CARBON FARM PLAN
Cal Poly Swanton Pacific Ranch
November, 2019

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SPONSORS

We would like to express our gratitude to the Clif Bar Family Foundation for their generous financial support of this Carbon Farm Plan. Many thanks also go to the staff at Swanton Pacific Ranch, and Grey Hayes in particular, for their assistance and to Cal Poly’s Center for Sustainability in the College of Agriculture, Food and Environmental Sciences for initiation and facilitation of the overall project.
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INTRODUCTION

Long taken for granted, carbon has largely been absent from discussion of elements essential to agriculture; yet it is the basis for all agricultural production. Carbon enters the farm system from the atmosphere, through the capture of carbon dioxide from the air by growing plants, which combine it with water and nutrients from the soil to create the products of agriculture. While plants produce food, fiber, fuel and flora, photosynthates (sugars) are also produced by the crop and moved directly to the soil: through plant roots, as exudates; indirectly through plant roots to beneficial soil mycorrhizal fungi; the sloughing of plant parts such as leaves and roots; and through deposition on the soil surface of above ground plant parts and manures. In addition to the transformation of carbon from the air into the harvestable crop, carbon can also be beneficially stored long-term (decades to centuries or more) in soil and woody vegetation through a process known as biological carbon sequestration. The importance of carbon to soil health and fertility has long been understood, and its significance has been increasingly recognized in recent years. Today, managing for increased soil organic matter, which is about 50% carbon, is at the core of the USDA-Natural Resources Conservation Service (NRCS) Soil Health Division and the California Department of Food and Agriculture’s Healthy Soils Program.

Increasing carbon capture on-farm has a host of agronomic and environmental benefits, including increasing soil water holding capacity and soil fertility, and the mitigation of rising levels of carbon dioxide (CO₂) and other greenhouse gases (GHG) in the atmosphere, currently contributing to climate destabilization through global warming. Carbon farming involves implementing on-farm practices that: 1) decrease the production of greenhouse gases on-farm, and/or, 2) increase the rate at which the farm supports photosynthetically-driven transfer of CO₂ from the atmosphere to plant productivity and/or soil organic matter. Enhancing agroecosystem carbon, whether in plants or soils, results in beneficial changes in a wide array of system attributes, including: soil water holding capacity and hydrological function, biodiversity, soil fertility, and resilience to drought and flood, along with increasing agricultural productivity.

The Carbon Farm Planning Process

Technically, all farming is “carbon farming,” because all agricultural production depends upon plant photosynthesis to move CO₂ out of the atmosphere and into the plant where it is transformed into agricultural products, whether food, flora, fuel or fiber. Carbon entering the farm from the atmosphere can end up in several locations: in the harvested portion of the crop, in the soil as root exudates and soil organic matter, in “waste” materials such as compost or manure, in standing carbon stocks, such as grassland vegetation or woody perennials (vines, orchards, etc.), or in other permanent woody or herbaceous vegetation such as windbreaks, vegetated filter strips, or riparian buffers, forests and woodlands.
While all farming is completely dependent upon atmospheric CO$_2$ in order to produce agricultural products, different farming practices, and different farm systems, can lead to very different amounts of on-farm carbon capture and storage. The carbon farm planning process differs from other approaches to agricultural planning by focusing on increasing the capacity of the farm or ranch to capture carbon and to store it beneficially – in the crop, as soil organic matter and/or as standing carbon stocks in permanent vegetation.

While agricultural practices often lead to a gradual loss of carbon from the farm system, particularly from soils, carbon farm planning is successful when it leads to a net increase in farm-system carbon. By increasing the amount of photosynthetically-captured carbon held, or “sequestered,” in long-term carbon pools on the farm or ranch (including soil organic matter, perennial plant roots and standing woody biomass) carbon farming results in a direct reduction in the amount of CO$_2$ in the atmosphere while supporting crop production and farm resilience to environmental stress, including flood and drought.

On-farm carbon in all its forms (soil organic matter, perennial and annual herbaceous vegetation, plant roots, root exudates and standing woody biomass) contains the solar energy used by the plant to synthesize carbohydrates from atmospheric CO$_2$ and water and nutrients from the soil. Plant and soil biomass can thus be best understood as embodied solar energy. As such, carbon provides the energy needed to drive on-farm processes, including the essential soil ecological processes that determine water and nutrient holding capacity and availability for the growing crop. Consequently, carbon farm planning 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.

Carbon farm planning is based upon the USDA Natural Resource Conservation Service (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, soil health and agricultural productivity.

Like NRCS Conservation Planning, carbon farm planning begins with an overall inventory of natural resource conditions on the farm or ranch, then proceeds to identification of 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; it should be as extensive as possible, including everything the farmer and planners can think of that could potentially reduce emissions and capture and sequester carbon on the farm. While actions proposed in the plan should reflect the inherent limits of the farm ecosystem, financial considerations should not limit this initial brainstorming process, as one goal of the carbon farm planning process is to identify potential funding, above and beyond existing resources, to realize implementation of the plan. Additionally, a carbon farm plan (CFP) is not static, and should evolve over time, as may ground conditions and management options.
During the planning process, maps of the ranch are developed, showing existing ranch infrastructure, farming operations/activities/crops, and natural resource conditions. These maps can be used to locate potential carbon capture practices on the ranch. Next, the carbon benefits of each practice are quantified using the on-line USDA greenhouse gas model, COMET-Farm (http://cometfarm.nrel.colostate.edu/), COMET-Planner, (http://comet-planner.com/), or similar tools and data sources to estimate metric tonnes (MT) of carbon dioxide equivalent (CO$_2$e) that would be 1) avoided or 2) removed from the atmosphere and sequestered on-farm by implementing each practice. A list of potential practices and their on-farm and climate mitigation benefits is then developed.

Finally, practices are prioritized based on needs and goals of the farm or ranch, choosing high carbon-benefit practices wherever possible. Economic considerations may be used to filter the comprehensive list of options, and funding mechanisms are identified, including: cap and trade, CEQA, or other GHG mitigation offset credits, USDA-NRCS and other state and federal programs, and private funding. Projects 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, using the fully implemented plan scenario as a goal. Where plan implementation is linked to carbon markets or other ecosystem service markets, periodic plan evaluation may be tied to those verification schedules.

Additional information about carbon farming can be found online at: www.marincarbonproject.org and www.carboncycle.org

Swanton Pacific Ranch Overview and Carbon Farm Plan Scope

Swanton Pacific Ranch (SPR) is located in the Santa Cruz Mountains, on the Central Coast of California on the northern flank of the Monterey Bay, 15 miles northwest of Santa Cruz and 70 miles south of San Francisco (Figure 1). The 3,200 acre property is a landscape composed of a majestic redwood forest, lush riverine ecosystems, diverse scrub and chaparral communities, and expansive coastal grasslands overlooking the bay and the Pacific Ocean. Recognized for its high biodiversity and abundant resources, this area provides a valuable opportunity to study the methods of resource conservation applied through sustainable management techniques.

The property is located in the 30-square mile Scotts Creek watershed, the majority of which is owned by four property owners (Cal Poly Corporation, Big Creek Lumber, Lockheed-Martin and the San Vicente Redwoods partnership). The Pacific Ocean and Hwy 1 form the western boundary, the Cotoni Coast Dairies property (federal land, held by the Bureau of Land Management) lies to the south, the Big Creek Lumber Company property is to the north and east, and the San Vicente Redwoods property (owned by the Peninsula Open Space Trust and Sempervirens Fund, with a conservation easement owned by the Save the Redwoods League) is to the east.

Swanton Pacific Ranch - Carbon Farm Plan
The following are general goals for each of the principal activities at SPR (from the SPR 2015 management plan)¹:

- **Education** - To expand the present educational facilities and curriculum so as to offer additional ‘learn by doing’ experiences including ‘learning by living’ at SPR.
- **Agriculture** - To foster healthy crop production with minimal cost and artificial inputs.
- **Forestry** - To develop and demonstrate uneven-aged forest management that protects ecosystem function, maintains biodiversity, and generates locally produced resources.
- **Grassland** - To improve the grassland and the water supply, resulting in a sustainable rangeland that supports biodiversity and protects the natural habitat for animals and plants.
- **Natural Habitat Management** - To protect and enhance the natural functions and diversity of the varied ranch ecosystems.

**This Carbon Farm Plan (CFP)** focuses on 75 acres that are organically farmed within the 3,200 acre ranch. Of the 75-acre focus area, 65 acres are leased to Jacobs Farm Del Cabo for production of culinary herbs, dry-farmed tomatoes and a variety of squashes; 4 acres at the northern end of the ranch are managed by SPR for apple and pumpkin production; and 6 acres are currently open for other crops or uses yet to be defined. This CFP focuses exclusively on the 75-acre cropland area of SPR following a request from Cal Poly staff. However, there are many additional opportunities for carbon farming within the entire property, which could be explored in a future broader scope. This CFP can be considered as a first step potentially leading to a broader and more impactful plan.

Figure 1. Swanton Pacific Ranch (SPR) location and Carbon Farm Plan (CFP) focus area
SWANTON PACIFIC RANCH HISTORY

The following two sections compile excerpts from Cal Poly Swanton Pacific Ranch’s website and the 2015 SPR Management Plan.

History of the Property

Swanton Pacific Ranch has had a rich historical background in the space of little more than a hundred years. During this time, it has passed from the stewardship of local indigenous tribes to large land grants interspersed with smallholdings. Nine hundred acres of the original Agua Puerca y Las Trancas land grant were re-purchased through the efforts of Al Smith to form what is Swanton Pacific Ranch, which has subsequently become the property of the Cal Poly Foundation. The three principal users of the area have been Native Americans (Costanoan linguistic family), Mexican land grant recipients and early settlers. Logging, settlement, crop production, floods and earthquake/landslide activity have been the principal impacts on the recent regional history.

The ranch was donated to Cal Poly San Luis Obispo in 1994 by the late Al Smith, a Cal Poly graduate and founder of Orchard Supply Hardware. Al Smith wished to maintain SPR "intact and natural, a lab and a classroom for the College of Agriculture for Learn by Doing forever." He had the vision of acquiring as much of the land contained in the original Las Puerca y Trancas land grant as possible. He wanted the property to remain as open space, the railroad to be maintained intact and available to the public and the remaining large redwoods, including the tree known as General Smith, left untouched.

The 3,200-acre SPR comprises much of the original Rancho Agua Puerca y Las Trancas Land Grant. One of the early settlers, James Archibald, a farmer from Scotland, owned Rancho Agua Puerca y las Trancas in the 1860’s. He was reported to have 120 cows in his dairy in 1878. He arranged for a Swiss dairyman, Ambrogio Gianone, who settled in the area in 1869, to run the dairy. Gianone became a well-known dairyman and built a rock house cheese factory on the Old Coast Road (now known as Swanton Road), opposite the headquarters of the ranch of James Archibald. The cheese produced was called Santa Cruz Jack Cheese, said to be the forerunner of Monterey Jack Cheese. Later, Mr. Gianone bought the north third of the rancho, where Swanton Road crosses back over the ridge. It is known locally as Gianone Hill, and there are two families with fourth generation children living there today. Mr. Archibald died in Scotland in 1875 and after a two-year lawsuit, Mrs. Archibald sold out to Joseph Bloom, who lined up water rights and farmed the valley. The Staub family eventually settled a portion of the ranch, as well as the Coast Dairies and Land Company and the Ocean Pacific and Southern Pacific railroad lines. The Staub family sold their holdings to the Castro family in the 1940s who

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2 https://spranch.calpoly.edu/mission
sold it soon afterwards to the Jani family. These lands were used primarily for cattle, artichokes, Brussels sprouts and hay.

