Cal Poly Ranches
Carbon Farm Plan
2020

Prepared by the Coastal San Luis RCD

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1. Introduction

Largely taken for granted, carbon has been absent from the discussion of elements essential to agriculture and the management of working lands; yet carbon is the basis for all agricultural production. Carbon enters the farm system from the atmosphere through the process of plant photosynthesis, which uses the energy of sunlight to capture carbon dioxide (CO2) from the air and combine it with water and nutrients from the soil to produce the products of agriculture: food, fiber, fuel and flora. Furthermore, photosynthates (sugars) produced by the plant are moved to the soil directly as exudates from plant roots and from the soil surface through litter from plant parts such as leaves and stems. These feed soil mycorrhiza, thus adding additional carbon to the soil. Another pathway for added soil carbon is through manure from animals.

In addition to its transformation from CO2 into the sugars, cellulose and lignin of the harvestable crop, carbon can also be beneficially stored long-term (decades to centuries or more) in soils and woody vegetation in a process known as terrestrial carbon sequestration. While the importance of carbon to soil health and fertility has long been understood, its significance has begun to be increasingly recognized in recent years. Today, managing for increased soil organic matter (SOM), which is about 50% carbon, is the core of the United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) healthy soils program and the California Department of Food and Agriculture's 2015 Healthy Soils Initiative.

Carbon Farm Planning is the process of identifying opportunities to decrease the production of greenhouse gases (GHG) on-farm and increase the photosynthetically driven transfer of atmospheric CO2 to stored carbohydrates in soils and above and below ground biomass. Enhancing working land carbon, whether in plants or soils, results in beneficial changes in a wide array of system attributes including: soil water holding capacity, soil hydrological function, biodiversity, soil fertility, agricultural productivity, as well as, resilience to drought and flood. Increasing carbon capture on working lands also helps slow rising levels of CO2 and other GHGs in the atmosphere, currently contributing to climate destabilization and unpredictability through global warming.

1.1 Carbon Farming

Technically, all farming is "carbon farming," because all agricultural production depends on the photosynthetic process of moving CO2 out of the atmosphere and into the plant where it is transformed into agricultural products, whether food, flora, fuel or fiber. Atmospheric carbon entering the farm can end up in several locations: the harvested portion of the crop; the standing crop carbon stocks (grassland vegetation, vines and orchards, etc.); the soil as root exudates; the soil organic matter from "waste" materials (compost or manure); or as other permanent woody or herbaceous vegetation (windbreaks, vegetated filter strips, forests and woodlands). While all farming is completely dependent upon carbon, the various farming practices, and the different farm systems, can lead to variable amounts of on- farm carbon capture and storage. The Carbon Farm

Planning (CFP) process differs from other approaches to land use planning by focusing on increasing the capacity of the working farm or ranch to capture carbon and to store it beneficially in the crop, in the standing carbon stocks, and/or in the soil.

While agricultural practices often lead to a gradual loss of carbon from the farm system, particularly from working land soils, CFP is successful when it leads to a net increase in farm-system carbon. By increasing the amount of photosynthetically captured carbon stored, or "sequestered," in long-term carbon pools on the farm or ranch, carbon farming results in a direct reduction in the amount of CO2 in the atmosphere, while supporting crop production and farm resilience to environmental stress, including flood and drought.

On-farm carbon in all its forms (SOM, perennial and annual herbaceous vegetation, plant roots, root exudates and standing woody biomass), contains energy, which originated as the solar energy used by the plant to synthesize carbohydrates from atmospheric CO2 and water and nutrients from the soil. The carbon in plants and SOM can thus be understood as the embodied solar energy that drives on-farm processes, including the essential soil ecological processes that determine water and nutrient holding capacity and availability for the growing crop. **Consequently, CFP places carbon at the center of the planning process and views carbon as the single most important element, upon which all other on-farm processes depend.**

CFP is based upon the USDA NRCS Conservation Planning process, but uses carbon and carbon capture as the organizing principle around which the farm or ranch plan is constructed. This simplifies the planning process and connects on-farm practices directly with ecosystem processes, including climate change mitigation and increases in: on-farm climate resilience, water holding capacity, soil health and agricultural productivity.

1.2 Carbon Farm planning process

Increasing on-farm carbon capture as biomass and, most importantly, soil carbon, is the resource concern of overriding importance for the CFP process. Similar to NRCS Conservation Planning, CFP begins with an overall inventory of natural resource conditions on the farm or ranch, but CFP focuses on identifying opportunities for reduction of GHG emissions and enhanced carbon capture and storage by both plants and soils. Building this list of opportunities is a brain-storming process that aims to be as extensive as possible, including everything the farmer and planners can think of that could potentially reduce emissions, capture and sequester on the farm. While actions proposed in the CFP should reflect the inherent limits of the farm ecosystem, financial considerations should not limit this initial brainstorming process, as one goal of the CFP process is to identify potential funding, above and beyond existing resources, to realize implementation of the CFP. Because carbon is so central to ecosystem processes, placing carbon at the center of the CFP process ensures "other," or more traditional, resource concerns are addressed in the planning process. Soil erosion or water quality issues, for example, are addressed in the plans by recognizing the carbon capture

opportunities associated with addressing these resource concerns. It is the premise of the CFP process that these resource concerns arise due to a failure to recognize the central role of carbon in the farm or ranch system, and that by addressing system carbon capture potential, virtually all other resource concerns will be addressed.

During this process, a map or maps of the ranch is developed, showing existing ranch infrastructure and natural resource conditions. These maps and field reconnaissance are used to locate potential carbon capture practices on the ranch and to envision how the ranch may be expected to look years down the road, following plan implementation. Next, the carbon benefits of each practice, as potentially applied at the farm scale are quantified using the online USDA GHG model, COMET-Farm (cometfarm.nrel.colostate.edu), COMET-Planner, (comet-planner.com), or similar tools and data sources, to estimate metric tons (Mg) of carbon dioxide equivalent (CO2e) that would be 1) avoided, or 2) removed from the atmosphere and sequestered on farm by implementing the identified conservation practices. A site-specific list of potential practices and their on-farm and climate mitigation benefits is then developed.

Finally, practices are prioritized based on the needs and goals of the farm or ranch, choosing high carbon-benefit NRCS conservation practice standards (CPS), wherever possible (Appendix B). Economic considerations may be used to filter the comprehensive list of practices, and funding mechanisms are identified, including: cap and trade, CEQA mitigation, or other GHG mitigation offset credits, USDA-NRCS and/or other state and federal programs, and private funds. Practices are implemented as funding, technical assistance and farm scheduling allow. Over time, the CFP is evaluated, updated, and altered as needed to meet changing farm objectives and implementation opportunities. The fully implemented plan scenario is the ultimate goal or point of reference. Where plan implementation is linked to carbon markets or other ecosystem service markets, periodic Plan evaluation may be tied to those verification or monitoring schedules.

Additional information about Carbon Farming is online at: 1) www.marincarbonproject.org and 2) www.carboncycle.org.

2. Purpose + Need

Totaling nearly 4,000 acres, the Ranches owned by California Polytechnic State University at San Luis Obispo (Cal Poly) present an ideal location and opportunity for the first carbon farm plan completed in San Luis Obispo County. With over 1,000,000 acres in rangeland, San Luis Obispo county ranchers feel the impacts of climate change on a daily basis. Arid temperatures, erodible soils, and prolonged periods of droughts have demonstrated the necessity for climate resilient farming. Cal Poly sold off nearly all their herd during the early years of the drought from 2012 to 2015. An estimated $7.3 million dollar loss in revenue occurred across 1 million acres of rangeland in San Luis Obispo County from 2014-2015 (Macon et al. 2016). Through adaptive and resilient management, the Cal Poly rangeland manager hopes to avoid similar predicaments in the future.

2.1 Regional Nexus

Cal Poly has long been a leader in California for educating new generations of producers and technical specialists in the science and practice of managing livestock and the landscapes used by them in grazing operations. In fact, current and historical master plan updates for the campus have been protective of agricultural lands, as opposed to converting ag lands into additional housing facilities and parking structures. By developing the carbon farm plan in collaboration with faculty and staff, we are increasing awareness and early adoption of these carbon-centric practices by the future land managers and technical assistance providers in the state. If 25 students are exposed to carbon farming methods through courses in rangeland management, soil health, or natural resources management every year, by 2035 nearly 400 carbon farmers will be trained and positioned to progress carbon sequestration through rangeland management, just through this one plan.

The City of San Luis Obispo has set the most ambitious carbon emission targets in the country, aiming to be carbon neutral by 2035. The City faces a huge obstacle in reaching this target: transportation emission reductions are often the most challenging to achieve, and Climate Action Plans often identify sequestration opportunities to offset these emissions. By developing a comprehensive Carbon Fam Plan for the Cal Poly Ranches, we are providing the City of San Luis Obispo with an offset option to help meet its ambitious 2035 goals.

2.2 Resources

The Coastal San Luis RCD (RCD) staff collaborated closely with an interdisciplinary team of Cal Poly faculty, staff and students to develop this plan, including support from the Natural Resource Management department, Soils, Rangeland Management, Agricultural Operations, and City and Regional Planning.

Aaron Lazanoff, Rangeland Manager, provided unparalleled insight into his approach to effective rangeland management, guided the development of maps and baseline reports, and collaborated to identify additional carbon-focused practices to improve soil health, water holding capacity and forage production of his ranches while also maximizing carbon sequestration potential. Aaron also provided unlimited access to all rangeland resources, including Pasture Map and Cattle Max, and a number of GIS resources. He also participated in a working group pursuing funding for a Rancher 2 Rancher program in San Luis Obispo County.

Kevin Piper, Agricultural Operations Manager, was an indispensable source of management data and was always available and engaged in planning activities. As the compost facilities manager, his insight was integral in identifying appropriate locations and application rates for compost. Kevin's

long-time involvement in all agricultural operations on campus served as valuable material for baseline reporting.

Mark Horney, Rangeland Resource Management Professor, consulted extensively with RCD staff to identify potential opportunities for carbon sequestration and general rangeland goals, and provide numerous opportunities for student engagement. Mark initiated GPS data collection of all rangeland resources through his courses and partnered with GIS staff to upload this data to ArcGIS online. His students have done extensive residual dry matter and plant materials sampling with 8 sampling points per pasture. He also participated in a working group pursuing funding for a Rancher 2 Rancher program in San Luis Obispo County.

Chip Appel, Natural Resource Management faculty, provided ideas and opportunities for future student involvement in soil characterization.

Beth Reynolds, Sheep and Goat enterprise supervisor, provided insight and management history for Cheda Ranch and guided the management plan for that ranch.

Craig Stubler, soil science technician, provided soil data and resources for baseline assessments, as well as a number of opportunities for future student involvement in the implementation of this plan.

Royce Larson, UC Cooperative Extension Watershed Advisor, has conducted rangeland monitoring research in San Luis Obispo and Monterey counties for over 20 years. He produces forage production reports summarizing this research, available through the Cooperative Extension. He participated in a working group pursuing funding for a Rancher 2 Rancher program in San Luis Obispo County.

Adrienne Greve, City and Regional Planning Professor, provided insight on campus-wide planning efforts, Climate Action Plan background and updates, and invited RCD staff into her classrooms to discuss the importance of Carbon farming with students who would otherwise not be exposed to the concept.

2.3 Management Applications:

Rangeland Manager Aaron Lazanoff utilizes the application Pasture Map in conjunction with Cattle Max, to track cattle, optimize grazing rotations, and efficiently manage over 4,000 acres of rangeland. His students are also trained to use these apps, and full access was provided to RCD staff during the development of this plan.

Russ White, Cal Poly GIS and Data specialist, provided RCD staff access to key GIS data and files as well as technical support in GIS and mapping efforts.

2.4 Studies, Plans and Assessments:

The Cal Poly Climate Action Plan, developed in 2012 by a student team led by Professor Adrienne Greve, provided invaluable baseline information on emissions and sequestration potential on the Cal Poly Ranches. RCD staff and the Cal Poly team will work with Dr. Greve during subsequent plan updates. Similarly, the Cal Poly Master Plan was an indispensable source for baseline development and insight into long-range planning for the campus. The San Luis Obispo County 2016 Energy Wise Plan update identifies efforts led by Cal Poly and the RCD as integral in achieving county-wide emission targets. RCD Staff will work with SLO county in the future to increase opportunities for carbon sequestration.

The SLO Creek Watershed Enhancement Plan, prepared by the SLO Land Conservancy for the Coastal Commission in 2002, the SLO Creek TMDL for nutrients and sediment, and the Pacific Watershed Associations watershed assessment informed riparian management and restoration sections described in this plan.

2.5 Data Gaps

Soils Mapping

The soils on Cal Poly rangeland have been inconsistently characterized by various Cal Poly student fieldwork efforts, and no complete, site specific, soil survey exists beyond the USDA Soil Survey for the region. There are excellent soil science staff on-campus who have expressed interest in conducting soil organic matter and carbon sampling as funding becomes available. This characterization would help describe co-benefits of practices such as compost application, Keyline plowing, silviculture, and rangeland planting.

Vegetation mapping

Some vegetation mapping on Cal Poly rangeland has been done by Mark Horney's Rangeland management students and Royce Larsen. Larsen has characterized the grassland dominated by perennial ryegrass (*Festuca perennis*) and wild oats (*Avena sp.*). Mark's students have collected grass herbarium specimens and recently established Residual Dry Matter (RDM) monitoring plots on Walters and Escuela. Work needs to be done to make this data readily available, such as digitizing existing herbarium specimens. Characterizing the grass species at each ranch could be done in partnership with Cal Poly students and a UC Cooperative Extension agent.

3. Cal Poly Agricultural Operations

The Agricultural Operations (Ag Ops) division of the College of Agriculture, Food, and Environmental Sciences (CAFES) at Cal Poly supports the large, diversified ranching and farming enterprises of departments within the College, which is the focus of this plan. This enterprise encompasses 6,000-plus acres of ranching operations, which include the Cheda (133 acres), Chorro Creek (415 acres),

Escuela/Walters (2,400 acres), Peterson (417 acres), and Serrano (632 acres) ranches that are managed by the Animal Science Department.

Each of the enterprises within the Ag Ops represent an important component of the holistic and diverse activities and land uses present at Cal Poly. In addition to the ranches are the Dairy, Swine, and Poultry units, the crop unit, including both conventional and organic crops, orchards and vineyards, the compost facility and the sports complex.

3.1 Dairy, Swine, and Poultry units

The dairy, swine and poultry units are run as campus enterprises, with meat, eggs and other products available for sale to the public. The Cal Poly Poultry Center has housing facilities for 7,000 broilers and 7,000 replacement pullets. In addition, the Poultry Center has two egg production facilities—a two-story turbo house and a stack-deck house. Both houses are exact replicas of the facilities currently used by the commercial egg production industry. The Poultry Center also contains a research house that can hold approximately 2,200 birds. With 96 pens each capable of holding 22 to 25 birds, this research building has the capacity for various contract research and in the past, has been used for research in nutritional immunology.

The swine facility and the swine herd are managed by student resident managers. Gestating sows are kept outside in pasture lots until farrowing. The farrowing barn is equipped with 16 stalls and sows are brought into the barn as a group. Piglets are weaned at three to four weeks of age and moved into the enclosed, temperature-controlled nursery. Sows are rebred using artificial insemination and returned to the pasture lots. The nursery-grower building with two rooms, each equipped with 14 pens, nipple waterers and stainless-steel feeders. Pigs stay in the nursery-grower for eight weeks, and then move to the finisher. A battery room with 96 individual brooding pens is also available and used for short-term trials.

The Cal Poly Dairy Products Technology Center, the predecessor of the Dairy Innovation Institute, was formed in 1986 to meet the growing needs of the dairy industry for relevant research, industry training, and skilled graduates. In 2016, this Center was combined with the dairy educational programs and commercial activities at Cal Poly to form the Dairy Innovation Institute.

3.2 Crop Unit

The Crop unit includes both conventional crops as well as an organic farm. The organic farm is a 9-acre production unit certified organic by the California Certified Organic Farmers (CCOF) with the primary mission of providing undergraduate students a place to experience hands-on learning in organic and sustainable farming and gardening practices. The vegetable production includes dozens of varieties of produce that are marketed in several local direct sales events like farmer's markets, a campus farm market and to local vendors and restaurants; produce not sold is donated to the Food

Bank. The organic farm also serves as a classroom and laboratory to other Cal Poly courses and research programs. Faculty, staff and students jointly manage and steward the farm. The organic farm is supported by the Horticulture and Crop Science Department, the College of Agriculture, Food and Environmental Sciences, and also by grants and private donations.

3.3 Orchards and Vineyards

The San Luis Obispo region is known as one of the best areas for growing avocados and citrus throughout California and Mexico. Because of this, as well as the high level of profit these crops can bring to the Cal Poly College of Agriculture, avocados and citrus are popular crops throughout Cal Poly land. In total, 60 acres of avocado crops are currently being grown on Cal Poly land, including 50 acres on Cheda Ranch. The majority of these crops are maintained by Mission Avocado.

Cal Poly features a 14-acre state-of-the-art commercial vineyard and pilot winery, providing students an excellent opportunity to practice the Learn by Doing method of education. All students are required to complete internships in the grape or wine industry and to participate in undergraduate research programs, clubs and enterprise projects on campus. A new Wine and Viticulture Innovation Center is currently under construction.

3.4 Compost Facility and Manure Management

Cal Poly operates a state-of-the-art composting facility that produces a certified organic material in bulk to the public. In 2011 the Cal Poly composting operations became members of the U.S. Composting Council's Seal of Testing Assurance Program. Cal Poly began on-campus composting operations during the 1990s. Initially, the operations relied on static piles to compost manure. In 1997, Dr. Doug Williams initiated windrow composting operations, which developed into an enterprise project with the BioResource and Agricultural Engineering Department. As the composting operations expanded and required increased management, they were assigned to the Agricultural Operations Department. Today, under the guidance of department staff and supervision of student employees, the compost unit processes over 7,000 cubic yards of manure and 3,500 cubic yards of green waste and wood chips into 3,500 cubic yards of finished compost annually. Cal Poly sells 1,000 cubic yards and uses the rest of the compost.

The composting operations process livestock manure from the dairy, beef evaluation center, beef unit, equine center, and poultry unit and incorporate the green waste generated from campus landscaping. As part of Cal Poly's Water Quality Management Plan, Agricultural Operations is responsible for maintaining the confined livestock operations on the campus farm. This involves manure management of both solids and liquids. Solids are removed routinely and composted or spread on approved fields and pastures identified in the water quality management plan. Liquids are captured within lagoons at several of the animal units. The accumulated lagoon water is then utilized as an irrigation resource on fields and pastures approved within the water quality

management plan. Associated with the use of both lagoon water and lagoon solids are specific quarterly water quality monitoring requirements designed to ensure proper use and monitoring of groundwater resources.

3.5 Nexus with the Cal Poly Climate Action Plan (CAP)

Cal Poly's 2016 Climate Action plan, developed by students in the City and Regional Planning department and led by professors Adrienne Greve and William Riggs, assesses baseline emissions and opportunities for carbon sequestration and emission reductions in eight campus-wide categories: Buildings, Agriculture, Transportation, Water, Solid Waste, Campus Life, Renewable Energy, and the Public Private Partnership. The plan development process included a campus-wide green-house gas emission inventory that quantified all emissions on campus, including those from the ranches and ag ops department. A background report was generated that included a vulnerability assessment and summary of current laws and policies. The Climate Action Plan was developed based on these steps, and included goals, objectives and strategies; quantified potential emission reductions; opportunities for adaptation, and an implementation strategy. The plan is now used as a tool by facilities management and development to guide future development and maximize carbon sequestration opportunities and GHG reductions campus-wide.

It stands to reason that each of the enterprises housed within the Ag Ops department is deserving of stand-alone carbon farm plans that investigate the distinct and specific opportunities for carbon sequestration and greenhouse gas emission reductions, and develop enterprise-specific solutions for each. Encompassing all enterprises in one plan was determined to be too broad an approach.

This carbon farm plan focuses on the baseline assessment, strategies and opportunities identified in the agricultural category, which include strategies that reduce GHG emissions on campus by focusing on sustainable rangeland management, enhancing digital tracking systems for both animals and fertilizers, preparing the agricultural departments for climate adaptation, and installing an anaerobic digester. Several practices within campus agricultural activities influence GHG emissions, including enteric fermentation, fertilizer application, composting operations, and waste lagoon management. Ag operations employs strategic agricultural practices to promote sustainable operations including ag water use efficiency, rest-rotational grazing, and on-site composting, however faculty and land managers acknowledge the importance of climate resilience and carbon sequestration and are actively adopting and promoting opportunities, identified in this plan, to continue these efforts. For instance, the CAP identifies the implementation of an anaerobic digester with the potential to sequester 334 metric tons of CO2 by 2040, or implementing a livestock feeding regime to reduce enteric fermentation with the potential to avoid emitting 29 metric tons of CO2 by 2040. While these values seem exceptionally conservative, it shows the potential for increased sequestration and emissions avoidance through on-campus infrastructure projects. The CAP also identifies

as sequestration opportunities with the potential to sequester 2,428 metric tons of CO2 by 2040, however the CAP acknowledges this opportunity may already be in the process of being realized, through the work of range manager Aaron Lazanoff and his use of Cattle Max and Pasture Map to optimize grazing efficiencies.

3.6 Swanton Pacific Ranch CFP

A Carbon Farm Plan was completed for the Swanton Pacific Ranch (SPR), a satellite property of the University in Santa Cruz County, in November 2019 (https://cfs.calpoly.edu/carbon_farm_plan). The Cal Poly Foundation acquired the Swanton Pacific Ranch from alum and founder of Orchard Supply Hardware, Al Smith, in 1994, with the understanding that the ranch would remain intact and natural, a lab and a classroom for the College of Agriculture for Learn by Doing forever. The 3,200-acre SPR comprises much of the original Rancho Agua Puerca y Las Trancas Land Grant and has passed from the stewardship of local indigenous tribes to large land grants interspersed with smallholdings. At this time, the Swanton Carbon Farm Plan focuses on 75 organically farmed acres within the 3,200-acre Ranch.

The SPR CFP details the benefits from carbon farm practices already completed, including stream habitat improvement, critical area planting, grassed waterways, and stream and shoreline protection. These past restoration practices have accrued 116.7 Megagrams 1 Mg = 1 million grams, or one megagram) = one metric ton s of carbon dioxide (Sacha Lozano, Jeffrey Creque and Lynette Niebrugge 2019). The plan also identifies opportunities for additional carbon farm planning including cropland and orchard management, conservation crop rotation and cover cropping, composting, tillage management, forage and biomass plantings, prescribed grazing, and establishment of windbreaks and hedgerows.

As a living document, the Cal Poly Ranches CFP will be modified and updated to include adapted goals and objectives and lessons learned, including from the CAP and SPR CFP

4. Cal Poly Ranches overview

Cal Poly's 4,000-acre rangeland operation is managed as five separate ranches, including Cheda (133 acres), Chorro Creek (415 acres), Escuela/Walters (2,400 acres), Peterson (417 acres), and Serrano (632 acres). Ranches are managed using rest-rotational grazing, ensuring a stable balance between herd health and rangeland health. Goals for this project are to manage rangeland to increase carbon sequestration, increase the ecological integrity of Cal Poly lands, and provide a learning opportunity to Cal Poly students.

Figure 1. Escuela/Walters and Chorro Ranch are to the northeast of San Luis Obispo and Cheda, Serrano, and Peterson Ranches are southeast of the campus

4.1 Existing Environmental Conditions

4.1.1 Climate

San Luis Obispo supports a Mediterranean climate which is distinguished by warm, wet winters under prevailing westerly winds and calm, hot, dry summers, as is characteristic of the Mediterranean region and parts of California, Chile, South Africa, and southwestern Australia. The overall average temperature in San Luis Obispo is 59.3 degrees Fahrenheit, with an average high of 71.3 degrees and an average low of 47.3 degrees.

4.1.2 Weather

Average annual rainfall in San Luis Obispo is 19.02 inches. The following weather data was retrieved from the MesoWest online weather database, specifically the ARGC1 weather station located approximately 0.5 miles from Cal Poly and is categorized by season.

Months	Average Precipitation	Average Temperature	Average Wind Speed	Average Humidity
September - November	2.80 in	63.47 deg F	1.66 mph	54.73%
December - February	11.38 in	50.25 deg F	2.14 mph	73.31%
March - May	4.68 in	56.56 deg F	4.35 mph	77.32%
June - August	0.16 in	65.33 deg F	3.65 mph	74.59%

4.1.3 Vegetation

The Cal Poly ranches are classified as grassland and savanna ecosystems dominated by non-native perennial grasses and annual forbs interspersed with some native species, and managed under continuous grazing management. Species that dominate this grassland include Rye Grass (*Lolium perenne*), Wild oats (*Avena sp*.), False Brome (*Brachypodium distachyon*), and bur clover (*Medicago polymorpha*) (Larsen 2019). Savanna species include Fremont cottonwood (Populus fremontii) , Western sycamore (Platanus racemosa) , and various Oaks (Quercus xx). This rangeland is also frequently crossed by legacy roads which were designed poorly and erode significantly during storm events. In addition to the grassland and savanna ecosystems, there are distinct riparian ecosystems along perennial springs and streams in the watershed which, in many locations, are impacted by animals grazing in the riparian zone, mobilizing sediment into adjacent drainages. There are also some oak woodland and chaparral ecosystems in the upper watershed which are relatively healthy and well-managed. Hiking and mountain biking trails blanket the watershed, and have a variety of conditions - some are very stable and some see significant erosion during storm events.

4.1.4 Hydrology/Watershed

Cheda Ranch, Serrano Ranch and Peterson Ranch are within the Stenner Creek Watershed, a sub-watershed of the San Luis Obispo Creek watershed which flows into the Pacific Ocean approximately 15 miles south of Morro Bay. Walters, Escuela and Chorro Creek ranches are in the Chorro Creek watershed, with Chorro Creek, Pennington creek, and Walters creek flowing through the ranches. Chorro Creek flows through public and private rangeland and cropland for approximately 10 miles before it discharges into the Morro Bay Estuary. The Walters and Escuela ranches include numerous springs which have been developed for stock water sources.

Serrano and Peterson Ranches have 10 miles of access roads with many undersized culverts and social trails that disrupt local hydrology (Casarez 2009). This has merited a grant application for restoration within the Stenner Creek watershed to the California Department of Fish and Wildlife by Pacific Watershed Associates, Creek Lands Conservation, and the RCD. Escuela and Walters have 27 miles of access roads, and a restoration project was completed in 2015 that addresses sediment delivery from undersized culverts, eroded road crossings, and bank failures.

4.1.5 Wildlife

These ranches support a diversity of wildlife species. Wildlife species include large carnivores such as mountain lions and bears. Carnivore presence on these lands indicates a healthy food-web of smaller carnivores and herbivores such as skunk, ground squirrel, wild pig, coyote, fox and bobcat. Riparian corridors support a diversity of bird species, amphibians, and insects.

Chorro and Stenner creeks and their tributaries are important streams for populations of threatened south coast steelhead trout (Casarez 2009). Any activities which reduce the loading of fine sediment to these tributaries, will improve spawning and rearing habitat. In addition, the California Department of Fish and Wildlife has observed over 10 barriers in the watershed to fish passage (Stark and Wilkison 2002). Other possible listed species include western pond turtle, giant garter snake, monarch butterfly, and Smith's blue butterfly. Listed amphibians include California red-legged frog, Foothill yellow-legged frog, and California Tiger Salamander. Listed bird species include California black rail, Western yellow-billed cuckoo, California clapper rail, bald eagle, Southwestern willow flycatcher, bank swallow, Least Bell's vireo, and California condor.

4.1.6 Topography

All ranches, except for Chorro, are composed of rolling hills that lead to coastal foothills covered with oak woodlands. The elevation across the rangeland varies from 200 feet at Chorro Ranch to 2000 feet in Serrano Ranch. Most fields have a slope greater than 20% grade. The northern portion of the area extends into the Los Padres Mountains, with hillslopes exceeding 70% grade along tributaries (Casarez 2009).

4.1.7 Ecological Site Description

Ecological Site descriptions (ESDs) provide a consistent framework for classifying and describing rangeland soils and vegetation, delineating land units that share similar capabilities to respond to management activities or disturbance. ESDs include site-specific management information about natural vegetation, weeds, forestry, grazing, wildlife, and dynamic soil properties. Land managers can use this information to evaluate land suitability and respond to different management activities or disturbance processes (esis.sc.egov.usda.gov).

Land managers traditionally use visual assessment and experiential knowledge of their rangeland to delineate boundaries between ESDs. Each ranch can have few to many ecological sites which can dictate the response to implementation of planned practices, and the landscape's ability to sustain productivity over time. For example, the specific slope and aspect of a site can help determine what species of tree, shrub or grass will thrive. This, in turn, would also affect the degree of potential carbon sequestration due to survival rate or growth potential. For example, increasing soil organic carbon with compost applications may be a very productive strategy on a shallow soil on a south-facing slope of 30%, but of limited value on an organic matter-rich meadow site. Ecological sites correlate to which plant species will be suitable for a specific site or restoration project.

ESDs have been developed by the USDA-NRCS for certain parts of the country, however ESDs for San Luis Obispo County are general and lack definition. The following table includes the predominant ESDs for each of the Ranches in this plan. Cal Poly Rangeland Management professor Mark Horney, who previously worked for the NRCS and UC Cooperative Extension, acknowledges the benefits of refined, site specific ESDs in California and will lead a series of workshops for resource professionals and Cal Poly students about delineating and determining ESDs in mid-2020.

Range Ecological Site	Soil Type	Map Unit	% of Ranch
Escuela/Walters Ranch			
R015XD001CA — CLAYEY	Diablo and Cibo clays, 15 to 30 percent slopes	131	24.6
	Diablo clay, 5 to 9 percent slopes	129	6.2
	Diablo and Cibo clays, 30 to 50 percent slopes	132	6.2
	Cropley clay, 0 to 2 percent slopes	127	5.6
R015XD049CA — LOAMY CLAYPAN	Los Osos-Diablo complex, 30 to 50 percent slopes	165	10.8
	Los Osos loam, 15 to 30 percent slopes	160	8.8
	Los Osos loam, 30 to 50 percent slopes	161	6.8
Chorro Creek Ranch			
R015XD001CA — CLAYEY	Diablo clay, 5 to 9 percent slopes	129	33.9

R014XD001CA — CLAYEY	Cropley clay, 0 to 2 percent slopes	127	20.9
	Cropley clay, 2 to 9 percent slopes,	128	11.7
R015XD049CA — LOAMY CLAYPAN	Los Osos loam, 15 to 30 percent slopes	160	5.9
Serrano/Peterson Ranch			
R015XD146CA — SHALLOW CLAYEY SERPENTINE	Obispo-Rock outcrop complex, 15 to 75 percent slopes	183	24.0
R015XD049CA — LOAMY CLAYPAN	Los Osos loam, 15 to 30 percent slopes	160	13.5
R015XD024CA — FINE LOAMY	Gazos-Lodo clay loams, 30 to 50 percent slopes	144	16.4
R015XD001CA — CLAYEY	Diablo and Cibo clays, 30 to 50 percent slopes	132	8.2
	Diablo and Cibo clays, 15 to 30 percent slopes	131	10.8
Cheda Ranch			
R014XD105CA — LOAMY CLAYPAN	Concepcion loam, 15 to 30 percent slopes	123	6.8
R015XD001CA — CLAYEY	Diablo-Lodo complex, 15 to 50 percent slopes	133	7.7
R015XD070CA — SHALLOW FINE LOAMY	Lodo clay loam, 5 to 15 percent slopes	147	8.6
	Lodo clay loam, 15 to 30 percent slopes	148	30.4
R015XD049CA — LOAMY CLAYPAN	Los Osos loam, 15 to 30 percent slopes	160	13.7
	Los Osos-Diablo complex, 9 to 15 percent slopes	163	8.7
R014XD109CA — FINE LOAMY BOTTOM	Salinas silty clay loam, 0 to 2 percent slopes,	197	5.8

4.1.8 Soils

According to the USDA NRCS Web Soil Survey ((http://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx), the predominant soil types within the ranches are Diablo and Cibo clays, 15 to 30 percent slopes, Los Osos-Diablo complex, 30 to 50 percent slopes, Diablo clay, 5 to 9 percent slopes, Cropley clay, 0 to 2 percent slopes and 2 to 9 percent slopes, Obispo-Rock outcrop complex, 15 to 75 percent slopes, Los Osos loam, 15 to 30 percent slopes, Lodo clay loam, 15 to 30 percent slopes, Cropley clay, 0 to 2 percent slopes, and Gazos-Lodo clay loams, 30 to 50 percent slopes. The soil types are separated into soil map units and associated acreages are included in the following table.

The Cal Poly Soils department has recently expanded to include additional faculty whose expertise and area of interest include soil organic matter. While there has not yet been a comprehensive soil assessment of the Ranches, Soils department faculty have begun developing curriculum for 2020 courses to include developing sampling transects, collecting regular soil organic matter samples, and modeling SOM results. This ongoing data collection and analysis is essential to understanding and documenting carbon sequestration rates on rangeland. The UC

Cooperative Extension, led by Royce Larson, has developed monitoring plots on each of the ranches to monitor changes in Soil Organic matter as well.

Soil Type	Map Unit	% of Ranch
Escuela/Walters Ranch		
Diablo and Cibo clays, 15 to 30 percent slopes	131	24.6
Los Osos-Diablo complex, 30 to 50 percent slopes	165	10.8
Chorro Creek Ranch		
Diablo clay, 5 to 9 percent slopes	129	33.9
Cropley clay, 0 to 2 percent slopes	127	20.9
Cropley clay, 2 to 9 percent slopes,	128	11.7
Serrano/Peterson Ranch		
Obispo-Rock outcrop complex, 15 to 75 percent slopes	183	24.0
Los Osos loam, 15 to 30 percent slopes	160	13.5
Gazos-Lodo clay loams, 30 to 50 percent slopes	144	16.4
Cheda Ranch		
Lodo clay loam, 15 to 30 percent slopes	148	30.4
Los Osos loam, 15 to 30 percent slopes	160	13.7

4.1.9 Ranch Management

Cal Poly rangeland is managed through rest-rotational grazing. No pasture is grazed for more than 5 days at a time and some are grazed for only half a day. This practice controls brush and pests through concentration of livestock and encourages growth of perennials by prolonging periods during which livestock are absent. This grazing management approach results in an increase in annual carbon capture on these rangelands when compared to a more conventional single-pasture, set stocking approach. Hypothesized mechanisms include: enhanced nutrient cycling and increased periods of rest, during which time the plant community can accumulate carbon in roots and crowns and soils can recover from any negative impacts from livestock. Aaron Lazanoff has managed the ranches utilizing this approach since 2008, and has seen increases in livestock yields and meat quality, as well as rangeland health and increased forage production. All livestock are processed using the government Process verified Program (PVP), verifying age and source

Aaron has increased the fencing structure on Walters and Escuela ranch to achieve his rest-rotational grazing goals and would like to do the same on Peterson and Serrano ranches. All pasture water troughs are spring or well-fed using a gravity fed system.

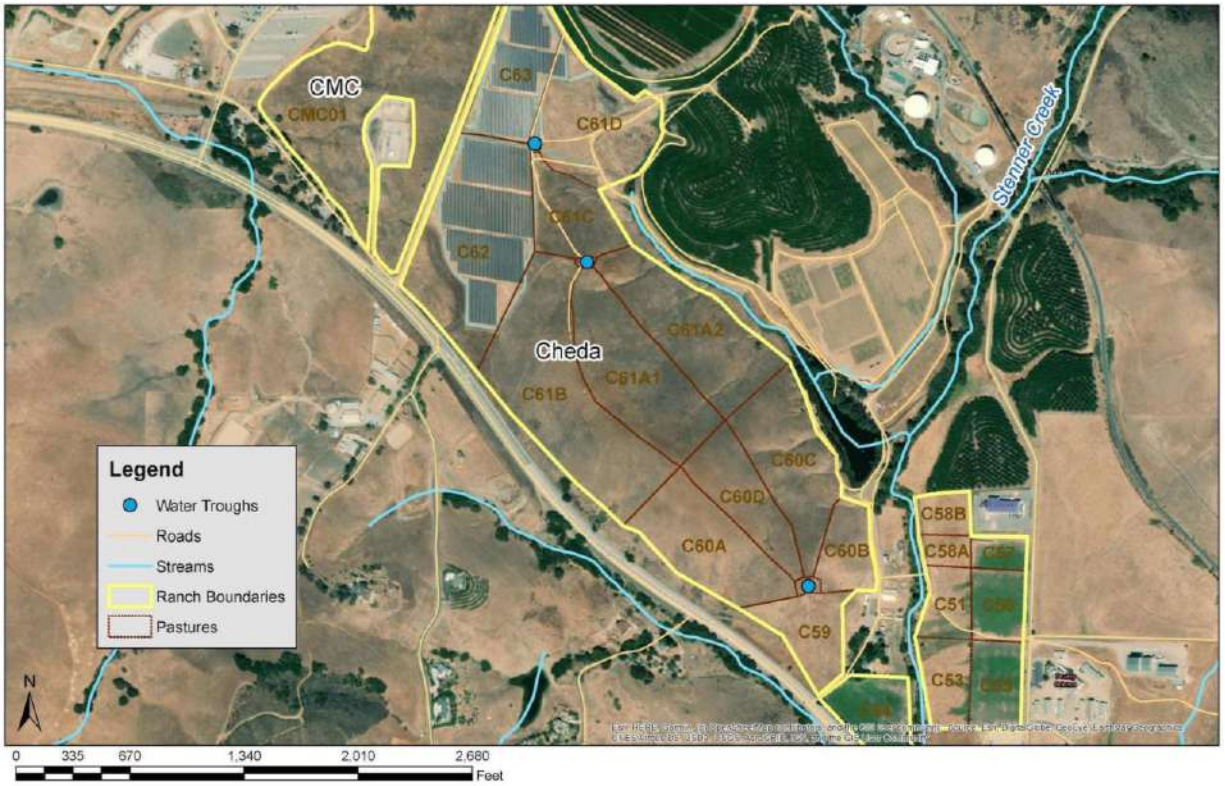
While Lazanoff does not use a traditional grazing management plan, he does utilize PastureMap, an app designed to track and manage cattle. All rangeland students, who manage the ranch use the PastureMap and cattle max apps to track the movement of cattle. From PastureMap, he can calculate grazing intensity across the rangeland within a given year. A grazing summary report generated in the PastureMap app is included as Appendix F.

As of March 2020, the ranches support a total of 264 cows and 199 calves: Walters and Escuela ranch support 156 cows and 154 calves on 2,562 acres. Chorro supports 53 cows on 538 acres. Peterson and Serrano support 41 cows and 37 calves on 1,194 acres. Cheda supports 120 sheep and 50 goats across 133 acres. This breaks down to 294 Animal Units (AU) on the ranches year-round (not including calves, and assuming 6 sheep/AU and 5 goats/AU). A summary of AUM from PastureMap is included in appendix F.

Other management practices that support increased carbon sequestration are; invasive species management, riparian fencing, riparian restoration, no till pastures, fencing, and spring development. Streamflow and well water quality monitoring is ongoing in partnership with the Morro Bay National Estuary Program (MBNEP) and Creek Lands Conservation. Large creek restoration projects - a particularly potent carbon sequestration strategy- in partnership with MBNEP have occurred along Pennington and Walters creek.

5. Description by Ranch

5.1 Cheda Ranch



Cheda Ranch is a 133-acre parcel owned by Cal Poly. Although it is the smallest ranch on campus it contains multiple land use types: irrigated pasture land dominated by grassland habitat, riparian habitat, man-made reservoirs, agricultural fields, and a grazed solar array. It is located two miles northwest of the Cal Poly, San Luis Obispo campus. The ranch lies within the Chorro Valley approximately 2.5 miles northwest of San Luis Obispo on Highway 1. It is bordered by the Cal Poly Main Campus to the southeast and the California Men's Colony to the northwest.

History: Cheda Ranch originally belonged to a larger parcel under the control of the San Luis Obispo Mission. In 1872 it became privately owned when John A. Cheda immigrated to the area and purchased first the 130 acres along Stenner Creek, followed by an additional 200 acres on either side of the railroad tracks, and finally 103 acres between the railroad and Highway 1. The single property consisted of 466 acres, as well as water rights to Stenner Creek, and was run mostly as a dairy for 40 cows with some area dedicated to grazing heifers and dry cows and some utilized to grow hay and bean crops. The current rangeland covers 133 acres. 27 acres of Cheda Ranch is irrigated acres used to raise grass-fed lamb. The Land Conservancy of SLO County completed a successful riparian planting project along Chorro Creek within Cheda Ranch in the late 1990s, and a trial soil health project was executed in 2015 by Cal Poly Faculty Beth Reynolds and Craig Stubler that included

tillage management, cover cropping, compost application, and soil organic matter analysis. A 4.5 MW solar array on the western side of Cheda Ranch covers 20 acres and provides a portion of the campus's energy. The array is grazed by goats and sheep, managed by Beth Reynolds. Solar grazing, as it is known, uses sheep and goats to manage the vegetation around the solar infrastructure. Goats and sheep are lower to the ground than cows, making them more agile around the panels, and are less likely to damage the infrastructure. Using livestock to manage the array provides an essential vegetation control service to the solar company that owns the array. It also provides high quality grazing acreage: studies have found land partially or fully covered by solar arrays produce up to 90% more biomass than land without solar arrays. This is thought to be a result of reduced evaporation and increased water efficiency that allows soils to store water in the plant's rootzone longer during the growing season (https://pv-magazine-usa.com).

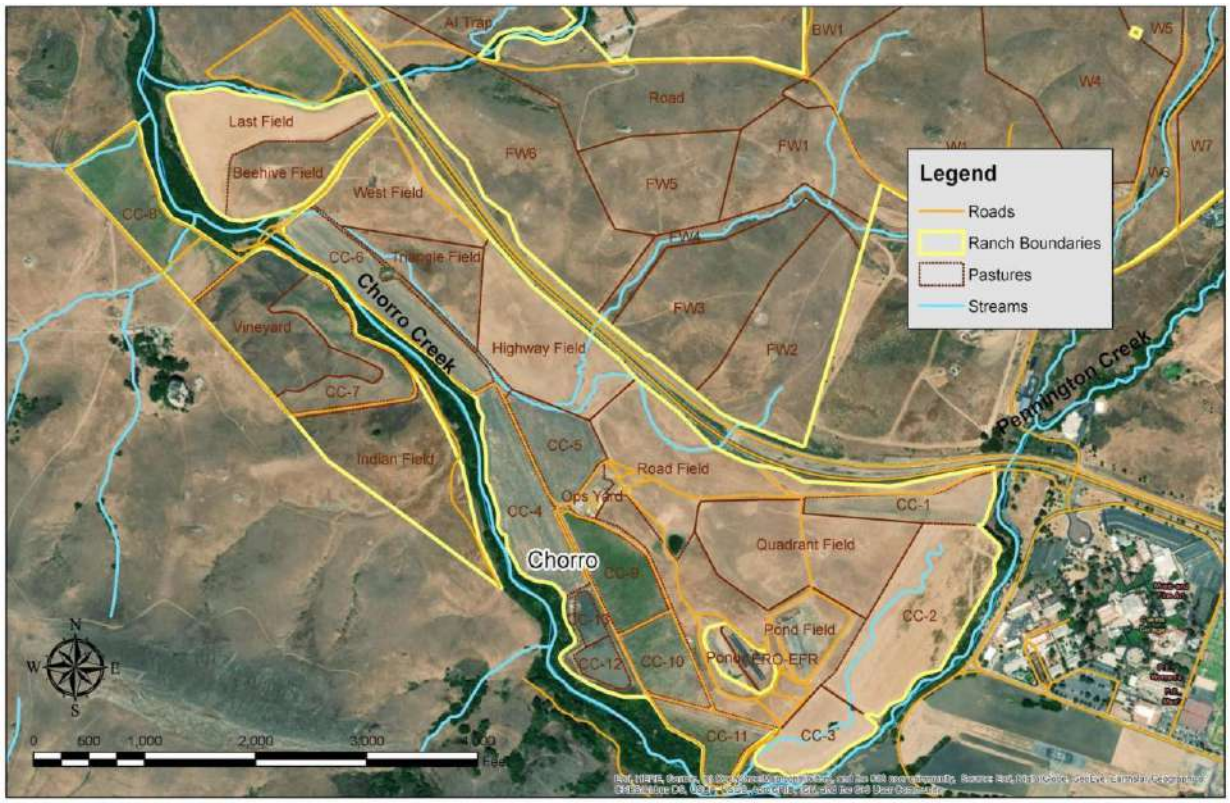
Soils: Soils on Cheda Ranch are primarily composed of Lodo Clay Loams between 5% and 30% slopes, Diablo Clay, Los Osos Diablo Complex, and Salinas Silty Clay Loams. Soil Organic matter levels range from 1 to 3.5%. See Appendix A for more detailed soil information.

