein (CP), than grasses do. This is especially true at the late maturity stage. Most annual grasses tested were similar in their CP content, which was about 7% at late maturity (peak growth, but still green (figure 10). Mature beef cows (1,200 lbs live weight; moderate milk production potential) need 6% (post-weaning) to 11% (early lactation) of CP to maintain body condition and health (National Research Council, 2000). Peak growth for this report is defined as the point at which the majority of the usable forage (chiefly annual grasses) have seeded out but are still green. Forbs tested were found to have a much higher protein content than grasses, ranging from about 14% to 25%. Figure 10 illustrates CP values for common grasses and forbs observed on the Central Coast during the 2018-2019 growing season.

The phenological stage of plants also plays an important role in forage quality for livestock. The CP of composite samples (both grasses and forbs) during the early phenological stages (pre-peak) had a higher CP content than during the peak growth stage. Also, once plants began their drying phase (post peak period) CP declined significantly because annual plants die, loosing protein post maturation (Figure 11).

Protein concentrations in plants are chiefly concentrated in living leaves, where photosynthesis is occurring. Early in the season, leaves make up most of the above-ground weight of herbaceous (non-woody) plants. As the season progresses, plants begin to extend stems to elevate their leaves, and later flowers, higher above the ground. While green, those stems have far fewer photosynthetically active (and protein-rich) tissues than leaves, and they weigh more than leaves. This depresses protein concentrations in the plant, even as the total amount of plant biomass greatly increases. As herbaceous plants mature (finish flowering and have seeded out), their above-ground structures die back (perennials) or the entire plant dies (annuals). As this process proceeds, the leaves are the first to decay and fall from the plants. The already significantly reduced protein concentrations in the above-ground structures, diminished by the accumulation of cellulose from growing stems, falls even lower as the proteins that remain are lost to leaching and leaf decomposition.

CP content of composite samples, both grasses and forbs, decreased significantly over the growing season. The CP decreased from 9.6% to 5.8% during the “drying out” period which is below livestock requirements to maintain proper body condition, Figure 11. In addition, other factors may influence CP content after the forages have dried. For example, during the 2018-2019 season a large rainfall event that produced approximately 1.5 inches at each site in mid-May leached out an additional 1.5% of CP from the “already” dried forage (Figure 11).