This educational and research facility is now owned by the Cal Poly Corporation and managed by Cal Poly’s College of Agriculture, Food and Environmental Sciences (CAFES). Faculty, graduate students and undergraduates actively pursue research opportunities, utilizing the forest, range, and watershed resources within the ranch. The ranch hosts a variety of functions, some of which include the production of natural beef, "U-pick" certified organic apples, hosting of professional meetings and workshops, and courses offered by Cal Poly, including the Department of Natural Resources Management and Environmental Sciences (NRES).

**Farming History**

Starting in the 1920s it was discovered that artichokes and Brussels sprouts grew well in the coastal area. Scotts Creek was dammed, and huge single cylinder gasoline engines were used to pump the water onto the upper terraces. There are the remnants of some twenty reservoirs and numerous gravity flow structures left on what is now rangeland. Some of the leading citizens of Santa Cruz spent their childhood here on windswept little farms with such nicknames as "Siberia" or "Poverty Flats". Some berries were also grown at this time.

In 1938 the Poletti and Morelli Families became the owners. World War II caused most of the tenant farmers to leave, and the ranch was divided into three phases. There was a Grade B dairy, a beef cattle operation, and row crops, mostly artichokes, Brussels sprouts, and some berries. Since these crops are labor-intensive, a labor camp was established with mostly Filipino workers east of Swanton Road along Archibald Creek. At this time, John and Bob Musitelli took over the beef cattle and they increased the acreage by converting waste brush land with a bulldozer, herbicide and fire. They had a cow-calf operation and used a jeep pickup with a bale of hay very effectively as a saddle horse. The Grade B dairy left and the Musitelli's expanded their operation. With the use of chicken manure and excellent water supply, the ranch produced excellent crops of sprouts year after year.

When Al Smith began ownership of Swanton Pacific in the late 1940’s, he tried a small cow-calf operation in Little Creek. After hiring a cowboy, he ran stockers at first and then a cow-calf operation, at the wrong time for the market. When the vegetable tenant left, Al leased the land to a flower grower, who grew cut flowers and market peas with little success.
SWANTON PACIFIC RANCH NATURAL RESOURCES AND LAND USES

Topography

Elevation ranges from sea level at the estuary of Scotts Creek to 1,000 feet at the eastern boundary of the property (Figure 2). An unnamed peak of 819 feet occupies the central portion of the site with Cooke’s Peak at 774 feet that is monumented with a USGS benchmark. The riparian corridor of Scotts Creek extends across the property in a north/south orientation that is frequently incised in the upper reaches but has a well-developed floodplain along the lowermost 2,000 feet as Scotts Creek approaches the estuary. The cropland of the property is contained in this floodplain region, with valley slopes on each side rising steeply in most locations. Several smaller drainages bisect the eastern slopes.

[From the SPR 2015 management plan]

Figure 2. SPR Topographic Map
Land Use and Vegetation Cover

The 3,200-acre SPR consists of approximately 100 acres of cropland (69 acres actively farmed in 2018-2019; the other 31 acres have been temporarily retired or converted to grassland), 1,435 of Coast Redwood/Douglas-fir forest type (including 80 acres with timber but not ownership rights) and 1,500 acres of grassland (Figures 3 and 4).

Figure 3. SPR 2015 Land Use Map

Figure 4. SPR Vegetation Map
Hydrology

SPR is located within the Scotts Creek watershed (Figure 5). Riparian corridors exist along Scotts Creek, Mill Creek, Little Creek, Archibald Creek, Queseria Creek, and some smaller unnamed drainages. These provide critical habitat to both the endangered Coho salmon and the threatened steelhead trout as do the wetlands at the mouth of Scotts Creek.

Figure 5. SPR Hydrology (Streams) Map
Soil Types

Soil type classification within the 3,200-acre SPR includes 16 different soil units (Figure 6). Loam and sandy-loam textures are predominant both across the entire ranch and within the CFP focus area. [Note: slight discrepancies between soil map unit acreages and actual SPR acreages resulted due to use of mapping software, but overall unit percentages indicated are reliable.]

Figure 6. SPR Soils Map: whole ranch and CFP focus area
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**Totals for Area of Interest:** 2,999.9 | 100.0%
Soils of fields leased to Jacobs Farms

Figure 7. Soils Map of SPR fields leased to Jacobs Farms with approx. acreages by soil type
Soils of northern fields

Figure 8. Soils Map of SPR northern fields
Recent lab test results (2017 and 2018) demonstrate a significant increase in soil organic matter (5-6% increase) relative to baseline data from the NRCS Soil Survey Geographic Database (SSURGO, Figure 9). Data used in SSURGO were prepared by soil scientists as part of the National Cooperative Soil Survey. Pertinent SSURGO samples were taken in the 1950s and 1970s. Decades of soil building management practices (mainly compost application and cover cropping) may in part be responsible for increases; however, lab methods used to determine organic matter content, and sampling methods in particular, make comparisons difficult. Nonetheless, the increase in organic matter indicated in these data are a potential reason for optimism and merit further investigation.

**Figure 9. Historic change in soil organic matter (%) within the CFP focus area**
Soil Infiltration and Managed Aquifer Recharge Potential

Infiltration refers to the ability of water to move into soil, involving both surface entry and transmission through the soil. In the map on the left below, soil infiltration capacity was calculated as the geometric mean of the infiltration range for each soil layer, followed by the harmonic mean of individual layers (weighted by layer thickness). Numeric values were categorized in a rating scale of 0-4, where 0 is low and 4 is high infiltration capacity.

In 2014, the RCD of Santa Cruz County partnered with UC Santa Cruz to complete a regional Managed Aquifer Recharge (MAR) and Runoff Analysis for Santa Cruz and Northern Monterey Counties, which can be used to optimize storm runoff collection. A MAR rating (where 0 is lowest suitability for water collection, and 8 is highest) is based on soil infiltration capacity and bedrock geology to estimate the likelihood of effective infiltration and storage of storm runoff if available and successfully captured. Soil infiltration capacity and MAR suitability maps indicate few opportunities for groundwater recharge at Swanton Ranch, and none of them occur within the acreage used for crop production (Figure 10), meaning that the areas considered in this study are not well suited to basin recharge in extreme weather events.

**Figure 10. SPR soil infiltration capacity and Managed Aquifer Recharge (MAR) suitability maps**

More information about the Santa Cruz MAR project can be found at: [http://www.rcdsantacruz.org/managed-aquifer-recharge](http://www.rcdsantacruz.org/managed-aquifer-recharge)
CARBON FARMING OPPORTUNITIES I: Floodplain and Riparian Restoration

Wildlife habitat protection and enhancement is an integral on-going component of SPR’s Management Plan. Riparian corridors within the ranch serve as important links for wildlife habitat integrity and are also a major source of species diversity. SPR has successfully integrated ranch operations with wildlife habitat management and maintenance. The lower portion of the property is at or near sea level and the marsh at the estuary contains brackish water from salt-water intrusion and tidal action. The lagoon at the estuary is closed by a sandbar in the summer months except when breached. There is a historic record of devastating floods in 1940, 1955, 1982 and 1998. Much of the riparian restoration and management has concentrated on the lower reaches of Scotts Creek.

Scotts Creek is an important perennial stream for steelhead and Coho salmon habitat and has the remnants of levees constructed by the Army Corps of Engineers fifty years ago. The creek’s banks contain a mixture of buckeye, elderberry, alder and some willows and redwoods. The riparian area contains a mixture of predominately willow and red alder, with some California bay, big leaf maple, box elder, and hazelnut interspersed. There is also an abundance of nettles, poison oak and native blackberry. Limited amounts of Himalayan blackberries also exist. German ivy, French broom and periwinkle have been species of concern along the riparian corridors, as they spread rapidly and need to be controlled to the extent possible. Higher up Scotts Creek there is a greater proportion of redwood and Douglas-fir trees (SPR 2015 Management Plan).

Scotts Creek and its tributaries have been the subject of numerous studies (cited in the 2015 SPR management plan) designed to better understand and improve anadromous fish habitat within SPR, as well as to investigate to what degree high flow events have caused changes to the main stream channel. Breaches to the levees along Scotts Creek have occurred during high flow events with subsequent flooding and damage to the ranch’s crop fields.

Floodplain, Riparian and In-Stream Habitat Restoration Previously Accomplished

Between 2008 and 2017, several restoration projects were implemented along lower reaches of Scotts Creek, Mill Creek, Queseria Creek, and Archibald Creek, which are all adjacent to cropland fields leased to Jacobs Farms (Figure 11). These projects were set to enhance riparian, in-stream and floodplain habitat, and to restore natural hydro-geomorphic function for steelhead and Coho salmon in these creeks. Projects were implemented through a program known as Integrated Watershed Restoration Program (IWRP), which involved several partners, including: Cal Poly, Swanton Pacific Ranch, the RCD of Santa Cruz County, USDA-NRCS, California Coastal Conservancy, Sustainable Conservation, National Marine Fisheries Service and California Department of Fish and Wildlife, among others. These restoration projects removed invasive plant species from the riparian corridor, revegetated it with native tree and shrub species, and restored in-stream and floodplain habitat and hydrology.
Figure 11. Riparian, in-stream and floodplain restoration projects previously implemented (2008-2015) between Scott’s Creek and SPR crop fields leased to Jacobs Farms.
**2008 projects** included:

1) **Queseria Creek in-stream restoration**: installation of a bridge; three in-stream crossvanes to create pool and riffle features to dissipate energy and offer temporary bedload; and revegetation. The vanes created critical habitat features for anadromous fish, such as clean gravels, undercut banks, large woody debris, and riparian cover. A pre-existing culvert crossing was removed in 2005 and replaced with a bridge crossing. The culvert structure was problematic during periods of high flow.

2) **Mill Creek in-stream restoration** to improve aquatic habitat conditions and hydrologic performance along two reaches: installation of three in-stream flow features designed to focus flow energy away from the channel boundaries and to protect the bank (reducing erosion and undercutting of the adjacent road); constructing a planted revetment structure to slow velocities along a sharp channel bend that was eroding the bank adjacent to the road. Project materials consisted of large woody debris, rock, vegetation, etc. The Mill Creek watershed is known to support Coho salmon, steelhead and California red-legged frogs.