Current Management: Currently, Cheda Ranch is used for a number of agricultural practices including rangeland for sheep and goat grazing, cropland for avocado orchards, and fourteen acres of vineyard. The sheep unit has utilized the Cheda Ranch rangeland since 1998. Today, it supplies feed for a flock of 130 Suffolk sheep which are raised as range flock, meaning the majority of their diet comes from grazing as opposed to supplemental feeding. Additionally, Cal Poly has achieved Certified level in the National Voluntary Scrapie Flock Program. Finally, two dormitories which house five students total are also located on the ranch for students involved in sheep enterprise study programs. In addition to 133 acres of rangeland, Cheda ranch includes 50 acres of avocados and 14 acres of vineyards.

Management Objectives: The ranch is managed to control and reduce fuel loads, and to educate students about multi-species grazing management.

Recommended Management Practices: Based on identified management objectives and resource concerns, we recommend seeding cover crops, applying compost, using a keyline plow, and rangeland planting to increase soil infiltration and structure and increase forage production. We also recommend prescribed grazing to reduce grazing pressure, hedgerows and windbreaks for additional carbon sequestration, and riparian plantings to enhance habitat along Chorro Creek. See quantification tables in section 7.7 of this plan.

5.2. Chorro Creek Ranch



Chorro Ranch is a 415-acre ranch dominated by a mixed grassland community and located northwest of Cuesta Community College campus. Chorro Creek runs along the western edge of the ranch, and many of the pastures are sub-surface irrigated because the groundwater table is extremely high. This ranch is distinctive from the other Cal Poly ranches in that it includes acres of vineyards and annual hay crop fields. An updated Chorro Creek Ranch management plan is being developed concurrently with this Carbon Farm Plan and will include management recommendation and land use objectives referenced in this plan. Additionally, a Healthy Soils Demonstration project proposal for compost application, nutrient management, tillage management and cover cropping is currently being developed by the RCD and Cal Poly for this ranch.

History: Chorro Creek Ranch has a rich history which dates back to utilization by the Chumash Indians and subsequent Spanish settlement. There are no records indicating that Chorro Creek Ranch was ever under the control of the missions, thus it is unlikely that the land was used for agricultural purposes before 1822 (Stechman 1985). The original grant for Rancho El Chorro was issued to Captain John Wilson and James Scott in October of 1845. The acreage of the grant was 3,167 acres, and the ranch was used primarily as rangeland for cattle, sheep and other livestock (Stechman 1985).

The ranch was purchased by Joseph Giuseppe and Charles Walters between 1894 and 1900, who also used the ranch for grazing beef and dairy cattle. Henry Gilardi assumed management of the

ranch in 1923 and during that time the land was leased to Barney Minetti and Joe Barta, who raised dairy cattle and grew crops (Stechman 1985).

In 1938, the State National Guard began buying properties in the valley for establishment of an Army training camp, later known as Camp San Luis Obispo. The majority of Chorro Creek Ranch was appropriated that year, with the rest being acquired in 1942. The land continued to be managed by the U.S. Army Corps of Engineers until 1961, when the army leased 582 acres of the land bordering Chorro Creek to Cal Poly. The following year the lower lands were leveled, and in 1963 a reservoir and two wells were constructed to provide water for crops and Angus cattle. In 1964, Cal Poly leased an additional 123 acres of the ranch. As part of a program to reduce holdings of excess federal lands, Chorro Creek Ranch was granted to Cal Poly by the U.S. government in March of 1968 (Stechman 1985).

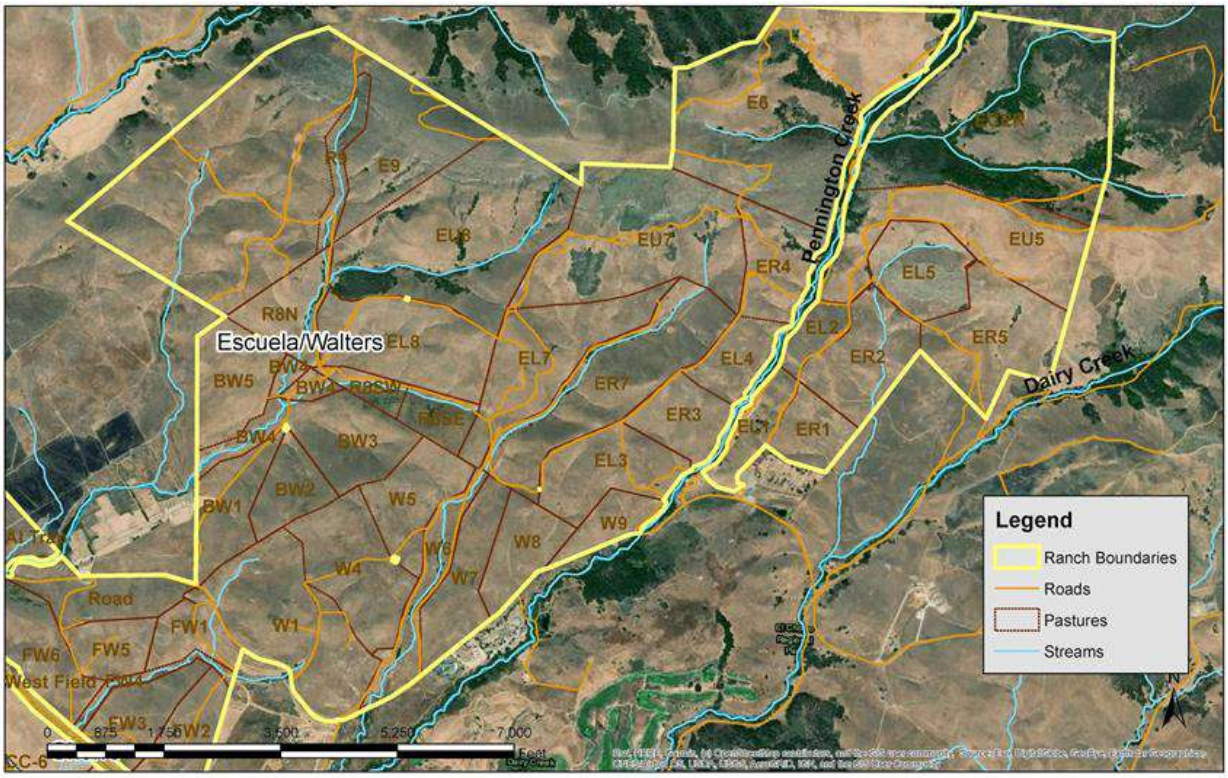
Soils: Soils on Chorro Creek Ranch are composed primarily of Diablo and Cropley Clays of minimal slopes. Soil Organic Matter levels range from 1 to 3.5%. See Appendix A for more detailed soil information

Current Management: This ranch is run in tandem with Walters Ranch and a single herd consisting of 53 cows is rotated through using the rest-rotational grazing method.

Management Objectives: Chorro Creek Ranch is managed with the objective of sustainably producing forage on hay fields and increasing pastureland while also improving wildlife habitat and riparian corridors.

Recommended Management Practices: Based on identified management objectives and resource concerns, we recommend seeding cover crops, applying compost, tillage and nutrient management and rangeland planting for improved soil health, infiltration and structure. Prescribed grazing, silvopasture, and hedgerows are recommended for reducing grazing impacts and improving livestock health, and filter strips, grassed waterways, and riparian plantings are recommended for improved water quality and aquatic health. See quantification tables in section 7.7 of this plan.

5.3. Walters and Escuela Ranch



Walters and Escuela Ranches are located north of Dairy Creek Golf Course and San Luis Obispo Botanic Garden, Escuela Ranch includes 1820 acres of pasture, while Walters Ranch covers 580 acres of pasture, both dominated by a mixed grassland community.

History: From the time the Chumash first settled the area to the present livestock operations, human use has shaped the land. When California became a Mexican territory in 1822, the lands previously owned by the Spanish Mission San Luis Obispo de Tolosa were divided into Ranchos San Luisito and El Chorro, which covered what is now known as Walters Ranch (Stechman 1985). In 1900, Charles Walter and Giuseppe Gilardi formed a partnership and purchased lands originally part of the Ranchos San Luisito and El Chorro. Upon the death of Charles Walter, the land was split with the northern half being retained by his widow Mary, and the southern half kept by Gilardi. In 1942, the U.S. government claimed these lands for military facilities and, when the war ended, the lands were declared surplus and divided among California state agencies, including Cal Poly and the Department of Parks and Recreation. Cal Poly was granted Walters Ranch in 1982 by the Department of Parks and Recreation, and since then it has been used by the student agricultural enterprise program (Stechman 1985).

Escuela Ranch was granted to Cal Poly in 1967 by the U.S. Department of Health, Education and Welfare (Stechman and Flanagan 1978). Cal Poly was initially granted 1,727 acres with only 1,420 acres suitable for grazing. Additional lands have since been added to the ranch, which now totals 1,820 acres (Stechman 1985). Prior to 1967, Escuela Ranch was subjected to heavy grazing pressure while under military lease to local ranchers. A highly effective riparian restoration project along

Walters and Pennington creeks was completed by the Morro Bay National Estuary Program and the CCC that includes bioengineering (gabions and willow mattresses), riparian plantings, and cattle exclusion for 3 years.

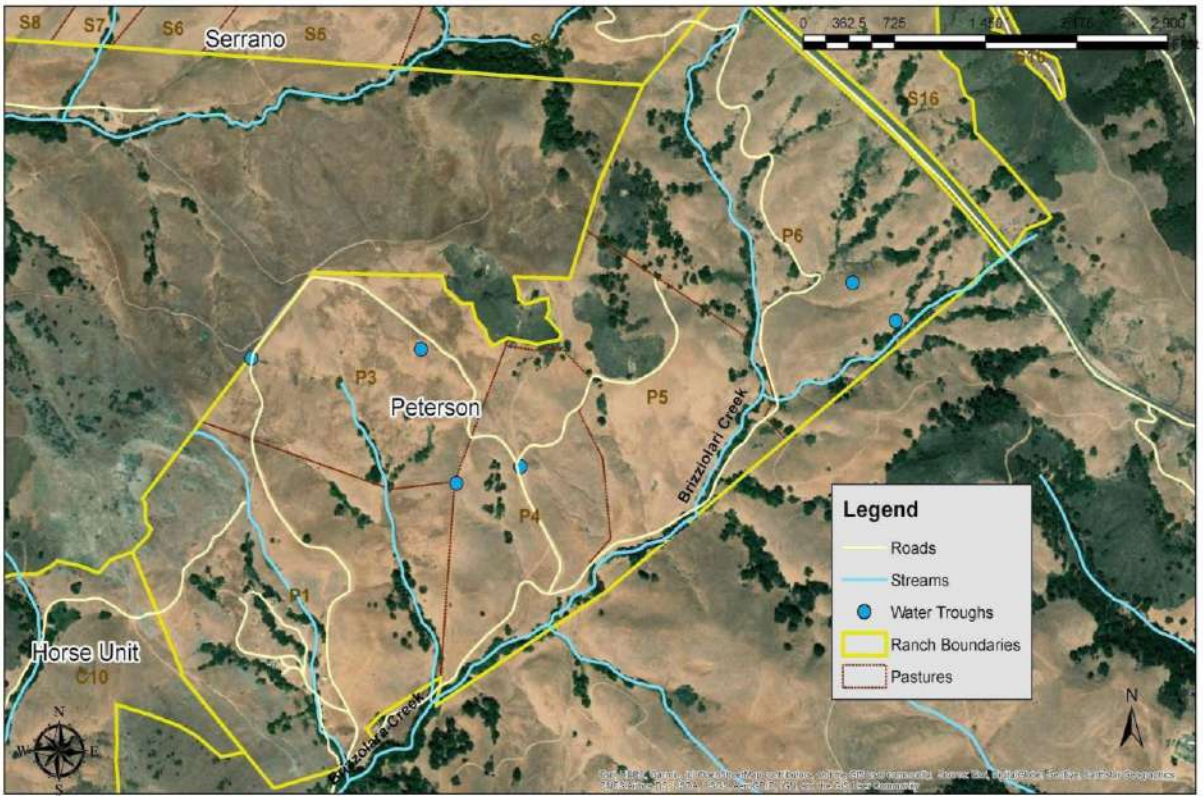
Soils: Soils on Escuela ranch are composed primarily of Diablo and Cibo Clays on slopes between 15 and 50%, and Los Osos-Diablo Complex soils on slopes between 30 and 50%. Soil Organic Matter levels range from 0.75% to 6% See Appendix A for more detailed soil information

Current Management: Walters and Escuela ranches are managed in tandem, rotating a single herd of 154 cows using the rest-rotational grazing method across 35 pastures.

Management Objectives: The management goals on these ranches include providing educational opportunities, improved soil health and forage production.

Recommended Management Practices: Based on identified management objectives and resource concerns, we recommend applying compost, and rangeland planting for improved soil health, infiltration and structure. We also recommend prescribed grazing and silvopasture for improved livestock health, and riparian planting for improved water quality. See quantification tables in section 7.7 of this plan.

5.5. Peterson Ranch



Peterson Ranch is a 417-acre ranch dominated by a mixed grassland community and located immediately north of Cal Poly campus, at the headwaters of Brizzolari Creek and Poly Canyon, in the Stenner Creek watershed. It extends eastward to the Southern Pacific Railroad tracks, on the first ridge of the Santa Lucia Range. Brizzolari Creek and a number of unnamed tributaries cross the ranch and eventually drain into Stenner Creek. Streams are moderately to highly impacted by cattle grazing and crossing, however more riparian pastures are being created to relieve this issue while still allowing controlled riparian grazing. This will not only allow for water availability to the cattle, but the disturbance created by the cattle will also control populations of invasive plant species such as Cape Ivy.

History: The Peterson Ranch was originally part of the 3,500-acre Rancho Potrero de San Luis Obispo. The first record of privatization occurred in the late 1820s when Estevan Quintana acquired 2,000 acres. When the Petersons occupied the land, it was used as rangeland for approximately 20 horses and 80 cattle, and the small flats adjacent to the creek were farmed for hay. Cal Poly purchased the land in 1950 to be utilized as rangeland for their purebred Hereford cattle herd.

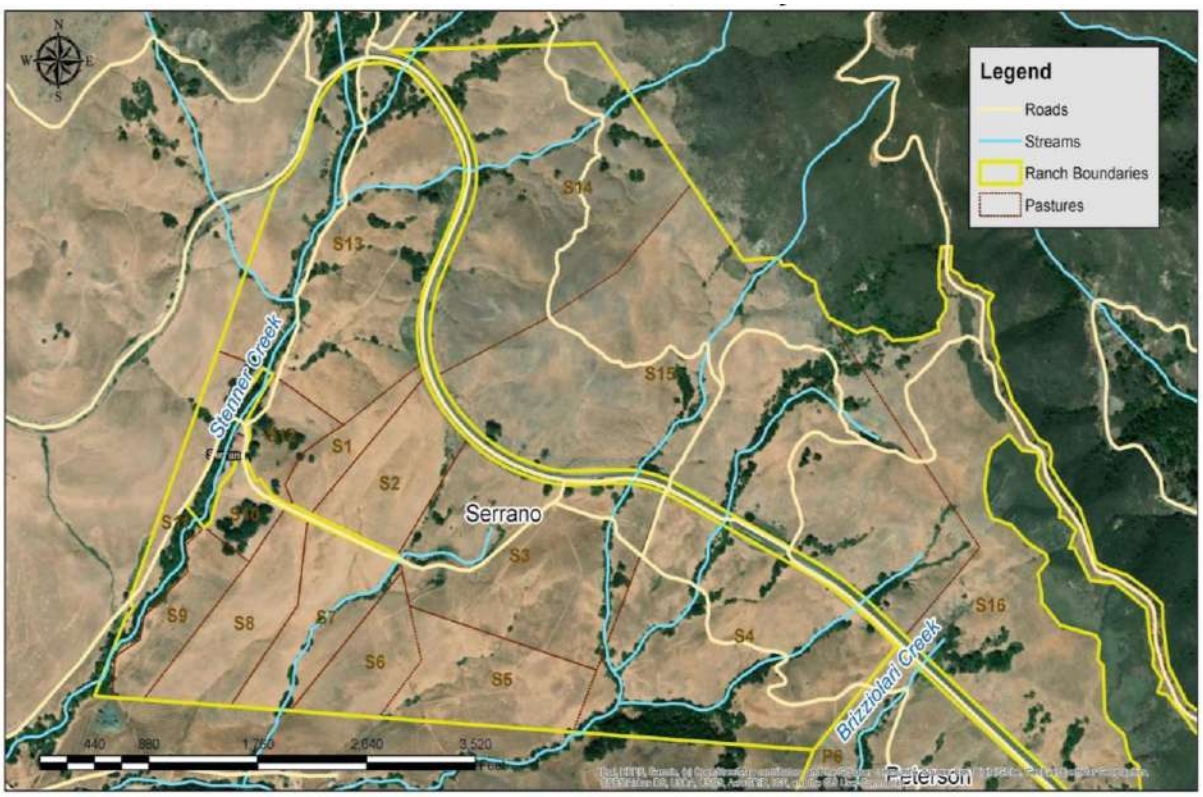
Soils: Soils on the Peterson Ranch are primarily composed of Gazos-Lodo Clay Loam of slopes greater than 30% and Diablo and Cibo Clays of slopes between 15 and 30%. Soil Organic Matter levels range from 0.75% to 3.5%. See Appendix A for more detailed soil information.

Current Management: Peterson Ranch is primarily a site for cattle grazing. It is run in tandem with Serrano Ranch and a single herd consisting of 37 calves and 41 cows is rotated through using the rest-rotational grazing method. Because the ranches are located immediately adjacent to campus, Cal Poly students are able to use them as a natural lab. Due to its proximity to the campus, Peterson Ranch also makes for a popular destination for student recreational use. Hiking and mountain-biking trails run throughout the area. These trails are generally narrow gauge single-track that see primarily foot, bicycle, and occasional equestrian traffic. This network is connected to trails on neighboring properties, creating a trail network more than 5 mi long within the Chorro Creek and Stenner Creek watersheds.

Management Objectives: The ranch is managed to provide educational and recreational opportunities, as well as for cattle production.

Recommended Management Practices: Based on identified management objectives and resource concerns, we recommend prescribed grazing and silvopasture for improved livestock health, and riparian planting for improved water quality. See quantification tables in section 7.7 of this plan.

5.6. Serrano Ranch



Serrano Ranch is a 632-acre ranch dominated by a mixed grassland community and located in the western foothills of the Santa Lucia Mountain Range, approximately 4.5 miles north of the City of San Luis Obispo. The ranch is bordered by the Los Padres National Forest to the north, the Southern Pacific Railroad tracks to the east and west, and by the Peterson Ranch to the southeast. The elevation over the property boundaries ranges from 600 feet in the southwest corner of the ranch to 1,600 feet in the northeast corner. Serrano Ranch is located within the watershed of the mainstem of Stenner Creek. Two main creeks run through the ranch: Stenner Creek in the western portion of the ranch and Brizzolari Creek in the eastern side. Both of these waterways eventually join with San Luis Creek outside of the ranch boundaries. Issues such as undersized culverts, lack of riparian fencing, minimal maintenance, and surface runoff are also seen throughout this property.

History: Serrano Ranch also was part of the 3,500-acre Rancho Potrero de San Luis Obispo. The Serrano's, along with the Herrera's, gained title to the lands of Rancho Potrero by 1880. The western portion of the ranch at the time included the headwaters of Stenner Creek, while the eastern portion drained into Arroyo del Potrero, later renamed Brizzolari Creek. In 1925, Victor Bello bought what is now known as Serrano Ranch. Bello never occupied the land, leasing it out instead. In 1941, Cal Poly leased the ranch for cattle grazing and in 1944, the ranch was sold to Walter Wells, who reinstated the Cal Poly lease and held the property until Cal Poly purchased it in 1950. Cal Poly has used the Serrano Ranch for livestock grazing since the purchase.

Soils: Soils on the Serrano Ranch are primarily composed of Gazos-Lodo Clay Loam slopes greater than 30% and Diablo and Cibo Clays of slopes between 15% and 30%. Soil Organic Matter levels range from 0.75% to 3.5%. See Appendix A for more detailed soil information.

Current Management: The current use for Serrano Ranch is primarily as a site for cattle grazing. It is run in tandem with Peterson Ranch and a single herd consisting of 37 calves and 41 cows is rotated through using the rest-rotational grazing method. Each fall, this ranch is also used to calf out the later-calving herd. Similar to Peterson ranch, this site is used for recreation by foot, bicycle and equestrians with multi-use trails throughout.

Management Objectives: The ranch is managed to provide educational and recreational opportunities, as well as for cattle production.

Recommended Management Practices: Based on identified management objectives and resource concerns, we recommend prescribed grazing and silvopasture for improved livestock health, and riparian planting for improved water quality. See quantification tables in section 7.7 of this plan.

6. Resource Concerns and Sequestration Opportunities

6.1 Goals and Objectives

This plan is unique in that its goals and objectives are based on those of Cal Poly: to support and develop responsible land management through learn-by-doing education. Through the collaborative process with the Cal Poly team, the following specific land management goals and objectives were identified:

1. Grow the Cal Poly rangeland reputation for innovative and responsible rangeland management
2. Ensure students are exposed to a breadth of management practices
3. Maintain an ecological balance between a stable grazing herd and climate resilient rangelands.

6.2 Resources Concerns

For the purpose of this plan, the principal resource concern to be addressed on the ranch is soil organic matter depletion, the effects of climate change, and the potential for carbon sequestration. Additional resource concerns are also identified through the planning process that may have a secondary cause and effect relationship with carbon capture potential. These may include, but are not limited to soil erosion, available livestock water, livestock distribution, and degraded plant condition. All resource concerns link to soil, water, animals, plants, air, and/or humans (SWAPA+H). It is the responsibility of the planner to identify and prioritize those resource concerns identified on-

farm, and identify planned practices that will address the resource concerns. These practices may be structural, vegetative, or management. This inventory and evaluation process take place through multiple site visits, discussions with the landowner, and field assessments. Another important resource concern to keep in mind is the economics of the ranch, and the cost-benefit ratio of the planned practice. Beyond field assessments, any planned practice must be economically viable, as well as sustainable, and address landowner's goals and objectives.

Soil Erosion

On Serrano, Peterson, Walters and Escuela Ranches, ephemeral and classic gully formation are increased by migrating head-cuts and streambank failure along the numerous drainages and tributaries criss-crossing these ranches. Riparian restoration and road maintenance efforts are proposed as part of the Stenner Creek Sediment reduction project.

Chorro Creek Ranch, relatively flat and exposed to highly erosive coastal winds, suffers from soil loss and crop stunting. Windbreaks and hedgerows could help increase forage production as well as serving as a useful carbon sink, wildlife habitat and insectary. Windbreaks are known to provide production benefits by reducing stress on both crops and livestock.

Water

Sedimentation and nutrient loading are a primary concern for water quality on the Cal Poly Ranches. Restoration work was completed in 2015 on Walters and Escuela Ranches to minimize sediment loading resulting from erosion, and riparian cross fencing as installed to create manageable riparian pastures, reducing nutrient loads in the creek. Similar work is being proposed on Serrano and Peterson Ranches. Water quality is less of an issue on Chorro and Cheda Ranches. Water quantity is also a concern on the upper ranches. A stormwater capture system was installed on Walters and Escuela Ranches as part of the restoration project in 2015. The stored water offsets water that would otherwise be drawn from Walter creek during the dry season for livestock water. A low-flow availability assessment is being proposed for Stenner Creek, which will assess and plan for increased water quantity on Serrano and Peterson Ranches.

Grazing

Much of the rangeland is efficiently managed through rest-rotational grazing using temporary electric fencing, the PastureMap app, and keen attention to ecological indicators like Ecological Sites, plant productivity and soil types. Pastures do exist, however, where increased fencing, development of livestock water infrastructure, and intensification of grazing management would

greatly benefit soil health and forage quality. Livestock concentrate in areas with available water and shade. By increasing cross fencing, developing channel water infrastructure, and establishing riparian pastures, land managers can graze riparian areas as needed while limiting negative impacts associated with concentrated grazing in riparian areas. Limited perennial native grassland has been identified as a resource concern. Annual grasses and invasive species are pushing out more beneficial forage types, impacting cattle yield and rangeland health. Rangeland seeding with perennial native grass species, combined with intensified management, may help improve rangeland diversity and increase forage production during the dry months.

<u>Fuels management/ Fire Risk Reduction</u>

Grassland fires are a constant and real threat in the arid central coast, especially during drought years. Serrano and Peterson Ranches are at particular risk given their steep terrain and often inaccessible valleys. Reducing fuels through grazing has long been a primary benefit of cattle, goats and sheep grazing on the ranches.

<u>Wildlife</u>

Serrano and Escuela Ranches reach nearly to the headwaters of their watersheds (Stenner and Chorro, respectively), and Chorro Ranch includes a long stretch of wetland and riparian habitat along Chorro Creek that constitutes 76 acres. This habitat could use some invasive species management for Cape ivy. These ranches are home to a diverse population of wildlife species, including a number of threatened or endangered species. Habitat and forage for these species can be impacted through over grazing and intensive cultivation practices. Practices that enhance wildlife habitat and forage such as riparian buffer establishment, hedgerows, and buffer strips will ensure existing habitat is protected and enhanced.

Public Access

Much of the rangeland is used for multiple types of recreation, including mountain biking, hiking, and cross-country running, as well as ranching. Impacts from illicit trails cause erosion and can degrade water quality. Public access is a requirement, however solutions like signage and education may reduce these impacts in the future.

7. Opportunities for Carbon Sequestration

Opportunities for carbon sequestration through rangeland management have been identified in each of the five Cal Poly Ranches included in this plan. Practices range from rangeland management to increased herbaceous cover, and work together to optimize carbon sequestration opportunities. Maps detailing practices for each ranch are included in Appendix C. The sections below detail those opportunities by land use and include practice codes associated with NRCS Conservation Practices. The following table categorizes the identified carbon sequestration opportunities by ranch. Sequestration values are based on calculations from COMET-planner (comet-planner.com) except where other calculations are indicated (i.e. Prescribed Grazing).

7.1 Cropland Management

Cover Cropping (NRCS 340) - A mixture of grasses, legumes and forbs planted for seasonal vegetation cover. This practice reduces the need for synthetic fertilizers by naturally adding nitrogen to the soil, and also reduces erosion, weed establishment, and soil compaction. We've proposed this management practice in conjunction with compost application on the existing, conventionally tilled vineyards on Chorro Ranch across 45 acres which may be converted to cropland. This practice has the potential to sequester 15 metric tons (Mg) of CO2e per year.

7.2 Grazing Lands

Ranches are currently managed using rest-rotational grazing and utilizing applications such as Pasture Map and Cattle Max. A holistic grazing plan is being developed by Cal Poly Rangeland manager and students and will be included in this plan once complete. The practices listed below will be implemented on the acreage indicated.

Rangeland Compost - Research conducted on northern California rangelands by the Silver Lab at the University of California at Berkeley has shown significant, ongoing, increases in forage production, soil carbon, and soil water holding capacity over multiple years in response to a single ½" compost application on grazed sites in both coastal and foothill rangelands (Ryals and Silver 2013). Forage production increased by approximately 40% and 70%, respectively, and soil water holding capacity increased by nearly 25%, while soil carbon increased by about 0.4 metric tons (1.49 Mg CO2e) per acre per year. These changes have persisted across six years of data collection, and ecosystem models suggest this improvement will continue for at least 20-30 years in response to the single compost application in year one, reflected in improved forage and improved soil water holding capacity. Based on this research, carbon sequestration rates for compost application to rangeland were determined assuming that 1.49 Mg of CO2e were sequestered per acre annually.

Compost application, therefore, is recognized as an effective means of increasing carbon capture, through increased forage production, on grazed rangelands, particularly where low SOM is a limiting factor. Importantly, compost applications enable increasing soil carbon stocks above what could

otherwise be achieved through the management of vegetation and soils on a given site. Improved management alone, such as application of a carbon-focused grazing program, increased use of cover crops, implementation of a no-till program, etc., can all lead to soil carbon increase. Over time, the carbon content of soils under consistent management will tend to reach equilibrium, where annual carbon inputs and losses tend to balance out. Addition of off-site sources of carbon, such as compost, can elevate soil carbon levels and, in some cases, enable increased carbon capture above that of equilibrium conditions (Ryals and Silver 2013). Compost can thus be a powerful tool for soil carbon increase, but is not always a realistic option. This is especially the case where target fields are far from sources of compost. However, on-farm compost production is one option that allows for increasing conservation of on-farm carbon and its addition to origin-farm soils at relatively low cost. Cal Poly operates an organic certified compost facility and all compost will be self-sourced.

This practice will be applied to 26.2 acres at Cheda ranch, 230 acres at Chorro ranch and 62 acres at Walters and Escuela ranch. This has the potential to sequester 474 Mg of CO2e per year and approximately 9500 Mg CO2e/ 20 years.

Grazing Land Mechanical Treatment (NRCS 548) is modifying the physical soil conditions by treatments such as Keyline plowing, contour furrowing, chiseling, ripping or subsoiling. The purpose of this practice is to improve soil permeability, infiltration, and forage quality. Keyline plowing, which is a form of grazing land mechanical treatment, is proposed for 26.2 Acres at Cheda ranch, with the potential to sequester 2 Mg of CO2e per year. Keyline plowing will be scheduled based on optimal soil moisture levels and soon after compost application.

Prescribed Grazing (NRCS 528) is managing the harvest of vegetation with grazing animals with the intent to achieve specific ecological, economic, and management objectives. Goals are to improve forage quality, species composition, watershed function, and soil health. These goals are achieved by managing stocking rates and grazing periods to adjust the intensity, frequency, timing, duration, and disturbance of grazing to meet planned objectives. This practice is applied to all fields within the ranches that are actively grazed by cows. Prescribed grazing will occur on 1,425 total acres across the 5 ranches. Current CO2e sequestration rates acquired from COMET planner are extremely low, due to lack of empirical data. As Cal Poly monitors actual soil change over time, this value can be replaced with site-specific data. 12 Mg Co2e/year COMET Planner - CDFA, 2020

Silvopasture: Silvopasture systems are defined by the integration of woody species, particularly trees, into grazed pastures. Trees can provide long-term economic returns, shade and other benefits, while livestock and forages generate an annual income from the same pasture. Silvopasture systems have three management components: trees, forages, and livestock. Correctly managed, the combined production from a silvopasture can be greater than traditional forestry and forage livestock systems. Intensive livestock management is required, particularly in the early years during tree establishment, (http://nac.unl.edu/practices/silvopasture.htm).

Trees in pastures provide evaporative cooling, reduce radiant heat loss at night, and reduce wind speed. These improved conditions allow animals to spare energy for growth, particularly under hot conditions. Increased weight gain, milk yield, and conception rates have been reported for cattle and sheep grazing pastures with trees in warm environments. Forage nutritive value, digestibility, and botanical composition can be improved in silvopasture systems. In the winter, trees can provide protection from cold and reduce wind velocity (https://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=1009&context=workingtrees).

Throughout Cal Poly rangeland, we've identified north-facing slopes that are suitable for oak planting. These trees would need to be protected from browsing and herbivory with cages for the first few years. Suitable sites for oak planting occur on 112 acres at Escuela/Walters, 48 acres at Peterson, 23 acres on Cheda Ranch, 38 acres on Chorro Creek Ranch, and 73 acres on Serrano ranch. Cumulatively, this has the potential to sequester 211 Mg of CO2e per year, and 4220 Mg of CO2e over 20 years.

Range Planting (NRCS 550) is the establishment of adapted perennial or self-sustaining vegetation such as grasses, forbs, legumes, shrubs, and trees. The goal of rangeland planting is to restore a plant community, provide improved forage for livestock and wildlife, improve water quality and quantity, and increase carbon sequestration. Across the Cal Poly rangeland, we've identified areas that were formerly farmed that are 15% grade or less that would be accessible to seeding equipment and suitable for rangeland seeding of grasses and forbs. These sites were selected because the native seedbank has been depleted over time, with reduced species diversity and therefore forage quality. Rangeland planting is proposed on 75 acres on Chorro Creek Ranch, 48 on Serrano ranch, and 43 on Cheda Ranch, with the potential to sequester 56 Mg of CO2e per year and 1120 Mg of CO2e over 20 years.

7.3 Woody Planting

NRCS defines hedgerows, windbreaks and shelterbelts as, "single or multiple rows of trees or shrubs planted in linear configurations." These plantings have numerous benefits: increase carbon storage in biomass and soils, reduce soil erosion and loss of soil moisture from wind, protect pastures and crops from wind related damage, improve the microclimate for plant growth, provide shelter for livestock, and enhance wildlife habitat. In addition, windbreaks and shelterbelts provide noise and visual screens, improve irrigation efficiency, increase biodiversity, increase production, and act as shaded fuel breaks to limit the spread of wildfire (http://nfs.unl.edu/documents/windbreaklivestock.pdf). Shelterbelts and hedgerows can also be configured to capture or distribute surface runoff to optimize moisture, sediment and nutrient retention. Windbreaks are hedgerows or shelterbelts that are planted approximately perpendicular to the prevailing winds and structured to dissipate or deflect wind energy away from the area "behind," or downwind of the windbreak.

Hedgerow planting (NRCS 422) is the establishment of dense vegetation in a linear design to achieve natural resource conservation goals. This practice provides habitat and connectivity for wildlife,

intercepts airborne particulates, acts as a screen to noise and dust, and increases carbon storage. We've identified a location for a hedgerow where Chorro and Cheda ranch border Highway 1, a total of 1.5 miles, with the potential to sequester 12 tons of CO2e per year. Native species will be selected, particularly those that attract pollinators such as Asclepias speciosa (showy milkweed), Eschscholzia californica (California poppy), Artemisia californica (California sagebrush), Frangula californica (California coffeeberry), Elymus glaucus (blue wildrye), Stipa pulchra (purple needlegrass), and Lupinus nanus (sky lupine), Baccharis pilularis (coyote brush), and Sambucus caerulea (elderberry).

Riparian Forest Buffer (NRCS 391) is an area of trees and/or shrubs adjacent to and upslope from a waterbody. This improves habitat for aquatic organisms, reduces sedimentation and nutrient inputs, restores the riparian plant community, and stores carbon in plant biomass and soils. Riparian planting is proposed along portions of Brizzolari, Chorro, Chumash, Dairy, Pennington, and Stenner creeks to encourage the establishment of a 70-foot wide corridor of trees and shrubs (35' on either side of the stream). A total of 306 acres of riparian forest buffer is needed across the 5 ranches, with the potential to sequester 544 Mg of CO2e per year, and nearly 11,000 Mg of CO2e over 20 years.

7.4 Cropland to Herbaceous Cover

Filter Strips (NRCS 393) are strips of herbaceous vegetation that remove contaminants from overland flow. This practice reduces suspended solids and contaminants in runoff, tailwater, and surface waters. Filter strips, with a 30 ft flow length (3.4 acres total) would be planted adjacent to the grassed waterway on Chorro Ranch parallel to the creek, and have the potential to sequester 1 Mg of CO2e per year.

Grassed Waterways (NRCS 412) a graded vegetated channel which conveys surface water at a non-erosive velocity using a broad and shallow cross section to a stable outlet. The purpose of this practice is to convey surface water without erosion or flooding. This practice will be implemented along hayfields and pastureland adjacent to Chorro Creek, on approximately 3.4 acres, and will have the potential to sequester 1 Mg of CO2e per year.

Riparian herbaceous cover (NRCS 390) is the establishment of grasses, sedges, rushes and forbs tolerant of intermittent flooding in the transitional zone between upland and aquatic habitats. This practice restores a desired plant community, provides habitat for fish and wildlife, maintains water quality, enhances the stream bank and stores carbon. In all ranches, we've created a 70-foot habitat corridor for both riparian herbaceous cover and riparian forest buffer planting along all streams and their tributaries. A total of 306 acres of riparian herbaceous cover is needed across the 5 ranches, with the potential to sequester 12 Mg of CO2e per year.

7.5 Restoration of Disturbed Lands

Critical Area Planting (NRCS 342) is the establishment of permanent vegetation on sites with high erosion rates or conditions that prevent vegetation growth without seeding or planting. This practice will be implemented in combination with a grassed waterway across 3.4 acres on Chorro Ranch in an area with surface water flow, with the potential to sequester 4 tons of CO2e per year, and on 169 acres along Walters and Pennington creek on Walters/Escuela Ranch, with the potential to sequester 177 Mg of CO2e per year.

7.6 Supporting Practices

Fencing (NRCS 382) is a constructed barrier to livestock, wildlife or people. Nearly 42,000 linear feet of permanent cattle fencing will be installed in strategic locations to enhance rest-rotational grazing pastures, maintain riparian corridors, and promote rangeland health. This practice will be implemented in coordination with other rangeland practices.

Livestock pipeline (NRCS 516) is a pipeline installed to convey water for livestock or wildlife. This practice provides water to an area where it is used and reduces energy use. Sites for this practice have not been identified but improvements could be made on all ranches to support prescribed grazing and increased fencing infrastructure.

Stormwater Runoff Control (NRCS 570) is designed to reduce the impact of stormwater on habitat and soil health. This practice minimizes erosion and sedimentation, reduces runoff quantity and improves runoff quality. Sites for this practice have not been identified, but stormwater runoff should be managed adjacent to all ranch buildings.

7.7 Quantification of Recommended Management Practices

The table below quantifies the carbon sequestration potential for each of the recommended practices in annual metric tons.

Practice name	NRCS Code	area (acs)	Fields	Description	Metric tons (Mg) CO2e sequestered/ Yr
Escuela/Walters Ranch					
Cropland Management					
Compost	-	62	EL3, W8	Applied to select fields where slope is less than 20% and no serpentine soils exist	92
Grazing Lands					
Prescribed Grazing	528	588	E9, ER7, E6	Managed grazing to enhance rangeland health	3
Silvopasture	381	112	R9, EU8, R8SE, E6, ER5, EU5	Establishment of oak woodlands on NE slopes	73
Cropland to Herbaceous Cover					
Riparian herbaceous cover	390	169	Bordering Creek	Mechanical, biological and manual removal of non-native invasives along riparian corridor	7
Riparian forest buffer	391	169		Develop and enhance riparian canopy along Walters and Pennington creeks to include herbaceous and woody native vegetative cover.	300
Restoration of Disturbed Lands					
Critical area planting	342	169	Bordering Creek	establishing permanent vegetation on sites with high erosion	177
Co-Beneficial practices					
Fencing	382	7513 ft	Throughout	Fencing for riparian pastures along Walters creek and to split fields for grazing	0
TOTAL Tons CO2e sequestered/ year on Escuela/Walters Ranch					**652**
Chorro Creek Ranch					
Cropland Management					
Cover Cropping	340	28	CC9-11	Incorporating a cool season multi-species cover crop mix between fall harvest and spring planting	6
Compost	-	230	West, Tri, Hwy, Rd, Quad, Pond, CC4-CC6, CC1-CC3	Applied to select fields where slope is less than 20%, where no serpentine soils exist, and including a 100 ft riparian buffer	342.7
Tillage mgmt: No-Till	329	28	CC9-11, vineyard	Cease tillage on rehabbed vineyard acres	4
Grazing Lands					

Prescribed Grazing	528	188	Beehive, Indian, West, Tri, Hwy, Rd, Quad, Pond	Establishing High Intensity, Low Duration grazing mgmt plan for field p6	1
Silvopasture	381	38	Hwy, Last, Beehive, CC8, Vineyard	Establishment of oak woodlands on NE slopes and sycamores in floodplain	25
Rangeland planting	550	75	Last, CC8, Vineyard, CC7	Establishment of native rangeland species on 25% of total rangeland with slopes less than 15%	25
Woody Planting					
Hedgerow	422	1.5	Bordering Highway	Establishing Ca native trees along Hwy 1; 7806 feet long	12
Cropland to Herbaceous Cover					
Filter Strip	393	3.4	Bordering Creek	A strip of herbaceous vegetation that removes contaminants from overland flow	1
Grassed Waterways	412	3.4		A graded vegetated channel which conveys surface water at a non-erosive velocity using a broad and shallow cross section to a stable outlet	1
Riparian herbaceous cover	390	76		Mechanical, biological and manual removal of non-native invasives along riparian corridor	3
Riparian forest buffer	391	76		Establishing native woody and herbaceous habitat where invasives were removed.	135
Restoration of Disturbed Lands					
fencing	382	15,300 ft	bordering Creek	Establishing riparian corridors along Pennington and Chorro Creek	0
critical area planting	342	3.4	Bordering Creek	establishing permanent vegetation on sites with high erosion	4
TOTAL Tons CO2 sequestered/ year on Chorro Ranch					**559.7**
Peterson Ranch					
Grazing Lands					
Prescribed Grazing	528	283	P3-P6	establishing High Intensity, Low Duration grazing mgmt plan for field p6	1
Silvopasture	381	48	P1, P6, S16 (Serrano)	Establishment of oak woodlands on NE slopes	31
Cropland to Herbaceous Cover					
Riparian herbaceous cover	390	24	Bordering Creek	Mechanical, biological and manual removal of non-native invasives along riparian corridor	1
Riparian forest buffer	391	24		Establishing native woody and herbaceous habitat along Brizzolari creek and tributaries	43
Co-Beneficial practices					
Fencing	382	9244	Throughout	Development of riparian pastures along all riparian corridors	0
TOTAL Tons CO2e sequestered/ year on Peterson Ranch					**76**
Serrano Ranch					

Grazing Lands					
Prescribed Grazing	528	254	S3, S4, S15	establishing High Intensity, Low Duration grazing mgmt plan for field S15	1
Silvopasture	381	73	S16, S14	Establishment of oak woodlands in the north portion of field S-16	48
Rangeland planting	550	48	S2, S8	Establishment of native rangeland species on 25% of total rangeland with slopes less than 15%	16
Cropland to Herbaceous Cover					
Riparian forest buffer	391	32	Bordering Creek	Establishing native woody and herbaceous habitat along Brizzolari creek and tributaries	57
Riparian herbaceous cover	390	32		Mechanical, biological and manual removal of non-native invasives along riparian corridor	1
Co-Beneficial practices					
Fencing	382	7300	S3, S14	Fencing to create riparian pastures	0
TOTAL Tons CO2 sequestered/ year on Serrano Ranch					**123**
Cheda Ranch					
Cropland Management					
Cover Cropping	340	17	C51-C58,	Incorporating a cool season multi-species cover crop mix between fall harvest and spring planting	9
Compost Application	-	26.2	C51-C58,	Applied to select fields where slope is less than 20% and no serpentine soils exist	39
Forage + Biomass Planting	512	3.6	C55	Seeding for improved biomass and increased residue	1
Grazing Lands					
Keyline (Grazing Land Mechanical Treatment)	548	26.2	C51-C58,	modifying physical soil conditions by ripping/loosening the topsoil to increase infiltration	2
Prescribed Grazing	528	112	C59-C63	establishing High Intensity, Low Duration grazing mgmt plan for field p6	1
Rangeland planting	550	43	C62-C63	Establishment of native rangeland species on 25% of total rangeland with slopes less than 15%	15
Silvopasture	381	23	C59-C61	Establishment of oak woodlands opportunistically throughout pastures	34
Woody Planting					
Hedgerow	422	2287 ft	C62, C61A1	Establishing native pollinator habitat outside of Solar array and SE edge of C61a1	0
Cropland to Herbaceous Cover					
Riparian herbaceous cover	390	5.3	-	Mechanical, biological and manual removal of non-native invasives along riparian corridor	0
Riparian forest buffer	391	5.3	-	Establishing native woody and herbaceous habitat along Brizzolari creek and tributaries	9
Co-Beneficial practices					

Fencing	382	2,630	C51, C56	Fencing to improve rest- rotational grazing and relieve riparian grazing pressures	0
Irrigation System improvements	442	3	C51, C56	Installation of K-line pod irrigation	0
TOTAL Tons CO2e sequestered/ year on Cheda Ranch					**110**
TOTAL Tons CO2e sequestered/ year on all ranches					**1,521**

7.8 Soil, Water & Carbon

NRCS suggests that a 1% increase in SOM results in an increase in soil water holding capacity (WHC) of approximately 1-acre inch, or 27,152 gallons of increased soil water storage capacity per acre. A 1% increase in SOM represents roughly 20,000 pounds (10 short tons) of organic matter, or 5 short tons of organic carbon. The soil water table below shows estimated additional water storage capacity associated with soil carbon increases on Cal Poly Ranch land resulting from implementation of the CFP.