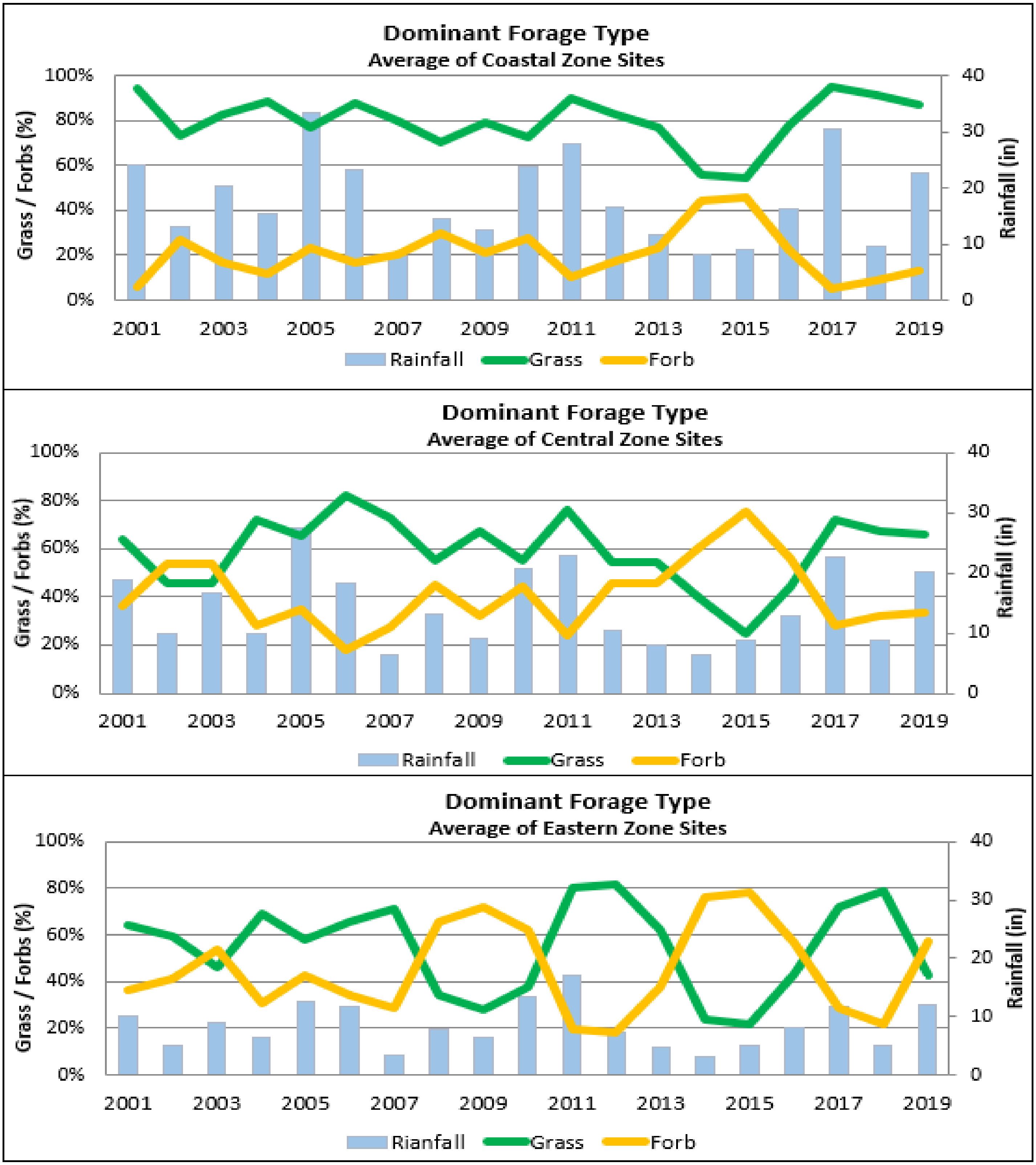

Figure 9. Average of dominant forage type, grass versus forbs, for each zone. Note that the grass and forbs added together equal 100%.