3) **Queseria Creek water quality protection**: the goal of this project was to reduce the potential entry of sediments, nutrients, and pathogens into Queseria Creek from an adjacent horse paddock. This watershed is also known to support Coho, steelhead and California red-legged frogs. The project included capturing and treating runoff water that would otherwise pass through the confined paddock. Project activities included the installation of a grassed waterway and associated structure for water control. The grassed waterway was fenced off from the paddock activity. The grassed waterway allows for a greater area of infiltration as well as decreased soil saturation in the grazed area thereby reducing erosion and the delivery of nutrients and pathogens from livestock. The associated structure for water control allows water to be conveyed underneath a crossing that is used for entry into the livestock enclosure/pasture area and eliminates potential soil structure degradation (i.e., compaction) and vegetation damage that could otherwise result from traffic on saturated soil.

**2014 projects** included: 1) floodplain scour feature: a connection was excavated between an existing floodplain scour feature and lower Queseria Creek (a tributary to lower Scotts Creek) to increase stream complexity and create additional alcove habitat for aquatic species; 2) confluence enhancement: a culvert and a portion of the historic levee were removed that limited connectivity between lower Scotts Creek and the floodplain at the location of an existing agricultural drain. The proposed grading occurred on the left bank and floodplain adjacent to Scotts Creek 3,000 feet upstream from the CA-1 bridge crossing over Scotts Creek; 3) large woody debris: four in-stream large woody debris (LWD) structures were constructed using a combination of alders, redwood logs and rootwads, and boulders, to provide in-stream cover, improve sediment sorting, and encourage the formation of in-stream pool habitat along an identified sub-reach of low habitat complexity; 4) selective levee breaching: five new connections were created between lower Scotts Creek and the floodplain by grading selected breaches through portions of the levee for the purpose of improving floodplain connectivity and facilitating a return to a natural flood cycle; and 5) riparian revegetation with native trees and shrub species found in the project area.
2015 projects included: 1) construction of nine in-stream wood structures; 2) grading of two backwater connections with two existing off-channel ponds and one backwater connection with an existing floodplain drain; 3) reconfiguration of the confluence area of Archibald Creek to form a backwater connection with Scotts Creek; and 4) riparian revegetation for habitat enhancement and erosion control (a diverse array of native trees and shrub species were planted based on location).

2017 projects included: 1) construction of eleven instream wood complexes; 2) enhancing two existing debris jams; 3) grading two connections with the floodplain adjacent to the stream channel; and 4) riparian revegetation for habitat enhancement and erosion control (a diverse array of native trees and shrub species were planted based on location).

Table 1. Riparian, in-stream and floodplain habitat restoration projects completed along lower reaches of Scotts Creek and some of its tributaries within SPR between 2008 and 2017

<table>
<thead>
<tr>
<th>Projects by Year</th>
<th>NRCS CPS</th>
<th>Practice Extent</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008</td>
<td></td>
<td></td>
</tr>
<tr>
<td>In-stream cross vanes to create pool and riffle features</td>
<td>Stream Habitat Improvement and Management (395)</td>
<td>No data</td>
</tr>
<tr>
<td>Riparian revegetation (Queseria and Mill Creek)</td>
<td>Critical Area Planting (342)</td>
<td>0.4 ac (estimated)</td>
</tr>
<tr>
<td>Planted revetment structure to slow velocities along a sharp channel bend</td>
<td>Critical Area Planting (342)</td>
<td>No data</td>
</tr>
<tr>
<td>In-stream large woody debris structures</td>
<td>Stream Habitat Improvement and Management (395)</td>
<td>No data</td>
</tr>
<tr>
<td>Grassed waterway and associated structure for water control</td>
<td>Grassed Waterway (412)</td>
<td>No data</td>
</tr>
<tr>
<td>2014</td>
<td></td>
<td>1.67 ac</td>
</tr>
<tr>
<td>In-stream large woody debris structures</td>
<td>Stream Habitat Improvement and Management (395)</td>
<td>3,600 ft² (0.08 ac)</td>
</tr>
<tr>
<td>Levee breaches, confluence enhancement and Queseria Creek floodplain scour feature</td>
<td>Streambank &amp; Shoreline Protection (580)</td>
<td>13,487 ft² (0.3 ac)</td>
</tr>
<tr>
<td>Wood features</td>
<td>Streambank &amp; Shoreline Protection (580)</td>
<td>41,184 ft² (0.94 ac)</td>
</tr>
<tr>
<td>Riparian revegetation (Queseria and Scotts Creeks)</td>
<td>Critical Area Planting (342) COMET Planner “Riparian Restoration”</td>
<td>15,246 ft² (0.35 ac)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2015</td>
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<tr>
<td>---------------</td>
<td>--------------------------------------</td>
<td>------</td>
</tr>
<tr>
<td>In-stream</td>
<td>Stream Habitat Improvement and</td>
<td>6,000</td>
</tr>
<tr>
<td>large woody</td>
<td>Management (395)</td>
<td>ft²</td>
</tr>
<tr>
<td>debris</td>
<td></td>
<td></td>
</tr>
<tr>
<td>structures</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Floodplain</td>
<td>Streambank and Shoreline Protection</td>
<td>7,000</td>
</tr>
<tr>
<td>connections</td>
<td>(580)</td>
<td>ft²</td>
</tr>
<tr>
<td>Riparian</td>
<td>Critical Area Planting (342)</td>
<td>41,200</td>
</tr>
<tr>
<td>revegetation</td>
<td>COMET Planner “Riparian Restoration”</td>
<td></td>
</tr>
<tr>
<td>(Archibald</td>
<td></td>
<td></td>
</tr>
<tr>
<td>and Scotts</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Creeks)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Streambank</td>
<td>Critical Area Planting (342)</td>
<td>15,000</td>
</tr>
<tr>
<td>revegetation</td>
<td></td>
<td>ft²</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>2017</td>
</tr>
<tr>
<td>In-stream</td>
<td>Stream Habitat Improvement and</td>
<td>16,000</td>
</tr>
<tr>
<td>large woody</td>
<td>Management (395)</td>
<td>ft²</td>
</tr>
<tr>
<td>debris</td>
<td></td>
<td></td>
</tr>
<tr>
<td>structures</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Floodplain</td>
<td>Streambank and Shoreline Protection</td>
<td>21,595</td>
</tr>
<tr>
<td>connections</td>
<td>(580),</td>
<td>ft²</td>
</tr>
<tr>
<td>Riparian</td>
<td>Critical Area Planting (342)</td>
<td>9,200</td>
</tr>
<tr>
<td>revegetation</td>
<td>COMET Planner “Riparian Restoration”</td>
<td></td>
</tr>
<tr>
<td>(Scotts Creek)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total Area</strong></td>
<td></td>
<td><strong>4.73 ac</strong></td>
</tr>
<tr>
<td><strong>Impacted</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Restoration benefits**

Together these projects accomplished the following benefits:

- Improved hydrologic connection between the main channel and floodplain
- Increased duration and frequency of floodplain inundation, while reducing floodplain flow velocities
- Improved floodplain circulation and nutrient cycling through longer inundation periods and creation of multiple paths for access and egress of floodwaters
- Enhanced riparian, floodplain and instream habitat via re-establishment of more natural geomorphic features
- Installation of backwatering elements such as LWD and the confluence wetland
- Enhanced instream habitat and restored natural hydro-geomorphic function has improved the creek’s capacity as a spawning and rearing ground for Coho salmon, steelhead trout, and the California red-legged frog

Prior to these projects, by 2004, approximately 4 acres of cropland had been retired from production to allow restoration of Queseria Creek’s channel and riparian buffer. The following sequence of historic photographs (Figures 12-14) illustrates visible changes in the landscape as a result of these restoration projects and land use changes over almost 50 years:
Figure 12. 1970 and 1991 aerial photos of SPR cropland fields leased to Jacobs Farms, showing landscape changes over time as a result of riparian and floodplain restoration, and land use changes.
Figure 13. 2004 and 2006 aerial photos of SPR cropland fields leased to Jacobs Farms, showing landscape changes over time as a result of riparian and floodplain restoration, and land use changes.

Farmland retirement gave way to floodplain and riparian restoration between Scotts and Queseria Creeks.
**Figure 14.** 2011 and 2018 aerial photos of SPR cropland fields leased to Jacobs Farms, showing landscape changes over time as a result of riparian and floodplain restoration, and land use changes.

- Lower Queseria Creek’s stream flow and riparian area restored.
- Wider riparian buffer along Scotts Creek, and better connectivity to floodplain and Queseria Creek.
Carbon Benefits from Restoration Activities Previously Completed

In addition to the ecological benefits from a wildlife habitat and floodplain hydrological function point of view, some of the practices included in the aforementioned restoration projects also have carbon-related benefits that can be quantified (Table 2). Specifically, conversion of cropland to restored riparian habitat along Queseria Creek, invasive plant species removal and revegetation with native trees and shrubs along disturbed riparian reaches of Scotts, Queseria, Mill and Archibald Creeks, have all provided CO₂ removal and carbon storage benefits, which have been accruing every year since each practice/project was implemented. Table 2 summarizes carbon benefits from restoration projects completed along Scotts Creek and its tributaries within SPR between 2004 and 2017.

Table 2. Summary of annual and accrued carbon benefits from restoration activities previously completed along Scotts Creek and its tributaries within SPR between 2004 and 2017. Annual carbon benefits are estimated using COMET-Planner.

<table>
<thead>
<tr>
<th>Project Activity</th>
<th>Year</th>
<th>NRCS CPS</th>
<th>Area</th>
<th>Annual CO₂ benefit (MT of CO₂eq/yr)</th>
<th>Accrued CO₂ benefit by 2019 (MT of CO₂eq)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cropland retirement and Queseria riparian restoration</td>
<td>2004</td>
<td>Riparian Forest Buffer (391)</td>
<td>4ac</td>
<td>7</td>
<td>105</td>
</tr>
<tr>
<td>Riparian revegetation (Queseria and Mill Creeks)</td>
<td>2008</td>
<td>Critical Area Planting (342)</td>
<td>0.4ac</td>
<td>0.4</td>
<td>4.4</td>
</tr>
<tr>
<td>Riparian revegetation (Queseria and Scotts Creeks)</td>
<td>2014</td>
<td>Critical Area Planting (342)</td>
<td>0.35ac</td>
<td>0.35</td>
<td>1.75</td>
</tr>
<tr>
<td>Riparian revegetation (Archibald and Scotts Creeks)</td>
<td>2015</td>
<td>Critical Area Planting (342)</td>
<td>1.28ac</td>
<td>1.28</td>
<td>5.12</td>
</tr>
<tr>
<td>Riparian revegetation (Scotts Creek)</td>
<td>2017</td>
<td>Critical Area Planting (342)</td>
<td>0.21ac</td>
<td>0.21</td>
<td>0.42</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>9.2</strong></td>
<td><strong>116.7</strong></td>
</tr>
</tbody>
</table>
Additional Watershed Restoration Opportunities Linked to Carbon Farming

In preparation of this carbon farm plan, the planning team (including staff from Cal Poly, SPR, RCDSCC, and Carbon Cycle Institute) identified and discussed several opportunities for expanding riparian habitat restoration and floodplain management with additional practices and related carbon benefits (Figure 15 and Table 3). The following sections describe these additional watershed restoration opportunities and their links to carbon farming.