Total estimated additional water storage capacity associated with soil carbon increases on Cal Poly Ranches resulting from implementation of the CFP are estimated to be 101.34-acre feet. This is a significant quantity of additional water storage capacity, yet represents an average increase of less than 0.30 inches of water holding capacity per acre over the ranch land. This analysis is assumed conservative, yet reveals the potential significance of even small increases in soil carbon storage for overall Farm dynamics.

Soil Water Holding Table Estimated Additional Annual Soil Water Holding Capacity (WHC) at Cal Poly Ranches With Carbon Farm Plan Implementation, Year 20.

PRACTICES	DESCRIPTION	20 YEAR SOM INCREASE (Mg)	ANNUAL WHC INCREASE BY YEAR 20 (AF)
Compost application on Rangeland (NRCS practice standard in development)	Application of 1/4" of compost to 318.2 acres of rangeland.	9482.36	47.37
Prescribed Grazing	Grazing management to favor perennials and improve production on 1425 acres	140	0.70
Forage and Biomass and Range Planting	169.6 acres	1140	2.85
Silvopasture	294 acres	4220	10.54
Hedgerow Planting	1.5 acres of 10” wide hedgerows.	240	.60
Riparian Herbaceous Cover and Riparian Forest Buffer	306.3 acres	11120	36.39

Filter Strip and Grassed Waterway	3.4 acres each	200	1
Cover Cropping	45 acres	300	1.50
Tillage Management- No- till	28	80	0.40
Total		30370.36	101.34

8. Conclusions

There is significant potential for GHG reduction and terrestrial carbon capture on the nearly 4,000 acres of actively grazed rangeland within the Cal Poly Ranches, as well as additional benefits to soil health, water quality, wildlife, and livestock health. The focus on providing educational opportunities, coupled with Cal Poly land managers commitment to holistic management practices, has broadened the scope of this plan to include a diverse suite of practices and exciting opportunities for implementation, monitoring, and engaging students and the public. Through implementation of cropland and rangeland management and restoration practices described above, an estimated 1,521 tons of CO2e could be sequestered in soils in above- and below-ground biomass per year, and 30,422 tons of CO2e over 20 years. This equates to removing 362 passenger vehicles from the road annually or 7,233 passenger cars over 20 years (EPA HGH equivalencies calculator). Proposed cropland and rangeland management and restoration practices include are listed in the table below:

Practice Name	NRCS Code	Area (acres)	Mg CO2e sequ'd/ 1 Yr	Mg CO2e sequ'd/ 20 yrs
Cropland Management				
Compost	-	318.2	474	9482
Cover Cropping	340	45	15	300
Tillage mgmt: No-Till	329	28	4	80
Forage + Biomass Planting	512	3.6	1	20
Grazing Lands				
Prescribed Grazing	528	1425	7	140
Silvopasture	381	294	211	4220
Rangeland planting	550	166	56	1120
Keyline (Grazing Land Mechanical Treatment)	548	26.2	2	40
Woody Planting				
Hedgerow	422	1.5	12	240
Cropland to Herbaceous Cover				

Riparian herbaceous cover	390	306.3	12	240
Riparian forest buffer	391	306.3	544	10880
Filter Strip	393	3.4	1	20
Grassed Waterways	412	3.4	1	20
Restoration of Disturbed Lands				
Critical area planting	342	172.4	181	3620
Co-Beneficial practices				
Fencing	382	42,000 lnft	0	0
Irrigation System improvements	442	3	0	0
TOTAL			**1,521**	**30,422**

Sequestration values are based on calculations from CDFA legacy 2020 COMET-planner (comet-planner.com) except Prescribed Grazing calculations, which were derived from the 2013 publication by Ryals and Silver (Ryals and Silver 2013). Cover Cropping and Residue + Tillage management (no-till) will be applied to hay fields on Chorro Ranch to improve soil health and structure, while adjacent transitional pasture land will receive compost application. Increased Prescribed Grazing and Silvopasture establishment of oak woodlands on north-facing rangeland slopes will be applied to each ranch, and Range Planting to establish perennial grasslands will happen on disturbed soils on Cheda, Chorro and Serrano ranches. Windbreaks, Shelterbelts and hedgerows will be planted on windy Cheda and Chorro ranches, and practices to improve water quality and riparian habitat will be applied on each of the ranches, including expanded Riparian Forest Buffers and Riparian herbaceous cover, Filter Strips, Grassed Waterways and Critical Area Planting.

Currently, rangeland manager Aaron Lazanoff utilizes Pasture Map software and rest- rotational grazing practices to manage the ranches with efficiency and holistically. There are areas, however, where increased efficiencies in rangeland management are needed and identified in this plan. Unique to this plan, the ranches are managed for education and training opportunities. Therefore, many opportunities for experimentation and demonstration exist, i.e. compost application and keyline plowing on rangeland. Approximately 3,000 cubic yards of compost are made on-site, providing potential for 88 acres of compost application annually (assuming a ¼" application) as an additional source of on-farm carbon capture and reduced GHG emissions resulting from transportation.

8.1 Timeline and Implementation Strategy

The Cal Poly team has indicated which practices, on which ranches, are higher and lower priorities. For instance, Chorro Creek is currently going through major land use changes with the potential development of a new well, and removal of vineyards. An updated management plan will be developed in the coming years, and the proposed carbon farming practices assigned to that ranch

will be incorporated. The table below indicates which practices may be implemented on a 5-year, 10-year and 15-year timeline, based on input from the Cal Poly team.

Practice	5 years	10 years	15 years
Escuela/Walters			
Compost	x	x	x
Prescribed Grazing	x	x	x
Silvopasture	x	x	x
Riparian Herbaceous Cover	x		
Riparian Forest Buffer	x		
Fencing	x		
Chorro Creek			
Cover Cropping			x
Compost		x	
Prescribed Grazing		x	
Silvopasture			x
Rangeland Planting			x
Hedgerow			x
Filter Strip			x
Grassed Waterways			x
Riparian herbaceous cover		x	
Riparian forest buffer		x	
critical area planting		x	
Peterson			
Prescribed Grazing	x		
Silvopasture		x	
Riparian herbaceous cover	x		
Riparian forest buffer	x		

Fencing	x		
Stream habitat improvement and mgmt.	x		
Streambank and Shoreline Protection	x		
Serrano			
Prescribed Grazing	x		
Silvopasture		x	
Rangeland planting		x	
Riparian forest buffer	x		
Riparian herbaceous cover	x		
Fencing	x		
Stream habitat improvement and mgmt.	x		
Streambank and Shoreline Protection	x		
Cheda			
Cover Cropping		x	
Compost Application	x		
Keyline (Grazing Land Mechanical Treatment)		x	
Prescribed Grazing	x		
Rangeland planting		x	
Hedgerow planting			x
Windbreak			x
Riparian herbaceous cover			x
Riparian forest buffer			x

8.2 Alignment with Funding Opportunities, Campus Strategic Planning

Funding for implementation will be sought both by the Cal Poly team and by RCD staff. Because the ranches are on public land, funding sources will be more limited than on private lands. For instance, the ranches are not eligible for HSP Incentives funding and may not be eligible for NRCS EQIP

funding. A proposal for Stenner Creek watershed restoration was submitted in early 2020 that was not funded.

No known updates to the Campus Strategic Plan or Climate Action Plan are scheduled at this time. Both the Cal Poly team and RCD staff will work to incorporate elements of this plan into future iterations of campus-wide plans.

8.3 Monitoring

The frequency and extent of monitoring requirements will be determined by the funding sources, and will likely be carried out by Cal Poly students, providing an excellent learn-by-doing experience in monitoring, effectiveness evaluation, and data management. RCD staff will support where funding allows, especially with monitoring design. Baseline data and records of implementation activities, including locations, extent of project(s), dates of implementation, etc. will be included in plan implementation documentation.

This plan should be viewed as a living document. Things change, including goals. This plan should evolve as practices are implemented and new information/feedback, tools and resources become available. Additional carbon-beneficial practices may be considered for inclusion in the plan in the future. GHG values presented here as associated with specific practices are considered to be both conservative and based upon the best available information at the time of this plan's preparation (2020). They likewise may be revised as evaluation techniques are refined.

8.4 Education & Outreach

As discussed previously, one of the primary land management objectives on the Cal Poly Ranches is education. As such, there have been many projects, including research, monitoring, and management, on these ranches over the years. Marc Horney, Rangeland management instructor, has led classes on collecting residual dry matter samples and analyzing the results. That data has been used by Aaron Lazanoff and his students to fine tune rest-rotational grazing management.

Adrienne Greve approached the RCD about guest lecturing in her Graduate Environmental Planning (Winter 2020) and Climate Action Planning (Spring 2020) courses. In the Graduate Environmental Planning course, we hosted a field trip to Chorro Creek Ranch to discuss the Carbon Farm Plan and future opportunities for implementation. In the Climate Action Planning course, we will share the details of the carbon farm plan. Both courses are an opportunity to recruit graduate students interested in helping with implementation of the plan for their Master's thesis in Fall 2020-Spring 2021.

A Rancher 2 Rancher event will be co-hosted this April with the Upper Salinas Las Tablas RCD funded by the Carbon Coalition. The RCDs will be volunteering their time for this event. The workshop will be facilitated by Richard King to demonstrate holistic management grazing practices. We will

present the Cal Poly Ranches Carbon Farm Plan at this event and provide outreach to ranchers in Coastal San Luis Obispo County. As interest grows, we hope to develop a Rancher 2 Rancher program in San Luis Obispo county modeled after the program in Santa Barbara. This would be achieved through partnership with the UC Cooperative Extension, Cal Poly, and local ranchers. One funding opportunity that we are considering applying for is the Western SARE grant.

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10. Appendices

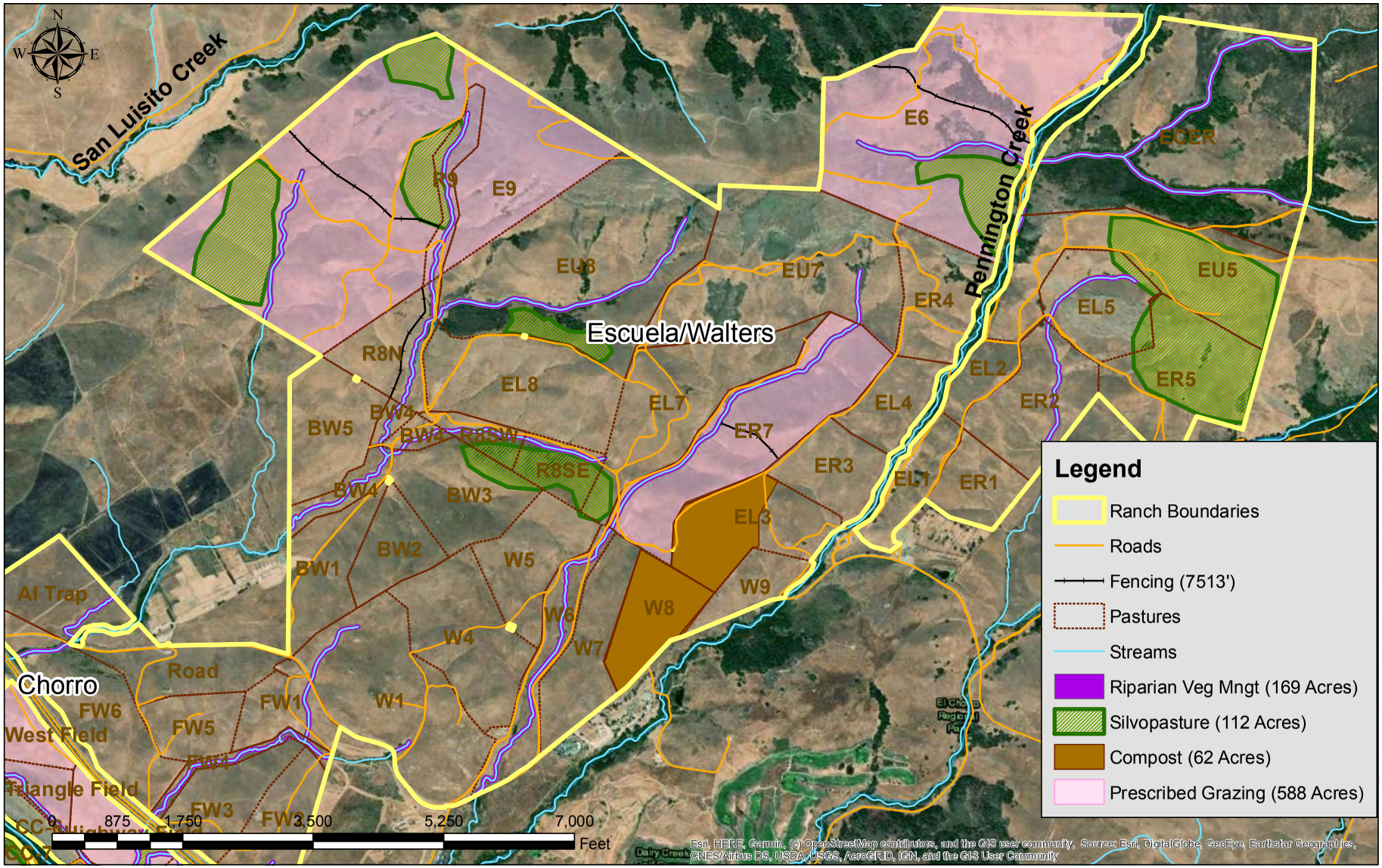
A. Soils and SOM Reports
B. NRCS Practice Standards
C. Maps: Carbon Farm practices by Ranch
D. COMET Planner Emission Reduction Calculations
E. Ecological Site Descriptions
F. PastureMap Grazing Summary Report

Cal Poly Ranches
Carbon Farm Plan

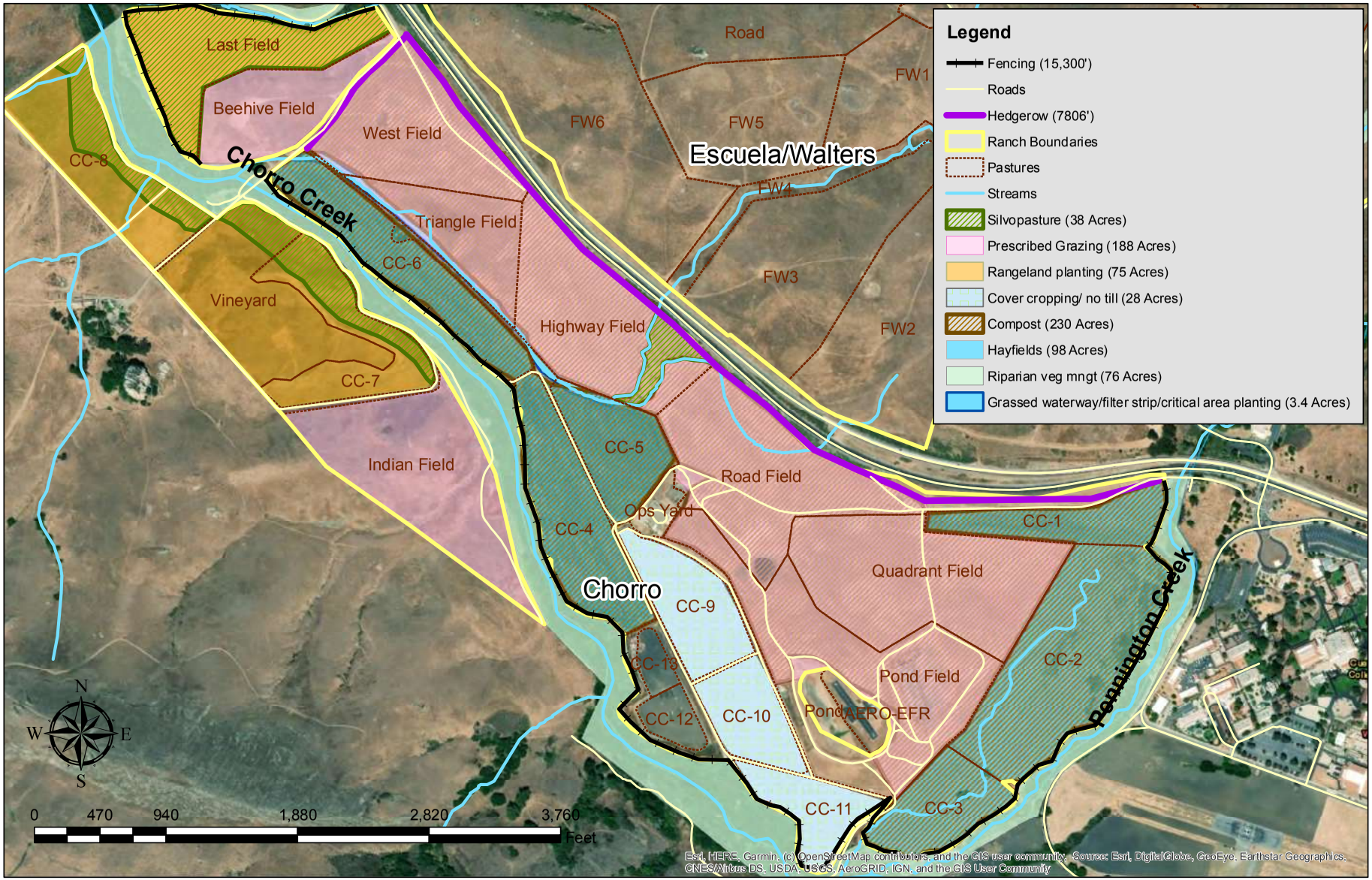
2020

Appendices

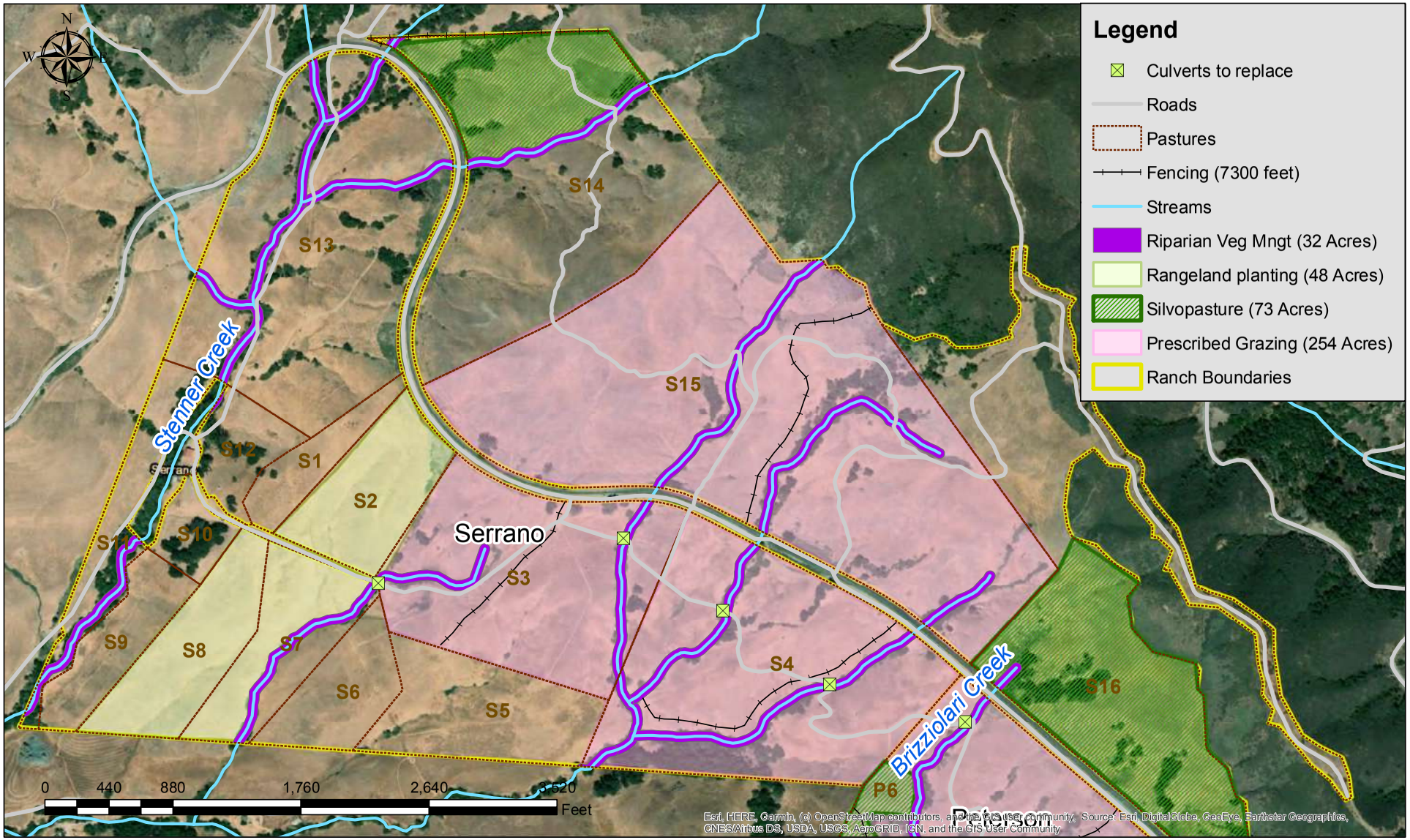
Escuela/Walters Ranch, Cal Poly



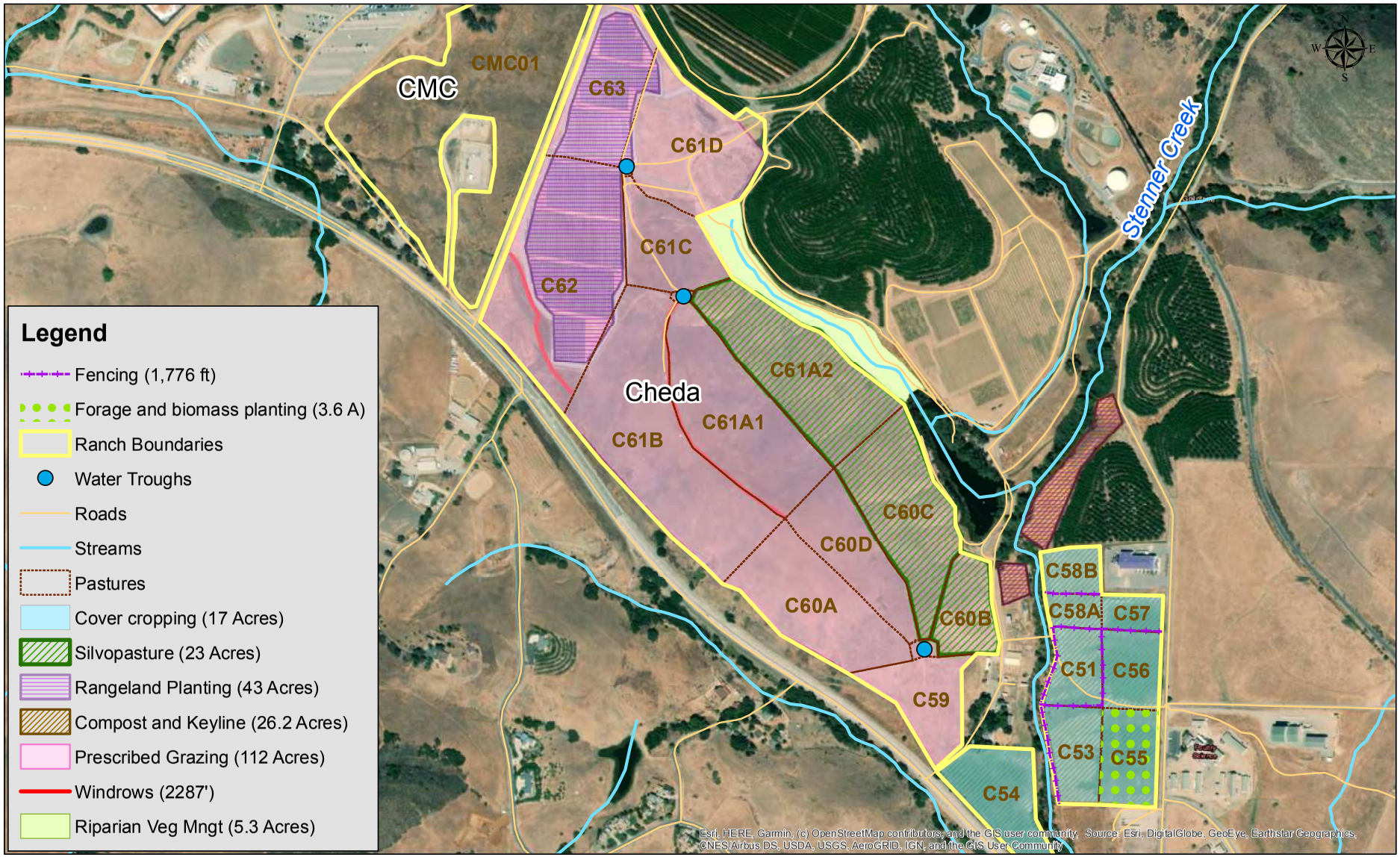
Chorro Ranch, Cal Poly



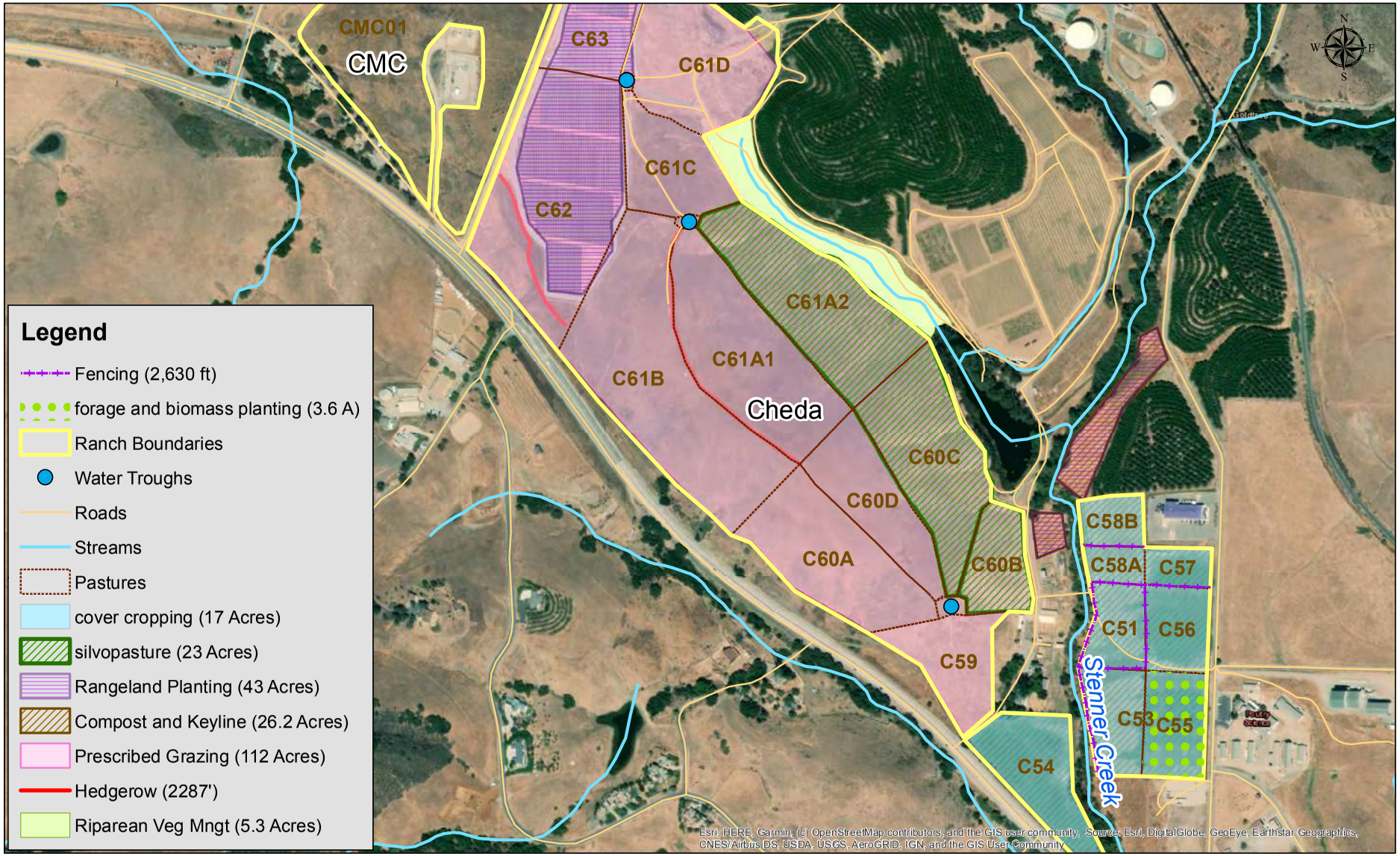
Serrano Ranch, Cal Poly



Cheda Ranch, Cal Poly



Cheda Ranch, Cal Poly



0 325 650 1,300 1,950 2,600
Feet

Soil Map—San Luis Obispo County, California, Coastal Part
(Cheda Ranch)

Map Scale: 1:10,900 if printed on A portrait (8.5" x 11") sheet.

N

Meters
0 150 300 600 900

Feet
0 500 1000 2000 3000

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 10N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils
- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features
- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: San Luis Obispo County, California, Coastal Part
Survey Area Data: Version 11, Sep 12, 2018

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

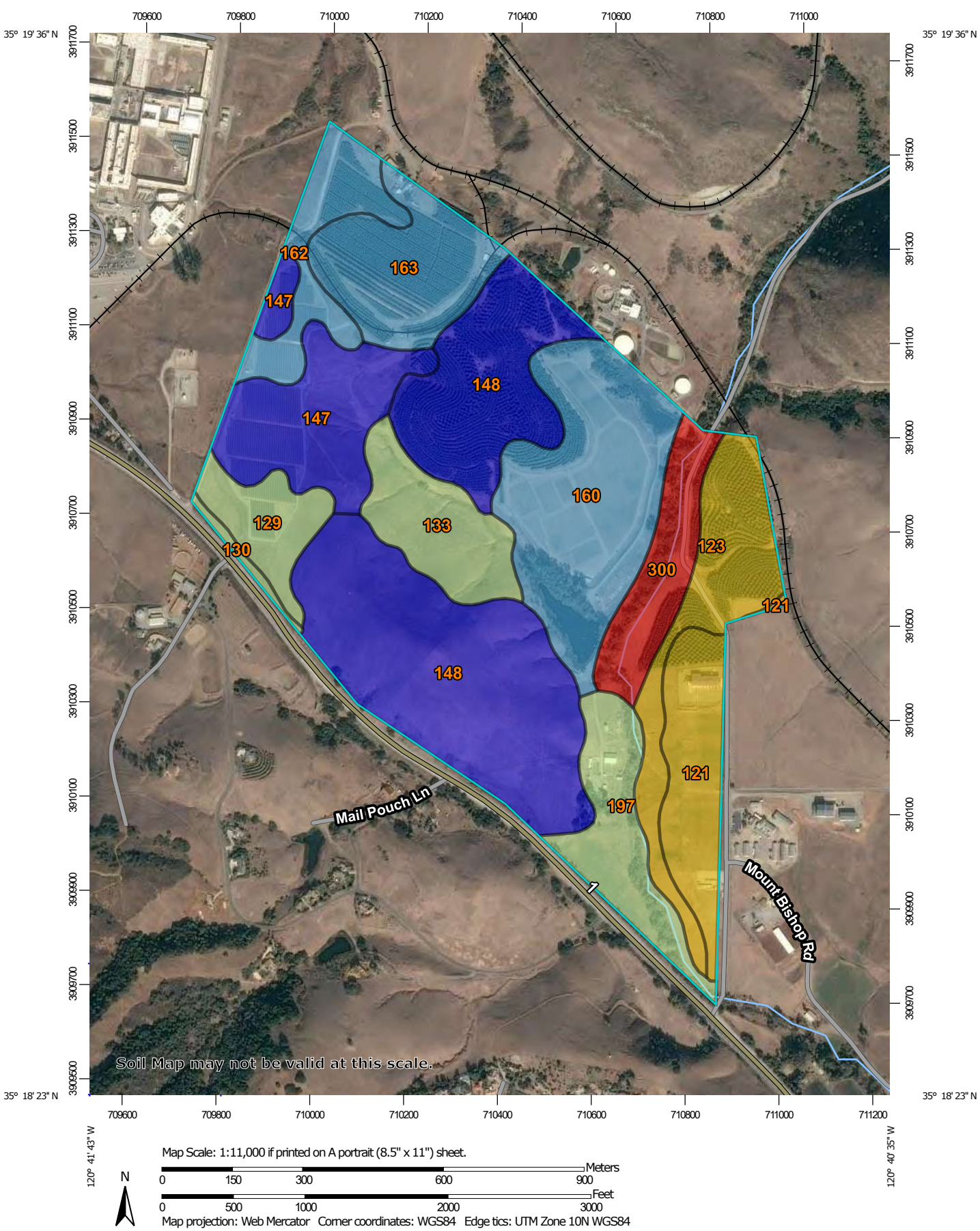
Date(s) aerial images were photographed: Data not available.

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
121	Concepcion loam, 5 to 9 percent slopes	11.9	6.6%
123	Concepcion loam, 15 to 30 percent slopes	5.0	2.8%
129	Diablo clay, 5 to 9 percent slopes, MLRA 15	22.8	12.6%
130	Diablo and Cibo clays, 9 to 15 percent slopes	4.1	2.2%
133	Diablo-Lodo complex, 15 to 50 percent slopes	14.0	7.7%
147	Lodo clay loam, 5 to 15 percent slopes	28.5	15.7%
148	Lodo clay loam, 15 to 30 percent slopes	52.6	29.0%
160	Los Osos loam, 15 to 30 percent slopes, MLRA 15	2.3	1.3%
162	Los Osos-Diablo complex, 5 to 9 percent slopes	18.8	10.4%
163	Los Osos-Diablo complex, 9 to 15 percent slopes	1.0	0.6%
197	Salinas silty clay loam, 0 to 2 percent slopes, MLRA 14	18.8	10.4%
300	Corducci-Typic Xerofluvents, 0 to 5 percent slopes, occasionally flooded, MLRA 14	1.3	0.7%
Totals for Area of Interest		**181.2**	**100.0%**

Soil Health - Organic Matter—San Luis Obispo County, California, Coastal Part
(Cheda Ranch SOM)



Map Scale: 1:11,000 if printed on A portrait (8.5" x 11") sheet.

N

Meters: 0 150 300 600 900

Feet: 0 500 1000 2000 3000

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 10N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils

Soil Rating Polygons
- <= 1.00
- > 1.00 and <= 2.00
- > 2.00 and <= 2.50
- > 2.50 and <= 3.00
- > 3.00 and <= 3.50
- Not rated or not available

Soil Rating Lines
- <= 1.00
- > 1.00 and <= 2.00
- > 2.00 and <= 2.50
- > 2.50 and <= 3.00
- > 3.00 and <= 3.50
- Not rated or not available

Soil Rating Points
- <= 1.00
- > 1.00 and <= 2.00
- > 2.00 and <= 2.50
- > 2.50 and <= 3.00
- > 3.00 and <= 3.50
- Not rated or not available

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: San Luis Obispo County, California, Coastal Part
Survey Area Data: Version 12, Sep 16, 2019

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

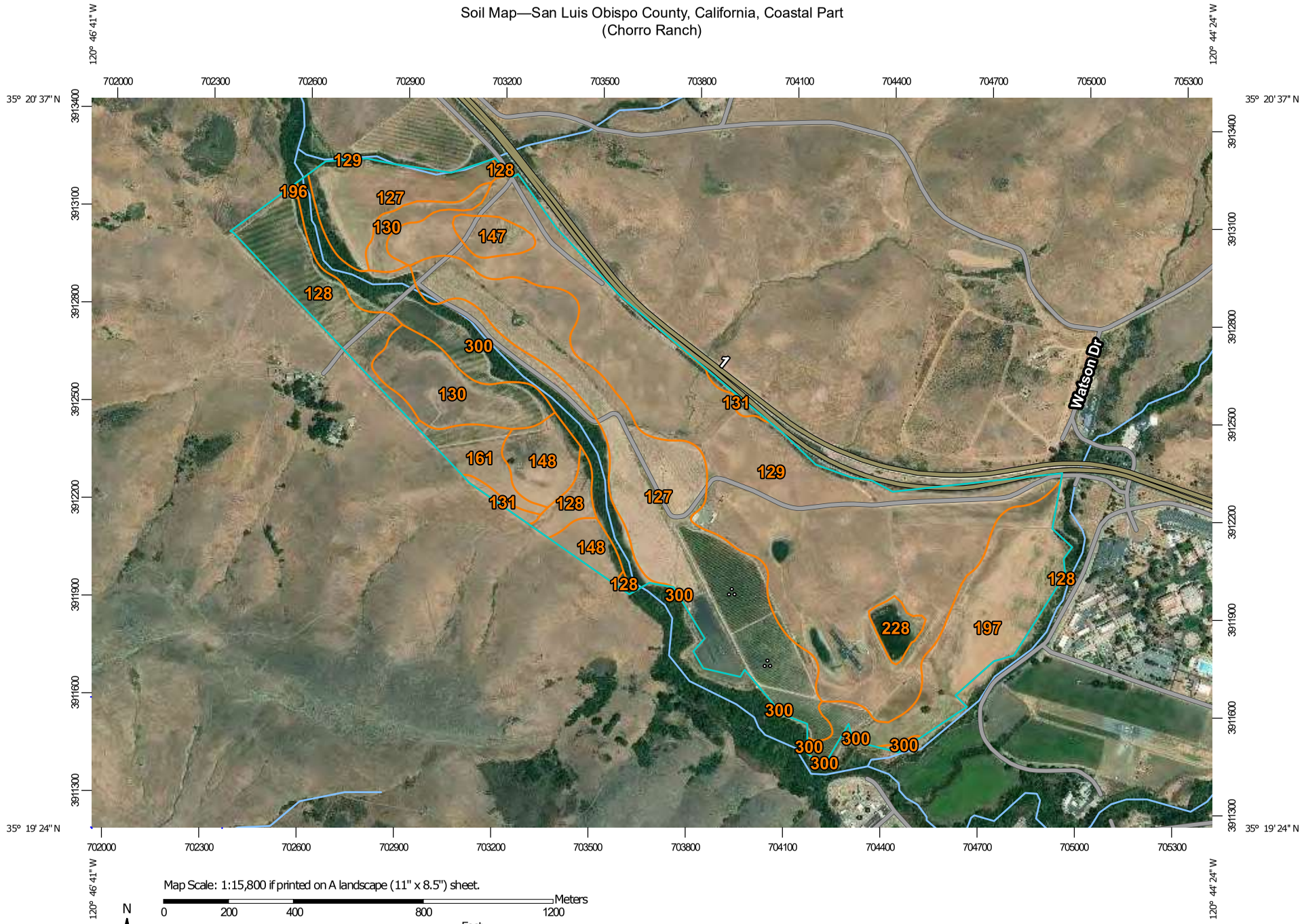
Date(s) aerial images were photographed: Data not available.

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Soil Health - Organic Matter

Map unit symbol	Map unit name	Rating (percent)	Acres in AOI	Percent of AOI
121	Concepcion loam, 5 to 9 percent slopes	2.00	18.6	6.2%
123	Concepcion loam, 15 to 30 percent slopes	2.00	23.0	7.7%
129	Diablo clay, 5 to 9 percent slopes, MLRA 15	2.50	11.1	3.7%
130	Diablo and Cibo clays, 9 to 15 percent slopes	2.50	1.5	0.5%
133	Diablo-Lodo complex, 15 to 50 percent slopes	2.50	17.3	5.8%
147	Lodo clay loam, 5 to 15 percent slopes	3.50	27.0	9.1%
148	Lodo clay loam, 15 to 30 percent slopes	3.50	85.1	28.5%
160	Los Osos loam, 15 to 30 percent slopes	3.00	43.4	14.6%
162	Los Osos-Diablo complex, 5 to 9 percent slopes	3.00	14.8	5.0%
163	Los Osos-Diablo complex, 9 to 15 percent slopes	3.00	23.2	7.8%
197	Salinas silty clay loam, 0 to 2 percent slopes, MLRA 14	2.50	18.2	6.1%
300	Corducci and Typic Xerofluvents, 0 to 5 percent slopes, occasionally flooded, MLRA 14	1.00	15.2	5.1%
Totals for Area of Interest			**298.2**	**100.0%**

Soil Map—San Luis Obispo County, California, Coastal Part
(Chorro Ranch)



Map Scale: 1:15,800 if printed on A landscape (11" x 8.5") sheet.