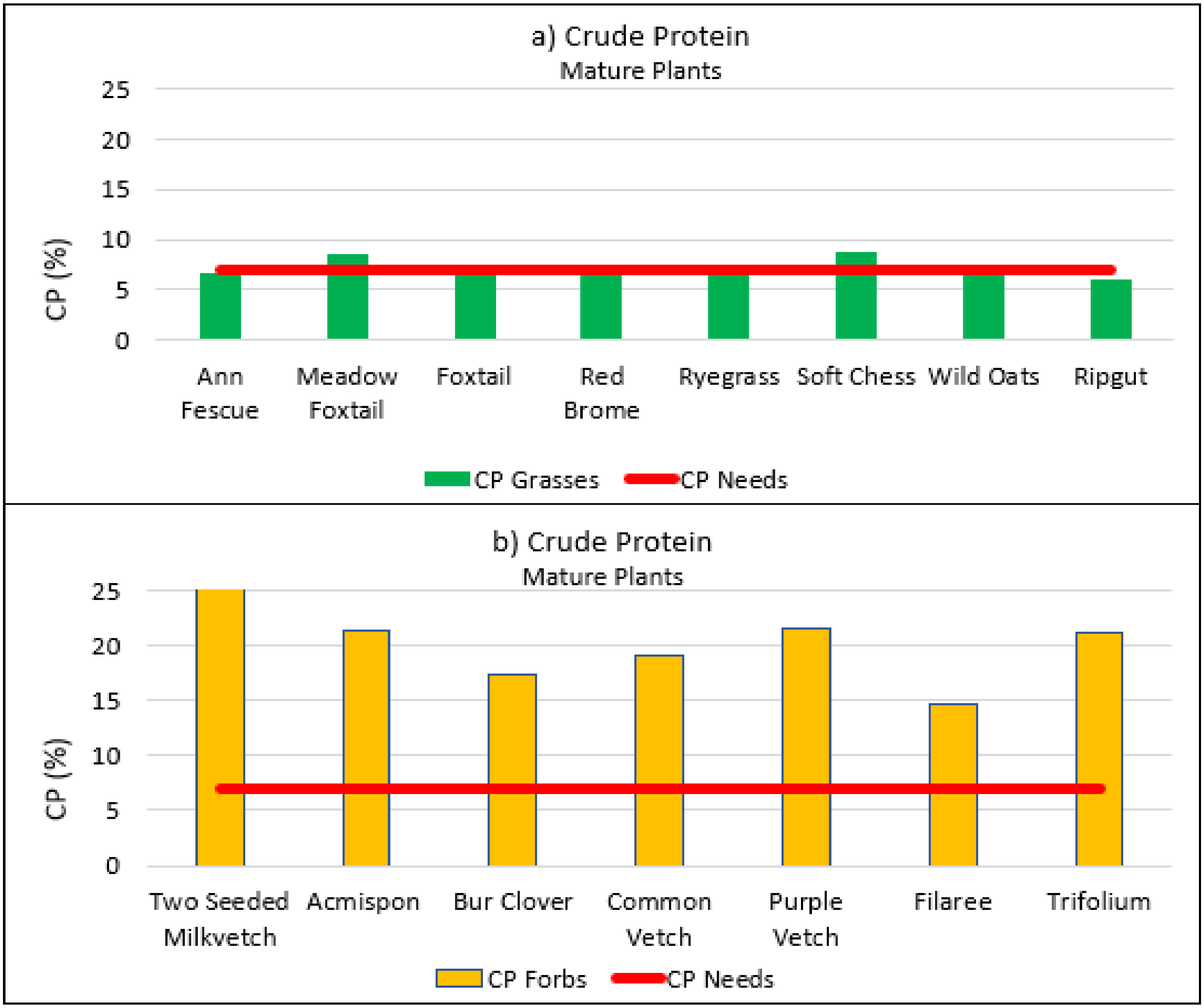

Figure 10. Crude protein values for different grasses and forbs on the Central Coast during the 2018-2019 growing season. Graph (a) shows the CP of grasses, while graph (b) shows CP content of forbs.