Further expansion of Scotts Creek riparian buffers along cropland fields
According to SPR staff, the existing fence line between Scotts Creek and cropland fields 5-8 (leased to Jacobs Farms) can be moved 50-100 feet onto currently farmed cropland to allow further riparian buffer expansion along a field strip that gets regularly flooded (approx. 6 ac). This riparian buffer expansion will allow the opportunity to plant native trees and shrubs, which can store significant amounts of carbon and have several co-benefits (Table 3). Planting grasses and other herbaceous cover along this strip can also help to reduce water velocity and scouring/eroding power during flood events, which is an existing issue on these fields. These restoration activities fall under the description of two NRCS Conservation Practice Standards (CPS): Riparian Herbaceous Cover (CPS 390) and Riparian Forest Buffer (CPS 391).

Riparian Restoration and Revegetation in Queseria and Archibald Creeks
There are opportunities to expand riparian restoration and revegetation along lower reaches of Queseria Creek and Archibald Creek (approx. 1.5 ac). Riparian revegetation along Queseria with herbaceous cover (forage/forbs) can be added to existing prescribed grazing area. These restoration activities fall under the description of two NRCS Conservation Practice Standards (CPS): Critical Area Planting (CPS 342) and Prescribed Grazing (CPS 528).

Forage and Biomass Planting and Prescribed Grazing
Forage and Biomass Plantings can be established on the northern field Squirrel Flats and southern crop fields 7-8 to produce additional feedstock for cattle. Forage plant biomass will capture and store carbon, and it can be managed through prescribed grazing rotations during dry periods. This practice will build soil carbon content and improve soil water holding capacity. These restoration activities fall under the description of two NRCS Conservation Practice Standards (CPS): Forage and Biomass Planting (CPS 512) and Prescribed Grazing (CPS 528).

Invasive Plant Species Removal and Riparian Revegetation
Invasive plant species removal has been an integral part of riparian restoration activities within SPR for many years, and it is called out as an important on-going need in the 2015 SPR Management Plan. In addition to existing and planned efforts to remove invasive species, SPR could consider the use of livestock (and prescribed grazing) to remove cape ivy and broom. Periwinkle can be controlled by smothering with cardboard and heavy woodchip mulch for a
year or more, where site conditions permit. Eradication of these species should be followed by planting of appropriate native species as needed to achieve desired vegetation cover. The use of mulch, animal grazing and revegetation with native species would all represent additional carbon benefits. These restoration activities fall under the description of three NRCS Conservation Practice Standards (CPS): Mulching (CPS 484); Critical Area Planting (CPS 342); and Prescribed Grazing (CPS 528).

**Wetland Restoration**

Forage and Biomass Planting will be integrated to Wetland Restoration on the lower half of Squirrel Flats, which is persistently wet/saturated during the rainy season. Prescribed grazing rotations can be used during dry periods to manage vegetation as needed. These restoration activities fall under the description of three NRCS Conservation Practice Standards (CPS): Forage and Biomass Planting (CPS 512); Wetland Restoration (CPS 657); and Prescribed Grazing (CPS 528).

![Figure 15. SPR map highlighting carbon farming opportunities linked to watershed restoration activities within or adjacent to cropland fields only (focus area of this CFP)](image-url)
Carbon Benefits from Proposed Additional Watershed Restoration Activities

Carbon benefits of proposed additional watershed restoration activities result from carbon capture and storage in the soil and plant biomass. Combined, the proposed restoration activities have an estimated total carbon benefit of 29 tonnes CO₂eq/yr, which if maintained over 20 years would accrue a total of 576 tonnes CO₂eq (Table 3).

Table 3. Summary of new recommended restoration activities within the CFP scope area and associated carbon benefits. Annual carbon benefits are estimated using COMET-Planner.

<table>
<thead>
<tr>
<th>Proposed Activity</th>
<th>NRCS CPS</th>
<th>Area</th>
<th>Annual CO₂ benefit (MT of CO₂eq/yr)</th>
<th>Accrued CO₂ benefit over 20yrs (MT of CO₂eq)</th>
<th>Co-Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scotts Creek riparian buffer expansion along crop fields 5-8</td>
<td>Riparian Forest Buffer (391)</td>
<td>6ac</td>
<td>10</td>
<td>200</td>
<td>Improve wildlife habitat; reduce soil erosion; protect streambank</td>
</tr>
<tr>
<td>Wetland restoration (Squirrel Flats field)</td>
<td>Wetland Restoration (657) / Critical Area Planting (342)</td>
<td>3ac</td>
<td>6</td>
<td>120</td>
<td>Improve wildlife habitat; protect stream water quality</td>
</tr>
<tr>
<td>Forage and biomass planting for prescribed grazing (Squirrel Flats &amp; fields 7-8)</td>
<td>Forage and Biomass Planting (512)</td>
<td>15ac</td>
<td>4</td>
<td>80</td>
<td>Augment feedstock for cattle; reduce soil erosion</td>
</tr>
<tr>
<td>Invasive species removal and riparian re-vegetation (Scotts Creek)</td>
<td>Critical Area Planting (342)</td>
<td>6ac</td>
<td>6.3</td>
<td>126</td>
<td>Protect native biodiversity; improve wildlife habitat;</td>
</tr>
<tr>
<td>Invasive species removal and riparian re-vegetation (Scotts Creek)</td>
<td>Mulching (448)</td>
<td>3ac</td>
<td>1</td>
<td>20</td>
<td>Protect native biodiversity; improve wildlife habitat;</td>
</tr>
<tr>
<td>Queseria Creek riparian expansion</td>
<td>Critical Area Planting (342)</td>
<td>0.5ac</td>
<td>0.5</td>
<td>10</td>
<td>Augment feedstock for cattle; reduce soil erosion; protect stream water quality</td>
</tr>
<tr>
<td>Archibald Creek riparian restoration and re-vegetation</td>
<td>Critical Area Planting (342)</td>
<td>1ac</td>
<td>1</td>
<td>20</td>
<td>Improve wildlife habitat; reduce soil erosion; protect streambank</td>
</tr>
</tbody>
</table>

TOTAL | | | 29 | 576 |
**Beavers, Water and Carbon**

One significant factor in the drying of the West has been the virtual eradication of the region’s native hydrological engineer – the beaver. Loss of the beaver from most of its native habitat in the Western US is associated with initiation of an “epicycle of erosion” throughout the region, as beaver dams decayed and washed away, wet beaver meadows were incised and subjected to drying and soil loss, and as watersheds responded to the resulting changes in hydrology with flashier flood events, increased erosion and less water retention. Today, beavers are increasingly recognized as a “keystone species;” ecosystem engineers that play a critical role in watershed dynamics where they are present, including benefiting steelhead populations. Beaver ponds can replenish aquifers, allowing groundwater to recharge streams and meadows in dry summers, and provide perennial pools for over-summering trout smolt.

Beaver dams have also been shown to benefit fish abundance and diversity, to stabilize stream incision, and to reduce discharge of sediment and nutrients. These effects could greatly assist in the recovery of the near-extinct populations of Coho salmon in California. Beaver have not been considered native to the portion of Coho salmon’s native range in the north coast of California that runs from the Klamath River to the Monterey Bay (including San Francisco Bay). Current California beaver management policies appear to rest on assertions that date from the first half of the twentieth century. A 2013 study re-evaluates those long-held assumptions. Recently uncovered direct (physical) evidence of beaver remains and indirect evidence such as historical records, newspapers accounts and Native American ethnographic information found in the north coast and the San Francisco Bay suggest that beaver were in fact native to these areas. Understanding that beaver are native to the north coast and the San Francisco Bay is important to contemporary management of beaver populations and the myriad species that depend on the habitat they create, especially endangered Coho salmon.

In the context of carbon farm planning, beavers can have a significant positive impact on soil carbon within their zone of influence, both through enhanced production associated with increased soil water adjacent to beaver impoundments and through increased allocation of woody biomass to the soil at the beaver-constructed wetland interface (Rosell et al, 2005). While beavers are unlikely to make a home on Swanton Ranch in the near term, opportunities for enhancing beaver habitat could be seized when designing and implementing riparian restoration efforts on the ranch to facilitate return of this keystone hydrological engineer to the ranch ecosystem. In this context, it is interesting to note the numerous engineered dam/drop inlet structures constructed on the ranch in the past, which have been highly successful in catching sediment and aggrading stream channels throughout the ranch watersheds. Beaver activity could be expected to have similar beneficial impacts on ranch hydrology and surface geomorphology, while being constructed and maintained by the beavers themselves. Beaver reintroduction to stream habitats within SPR is suggested in this plan merely as a possibility in the longer-term future.

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CARBON FARMING OPPORTUNITIES II: Cropland Management

The philosophy behind the cropland operations at SPR is to practice organic farming while providing hands-on educational opportunities to optimize student Learning by Doing. The long-term goal is to manage a diversified crop operation that is self-sustaining and offers marketing opportunities to balance out operating expenses and potentially generate income. Carbon farm planning fits well within and enhances SPR’s cropland management philosophy by emphasizing the goal of building carbon within the farm’s agroecosystem, whether in plants or soils, to improve: soil water holding capacity and hydrological function, biodiversity, soil fertility, resilience to drought and flood, and agricultural productivity. While most of the suitable cropland is actively managed for a diversity of crops, there are two coastal fields and three other fields that have been converted to grassland. These contain a predominance of wild mustard, oxalis, thistle and ripgut brome weedy species.

In 2019, 69 acres are actively being farmed; 65 of these acres are CCOF certified organic and leased to Jacobs Farms for production of culinary herbs (primarily), and 4 acres are organically managed by SPR in an apple orchard. This carbon farm plan focuses on those 69 acres plus 6 acres in the northern fields (which are currently open to different management ideas), for a total of 75 acres.

Existing Cropland Operations and Management Practices

Apple Orchard

Four acres (4 ac) near the northern end of the ranch are dedicated to a U-Pick organic apple orchard (Figure 16), which is seasonally open to the public, Cal Poly alumni, and school groups to experience Cal Poly’s "living laboratory". The orchard produces five tons of multiple apple varieties per year. The 16 distinct varieties ripen progressively throughout the fall allowing for an extended picking season. Grade-school groups are encouraged to arrange visits to the U-Pick where children receive an overview of ecological processes in organic farming before they set out to collect apples.

The orchard’s soil is not tilled. Alleys are periodically planted with cover crops, mostly vetch, but soil building legume and cereal grass mixes have also been used. Clippings from pruning are piled and chipped, but currently they are not composted and/or applied as mulch. SPR is interested in diversifying understory plantings (alley cropping) to add new marketable products, stimulate microbial diversity and store more carbon.
Swanton Pacific Ranch - Carbon Farm Plan

Figure 16. 4-acre apple orchard planted at the northern fields of the SPR property

Culinary Herbs and Annual Row Crops

The other 65 acres cover 6 different fields near the southern end of the ranch and are managed by Jacobs Farm/Del Cabo Inc. through an education-oriented lease and partnership with SPR (Figure 17). Jacobs Farm manages a multi-crop operation including perennial and annual culinary herbs (cilantro, rosemary, thyme, dill, Italian parsley, marjoram), dry-farmed tomatoes and a variety of squashes. Through the partnership between SPR and Jacobs Farm/Del Cabo, students interested in crop production can gain practical and professional experience through crop focused internships.