N

Meters
0 200 400 800 1200

Feet
0 500 1000 2000 3000

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 10N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils
- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features
- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: San Luis Obispo County, California, Coastal Part
Survey Area Data: Version 11, Sep 12, 2018

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

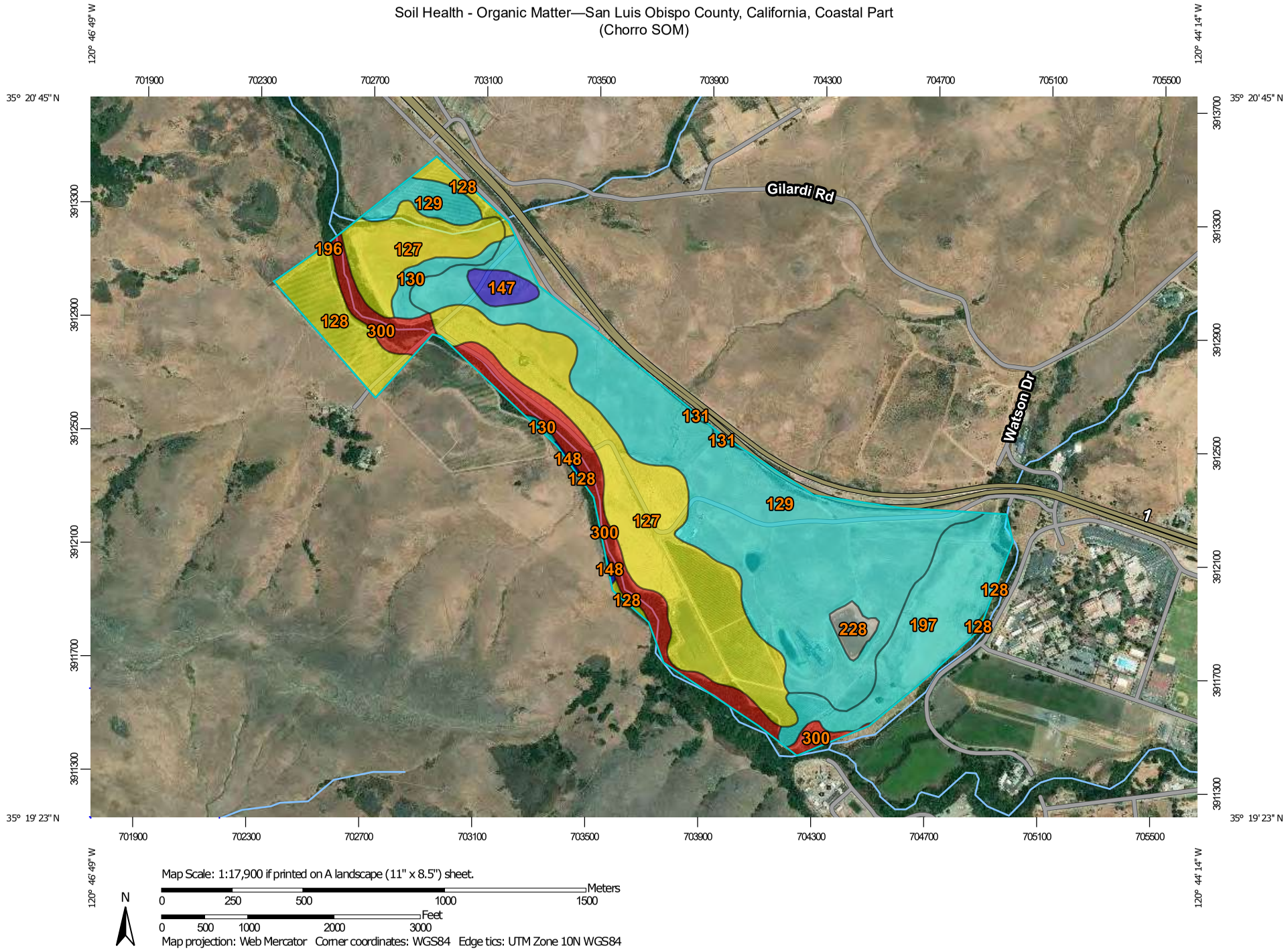
Date(s) aerial images were photographed: Dec 31, 2009—Sep 30, 2017

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
127	Cropley clay, 0 to 2 percent slopes, MLRA 14	110.4	23.6%
128	Cropley clay, 2 to 9 percent slopes, MLRA 14	29.7	6.4%
129	Diablo clay, 5 to 9 percent slopes, MLRA 15	171.6	36.8%
130	Diablo and Cibo clays, 9 to 15 percent slopes	28.6	6.1%
131	Diablo and Cibo clays, 15 to 30 percent slopes	2.8	0.6%
147	Lodo clay loam, 5 to 15 percent slopes	6.0	1.3%
148	Lodo clay loam, 15 to 30 percent slopes	17.5	3.7%
161	Los Osos loam, 30 to 50 percent slopes	10.1	2.2%
196	Salinas loam, 0 to 2 percent slopes, MLRA 14	0.3	0.1%
197	Salinas silty clay loam, 0 to 2 percent slopes, MLRA 14	45.5	9.7%
228	Water	4.9	1.1%
300	Corducci-Typic Xerofluvents, 0 to 5 percent slopes, occasionally flooded, MLRA 14	39.7	8.5%
Totals for Area of Interest		**467.0**	**100.0%**

Soil Health - Organic Matter—San Luis Obispo County, California, Coastal Part
(Chorro SOM)



MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils

Soil Rating Polygons
- <= 1.00
- > 1.00 and <= 1.50
- > 1.50 and <= 2.50
- > 2.50 and <= 3.50
- Not rated or not available

Soil Rating Lines
- <= 1.00
- > 1.00 and <= 1.50
- > 1.50 and <= 2.50
- > 2.50 and <= 3.50
- Not rated or not available

Soil Rating Points
- <= 1.00
- > 1.00 and <= 1.50
- > 1.50 and <= 2.50
- > 2.50 and <= 3.50
- Not rated or not available

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: San Luis Obispo County, California, Coastal Part
Survey Area Data: Version 12, Sep 16, 2019

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

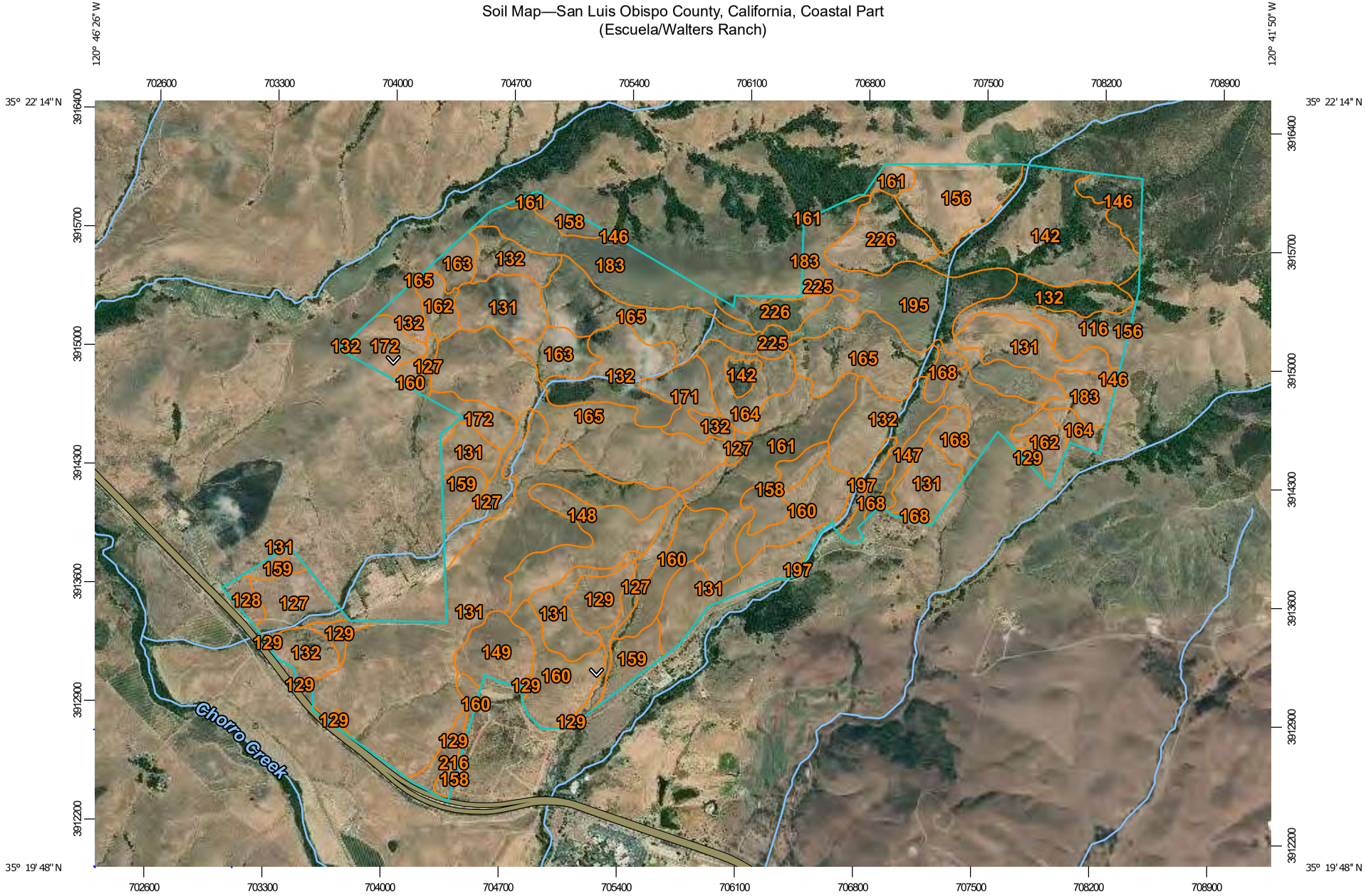
Date(s) aerial images were photographed: Dec 31, 2009—Sep 30, 2017

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Soil Health - Organic Matter

Map unit symbol	Map unit name	Rating (percent)	Acres in AOI	Percent of AOI
127	Cropley clay, 0 to 2 percent slopes, MLRA 14	1.50	117.8	27.5%
128	Cropley clay, 2 to 9 percent slopes, MLRA 14	1.50	26.7	6.2%
129	Diablo clay, 5 to 9 percent slopes, MLRA 15	2.50	174.3	40.8%
130	Diablo and Cibo clays, 9 to 15 percent slopes	2.50	6.9	1.6%
131	Diablo and Cibo clays, 15 to 30 percent slopes	2.50	0.7	0.2%
147	Lodo clay loam, 5 to 15 percent slopes	3.50	6.0	1.4%
148	Lodo clay loam, 15 to 30 percent slopes	3.50	0.6	0.1%
196	Salinas loam, 0 to 2 percent slopes, MLRA 14	2.50	0.3	0.1%
197	Salinas silty clay loam, 0 to 2 percent slopes, MLRA 14	2.50	48.6	11.4%
228	Water		4.9	1.2%
300	Corducci and Typic Xerofluvents, 0 to 5 percent slopes, occasionally flooded, MLRA 14	1.00	40.9	9.6%
Totals for Area of Interest			**427.6**	**100.0%**

Soil Map—San Luis Obispo County, California, Coastal Part
(Escuela/Walters Ranch)



Map Scale: 1:31,900 if printed on A landscape (11" x 8.5") sheet.

N

Meters
0 450 900 1800 2700

Feet
0 1500 3000 6000 9000

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 10N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils
- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features
- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: San Luis Obispo County, California, Coastal Part
Survey Area Data: Version 11, Sep 12, 2018

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Dec 31, 2009—Nov 18, 2018

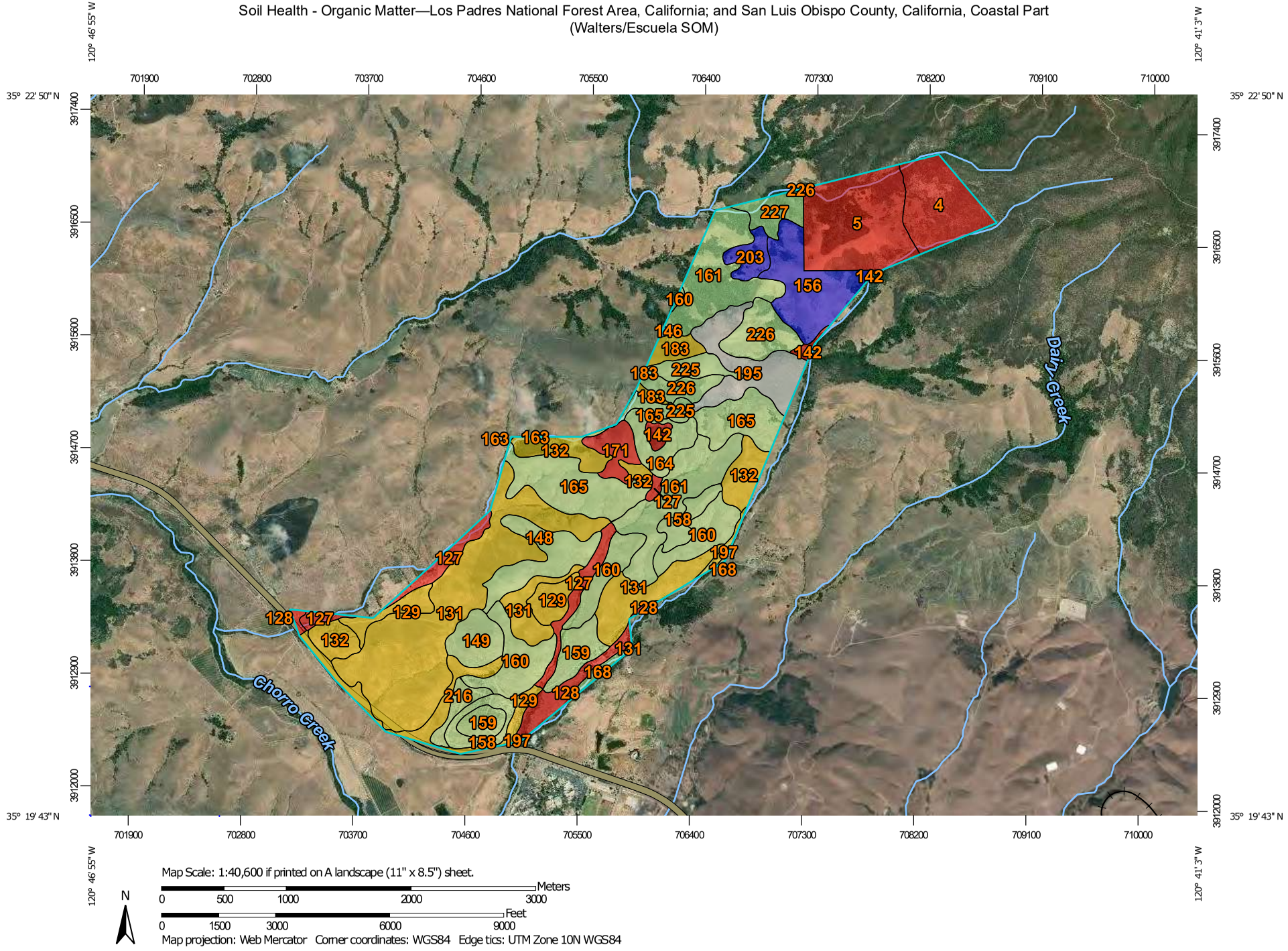
The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
116	Chamise channery loam, 15 to 30 percent slopes, MLRA 15	32.9	1.3%
127	Cropley clay, 0 to 2 percent slopes, MLRA 14	97.1	3.9%
128	Cropley clay, 2 to 9 percent slopes, MLRA 14	9.3	0.4%
129	Diablo clay, 5 to 9 percent slopes, MLRA 15	58.7	2.4%
131	Diablo and Cibo clays, 15 to 30 percent slopes	490.6	19.8%
132	Diablo and Cibo clays, 30 to 50 percent slopes	261.4	10.6%
142	Gaviota fine sandy loam, 15 to 50 percent slopes	136.3	5.5%
146	Henneke-Rock outcrop complex, 15 to 75 percent slopes	25.7	1.0%
147	Lodo clay loam, 5 to 15 percent slopes	13.6	0.5%
148	Lodo clay loam, 15 to 30 percent slopes	65.1	2.6%
149	Lodo clay loam, 30 to 50 percent slopes, MLRA 15	35.9	1.5%
156	Lopez very shaly clay loam, 30 to 75 percent slopes	61.1	2.5%
158	Los Osos loam, 5 to 9 percent slopes	34.9	1.4%
159	Los Osos loam, 9 to 15 percent slopes	44.6	1.8%
160	Los Osos loam, 15 to 30 percent slopes, MLRA 15	128.8	5.2%
161	Los Osos loam, 30 to 50 percent slopes	111.2	4.5%
162	Los Osos-Diablo complex, 5 to 9 percent slopes	35.0	1.4%
163	Los Osos-Diablo complex, 9 to 15 percent slopes	39.1	1.6%
164	Los Osos-Diablo complex, 15 to 30 percent slopes	48.7	2.0%
165	Los Osos-Diablo complex, 30 to 50 percent slopes	286.0	11.6%
168	Los Osos variant clay loam, 15 to 50 percent slopes	41.2	1.7%
171	Millsap loam, 15 to 50 percent slopes	29.2	1.2%

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
172	Millsap-Rock outcrop complex, 30 to 75 percent slopes	45.2	1.8%
183	Obispo-Rock outcrop complex, 15 to 75 percent slopes	102.0	4.1%
195	Rock outcrop-Lithic Haploxerolls complex, 30 to 75 percent slopes	135.1	5.5%
197	Salinas silty clay loam, 0 to 2 percent slopes, MLRA 14	12.1	0.5%
216	Tierra sandy loam, 2 to 9 percent slopes, MLRA 14	6.1	0.2%
225	Zaca clay, 15 to 30 percent slopes	17.3	0.7%
226	Zaca clay, 30 to 50 percent slopes	68.6	2.8%
Totals for Area of Interest		**2,472.8**	**100.0%**

Soil Health - Organic Matter—Los Padres National Forest Area, California; and San Luis Obispo County, California, Coastal Part
(Walters/Escuela SOM)



MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils

Soil Rating Polygons
- <= 1.50
- > 1.50 and <= 2.50
- > 2.50 and <= 3.50
- > 3.50 and <= 4.50
- > 4.50 and <= 6.00
- Not rated or not available

Soil Rating Lines
- <= 1.50
- > 1.50 and <= 2.50
- > 2.50 and <= 3.50
- > 3.50 and <= 4.50
- > 4.50 and <= 6.00
- Not rated or not available

Soil Rating Points
- <= 1.50
- > 1.50 and <= 2.50
- > 2.50 and <= 3.50
- > 3.50 and <= 4.50
- > 4.50 and <= 6.00
- Not rated or not available

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Los Padres National Forest Area, California
Survey Area Data: Version 11, Sep 16, 2019

Soil Survey Area: San Luis Obispo County, California, Coastal Part
Survey Area Data: Version 12, Sep 16, 2019

Your area of interest (AOI) includes more than one soil survey area. These survey areas may have been mapped at different scales, with a different land use in mind, at different times, or at different levels of detail. This may result in map unit symbols, soil properties, and interpretations that do not completely agree across soil survey area boundaries.

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Dec 31, 2009—Nov 18, 2018

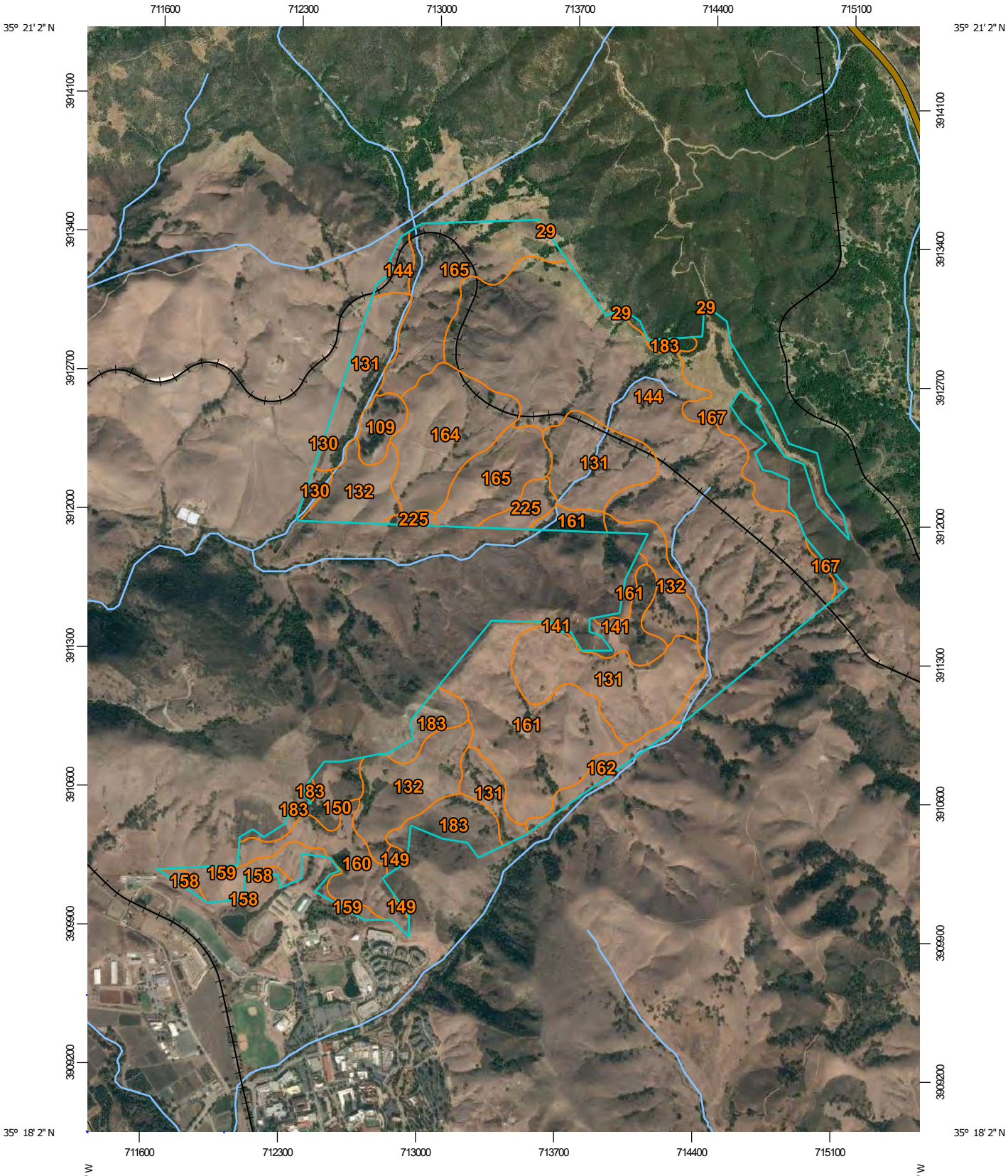
The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Soil Health - Organic Matter

Map unit symbol	Map unit name	Rating (percent)	Acres in AOI	Percent of AOI
4	Cuesta-Henneke families complex, 15 to 60 percent slopes	1.00	91.1	4.4%
5	Diablo-Altamont-Henneke families association, 10 to 60 percent slopes	1.00	152.9	7.4%
Subtotals for Soil Survey Area			**244.0**	**11.8%**
Totals for Area of Interest			**2,076.5**	**100.0%**

Map unit symbol	Map unit name	Rating (percent)	Acres in AOI	Percent of AOI
127	Cropley clay, 0 to 2 percent slopes, MLRA 14	1.50	58.7	2.8%
128	Cropley clay, 2 to 9 percent slopes, MLRA 14	1.50	40.0	1.9%
129	Diablo clay, 5 to 9 percent slopes, MLRA 15	2.50	103.0	5.0%
131	Diablo and Cibo clays, 15 to 30 percent slopes	2.50	375.6	18.1%
132	Diablo and Cibo clays, 30 to 50 percent slopes	2.50	93.3	4.5%
142	Gaviota fine sandy loam, 15 to 50 percent slopes	1.50	13.8	0.7%
146	Henneke-Rock outcrop complex, 15 to 75 percent slopes	4.50	1.8	0.1%
148	Lodo clay loam, 15 to 30 percent slopes	3.50	65.0	3.1%
149	Lodo clay loam, 30 to 50 percent slopes, MLRA 15	3.50	38.2	1.8%
156	Lopez very shaly clay loam, 30 to 75 percent slopes	6.00	96.7	4.7%
158	Los Osos loam, 5 to 9 percent slopes	3.00	48.5	2.3%
159	Los Osos loam, 9 to 15 percent slopes	3.00	52.5	2.5%

Map unit symbol	Map unit name	Rating (percent)	Acres in AOI	Percent of AOI
160	Los Osos loam, 15 to 30 percent slopes	3.00	133.5	6.4%
161	Los Osos loam, 30 to 50 percent slopes	3.00	197.5	9.5%
163	Los Osos-Diablo complex, 9 to 15 percent slopes	3.00	0.2	0.0%
164	Los Osos-Diablo complex, 15 to 30 percent slopes	3.00	37.4	1.8%
165	Los Osos-Diablo complex, 30 to 50 percent slopes	3.00	157.2	7.6%
168	Los Osos variant clay loam, 15 to 50 percent slopes	3.00	7.5	0.4%
171	Millsap loam, 15 to 50 percent slopes	0.75	29.2	1.4%
183	Obispo-Rock outcrop complex, 15 to 75 percent slopes	2.00	22.9	1.1%
195	Rock outcrop-Lithic Haploxerolls complex, 30 to 75 percent slopes		82.5	4.0%
197	Salinas silty clay loam, 0 to 2 percent slopes, MLRA 14	2.50	6.4	0.3%
203	Santa Lucia channery clay loam, 30 to 50 percent slopes, MLRA 15	6.00	23.4	1.1%
216	Tierra sandy loam, 2 to 9 percent slopes, MLRA 14	3.00	17.1	0.8%
225	Zaca clay, 15 to 30 percent slopes	3.00	31.2	1.5%
226	Zaca clay, 30 to 50 percent slopes	3.00	69.9	3.4%
227	Zaca clay, 50 to 75 percent slopes	3.00	29.6	1.4%
Subtotals for Soil Survey Area			**1,832.5**	**88.2%**
Totals for Area of Interest			**2,076.5**	**100.0%**



Map Scale: 1:27,200 if printed on A portrait (8.5" x 11") sheet.

N

Meters: 0 400 800 1600 2400

Feet: 0 1000 2000 4000 6000

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 10N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils
- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features
- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Los Padres National Forest Area, California
Survey Area Data: Version 10, Sep 12, 2018

Soil Survey Area: San Luis Obispo County, California, Coastal Part
Survey Area Data: Version 11, Sep 12, 2018

Your area of interest (AOI) includes more than one soil survey area. These survey areas may have been mapped at different scales, with a different land use in mind, at different times, or at different levels of detail. This may result in map unit symbols, soil properties, and interpretations that do not completely agree across soil survey area boundaries.

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Dec 31, 2009—Nov 18, 2018

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

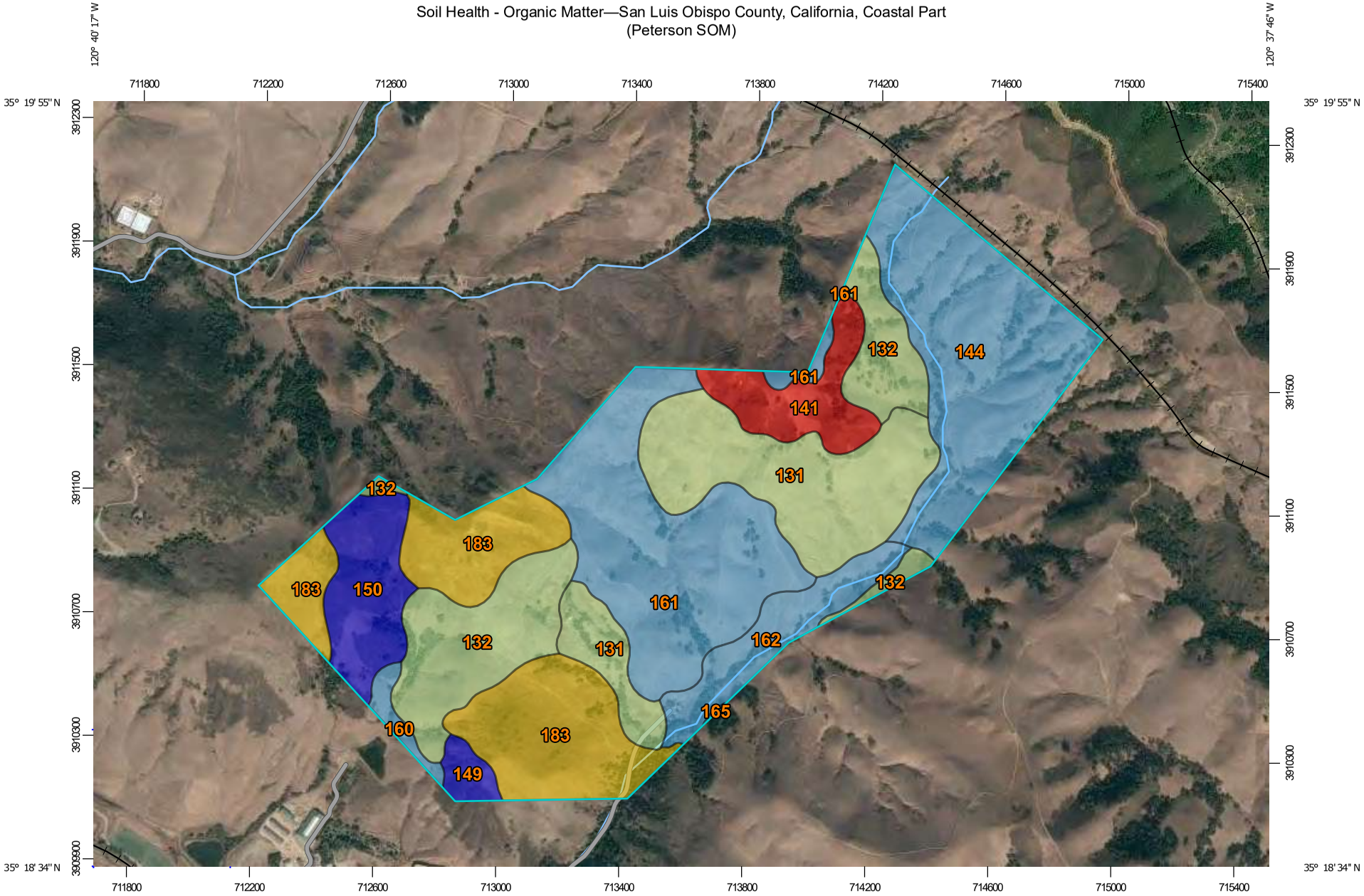
Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
29	Millsholm-Exchequer-Stonyford families complex, 30 to 75 percent slopes	0.7	0.1%
Subtotals for Soil Survey Area		**0.7**	**0.1%**
Totals for Area of Interest		**1,259.9**	**100.0%**

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
109	Briones-Pismo loamy sands, 9 to 30 percent slopes	15.2	1.2%
130	Diablo and Cibo clays, 9 to 15 percent slopes	5.3	0.4%
131	Diablo and Cibo clays, 15 to 30 percent slopes	180.8	14.3%
132	Diablo and Cibo clays, 30 to 50 percent slopes	108.8	8.6%
141	Gaviota sandy loam, 50 to 75 percent slopes, MLRA 15	20.9	1.7%
144	Gazos-Lodo clay loams, 30 to 50 percent slopes	378.7	30.1%
149	Lodo clay loam, 30 to 50 percent slopes, MLRA 15	2.8	0.2%
150	Lodo clay loam, 50 to 75 percent slopes, MLRA 15	21.0	1.7%
158	Los Osos loam, 5 to 9 percent slopes	5.2	0.4%
159	Los Osos loam, 9 to 15 percent slopes	23.1	1.8%
160	Los Osos loam, 15 to 30 percent slopes, MLRA 15	41.0	3.3%
161	Los Osos loam, 30 to 50 percent slopes	122.3	9.7%
162	Los Osos-Diablo complex, 5 to 9 percent slopes	15.1	1.2%
164	Los Osos-Diablo complex, 15 to 30 percent slopes	71.7	5.7%
165	Los Osos-Diablo complex, 30 to 50 percent slopes	122.6	9.7%
167	Los Osos-Lodo complex, 30 to 75 percent slopes	63.6	5.0%
183	Obispo-Rock outcrop complex, 15 to 75 percent slopes	45.1	3.6%
225	Zaca clay, 15 to 30 percent slopes	16.1	1.3%

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
Subtotals for Soil Survey Area		**1,259.1**	**99.9%**
Totals for Area of Interest		**1,259.9**	**100.0%**

Soil Health - Organic Matter—San Luis Obispo County, California, Coastal Part
(Peterson SOM)



Map Scale: 1:17,500 if printed on A landscape (11" x 8.5") sheet.

N

Meters
0 250 500 1000 1500

Feet
0 500 1000 2000 3000

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 10N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils

Soil Rating Polygons
- <= 0.75
- > 0.75 and <= 2.00
- > 2.00 and <= 2.50
- > 2.50 and <= 3.00
- > 3.00 and <= 3.50
- Not rated or not available

Soil Rating Lines
- <= 0.75
- > 0.75 and <= 2.00
- > 2.00 and <= 2.50
- > 2.50 and <= 3.00
- > 3.00 and <= 3.50
- Not rated or not available

Soil Rating Points
- <= 0.75
- > 0.75 and <= 2.00
- > 2.00 and <= 2.50
- > 2.50 and <= 3.00
- > 3.00 and <= 3.50
- Not rated or not available

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: San Luis Obispo County, California, Coastal Part
Survey Area Data: Version 12, Sep 16, 2019

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

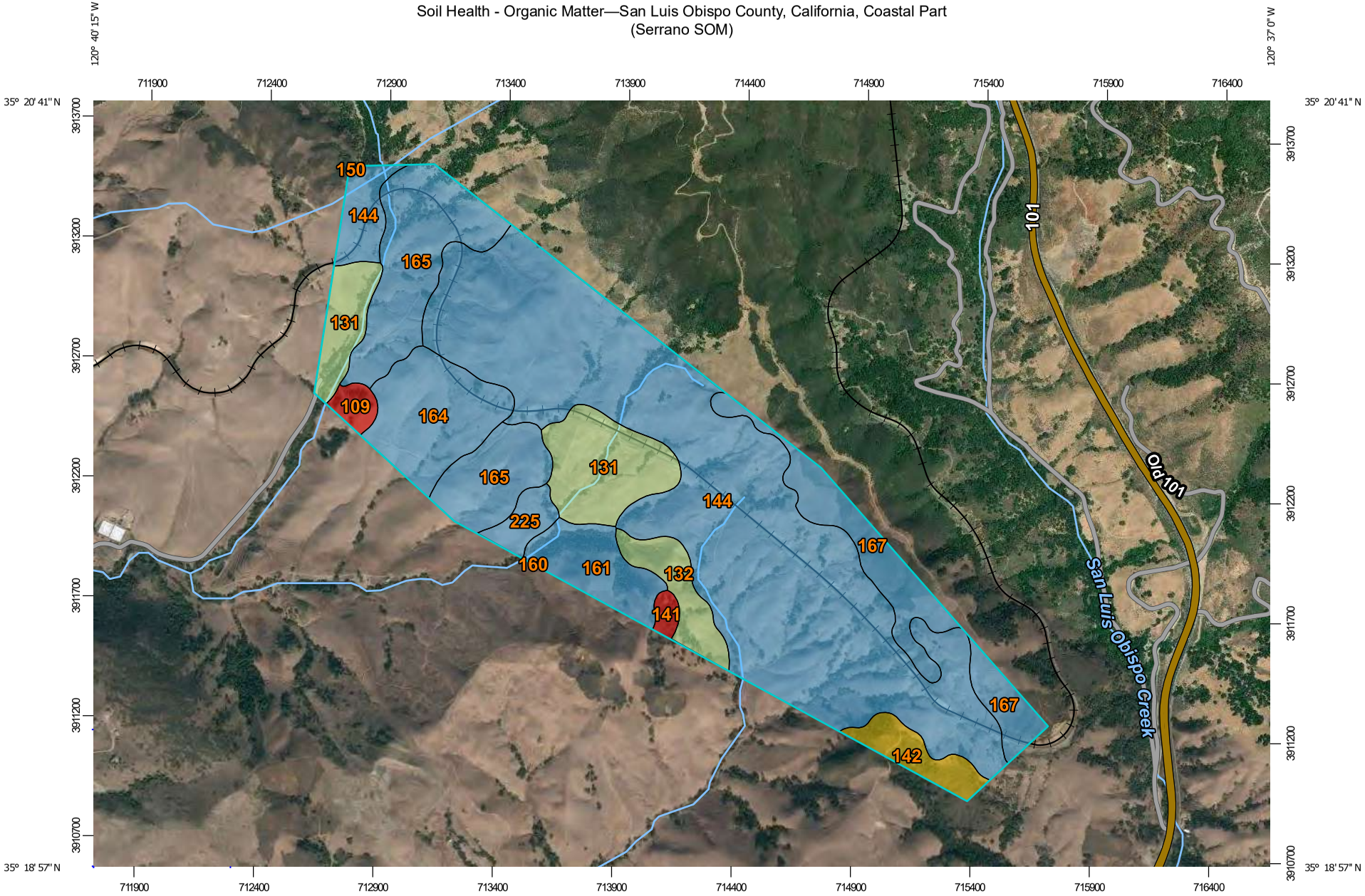
Date(s) aerial images were photographed: Data not available.

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Soil Health - Organic Matter

Map unit symbol	Map unit name	Rating (percent)	Acres in AOI	Percent of AOI
131	Diablo and Cibo clays, 15 to 30 percent slopes	2.50	94.9	15.8%
132	Diablo and Cibo clays, 30 to 50 percent slopes	2.50	78.2	13.0%
141	Gaviota sandy loam, 50 to 75 percent slopes, MLRA 15	0.75	28.9	4.8%
144	Gazos-Lodo clay loams, 30 to 50 percent slopes	3.00	108.3	18.0%
149	Lodo clay loam, 30 to 50 percent slopes, MLRA 15	3.50	7.0	1.2%
150	Lodo clay loam, 50 to 75 percent slopes, MLRA 15	3.50	35.3	5.9%
160	Los Osos loam, 15 to 30 percent slopes	3.00	5.7	0.9%
161	Los Osos loam, 30 to 50 percent slopes	3.00	112.4	18.7%
162	Los Osos-Diablo complex, 5 to 9 percent slopes	3.00	30.4	5.1%
165	Los Osos-Diablo complex, 30 to 50 percent slopes	3.00	0.2	0.0%
183	Obispo-Rock outcrop complex, 15 to 75 percent slopes	2.00	99.7	16.6%
Totals for Area of Interest			**601.1**	**100.0%**

Soil Health - Organic Matter—San Luis Obispo County, California, Coastal Part
(Serrano SOM)



Map Scale: 1:22,500 if printed on A landscape (11" x 8.5") sheet.

N

Meters
0 300 600 1200 1800

Feet
0 1000 2000 4000 6000

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 10N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils

Soil Rating Polygons
- <= 0.75
- > 0.75 and <= 1.50
- > 1.50 and <= 2.50
- > 2.50 and <= 3.00
- > 3.00 and <= 3.50
- Not rated or not available

Soil Rating Lines
- <= 0.75
- > 0.75 and <= 1.50
- > 1.50 and <= 2.50
- > 2.50 and <= 3.00
- > 3.00 and <= 3.50
- Not rated or not available

Soil Rating Points
- <= 0.75
- > 0.75 and <= 1.50
- > 1.50 and <= 2.50
- > 2.50 and <= 3.00
- > 3.00 and <= 3.50
- Not rated or not available

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: San Luis Obispo County, California, Coastal Part
Survey Area Data: Version 12, Sep 16, 2019

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Dec 31, 2009—Nov 18, 2018

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Soil Health - Organic Matter

Map unit symbol	Map unit name	Rating (percent)	Acres in AOI	Percent of AOI
109	Briones-Pismo loamy sands, 9 to 30 percent slopes	0.75	7.3	0.9%
131	Diablo and Cibo clays, 15 to 30 percent slopes	2.50	70.0	8.8%
132	Diablo and Cibo clays, 30 to 50 percent slopes	2.50	23.1	2.9%
141	Gaviota sandy loam, 50 to 75 percent slopes, MLRA 15	0.75	4.2	0.5%
142	Gaviota fine sandy loam, 15 to 50 percent slopes	1.50	19.4	2.4%
144	Gazos-Lodo clay loams, 30 to 50 percent slopes	3.00	406.4	51.2%
150	Lodo clay loam, 50 to 75 percent slopes, MLRA 15	3.50	0.1	0.0%
160	Los Osos loam, 15 to 30 percent slopes	3.00	0.0	0.0%
161	Los Osos loam, 30 to 50 percent slopes	3.00	33.0	4.2%
164	Los Osos-Diablo complex, 15 to 30 percent slopes	3.00	55.8	7.0%
165	Los Osos-Diablo complex, 30 to 50 percent slopes	3.00	102.7	12.9%
167	Los Osos-Lodo complex, 30 to 75 percent slopes	3.00	59.8	7.5%
225	Zaca clay, 15 to 30 percent slopes	3.00	11.8	1.5%
Totals for Area of Interest			**793.7**	**100.0%**

NATURAL RESOURCES CONSERVATION SERVICE

CONSERVATION PRACTICE STANDARD

COVER CROP

(Ac.)

CODE 340

DEFINITION

Grasses, legumes, and forbs planted for seasonal vegetative cover.

PURPOSE

This practice is applied to support one or more of the following purposes:

- Reduce erosion from wind and water.
- Maintain or increase soil health and organic matter content.
- Reduce water quality degradation by utilizing excessive soil nutrients.
- Suppress excessive weed pressures and break pest cycles.
- Improve soil moisture use efficiency.
- Minimize soil compaction.

CONDITIONS WHERE PRACTICE APPLIES

All lands requiring seasonal vegetative cover for natural resource protection or improvement.

CRITERIA

General Criteria Applicable to All Purposes

Plant species, seedbed preparation, seeding rates, seeding dates, seeding depths, fertility requirements, and planting methods will be consistent with applicable local criteria and soil/site conditions.

Select species that are compatible with other components of the cropping system.

Ensure herbicides used with crops are compatible with cover crop selections and purpose(s).

Cover crops may be established between successive production crops, or companion-planted or relay-planted into production crops. Select species and planting dates that will not compete with the production crop yield or harvest.

Do not burn cover crop residue.

Determine the method and timing of termination to meet the grower's objective and the current NRCS Cover Crop Termination Guidelines.

When a cover crop will be grazed or hayed ensure the planned management will not compromise the selected conservation purpose(s).

Do not harvest cover crops for seed.

If the specific rhizobium bacteria for the selected legume are not present in the soil, treat the seed with the appropriate inoculum at the time of planting.

Additional Criteria to Reduce Erosion from Wind and Water

Time the cover crop establishment in conjunction with other practices to adequately protect the soil during the critical erosion period(s).

Select cover crops that will have the physical characteristics necessary to provide adequate erosion protection.

Use the current erosion prediction technology to determine the amount of surface and/or canopy cover needed from the cover crop to achieve the erosion objective.

Additional Criteria to Maintain or Increase Soil Health and Organic Matter Content

Cover crop species will be selected on the basis of producing higher volumes of organic material and root mass to maintain or increase soil

organic matter.

The planned crop rotation including the cover crop and associated management activities will score a Soil Conditioning Index (SCI) value > 0, as determined using the current approved NRCS Soil Conditioning Index (SCI) procedure, with appropriate adjustments for additions to and or subtractions from plant biomass.

The cover crop shall be planted as early as possible and be terminated as late as practical for the producer's cropping system to maximize plant biomass production, considering crop insurance criteria, the time needed to prepare the field for planting the next crop, and soil moisture depletion.

Additional Criteria Reduce Water Quality Degradation by Utilizing Excessive Soil Nutrients

Establish cover crops as soon as practical prior to or after harvest of the production crop. (i.e. before or after harvest)

Select cover crop species for their ability to effectively utilize nutrients.

Terminate the cover crop as late as practical to maximize plant biomass production and nutrient uptake. Practical considerations for termination date may include crop insurance criteria, the amount of time needed to prepare the field for planting the next crop, weather conditions, and cover crop effects on soil moisture and nutrient availability to the following crop.

If the cover crop will be harvested for feed (hay/balage/etc.), choose species that are suitable for the planned livestock, and capable of removing the excess nutrients present.

Additional Criteria to Suppress Excessive Weed Pressures and Break Pest Cycles

Select cover crop species for their life cycles, growth habits, and other biological, chemical and or physical characteristics to provide one or more of the following:

- To suppress weeds, or compete with weeds.
- Break pest life cycles or suppress of plant pests or pathogens.
- Provide food or habitat for natural enemies of pests.
- Release compounds such as glucosinolates that suppress soil borne pathogens or pests.

Select cover crop species that do not harbor pests or diseases of subsequent crops in the rotation.

Additional Criteria to Improve Soil Moisture Use Efficiency

In areas of limited soil moisture, terminate growth of the cover crop sufficiently early to conserve soil moisture for the subsequent crop. Cover crops established for moisture conservation shall be left on the soil surface.

In areas of potential excess soil moisture, allow the cover crop to grow as long as possible to maximize soil moisture removal.

Additional Criteria to Minimize Soil Compaction

Select cover crop species that have the ability to root deeply and the capacity to penetrate or prevent compacted layers.

CONSIDERATIONS

Plant cover crops in a timely matter and when there is adequate moisture to establish a good stand.

When applicable, ensure cover crops are managed and are compatible with the client's crop insurance criteria.

Maintain an actively growing cover crop as late as feasible to maximize plant growth, allowing time to prepare the field for the next crop and to optimize soil moisture.

Select cover crops that are compatible with the production system, well adapted to the region's

climate and soils, and resistant to prevalent pests, weeds, and diseases. Avoid cover crop species that harbor or carry over potentially damaging diseases or insects.

Cover crops may be used to improve site conditions for establishment of perennial species.

When cover crops are used for grazing, select species that will have desired forage traits, be palatable to livestock, and not interfere with the production of the subsequent crop.

Use plant species that enhance forage opportunities for pollinators by using diverse legumes and other forbs.

Cover crops may be selected to provide food or habitat for natural enemies of production crop pests.

Cover crops residues should be left on the soil surface to maximize allelopathic (chemical) and mulching (physical) effects.

Seed a higher density cover crop stand to promote rapid canopy closure and greater weed suppression. Increased seeding rates (1.5 to 2 times normal) can improve weed-competitiveness.

Cover crops may be selected that release biofumigation compounds that inhibit soil-borne plant pests and pathogens.

Species can be selected to serve as trap crops to divert pests from production crops.

Select a mixture of two or more cover crop species from different plant families to achieve one or more of the following: (1) species mix with different maturity dates, (2) attract beneficial insects, (3) attract pollinators, (4) increase soil biological diversity, (5) serve as a trap crop for insect pests, or (6) provide food and cover for wildlife habitat management.

Plant legumes or mixtures of legumes with grasses, crucifers, and/or other forbs to achieve biological nitrogen fixation. Select cover crop species or mixture, and timing and method of termination that will maximize efficiency of nitrogen utilization by the following crop, considering soil type and conditions, season and weather conditions, cropping system, C:N ratio of the cover crop at termination, and anticipated nitrogen needs of the subsequent crop. Use LGU- recommended nitrogen credits from the legume and reduce nitrogen applications to the subsequent crop accordingly. “If the specific rhizobium bacteria for the selected legume are not present in the soil, treat the seed with the appropriate inoculum at the time of planting.

Time the termination of cover crops to meet nutrient release goals. Termination at early vegetative stages may cause a more rapid release compared to termination at a more mature stage.

Both residue decomposition rates and soil fertility can affect nutrient availability following termination of cover crops

Allelopathic effects to the subsequent crop should be evaluated when selecting the appropriate cover crop.

Legumes add the most plant-available N if terminated when about 30% of the crop is in bloom.

Additional Considerations to Reduce Erosion by Wind or Water

To reduce erosion, best results are achieved when the combined canopy and surface residue cover attains 90 percent or greater during the period of potentially erosive wind or rainfall.

Additional Considerations to Reduce Water Quality Degradation by Utilizing Excessive Soil Nutrients

Use deep-rooted species to maximize nutrient recovery.

When appropriate for the crop production system, mowing certain grass cover crops (e.g., sorghum-sudangrass, pearl millet) prior to heading and allowing the cover crop to regrow can enhance rooting depth and density, thereby increasing their subsoiling and nutrient-recycling efficacy.