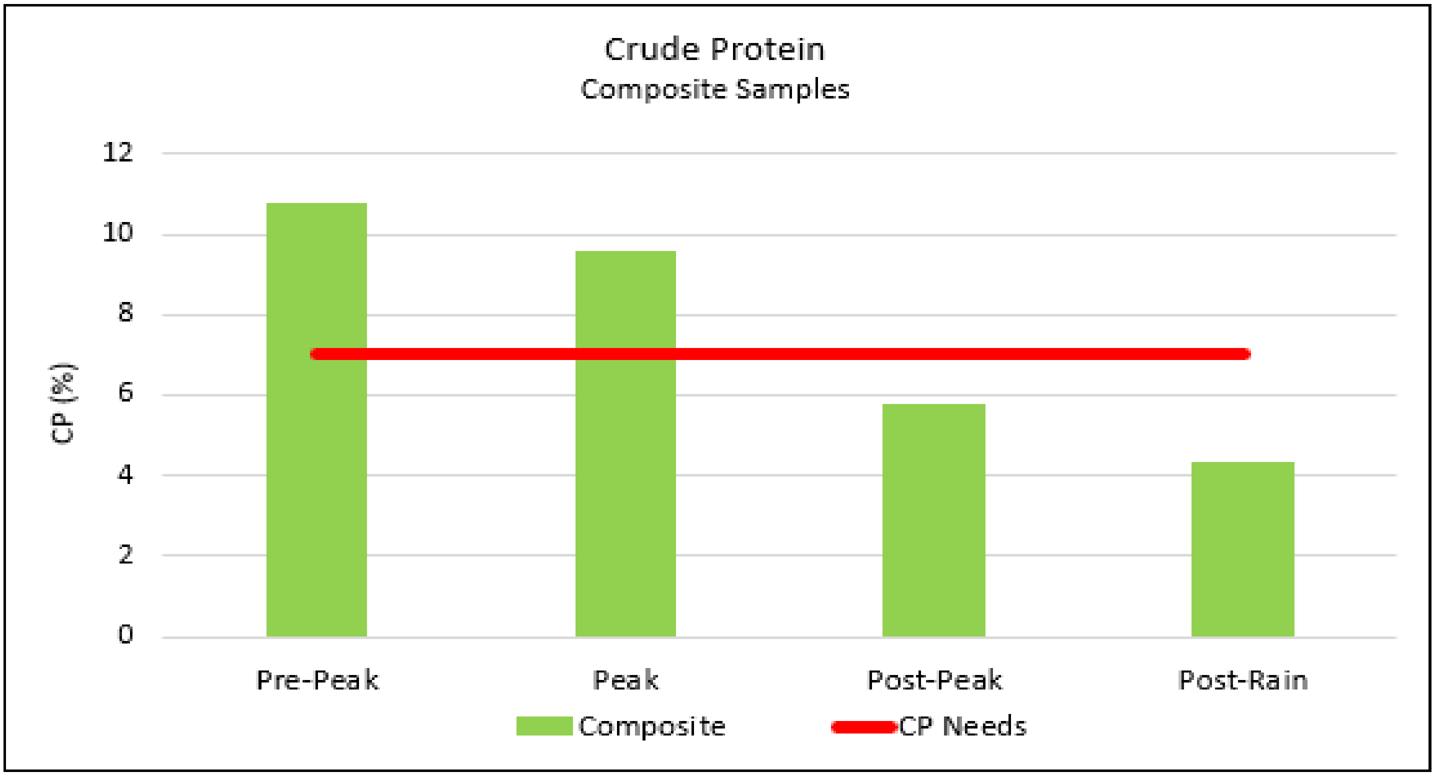

Figure 11. Crude protein of composite samples (both forbs and grasses) for 2018-2019 growing season. Pre-Peak is early phenological stage, Peak is when the plants have reached maturity (seeded out, still green), and Post-Peak is when plants have dried out after senescence. Post-Rain period was after a rainfall event occurred in May, after the forage had already dried. The red bar represents a mature cow's minimum CP required to maintain proper body condition and health.

SUMMARY

Rainfall for 2018–2019 water year for all sites combined was above average at 157%. Rainfall for the coastal zone was 170%, the central zone was 159%, and the eastern zone was 142% of the average rainfall. Usable forage production for the 2018-2019 growing season was above average overall at 120%. The coastal zone was 98%, the central zone was 105%, while the eastern zone was 155% of average. Grasses were the dominant forage type for the coastal and central sites, while forbs were more dominant for the eastern sites. Crude protein levels were approximately 7% for the grasses, and much higher for the forbs, ranging from 15% - 25% depending on the species. As expected, crude protein was higher for the composite samples (both grasses and forbs) during the early growth stages (10.7%) and began dropping at late growth stages (9.6%). Crude protein then dropped to less 5.8% after the forage had dried. Once the forage had dried, it no longer provided adequate protein to maintain proper livestock health without protein supplements. The late rain in May reduced crude protein from the forage by additional 1.5% to 4.3%. This unusual protein leaching event in May meant that livestock needed even more protein supplements than normal throughout the summer period.

References

Bartolome, J.W., W.F. Frost, N.K. McDougald. 2006. California Guidelines for Residual Dry Matter (RDM) Management on Coastal and Foothill Annual Rangelands. ANR Publication 8092. University of California Agriculture and Natural Resources Communication Services 6701 San Pablo Avenue, 2nd Floor Oakland, California 94608-1239. http://anrcatalog.ucdavis.edu/Items.aspx?hierId=10450 accessed May 18, 2015.