Jacobs Farm was founded in 1980 as a small organic family farm dedicated to growing fresh, high quality, delicious food without damaging the environment. Early pioneers in organic farming methods, organic certification, and Fair Trade practices, husband and wife co-founders Larry Jacobs and Sandra Belin began pursuing a healthier way of farming after Larry fell unconscious as a result of exposure to toxic pesticides. Since then, they’ve dedicated themselves to farming without the use of harmful chemicals.
Figure 17. SPR cropland fields (65ac) leased to Jacobs Farm. This is a subset of the total acreage (471ac) managed by Jacobs Farms on the Santa Cruz County north coast, and it covers 93% of the focus area for this Carbon Farm Plan.

Conservation Crop Rotation and Cover Cropping
The six fields leased to Jacobs Farm are alternately planted following three different crop rotations, all of which minimize the duration of fallow periods with exposed soil and include one or more herb crops, at least one annual row crop, and cover crops between cash crops. Crop rotations vary somewhat between years but are generally as follows:

- **Rotation 1 (3 year Dry-farm):**
  - Dry Farm Tomatoes – cover crop – Dill/Cilantro – cover crop – Hard Squash - cover crop
- **Rotation 2 (3 year Marjoram):**
  - Marjoram – cover crop – Pumpkin – cover crop – Dill/Cilantro – cover crop
- **Rotation 3 (4 year Thyme):**
  - Thyme – cover crop – Dry Farm Tomatoes – cover crop - Hard Squash – cover crop-Dill/Cilantro
Cover crops are typically a mix of 30% bell beans, 30% purple (lana or hairy) vetch and 40% oats, planted at a rate of 150 pounds/acre.

These management practices align with two NRCS conservation practice standards (CPS): Conservation Crop Rotation (CPS 328) and Cover Cropping (CPS 340).

**Compost and other soil amendments**

All crop soils receive compost 3 to 4 weeks prior to planting. Certified organic compost is outsourced from Central Coast Compost LLC and is applied at 8 tons/acre on approximately 50 acres (not each field is farmed each year). In many cases, compost is incorporated into soil. Assuming one application per year on each field, the total amount of compost applied is approximately 400 tons/yr. The main feedstock source for this compost is horse manure and beddings, and its organic matter content (dry wt. basis) is 26.8%. Organic carbon (dry wt. basis) is 14%, and C:N ratio is 11.7 [Soil Control Lab compost test results, 2017]. Other soil amendments at planting time include gypsum (0.6 tons/ac) and pelletized organic fertilizer 7.5-5-7.5 (0.3 tons/ac). Above-ground “mulch” is used in conjunction with plastic mulch for weed control on transplanted crops that are not direct-seeded, such as cilantro. In this case, a lower-grade (lower fertility) compost is applied in transplant holes within the plastic to support plants and prevent weed emergence. Where this compost “mulch” is employed (at the time of transplant), herbs use about 24 tons/ac, and squash use up to 10 tons/ac. Assuming an average application rate of 17 tons/ac every year, on about 20 acres of the total 65-acre production area, this is equivalent to 340 tons/year. Irrigation uses a combination of sprinkler and drip systems, and the main water source is groundwater.

**Carbon Benefits from Existing Cropland Management Practices**

In addition to their benefits from an agronomic point of view, some of the previously described cropland management practices also have carbon-related benefits that can be quantified (Tables 4 and 5). Specifically, annual application of compost and mulch, as currently practiced by Jacobs Farm on the 65 acres leased from SPR, transfers an annual total of 470 MT CO₂eq/yr from the atmosphere to the soil ⁵(Table 4). In addition, cover cropping, conservation crop rotation and no-till farming (orchard), have also provided CO₂ removal and carbon storage benefits, which have been accruing every year since each practice was first implemented. Table 5 summarizes carbon benefits from existing cropland management practices in SPR. It should be noted that these are estimates. Fallow periods during crop rotations can vary and in some cases could be shortened further for maximum benefit. Also, methods of incorporation of cover crops and crop residues may yield variations in carbon benefits. A good overview of conservation tillage practices for California row crops can be found at:

http://casi.ucanr.edu/files/43650.pdf

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⁵ This amount is equivalent to the GHG emissions from 100 passenger vehicles driven for one year, or the amount of carbon sequestered by 7,758 tree seedlings grown for 10 years. Source: https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator
Table 4. Summary of carbon benefits from compost and mulch application as currently practiced by Jacobs Farm on the 65 acres leased from SPR. Source: Carbon Cycle Institute.

<table>
<thead>
<tr>
<th>Soil Amendment Type</th>
<th>Application Rate (tons/yr)</th>
<th>C:N Ratio</th>
<th>Organic Carbon Content (dry wt. basis)</th>
<th>Annual Carbon Input (MT C/yr)</th>
<th>Annual Carbon Benefit (MT CO₂eq/yr)</th>
<th>Carbon from atmosphere to soil (MT CO₂eq/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compost</td>
<td>400</td>
<td>11.7</td>
<td>14%</td>
<td>56</td>
<td>206</td>
<td>186.8</td>
</tr>
<tr>
<td>Mulch</td>
<td>340</td>
<td>18</td>
<td>25%</td>
<td>85</td>
<td>312</td>
<td>283.5</td>
</tr>
</tbody>
</table>

Table 5. Summary of existing cropland management practices and associated carbon benefits (annual and accrued over 20 years)

<table>
<thead>
<tr>
<th>Cropland Management Practice</th>
<th>NRCS CPS</th>
<th>Area</th>
<th>Annual CO₂ benefit (MT of CO₂eq/yr)</th>
<th>Accrued CO₂ benefit over 20yrs (MT of CO₂eq)</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>No-till farming (apple orchard)</td>
<td>Residue and Tillage Management – No Till (CPS 329)</td>
<td>4ac</td>
<td>1</td>
<td>20</td>
<td>COMET Planner</td>
</tr>
<tr>
<td>Crop rotation that limits fallow periods (Jacobs Farm fields)</td>
<td>Conservation Crop Rotation (CPS 328)</td>
<td>65ac</td>
<td>17</td>
<td>340</td>
<td>COMET Planner</td>
</tr>
<tr>
<td>Crop rotation that includes cover crops every year (Jacobs Farm fields &amp; apple orchard)</td>
<td>Cover Crop (CPS 340)</td>
<td>69ac</td>
<td>34</td>
<td>680</td>
<td>COMET Planner</td>
</tr>
<tr>
<td>Compost application (Jacobs Farm fields)</td>
<td>NA</td>
<td>50ac</td>
<td>206</td>
<td>5,140</td>
<td>Carbon Cycle Institute</td>
</tr>
<tr>
<td>Mulch application for weed control (Jacobs Farm fields)</td>
<td>Mulching (CPS 484)</td>
<td>20ac</td>
<td>312</td>
<td>20,280</td>
<td>Carbon Cycle Institute</td>
</tr>
</tbody>
</table>

TOTAL | 570 | 11,400
Additional Cropland Management Opportunities Linked to Carbon Farming

In preparation of this carbon farm plan, the planning team (including staff from Cal Poly, SPR, RCDSCC, and Carbon Cycle Institute) identified and discussed several management practices that can augment carbon farming benefits from croplands within SPR (Figure 20 and Table 8). The following sections describe these additional cropland management opportunities and their links to carbon farming.

**Reduced Till**

Although Jacobs Farm manages all their crop production within SPR organically, current soil cultivation involves tillage (6 disk passes, 1 ripper, 1 plow chisel, 1 flail mowing – per year). There is an opportunity to reduce CO$_2$ emissions and augment carbon storage in the soil by reducing tillage frequency and intensity. Reduced tillage can be achieved by reducing the number of passes and/or limiting the depth of soil cultivation prior to planting. This reduces soil structure disruption and the loss of soil organic matter (SOM). Both aggregate soil structure and SOM take a long time to build up and are important for supporting microbial diversity and activity. As an example, JV Farms in King City CA, practices reduced till by planting annual crop rotations on permanent beds with minimal tillage (Figure 18). Their crop rotation includes frequent cover crops and limits the duration of fallow periods with exposed soil. The farmer has adapted his own selection of tools and reduced the number of passes in order to minimize soil disruption (Figure 19). Soils are kept covered as much as possible, with (low C:N ratio) green covers and residues incorporated into the ground before planting.

*Figure 18. Example of Reduced Till practiced at a commercial 150-ac organic farm (JV Farms) in King City, California Central Coast. This farm plants annual conservation crop rotations, including cover crops, on permanent beds with minimal tillage and fallow periods.*
This management practice falls under the description of NRCS CPS 345: Residue and Tillage Management - Reduced Till.
Alternative Weed Control Methods
Jacobs Farm uses mulch and a flame cultivator for weed control on approximately 10 acres currently leased from SPR. The flame cultivator uses on average 100 gallons of propane per acre (a total of 1,000 gallons of propane burned each year). This equates to annual GHG emissions of 5.76 tonnes CO\textsubscript{2}eq/yr (Table 6). There is an opportunity to eliminate or at least reduce these CO\textsubscript{2} emissions by identifying and adopting alternative methods for weed control that can be effective without burning propane. Increasing frequency and planting density of cover crops could help to suppress weeds and reduce their seed bank over time. Adding summer cover crops to the crop rotation schedules of fields 1-8 could help achieve this goal and provide ecological co-benefits. This management practice falls under the description of NRCS CPS 340: Cover Crop.

Table 6. Calculation of avoided CO\textsubscript{2} emissions if flame cultivator were replaced by an alternative weed control method. Source: https://www.eia.gov/environment/emissions/co2_vol_mass.php

<table>
<thead>
<tr>
<th>Propane CO\textsubscript{2} emissions (kg CO\textsubscript{2}/gal)</th>
<th>Propane used by flame cultivator (gal/yr)</th>
<th>Total Annual CO\textsubscript{2} emissions by flame cultivator (kg CO\textsubscript{2}/yr)</th>
<th>Total avoided carbon emissions if flame cultivator is replaced by an alternative weed control method (MT CO\textsubscript{2}eq/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.76</td>
<td>1,000</td>
<td>5,760</td>
<td>5.76</td>
</tr>
</tbody>
</table>

On-site Compost and Mulch Production
There is an opportunity to sequester additional carbon and store it in the soil by locally producing at least part of the compost and mulch that is needed, from plant residues, windbreak trimmings, orchard trimmings, etc., which are regularly produced within the ranch and need to be handled and disposed of. Given the large volume of outsourced compost that is applied to the fields every year, it seems worthwhile to at least estimate the potential volume of plant biomass that could be harvested from farm maintenance and management activities and used as feedstock for on-site compost and mulch production. Knowing this volume would help to determine whether or not this could be a cost-effective or financially viable idea. During the initial site visit, SPR staff also mentioned that they would be interested in applying compost tea as fertilizer to the apple orchard. On-site compost production could generate such liquid fertilizer as a by-product.