Additional Considerations to Increase Soil Health and Organic Matter Content

Increase the diversity of cover crops (e.g., mixtures of several plant species) to promote a wider diversity of soil organisms, and thereby promote increased soil organic matter.

Plant legumes or mixtures of legumes with grasses, crucifers, and/or other forbs to provide nitrogen through biological nitrogen fixation.

Legumes add the most plant-available N if terminated when about 30% of the crop is in bloom.

PLANS AND SPECIFICATIONS

Prepare plans and specifications for each field or treatment unit according to the planning criteria and operation and maintenance requirements of this standard. Specifications shall describe the requirements to apply the practice to achieve the intended purpose for the practice site. Plans for the establishment of cover crops shall, as a minimum, include the following specification components in an approved Cover Crop, 340, Implementation Requirements document:

- Field number and acres
- Species of plant(s) to be established.
- Seeding rates.
- Seeding dates.
- Establishment procedure.
- Rates, timing, and forms of nutrient application (if needed).
- Dates and method to terminate the cover crop.
- Other information pertinent to establishing and managing the cover crop e.g., if haying or grazing is planned specify the planned management for haying or grazing.

OPERATION AND MAINTENANCE

Evaluate the cover crop to determine if the cover crop is meeting the planned purpose(s). If the cover crop is not meeting the purpose(s) adjust the management, change the species of cover crop, or choose a different technology.

REFERENCES

A. Clark (ed.). 2007. Managing cover crops profitably. 3rd ed. Sustainable Agriculture Network Handbook Series; bk 9.

Hargrove, W.L., ed. Cover crops for clean water. SWCS, 1991.

Magdoff, F. and H. van Es. Cover Crops. 2000. p. 87-96 *In* Building soils for better crops. 2nd ed. Sustainable Agriculture Network Handbook Series; bk 4. National Agriculture Library. Beltsville, MD.

Reeves, D.W. 1994. Cover crops and erosion. p. 125-172 *In* J.L. Hatfield and B.A. Stewart (eds.) Crops Residue Management. CRC Press, Boca Raton, FL.

NRCS Cover Crop Termination Guidelines: http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/climatechange/?cid=stelprdb1077238

Revised Universal Soil Loss Equation Version 2 (RUSLE2) website: http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/technical/tools/rusle2/

Wind Erosion Prediction System (WEPS) website: http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/technical/tools/weps/

USDA, Natural Resources Conservation Service, National Agronomy Manual, 4th Edition, Feb. 2011. Website: http://directives.sc.egov.usda.gov/ Under Manuals and Title 190.

NATURAL RESOURCES CONSERVATION SERVICE

CONSERVATION PRACTICE STANDARD

GRAZING LAND MECHANICAL TREATMENT

(Ac.)

CODE 548

DEFINITION

Modifying physical soil and/or plant conditions with mechanical tools by treatments such as pitting, contour furrowing, and chiseling, ripping or subsoiling.

PURPOSE

- Fracture compacted soil layers and improve soil permeability
- Reduction in water runoff and increased infiltration
- Break up root-bound conditions and thatch to increase plant vigor
- Renovation and stimulation of plant community for greater productivity and yield

CONDITIONS WHERE PRACTICE APPLIES

This standard may be applied on pasture, range, and grazed forest where the slopes are less than 30 percent.

CRITERIA

General Criteria Applicable to All Purposes

Mechanical treatments such as contour furrowing, pitting, chiseling, ripping, or subsoiling shall be designed and applied in a manner to accomplish the desired objectives and address the natural resource concerns. These treatments shall be limited to soils and slopes where surface disturbances will not result in unacceptable levels of soil erosion and/or sedimentation.

Prescribed Grazing (528) will follow any Grazing Land Mechanical Treatment application.

Areas to be treated shall be relatively free of undesirable or noxious plants that are likely to increase because of surface disturbance.

If natural plant community is desired, desirable plant species shall be of sufficient quantity and have a distribution pattern that allows the plants to take advantage of the improved moisture and to spread into disturbed areas.

Adequate rest from grazing shall be applied to ensure desired plant responses from this treatment.

All treatments should be planned on the contour when conditions warrant.

Assure soil is not too wet prior to treatment.

All work performed under this standard shall comply with State, federal, and local laws and regulations.

CONSIDERATIONS

Conservation practice standards Range Planting (550), Forage and Biomass Planting (512), Herbaceous Weed Control (315), Prescribed Grazing (528), Integrated Pest Management (595), and Nutrient Management (590) may be used in conjunction with Grazing Land Mechanical Treatment.

Increase in noxious or invasive plants may occur following treatment.

Increased surface roughness may make the treated area undesirable for some uses.

Investigate for compacted layers with a probe or other appropriate tool prior to treatment.

Investigate for tile drainage systems, pipelines and other buried structures prior to work.

Consider animal's ability to navigate terrain following treatment.

Consider cultural resources when planning this practice. If the selected mechanical treatment will exceed the depth of prior ground disturbance, this activity could affect buried cultural resources.

PLANS AND SPECIFICATIONS

Specifications for installation of Grazing Land Mechanical Treatment shall be prepared for each site or planning unit according to the criteria. Specifications shall be recorded using State-developed specification sheets, job sheets, narrative statements in conservation plans, or other acceptable documents.

OPERATION AND MAINTENANCE

Implementation of a prescribed grazing plan according to the 528 standard is essential for the long-term operation of this practice. Heavy equipment use that will compact the soil in treated areas shall be deferred until autogenic repair processes have been restored. If the desired effects of grazing land mechanical treatment are lost over time, the practice may need to be repeated.

REFERENCES

Griffith, L.W., G.E. Schuman, F. Rauzi, and R.E. Baumgartner. 1985. Mechanical Renovation of Shortgrass Prairie for Increased Herbage Production. J. Range Manage. 38:7-10.

Vallentine, J.F. 1977. Range Development and Improvements. Brigham Young University Press, Provo, Utah.

Whisenant, S.G. 1999. Repairing Damaged Wildlands. Cambridge University Press, United Kingdom.

Natural Resources Conservation Service

CONSERVATION PRACTICE STANDARD

PRESCRIBED GRAZING

Code 528

(Ac)

DEFINITION

Managing the harvest of vegetation with grazing and/or browsing animals with the intent to achieve specific ecological, economic, and management objectives.

PURPOSE

Apply this practice as a part of a conservation management system to achieve one or more of the following:

- Improve or maintain desired species composition, structure and/or vigor of plant communities.
- Improve or maintain quantity and/or quality of forage for grazing and browsing animals' health and productivity.
- Improve or maintain surface and/or subsurface water quality and/or quantity.
- Improve or maintain riparian and/or watershed function.
- Reduce soil erosion, and maintain or improve soil health.
- Improve or maintain the quantity, quality, or connectivity of food and/or cover available for wildlife.
- Manage fine fuel loads to achieve desired conditions.

CONDITIONS WHERE PRACTICE APPLIES

This practice applies to all lands where grazing and/or browsing animals are managed.

CRITERIA

General Criteria Applicable to All Purposes

Manage stocking rates and grazing periods to adjust the intensity, frequency, timing, duration, and distribution of grazing and/or browsing to meet the planned objectives for the plant communities, and the associated resources, including the grazing and/or browsing animals.

Remove forage in accordance with site production limitations, rate of plant growth, the physiological needs of forage plants, and the nutritional needs of the animals.

Provide desired grazed/browsed plants sufficient recovery time from grazing/browsing to meet planned objectives. The recovery period can be provided for part or all of the growing season of key plants. Deferment and/or rest will be planned for critical periods of plant or animal needs.

Manage livestock movements based on rate of plant growth, available forage, and identified objectives such as utilization, plant height or standing biomass, residual dry matter, and/or animal performance.

Manage grazing and/or browsing animals to maintain adequate vegetative cover on sensitive areas (i.e., riparian, wetland, habitats of concern, and karst areas).

Provide adequate quantity and quality of drinking water during period of occupancy.

Develop contingency plans to deal with expected episodic disturbance events (e.g., drought, wildfire, insect infestation, etc.).

Develop monitoring plans that directly support adaptive management decisions based upon identified ecologic triggers and thresholds to optimize the conservation outcome for the selected purposes.

Conform to all applicable Federal, State, Tribal and local laws. Seek measures to avoid adverse effects to endangered, threatened, and candidate species and their habitats.

Additional Criteria to Improve or Maintain the Health and Vigor of Desired Plant Communities.

Base the intensity, frequency, timing, and duration of grazing and/or browsing on desired plant health, expected productivity, and composition of key species to meet management objectives.

Plan periodic deferment from grazing and/or browsing to maintain or restore the desired plant community following grazing/browsing and episodic events, such as wildfire or severe drought.

Where appropriate, test soil periodically for nutrient status and soil reaction, and apply fertilizer and/or soil amendments according to soil test results to improve or maintain plant vigor.

Additional Criteria to Improve or Maintain Quantity and Quality of Forage for Animal Health and/or Productivity

Plan grazing and/or browsing to match forage quantity and/or quality goals of the producer within the capability of the resource to respond to management.

Enhance diversity of rangeland and pasture plants to optimize delivery of nutrients to the animals by planning intensity, frequency, timing, and duration of grazing and/or browsing.

Plan intensity, frequency, timing, and duration of grazing and/or browsing to reduce animal stress and mortality from toxic and/or poisonous plants.

Provide supplemental feed and/or minerals as needed to balance with forage consumption to meet the desired nutritional level for the kind and class of grazing and/or browsing livestock.

Base the dietary needs of livestock on the National Research Council's Nutrient Requirements of Domestic Animals or similar scientific sources with appropriate adjustments made for increased energy demand required by browsing or grazing animals foraging for food including travel to and from grazing/browsing area.

Additional Criteria to Improve or Maintain Surface and/or Subsurface Water Quality and/or Quantity.

Minimize concentrated livestock areas to enhance nutrient distribution and improve or maintain ground cover.

Manage intensity, frequency, timing, and duration of grazing, browsing and/or feeding to—

- Minimize deposition or flow of animal wastes into water bodies.
- Minimize animal impacts on stream bank or shoreline stability.
- Maintain or improve hydrologic function including infiltration and/or filtering capacity and soil surface stability to reduce runoff by providing adequate ground cover, plant spacing, and plant density.

Additional Criteria to Improve or Maintain Riparian and/or Watershed Function.

Minimize concentrated livestock areas to improve or maintain riparian/floodplain plant community structure and functions.

Plan intensity, frequency, timing and duration of grazing and/or browsing to—

- Provide adequate ground cover and plant density to maintain or improve infiltration capacity and reduce runoff.
- Provide optimum ground cover, plant density, and/or plant structure to maintain or improve filtering capacity of the vegetation.
- Maintain adequate riparian community structure and function to sustain associated riparian, wetland, floodplain, and stream species.

Additional Criteria to Reduce Soil Erosion and Maintain or Improve Soil Health

Minimize concentrated livestock areas, trailing, and trampling to reduce soil compaction, excess runoff and erosion, and maintain soil organic matter.

Plan intensity, frequency, timing, and duration of grazing and/or browsing to provide adequate ground cover, litter, and canopy to maintain or improve infiltration.

Additional Criteria to Improve or Maintain Food and/or Cover for Fish and/or Wildlife Species of Concern

Identify species of concern in the objectives of the prescribed grazing plan.

Plan intensity, frequency, timing, and duration of grazing and/or browsing to provide for the development and maintenance of the plant structure, density, and diversity needed for the habitat requirements of the desired fish and wildlife species of concern.

Additional Criteria for Management of Fine Fuel Load

Plan intensity, frequency, timing, and duration of grazing and/or browsing to manage fuel continuity and loading to reduce wildfire hazard and/or facilitate desired conditions for prescribed burns.

CONSIDERATIONS

Protect soil, water, air, plant, and animal resources when locating livestock feeding, supplementation, handling, and watering facilities.

Design and install livestock feeding, handling, and watering facilities in a manner to improve and/or maintain animal distribution. Design and install facilities to minimize stress, the spread of disease, parasites, contact with harmful organisms, and toxic plants.

Utilization, stubble height, and other target levels are tools that can be used in conjunction with monitoring to help ensure that resource conservation and producer objectives are met.

Where practical and beneficial, start the grazing sequence in a different management unit each growing season.

When weeds are a significant problem prescribed grazing and/or browsing should be implemented in conjunction with other pest management practices to promote plant community resistance to invasive species and protect desired plant communities.

Prescribed grazing should consider the needs of other enterprises utilizing the same land, such as wildlife and recreational uses.

Develop alternatives that minimize additional grazing management infrastructure while still achieving plan objectives for the desired fish and wildlife species of concern.

Provide deferment or rest from grazing or browsing as necessary to ensure the success of prescribed fire, brush management, seeding, or other conservation practices to prevent stress or damage to key plants

Use drought forecasting tools and soil water forecasts where available to promote the accuracy of forage production projections.

Improve carbon sequestration in biomass and soils through management of grazing and/or browsing to produce the desired results.

Plan biosecurity safeguards to prevent the spread of disease between on-farm or ranch classes of livestock and between livestock farm or ranch units.

Provide shelter in the form of windbreaks, sheds, shade structures, and other protective features where conditions warrant to protect livestock from severe weather, intense heat/humidity, and predators.

If nutrients are being applied, CPS Nutrient Management (Code 590) will be applied.

Maintain conservative stocking rates as a drought contingency strategy to minimize detrimental consequences during drought on economic and ecological sustainability.

PLANS AND SPECIFICATIONS

Prepare a prescribed grazing plan for all planned conservation management units where grazing and/or browsing will occur according to State standards and specifications.

Prescribed grazing plan will include—

- Goals and objectives clearly stated.
- Resource inventory that identifies—
  - Existing resource conditions and concerns.
  - Ecological site or forage suitability group.
  - Opportunities to enhance resource conditions.
  - Location and condition of structural improvements such as fences, water developments, etc., including seasonal availability and quality of watering sites.
- Forage inventory of the expected forage quality, quantity, and species in each management unit(s).
- Forage-animal balance developed for the grazing plan that ensures forage produced or available meets forage demand of livestock and/or wildlife.
- Grazing plan developed for livestock that identifies periods of grazing and/or browsing, deferment, rest, and/or other treatment activities for each management unit that accommodates the flexibility needed for adaptive management decisions as supported by the contingency plan and monitoring plan in order to meet goals and objectives.
- Contingency plan developed that details potential problems (i.e., drought, flooding, and insects) and serves as a guide for adaptive management decisions in grazing prescription adjustments in order to mitigate resource and economic effects.
- Monitoring plan developed with appropriate protocols and records that assess whether the grazing strategy is resulting in a movement toward meeting goals and objectives. Short-term and long-term monitoring may be needed to determine outcomes and support timely adaptive management decisions. Identify the key areas, key plants, or other monitoring indicators that the manager should evaluate in making grazing management decisions.

OPERATION AND MAINTENANCE

Operation

Prescribed grazing will be applied on a continuing basis throughout the livestock occupation period of all planned grazing units.

Adaptive management decisions will be made as needed and documented within the plan to ensure that the goals and objectives of the prescribed grazing strategy are met.

Maintenance

Monitoring data and grazing records will be used on a regular basis within the prescribed grazing plan to ensure that objectives are being met, or to make necessary changes in the prescribed grazing plan to meet objectives.

All facilitating and accelerating conservation practices (e.g., CPS Fence (Code 382), Pest Management (Code 595), Brush Management (Code 314), Forage and Biomass Planting (Code 512), etc.) that are needed to effect adequate grazing and/or browsing distribution as planned by this practice standard will be maintained in good working order and operated as intended.

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Natural Resources Conservation Service

CONSERVATION PRACTICE STANDARD

SILVOPASTURE

Code 381

(Ac)

DEFINITION

Establishment and/or management of desired trees and forages on the same land unit.

PURPOSE

- Provide forage, shade, and/or shelter for livestock.
- Improve the productivity and health of trees/shrubs and forages.
- Improve water quality.
- Reduce erosion.
- Enhance wildlife habitat.
- Improve biological diversity.
- Improve soil quality.
- Increase carbon sequestration and storage.
- Provide for beneficial organisms and pollinators.

CONDITIONS WHERE PRACTICE APPLIES

This practice may be applied on any area that is suitable for the desired forages, trees, and livestock.

CRITERIA

General Criteria Applicable to All Purposes

Use plant species (i.e., trees and forages; shrubs where desired) that are adapted to the climate, soil, and biological conditions of the site and compatible with its planned use and management.

Establish and maintain silvopasture in a forested condition that is at least 10-percent stocked by single-stemmed woody species of any size that will be at least 4 meters (13 feet) tall at maturity.

Do not plant species on the Federal or State invasive species or noxious weeds lists.

Manage grazing at appropriate levels to establish and maintain silvopasture productivity and function. Facilities for providing water, minerals, or supplemental feed will be located and distributed such that livestock will properly utilize forages in the silvopasture. Control livestock access to areas with sensitive soils (e.g., wetlands, riparian zones, habitats of concern, karst areas, etc.). Use NRCS Conservation Practice Standard (CPS) Prescribed Grazing (Code 528).

Where trees, or a combination of trees and shrubs, are added to existing pasture, range, or crop land, perform site preparation and tree/shrub planting as needed based on existing vegetation and soil

conditions. Conduct site preparation using NRCS CPS Tree/Shrub Site Preparation (Code 490), and establish trees/shrubs using criteria in NRCS CPS Tree/Shrub Establishment (Code 612), as needed. Plant trees according to design specifications for the desired tree species and configuration (e.g., rows, clumps, or single trees). Design the tree planting based on site factors (e.g., climate, topography, aspect, wind, etc.) to optimize the amount of sunlight reaching the ground to maintain desired forages, while providing the desired shelter and/or shade for livestock.

Protect plantings from unacceptable adverse impacts from pests, wildlife, livestock, and/or fire. Refer to plant protection criteria in NRCS CPS Tree/Shrub Establishment (Code 612), and Prescribed Grazing (Code 528).

When establishing silvopasture in existing forestland, remove a sufficient number of trees, and/or prune existing trees, to allow adequate light penetration for forage establishment and growth. For tree pruning, use criteria in NRCS CPS Tree/Shrub Pruning (Code 660). For establishment of forage species, use criteria in NRCS CPS Forage and Biomass Planting (Code 512) or Range Planting (Code 550).

Removal of products (e.g., trees, medicinal herbs, nuts, and fruits) is allowed, provided that silvopasture conservation purpose(s) are not compromised by the loss of vegetation or by harvesting disturbance.

Additional Criteria to Provide Forage, Shade, and/or Shelter for Livestock

Use forage species that are suitable for the targeted livestock and compatible with the tree species.

Additional Criteria to Improve Water Quality

Select trees and forages that have growth characteristics conducive to high nutrient uptake.

Additional Criteria to Reduce Erosion

Plant trees on or near the contour and use supporting erosion control practices as needed, such as NRCS CPS Grassed Waterway (Code 412).

Additional Criteria to Enhance Wildlife Habitat

Establish plant species that will provide forage, browse, seed, cover, or nesting habitat for the desired wildlife species. Refer to species selection and establishment criteria in NRCS CPS Upland Wildlife Habitat Management (Code 645).

Select diverse seed mixes that include native forbs and/or legumes to benefit wildlife.

Additional Criteria to Improve Biological Diversity

Select plant species/varieties that provide the desired biological diversity. Selected species may vary in attributes such as timing of flowering, production of leaves and fruit, or attractiveness to wildlife and pollinators of interest.

Additional Criteria to Increase Carbon Sequestration and Storage

Select stocking rates and tree species to optimize growth rates and lifespans, suited to site capability, to enhance and sustain carbon sequestration. Use forage species that are deeply rooted and allocate higher amounts of carbon to below-ground portions.

Additional Criteria to Provide Habitat for Beneficial Organisms and Pollinators

Manage silvopasture consistent with National Organic Program (NOP) guidelines for organic and transition-to-organic agricultural systems. Select a diverse variety of plant species that provide dietary, nesting, and cover requirements for desired beneficial organisms (e.g., soil microflora, pollinators, predatory and parasitic insects, spiders, insectivorous birds and bats, raptors, etc.), during critical periods for controlling target pests and pollinating desired plants, at a minimum, and ideally year-round.

Protect beneficial organisms from harmful pesticides and chemicals.

During vegetation establishment, natural mulches, such as wood products or hay can be used to control competing vegetation as an alternative to using herbicides.

CONSIDERATIONS

Failure to maintain adequate forage for livestock may result in excessive tree damage and/or loss.

Failure to maintain adequate shade and shelter can lead to excessive soil compaction beneath tree canopies, damaging tree roots and leading to mortality.

Management practices such as no-till seeding, rotational grazing, and soil fertility maintenance can support greater soil biodiversity and health.

Integrated pest management techniques may be used for pest prevention, avoidance, monitoring and suppression.

Where new tree/shrub plantings are being protected through grazing deferral, forages may be harvested for hay, silage, etc.

If grazing does not maintain reduced fuel loads, consider using NRCS CPS Prescribed Burning (Code 338), as needed for habitat maintenance and reduction of fuel loads, providing the desired woody plants are fire-adapted and will not be damaged.

Silvopasture establishment is not appropriate in certain existing forest and woodland communities (e.g., sites with high conservation value, sites supporting species of concern that may be sensitive to grazing or changes in forest density, areas where soil erosion or nutrients are difficult to manage, etc.).

Considerations for Organic Agricultural Systems

If needed, pests may be managed through augmentation or introduction of predators or parasites, and development of habitat for natural enemies of pests; nonsynthetic controls such as lures, traps, and repellents may be used.

If needed, invasive plant species may be controlled through mulching with fully biodegradable materials; mowing; livestock grazing; hand weeding and mechanical cultivation; pre-irrigation; flame, heat, or electrical means.

PLANS AND SPECIFICATIONS

Prepare specifications for applying this practice using job sheets or other acceptable documentation. At a minimum, provide—

- Objective(s).
- Drawings to illustrate installation or implementation requirements.
- Map showing the location of the silvopasture and any areas planned for planting.
- Soils map, and description of soils and ecological sites (where available).
- Establishment methods.
- Number of trees/shrubs to be planted per acre, by species.
- Timing of establishment relative to considerations for seasonal factors, disease, insects, wildlife impacts, etc.
- Mitigation measures, if needed, to reduce wildfire hazard or the potential for pest damage.

OPERATION AND MAINTENANCE

The following actions shall be carried out to ensure this practice functions as intended throughout its lifespan. These actions include normal repetitive activities in the application and use of the practice (operation), and repair and upkeep of the practice (maintenance), such as:

- Manage trees, forages, and shrubs as needed to provide appropriate light conditions for forages, and shade/shelter conditions for livestock.
- Inspect the site at an appropriate time following planting to determine whether the tree and shrub survival rate meets practice and client objectives. Replant or provide supplemental planting when survival is inadequate.
- Control competing vegetation and livestock impacts until plantings are established.
- Apply nutrients as needed for establishment and to maintain plant vigor.
- Inspect trees and/or shrubs periodically following establishment, and protect them from adverse impacts including insects, diseases, competing vegetation, wildfire, livestock, wildlife, etc.
- Where wildlife habitat enhancement is an objective, maintenance practices and activities shall not disturb vegetative cover during the primary reproductive period (e.g., nesting period) of wildlife. Exceptions can be considered for periodic burning or mowing when necessary to maintain the health of the plant community.

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NATURAL RESOURCES CONSERVATION SERVICE

CONSERVATION PRACTICE STANDARD

RANGE PLANTING

(Ac.)

CODE 550

DEFINITION

Establishment of adapted perennial or self-sustaining vegetation such as grasses, forbs, legumes, shrubs and trees.

PURPOSE

- Restore a plant community similar to the Ecological Site Description reference state for the site or the desired plant community.
- Provide or improve forages for livestock.
- Provide or improve forage, browse or cover for wildlife.
- Reduce erosion by wind and/or water.
- Improve water quality and quantity.
- Increase carbon sequestration

CONDITIONS WHERE PRACTICE APPLIES

On rangeland, native or naturalized pasture, grazed forest or other suitable location where the principle goals and method of vegetation management is herbivore based. This practice shall be applied where desirable vegetation is below the acceptable level for natural reseeding to occur, or where the potential for enhancement of the vegetation by grazing management is unsatisfactory

CRITERIA

General Criteria Applicable to All Purposes

Specified seeding/plant material rates, methods of planting, date of planting and/or species selection shall be consistent with documented guidance cited by Plant Materials Program, research institutions or agency demonstration trials for achieving satisfactory establishment.

Species, cultivars or varieties selected for richness and or diversity, must be compatible with ecological site description(s), local laws and regulations, management objectives and adapted to climate conditions, soils, landform, or position, (e.g., aspect), and recommended seed transfer zones.

Species, cultivars or varieties selected shall provide adequate cover to control erosion by wind and/or water within an acceptable period of time.

Pre-planting treatments to control invasive plants in highly degraded areas is required for enduring management and restoration.

Seedbed preparation and planting methods will be suitable to meet any special needs for obtaining an acceptable establishment of planted materials.

Recommended planting depths, hydrologic conditions, dates, seeding rates, soil amendments needed for establishment, minimum seed quality standards and management during the establishment period such as weed control and deferment from grazing shall be followed to enhance establishment success.

Seeding rates will be calculated on a pure live seed (PLS) basis .

Additional Criteria to Restore a Plant Community Similar to Its Ecological Site Description Reference State or the Desired Plant Community.

Selection of species or combination of species shall be designed to meet or move the site to the Ecological Site Description reference state or the desired plant community.

Additional Criteria to Improve Forages for Livestock

Selection of a species or combination of species shall be designed to meet the desired nutritional requirements for the kind and class of livestock.

Selection of species or combination of species shall be designed to meet the desired season of use or grazing period.

Species planted as mixtures will exhibit compatible palatability to avoid selective grazing.

Additional Criteria for Improved Water Quality and Quantity

Select a species or combination of species that will maintain a stable soil surface and increase infiltration.

Species that have high evapotranspiration rates shall not be planted when watershed yields are the primary objective.

A mixture of functional groups inherent to the site's hydrologic zone(s) shall be planted when riparian area stream bank stability, and water temperature criteria are important.

Additional Criteria for Improving Forage, Browse or Cover for Wildlife

Selection of planted species shall meet nectar, dietary and palatability requirements for the intended wildlife species.

Species will be selected and planted in a designed manner that will meet the cover and life history requirements of the wildlife species of concern.

Additional Criteria to Increase Carbon Sequestration

For optimal carbon storage, select species that increase site biomass.

Where carbon sequestration goals are at an appropriate spatial scale, deep rooted perennial species that will increase soil carbon storage will be selected.

Reduce the temporal frequency of carbon releases caused by non-historical repetition of wildfires on degraded sites by selecting less flammable perennial plants appropriate for the site.

CONSIDERATIONS

Planting materials selected should contribute to wildlife and aesthetics when opportunities exist.

Use of certified planting materials should be encouraged, however, distance and source limitations on seed and planting stock should be considered in terms of logistics and costs.

Any special handling requirements for planting materials need to be followed for best results, (e.g., beards or awns on seed, hard seed coats, seed mixture ratios).

Where air quality concerns exist, site preparation techniques should be utilized that will minimize airborne particulate matter generation and transport.

PLANS AND SPECIFICATIONS

For standard plantings, appropriate forms, worksheets, etc. may be used to develop specifications and documentation. Where plantings require more detailed information or require the use of other conservation practices prior to planting, a specific site specification will be prepared.

OPERATION AND MAINTENANCE

Operation. Identify any required items needed to assist in stand establishment such as mowing, burning, flash or target grazing, or herbicides to control weeds and vestige of invasive plants. Address insect and disease control needs where they are likely to create establishment problems. Focusing on the ecological mechanisms and processes that direct succession is central to successful stand establishment.

Maintenance. The cooperator has an understanding of the management required to maintain the resulting plant community Any necessary replanting due to drought, insects or other uncontrollable event which prevented adequate stand establishment should be addressed. Recommendations may vary from complete re-establishment to overseeding or spot replanting. Thin stands may only need additional grazing deferment during the growing season.

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NATURAL RESOURCES CONSERVATION SERVICE

CONSERVATION PRACTICE STANDARD

HEDGEROW PLANTING

(Ft.)

CODE 422

DEFINITION

Establishment of dense vegetation in a linear design to achieve a natural resource conservation purpose.

PURPOSE

Providing at least one of the following conservation functions:

- Habitat, including food, cover, and corridors for terrestrial wildlife.
- To enhance pollen, nectar, and nesting habitat for pollinators.
- Food, cover, and shade for aquatic organisms that live in adjacent streams or watercourses.
- To provide substrate for predaceous and beneficial invertebrates as a component of integrated pest management.
- To intercept airborne particulate matter.
- To reduce chemical drift and odor movement.
- Screens and barriers to noise and dust
- To increase carbon storage in biomass and soils.
- Living fences
- Boundary delineation and contour guidelines

CONDITIONS WHERE PRACTICE APPLIES:

This practice applies wherever it will accomplish at least one of the purposes stated above.

CRITERIA

General Criteria Applicable to All Purposes

Hedgerows shall be established using woody plants or perennial bunch grasses producing erect stems attaining average heights of at least 3 feet persisting over winter.

Plants selected must be suited and adapted to soil and site conditions, climate, and conservation purpose.

No plant listed by the state as a noxious weed shall be established in a hedgerow.

Species shall be selected that do not host pests or diseases that could pose a risk to nearby crops.

The practice shall be protected from livestock grazing and trampling to the extent necessary to ensure that it will perform the intended purpose(s).

Competing vegetation shall be controlled until the hedgerow becomes established. Control shall continue beyond the establishment period, if necessary.

All planned work shall comply with federal, state and local laws and regulations.

No minimum width beyond a single row is required except where wildlife food and cover is an objective.

Additional Criteria for Wildlife Food, Cover and Corridors

Establish at least two compatible species of native vegetation. Multiple species increase food and habitat diversity while reducing pest and disease risk.

Selected plants shall provide cover and/or food to support the landowner's wildlife objectives.

Minimum hedgerow width, at maturity, shall be 15 feet. This may necessitate the

establishment of more than one row of plants.

Additional Criteria for Pollinator Habitat

Hedgerow plants must provide abundant pollen and nectar resources.

Multiple species with different blooming periods (early spring through late summer) shall be included in the planting. The actual number of species is dependent upon the availability of adjacent flowering plants. Plants that bloom during the same period as adjacent insect-pollinated crops can be excluded.

Pollinator hedgerows will be protected from pesticides that may harm pollinators. If pest control is required, only non-blooming plants will be treated, and/or only pesticides non-toxic to pollinators shall be used.

Additional Criteria for Living Fences

Selected plants shall attain a size and density adequate to create a barrier to contain livestock or humans, as needed.

If the purpose is to contain livestock, selected plants shall not be poisonous or hazardous to the animals.

Additional Criteria for Boundary Delineation

Hedgerows shall be aligned along boundaries of fields, or forestlands to differentiate land management units.

Additional Criteria for Contour Guidelines

Hedgerows shall be aligned so they provide permanent contour markers supporting implementation of Contour Farming (330) or Stripcropping (585). Refer to those conservation practice standards for alignment criteria.

Additional Criteria for Screens and Noise Barriers

Screening hedgerows provide privacy, hide unsightly areas from view or reduce noise.

Hedgerows shall be located where they most completely obstruct a line of sight or offensive sound.

Selected plants shall attain a height and fullness sufficient to break the line of sight or baffle sound.

Additional Criteria for Improvement of Landscape Appearance

The hedgerow design shall meet the aesthetic objectives of the landowner.

Plants shall be selected based upon the landowner's preferences for color, texture and growth habit.

Additional Criteria for Reducing Particulate Matter Movement

The hedgerow will be oriented as close to perpendicular to the prevailing wind direction as possible.

Hedgerow density on the upwind side shall be at least 50% at maturity.

Hedgerow density adjacent to the particulate source shall be at least 65% at maturity.

Additional Criteria to Reduce Odor Movement and/or Chemical Drift

Orientation of the hedgerow shall be as close to perpendicular to the prevailing wind direction during the period of concern as possible, and between the source of the odor or chemical drift and the sensitive areas.

Hedgerows shall be located upwind of the odor producing area and the chemical application area.

Tree and shrub species used shall have foliar and structural characteristics that optimize interception, adsorption and absorption of airborne chemicals or odors. Plant species shall be selected that are tolerant of anticipated chemical use.

CONSIDERATIONS

General

Planting a hedgerow larger than the required length and minimum width will increase the amount of carbon stored in the soil and biomass. Larger and more diverse hedgerows will generally enhance most other resource values.

Hedgerows should be planned in combination with other practices to develop holistic conservation systems that enhance landscape aesthetics, reduce soil erosion, improve sediment trapping, improve water quality and provide wildlife habitat.

Hedgerows following land contours create meandering lines on the landscape, produce a

natural appearance and increase the availability of “edge” wildlife habitats.

Hedgerows containing a mixture of native shrubs and small trees provide greatest environmental benefits.

Use of bareroot and containerized seedlings will accelerate hedgerow development.

Consider the amount of shading a hedgerow will provide at maturity. Shading may impact growth of adjacent plants, microclimate and aesthetics.

Limiting renovation events to one-third of a hedgerow’s length or width will prevent sudden elimination of the practice’s wildlife habitat function.

Periodic root pruning can reduce nutrient and water robbing from adjacent cropland.

Consider avoiding the use of plants that spread by root suckers as hedgerow may expand beyond the desired treatment area.

Wildlife Food, Cover and Corridors

Hedgerows can provide travel lanes, or corridors that allow wildlife to move safely across a landscape.

Generally, wider corridors accommodate more wildlife use.

Linking fragmented habitats may increase wildlife use of an area.

In grassland ecosystems, hedgerows may adversely affect area-sensitive nesting birds by fragmenting habitat patches and increasing the risk of predation.

Hedgerows can complement the availability of naturally occurring wildlife foods.

Hedgerows can provide wildlife with cover for feeding, loafing, nesting and caring for young.

Dense or thorny shrub thickets provide songbirds with important nesting sites and a refuge to escape predators.

Establishment of evergreen plants provides year-round concealment and thermal cover for wildlife.

Establishment of herbaceous vegetation along the edges of a hedgerow can further enhance the habitat functions of a hedgerow.

Installation of artificial nest boxes with predator guards can encourage cavity-nesting birds and small mammals to utilize a hedgerow.

Living Fences

Thorny shrubs and trees can improve a living fence’s barrier effect.

Screens and Noise Barriers

From eye-level, hedgerows reduce the line-of-sight across open areas, concealing objects behind them from view.

Consider the design from viewpoints on both sides of the screen.

Locate noise barriers as close to the source of noise as possible.

Combination of shrubs and/or trees can create more effective screens than single species plantings.

Evergreens provide foliage that can maintain a screen’s year-round effectiveness.

Improving Landscape Appearance

Consider plants’ seasonal display of colors on bark, twigs, foliage, flowers and fruit.

Consider plants’ growth habits (outline, height and width).

Water Quality and Quantity

Water quality benefits may arise from:

- Arresting sediment movement and trapping sediment-attached substances.
- Infiltration and assimilation of plant nutrients.
- Water cooling effects resulting from reducing the incidence of solar radiation on small watercourses through shading.

A hedgerow will increase surface water infiltration by improving soil structure around its root zone. However, evapotranspiration may reduce groundwater recharge benefits.

Incidental Trapping of Snow or Soil

Although not a primary purpose, hedgerows may incidentally trap wind blown snow or soil.

Consider installing hedgerows on alignments that prevent trapping and accumulation of snow and sand on public roads.

Refer to the Windbreak/Shelterbelt Establishment (380) standard for criteria when

snow or sand trapping is a primary conservation purpose.

PLANS AND SPECIFICATIONS

Plans and specifications for this practice shall be prepared for each site. Plans and specifications shall be recorded using approved specification sheets, job sheets, or narrative documentation in the conservation plan, or other acceptable documentation.

OPERATION AND MAINTENANCE

Vegetation shall be maintained to ensure continued control of odor movement and chemical drift.

Supplemental planting may be required when survival is too low to produce a continuous hedgerow.

Vegetation shall be protected from unwanted fire and grazing throughout its life span.

Pests shall be monitored and controlled.

Periodic applications of nutrients may be needed to maintain plant vigor.

Renovation activities shall be scheduled to prevent disturbance during the wildlife nesting season.

REFERENCES

National Biology Handbook, Part 614.4, "Conservation Corridor Planning at the Landscape Level". Natural Resources Conservation Service, August 1999.

Shepherd, M., S. L. Buchmann, M. Vaughan, and S. H. Black. 2003. Pollinator Conservation Handbook. Xerces Society. Portland, OR.

NATURAL RESOURCES CONSERVATION SERVICE

CONSERVATION PRACTICE STANDARD

WINDBREAK/SHELTERBELT ESTABLISHMENT

(Ft.)

CODE 380

DEFINITION

Windbreaks or shelterbelts are single or multiple rows of trees or shrubs in linear configurations.

PURPOSE

- Reduce soil erosion from wind.
- Protect plants from wind related damage.
- Alter the microenvironment for enhancing plant growth.
- Manage snow deposition.
- Provide shelter for structures, animals, and people.
- Enhance wildlife habitat.
- Provide noise screens.
- Provide visual screens.
- Improve air quality by reducing and intercepting air borne particulate matter, chemicals and odors.
- Delineate property and field boundaries.
- Improve irrigation efficiency.
- Increase carbon storage in biomass and soils.
- Reduce energy use

CONDITIONS WHERE PRACTICE APPLIES

Apply this practice on any areas where linear plantings of woody plants are desired and suited for controlling wind, noise, and visual resources. Use other tree/shrub practices when wind, noise and visual problems are not concerns.

CRITERIA

General Criteria Applicable to All Purposes

The location, layout and density of the planting will accomplish the purpose and function intended within a 20-year period.

Refer to Tree/Shrub Site Preparation Standard 490, for preparing site conditions for plant establishment.

The maximum design height (H) for the windbreak or shelterbelt shall be the expected height of the tallest row of trees or shrubs at age 20 for the given site.

Species must be adapted to the soils, climate and site conditions.

No plants on the Federal or state noxious weeds list shall be planted.

Spacing between individual plants shall be based on the needed growing space for plant type and species, the accommodation of maintenance equipment, and the desired characteristics of the stem(s), branches and canopy as required for a specific purpose.

The windbreak will be oriented as close to perpendicular to the troublesome wind as possible.

The length of the windbreak will be sufficient to protect the site including consideration for the “end effect” and changes in wind direction.

Avoid planting trees or shrubs where they will interfere with structures and above or below ground utilities.

Moisture conservation or supplemental watering shall be provided for plant establishment and growth where natural precipitation is too low for the selected species.

Refer to Tree/Shrub Establishment Standard

612 for further guidance on planting trees and shrubs.

Additional Criteria to Reduce Wind Erosion and Protect Growing Plants

The interval between windbreaks shall be determined using current, approved, wind erosion technology. Interval widths shall not exceed that permitted by the soil loss tolerance (T), or other planned soil loss objective. Calculations shall account for the effects of other practices in the conservation management system.

For wind erosion control, temporary measures will be installed to supplement the windbreak until it is fully functional.

Sites, fields, and plants are protected within an area 10 times the design height (H) on the leeward side and two times the design height (H) on the windward side of the windbreak.

Select species that are taller than the crops being protected.

Additional Criteria to Manage Snow Deposition

The windbreak will be oriented as close to perpendicular to the snow-bearing wind as possible.

For snow distribution across a field, the windbreak density (during expected snow-producing months) shall not be less than 25 percent or greater than 50 percent. The interval between barriers will not exceed 20H.

For snow accumulation, the minimum barrier density, during expected snow-producing months, will be 50 percent.

The length of the windbreak will extend beyond the area being protected to allow for end drifts.

Windbreaks will be located so that snow deposition will not pose a health or safety problem, management constraints, or obstruct human, livestock or vehicular traffic.

Where water erosion and/or runoff from melting snow is a hazard, it shall be controlled by supporting practices.

Additional Criteria to Provide Shelter for Structures, Livestock and People

For wind protection, the minimum barrier density will be 65 percent during the months of most troublesome wind.

The area to be protected will fall within a leeward distance of 10H.

Drainage of snowmelt from the windbreak shall not flow across the livestock area.

Drainage of livestock waste from the livestock area shall not flow into the windbreak.

Additional Criteria for Noise Screens

Noise screens shall be at least 65 percent dense during the time of the year when noise is a problem, as tall as, and as close to the noise source as practicable.

The length of the noise screen shall be twice as long as the distance from the noise source to the receiver.

For high-speed traffic noise, the barrier shall not be less than 65 feet wide. For moderate speed traffic noise, the barrier width shall not be less than 20 feet wide.

Species selected will be tolerant to noxious emissions, sand, gravel depositions or salt spray from traffic areas.

Additional Criteria for Visual Screens

Visual screens shall be located as close to the observer as possible with a density, height and width to sufficiently block the view between the area of concern and the sensitive area.

Additional Criteria to Improve Air Quality by Reducing and Intercepting Airborne Particulate Matter, Chemicals and Odors

The windbreak interval shall be less than or equal to 10h depending on site conditions and related supporting conservation practices.

Windbreak density on the windward side of the problem source, (i.e. particulate, chemical or odor) shall be greater than 50% to reduce the airflow into the source area.

Windbreak density on the leeward side of the problem source, and windward of the area to be protected, shall be greater than 65%.

Select and maintain tree and shrub species with foliar and structural characteristics to optimize interception, adsorption and absorption of airborne chemicals or odors.

Additional Criteria for Increasing Carbon Storage in Biomass and Soils

Maximize width and length of the windbreak to fit the site.

For optimal carbon sequestration, select plants that have higher rates of sequestration in biomass and soils.

Plant and manage the appropriate plant spacing for the site that will maximize above and below ground biomass production

Minimize soil disturbance during establishment and maintenance of the windbreak/shelterbelt.

Additional Criteria for Enhancing Wildlife Habitat

Plant species selection shall benefit targeted wildlife species including pollinators.

Design dimensions of the planting shall be adequate for targeted wildlife species.

Additional Criteria for Improving Irrigation Efficiency

For sprinkler irrigation systems, the windbreak shall be taller than the spray height.

The windbreak shall not interfere with the operation of the irrigation system.

Additional Criteria to Reduce Energy Use

Orient the windbreak as close to perpendicular to the troublesome wind as possible

Use proper plant density to meet energy reduction needs.

Use plants with a potential height growth that will be taller than the structure or facility being protected.

CONSIDERATIONS

Consider enhancing aesthetics by using evergreen species or species with features such as showy flowers, brilliant fall foliage, or persistent colorful fruits.

When designing and locating a windbreak or shelterbelt, consider the impact upon the landowner's or public's view of the landscape.

Selection of plants for use in windbreaks should favor species or varieties tolerant to herbicides used in the area.

Plants that may be alternate hosts to undesirable pests should be avoided.

All plantings should complement natural features.

Tree or shrub rows should be oriented on or near the contour where water erosion is a concern. Where water erosion and/or runoff from melting snow is a hazard, it should be controlled by supporting practices.

Wildlife and pollinator needs should be considered when selecting or siting tree or shrub species. Species diversity, including use of native species, should be considered.

Species diversity, including use of native species, should be considered to avoid loss of function due to species-specific pests.

Consider the invasive potential when selecting plant species.

Windbreaks for odor and chemical control increase in effectiveness as the amount of foliage available for intercept increases. Multiple-row, wide plantings offer greater interception potential than do smaller plantings.

When using trees and shrubs for greenhouse gas reductions, prediction of carbon sequestration rates should be made using current, approved carbon sequestration modeling technology.

A shelterbelt can be used as a travel corridor to connect existing patches of wildlife habitat.

In cropping systems select windbreak and shelterbelt species that minimize adverse affects to crop growth (e.g. shade, allelopathy, competing root systems or root sprouts).

PLANS AND SPECIFICATIONS

Specifications for applying this practice shall be prepared for each site and recorded using approved specification sheets, job sheets, technical notes, and narrative statements in the conservation plan, or other acceptable documentation.

OPERATION AND MAINTENANCE

The following actions shall be carried out to insure that this practice functions as intended throughout its expected life. These actions include normal repetitive activities in the application and use of the practice (operation), and repair and upkeep of the practice (maintenance).

Replacement of dead trees or shrubs will be continued until the windbreak/shelterbelt is functional.

Supplemental water will be provided as needed.

Thin or prune the windbreak/shelterbelt to maintain its function.

Inspect trees and shrubs periodically and protect from adverse impacts including insects, diseases or competing vegetation. The trees or shrubs will also be protected from fire and damage from livestock and wildlife.

Periodic applications of nutrients may be needed to maintain plant vigor.

REFERENCES

Bentrup, Gary 2008. Conservation buffers: design guidelines for buffers, corridors, and greenways. Gen. Tech. Rep. SRS-109. Asheville, NC: Department of Agriculture, Forest Service, Southern Research Station.