Bartolome, J.W., R.D. Jackson, A.D.K. Betts, J.M. Connor, G.A. Nader, K.W. Tate. 2007. Effects of Residual Dry Matter on Net Primary Production and Plant Functional Groups in Californian Annual Grasslands. Grass and Forage Science 62:445-452.

Becchetti, T., M. George, N. McDougald, D. Dudley, M. Connor, C. Vaughn, L. Forero, W. Frost, R. Larsen, J. Davy, K. Striby, M. Doran, G. Marrkegard. 2016. Rangeland Management Series: Annual Range Forage Production. University of California Division of Agriculture and Natural Resources Publication 8018

City of El Paso de Robles, California. 2019. Public Works Department. Accessed December 2019. http://www.prcity.com/government/departments/publicworks/water/rainfall.asp .

Frost, W.E., N.K. McDougald, R. Larsen, K. Churches and J. Bartolome. 2008. Disappearance of residual dry matter on the coastal and Sierran annual rangeland of California. Society for Range Management: Building Bridges Grasslands to Rangelands. Louisville, KY. Abstract No. 2435.

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/.

Global Rangelands. 2019. https://globalrangelands.org/inventorymonitoring/dryweight Accessed December 2019.

National Research Council. 2000. Nutrient Requirements of Beef Cattle, Seventh Revised Edition: Update 2000. Washington, DC: The National Academies Press. From web: https://www.nap.edu/catalog/9791/ nutrient-requirements-of-beef-cattle-seventh-revised-edition-update-2000. Accessed Dec. 16, 2019.

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.

Ratliff, R. D., W.E. Frost. 1990. Estimating Botanical Composition by the Dry-Weight-Rank method in California's Annual Grasslands. USDA Forest Service PSW Research Station, Research Notes PSW-410. October 1990.

Society for Range Management. 2016. Glossary of terms used in range management, fourth edition. Edited by the Glossary Update Task Group, Thomas E. Bedell, Chairman in 1998. Used with permission. Accessed online June 2016: https://globalrangelands.org/glossary/U?term=usable%20forage

Weitkamp, B. 1993. 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.

2016 San Luis Obispo County Annual Crop Report. https://www.slocounty.ca.gov/Departments/Agriculture-Weights-and-Measures/All-Forms-Documents/Information/Crop-Report/Crop-Report-Archive/Crop-Report-2016.aspx Accessed December 17, 2019.

Appendix 1.

Design of each site included 4 exclosures. The exclosures were made from 16' welded wire cattle panels. Three of the exclosures were put together using two 16' panels and 4 t-posts to form a 10' diameter exclosure, Figure 1. The fourth exclosure was put together using 3 ¼ cattle panels to form a 16' diameter circle (Fig. 1), which also housed the weather station, Figure 2.

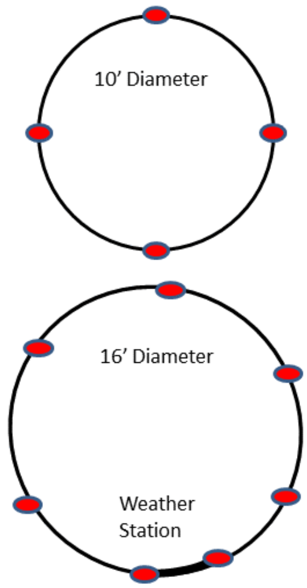

Figure 1. Exclosure design. Showing how the 4 exclosures are designed on each plot. They are made by using welded wire cattle panels and t-posts. Three exclosures were 10 feet diameter, while one exclosure was over 16 feet diameter.