Forage and Biomass Planting and Prescribed Grazing
Forage and biomass plantings can also be established along riparian buffers adjacent to southern crop fields 5-8, to be managed with prescribed grazing. Forage plant biomass captures and stores carbon. This practice will build soil carbon content and improve soil water holding capacity. These management activities fall under the description of two NRCS Conservation Practice Standards (CPS): Forage and Biomass Planting (CPS 512) and Prescribed Grazing (CPS 673).
It should additionally be noted that, in some instances and with adequate resources, prescribed grazing can be performed directly on cropland, especially orchards. This is discussed further below and should be considered as a future management option.

**Paludiculture: Integrating Riparian Restoration and Cropland Production**

A portion of the proposed riparian buffer expansion could be used to grow flood-tolerant plants that can be harvested and marketed or used on site, adapting the concept of *paludiculture*, which is the productive use of wet peatlands. Paludiculture includes traditional peatland cultivation (reed mowing, litter usage, but not tillage) and new approaches for utilization, for example the energetic use of plant biomass of wet peatlands. It includes the preservation of peat as a main objective. In many cases, even peat growth may occur for example in reed usage. While the above ground biomass is harvested (typically by mowing), the underground biomass accumulates, and new peat formation may take place. The focus area for this CFP within SPR does not have peatlands, but the concept and practice of paludiculture (i.e. growing, harvesting and marketing or using on site, aboveground plant biomass in regularly flooded areas) could be integrated to the implementation of Riparian Herbaceous Cover (CPS 390), Riparian Forest Buffer (CPS 391), and conversion of lower elevation cropland to permanent grass/legume cover (CPS 512 – Forage and Biomass Planting). This would be a multi-benefit approach to productively manage the buffer zone between Scotts Creek and crop fields 5-8, while favoring restoration of floodplain hydrology and periodically flooded soils and plant communities.

The use of wet peatlands allows the re-establishment or maintenance of ecosystem services such as sequestration and carbon storage, water and nutrient retention as well as local climate cooling and habitat provision for rare species. Paludiculture combines the reduction of greenhouse gas emissions through peatland rewetting with the avoidance of greenhouse gas emissions through substitution of fossil fuels and raw material. This practice can also act as a buffer zone between intensively used agriculture sites and regularly flooded areas, reducing erosion power and nutrient loads of the incoming water (van de Riet et al. 2014). Cultivation of biomass on rewetted fen peatlands has a three-fold beneficial effect on climate. It stops the release of CO₂ and N₂O from drained peatlands, it contributes to substitution of fossil fuels and raw material, and it can support the sequestration of atmospheric CO₂ as organic carbon in soils and biomass.

The Database of Potential Paludiculture Plants (DPPP) lists more than 1,000 wetland plants (Abel et al. 2013). However, not all of those plants combine the preservation of the peat carbon stock (perennials of which the aboveground biomass is used) with an existing or highly probable market demand. Also, some of the listed plants (such as common reeds and reed canary grass) can escape cultivation and easily become an invasive nuisance, which once established is very difficult to eradicate. Therefore, plant selection should be limited to non-invasive species and whenever possible, prioritize natives. Ideally, the harvested plant biomass can be used and

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marketed as raw material for construction, renewable fuel, or can be used onsite as fodder or compost feedstocks\(^7\).

**Hedgerows, Windbreaks and Shelterbelts**

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 also provide noise and visual screens, improve irrigation efficiency, increase biodiversity, slow down and filter surface runoff, and can act as *shaded fuel breaks* to limit the spread of wildfire\(^8\). A *shaded* fuel break is different from the NRCS CPS 383 “Fuel Break” practice, but it achieves the same goal (of diminishing the risk of fire spreading) by creating enough shade, via tree canopy density, to greatly reduce understory vegetation (fine fuels).

According to the 2015 SPR Management plan, “it would be desirable to plant an insectary hedgerow windbreak between the Green House and Scotts Creek to create habitat for beneficial insects and reduce wind damage”. The management plan also recommends establishing perennial grasses, sedges and rushes for the drainage ditches in the crop fields to provide additional corridors between other natural habitat areas and potentially use for seed harvest.

There are opportunities to plant hedgerows along the edge of southern fields 2, 8 and northern field Mill Creek, and plant a long shelterbelt (shaded fuel break) along Swanton road from field 6 to field 2 (Table 7 and Figure 20).

*Table 7. Proposed location and extent for new hedgerows and shelterbelts (shaded fuel breaks) along SPR crop fields*

<table>
<thead>
<tr>
<th>Proposed hedgerow/shelterbelt</th>
<th>Linear Distance (ft)</th>
<th>Width (ft)</th>
<th>Area (ac)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hedgerow – Mill Creek field</td>
<td>175</td>
<td>8</td>
<td>0.03</td>
</tr>
<tr>
<td>Hedgerow – Jacobs Field 2</td>
<td>820</td>
<td>8</td>
<td>0.15</td>
</tr>
<tr>
<td>Hedgerow – Jacobs Field 7-8</td>
<td>500</td>
<td>8</td>
<td>0.09</td>
</tr>
<tr>
<td>Shelterbelt – Swanton Rd</td>
<td>3,900</td>
<td>6</td>
<td>0.53</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td></td>
<td><strong>0.8</strong></td>
</tr>
</tbody>
</table>

**Cover Cropping and Prescribed Grazing**

Prescribed grazing is proposed as a seasonal practice to be used in conjunction with cover crop rotations on crop fields 1-8. Using livestock to graze down crop residue, followed by a non-edible cover crop is one option. Another one is using livestock to graze down a standing cover

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\(^7\) [http://www.fao.org/climatechange/41819-03264614a79a4ddfb96dcde71df193a1d.pdf](http://www.fao.org/climatechange/41819-03264614a79a4ddfb96dcde71df193a1d.pdf)

\(^8\) [http://nfs.unl.edu/documents/windbreaklivestock.pdf](http://nfs.unl.edu/documents/windbreaklivestock.pdf)
crop, followed by a long-maturing edible crop. The main challenge here will be to respect food safety requirements, which can be done with acceptable harvest time intervals (at least 120 days post-grazing). These management activities fall under the description of two NRCS Conservation Practice Standards (CPS): Cover Crop (CPS 340) and Prescribed Grazing (CPS 528).

![Image of SPR map highlighting carbon farming opportunities and linked cropland management activities (within focus area of this CFP)](image)

**Figure 20. SPR map highlighting carbon farming opportunities and linked cropland management activities (within focus area of this CFP)**

**Carbon Benefits from Proposed Cropland Management Practices**

Carbon benefits from proposed cropland management practices result from: a) capture and storage of carbon in the soil and plant biomass, and b) avoided CO₂ emissions from ceasing propane flaming for weed control. Together, all the proposed practices have an estimated total carbon benefit of 68 tonnes CO₂eq/yr, which if maintained over 20 years would accrue a total of 1,356 tonnes CO₂eq (Table 8). There are also potentially significant carbon benefits from recycling vegetation residue (orchard and windbreak trimmings; harvested riparian vegetation) to produce compost on-site and reduce the amount of compost that is outsourced, but those benefits are not calculated in this plan.
Table 8. Summary of new recommended cropland management practices within the SPR CFP scope area and associated carbon benefits.

<table>
<thead>
<tr>
<th>Proposed Activity</th>
<th>NRCS CPS</th>
<th>Area</th>
<th>Annual CO₂ benefit (MT of CO₂eq/yr)</th>
<th>Accrued CO₂ benefit over 20yrs (MT of CO₂eq)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduced till (crop fields 1-6)</td>
<td>Reduced Till (345)</td>
<td>65ac</td>
<td>7</td>
<td>140</td>
</tr>
<tr>
<td>Hedgerows along edge of southern fields 2, 8 and northern field Mill Creek (1495ft x 8ft = 11,960sqft = 0.27ac)</td>
<td>Hedgerow Planting (422)</td>
<td>0.27ac</td>
<td>1</td>
<td>20</td>
</tr>
<tr>
<td>Intercropping cash crops with rows of perennials that can also yield marketable products (apple orchard and fields 3&amp;5)</td>
<td>Alley Cropping (311)</td>
<td>0.3ac</td>
<td>1</td>
<td>20</td>
</tr>
<tr>
<td>Shelterbelts / shaded fuel breaks along Swanton Rd (3,900ft x 12ft = 23,400sqft = 1ac)</td>
<td>Windbreak / Shelterbelt Establishment (380)</td>
<td>1ac</td>
<td>5</td>
<td>100</td>
</tr>
<tr>
<td>Paludiculture (Scotts Creek riparian buffer)</td>
<td>Critical Area Planting (342)</td>
<td>6ac</td>
<td>11</td>
<td>220</td>
</tr>
<tr>
<td>Recycle orchard trimmings as on-site mulch (apple orchard)</td>
<td>Mulching (484)</td>
<td>4ac</td>
<td>1</td>
<td>20</td>
</tr>
<tr>
<td>Recycle windbreak / shelterbelt trimmings and harvested riparian vegetation to produce on-site compost</td>
<td>NA</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Replace flame cultivator with alternative weed control method (avoided emissions from ceased propane flaming)</td>
<td>NA</td>
<td>10ac</td>
<td>5.8</td>
<td>116</td>
</tr>
<tr>
<td>Augment frequency and planting density of cover crops, including Summer cover crops</td>
<td>Cover Cropping (340)</td>
<td>65ac</td>
<td>34</td>
<td>680</td>
</tr>
<tr>
<td>Use livestock to graze down cover crops and/or crop residue on crop fields 1-8 (Jacobs Farms Fields)</td>
<td>Prescribed Grazing (528)</td>
<td>65ac</td>
<td>2</td>
<td>40</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td>68</td>
<td></td>
<td>1,356</td>
</tr>
</tbody>
</table>
SUMMARY OF SPR CARBON FARMING PRACTICES BY FIELD

North Fields

North Fields
Proposed Practices:
- Wetland Restoration – NRCS CPS 657
- Forage and Biomass Planting – NRCS CPS 512
- Prescribed Grazing – NRCS CPS 528
- Hedgerow Planting – NRCS CPS 422
- Alley Cropping – NRCS CPS 311

Forage and Biomass Planting will be integrated to Wetland Restoration to produce plant biomass that captures and stores carbon, and can be managed through prescribed grazing rotations during dry periods to build soil carbon and other benefits.

There is also an idea of using the top half of this field to establish a new orchard (though not the preferred option).

This field is not suitable for groundwater recharge (according to MAR suitability map developed by UCSC hydrogeology team), but could potentially store more water with increases in soil organic matter.
Proposed Practices:

- **Alley Cropping** — NRCS CPS 311
- **Hedgerow** — NRCS CPS 422
- **Mulching** — NRCS CPS 484

**Alley Cropping** is defined as: “planting trees or shrubs in sets of single or multiple rows with agronomic, horticultural crops or forages produced in alleys between sets of woody plants that produce additional products”. SPR staff prefers alley cropping over hedgerows for this field, and would prefer plants that have a marketable value (e.g. rosemary, lavender, elderberry), while offering multiple eco-services (carbon, pollinators, insectary, etc.). This is a highly visible and marketable area of the ranch, which offers an opportunity to highlight multi-purpose management practices. Adding legumes to orchard floor grasses can also have carbon benefits.

Orchard trimmings can be processed and applied (recycled) as mulch.