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NATURAL RESOURCES CONSERVATION SERVICE

CONSERVATION PRACTICE STANDARD

RIPARIAN FOREST BUFFER

(Ac.)

CODE 391

DEFINITION

An area predominantly trees and/or shrubs located adjacent to and up-gradient from watercourses or water bodies.

PURPOSE

- Create shade to lower or maintain water temperatures to improve habitat for aquatic organisms.
- Create or improve riparian habitat and provide a source of detritus and large woody debris.
- Reduce excess amounts of sediment, organic material, nutrients and pesticides in surface runoff and reduce excess nutrients and other chemicals in shallow ground water flow.
- Reduce pesticide drift entering the water body.
- Restore riparian plant communities.
- Increase carbon storage in plant biomass and soils.

CONDITIONS WHERE PRACTICE APPLIES

Riparian forest buffers are applied on areas adjacent to permanent or intermittent streams, lakes, ponds, and wetlands. They are not applied to stabilize stream banks or shorelines.

CRITERIA

General Criteria Applicable to All Purposes

The riparian forest buffer shall be positioned appropriately and designed to achieve sufficient width, length, vertical structure/density and connectivity to accomplish the intended purpose(s).

Dominant vegetation will consist of existing, naturally regenerated, or seeded/planted trees and shrubs suited to the soil and hydrology of the site and the intended purpose(s).

The vegetation will extend a minimum width to achieve the purpose(s). Measurement shall begin at and perpendicular to the normal water line, bank-full elevation, or the top of the bank as determined locally.

Overland flow through the riparian area will be maintained as sheet flow.

For sites to be regenerated or planted, excessive sheet-rill and concentrated-flow erosion will be controlled.

Excessive sheet-rill and concentrated-flow erosion will be controlled in the areas immediately adjacent and up-gradient of the buffer site.

Use tree and shrub species that are native and non-invasive. Substitution with improved and locally accepted cultivars or purpose-specific species is allowed. For plantings and seeding, only viable, high-quality and adapted plant materials will be used.

Favor tree and shrub species that have multiple values such as those suited for timber, nuts, fruit, florals, browse, nesting, and aesthetics.

Periodic removal of some forest products such as high value trees, medicinal herbs, nuts, and fruits is permitted provided the intended purpose is not compromised by the loss of vegetation or harvesting disturbance.

Necessary site preparation and planting shall be done at a time and manner to insure

survival and growth of selected species for achieving the intended purpose(s).

Livestock shall be controlled or excluded as necessary to achieve the intended purpose. Refer to the standards Prescribed Grazing, 528, and/or Access Control, 472, as applicable.

Harmful plant and animal pests present on the site will be controlled or eliminated as necessary to achieve and maintain the intended purpose. If pesticides are used, refer to the standard Pest Management, 595.

Additional Criteria to Reduce Excess Amounts of Sediment, Organic Material, Nutrients and Pesticides in Surface Runoff and Reduce Excess Nutrients and Other Chemicals in Shallow Ground Water Flow

The minimum width shall be at least 35 feet measured horizontally on a line perpendicular to the water body beginning at the normal water line, bank-full elevation, or the top of the bank as determined locally.

The width will be extended in high nutrient, sediment, and animal waste application areas, where the contributing area is not adequately treated or where an additional level of protection is needed.

Existing, functional underground drains through the riparian area will pass pollutants directly to the outlet. To filter such pollutants, drains can be plugged, removed or replaced with perforated pipe/end plugs or water control structures (see Structure for Water Control - 587) to allow passage and filtration of drain water through the riparian forest root zone. Caution is advised that saturated conditions in the riparian and adjacent areas may limit existing land use and management.

Additional Criteria to Create or Improve Riparian Habitat and Provide a Source of Detritus and Large Woody Debris.

The width will be extended to meet the minimum habitat requirements of the wildlife or aquatic species of concern.

Establish plant communities that address the target aquatic and terrestrial wildlife and pollinator needs and have multiple values such as habitat, nutrient uptake and shading. The establishment of diverse native woody and herbaceous species will enhance wildlife and pollinator values.

Additional Criteria for Increasing Carbon Storage in Biomass and Soils

Maximize width and length of the riparian forest buffer.

Select plants that have higher rates of carbon sequestration in soils and plant biomass and are adapted to the site to assure strong health and vigor. Plant the appropriate stocking rate for the site.

CONSIDERATIONS

Tree and shrub species, which may be alternate hosts to undesirable pests, should be avoided. Species diversity should be considered to avoid loss of function due to species-specific pests.

Using seed and/or seedlings collected or propagated from multiple sources can increase genetic diversity.

Consider selecting species with tolerance to herbicide leakage from adjoining fields.

Allelopathic impacts of plants should be considered.

The location, layout and density of the buffer should complement natural features, and mimic natural riparian forests.

For sites where continued function of drains is desired, woody root penetration may eventually plug the underground structure. In these cases, a setback of woody vegetation planted over the drain maintained in herbaceous cover or using rigid, non-perforated pipe will minimize woody root penetration.

Maximize widths, lengths, and connectivity of riparian forest buffers.

The species and plant communities that attain biomass more quickly will sequester carbon/ faster. The rate of carbon sequestration is enhanced as riparian plants mature and soil organic matter increases.

PLANS AND SPECIFICATIONS

Specifications for applying this practice shall be prepared for each site and recorded using approved specification sheets, job sheets, technical notes, and narrative statements in the conservation plan, or other acceptable documentation.

OPERATION AND MAINTENANCE

The riparian forest buffer will be inspected periodically and protected from adverse impacts such as excessive vehicular and pedestrian traffic, pest infestations, concentrated flows, pesticides, livestock or wildlife damage and fire.

Replacement of dead trees or shrubs and control of undesirable vegetative competition will be continued until the buffer is, or will progress to, a fully functional condition.

Any manipulation of species composition, stand structure and stocking by cutting or killing selected trees and understory vegetation shall sustain the intended purpose(s). Refer to the standard Forest Stand Improvement, 666.

Control or exclusion of livestock and harmful wildlife shall continue. Refer to the standards Prescribed Grazing, 528, and/or Access Control, 472, as applicable.

Fertilizers, pesticides and other chemicals used to maintain buffer function shall not impact water quality.

REFERENCES

Bentrup, Gary 2008. Conservation buffers: design guidelines for buffers, corridors, and greenways. Gen. Tech. Rep. SRS-109. Asheville, NC: Department of Agriculture, Forest Service, Southern Research Station.

Natural Resources Conservation Service

CONSERVATION PRACTICE STANDARD

FILTER STRIP

Code 393

(Ac)

DEFINITION

A strip or area of herbaceous vegetation that removes contaminants from overland flow.

PURPOSE

- Reduce suspended solids and associated contaminants in runoff and excessive sediment in surface waters.
- Reduce dissolved contaminant loadings in runoff.
- Reduce suspended solids and associated contaminants in irrigation tailwater and excessive sediment in surface waters.

CONDITIONS WHERE PRACTICE APPLIES

Filter strips are established where environmentally sensitive areas need to be protected from sediment, other suspended solids, and dissolved contaminants in runoff.

CRITERIA

General Criteria Applicable to All Purposes

Overland flow entering the filter strip will be uniform sheet flow.

Concentrated flow will be dispersed before it enters the filter strip.

The maximum gradient along the leading edge of filter strip will not exceed one-half of the up-and-down-hill slope percent, immediately upslope from the filter strip, up to a maximum of five percent.

Filter strips will not be used as a travel lane for equipment or livestock.

Additional Criteria to Reduce Dissolved Contaminants, Suspended Solids and Associated Contaminants in Runoff and Excessive Sediment in Surface Waters.

The filter strip will be designed to have a 10-year life span, following the procedure in Agronomy Technical Note No. 2, “Using Revised Universal Soil Loss Equation, Version 2 (RUSLE2) for the Design and Predicted Effectiveness of Vegetative Filter Strips (FVS) for Sediment,” based on the amount of sediment delivery to the upper edge of the filter strip and ratio of filter strip flow length to length of flow path from the contributing area. The minimum flow length through the filter strip will be 20 feet for suspended solids and associated contaminants in runoff and 30 feet for dissolved contaminants and pathogens in runoff.

The filter strip will be located immediately downslope from the source area of contaminants.

The drainage area immediately above the filter strip will have a slope of one percent or greater.

Vegetation. The filter strip will be established to permanent herbaceous vegetation.

Species selected will be—

- Able to withstand partial burial from sediment deposition.
- Tolerant of herbicides used on the area that contributes runoff to the filter strip.
- Stiff stemmed and a high stem density near the ground surface.
- Suited to current site conditions and intended uses.
- Able to achieve adequate density and vigor within an appropriate period to stabilize the site sufficiently to permit suited uses with ordinary management activities.

Plant species, rates of seeding (lbs/ac), vegetative planting (plants/ac), minimum quality of planting stock (pure live seed [PLS] or stem caliper), and method of establishment shall be specified before application. Only viable, high quality seed or planting stock will be used.

Perform site preparation and seeding/planting at a time and in a manner that best ensures survival and growth of selected species. Successful establishment parameters, (e.g., minimum percent ground/ canopy cover, percent survival, stand density) will be specified before application.

Schedule planting dates during periods when soil moisture is adequate for germination and establishment. Seeding will be timed so that tillage for adjacent crop does not damage the seeded filter strip.

Where the purpose is to remove phosphorus, remove (or harvest) the filter strip aboveground biomass at least once each year.

The minimum seeding and stem density will be equivalent to the seeding rate for a high quality grass hay seeding rate for the climate area or the density of vegetation selected in current water erosion technology to determine trapping efficiency, whichever is the higher seeding rate.

Additional Criteria to Reduce Suspended Solids and Associated Contaminants in Irrigation Tailwater and Excessive Sediment in Surface Waters.

Filter strip vegetation will be a small grain or other suitable annual plant.

The seeding rate shall be sufficient to ensure that the plant spacing does not exceed 4 inches (about 16–18 plants per square foot).

Establish filter strips prior to the irrigation season so that the vegetation is mature enough to filter sediment from the first irrigation.

CONSIDERATIONS

General Considerations.

Filter strip width (flow length) can be increased as necessary to accommodate harvest and maintenance equipment.

Filters strips with the leading edge on the contour will function better than those with a gradient along the leading edge.

Seeding rates that establish a higher stem density than the normal density for a high quality grass hay crop will be more effective in trapping and treating contaminants.

When needed, invasive plant species may be controlled through mowing, herbicides, and hand weeding.

Consideration for Reducing Suspended Solids and Associated Contaminants in Runoff. Increasing the width of the filter strip beyond the minimum required will increase the potential for capturing more contaminants in runoff.

Considerations for Creating, Restoring or Enhancing Herbaceous Habitat for Wildlife and Beneficial Insects and Pollinators. Filter strips are often the only break in the monotony of intensively-cropped areas. The wildlife and pollinator benefits of this herbaceous cover can be enhanced by the following:

- When appropriate, use native grass species that fulfill the purpose(s) of the practice while also providing habitat for priority wildlife.
- Adding herbaceous plant species (including native forbs) to the seeding mix that are beneficial to wildlife and pollinators and are compatible for one of the listed purposes. Changing the seeding mix should not detract from the purpose for which the filter strip is established.
- Increasing the width beyond the minimum required. The additional area can increase food and cover for wildlife and pollinators.
- Management activities on filter strips (mowing, burning, or light disking), should not be done more often than every other year with frequency dependent on geographical location to maintain the purpose(s) of the practice.
- Management activities should be completed outside of the primary nesting, fawning, and calving seasons. Activities should be timed to allow for regrowth before the growing season ends.
- Organic producers should submit plans and specifications to their certifying agent for approval prior to installation, as part of the organic producer's organic system plan.

Considerations to Maintain or Enhance Watershed Functions and Values. Filter strips may be used to enhance connectivity of corridors and noncultivated patches of vegetation within the watershed, enhance the aesthetics of a watershed, and be strategically located to reduce runoff, and increase infiltration and groundwater recharge throughout the watershed.

Increase Carbon Storage. Increasing the width of the filter strip beyond the minimum required will increase potential for carbon sequestration.

PLANS AND SPECIFICATIONS

Specifications for establishment and operation of this practice will be prepared for each field or treatment unit. Record the specifications using the implementation requirements document. The specifications will identify at a minimum the following:

- Practice purpose(s).
- Length, width (width refers to flow length through the filter strip), and slope of the filter strip to accomplish the planned purpose(s).
- Plant species selection and seeding/planting/sprigging rates to accomplish the planned purpose.
- Planting dates and planting method(s).
- Specific care and handling requirements of the seed or plant material to ensure that planted materials have an acceptable rate of survival.
- A statement that only viable, high quality, and adapted seed will be used.
- Site preparation instructions sufficient to establish and grow selected species.

OPERATION AND MAINTENANCE

For the purposes of filtering contaminants and nutrients (phosphorus), permanent filter strip vegetative plantings will be harvested and removed as appropriate to encourage dense growth, maintain an upright growth habit and remove nutrients and other contaminants that are contained in the plant tissue.

Control undesired weed species, especially State-listed noxious weeds.

If Conservation Practice Standard (CPS) Prescribed Burning (Code 338) is used to manage and maintain the filter strip, an approved burn plan must be developed.

Inspect the filter strip after storm events and repair any gullies that have formed, remove unevenly deposited sediment accumulation that will disrupt sheet flow, reseed disturbed areas and take other measures to prevent concentrated flow through the filter strip.

Apply supplemental nutrients as needed to maintain the desired species composition and stand density.

Periodically regrade and reestablish the filter strip area when sediment deposition at the filter strip-field interface jeopardizes its function. Reestablish the filter strip vegetation in regraded areas, if needed.

If grazing is used to harvest vegetation from the filter strip, the grazing plan must ensure that the integrity and function of the filter strip is not adversely affected.

REFERENCES

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NATURAL RESOURCES CONSERVATION SERVICE

CONSERVATION PRACTICE STANDARD

GRASSED WATERWAY

(Ac.)

CODE 412

DEFINITION

A shaped or graded channel that is established with suitable vegetation to convey surface water at a non-erosive velocity using a broad and shallow cross section to a stable outlet.

PURPOSE

- To convey runoff from terraces, diversions, or other water concentrations without causing erosion or flooding.
- To prevent gully formation.
- To protect/improve water quality.

CONDITIONS WHERE PRACTICE APPLIES

This practice is applied in areas where added water conveyance capacity and vegetative protection are needed to prevent erosion and improve runoff water quality resulting from concentrated surface flow.

CRITERIA

General Criteria Applicable to All Purposes

Plan, design, and construct grassed waterways to comply with all federal, state, and local laws and regulations.

Capacity. Design the waterway to convey the peak runoff expected from the 10-year frequency, 24-hour duration storm. Increase capacity as needed to account for potential volume of sediment expected to accumulate in the waterway between planned maintenance activities. When the waterway slope is less than 1 percent, out-of-bank flow may be permitted if such flow will not cause excessive erosion. Ensure that the design capacity, at a minimum, will remove the water before crops are damaged.

Stability. Determine the minimum depth and width requirements for stability of the grassed waterway using the procedures in the NRCS National Engineering Handbook, Part 650, Engineering Field Handbook, Chapter 7, Grassed Waterways or Agricultural Research Service (ARS) Agriculture Handbook 667, Stability Design of Grass-Lined Open Channels.

Ensure that the vegetation species selected are suited to the current site conditions and intended uses. Select species that have the capacity to achieve adequate density, height, and vigor within an appropriate time frame to stabilize the waterway.

Width. Keep the bottom width of trapezoidal waterways less than 100 feet unless multiple or divided waterways or other means are provided to control meandering of low flows.

Side slopes. Keep the side slopes flatter than a ratio of two horizontal to one vertical. Reduce the side slopes as needed to accommodate the equipment anticipated to be used for maintenance and tillage/harvesting equipment so that damage to the waterway is minimized.

Depth. The capacity of the waterway must be large enough so that the water surface of the waterway is below the water surface of the tributary channel, terrace, or diversion that flows into the waterway at design flow.

Provide 0.5 foot freeboard above the designed depth when flow must be contained to prevent damage. Provide freeboard above the designed depth when the vegetation has the maximum expected retardance.

Drainage. When needed to establish or maintain vegetation on sites having prolonged flows, high water tables, or seepage problems, use Subsurface Drain (606), Underground Outlet (620), or other suitable measures in waterway designs.

Where drainage practices are not practicable or sufficient to solve these seepage problems, use conservation practice Lined Waterway or Outlet (468) in place of Grassed Waterway (412).

Outlets. Provide a stable outlet with adequate capacity. The outlet can be another vegetated channel, an earthen ditch, a grade-stabilization structure, filter strip or other suitable outlet.

Vegetative Establishment. Establish vegetation as soon as possible using the criteria listed under "Establishment of Vegetation" in the conservation practice standard Critical Area Planting (342) and/or the state planting guide.

Establish vegetation as soon as conditions permit. Use mulch anchoring, nurse crop, rock or straw or hay bale dikes, fabric or rock checks, filter fences, or runoff diversion to protect the vegetation until it is established. Planting of a close growing crop, e.g. small grains or millet, on the contributing watershed prior to construction of the grassed waterway can also significantly reduce the flow through the waterway during establishment.

Provide livestock and vehicular crossings as necessary to prevent damage to the waterway and its vegetation.

CONSIDERATIONS

Where environmentally-sensitive areas need to be protected from dissolved contaminants, pathogens, or sediment in runoff, consider establishment of an increased width of vegetation on the waterway above the flow area. Increasing the width of the waterway above the flow area will increase filtering of sediment and pathogens as well as increase infiltration of runoff and increase nutrient removal. Where sediment control is the primary concern, consider using vegetation in the waterway which can withstand partial burial and adding sediment control measures above the waterway such as residue management. Consider increasing the channel depth and/or designing areas of increased width or decreased slope to trap and store sediment to reduce the amount of sediment that leaves a field. Be sure to provide for regular cleaning out of the waterway when trapping sediment in this manner.

Tillage and crop planting often takes place parallel to the waterway, resulting in preferential flow – and resulting erosion – along the edges of the waterway. Consider installation of measures that ensure that runoff from adjacent areas will enter the waterway. Measures such as directing spoil placement or small swales can direct this preferential flow into the grassed waterway.

Avoid areas where unsuitable plant growth limiting subsoil and/or substratum material such as salts, acidity, root restrictions, etc. may be exposed during implementation of the practice. Where areas cannot be avoided, seek recommendations from a soil scientist for improving the condition or, if not feasible consider over-cutting the waterway and add topsoil over the cut area to facilitate vegetative establishment.

Avoid or protect, if possible, important wildlife habitat, such as woody cover or wetlands when determining the location of the grassed waterway. If trees and shrubs are incorporated, they should be retained or planted in the periphery of grassed waterways so they do not interfere with hydraulic functions. Medium or tall bunch grasses and perennial forbs may also be planted along waterway margins to improve wildlife habitat. Waterways with these wildlife features are more beneficial when connecting other habitat types; e.g., riparian areas, wooded tracts and wetlands. When possible, select plant species that can serve multiple purposes, such as benefiting wildlife, while still meeting the basic criteria needed for providing a stable conveyance for runoff.

Water-tolerant vegetation may be an alternative to subsurface drains or stone center waterways on some wet sites.

Use irrigation in dry regions or supplemental irrigation as necessary to promote germination and vegetation establishment.

Wildlife habitat benefits can be provided by adding width of appropriate vegetation to the sides of the waterway. Care should be taken to avoid creating small isolated planting zones that could become population sinks where wildlife attracted to an area experience reproductive loss due to predation.

Consider including diverse legumes, forbs, and flowering plants such as milkweeds that provide pollen and nectar for native bees and other pollinators. In dry regions, these sites may be able to support flowering forbs with higher water requirements and thus provide bloom later in the summer

The construction of a grassed waterway can disturb large areas and potentially affect cultural resources. Be sure to follow state cultural resource protection policies before construction begins.

PLANS AND SPECIFICATIONS

Prepare plans and specifications for grassed waterways that describe the requirements for applying the practice according to this standard. As a minimum include:

- A plan view of the layout of the grassed waterway.
- Typical cross sections of the grassed waterway(s).
- Profile(s) of the grassed waterway(s).
- Disposal requirements for excess soil material.
- Site specific construction specifications that describe in writing the installation of the grassed waterway. Include specification for control of concentrated flow during construction and vegetative establishment.
- Vegetative establishment requirements.

OPERATION AND MAINTENANCE

Provide an operation and maintenance plan to review with the landowner. Include the following items and others as appropriate in the plan.

- Establish a maintenance program to maintain waterway capacity, vegetative cover, and outlet stability. Vegetation damaged by machinery, herbicides, or erosion must be repaired promptly.
- Protect the waterway from concentrated flow by using diversion of runoff or mechanical means of stabilization such as silt fences, mulching, hay bale barriers and etc. to stabilize grade during vegetation establishment.
- Minimize damage to vegetation by excluding livestock whenever possible, especially during wet periods. Permit grazing in the waterway only when a controlled grazing system is being implemented.
- Inspect grassed waterways regularly, especially following heavy rains. Fill, compact, and reseed damaged areas immediately. Remove sediment deposits to maintain capacity of grassed waterway.
- Avoid use of herbicides that would be harmful to the vegetation or pollinating insects in and adjacent to the waterway area.
- Avoid using waterways as turn-rows during tillage and cultivation operations.
- Mow or periodically graze vegetation to maintain capacity and reduce sediment deposition. Mowing may be appropriate to enhance wildlife values, but must be conducted to avoid peak nesting seasons and reduced winter cover.
- Apply supplemental nutrients as needed to maintain the desired species composition and stand density of the waterway.
- Control noxious weeds.
- Do not use waterways as a field road. Avoid crossing with heavy equipment when wet.
- Lift tillage equipment off the waterway when crossing and turn off chemical application equipment.

REFERENCES

USDA, ARS. 1987. Stability design of grass-lined open channels. Agriculture Handbook 667.

USDA, NRCS. 2007. National Engineering Handbook, Part 650, Engineering Field Handbook, Chap. 7, Grassed waterways.

NATURAL RESOURCES CONSERVATION SERVICE

CONSERVATION PRACTICE STANDARD

RIPARIAN HERBACEOUS COVER

(Ac.)

CODE 390

DEFINITION

Grasses, sedges, rushes, ferns, legumes, and forbs tolerant of intermittent flooding or saturated soils, established or managed as the dominant vegetation in the transitional zone between upland and aquatic habitats.

PURPOSE

This practice may be applied as part of a conservation management system to accomplish one or more of the following purposes

- Provide or improve food and cover for fish, wildlife and livestock,
- Improve and maintain water quality.
- Establish and maintain habitat corridors.
- Increase water storage on floodplains.
- Reduce erosion and improve stability to stream banks and shorelines.
- Increase net carbon storage in the biomass and soil.
- Enhance pollen, nectar, and nesting habitat for pollinators.
- Restore, improve or maintain the desired plant communities.
- Dissipate stream energy and trap sediment.
- Enhance stream bank protection as part of stream bank soil bioengineering practices.

CONDITIONS WHERE PRACTICE APPLIES

- Areas adjacent to perennial and intermittent watercourses or water bodies where the natural plant community is dominated by herbaceous vegetation that is tolerant of periodic flooding or saturated soils. For seasonal or ephemeral watercourses and water bodies, this zone extends to the center of the channel or basin.
- Where channel and stream bank stability is adequate to support this practice.
- Where the riparian area has been altered and the potential natural plant community has changed.

CRITERIA

General Criteria Applicable to All Purposes

Where available, use Ecological Site Description to guide restoration to appropriate vegetative community phase and include appropriate vegetative functional groups.

Select perennial plants that are adapted to site and hydrologic conditions and provide the structural and functional diversity preferred by fish and wildlife likely to benefit from the installation of the practice.

In areas where native seeds and propagules are present, natural regeneration can be used in lieu of planting. Planting is required if no native seed bank is present.

Protect riparian vegetation and water quality by reducing or excluding haying and grazing until the desired plant community is well established.

Stream type and site hydrology must be considered. Selected plant species must be adapted to the projected duration of saturation and inundation of the site.

Harmful pests present on the site will be controlled or eliminated as necessary to achieve and maintain the intended purpose.

Pest management will be conducted in a manner that mitigates impacts to pollinators.

Management systems applied will be designed to maintain or improve the vigor and reproduction of the desired plant community.

Necessary site preparation and planting shall be done at a time and manner to insure survival and growth of selected species. Only viable, high quality and site-adapted planting stock will be used.

Determine the width of the riparian herbaceous cover planting based on the geomorphic potential of the site and project purposes, including the life history requirements of local fish and wildlife species, including pollinators.

Existing underground functional drains that pass through these areas shall be replaced with rigid, non perforated pipe through the buffer or equipped with a management regulating structure to allow control of overflow.

Domestic grazing should be deferred for a minimum of two years or until such time as the desired plant community is established.

Additional Criteria to Maintain or Improve Water Quality and Quantity

Minimum width shall be increased to 2.5 times the stream width (based on the horizontal distance between bank-full elevations) or 35 feet for water bodies. Concentrated flow erosion or mass soil movement shall be controlled in the up gradient area prior to establishment of the riparian herbaceous cover.

Species selected shall have stiff stems and high stem density near the ground surface to reduce water velocities and facilitate infiltration into the floodplain.

Additional Criteria to Stabilize Streambanks and Shorelines

Select native or accepted, introduced species that provide a deep, binding root mass to strengthen streambanks and improve soil health.

Additional Criteria for Increasing Net Carbon Storage in Biomass and Soils

Maximize width and length of the herbaceous riparian cover to fit the site.

Plant species used will have the highest rates of biomass production for the soil and other site conditions, consistent with meeting fish and wildlife habitat requirements.

Additional Criteria for Pollinator Habitat

Include forbs and legumes that provide pollen and nectar for native bees. Utilize a diverse mix of plant species that bloom at different times throughout the year.

Additional Criteria for Terrestrial Wildlife

Select native species adapted to the site.

Density of the vegetative stand established for this purpose shall be managed for targeted wildlife habitat requirements and shall encourage plant diversity.

If mowing is necessary to maintain herbaceous cover it will occur outside the nesting and fawning season and allow for adequate re-growth for winter cover. To protect pollinators and maintain habitat with a diversity of plant structure, a third or less of the site should be disturbed (mowed, grazed, burned, etc.) each year, allowing for recolonization of pollinators from surrounding habitat.

The management plan shall consider habitat and wildlife objectives such as habitat diversity, habitat linkages, daily and seasonal habitat ranges, limiting factors and native plant communities.

Additional Criteria for Restoring Desired Plant Community

Use Ecological Site Description (ESD) State and Transition models, where available, to determine if proposed actions are ecologically sound and defensible. Treatments need to be congruent with dynamics of the ecological site(s) and keyed to states and plant community phases that have the potential and capability to support the desired plant community. If an ESD is not available, base design criteria on best approximation of the desired plant community composition, structure, and function.

CONSIDERATIONS

Selection of native plant species is preferred. All selected species should have multiple values such as those suited for biomass, wintering and nesting cover, aesthetics, forage value for aquatic invertebrates, and tolerance to locally used herbicides.

Other conservation practices that may facilitate the establishment of Riparian Herbaceous Cover or enhance its performance include:

- Stream Habitat Improvement and Management (395)
- Streambank and Shoreline Protection – (580)
- Fence – (382)
- Pasture and Hayland Planting – (512)
- Range Planting – (550)
- Filter Strip – (393)
- Access Control – (472)
- Prescribed Grazing – (528A)
- Brush/Shrub Management – (314)
- Stream Herbaceous Weed Control Management – (315)
- Heavy Use Area Protection (561)
- Critical Area Planting (342)
- Riparian Forest Buffer (391)
- Early Successional Habitat Improvement Development and Management (395-(643)
- Conservation Cover - (327)
- Restoration and Management of Rare and Declining Habitat - (647)
- Stream Crossing (578)
- Watering Facility (614)

Considerations should be given to how this practice will complement the functions of adjacent riparian, terrestrial and aquatic habitats.

Consider the effects of upstream and downstream conditions, structures, facilities, and constraints on the planned activities.

Control of invasive trees and shrubs may be required to prevent dominance of the riparian zone by woody plants and maintain openness in riparian system.

Establish alternative water sources or controlled access stream crossings to manage livestock access to the stream and riparian area.

Selection of native plant species is recommended. Introduced species may be used. All selected species should have multiple values such as those suited for biomass, wintering and nesting cover, aesthetics, forage value for aquatic invertebrates, and tolerance to locally used herbicides.

Herbaceous riparian areas can function to link pollinators with adjacent fragmented habitat, and can serve as a conduit to move pollinators into areas requiring insect pollination. Different flower sizes and shapes appeal to different categories of pollinators. To support many species, consider establishing the greatest diversity possible. Consider incorporating nesting habitat, including patches of unshaded bare soil for ground nesting bees or where bumble bee conservation is a priority, clump forming warm-season native grasses.

Avoid plant species which may be alternate hosts to pests. Species diversity should be considered to avoid loss of function due to species-specific pests.

The location, layout and vegetative structure and composition of the buffer should complement natural features.

Corridor configuration, establishment procedures and management should enhance habitats for threatened, endangered and other plant or animal species of concern, where applicable.

Use plant species that provide full ground coverage to reduce particulate matter generation during establishment and maintenance operations.

PLANS AND SPECIFICATIONS

Specifications for this practice shall be prepared for each site. Specification shall be recorded using approved specifications sheets, job sheets, narrative statements in the conservation plan, or other acceptable documentation.

OPERATION AND MAINTENANCE

The purpose of operation, maintenance and management is to insure that the practice functions as intended over time.

The riparian area will be inspected periodically in order to detect adverse impacts and make adjustments in management to maintain the intended purpose.

Control of concentrated flow erosion or mass soil movement shall be continued in the up-gradient area to maintain riparian function.

Any use of fertilizers, pesticides and other chemicals to assure riparian area function shall not compromise the intended purpose.

Harmful pests present on the site will be controlled or eliminated as necessary to achieve and maintain the intended purpose.

Pest management will be conducted in a manner that mitigates impacts to pollinators.

Avoid haying or grazing when streambanks and riparian areas are vulnerable to livestock or mechanical damage.

Manage grazing to sustain riparian functions and values.

Management systems will be designed and applied to maintain or improve the vigor and reproduction of the desired plant community, e.g., the riparian functions and values.

Where the primary purpose of the practice is to provide terrestrial wildlife habitat, the density of the vegetative stand shall be managed for targeted wildlife habitat requirements and shall encourage plant diversity. If mowing is necessary to maintain herbaceous cover, it will occur outside the nesting and fawning season and allow for adequate re-growth for winter cover.

REFERENCES

FISRWG (Federal Interagency Stream Restoration Working Group). 1998. Stream Corridor Restoration: Principles, Processes and Practices. National Technical Information Service, U. S. Department of Commerce, Springfield, VA. Also published as NRCS, U.S. Department of Agriculture (1998) *Stream Corridor Restoration: Principles, Processes, and Practices*. National Engineering Handbook (NEH), Part 653. Washington, D.C.

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United States Department of Agriculture, Natural Resources Conservation Service. 2003. National Range and Pasture Handbook. Washington, DC.

http://plants.usda.gov/pollinators/Using_Farm_Bill_Programs_for_Pollinator_Conservation.pdf

Agroforestry Notes on supporting pollinators (General 6, 7, 8 and 9):

http://www.unl.edu/nac/agroforestrynotes.htm

Natural Resources Conservation Service

CONSERVATION PRACTICE STANDARD

Critical Area Planting

Code 342

(Ac)

DEFINITION

Establishing permanent vegetation on sites that have, or are expected to have, high erosion rates, and on sites that have physical, chemical, or biological conditions that prevent the establishment of vegetation with normal seeding/planting methods.

PURPOSE

- Stabilize areas with existing or expected high rates of soil erosion by wind or water.
- Stabilize stream and channel banks, pond and other shorelines, earthen features of structural conservation practices.
- Stabilize areas such as sand dunes and riparian areas.

CONDITIONS WHERE PRACTICE APPLIES

This practice applies to highly disturbed areas such as—

- Active or abandoned mined lands.
- Urban restoration sites.
- Construction areas.
- Conservation practice construction sites.
- Areas needing stabilization before or after natural disasters such as floods, hurricanes, tornados, and wildfires.
- Eroded banks of natural channels, banks of newly constructed channels, and lake shorelines.
- Other areas degraded by human activities or natural events.

CRITERIA

General Criteria Applicable to All Purposes

Site preparation. Conduct a site investigation to identify any physical, chemical, or biological conditions that could affect the successful establishment of vegetation.

Clear areas to be planted of unwanted materials and smooth or shape, if needed, to meet planting purpose(s).

Prepare a suitable seedbed for all seeded species. Rip compacted layers and re-firm the soil prior to seedbed preparation, as needed.

As site conditions dictate, when grading slopes, stockpile topsoil to be redistributed over area to be planted.

Species selection. Select species for seeding or planting that are suited to local site conditions and intended uses, and common to the site or location.

Selected species will have the capacity to achieve adequate density and vigor to stabilize the site within an appropriate period.

Establishment of vegetation. Plant seeds using the method or methods best suited to site and soil conditions.

Limit sod placement to areas that can naturally supply needed moisture or sites that can be irrigated during the establishment period. Place and anchor sod using techniques to ensure that it remains in place until established.

Specify species, rates of seeding or planting, legume inoculation, minimum quality of planting stock (e.g., pure live seed (PLS) or stem caliper), method of seedbed preparation, and method of establishment before application. Use only viable, high-quality seed or planting stock.

Seed or plant at a time and in a manner that best ensures establishment and growth of the selected species.

Plant during approved times for the species to be used.

Apply soil amendments (e.g., lime, fertilizer, compost) according to the requirements in the local Field Office Technical Guide.

Mulch or otherwise stabilize (e.g., polyacrylamide (PAM)) plantings as necessary to ensure successful establishment.

Additional Criteria to Stabilize Stream and Channel Banks, Pond and Other Shorelines, Earthen Features of Structural Conservation Practices

Bank and channel slopes. Shape channel side slopes so that they are stable and allow establishment and maintenance of desired vegetation.

A combination of vegetative and structural measures may be necessary on slopes steeper than 3:1 to ensure adequate stability.

Species selection. Plant material used for this purpose must—

- Be adapted to the hydrologic zone into which they will be planted.
- Be adapted and proven in the regions in which they will be used.
- Be compatible with existing vegetation in the area.
- Protect the channel banks but not restrict channel capacity.

Establishment of vegetation. Specify species, planting rates, spacing, methods and dates of planting based on local planting guides or technical notes.

Identify and protect desirable existing vegetation during practice installation.

Use a combination of vegetative and structural practices with living and inert material when flow velocities, soils, and bank stability preclude stabilization by vegetative establishment alone. Use Conservation Practice Standard (CPS) Streambank Stabilization (Code 580) for the structural measures.

Control existing vegetation on a site that will compete with species to be established vegetatively (e.g.. bare-root, containerized, ball-and-burlap, potted) to ensure successful establishment of the planted species.

Plant streambank stabilization vegetation in accordance with the NRCS Engineering Field Handbook Part 650, Chapter 16, “Streambank and Shoreline Protection,” and Chapter 18, “Soil Bioengineering for Upland Slope Protection & Erosion Reduction.”

Site protection and access control. Restrict access to planted areas until fully established.

Additional Criteria to Stabilize Areas Such As Sand Dunes and Riparian Areas

Plants for sand dunes and coastal sites must be able to survive being buried by blowing sand, sand blasting, salt spray, salt water flooding, drought, heat, and low nutrient supply.

Include sand trapping devices such as sand fences or brush matting in the revegetation/stabilization plans where applicable.

CONSIDERATIONS

Species or diverse mixes that are adapted to the site and have multiple benefits should be considered. Native species may be used when appropriate for the site.

To benefit pollinators and other wildlife, flowering shrubs and wildflowers with resilient root systems and good soil-holding capacity also should be considered for incorporation as a small percentage of a larger grass-dominated planting. Where appropriate consider a diverse mixture of forbs to support pollinator habitat.

Planning and installation of other CPSs such as Diversion (Code 362), Obstruction Removal (Code 500), Subsurface Drain (Code 606), Underground Outlet (Code 620), or Anionic Polyacrylamide Application (Code 450) may be necessary to prepare the area or ensure vegetative establishment.

Areas of vegetation established with this practice can create habitat for various type of wildlife. Maintenance activities, such as mowing or spraying, can have detrimental effects on certain species. Perform management activities at the times and in a manner that causes the least disruption to wildlife.

PLANS AND SPECIFICATIONS

Prepare plans and specifications for each field or management unit according to the criteria and operation and maintenance sections of this standard. Record practice specifications using approved Implementation Requirements document.

Address the following elements in the plan, as applicable, to meet the intended purpose(s):

- Practice purpose(s)
- Site preparation
- Topsoil requirements
- Fertilizer application
- Seedbed/planting area preparation
- Timing and method of seeding/planting
- Selection of species
- Seed/plant source
- Seed analysis/pure live seed (PLS)
- Seeding rate/plant spacing
- Mulching, PAM, or other stabilizing materials
- Supplemental water needed for establishment
- Protection of plantings
- Describe successful establishment (e.g., minimum percent ground/canopy cover, percent survival, stand density)

OPERATION AND MAINTENANCE

- Control access to the area to ensure the site remains stable.
- Protect plantings shall be protected from pests (e.g., weeds, insects, diseases, livestock, or wildlife) as necessary to ensure long-term survival.
- Inspections, reseeding or replanting, and fertilization may be needed to ensure that this practice functions as intended throughout its expected life.
- Observe establishment progress and success at regular intervals until the practice has met the criteria for successful establishment and implementation.
- Description of successful establishment (e.g., minimum percent ground/canopy cover, percent survival, stand density).

REFERENCES

Federal Interagency Stream Restoration Working Group. 1998. Stream corridor restoration: principles, processes, and practices. USDA NRCS National Engineering Handbook, Part 653.

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Natural Resources Conservation Service

CONSERVATION PRACTICE STANDARD

STREAM HABITAT IMPROVEMENT AND MANAGEMENT

CODE 395

(ac)

DEFINITION

Improve, restore, or maintain the ecological functions of a stream and its adjacent floodplain and riparian area.

PURPOSE

This practice is used to accomplish one or more of the following purposes:

- Improve or manage stream habitat by evaluating and addressing factors that impair stream function and structure.

CONDITIONS WHERE PRACTICE APPLIES

All streams and their associated backwaters, floodplains, wetlands, and riparian areas with impaired habitat.

This practice does not apply to—

- The management of fish and wildlife habitat on wetlands enhanced under this standard.
- Streambed or bank stabilization; instead, use Conservation Practice Standard (CPS) Streambank and Shoreline Protection (Code 580), or CPS Channel Bed Stabilization (Code 584).

This practice may be used in conjunction with other practices to address multiple resource concerns at the site.

CRITERIA

General Criteria Applicable to All Purposes

Use this practice to assess, evaluate, and prescribe a comprehensive plan for stream habitat improvement, including the use of associated practices to address functionally connected floodplains and wetlands.

Planned stream habitat improvements must—

- Be applied within the context of the overall watershed conditions and with clear objectives for stream habitat management goals.
- Be based on a site-specific assessment of local hydrology, channel morphology, geomorphic setting, fish and other aquatic species present, riparian area and floodplain conditions, and any habitat limitations including streamflow conditions, water quality, food supply, and restriction on upstream and downstream movement of aquatic species, as determined using the NRCS Stream Visual Assessment Protocol, Version 2 (SVAP2) or comparable State-approved aquatic habitat evaluation tool.

- When applied, results in a conservation system that addresses specific habitat objectives and meets or exceeds the minimum planning criteria for stream and aquatic habitat established in Section III of the Field Office Technical Guide.
- Design in-stream structures to be compatible with the dynamic nature of streams and rivers, facilitate natural geomorphic recovery where possible, and minimize disruption of recreational and other traditional uses of the stream corridor.
- Use acceptable design methodologies and criteria for in-stream structures. Coordinate with State-level technical experts to determine design methodologies applicable to your State or area.
- Enable adjoining floodplain and riparian areas to support a diverse vegetation community suitable for the site conditions and desired ecological benefits to the greatest extent possible.
- Use native plant materials in project installations to the maximum extent possible.
- Manage livestock to sustain a healthy stream corridor and associated habitats.

Structures installed for the purposes of this standard must not—

- Impede or prevent passage of fish and other aquatic organisms, unless they are intended to isolate populations of native species of conservation concern as directed by State or Federal species management plans or similar guidance.
- Cause unintentional lateral migration, aggradation, or degradation of the channel.
- Hinder channel-floodplain interactions.

CONSIDERATIONS

Restore or maintain stream habitat and channel-forming processes such as natural flow regime, meander migration, sediment transport, recruitment and storage of large wood, and stream interactions with the floodplain.

Incorporate riparian buffers to facilitate channel-forming processes, as well as encourage activities that promote riparian function to provide stream temperature moderation, recruitment of in-stream large wood and fine organic matter, input of riparian nutrients, habitat for terrestrial insects and other riparian dependent species, streambank integrity, and filtration of contaminants from surface runoff (see CPSs Riparian Forest Buffer (Code 391) and Riparian Herbaceous Cover (Code 390)).

Project design should consider risks resulting from adjustment of in-stream structures. Habitat objectives can be met as structures transition or change over time; however, consider potential damage and resulting effects on offsite property, public infrastructure, and human safety from structure movement.

Specific measures that should be considered either singularly or in combination to improve stream habitat include—

- Providing aquatic organism passage upstream and downstream to the extent possible and when compatible with State and Federal species recovery or management objectives (see CPS Aquatic Organism Passage (Code 396)).
- If possible, locating stream crossings in areas with the least effect on stream geomorphic function or aquatic habitat.
- Providing screens on water pumps, diversion ditches, or any areas that are within the landowner's control, where unintentional entrainment of aquatic species is likely to occur .
- To the greatest extent possible, maintaining adequate in-stream flows to sustain diverse habitats for fish and other aquatic species, especially during critical life-history stages.
- Maintaining natural surface water, hyporheic, and groundwater interactions to the extent possible.
- Improving floodplain-to-channel connectivity for development of seasonal or permanent backwater, wetland, and off-channel habitats consistent with the local climate and stream hydrology.
- Restoring stream and riparian area function by utilizing natural materials and methodologies such

as, but not limited to, flexible wood placement (unanchored, unpinned), beaver habitat restoration, spawning riffles, and boulder complexes where and when practical and feasible.

- Restoring or protecting riparian area and floodplain vegetation and associated riverine wetlands.
- If planting in adjoining floodplains and riparian areas, selecting plants that provide pollen and nectar for pollinators. Maximizing plant diversity in riparian areas can result in increased populations of pollinators and other terrestrial insects upon which fish feed.
- Controlling the spread of exotic plant and animal species to the greatest extent possible.
- Reducing or managing excessive runoff due to watershed development, road construction, or land-use activities that are within the landowner's control.
- Adjusting stream management actions to address the timing, intensity, frequency, and duration of recreation, grazing, planting, fertilizing, watering, or resource removal activities for the improvement and maintenance of stream and associated floodplain and riparian area habitat.
- Integrating other closely related practices to develop a comprehensive and multidisciplinary plan for the project site.

PLANS AND SPECIFICATIONS

Develop plans and specifications for each site to implement stream habitat management and improvement actions.

As a minimum, plans must include—

- Goals and objectives of the planned actions.
- A site description, including survey data that depict existing conditions and illustrate proposed changes to a subject reach's dimension, pattern, and profile.
- Data that characterize the structure and composition of the streambed and banks.
- Design drawings and job sheets that document quality, quantity, placement, dimensions, and elevations of structures, including installation timing and location.
- All facilitating practices including their respective specifications and their operation and maintenance requirements.
- The dates and sequencing for improvements or management actions.
- If planting is a component of the project, include a vegetation planting plan that identifies species, stocking rates, planting dates, care of seed or other plant materials, acceptable rate of survival, replanting requirements; alternatively, use specifications outlined within the facilitating and component practices.
- Incorporation of permit requirements, if any, into the specifications, design, and operation and maintenance requirements of the practice.
- Responsible party for collecting any post-construction survey data.

OPERATION AND MAINTENANCE

Develop a detailed operation and maintenance plan for all applications that details periodic inspection and prompt repair or modification of any structures that are not meeting design objectives.

Provide monitoring guidelines for evaluating the effectiveness of the conservation actions in the short- and long-term.

Conduct postproject evaluation of stream and riparian habitat conditions using the same preproject evaluation tool (e.g., SVAP2, or other) to determine if the implemented actions have resulted in improved habitat or have fully addressed resource concerns.

Coordinate any needed repair actions in order to comply with State and Federal guidelines for protecting aquatic and terrestrial species.