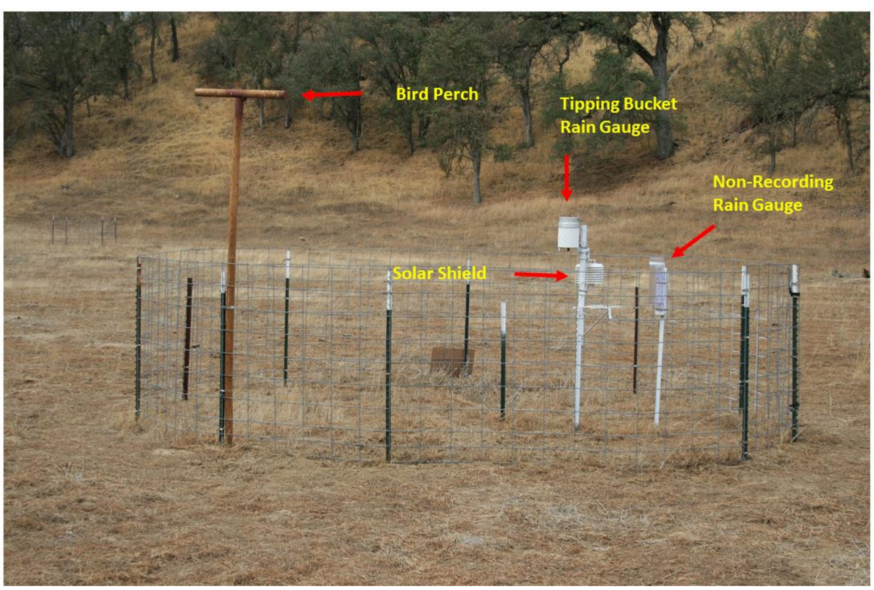

Figure 2. Tipping bucket rain guage. Pictorial showing the tipping bucket rain gauge, a non-recording rain gauge, a solar shield for the temperature sensor inside exclosure #4. The bird perch helps reduce birds perching on the rain gauge.

Since the amount of Residual Dry Matter (RDM) influences forage growth, the exclosures were moved each fall just prior to the rainy season. They were moved in a random direction and distance between 20 and 60 feet. They were kept on the same soil type, aspect, and slope. Exclosures 1-3 were moved each fall. Exclosure 4 was not moved, since the fourth one had the weather station. That exclosure was weed-whacked to reduce the RDM and to match the surrounding plot condition that existed at the time of movement in the fall, Figure 3. For peak production, three-1 ft^2 quadrats are clipped for production (composite samples), for a total of 12 quadrates for each plot. Composite samples included all forage, grasses and forbs, within the 1 ft^2 quadrats. The dry-eight-rank method was used to determine species composition for each quadrat.

Figure 3. Exclosure example. Pictorial demonstration showing how the exclosures were set up on each site. Exclosures 1-3 were moved each fall, while exclosure 4 was not moved due to the weather station set up. Exclosure 4 was weed-whacked to reduce RDM to match the surrounding area.

Appendix 2.

California rangeland stewardship guidelines emphasize managing for residual dry matter (RDM) levels at the beginning of the rainy season. University of California Division of Agriculture and Natural Resources has published recommended minimum values of RDM (Bartolome et al, 2006). However, many land managers are not aware that even if livestock are removed at the end of spring, forage residue levels continue to decline through the dry season due to physical and chemical breakdown, and losses incurred by small rodents or insects. Frost el al., 2008, found that dry vegetation can disappear at a rate of 7% per month from the end of growing season until the beginning of the rainy season. For this report we assumed a 5-month dry period from the time of peak production to the beginning of the wet period, mid-May to mid-October. It could be shorter or longer. Ranches that remove livestock by early spring, we advise adding an additional 7% RDM per month from the time cattle are removed until the rains begin. This will ensure that the minimum RDM levels are achieved when the rains return in the fall. Table 1 shows the recommended minimum RDM level for each site, the Peak Forage RDM Equivalent (the amount of forage needed in mid-May to achieve recommended minimum RDM values by mid-October if not grazed. The last two columns represent Total Forage Production and Usable Forage Production (Total Forage Production – Peak forage RDM Equivalent).

Table 1. Minimum RDM by Site. Minimum RDM values suggested for each site, peak forage RDM equivalent, and the total forage production and usable forage production values for each site. These peak forage RDM equivalent values are the amount of losses through the summer dry period (beginning of forage desiccation) and the first germination rain occurs mid-October, or 5-month period. There was an assumed loss of 7% per month.