Proposed practices:

- **Reduced Till** — NRCS CPS 345 (fields 1-6)
- **Hedgerow Planting** — NRCS CPS 422 (fields 28&8)
- **Alley cropping** — NRCS CPS 311 (fields 38&5)
- **Riparian Herbaceous Cover** (restoration) — NRCS CPS 390 (fields 5-8)
- **Riparian Forest Buffer** — NRCS CPS 391 (fields 5-8)
- **Prescribed Grazing** — NRCS CPS 528 (fields 1-8)
- **Compost on-site (possible but not preferred)**
- **Cover Cropping (Summer)** — NRCS CPS 340 (fields 1-8)

**Current Tilling practice:**
6 Disk passes, 1 ripper, 1 plow chisel, flame cultivation, flail mowing
Prescribed grazing is proposed as a seasonal practice to be used in conjunction with cover crop rotations on crop fields 1-8. Using livestock to graze down crop residue, followed by a non-edible cover crop is one option. Another one is, using livestock to graze down a standing cover crop, followed by a long-maturing edible crop. The main challenge here will be to respect food safety requirements, which can be done with acceptable harvest time intervals (at least 120 days post-grazing).
Proposed practices:

- Reduced Till – NRCS CPS 345
- Riparian Herbaceous Cover* (Scotts Creek) – NRCS CPS 390
- Riparian Forest Buffer – NRCS CPS 391
- Alley cropping – NRCS CPS 311
- Cover Crop (Summer) – NRCS CPS 340
- Prescribed Grazing – NRCS CPS 528

*Current fence line (along Scotts Creek) would be pushed 50-100ft to allow riparian buffer expansion along a field strip that gets regularly flooded (approx. 2ac). This riparian buffer expansion could be used to grow flood-tolerant plants (Riparian Herbaceous Cover) that can be harvested and marketed, or used on site (paludiculture). Planting herbaceous riparian cover along this strip will also help to reduce water velocity and scouring/eroding power during flood events (which is a current issue).

The existing windbreak can be periodically coppiced and the harvested biomass from tree tops used to incorporate carbon in the soil (as mulch or compost). This would also address current concerns about proximity to power lines and crop shading. On site use of harvested biomass will depend on financial viability (further discussed in the implementation plan).

Proposed practices:

- Reduced Till – NRCS CPS 345
- Riparian Herbaceous Cover (Scotts and Queeseria creeks) – NRCS CPS 390
- Riparian Forest Buffer – NRCS CPS 391
- Cover Crop (Summer) – NRCS CPS 340
- Prescribed Grazing – NRCS CPS 528

Again, fence line (along Scotts Creek) would be pushed 50-100ft to allow riparian buffer expansion along a field strip that gets regularly flooded (approx. 2ac). This riparian buffer expansion could be used to grow flood-tolerant plants (Riparian Herbaceous Cover) that can be harvested and offer marketable value (paludiculture), or could become a new prescribed grazing area. Planting herbaceous riparian cover along this strip will also help to reduce water velocity and scouring/eroding power during flood events.

Queeseria Creek riparian expansion with herbaceous cover (forage/forbs) would be added to existing prescribed grazing area along Queeseria.
Proposed practices:

- Riparian Herbaceous Cover – NRCS CPS 390
- Forage and Biomass Planting – NRCS CPS 512
- Prescribed Grazing – NRCS CPS 528
- Hedgerow – NRCS CPS 422
SUMMARY OF EXISTING AND PROPOSED CARBON BENEFITS

Previously Accomplished Restoration and Existing Cropland Management

Carbon benefits of previously accomplished watershed restoration projects and existing cropland management practices result from carbon capture and storage in the soil and plant biomass. Restoration projects completed between 2004 and 2017 had an estimated combined carbon benefit of 9.2 tonnes CO$_2$eq/yr, which based on the implementation year of each project, have accrued a combined total benefit of 116.7 tonnes CO$_2$eq by 2019 (Table 9). Existing cropland management practices have an estimated combined carbon benefit of 570 tonnes CO$_2$eq/yr. Assuming most of these practices have been in place for at least 20 yrs (the ranch was donated to Cal Poly in 1994), their total accrued carbon benefit by 2019 is 11,400 tonnes CO$_2$eq (Table 9). Altogether, all previously accomplished restoration projects and cropland management practices have accrued an estimated total carbon benefit of 11,517 tonnes CO$_2$eq (Table 9).

Table 9. Summary of annual and accrued carbon benefits from previously accomplished watershed restoration projects and existing cropland management practices.

<table>
<thead>
<tr>
<th>Previously Accomplished Restoration Activity / Existing Cropland Management Practice</th>
<th>NRCS CPS</th>
<th>Area</th>
<th>Annual CO2 benefit (MT of CO2eq/yr)</th>
<th>Accrued CO2 benefit by 2019 (MT of CO2eq)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cropland retirement and Queseria riparian restoration</td>
<td>Riparian Forest Buffer (391)</td>
<td>4ac</td>
<td>7</td>
<td>105</td>
</tr>
<tr>
<td>Riparian revegetation (Queseria and Mill Creeks)</td>
<td>Critical Area Planting (342)</td>
<td>0.4ac</td>
<td>0.4</td>
<td>4.4</td>
</tr>
<tr>
<td>Riparian revegetation (Queseria and Scotts Creeks)</td>
<td>Critical Area Planting (342)</td>
<td>0.35ac</td>
<td>0.35</td>
<td>1.75</td>
</tr>
<tr>
<td>Riparian revegetation (Archibald and Scotts Creeks)</td>
<td>Critical Area Planting (342)</td>
<td>1.28ac</td>
<td>1.28</td>
<td>5.12</td>
</tr>
<tr>
<td>Riparian revegetation (Scotts Creek)</td>
<td>Critical Area Planting (342)</td>
<td>0.21ac</td>
<td>0.21</td>
<td>0.42</td>
</tr>
<tr>
<td>Previous Restoration Subtotal</td>
<td></td>
<td></td>
<td>9.2</td>
<td>116.7</td>
</tr>
<tr>
<td>No-till farming (apple orchard)</td>
<td>Tillage Management No Till (CPS 329)</td>
<td>4ac</td>
<td>1</td>
<td>20</td>
</tr>
<tr>
<td>Crop rotation that limits fallow periods (Jacobs Farm fields)</td>
<td>Conservation Crop Rotation (CPS 328)</td>
<td>65ac</td>
<td>17</td>
<td>340</td>
</tr>
<tr>
<td>Crop rotation that includes cover crops every year (Jacobs Farm fields)</td>
<td>Cover Crop (CPS 340)</td>
<td>69ac</td>
<td>34</td>
<td>680</td>
</tr>
<tr>
<td>Compost application (Jacobs Farm fields)</td>
<td>NA</td>
<td>50ac</td>
<td>206</td>
<td>5,140</td>
</tr>
<tr>
<td>Mulch application for weed control (Jacobs Farm fields)</td>
<td>Mulching (CPS 484)</td>
<td>20ac</td>
<td>312</td>
<td>20,280</td>
</tr>
<tr>
<td>Existing Cropland Subtotal</td>
<td></td>
<td></td>
<td>570</td>
<td>11,400</td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td></td>
<td>579</td>
<td>11,517</td>
</tr>
</tbody>
</table>
New Proposed Restoration and Cropland Management Activities

Carbon benefits from proposed restoration and cropland management practices result from: a) carbon capture and storage in the soil and plant biomass, and b) avoided CO₂ emissions from ceasing propane flaming for weed control. The proposed restoration activities combined have an estimated total carbon benefit of 29 tonnes CO₂eq/yr, which if maintained over 20 years would accrue a total of 576 tonnes CO₂eq (Table 10). The proposed cropland management practices combined have an estimated total carbon benefit of 68 tonnes CO₂eq/yr, which if maintained over 20 years would accrue a total of 1,356 tonnes CO₂eq (Table 10). Natural weed control (such as mulch) to replace propane-based flaming could add to that number. There are also potentially significant carbon benefits from recycling vegetation residue (orchard and windbreak trimmings; harvested riparian vegetation) to produce compost on-site and reduce the amount of compost that is outsourced, but those benefits are not calculated in this plan. Altogether, the proposed restoration and cropland management activities combined have the potential to accrue a total of 1,932 tonnes CO₂eq if maintained over 20 years (Table 10).

Table 10. Summary of annual and expected carbon benefits (potentially accrued over 20 years) from new proposed watershed restoration and cropland management practices. Carbon benefits are estimated with COMET Planner as approximate Carbon Sequestration and Greenhouse Gas Emission Reductions (Metric Tonnes CO₂ equivalent per year)

<table>
<thead>
<tr>
<th>Proposed Restoration or Cropland Management Activity</th>
<th>NRCS CPS</th>
<th>Area</th>
<th>Annual CO₂ benefit (MT of CO₂eq/yr)</th>
<th>Accrued CO₂ benefit over 20yrs (MT of CO₂eq)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scotts Creek riparian buffer expansion along crop fields 5-8</td>
<td>Riparian Forest Buffer (391)</td>
<td>6ac</td>
<td>10</td>
<td>200</td>
</tr>
<tr>
<td>Wetland restoration (Squirrel Flats field)</td>
<td>Wetland Restoration (657) / Critical Area Planting (342)</td>
<td>3ac</td>
<td>6</td>
<td>120</td>
</tr>
<tr>
<td>Forage and biomass planting for prescribed grazing (Squirrel Flats &amp; field 7-8)</td>
<td>Forage and Biomass Planting (512)</td>
<td>15ac</td>
<td>4</td>
<td>80</td>
</tr>
<tr>
<td>Invasive species removal and riparian re-vegetation (Scotts Creek)</td>
<td>Critical Area Planting (342)</td>
<td>6ac</td>
<td>6.3</td>
<td>126</td>
</tr>
<tr>
<td>Invasive species removal and riparian re-vegetation (Scotts Creek)</td>
<td>Mulching (448)</td>
<td>3ac</td>
<td>1</td>
<td>20</td>
</tr>
<tr>
<td>Queseria Creek riparian expansion</td>
<td>Critical Area Planting (342)</td>
<td>0.5ac</td>
<td>0.5</td>
<td>10</td>
</tr>
<tr>
<td>Archibald Creek riparian restoration and re-vegetation</td>
<td>Critical Area Planting (342)</td>
<td>1ac</td>
<td>1</td>
<td>20</td>
</tr>
<tr>
<td><strong>Proposed Restoration Subtotal</strong></td>
<td></td>
<td></td>
<td><strong>29</strong></td>
<td><strong>576</strong></td>
</tr>
<tr>
<td>Proposed Restoration or Cropland Management Activity</td>
<td>NRCS CPS</td>
<td>Area</td>
<td>Annual CO2 benefit (MT of CO2eq/yr)</td>
<td>Accrued CO2 benefit over 20yrs (MT of CO2eq)</td>
</tr>
<tr>
<td>-----------------------------------------------------</td>
<td>----------</td>
<td>------</td>
<td>-------------------------------------</td>
<td>------------------------------------------</td>
</tr>
<tr>
<td>Reduced Till (crop fields 1-6)</td>
<td>Reduced Till (345)</td>
<td>65ac</td>
<td>7</td>
<td>140</td>
</tr>
<tr>
<td>Hedgerows along edge of southern fields 2, 8 and northern field Mill Creek (1495ft x 8ft = 11,960sqft = 0.27ac)</td>
<td>Hedgerow Planting (422)</td>
<td>0.27ac</td>
<td>1</td>
<td>20</td>
</tr>
<tr>
<td>Intercropping cash crops with rows of perennials that can also yield marketable products (apple orchard and fields 3&amp;5)</td>
<td>Alley Cropping (311)</td>
<td>0.3ac</td>
<td>1</td>
<td>20</td>
</tr>
<tr>
<td>Shelterbelts / shaded fuel breaks along Swanton Rd (3,900ft x 12ft = 23,400sqft = 1ac)</td>
<td>Windbreak / Shelterbelt Establishment (380)</td>
<td>1ac</td>
<td>5</td>
<td>100</td>
</tr>
<tr>
<td>Paludiculture (Scotts Creek riparian buffer)</td>
<td>Critical Area Planting (342)</td>
<td>6ac</td>
<td>11</td>
<td>220</td>
</tr>
<tr>
<td>Recycle orchard trimmings as on-site mulch (apple orchard)</td>
<td>Mulching (484)</td>
<td>4ac</td>
<td>1</td>
<td>20</td>
</tr>
<tr>
<td>Recycle windbreak / shelterbelt trimmings and harvested riparian vegetation to produce on-site compost</td>
<td>NA</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Replace flame cultivator with alternative weed control method (avoided emissions from ceased propane flaming)</td>
<td>NA</td>
<td>10ac</td>
<td>5.8</td>
<td>116</td>
</tr>
<tr>
<td>Augment frequency and planting density of cover crops, including summer cover crops</td>
<td>Cover Cropping (340)</td>
<td>65ac</td>
<td>34</td>
<td>680</td>
</tr>
<tr>
<td>Use livestock to graze down cover crops and/or crop residue on crop fields 1-8 (Jacobs Farms Fields)</td>
<td>Prescribed Grazing (528)</td>
<td>65ac</td>
<td>2</td>
<td>40</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Proposed Cropland Management Subtotal</th>
<th>68</th>
<th>1,356</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOTAL</td>
<td>97</td>
<td>1,932</td>
</tr>
</tbody>
</table>
CONCLUSION