REFERENCES

Bureau of Land Management. 1998. Riparian Area Management: A User Guide to Assessing Proper Functioning Condition and the Supporting Science for Lotic Areas. TR-1737-15.

Federal Interagency Stream Restoration Working Group (FISRWG). 1998, revised October 2010. National Engineering Handbook, Part 653, Stream Corridor Restoration: Principles, Processes and Practices.

Gregory, S V., K.L. Boyer, and A.M. Gurnell, editors. 2003. The Ecology and Management of Wood in World Rivers. American Fisheries Society, Symposium 37. Bethesda, MD.

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NATURAL RESOURCES CONSERVATION SERVICE

CONSERVATION PRACTICE STANDARD

LIVESTOCK PIPELINE

(Ft.)

CODE 516

DEFINITION

A pipeline and appurtenances installed to convey water for livestock or wildlife.

PURPOSE

This practice may be applied as part of a resource management system to achieve one or more of the following purposes:

- Convey water to points of use for livestock or wildlife.
- Reduce energy use.
- Develop renewable energy systems.

CONDITIONS WHERE PRACTICE APPLIES

This standard applies to the conveyance of water through a closed conduit, from a source of supply to a watering facility, for use by livestock or wildlife.

This practice does not apply to the use of pipelines for irrigation, which are addressed by NRCS Conservation Practice Standard, Irrigation Pipeline (430).

CRITERIA

General Criteria Applicable to All Purposes

The volume, quality, and rate of delivery by the pipeline shall be sufficient to make use for livestock or wildlife practical and feasible.

Pipelines shall be placed only in or on soils with environmental conditions suitable for the type of material selected.

Capacity. Capacity shall be sufficient to convey the design delivery flow rate for the planned conservation practices.

For livestock or wildlife, provide the capacity necessary to meet the seasonal high daily water requirements for the number and species of animals to be supplied.

In computing the capacity requirements, allowance must be made for reasonable water losses during conveyance and use.

Friction and Other Losses. For design purposes, head loss for hydraulic grade line computations shall be based using one of the following equations: Hazen-Williams, Darcy-Weisbach, or Manning's. Equation selection shall be based on the given flow conditions and the pipe materials used. Other head losses (also called minor losses) from change in velocity and direction of flow due to inlet type, valves, bends, enlargements or contractions can be significant and shall be included as appropriate. For closed, pressurized systems, the hydraulic grade line for all pipelines shall be maintained above the top of the pipeline at all locations for all flows, unless specifically designed for negative internal pressures.

Pipe Design. Pipelines shall be designed to meet all service requirements such that internal pressure, including hydraulic transients or static pressure at any point is less than the pressure rating of the pipe.

Flexible conduits such as plastic and metal pipe shall be designed using NRCS National Engineering Handbook (NEH), Part 636, Chapter 52, Structural Design of Flexible Conduits, and the following criteria:

Plastic Pipe. When operating at design capacity, the full-pipe flow velocity should not exceed 5 feet per second in pipelines with valves or some other flow control appurtenances placed within the pipeline or at the downstream end. As a safety factor against transient pressures, the working pressure at any point should not exceed 72 percent of the pressure rating of the pipe. If either of these limits is exceeded, special design consideration must be given to the flow conditions, and measures must

be taken to adequately protect the pipeline against transient pressures.

Pressure ratings for pipes are normally based on a pipe temperature of 73.4ºF. When operating temperatures are higher, the effective pressure rating of the pipe shall be reduced accordingly.

Metal Pipe. The specified maximum allowable pressure shall be determined using the hoop stress formula, limiting the allowable tensile stress to 50 percent of the yield-point stress for the material selected. Design stresses for commonly used metal pipes are shown in NEH, Part 636, Chapter 52.

Support of Pipe. Pipelines installed above ground shall be supported, where needed, to provide stability against external and internal forces. Pipe support shall be designed using NEH, Part 636, Chapter 52.

Joints and Connections. All connections shall be designed and constructed to withstand the pipeline working pressure without leakage and leave the inside of the pipeline free of any obstruction that would reduce capacity.

Permissible joint deflection shall be obtained from the manufacturer for the type of joint and pipe material used.

For sloping metal pipe, expansion joints shall be placed adjacent to and downhill from anchors or thrust blocks.

For welded pipe joints, expansion joints shall be installed, as needed, to limit pipeline stresses to the allowable values.

The allowable longitudinal bending for the pipeline shall be based on type of material and the pressure rating, and shall be in accordance with industry standards, or as described in NEH, Part 636, Chapter 52.

For suspended pipelines, joints shall be designed for pipe loading, including the water in the pipe, wind, ice, and the effects of thermal expansion and contraction.

Joints and connections for metal pipes should be of similar materials whenever possible. If dissimilar materials are used, the joints or connections shall be protected against galvanic corrosion.

Depth of Cover. Buried pipe shall be installed at sufficient depth below the ground surface to provide protection from hazards imposed by traffic loads, farming operations, freezing temperatures, or soil cracking, as applicable.

Pipelines shall have sufficient strength to withstand all external loads on the pipe for the given installation conditions. Appropriate live loads shall be used for the anticipated traffic conditions.

Where it is not possible to achieve sufficient cover or sufficient strength, a carrier (encasement) pipe or other mechanical measures shall be used.

Pressure Reduction. Pressure Reducing Valves or Breaker Tanks shall be incorporated in circumstances such as head gain exceeding pressure loss by a significant amount, excessive static pressures, or excessive flow rates.

Valves and Other Appurtenances. Pressure ratings of valves and other appurtenances shall equal or exceed the design working pressure. When lever operated valves are used, an analysis shall be performed to evaluate potential transient pressures, assuming rapid valve closure.

Check Valves and Backflow Prevention. A Check Valve shall be installed between the pump discharge and the pipeline if detrimental backflow may occur.

Approved backflow prevention devices shall be used on all pipelines where back flow may contaminate the source water supply or groundwater.

Pressure Relief Valves. A Pressure Relief Valve shall be installed between the pump discharge and the pipeline if excessive pressure can build up when all valves are closed. If needed to protect the pipeline against malfunction or failure of Pressure Reducing Valves, Pressure Relief Valves shall be installed downstream of Pressure Reducing Valves.

Pressure Relief Valves shall be set to open at a pressure as low as practical, but no greater than 5 pounds per square inch above the design working pressure rating or maximum allowable pressure of the pipe. The valves shall have sufficient flow capacity to reduce the excessive pressures in the pipeline. The pressure at which the valves start to open shall be marked on each Pressure Relief Valve. Adjustable Pressure Relief Valves shall be sealed or otherwise altered to prevent changing the adjustment from that marked on the valve.

In lieu of a detailed transient pressure analysis, the minimum size of Pressure Relief Valve shall be ¼ inch nominal valve size per inch of the nominal pipeline diameter.

Air Vents. Provide for entry and removal of air along the pipeline, as needed to prevent air locking, hydraulic transients, or pipe collapse. Include provisions for air release and vacuum relief, as needed to protect the pipeline. Design the pipeline to remain below the hydraulic grade line during operation. If parts of the pipeline will be located above the hydraulic gradient, periodic use of an air pump may be required.

Surge Tanks and Air Chambers. Where surge tanks or air chambers are required for control of hydraulic transients or water column separation, they shall be of adequate size to ensure the water volume needs of the pipeline are met without the tank/chamber being emptied, and the required flow rate into the pipeline for the calculated pressure drop is met.

Outlets and Water Level Control.
Appurtenances to deliver water from the pipe to the watering facility shall have adequate capacity to deliver the required flow. Where water is supplied continuously to the watering facility, use automatic water level controls (such as Float Valves) to control the flow of water and to prevent unnecessary overflows.

Design outlets and water level controls to withstand or be protected from damage by livestock, wildlife, freezing and ice damage. Outlets shall be designed to minimize erosion, physical damage, or deterioration due to exposure.

Thrust Control. Abrupt changes in pipeline grade, horizontal alignment, or size reductions, may require an anchor or thrust blocks to absorb pipeline axial thrust. Thrust control is typically needed at the end of the pipeline, and at in-line control valves. The pipe manufacturer's recommendations for thrust control shall be followed. In absence of manufacturer's data, thrust blocks shall be designed using NEH, Part 636, Chapter 52.

Thermal Effects. For plastic pipe, thermal effects must be properly factored into system design. Values and procedures for pressure rating reduction shall follow information described in the NEH, Part 636, Chapter 52.

Physical Protection. Steel pipe installed above ground shall be galvanized or shall be protected with a suitable protective paint coating.

Plastic pipe installed above ground shall be resistant to ultraviolet light throughout the intended life of the pipe, or measures must be taken to protect the pipe from damage due to ultraviolet light.

All pipes shall be protected from hazards presented by traffic loads, farm operations, freezing temperatures, fire, thermal expansion and contraction. Reasonable measures shall be taken to protect the pipe from potential vandalism.

Filling. The pipeline system shall have a means of controlling the filling of the pipeline to prevent entrapment of air or excessive transient pressures.

Filling velocities greater than 1 foot per second in a closed to the atmosphere pipe system (i.e., all outlets closed), requires special evaluation and provisions to remove entrapped air and prevent excessive transient pressures.

If filling at a low flow rate is not possible, the system shall be open to the atmosphere (outlets open) prior to pressurizing. The system shall be designed for air removal and excessive transient pressures that may develop at higher filling rates.

Flushing. If the sediment load in the water is significant, the pipeline shall have adequate velocity to ensure that sediment is moved through and flushed out of the pipeline.

If provisions are needed for flushing sediment or other foreign material, a suitable valve shall be installed at the distant end or low point of the pipeline.

Draining. Provisions shall be made for the complete removal of water from the pipeline by gravity or other means when:

- Freezing temperatures are a hazard.
- Draining is required by the pipe manufacturer.
- Draining of the pipeline is otherwise specified.

The water drained from pipelines shall not cause water quality, soil erosion, or safety problems upon release.

Safe Discharge of Water. Provisions shall be made for water being discharged from valves, especially air valves and pressure relief valves. These valves shall be located such that flows are directed away from system operators, livestock, electrical equipment, or other control valves.

Vegetation. Reestablish vegetation or otherwise stabilize disturbed areas as soon as practical after construction. Seedbed preparation, seeding, fertilizing, and mulching shall meet applicable criteria in NRCS Conservation Practice Standard, Critical Area Planting (342).

Additional Criteria Applicable to Reduce Energy Use

Provide analysis to demonstrate reduction of energy use from practice implementation.

Reduction of energy use is calculated as average annual or seasonal energy reduction compared to previous operating conditions.

Additional Criteria Applicable to Develop Renewable Energy Systems

Renewable energy systems shall meet applicable design criteria in NRCS and/or industry standards, and shall be in accordance with manufacturer's recommendations. Hydropower systems shall be designed, operated, and maintained in accordance with the Microhydropower Handbook, Sections 4 and 5, as appropriate.

CONSIDERATIONS

Safety. Pipeline systems may present a hazard to the safety of people, during installation and operation. Consider safety as follows:

- Address trench safety in design and during construction.
- Provide protection for people from high pressure water blowing from Pressure Relief, Air Release, and other valves.
- Determine the existence or non-existence of underground utilities prior to construction.

Economics. Consider economics in pipeline design, as follows:

- Select pipe sizes based on lifetime energy requirements, versus initial costs of materials.
- Select pipe material based upon the expected service life of practice.
- Consider hydropower applications as alternatives to the use of Pressure Reducing valves or reduced pipe diameters to induce friction loss.

Other Resources. Consider potential impacts to other resources as follows:

- Address rare plant species and cultural resources during the installation of buried pipelines. When possible, avoid these resources, as well as wetlands and other habitats that are highly sensitive to disturbance, or include measures to minimize impacts.
- Consider the visual design of pipelines and appurtenances, especially in areas of high public visibility.

PLANS AND SPECIFICATIONS

Prepare plans and specifications for Livestock Pipelines that describe the requirements for applying the practice according to this standard. As a minimum, the plans and specifications shall include:

- A plan view of the layout of the pipeline.
- Profile view of the pipeline.
- Pipe sizes and materials.
- Pipe joint requirements.
- Site specific construction specifications that describe in writing the installation of the pipeline. Include requirements for pressure testing of the pipeline.
- Depth of cover and backfill requirements.
- Vegetative establishment requirements.

OPERATION AND MAINTENANCE

An Operation and Maintenance (O&M) Plan shall be developed for each Livestock Pipeline system installed. The plan should document needed actions to ensure that practices perform adequately throughout their expected life.

O&M requirements shall be included as an identifiable part of the design. Depending on the scope of the project, this may be accomplished by written statements in the plans and specifications, the conservation plan narrative, or as a separate O&M Plan.

Other aspects of O&M, such as draining procedures, marking crossing locations, valve operation to prevent pipe or appurtenant damage, appurtenance or pipe maintenance, and recommended operating procedures, should be described as needed within the O&M Plan.

Monitoring of any cathodic protection systems shall be performed as specified in the O&M Plan.

A filling procedure shall be developed, which details allowable flow rates and appurtenance operation at the various phases of the filling process, required to assure safe filling of the pipeline. Flow measuring devices, such as flow meters or other means (e.g., number of turns of a gate valve), should be used to determine the rate of flow into the pipeline system. This information shall be provided to the operator, and shall be incorporated into the O&M Plan as appropriate.

REFERENCES

McKinney, J.D., et al. Microhydropower Handbook, IDO-10107, Volumes 1 & 2. U.S. Department of Energy, Idaho Operations Office.

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NATURAL RESOURCES CONSERVATION SERVICE

CONSERVATION PRACTICE STANDARD

STORMWATER RUNOFF CONTROL

(No. and Ac.)

CODE 570

DEFINITION

Controlling the quantity and quality of stormwater runoff.

PURPOSE

To control stormwater runoff to achieve one or more of the following:

- Minimize erosion and sedimentation during and following construction activities.
- Reduce the quantity of stormwater leaving developing or developed sites.
- Improve the quality of stormwater leaving developing or developed sites.

CONDITIONS WHERE PRACTICE APPLIES

This practice applies to sites where stormwater runoff causes or may cause undesirable downstream flooding, sedimentation or channel degradation and/or degradation of surface or ground water quality if left untreated. This practice may apply both to sites undergoing development as well as remedial work on already developed sites.

CRITERIA

General Criteria Applicable to All Purposes

Plan, design and construct stormwater runoff controls to comply with applicable federal, state, and local laws and regulations.

Develop a plan to reduce the impacts of stormwater runoff from the site based on an assessment of the downstream area. As applicable include in the plan practices or management activities that will:

- Reduce onsite erosion.
- Reduce offsite impacts from sedimentation.
- Reduce the quantity of stormwater leaving the site to levels that will not adversely affect downstream receiving channels.
- Improve the quality of runoff leaving the site.
- Leave the site in a stable condition after construction.

Vegetative Measures. Where appropriate, stabilize all areas disturbed by construction with vegetation as soon as possible after construction. Refer to Conservation Practice Standard, (342) Critical Area Planting for the establishment of vegetation. If vegetation is not appropriate for the site, use other measures to stabilize the area.

Safety. Detention ponds and other areas where water is detained or flows swiftly, can present hazards to the public. Where necessary, include appropriate safety features to warn of potential dangers or deter entry to hazardous areas such as fences, gates and warning signs.

Additional Criteria for the Reduction of Water Quantity. Design stormwater control systems to control flow from the area of concern to rates and volumes that will not cause degradation of downstream areas due to erosion or sedimentation. Acceptable peak rates are dependent upon the capacity and stability of the receiving channel. Local regulations may specify acceptable discharge rates for different storm frequencies.

Runoff is controlled by slowing the release of runoff from the site. This can be accomplished by onsite storage, increasing infiltration onsite, lengthening the flow path of runoff or a

combination of these methods.

All runoff control methods must include provisions to safely bypass runoff in excess of the design storm.

Additional Criteria for the Improvement of Water Quality. Runoff from developing areas can be contaminated with a variety of substances including sediment, oils, chemicals and trash. Runoff control systems must include provisions to reduce contaminates in the runoff leaving the site. This can include vegetated filtration areas and other biofilters, trash guards and settling areas that are readily accessible for cleanout. For runoff that is known to be contaminated with substances that may be particularly harmful to the water supply or fish and wildlife, additional measures may be necessary.

Additional Criteria for Erosion and Sediment Control. Control erosion on the site by limiting the amount and length of time that bare soil is exposed to precipitation. This can be accomplished by staging construction and only removing vegetation from a portion of the site at a time, revegetating areas incrementally during construction or using temporary seeding and mulching to stabilize areas until permanent vegetation can be established. Structural erosion control practices can also be installed to reduce the flow length and velocity of runoff to limit erosion.

When erosion cannot be stopped at the source, sediment laden runoff must be filtered or detained to allow sediment particles to settle out to acceptable levels before runoff is released from the site. This can be accomplished by sediment traps, sediment basins and other structures designed to detain or filter runoff. Refer to Conservation Practice Standard, (350) Sediment Basin for design requirements for sediment basins.

CONSIDERATIONS

Research has shown that the first runoff from a site is often the most contaminated. After this initial flush, less pollutants are available for removal and dilution lessens the impact. Consequently treatment of this “first flush” of runoff is often sufficient to address the water quality concern. The exact amount of runoff to treat varies depending upon the surface and level of contamination. Determine the amount of runoff to treat based on appropriate research or experience.

Stormwater control practices can affect downstream hydrology. While this is the point of most stormwater control systems the effect of changing the peak rate and volume of runoff should be considered on downstream areas. The effect of a single project should also be considered in context with other projects in the watershed to determine the cumulative effect. Generally peak rates of runoff should be kept at or below pre-development rates of runoff from the site for the 2 year 24 hour storm. For already developed areas consider reducing the peak flow from the current developed condition.

Design stormwater control practices to fit into the visual landscape as well as to function for runoff control. Since stormwater control practices are generally installed in public spaces, consider how the space will be used and the visual impact the practices will have.

If properly designed, stormwater control practices can be beneficial to wildlife. When possible use native vegetation to provide food and habitat for wildlife and pollinators. Since most stormwater control practices are in aquatic environments, they can inhibit the movements of aquatic organisms. When designing these structures include provisions for the safe passage of aquatic organisms that may inhabit the site.

To be most effective, stormwater control should include a system of practices working together. This might include detention along with infiltration areas and the maintenance of natural, undisturbed areas. However, it could also include managing the development of the site to limit the disturbed area, ensuring that revegation occurs in a timely manner and controlling where heavy equipment is allowed to travel on a site.

Large storms can quickly fill stormwater runoff practices with sediment that must be removed in order for the practices to function correctly. Consequently these practices should be designed for easy access and maintenance.

Since stormwater control practices are often installed in urban and public spaces, vandalism may be a problem. Consider using practices that cannot be easily vandalized such as grouting rock in place and installing barriers and locks where appropriate.

PLANS AND SPECIFICATIONS

Prepare plans and specifications for stormwater runoff control systems that describe the requirements for applying the practice according to this standard. As a minimum the plans and specifications shall include:

1. A plan view showing the extent of the practice.
2. Where appropriate, cross-sections and/or profiles showing elevations and distances.
3. Where appropriate, plans for structural details.
4. Where appropriate, seeding requirements.
5. Construction specifications that describe in writing site specific installation requirements for the stormwater runoff control systems.

OPERATION AND MAINTENANCE

Prepare an operation and maintenance plan for the operator. The minimum requirements to be addressed in the operation and maintenance plan are:

1. Periodic inspections, especially immediately following significant rainfall events.
2. Prompt repair or replacement of damaged components especially surfaces that are subjected to wear or erosion.
3. Regular inspection of settling basins, trash guards and other practices to collect and remove accumulated sediment and debris.
4. Where vegetation is specified, periodic mowing, fertilization and control of vegetation.

REFERENCES

Bannerman, Roger, and E. Considine, 2003. Rain Gardens: A How-to Manual for Homeowners. University of Wisconsin Extension Publication GWQ037 or Wisconsin Department of Natural Resources Publication PUB-WT-776 2003. Madison, WI

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NATURAL RESOURCES CONSERVATION SERVICE

CONSERVATION PRACTICE STANDARD

STREAMBANK AND SHORELINE PROTECTION

(Ft.)

CODE 580

DEFINITION

Treatment(s) used to stabilize and protect banks of streams or constructed channels, and shorelines of lakes, reservoirs, or estuaries.

PURPOSE

- To prevent the loss of land or damage to land uses, or facilities adjacent to the banks of streams or constructed channels, shoreline of lakes, reservoirs, or estuaries including the protection of known historical, archeological, and traditional cultural properties.
- To maintain the flow capacity of streams or channels.
- Reduce the offsite or downstream effects of sediment resulting from bank erosion.
- To improve or enhance the stream corridor for fish and wildlife habitat, aesthetics, recreation.

CONDITIONS WHERE PRACTICE APPLIES

This practice applies to streambanks of natural or constructed channels and shorelines of lakes, reservoirs, or estuaries where they are susceptible to erosion. It does not apply to erosion problems on main ocean fronts, beaches or similar areas of complexity.

CRITERIA

General Criteria Applicable to All Purposes

Treatments shall be in accordance with all applicable local, state and federal laws and regulations.

Treatments applied shall seek to avoid adverse effects to endangered, threatened, and candidate species and their habitats, whenever possible.

Treatments applied shall seek to avoid adverse effects to archaeological, historic, structural, and traditional cultural properties, whenever possible.

An assessment of unstable streambank or shoreline sites shall be conducted in sufficient detail to identify the causes contributing to the instability (e.g. livestock access, watershed alterations resulting in significant modifications of discharge or sediment production, in channel modifications such as gravel mining, head cutting, water level fluctuations, boat-generated waves, etc.).

Proposed protective treatments to be applied shall be compatible with improvements being planned or installed by others.

Protective treatments shall be compatible with the bank or shoreline materials, water chemistry, channel or lake hydraulics, and slope characteristics above and below the water line.

End sections of treatment areas shall be adequately anchored to existing treatments, terminate in stable areas, or be otherwise stabilized to prevent flanking of the treatment.

Protective treatments shall be installed that result in stable slopes. Design limitations of the bank or shoreline materials and type of measure installed shall determine steepest permissible slopes.

Designs will provide for protection of installed treatments from overbank flows resulting from upslope runoff and flood return flows.

Internal drainage for bank seepage shall be provided when needed. Geotextiles or properly

designed filter bedding shall be incorporated with structural measures where there is the potential for migration of material from behind the measure.

Treatments shall be designed to account for any anticipated ice action, wave action, and fluctuating water levels.

All disturbed areas around protective treatments shall be protected from erosion. Disturbed areas that are not to be cultivated shall be protected as soon as practical after construction.

Vegetation shall be selected that is best suited for the site conditions and achieves the intended purpose(s).

In order to ensure plant community establishment and integrity, a vegetative management plan shall be prepared in accordance with NRCS conservation practice standard Critical Area Planting, Code 342.

Additional Criteria for Streambanks

Stream segments to be protected shall be classified according to a system deemed appropriate by the state. Segments that are incised or that contain the 5-year return period (20 percent probability) or greater flows shall be evaluated for further degradation or aggradation.

A site assessment shall be performed to determine if the causes of instability are local (e.g. poor soils, high water table in banks, alignment, obstructions deflecting flows into bank, etc.) or systemic in nature (e.g. aggradation due to increased sediment from the watershed, increased runoff due to urban development in the watershed, degradation due to channel modifications, etc.). The assessment need only be of the extent and detail necessary to provide a basis for design of the bank treatments and reasonable confidence that the treatments will perform adequately for the design life of the measure.

Changes in channel alignment shall not be made without an assessment of both upstream and downstream fluvial geomorphology that evaluates the affects of the proposed alignment. The current and future discharge-sediment regime shall be based on an assessment of the watershed above the proposed channel alignment.

Bank protection treatment shall not be installed in channel systems undergoing rapid and extensive changes in bottom grade and/or alignment unless the treatments are designed to control or accommodate the changes. Bank treatment shall be constructed to a depth at or below the anticipated lowest depth of streambed scour.

If the failure mechanism is a result of the degradation or removal of riparian vegetation, stream corridor restoration shall be implemented, where feasible, (see Additional Criteria for Stream Corridor Improvement) as well as treating the banks.

Toe erosion shall be stabilized by treatments that redirect the stream flow away from the toe or by structural treatments that armor the toe. Additional design guidance is found in the EFH Part 650, Chapter 16, Streambank and Shoreline Protection.

Where toe protection alone is inadequate to stabilize the bank, the upper bank shall be shaped to a stable slope and vegetated, or shall be stabilized with structural or soil-bioengineering treatments.

Channel clearing to remove stumps, fallen trees, debris, and sediment bars shall only be performed when they are causing or could cause unacceptable bank erosion, flow restriction, or damage to structures. Habitat forming elements that provide cover, food, pools, and water turbulence shall be retained or replaced to the extent possible.

Treatments shall be functional and stable for the design flow and sustainable for higher flow conditions.

Treatments shall not induce an increase in natural erosion.

Treatments shall not limit stream flow access to the floodplain.

Where flooding is a concern, the effects of protective treatments shall not increase flow levels above those that existed prior to installation.

Additional Criteria for Shorelines

All revetments, bulkheads or groins are to be no higher than 3 feet (1 meter) above mean high tide, or mean high water in non-tidal areas

Structural shoreline protective treatments shall be keyed to a depth to prevent scour during low water.

For the design of structural treatments, the site characteristics below the waterline shall be evaluated for a minimum of 50 feet (15 meters) horizontal distance from the shoreline measured at the design water surface.

The height of the protection shall be based on the design water surface plus the computed wave height and freeboard. The design water surface in tidal areas shall be mean high tide.

When vegetation is selected as the protective treatment, a temporary breakwater shall be used during establishment when wave run up would damage the vegetation.

Additional Criteria for Stream Corridor Improvement

Stream corridor vegetative components shall be established as necessary for ecosystem functioning and stability. The appropriate composition of vegetative components is a key element in preventing excess long-term channel migration in re-established stream corridors. The establishment of vegetation on channel banks and associated areas shall also be in accordance with conservation practice standard Critical Area Planting, Code 342.

Treatments shall be designed to achieve habitat and population objectives for fish and wildlife species or communities of concern as determined by a site-specific assessment or management plan. Objectives shall be based on the survival and reproductive needs of populations and communities, which include habitat diversity, habitat linkages, daily and seasonal habitat ranges, limiting factors and native plant communities. The type, amount, and distribution of vegetation shall be based on the requirements of the fish and wildlife species or communities of concern to the extent possible.

Treatments shall be designed to meet aesthetic objectives as determined by a site-specific assessment or management plan. Aesthetic objectives shall be based on human needs, including visual quality, noise control, and microclimate control. Construction materials, grading practices, and other site development elements shall be selected and designed to be compatible with adjacent land uses.

Treatments shall be designed to achieve recreation objectives as determined by a site-specific assessment or management plan. Safety requirements shall be based on type of human use and recreation objectives.

CONSIDERATIONS

When designing protective treatments, consider should be given to the changes that may occur in the watershed hydrology and sedimentation over the design life of the treatments.

Consider utilizing debris removed from the channel or streambank into the treatment design when it is compatible with the intended purpose to improve benefits for fish, wildlife and aquatic systems.

Use construction materials, grading practices, vegetation, and other site development elements that minimize visual impacts and maintain or complement existing landscape uses such as pedestrian paths, climate controls, buffers, etc. Avoid excessive disturbance and compaction of the site during installation.

Utilize vegetative species that are native and/or compatible with local ecosystems. Avoid introduced, invasive, noxious or exotic species that could become nuisances. Consider species that have multiple values such as those suited for biomass, nuts, fruit, browse, nesting, aesthetics and tolerance to locally used herbicides. Avoid species that may be alternate hosts to disease or undesirable pests. Species diversity should be considered to avoid loss of function due to species-specific pests. Species on noxious plant lists should not be used.

Select plant materials that provide habitat requirements for desirable wildlife and pollinators. The addition of native forbs and legumes to grass mixes will increase the value of plantings for both wildlife and pollinators.

Treatments that promote beneficial sediment deposition and the filtering of sediment, sediment-attached, and dissolved substances should be considered.

Consider maintaining or improving the habitat value for fish and wildlife by including treatments that provide aquatic habitat in the treatment

design and that may lower or moderate water temperature and improve water quality.

Consider the need to stabilize side channel inlets and outlets and outlets of tributary streams from erosion.

Consider aquatic habitat when selecting the type of toe stabilization.

Consider maximizing adjacent wetland functions and values with the project design and minimize adverse effects to existing wetland functions and values.

Livestock exclusion shall be considered during establishment of vegetative treatments and appropriate grazing practices applied after establishment to maintain plant community integrity. Wildlife may also need to be controlled during establishment of vegetative treatments. Temporary and local population control methods should be used with caution and within state and local regulations.

When appropriate, establish a buffer strip and/or diversion at the top of the bank or shoreline protection zone to help maintain and protect installed treatments, improve their function, filter out sediments, nutrients, and pollutants from runoff, and provide additional wildlife habitat.

Consider conservation and stabilization of archeological, historic, structural and traditional cultural properties when applicable.

Consider safety hazards to boaters, swimmers, or people using the shoreline or streambank when designing treatments.

Protective treatments should be self-sustaining or require minimum maintenance.

PLANS AND SPECIFICATIONS

Plans and specifications for streambank and shoreline protection shall be prepared for specific field sites and based on this standard and shall describe the requirements for applying the practice to achieve its intended purpose. Plans shall include treatments to minimize erosion and sediment production during construction and provisions necessary to comply with conditions of any environmental agreements, biological opinions or other terms of applicable permits.

OPERATION AND MAINTENANCE

An operation and maintenance plan shall be prepared for use by the owner or others responsible for operating and maintaining the system. The plan shall provide specific instructions for operating and maintaining the system to insure that it functions properly. It shall also provide for periodic inspections and prompt repair or replacement of damaged components or erosion.

REFERENCES

NEH Part 650, Chapter 16, Streambank and Shoreline Protection..

COMET-Planner Carbon Sequestration and Greenhouse Gas Estimation Report

Project Name: Cal Poly: Escuela/Walters Ranch

State: CA

County: San Luis Obispo

Date Created: 5/10/2020 10:11:54 AM

	Enter Acreage	Carbon Dioxide	Nitrous Oxide	Methane	Total CO_2-Equivalent
NRCS Conservation Practices					
Riparian Herbaceous Cover (CPS 390) - Convert Non-Irrigated Cropland to Permanent Unfertilized Grass/Legume Cover Near Aquatic Habitats	169	43	-36	0	7
Critical Area Planting (CPS 342) - Restore Highly Disturbed Areas by Planting Permanent Vegetative Cover	169	177	0	0	177
Riparian Forest Buffer (CPS 391) - Replace a Strip of Grassland Near Watercourses or Water Bodies with Woody Plants	169	300	N.E.2	N.E.2	300
Prescribed Grazing (528) - Grazing Management to Improve Rangeland or Non-Irrigated Pasture Condition	588	3	0	0	3
Silvopasture (CPS 381) - Tree/Shrub Planting on Grazed Grasslands	112	73	0	0	73
	Total	596.00	-36.00	0.00	560.00

1Negative values indicate a loss of carbon or increased emissions of greenhouse gases

2Values were not estimated due to limited data on reductions of greenhouse gas emissions from this practice

For more information on how these estimates were generated, please visit www.comet-planner.com.

COMET-Planner Carbon Sequestration and Greenhouse Gas Estimation Report

Project Name: Cal Poly: Chorro Creek Ranch
State: CA
County: San Luis Obispo
Date Created: 5/10/2020 10:18:31 AM

	Enter Acreage	Carbon Dioxide	Nitrous Oxide	Methane	Total CO_2-Equivalent
NRCS Conservation Practices					
Riparian Herbaceous Cover (CPS 390) - Convert Non-Irrigated Cropland to Permanent Unfertilized Grass/Legume Cover Near Aquatic Habitats	76	19	-16	0	3
Critical Area Planting (CPS 342) - Restore Highly Disturbed Areas by Planting Permanent Vegetative Cover	3.4	4	0	0	4
Riparian Forest Buffer (CPS 391) - Replace a Strip of Grassland Near Watercourses or Water Bodies with Woody Plants	76	135	N.E.2	N.E.2	135
Prescribed Grazing (528) - Grazing Management to Improve Rangeland or Non-Irrigated Pasture Condition	188	1	0	0	1
Silvopasture (CPS 381) - Tree/Shrub Planting on Grazed Grasslands	38	25	0	0	25
Cover Crop (CPS 340) - Add Non-Legume Seasonal Cover Crop to Non-Irrigated Cropland	28	7	-1	0	6
Residue and Tillage Management - No-Till (CPS 329) - Intensive Till to No Till or Strip Till on Non-Irrigated Cropland	28	4	0	0	4
Range Planting (CPS 550) - Seeding Forages to Improve Rangeland Condition	75	25	0	0	25
Hedgerow Planting (CPS 422) - Replace a Strip of Cropland with 1 Row of Woody Plants	1.5	12	0	N.E.2	12
Filter Strip (CPS 393) - Convert Strips of Non-Irrigated Cropland to Permanent Unfertilized Grass/Legume Cover	3.4	1	-1	0	0
	Total	233.00	-18.00	0.00	215.00

1Negative values indicate a loss of carbon or increased emissions of greenhouse gases
2Values were not estimated due to limited data on reductions of greenhouse gas emissions from this practice

For more information on how these estimates were generated, please visit www.comet-planner.com.

COMET-Planner Carbon Sequestration and Greenhouse Gas Estimation Report

Project Name: Cal Poly: Peterson Ranch

State: CA

County: San Luis Obispo

Date Created: 5/10/2020 10:23:02 AM

	Enter Acreage	Carbon Dioxide	Nitrous Oxide	Methane	Total CO_2-Equivalent
NRCS Conservation Practices					
Riparian Herbaceous Cover (CPS 390) - Convert Non-Irrigated Cropland to Permanent Unfertilized Grass/Legume Cover Near Aquatic Habitats	24	6	-5	0	1
Riparian Forest Buffer (CPS 391) - Replace a Strip of Grassland Near Watercourses or Water Bodies with Woody Plants	24	43	N.E.2	N.E.2	43
Prescribed Grazing (528) - Grazing Management to Improve Rangeland or Non-Irrigated Pasture Condition	283	1	0	0	1
Silvopasture (CPS 381) - Tree/Shrub Planting on Grazed Grasslands	48	31	0	0	31
	Total	81.00	-5.00	0.00	76.00

1Negative values indicate a loss of carbon or increased emissions of greenhouse gases

2Values were not estimated due to limited data on reductions of greenhouse gas emissions from this practice

For more information on how these estimates were generated, please visit www.comet-planner.com.

COMET-Planner Carbon Sequestration and Greenhouse Gas Estimation Report

Project Name: Cal Poly: Serrano Ranch

State: CA

County: San Luis Obispo

Date Created: 5/10/2020 10:25:34 AM

	Enter Acreage	Carbon Dioxide	Nitrous Oxide	Methane	Total CO_2-Equivalent
NRCS Conservation Practices					
Riparian Herbaceous Cover (CPS 390) - Convert Non-Irrigated Cropland to Permanent Unfertilized Grass/Legume Cover Near Aquatic Habitats	32	8	-7	0	1
Riparian Forest Buffer (CPS 391) - Replace a Strip of Grassland Near Watercourses or Water Bodies with Woody Plants	32	57	N.E.2	N.E.2	57
Prescribed Grazing (528) - Grazing Management to Improve Rangeland or Non-Irrigated Pasture Condition	254	1	0	0	1
Silvopasture (CPS 381) - Tree/Shrub Planting on Grazed Grasslands	73	48	0	0	48
Range Planting (CPS 550) - Seeding Forages to Improve Rangeland Condition	48	16	0	0	16
	Total	130.00	-7.00	0.00	123.00

1Negative values indicate a loss of carbon or increased emissions of greenhouse gases

2Values were not estimated due to limited data on reductions of greenhouse gas emissions from this practice

For more information on how these estimates were generated, please visit www.comet-planner.com.

COMET-Planner Carbon Sequestration and Greenhouse Gas Estimation Report

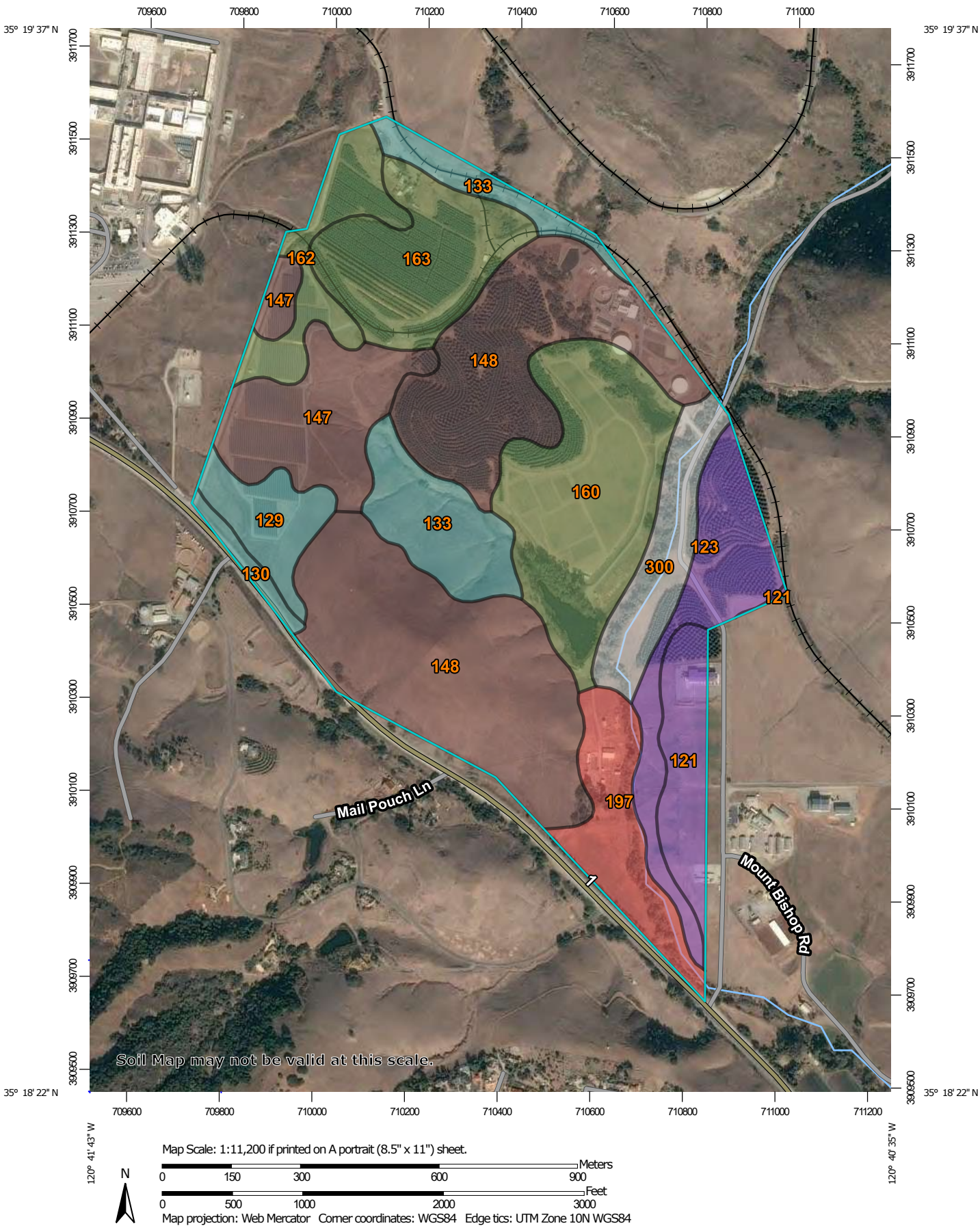
Project Name: Cal Poly: Cheda Ranch
State: CA
County: San Luis Obispo
Date Created: 5/10/2020 10:32:14 AM

	Enter Acreage	Carbon Dioxide	Nitrous Oxide	Methane	Total CO_2-Equivalent
NRCS Conservation Practices					
Riparian Herbaceous Cover (CPS 390) - Convert Non-Irrigated Cropland to Permanent Unfertilized Grass/Legume Cover Near Aquatic Habitats	5.3	1	-1	0	0
Riparian Forest Buffer (CPS 391) - Replace a Strip of Grassland Near Watercourses or Water Bodies with Woody Plants	5.3	9	N.E.2	N.E.2	9
Prescribed Grazing (528) - Grazing Management to Improve Rangeland or Non-Irrigated Pasture Condition	112	1	0	0	1
Silvopasture (CPS 381) - Tree/Shrub Planting on Grazed Grasslands	52	34	0	0	34
Range Planting (CPS 550) - Seeding Forages to Improve Rangeland Condition	43	15	0	0	15
Cover Crop (CPS 340) - Add Legume Seasonal Cover Crop to Irrigated Cropland	17	15	-6	0	9
Forage and Biomass Planting (CPS 512) - Conversion of Annual Cropland to Non-Irrigated Grass/Legume Forage/Biomass Crops	3.6	1	0	0	1
Residue and Tillage Management - Reduced Till (CPS 345) - Intensive Till to Reduced Till on Irrigated Cropland	26.2	2	0	0	2
Hedgerow Planting (CPS 422) - Replace a Strip of Grassland with 1 Row of Woody Plants	.05	0	N.E.2	N.E.2	0
	Total	78.00	-7.00	0.00	71.00

1Negative values indicate a loss of carbon or increased emissions of greenhouse gases
2Values were not estimated due to limited data on reductions of greenhouse gas emissions from this practice

For more information on how these estimates were generated, please visit www.comet-planner.com.

All Ecological Sites -- Rangeland—San Luis Obispo County, California, Coastal Part
(Cheda Ranch)



MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils

Soil Rating Polygons
- R014XD105CA
- R014XD109CA
- R015XD001CA
- R015XD049CA
- R015XD070CA
- Not rated or not available

Soil Rating Lines
- R014XD105CA
- R014XD109CA
- R015XD001CA
- R015XD049CA
- R015XD070CA
- Not rated or not available

Soil Rating Points
- R014XD105CA
- R014XD109CA
- R015XD001CA
- R015XD049CA
- R015XD070CA
- Not rated or not available

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: San Luis Obispo County, California, Coastal Part
Survey Area Data: Version 12, Sep 16, 2019

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Data not available.