Site NO.	Sites Name	Minimum RDM lbs/ac	Peak Forage RDM Equivalent lbs/ac	Total Production Spring 2019 2019 (lbs/ac)	Usable Forage Spring 2019 2019 (lbs/ac)
1	Adelaida	500	675	4270	3595
2	Office	700	945	6251	5306
3	Cambria	1200	1620	4463	2843
4	Carrizo	300	405	4530	4125
5	Huasna	500	675	4385	3710
6	Morro Bay-S	500	675	4304	3629
7	Shandon	500	675	2982	2307
8	Bitterwater	300	405	2920	2515
9	Soda Lake	300	405	2961	2556
10	Creston	400	540	1454	914
11	Pozo	500	675	2492	1817
12	Cal Poly-W6	500	675	4961	4286
13	Morro Bay-N	500	675	5118	4443
14	Bitterwater-2	300	405	4148	3743
15	Camatta Creek-N	400	540	2229	1689

16	Camatta Creek-S	400	540	2580	2040
17	Cayucos	500	675	6643	5968
18	Rock Pile Rd	400	540	3270	2730
19	San Miguel	400	540	2847	2307
20	Templeton	500	675	5012	4337
21	Topaz B3	300	405	600	195
22	Topaz ST	300	405	761	356
23	Cal Poly-EU8-N	700	945	2787	1842
24	Cal Poly-EU8-S	700	945	5195	4250
25	Estrella	400	540	4186	3646
26	Tepusquet	600	810	3193	2383
27	Shell Creek	400	540	2824	2284
28	Branch Mtn	300	405	1402	997
29	Camatta Creek-T	400	540	2010	1470
30	Creston-2	400	540	1382	842
31	Cambria-2	1200	1620	5007	3387
32	Gilliam-FS1	400	540	2246	1706
33	SLO	500	675	6056	5381
34	Willow-FS2	500	675	1755	1080
35	Zaca Station-1	500	675	3862	3187
36	King City	400	540	6146	5606
37	SLC	500	675	3811	3136
38	Los Alamos	500	675	4112	3437
39	HR 70	1200	1620	5896	4276
40	HR 65	800	1080	3096	2016
41	River Rd	800	1080	7148	6068
42	Zaca Station-2	500	675	3518	2843
43	Bradley	500	675	6322	5647

Appendix 3.

DRY-WEIGHT RANK METHOD - SPECIES COMPOSITION

The dry-weight rank method is described in the global rangelands' website (Global Rangelands, 2019). This method is specifically designed to determine species composition by providing a measure of the relative contribution of various species to the total biomass (based on dry matter content) for a site.

Dry-weight rank results are expressed only as percentage values, and do not quantify the actual biomass for each species. However, this problem can be circumvented by also determining the total biomass for the site, which is then proportioned to various species according to the percentage values derived from the dry-weight rank method.

This technique requires that the observer for each quadrat identify the first, second, and third most abundant species (on a dry weight basis), to which the ranks of 1, 2, and 3, are respectively assigned. When only 2 species occur in the quadrat, one of them should be given two ranks. For example, in a quadrat dominated by Lehmann lovegrass (*Eragrostis lehmanianna*) but including a few small croton (*Croton* spp.), the first and second rank may be assigned to Lehmann lovegrass, while croton is allocated the third rank If only one species is found, it receives all three ranks for that quadrat.

At the end of sampling, ranks are tallied for each species, and weighted by a set of multipliers, usually 0.7 for Rank 1, 0.2 for Rank 2 and 0.1 for Rank 3. The weighted values of the three ranks are then added together for each species, and the result represents species composition. For many observers, the seemingly arbitrary multipliers are a source of bemusement, because it effectively assumes the highest ranked species within the quadrat contributes 70% of the biomass, the second contributes 20%, and the third ranked species 10%, while other less conspicuous species are disregarded. However, these multipliers have been tested across a wide variety of vegetation types in USA, Australia and Southern Africa, and found to provide reasonably accurate and precise results. Table 1 shows the species composition for the 2018-2019 growing season. There were other plant species seen while sampling, but only those that had enough biomass to make one of the dry-weight-rank values were included in the table (Global Rangelands, 2019).