There is significant potential for additional GHG reduction and terrestrial carbon capture in the currently active cropland (75 acres) at Swanton Pacific Ranch. Through implementation of the watershed restoration and cropland management practices described above, an estimated 1,932 tonnes CO$_2$e could be sequestered in soils in above- and below-ground biomass over 20 years. Proposed restoration and cropland management practices include: riparian buffer expansion; removal of invasive plant species and revegetation with natives; hedgerow and shelterbelt plantings; reduced tillage; augmenting cover crop frequency and planting density; identifying and adopting alternative practices for weed control so that propane flaming can be discontinued; intercropping cash crops with perennial vegetation (alley cropping) that can yield additional marketable products; and planting forage and biomass for prescribed grazing along riparian buffers and on certain cropland fields. Currently, reduction of the number of tillage passes is a significant opportunity. This could perhaps be done if a roller-crimper were deployed. In that case, incorporation may or may not be necessary if crimp-kill has been successful and planting can be done with a furrow/slice type implement. Overall, the combination of tillage/non-tillage/mulch vs incorporation, etc. is very crop and site specific and the grower needs the flexibility to make the appropriate choice for the conditions at hand. Ideally, soils should be covered at all times if possible. In the meantime, even eliminating one pass would be a step in the right direction. There is also potential for additional on-farm carbon capture over this period through the harvesting and recycling of riparian buffer vegetation and tree pruning clippings (from hedgerows, shelterbelts, windbreaks and orchards) for on-site production of compost and mulch to be reapplied to croplands.

Monitoring and Record Keeping

Practice monitoring (riparian revegetation, hedgerow and shelterbelt plantings survival, cropland management implementation, cover cropping, compost/mulch applications, etc.) should be carried out in coordination with annual inspections by SPR staff and/or project managers from Cal Poly, Santa Cruz RCD or any other organizations involved in project implementation. Soil carbon and other ecosystem services should be monitored in accordance with market or voluntary protocol requirements (if applicable). Baseline data and records of implementation activities, including locations, extent of project(s), dates of implementation, etc., should all 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 (2019). They likewise may be revised as evaluation techniques are refined.
Recommended Action Plan

Because the scope of the Carbon Farm Plan is extensive, practices are likely to be implemented over time, based upon GHG and co-benefits, available funds, and ranch priorities. Table 11 provides a framework for prioritizing and recording Carbon Farm Plan practices as they are implemented, as well as potential funding sources. Practices are listed in the order of suggested priority.

*Table 11. SPR carbon farming practices prioritization and recordkeeping framework and potential funding sources*

<table>
<thead>
<tr>
<th>CONSERVATION PRACTICES</th>
<th>LOCATION &amp; EXTENT</th>
<th>CO2e BENEFIT</th>
<th>ASSOCIATED BENEFITS</th>
<th>Funding Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>NRCS Conservation Practice Standard &amp; Associated Number</td>
<td>Identify Location (see CFP Map) &amp; Monitoring Photo Points</td>
<td>Calculated Using: COMET-Farm, COMET-Planner, or Local Data</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Soil Health</td>
<td>Water Quality</td>
</tr>
<tr>
<td>Shaded Fuelbreak (Shelterbelt, CPS 380)</td>
<td>Shaded fuelbreak along Swanton Rd, 1.5 acres</td>
<td>COMET-Planner</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Critical Area Planting (CPS 342) and Prescribed Grazing (CPS 528)</td>
<td>Scotts, Queseria and Archibald Creeks</td>
<td>COMET-Planner</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Windbreak Renovation (650)</td>
<td>Coppice and chip willow windbreak / shelterbelt. Use chips as mulch or for compost</td>
<td>COMET-Planner and C-content of material</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Mulching (484)</td>
<td>Recycle orchard trimmings as on-site mulch (apple orchard, 4 acres)</td>
<td>COMET-Planner or see windbreak renovation</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Riparian Forest Buffer (391)</td>
<td>Scotts Creek riparian buffer expansion along crop fields 5-8 (6 acres)</td>
<td>COMET-Planner</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Alley Cropping (311)</td>
<td>Intercropping cash crops with rows of perennials that can also yield marketable products (apple orchard and fields 3&amp;5) (0.3 acres)</td>
<td>COMET-Planner</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>---------------------</td>
<td>-------------------------------------------------------------------------------------------------</td>
<td>---------------</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Cover Cropping (340)</td>
<td>Augment frequency and planting density of cover crops up to 65 ac</td>
<td>COMET-Planner</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Reduced Till (345)</td>
<td>Reduced till (crop fields 1-6) up to 65 ac</td>
<td>COMET-Planner</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>
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APPENDIX A

Description of Referenced NRCS Conservation Practice Standards (CPS)

Alley Cropping – NRCS CPS 311

Definition
Trees or shrubs are planted in sets of single or multiple rows with agronomic, horticultural crops or forages produced in the alleys between the sets of woody plants that produce additional products.

Purpose
• Enhance microclimatic conditions to improve crop or forage quality and quantity
• Reduce surface water runoff and erosion
• Improve soil health by increasing utilization and cycling of nutrients
• Alter subsurface water quantity or water table depths
• Enhance wildlife and beneficial insect habitat
• Increase crop diversity
• Decrease offsite movement of nutrients or chemicals
• Increase carbon storage in plant biomass and soils
• Develop renewable energy systems
• Improve air quality

Conservation Crop Rotation – NRCS CPS 328

Definition
A planned sequence of crops grown on the same ground over a period of time (i.e. the rotation cycle), designed to decrease fallow frequency and/or add perennial crops to rotations.

Purpose
This practice is applied to support one or more of the following purposes:
• Reduce sheet, rill and wind erosion
• Maintain or increase soil health and organic matter content
• Reduce water quality degradation due to excess nutrients
• Improve soil moisture efficiency
• Reduce the concentration of salts and other chemicals from saline seeps
• Reduce plant pest pressures
• Provide feed and forage for domestic livestock
• Provide food and cover habitat for wildlife, including pollinator forage, and nesting

Cover Crop – NRCS CPS 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

**Critical Area Planting – NRCS CPS 342**

**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

**Forage and Biomass Planting – NRCS CPS 512**

**Definition**
Establishing adapted and/or compatible species, varieties, or cultivars of herbaceous species suitable for pasture, hay, or biomass production.

**Purpose**

- Improve or maintain livestock nutrition and/or health
- Provide or increase forage supply during periods of low forage production
- Reduce soil erosion
- Improve soil and water quality
- Produce feedstock for biofuel or energy production

**Hedgerow Planting – NRCS CPS 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

Mulching – NRCS 484

Definition
Applying plant residues or other suitable materials to the land surface.

Purpose
This practice is applied to achieve the following purpose(s):
• Improve the efficiency of moisture management
• Reduce irrigation energy used in farming/ranching practices and field operations
• Improve the efficient use of irrigation water
• Prevent excessive bank erosion from water conveyance channels
• Reduce concentrated flow erosion
• Reduce sheet, rill, & wind erosion
• Improve plant productivity and health
• Maintain or increase organic matter content
• Reduce emissions of particulate matter

Prescribed Grazing – NRCS CPS 528

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
Residue and Tillage Management: No Till – NRCS CPS 329

**Definition**
Limiting soil disturbance to manage the amount, orientation and distribution of crop and plant residue on the soil surface year around.

**Purpose**
- Reduce sheet, rill and wind erosion and excessive sediment in surface waters
- Reduce tillage-induced particulate emissions
- Maintain or increase soil health and organic matter content
- Increase plant-available moisture
- Reduce energy use
- Provide food and escape cover for wildlife

Residue and Tillage Management: Reduced Till – NRCS CPS 345

**Definition**
Managing the amount, orientation, and distribution of crop and other plant residue on the soil surface year-round while limiting soil-disturbing activities used to grow and harvest crops in systems where the field surface is tilled prior to planting.

**Purpose**
- Reduce sheet, rill, and wind erosion and excessive sediment in surface waters (soil erosion)
- Reduce tillage-induced particulate emissions (air quality impact)
- Improve soil health and maintain or increase organic matter content (soil quality degradation)
- Reduce energy use (inefficient energy use)

Riparian Forest Buffer – NRCS 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
Riparian Herbaceous Cover – NRCS CPS 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

Wetland Restoration – NRCS CPS 657

**Definition**
The return of a wetland and its functions to a close approximation of its original condition as it existed prior to disturbance on a former or degraded wetland site.

**Purpose**
To restore wetland function, value, habitat, diversity, and capacity to a close approximation of the pre-disturbance conditions by restoring:

- Conditions conducive to hydric soil maintenance
- Wetland hydrology (dominant water source, hydroperiod, and hydrodynamics)
- Native hydrophytic vegetation (including the removal of undesired species, and/or seeding or planting of desired species)
- Original fish and wildlife habitats

Windbreak / Shelterbelt Establishment – NRCS CPS 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