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

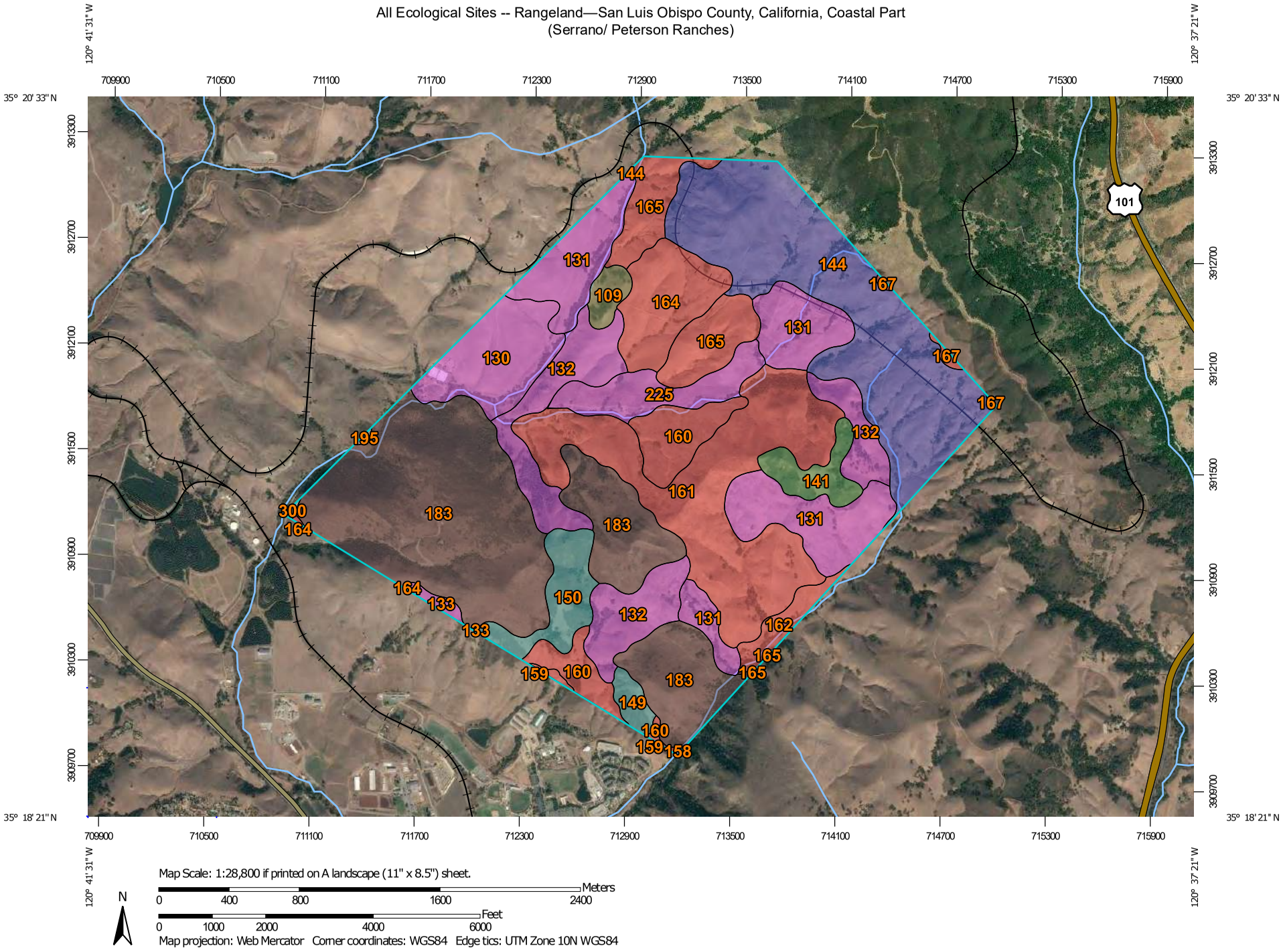
All Ecological Sites — Rangeland

Map unit symbol	Map unit name	Component name (percent)	Ecological site	Acres in AOI	Percent of AOI
121	Concepcion loam, 5 to 9 percent slopes	Concepcion (85%)	R014XD105CA — LOAMY CLAYPAN	14.2	4.4%
		Cropley, clay (3%)			
		Los Osos, loam (3%)			
		San Simeon, sandy loam (3%)			
		Tierra, loam (3%)			
123	Concepcion loam, 15 to 30 percent slopes	Concepcion (85%)	R014XD105CA — LOAMY CLAYPAN	21.9	6.8%
		Diablo, clay (3%)			
		Millsap, loam (3%)			
		San Simeon, sandy loam (3%)			
129	Diablo clay, 5 to 9 percent slopes, MLRA 15	Diablo (90%)	R015XD001CA — CLAYEY	11.2	3.5%
		Aridic Haploxererts, moderately deep (5%)			
		Cropley (5%)			
130	Diablo and Cibo clays, 9 to 15 percent slopes	Cibo (45%)	R015XD001CA — CLAYEY	2.9	0.9%
		Diablo (45%)	R015XD001CA — CLAYEY		
		Zaca, clay (3%)			
133	Diablo-Lodo complex, 15 to 50 percent slopes	Diablo (45%)	R015XD001CA — CLAYEY	24.7	7.7%
		Lodo (35%)	R015XD070CA — SHALLOW FINE LOAMY		
		Cibo, clay (3%)			
		Lopez, very shaly clay loam (3%)			
		Los Osos, loam (3%)			
		Millsap, loam (3%)			
		Obispo, clay (3%)			
		Rock outcrop (3%)			
		Unnamed (2%)			

Map unit symbol	Map unit name	Component name (percent)	Ecological site	Acres in AOI	Percent of AOI
147	Lodo clay loam, 5 to 15 percent slopes	Lodo (85%)	R015XD070CA — SHALLOW FINE LOAMY	27.7	8.6%
		Cibo, clay (3%)			
		Diablo, clay (3%)			
		Gazos, clay loam (3%)			
		Los Osos, loam (3%)			
148	Lodo clay loam, 15 to 30 percent slopes	Lodo (85%)	R015XD070CA — SHALLOW FINE LOAMY	97.9	30.4%
		Cibo, clay (3%)			
		Diablo, clay (3%)			
		Gazos, clay loam (3%)			
		Los Osos, loam (3%)			
160	Los Osos loam, 15 to 30 percent slopes	Los Osos (85%)	R015XD049CA — LOAMY CLAYPAN	44.1	13.7%
		Cibo (2%)			
		Diablo (2%)			
		Gazos (2%)			
		Lodo (2%)			
		Lompico (2%)			
		McMullin (2%)			
		Millsap (2%)			
		Rock outcrop (1%)			
162	Los Osos-Diablo complex, 5 to 9 percent slopes	Los Osos (35%)	R015XD049CA — LOAMY CLAYPAN	14.6	4.5%
		Diablo (30%)	R015XD001CA — CLAYEY		
		Cibo, clay (9%)			
		Lodo, clay loam (9%)			
		Millsap, loam (9%)			
		Unnamed (8%)			
163	Los Osos-Diablo complex, 9 to 15 percent slopes	Los Osos (35%)	R015XD049CA — LOAMY CLAYPAN	27.9	8.7%
		Diablo (30%)	R015XD001CA — CLAYEY		

Map unit symbol	Map unit name	Component name (percent)	Ecological site	Acres in AOI	Percent of AOI
		Cibo, clay (9%)			
		Lodo, clay loam (9%)			
		Millsap, loam (9%)			
		Unnamed (8%)			
197	Salinas silty clay loam, 0 to 2 percent slopes, MLRA 14	Salinas (85%)	R014XD109CA — FINE LOAMY BOTTOM	18.6	5.8%
		Agueda (3%)			
		Pachic Haploxerolls, gravelly (3%)			
		Pachic Haploxerolls, deep to sand (3%)			
		Mocho (2%)			
		Camarillo, loam (1%)			
		Cropley, clay (1%)			
		Marimel, silty clay loam (1%)			
		Pachic Haploxerolls, deep to clay (1%)			
300	Corducci and Typic Xerofluvents, 0 to 5 percent slopes, occasionally flooded, MLRA 14	Corducci (50%)		16.5	5.1%
		Typic Xerofluvents (30%)			
		Metz, very rarely flooded (5%)			
		Tujunga, very rarely flooded (5%)			
		Xerofluvents, frequently flooded (5%)			
		Xeropsamments, frequently flooded (5%)			
Totals for Area of Interest				**322.1**	**100.0%**

All Ecological Sites -- Rangeland—San Luis Obispo County, California, Coastal Part
(Serrano/ Peterson Ranches)



MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Rating Polygons

- R015XD001CA
- R015XD024CA
- R015XD049CA
- R015XD055CA
- R015XD070CA
- R015XD117CA
- R015XD146CA
- Not rated or not available

Soil Rating Lines

- R015XD001CA
- R015XD024CA
- R015XD049CA
- R015XD055CA
- R015XD070CA
- R015XD117CA
- R015XD146CA
- Not rated or not available

Soil Rating Points

- R015XD001CA
- R015XD024CA
- R015XD049CA
- R015XD055CA
- R015XD070CA
- R015XD117CA
- R015XD146CA
- Not rated or not available

Water Features

- Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background

- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: San Luis Obispo County, California, Coastal Part
Survey Area Data: Version 12, Sep 16, 2019

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Dec 31, 2009—Nov 18, 2018

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

All Ecological Sites — Rangeland

Map unit symbol	Map unit name	Component name (percent)	Ecological site	Acres in AOI	Percent of AOI
109	Briones-Pismo loamy sands, 9 to 30 percent slopes	Briones (40%)	R015XD055CA — SANDY	15.2	0.8%
		Pismo (30%)	R015XD076CA — SHALLOW SANDY		
		Arnold, loamy sand (10%)			
		Briones, sandy loam (10%)			
		Pismo, sandy loam (10%)			
130	Diablo and Cibo clays, 9 to 15 percent slopes	Cibo (45%)	R015XD001CA — CLAYEY	83.3	4.5%
		Diablo (45%)	R015XD001CA — CLAYEY		
		Zaca, clay (3%)			
131	Diablo and Cibo clays, 15 to 30 percent slopes	Cibo (45%)	R015XD001CA — CLAYEY	201.1	10.8%
		Diablo (45%)	R015XD001CA — CLAYEY		
		Lodo, clay loam (2%)			
		Los Osos, loam (2%)			
		Rock outcrop (2%)			
		Zaca, clay (2%)			
132	Diablo and Cibo clays, 30 to 50 percent slopes	Cibo (45%)	R015XD001CA — CLAYEY	151.4	8.2%
		Diablo (45%)	R015XD001CA — CLAYEY		
		Lodo, clay loam (3%)			
		Los Osos, loam (3%)			
		Rock outcrop (3%)			
133	Diablo-Lodo complex, 15 to 50 percent slopes	Diablo (45%)	R015XD001CA — CLAYEY	5.8	0.3%
		Lodo (35%)	R015XD070CA — SHALLOW FINE LOAMY		
		Cibo, clay (3%)			

Map unit symbol	Map unit name	Component name (percent)	Ecological site	Acres in AOI	Percent of AOI
		Lopez, very shaly clay loam (3%)			
		Los Osos, loam (3%)			
		Millsap, loam (3%)			
		Obispo, clay (3%)			
		Rock outcrop (3%)			
		Unnamed (2%)			
141	Gaviota sandy loam, 50 to 75 percent slopes, MLRA 15	Gaviota (80%)	R015XD117CA — SHALLOW COARSE LOAMY	31.3	1.7%
			R015XD118CA — STEEP SHALLOW COARSE LOAMY		
		Lopez (10%)			
		Pismo (5%)			
		Rock outcrop (5%)			
144	Gazos-Lodo clay loams, 30 to 50 percent slopes	Gazos (45%)	R015XD024CA — FINE LOAMY	304.2	16.4%
		Lodo (40%)	R015XD070CA — SHALLOW FINE LOAMY		
		Cibo, clay (4%)			
		Diablo, clay (4%)			
		Los Osos, loam (3%)			
		Unnamed (3%)			
149	Lodo clay loam, 30 to 50 percent slopes, MLRA 15	Lodo (85%)	R015XD070CA — SHALLOW FINE LOAMY	13.3	0.7%
		Diablo (4%)			
		Gazos (4%)			
		Los Osos (4%)			
		Cibo (3%)			
150	Lodo clay loam, 50 to 75 percent slopes, MLRA 15	Lodo (85%)	R015XD070CA — SHALLOW FINE LOAMY	48.4	2.6%
			R015XD120CA — VERY STEEP SHALLOW FINE LOAMY		
		Diablo (4%)			
		Gazos (4%)			
		Los Osos (4%)			

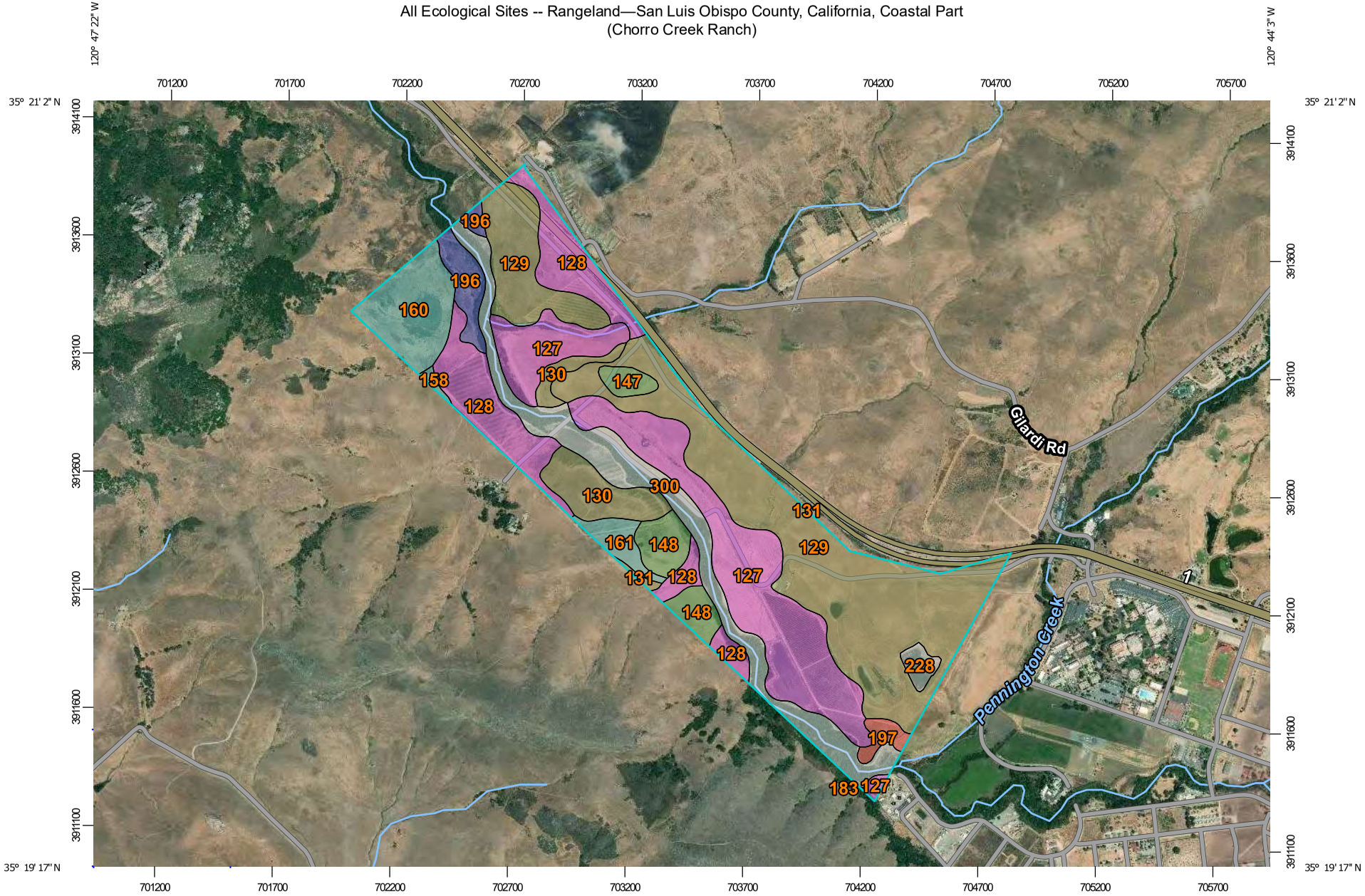
Map unit symbol	Map unit name	Component name (percent)	Ecological site	Acres in AOI	Percent of AOI
		Cibo (3%)			
158	Los Osos loam, 5 to 9 percent slopes	Los Osos (85%)	R015XD049CA — LOAMY CLAYPAN	0.3	0.0%
		Cibo, clay (2%)			
		Diablo, clay (2%)			
		Gazos, clay loam (2%)			
		Lodo, clay loam (2%)			
		Millsap, loam (2%)			
		Rock outcrop (2%)			
		Unnamed (2%)			
159	Los Osos loam, 9 to 15 percent slopes	Los Osos (85%)	R015XD049CA — LOAMY CLAYPAN	2.8	0.2%
		Cibo, clay (3%)			
		Diablo, clay (3%)			
		Gazos, clay loam (3%)			
		Lodo, clay loam (2%)			
		Millsap, loam (2%)			
		Rock outcrop (2%)			
160	Los Osos loam, 15 to 30 percent slopes	Los Osos (85%)	R015XD049CA — LOAMY CLAYPAN	68.0	3.7%
		Cibo (2%)			
		Diablo (2%)			
		Gazos (2%)			
		Lodo (2%)			
		Lompico (2%)			
		McMullin (2%)			
		Millsap (2%)			
		Rock outcrop (1%)			
161	Los Osos loam, 30 to 50 percent slopes	Los Osos (85%)	R015XD049CA — LOAMY CLAYPAN	249.8	13.5%
		Rock outcrop (3%)			
		Cibo (2%)			
		Diablo (2%)			
		Gazos (2%)			

Map unit symbol	Map unit name	Component name (percent)	Ecological site	Acres in AOI	Percent of AOI
		Lodo (2%)			
		Lompico (2%)			
		McMullin (2%)			
162	Los Osos-Diablo complex, 5 to 9 percent slopes	Los Osos (35%)	R015XD049CA — LOAMY CLAYPAN	21.1	1.1%
		Diablo (30%)	R015XD001CA — CLAYEY		
		Cibo, clay (9%)			
		Lodo, clay loam (9%)			
		Millsap, loam (9%)			
		Unnamed (8%)			
164	Los Osos-Diablo complex, 15 to 30 percent slopes	Los Osos (35%)	R015XD049CA — LOAMY CLAYPAN	72.3	3.9%
		Diablo (30%)	R015XD001CA — CLAYEY		
		Cibo, clay (5%)			
		Gazos, clay loam (5%)			
		Lodo, clay loam (5%)			
		Lompico, loam (5%)			
		McMullin, loam (5%)			
		Rock outcrop (5%)			
		Unnamed (5%)			
165	Los Osos-Diablo complex, 30 to 50 percent slopes	Los Osos (40%)	R015XD049CA — LOAMY CLAYPAN	81.4	4.4%
		Diablo (35%)	R015XD001CA — CLAYEY		
		Cibo, clay (3%)			
		Gaviota, sandy loam (3%)			
		Gazos, clay loam (3%)			
		Lompico (3%)			
		McMullin (3%)			
		Obispo, clay (3%)			
		Rock outcrop (3%)			
		Unnamed (3%)			

Map unit symbol	Map unit name	Component name (percent)	Ecological site	Acres in AOI	Percent of AOI
167	Los Osos-Lodo complex, 30 to 75 percent slopes	Los Osos (50%)	R015XD049CA — LOAMY CLAYPAN	3.9	0.2%
		Lodo (30%)	R015XD070CA — SHALLOW FINE LOAMY		
		Cibo, clay (2%)			
		Creneba, loam (2%)			
		Diablo, clay (2%)			
		Gazos, clay loam (2%)			
		Lompico (2%)			
		McMullin (2%)			
		Millsap, loam (2%)			
		Rock outcrop (2%)			
		Unnamed (2%)			
		Unnamed (2%)			
183	Obispo-Rock outcrop complex, 15 to 75 percent slopes	Obispo (50%)	R015XD146CA — SHALLOW CLAYEY SERPENTINE	444.9	24.0%
		Rock outcrop (30%)			
		Diablo, clay (7%)			
		Henneke, clay loam (7%)			
		Unnamed (6%)			
195	Rock outcrop-Lithic Haploxerolls complex, 30 to 75 percent slopes	Rock outcrop (55%)		0.8	0.0%
		Lithic Haploxerolls (25%)			
		Arnold (4%)			
		Briones (4%)			
		Diablo (4%)			
		Gaviota (4%)			
		Gazos (4%)			
225	Zaca clay, 15 to 30 percent slopes	Zaca (85%)	R015XD001CA — CLAYEY	54.5	2.9%
		Diablo, clay (3%)			
		Nacimiento, silty clay loam (3%)			
		Unnamed (3%)			
		Unnamed (3%)			
300	Corducci and Typic Xerofluvents, 0 to	Corducci (50%)		0.9	0.0%

Map unit symbol	Map unit name	Component name (percent)	Ecological site	Acres in AOI	Percent of AOI
	5 percent slopes, occasionally flooded, MLRA 14	Typic Xerofluvents (30%)			
		Metz, very rarely flooded (5%)			
		Tujunga, very rarely flooded (5%)			
		Xerofluvents, frequently flooded (5%)			
		Xeropsamments, frequently flooded (5%)			
Totals for Area of Interest				**1,854.7**	**100.0%**

All Ecological Sites -- Rangeland—San Luis Obispo County, California, Coastal Part
(Chorro Creek Ranch)



Map Scale: 1:22,900 if printed on A landscape (11" x 8.5") sheet.

N

Meters
0 300 600 1200 1800

Feet
0 1000 2000 4000 6000

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 10N WGS84

MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Rating Polygons

- R014XD001CA
- R014XD108CA
- R014XD109CA
- R015XD001CA
- R015XD049CA
- R015XD070CA
- R015XD146CA
- Not rated or not available

Soil Rating Lines

- R014XD001CA
- R014XD108CA
- R014XD109CA
- R015XD001CA
- R015XD049CA
- R015XD070CA
- R015XD146CA
- Not rated or not available

Soil Rating Points

- R014XD001CA
- R014XD108CA
- R014XD109CA
- R015XD001CA
- R015XD049CA
- R015XD070CA
- R015XD146CA
- Not rated or not available

Water Features

- Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background

- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: San Luis Obispo County, California, Coastal Part
Survey Area Data: Version 12, Sep 16, 2019

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Dec 31, 2009—Sep 30, 2017

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

All Ecological Sites — Rangeland

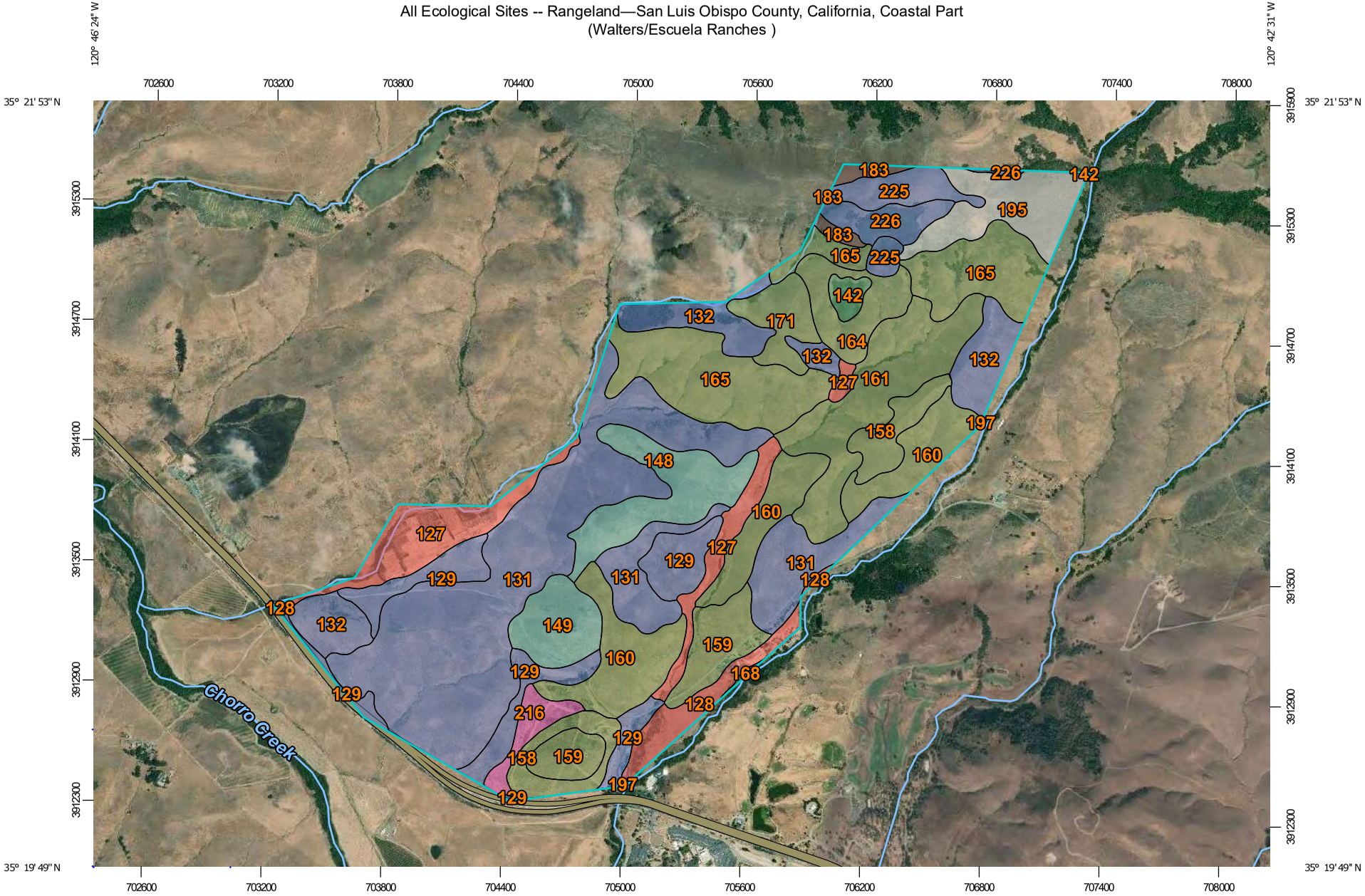
Map unit symbol	Map unit name	Component name (percent)	Ecological site	Acres in AOI	Percent of AOI
127	Cropley clay, 0 to 2 percent slopes, MLRA 14	Cropley (85%)	R014XD001CA — CLAYEY	120.5	20.9%
		Clear Lake (4%)			
		Concepcion (3%)			
		Diablo (3%)			
		Salinas (3%)			
		Sorrento (2%)			
128	Cropley clay, 2 to 9 percent slopes, MLRA 14	Cropley (90%)	R014XD001CA — CLAYEY	67.8	11.7%
		Los Osos (3%)			
		Salinas (3%)			
		Capay (2%)			
		Clear Lake (2%)			
129	Diablo clay, 5 to 9 percent slopes, MLRA 15	Diablo (90%)	R015XD001CA — CLAYEY	195.9	33.9%
		Aridic Haploxererts, moderately deep (5%)			
		Cropley (5%)			
130	Diablo and Cibo clays, 9 to 15 percent slopes	Cibo (45%)	R015XD001CA — CLAYEY	28.6	5.0%
		Diablo (45%)	R015XD001CA — CLAYEY		
		Zaca, clay (3%)			
131	Diablo and Cibo clays, 15 to 30 percent slopes	Cibo (45%)	R015XD001CA — CLAYEY	1.2	0.2%
		Diablo (45%)	R015XD001CA — CLAYEY		
		Lodo, clay loam (2%)			
		Los Osos, loam (2%)			
		Rock outcrop (2%)			
		Zaca, clay (2%)			
147	Lodo clay loam, 5 to 15 percent slopes	Lodo (85%)	R015XD070CA — SHALLOW FINE LOAMY	6.0	1.0%
		Cibo, clay (3%)			
		Diablo, clay (3%)			

Map unit symbol	Map unit name	Component name (percent)	Ecological site	Acres in AOI	Percent of AOI
		Gazos, clay loam (3%)			
		Los Osos, loam (3%)			
148	Lodo clay loam, 15 to 30 percent slopes	Lodo (85%)	R015XD070CA — SHALLOW FINE LOAMY	20.0	3.5%
		Cibo, clay (3%)			
		Diablo, clay (3%)			
		Gazos, clay loam (3%)			
		Los Osos, loam (3%)			
158	Los Osos loam, 5 to 9 percent slopes	Los Osos (85%)	R015XD049CA — LOAMY CLAYPAN	1.3	0.2%
		Cibo, clay (2%)			
		Diablo, clay (2%)			
		Gazos, clay loam (2%)			
		Lodo, clay loam (2%)			
		Millsap, loam (2%)			
		Rock outcrop (2%)			
		Unnamed (2%)			
160	Los Osos loam, 15 to 30 percent slopes	Los Osos (85%)	R015XD049CA — LOAMY CLAYPAN	33.9	5.9%
		Cibo (2%)			
		Diablo (2%)			
		Gazos (2%)			
		Lodo (2%)			
		Lompico (2%)			
		McMullin (2%)			
		Millsap (2%)			
		Rock outcrop (1%)			
161	Los Osos loam, 30 to 50 percent slopes	Los Osos (85%)	R015XD049CA — LOAMY CLAYPAN	9.4	1.6%
		Rock outcrop (3%)			
		Cibo (2%)			
		Diablo (2%)			
		Gazos (2%)			

Map unit symbol	Map unit name	Component name (percent)	Ecological site	Acres in AOI	Percent of AOI
		Lodo (2%)			
		Lompico (2%)			
		McMullin (2%)			
183	Obispo-Rock outcrop complex, 15 to 75 percent slopes	Obispo (50%)	R015XD146CA — SHALLOW CLAYEY SERPENTINE	0.0	0.0%
		Rock outcrop (30%)			
		Diablo, clay (7%)			
		Henneke, clay loam (7%)			
		Unnamed (6%)			
196	Salinas loam, 0 to 2 percent slopes, MLRA 14	Salinas (85%)	R014XD108CA — LOAMY BOTTOM	14.9	2.6%
		Camarillo, drained (3%)			
		Marimel, silty clay loam (3%)			
		Salinas, clay (3%)			
		Cropley (2%)			
		Mocho, silty clay loam (2%)			
		Pico (2%)			
197	Salinas silty clay loam, 0 to 2 percent slopes, MLRA 14	Salinas (85%)	R014XD109CA — FINE LOAMY BOTTOM	5.4	0.9%
		Agueda (3%)			
		Pachic Haploxerolls, gravelly (3%)			
		Pachic Haploxerolls, deep to sand (3%)			
		Mocho (2%)			
		Camarillo, loam (1%)			
		Cropley, clay (1%)			
		Marimel, silty clay loam (1%)			
		Pachic Haploxerolls, deep to clay (1%)			
228	Water	Water (100%)		4.9	0.9%
300	Corducci and Typic Xerofluvents, 0 to	Corducci (50%)		67.3	11.7%

Map unit symbol	Map unit name	Component name (percent)	Ecological site	Acres in AOI	Percent of AOI
	5 percent slopes, occasionally flooded, MLRA 14	Typic Xerofluvents (30%)			
		Metz, very rarely flooded (5%)			
		Tujunga, very rarely flooded (5%)			
		Xerofluvents, frequently flooded (5%)			
		Xeropsamments, frequently flooded (5%)			
Totals for Area of Interest				**577.2**	**100.0%**

All Ecological Sites -- Rangeland—San Luis Obispo County, California, Coastal Part
(Walters/Escuela Ranches)



MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Rating Polygons

- R014XD001CA
- R014XD109CA
- R015XD001CA
- R015XD013CA
- R015XD024CA
- R015XD049CA
- R015XD070CA
- R015XD117CA
- R015XD146CA
- Not rated or not available

Soil Rating Lines

- R014XD001CA
- R014XD109CA
- R015XD001CA
- R015XD013CA
- R015XD024CA
- R015XD049CA
- R015XD070CA
- R015XD117CA
- R015XD146CA
- Not rated or not available

Soil Rating Points

- R014XD001CA
- R014XD109CA
- R015XD001CA
- R015XD013CA
- R015XD024CA
- R015XD049CA
- R015XD070CA
- R015XD117CA
- R015XD146CA
- Not rated or not available

Water Features

Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background

Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: San Luis Obispo County, California, Coastal Part
Survey Area Data: Version 12, Sep 16, 2019

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Dec 31, 2009—Nov 18, 2018

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

All Ecological Sites — Rangeland

Map unit symbol	Map unit name	Component name (percent)	Ecological site	Acres in AOI	Percent of AOI
127	Cropley clay, 0 to 2 percent slopes, MLRA 14	Cropley (85%)	R014XD001CA — CLAYEY	80.4	5.6%
		Clear Lake (4%)			
		Concepcion (3%)			
		Diablo (3%)			
		Salinas (3%)			
		Sorrento (2%)			
128	Cropley clay, 2 to 9 percent slopes, MLRA 14	Cropley (90%)	R014XD001CA — CLAYEY	30.5	2.1%
		Los Osos (3%)			
		Salinas (3%)			
		Capay (2%)			
		Clear Lake (2%)			
129	Diablo clay, 5 to 9 percent slopes, MLRA 15	Diablo (90%)	R015XD001CA — CLAYEY	90.0	6.2%
		Aridic Haploxererts, moderately deep (5%)			
		Cropley (5%)			
131	Diablo and Cibo clays, 15 to 30 percent slopes	Cibo (45%)	R015XD001CA — CLAYEY	352.9	24.5%
		Diablo (45%)	R015XD001CA — CLAYEY		
		Lodo, clay loam (2%)			
		Los Osos, loam (2%)			
		Rock outcrop (2%)			
		Zaca, clay (2%)			
132	Diablo and Cibo clays, 30 to 50 percent slopes	Cibo (45%)	R015XD001CA — CLAYEY	89.1	6.2%
		Diablo (45%)	R015XD001CA — CLAYEY		
		Lodo, clay loam (3%)			
		Los Osos, loam (3%)			
		Rock outcrop (3%)			

Map unit symbol	Map unit name	Component name (percent)	Ecological site	Acres in AOI	Percent of AOI
142	Gaviota fine sandy loam, 15 to 50 percent slopes	Gaviota (85%)	R015XD117CA — SHALLOW COARSE LOAMY	8.6	0.6%
		Briones, loamy sand (3%)			
		Pismo, loamy sand (3%)			
		Unnamed (3%)			
148	Lodo clay loam, 15 to 30 percent slopes	Lodo (85%)	R015XD070CA — SHALLOW FINE LOAMY	65.0	4.5%
		Cibo, clay (3%)			
		Diablo, clay (3%)			
		Gazos, clay loam (3%)			
		Los Osos, loam (3%)			
149	Lodo clay loam, 30 to 50 percent slopes, MLRA 15	Lodo (85%)	R015XD070CA — SHALLOW FINE LOAMY	38.2	2.6%
		Diablo (4%)			
		Gazos (4%)			
		Los Osos (4%)			
		Cibo (3%)			
158	Los Osos loam, 5 to 9 percent slopes	Los Osos (85%)	R015XD049CA — LOAMY CLAYPAN	48.2	3.3%
		Cibo, clay (2%)			
		Diablo, clay (2%)			
		Gazos, clay loam (2%)			
		Lodo, clay loam (2%)			
		Millsap, loam (2%)			
		Rock outcrop (2%)			
		Unnamed (2%)			
159	Los Osos loam, 9 to 15 percent slopes	Los Osos (85%)	R015XD049CA — LOAMY CLAYPAN	52.5	3.6%
		Cibo, clay (3%)			
		Diablo, clay (3%)			
		Gazos, clay loam (3%)			
		Lodo, clay loam (2%)			

Map unit symbol	Map unit name	Component name (percent)	Ecological site	Acres in AOI	Percent of AOI
		Millsap, loam (2%)			
		Rock outcrop (2%)			
160	Los Osos loam, 15 to 30 percent slopes	Los Osos (85%)	R015XD049CA — LOAMY CLAYPAN	126.8	8.8%
		Cibo (2%)			
		Diablo (2%)			
		Gazos (2%)			
		Lodo (2%)			
		Lompico (2%)			
		McMullin (2%)			
		Millsap (2%)			
		Rock outcrop (1%)			
161	Los Osos loam, 30 to 50 percent slopes	Los Osos (85%)	R015XD049CA — LOAMY CLAYPAN	97.6	6.8%
		Rock outcrop (3%)			
		Cibo (2%)			
		Diablo (2%)			
		Gazos (2%)			
		Lodo (2%)			
		Lompico (2%)			
		McMullin (2%)			
164	Los Osos-Diablo complex, 15 to 30 percent slopes	Los Osos (35%)	R015XD049CA — LOAMY CLAYPAN	37.4	2.6%
		Diablo (30%)	R015XD001CA — CLAYEY		
		Cibo, clay (5%)			
		Gazos, clay loam (5%)			
		Lodo, clay loam (5%)			
		Lompico, loam (5%)			
		McMullin, loam (5%)			
		Rock outcrop (5%)			
		Unnamed (5%)			
165	Los Osos-Diablo complex, 30 to 50 percent slopes	Los Osos (40%)	R015XD049CA — LOAMY CLAYPAN	156.3	10.8%
		Diablo (35%)	R015XD001CA — CLAYEY		

Map unit symbol	Map unit name	Component name (percent)	Ecological site	Acres in AOI	Percent of AOI
		Cibo, clay (3%)			
		Gaviota, sandy loam (3%)			
		Gazos, clay loam (3%)			
		Lompico (3%)			
		McMullin (3%)			
		Obispo, clay (3%)			
		Rock outcrop (3%)			
		Unnamed (3%)			
168	Los Osos variant clay loam, 15 to 50 percent slopes	Los Osos variant (85%)	R015XD024CA — FINE LOAMY	1.1	0.1%
		Calodo, loam (3%)			
		Diablo, clay (3%)			
		Los Osos, clay loam (3%)			
		Millsap, loam (2%)			
		Nacimiento, silty clay loam (2%)			
		Rock outcrop (2%)			
171	Millsap loam, 15 to 50 percent slopes	Millsap (85%)	R015XD049CA — LOAMY CLAYPAN	29.2	2.0%
		Creneba, loam (3%)			
		Diablo, clay (2%)			
		Gazos, clay loam (2%)			
		Lodo, clay loam (2%)			
		Los Osos, loam (2%)			
		Unnamed (2%)			
		Unnamed (2%)			
183	Obispo-Rock outcrop complex, 15 to 75 percent slopes	Obispo (50%)	R015XD146CA — SHALLOW CLAYEY SERPENTINE	9.4	0.7%
		Rock outcrop (30%)			
		Diablo, clay (7%)			
		Henneke, clay loam (7%)			
		Unnamed (6%)			
195	Rock outcrop-Lithic Haploxerolls	Rock outcrop (55%)		56.1	3.9%

Map unit symbol	Map unit name	Component name (percent)	Ecological site	Acres in AOI	Percent of AOI
	complex, 30 to 75 percent slopes	Lithic Haploxerolls (25%)			
		Arnold (4%)			
		Briones (4%)			
		Diablo (4%)			
		Gaviota (4%)			
		Gazos (4%)			
197	Salinas silty clay loam, 0 to 2 percent slopes, MLRA 14	Salinas (85%)	R014XD109CA — FINE LOAMY BOTTOM	0.1	0.0%
		Agueda (3%)			
		Pachic Haploxerolls, gravelly (3%)			
		Pachic Haploxerolls, deep to sand (3%)			
		Mocho (2%)			
		Camarillo, loam (1%)			
		Cropley, clay (1%)			
		Marimel, silty clay loam (1%)			
		Pachic Haploxerolls, deep to clay (1%)			
216	Tierra sandy loam, 2 to 9 percent slopes, MLRA 14	Tierra (85%)	R015XD013CA — COARSE LOAMY CLAYPAN	17.0	1.2%
			R015XD115CA — CLAYPAN		
		Chamise (4%)			
		Concepcion (4%)			
		Diablo (4%)			
		Briones (3%)			
225	Zaca clay, 15 to 30 percent slopes	Zaca (85%)	R015XD001CA — CLAYEY	30.9	2.1%
		Diablo, clay (3%)			
		Nacimiento, silty clay loam (3%)			
		Unnamed (3%)			
		Unnamed (3%)			
226	Zaca clay, 30 to 50 percent slopes	Zaca (85%)	R015XD001CA — CLAYEY	24.6	1.7%

Map unit symbol	Map unit name	Component name (percent)	Ecological site	Acres in AOI	Percent of AOI
		Diablo, clay (3%)			
		Nacimiento, silty clay loam (3%)			
		Unnamed (3%)			
Totals for Area of Interest				**1,441.8**	**100.0%**

Ranch	**Cal Poly**	**Total ADAs this season**	62.99
Total acres	5,993	**Total ADs this season**	377,453.46
Total animals	872	**Total AUMs this season**	12,581.78
Total liveweight	677,047	**Total hay added this se**	0
Season start date	09/12/2017	**Standard animal weigh**	1,000
Season end date		**Standard animal DMI (l**	30
Total forage grazed this season (lbs)	11,323,604		

Ranch	Pasture name	Area (acs)	Perimeter (ft)	ADAs this season	ADs this season	AUMs this season	Forage grazed this season (lbs)	Recovery days
Cheda Ranch	C55	4	1,655	11	40	1	1,213	554
Cheda Ranch	C57	1	1,041	66	95	3	2,862	104
Chorro Creek Ranch	BEEHIVE FIELD	14	3,827	244	3,438	115	103,151	13
Chorro Creek ranch	CC-2	32	5,133	33	1,032	34	30,971	273
Chorro Creek Ranch	HIGHWAY FIELD	26	4,614	256	6,552	218	196,551	20
Chorro Creek Ranch	POND FIELD	40	7,810	250	9,909	330	297,275	6
Chorro Creek Ranch	QUADRANT FIELD	32	5,438	423	13,617	454	408,506	72
Chorro Creek Ranch	ROAD FIELD	33	9,136	270	9,031	301	270,932	
Chorro Ranch	LAST FIELD	20	5,264	16	329	11	9,874	11
Chorro Ranch	TRIANGLE FIELD	13	3,875	148	1,883	63	56,499	19
Escuela Ranch	E6	192	12,847	35	6,721	224	201,643	162
Escuela Ranch	E9	66	8,048	41	2,718	91	81,554	28
Escuela Ranch	E9 CALVING	227	13,521	126	28,600	953	858,004	24
Escuela Ranch	ECER	189	12,190	4	820	27	24,588	404
Escuela Ranch	EL1	22	5,095	82	1,809	60	54,256	99
Escuela Ranch	EL3	48	6,264	114	5,437	181	163,110	
Escuela Ranch	EL4	24	4,619	116	2,827	94	84,825	37
Escuela Ranch	EL5	50	6,937	107	5,384	179	161,508	42
Escuela Ranch	EL7	69	9,779	54	3,734	124	112,034	187
Escuela Ranch	EL8	70	7,542	78	5,482	183	164,468	22
Escuela Ranch	ER1	24	4,112	92	2,177	73	65,298	38
Escuela Ranch	ER2	61	6,497	67	4,145	138	124,356	40
Escuela Ranch	ER3	30	4,691	100	2,998	100	89,950	51
Escuela Ranch	ER4	38	5,616	102	3,906	130	117,182	36
Escuela Ranch	ER5	65	7,512	62	3,985	133	119,556	45
Escuela Ranch	ER7	67	10,317	51	3,422	114	102,672	50
Escuela Ranch	EU5	78	10,916	72	5,628	188	168,839	47
Escuela Ranch	EU7	121	10,565	49	5,893	196	176,782	33
Escuela Ranch	EU8	145	10,553	53	7,648	255	229,441	30
Escuela Ranch	Escuela Corrals	0	414	262	64	2	1,926	158
Escuela Ranch	FW1	22	4,528	134	2,973	99	89,205	61
Escuela Ranch	FW2	34	5,399	78	2,650	88	79,508	108
Escuela Ranch	FW3	32	5,455	120	3,891	130	116,731	4
Escuela Ranch	FW4	9	6,347	33	302	10	9,070	112
Escuela Ranch	FW5	23	4,042	109	2,510	84	75,293	10
Escuela Ranch	FW6	47	6,720	85	3,947	132	118,401	8
Escuela Ranch	ROAD	46	10,345	162	7,504	250	225,112	12
Escuela Ranch	WEST FIELD	21	4,224	275	5,886	196	176,586	15
Peterson Ranch	P1	109	8,653	5	522	17	15,669	339
Peterson Ranch	P3	61	6,579	77	4,654	155	139,623	25
Peterson Ranch	P4	55	6,939	71	3,948	132	118,441	32
Peterson Ranch	P5	63	8,962	65	4,068	136	122,034	37
Peterson Ranch	P6	130	9,976	38	4,915	164	147,452	48
Serrano Ranch	S1	8	3,226	204	1,572	52	47,155	70
Serrano Ranch	S11	14	6,278	33	467	16	13,998	308
Serrano Ranch	S12	9	2,772	32	272	9	8,149	70
Serrano Ranch	S13	74	7,183	69	5,156	172	154,678	18

Ranch	Pasture name	Area (acs)	Perimeter (ft)	ADAs this season	ADs this season	AUMs this season	Forage grazed this season (lbs)	Recovery days
Serrano Ranch	S15	141	11,506	36	5,062	169	151,848	237
Serrano Ranch	S2	17	3,735	113	1,961	65	58,836	12
Serrano Ranch	S3	51	6,094	92	4,635	154	139,044	22
Serrano Ranch	S4	67	7,131	74	4,967	166	148,999	
Serrano Ranch	S5	20	4,187	111	2,254	75	67,618	4
Serrano Ranch	S6	14	3,706	184	2,565	85	76,936	8
Serrano Ranch	S7	18	4,284	151	2,727	91	81,821	10
Serrano Ranch	S8	18	4,272	131	2,373	79	71,184	14
Serrano Ranch	S9	12	3,609	59	699	23	20,984	16
Walters Ranch	BW1	35	6,198	136	4,705	157	141,157	15
Walters Ranch	BW2	25	4,572	135	3,410	114	102,313	74
Walters Ranch	BW3	44	5,608	88	3,900	130	116,986	19
Walters Ranch	BW4A	6	2,675	73	443	15	13,280	130
Walters Ranch	BW4B	4	1,895	62	262	9	7,866	502
Walters Ranch	BW4C	13	4,197	133	1,667	56	50,024	17
Walters Ranch	BW5	41	5,565	106	4,372	146	131,149	21
Walters Ranch	W1	90	9,027	70	6,301	210	189,038	2
Walters Ranch	W4	58	7,020	67	3,874	129	116,205	1
Walters Ranch	W5	39	6,022	84	3,246	108	97,372	120
Walters Ranch	W6	34	9,196	80	2,707	90	81,200	57
Walters Ranch	W7	40	7,089	70	2,760	92	82,801	56
Walters Ranch	W8	31	5,181	100	3,077	103	92,312	55
Walters Ranch	W9	19	4,529	43	806	27	24,168	176