Table 1. Species composition for the 2018-2019 growing season, based on the dry-weight rank method. Other species were seen, but only in trace amounts, and therefore were not included in this table. A few species were grouped by genus, indicated by abbreviation for plural species (spp.).

Species Name	Common Name	Coastal	Central	Eastern	All Sites
Grasses		(%)	(%)	(%)	(%)
Festuca perennis.	Rye Grass	47.4%	1.0%	0.0%	**16.1%**
Avena Spp.	Wild Oat	12.2%	24.2%	7.1%	**14.5%**
Bromus rubens	Red Brome	0.0%	7.9%	13.3%	**7.1%**
Bromus hordeaceus	Soft Chess	8.5%	12.3%	3.1%	**8.0%**
Brachypodium distachyon	False Brome Grass	5.0%	0.1%	0.0%	**1.7%**
Festuca (Vulpia) spp.	Annual Fescue	2.4%	12.6%	10.4%	**8.5%**
Hordeum spp.	Foxtail	6.0%	3.9%	7.2%	**5.7%**
Bromus diandrus	Ripgut Grass	4.9%	4.4%	6.3%	**5.2%**
Stipa pulchra	Purple Needlegrass	0.6%	0.0%	0.0%	**0.2%**

Elymus triticoides	Creeping Wildrye	0.0%	0.1%	0.0%	**0.0%**
Poa bulbosa	Bulbous Blue Grass	0.0%	0.4%	0.0%	**0.1%**
Forbs					
Erodium spp.	Filaree	0.6%	13.2%	21.9%	**11.9%**
Medicago polymorpha	Bur Clover	6.6%	6.5%	0.0%	**4.4%**
Trifolium spp.	Annual Clover	0.8%	6.1%	7.9%	**4.9%**
Vicia spp.	Hairy or Purple vetch	0.6%	3.0%	0.0%	**1.2%**
Acmispon spp.	Deervetch, Spanish Clover	0.0%	0.1%	9.7%	**3.3%**
Lupine spp.	Lupine	0.0%	1.4%	4.9%	**2.1%**
Plantago lanceolatum	Plantain	0.6%	0.0%	0.0%	**0.2%**
Sisyrinchium atlanticum	Blue Eyed Grass	0.1%	0.0%	0.0%	**0.0%**
Convolvulus arvensis	Morning Glory	1.0%	0.0%	2.7%	**1.2%**
Calystegia macrostegia	Coast Morning Glory	0.0%	0.1%	0.0%	**0.0%**
Agoseris spp.	Dandelion	0.2%	0.0%	0.0%	**0.1%**
Chlorogalum pomeridianum	Soap Plant	0.6%	0.0%	0.0%	**0.2%**
Lomatium spp.	Lomatium	0.4%	0.0%	0.0%	**0.1%**
Castilleja spp.	Owl's Clover	0.1%	1.3%	1.3%	**0.9%**
Plagiobothrys spp.	Popcorn Flower	0.0%	0.3%	0.6%	**0.3%**
Astragalus didymocarpus	Two Seeded Milkvetch	0.0%	0.0%	0.2%	**0.1%**
Astragalus spp.	Loco Weed	0.0%	0.0%	1.3%	**0.4%**
Centaurea melitensis	Tocalote	0.0%	0.6%	0.3%	**0.3%**
Lepidium spp.	Pepper Weed	0.0%	0.0%	0.1%	**0.0%**
Descurainia pinnata	Tansy Mustard	0.0%	0.0%	0.1%	**0.0%**
Brassica nigra	Black Mustard	0.1%	0.4%	0.0%	**0.2%**
Leyia platyglossa	Tidy Tips	0.0%	0.0%	0.1%	**0.0%**
Ranunculus sp.	Buttercup	0.1%	0.1%	0.0%	**0.1%**
Unknown	Unknown	1.3%	0.0%	1.7%	**1.0%**