HUICHICA CREEK SUSTAINABLE DEMONSTRATION VINEYARD

CARBON FARM PLAN

NAPA COUNTY RCD
Resource Conservation District

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Introduction

In response to the rapid pace of global climate change, the North Coast Regional Resource Conservation Districts in partnership with other local resource organizations are working to engage agricultural producers as ecosystem stewards to provide on-farm ecological benefits, improve agricultural productivity, enhance agroecosystem resilience, and mitigate global climate change through a planning and implementation process known as "Carbon Farming."

Carbon can be beneficially stored long-term (decades to centuries or more) in soils and vegetation through biological carbon sequestration. Carbon Farming involves implementing on-farm practices that are known to improve the rate at which a given land area can support photosynthetically-driven transfer of carbon dioxide (CO2) from the atmosphere to plant productivity and/or soil organic matter. Enhancing agroecosystem carbon, whether in plants or soil, is known to drive beneficial changes in other system attributes, including soil water holding capacity, hydrological function, soil fertility, biodiversity, ecosystem resilience and agricultural productivity.

Carbon entering the farm from the atmosphere ends up in one of three locations: in the harvested portion of the crop, in the soil as soil organic matter, or in standing carbon stocks on the farm, such as woody perennials or other permanent vegetation such as windbreaks or riparian vegetation or other perennial vegetation. While all farming is completely dependent upon atmospheric carbon dioxide in order to produce its products, different farming practices, and different farm designs, can lead to very different amounts of carbon capture on the farm.

The Carbon Farm Planning Process

The Carbon Farm Planning (CFP) process differs from other approaches to agriculture by focusing on *increasing* the capacity of the farm or ranch to capture carbon and to store it beneficially as soil organic matter and/or standing carbon stocks in permanent vegetation. While most modern agriculture results in a gradual loss of carbon from the farm system, CFP works 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, such as soil organic matter, perennial plant roots and standing woody biomass, carbon farming results in a direct reduction in the amount of carbon dioxide in the atmosphere.

On-farm carbon in all its forms (soil organic matter, living and dead plant and animal material), represents 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 availability for the growing crop. Consequently, the CFP process views carbon as the single most important element, upon which all other on-farm processes depend. Carbon Farm Planning (CFP) is similar to Conservation Planning, but uses carbon and carbon capture as the organizing principle around which the Plan is constructed. This both 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 farm productivity.

Like the NRCS Conservation Planning Process, CFP begins with an overall inventory of natural resource conditions on the farm or ranch. Through that process, opportunities for enhanced carbon capture by both plants and soils are identified. Building this list of opportunities is a brainstorming process and is as extensive as possible, including everything the farmer and the planners can think of that could potentially sequester carbon on the farm. Financial considerations should not limit the brainstorming process. A map of the ranch is then developed, showing all potential carbon capture opportunities and practices and their locations on the ranch.

Next, needs and goals for the farm and economic considerations are used to filter the comprehensive list of options. The carbon benefits of each practice, if actually applied at the farm scale, are quantified using the USDA greenhouse gas model, COMET-Farm, COMET-Planner, or similar tool, and data sources, to estimate tons of carbon dioxide equivalent (CO2e) 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 greenhouse gas mitigation offset credits, USDANRCS 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 or point of reference.

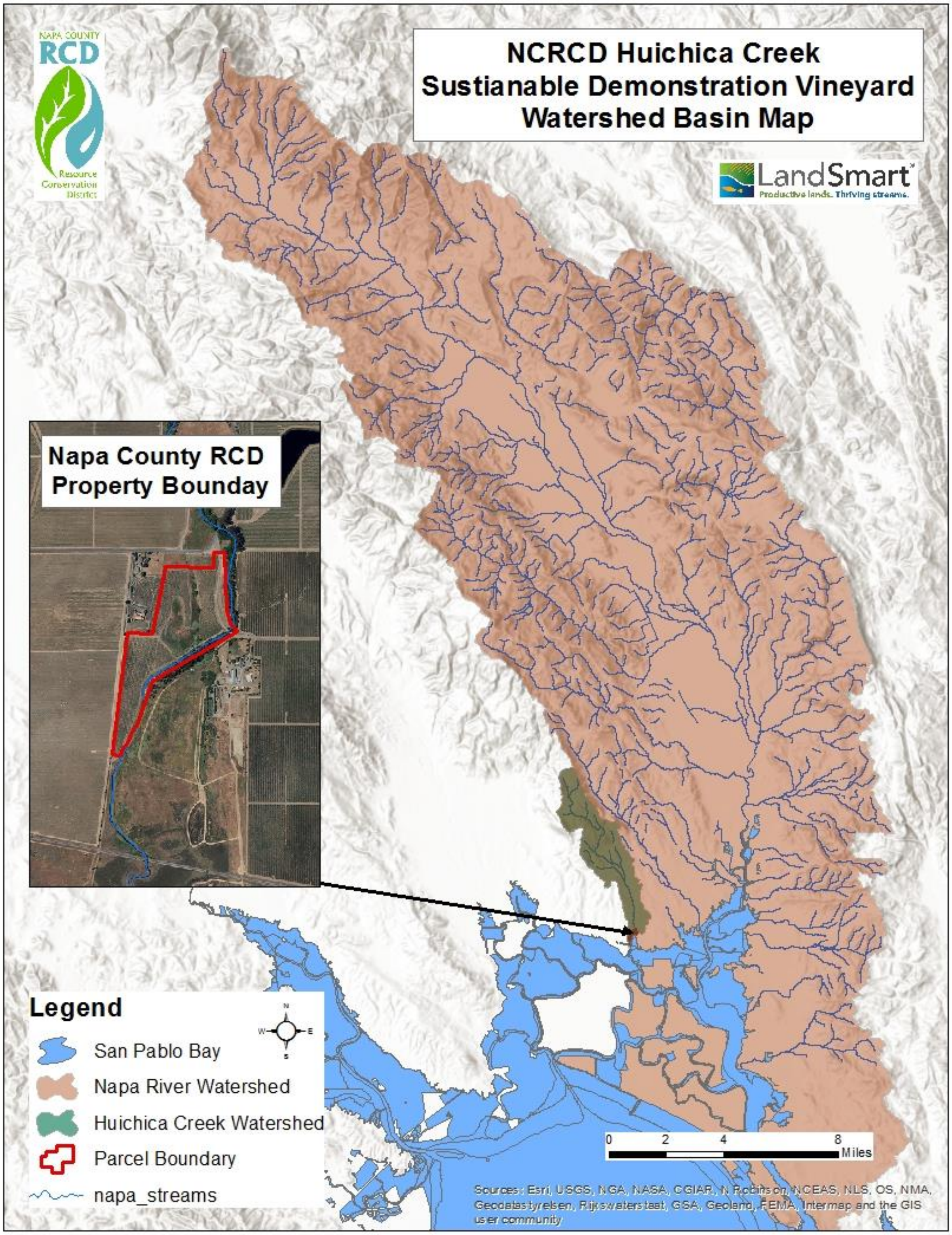
Huichica Creek Sustainable Demonstration Vineyard

The Huichica Creek Sustainable Demonstration Vineyard (HCV) is located in the Carneros AVA region of southwest Napa County. As the name of the vineyard implies, the property is within the Huichica Creek Watershed and Huichica Creek flows through the property. Huichica Creek is a salmon-bearing stream, and is home to many water fowl and migratory birds. HCV borders the Napa Marsh State Wildlife Area and was purchased by the Napa County Resource Conservation District in 1990 via a grant from the State Coastal Conservancy and the State Wildlife Conservation Board. The parcel is 21 acres total with 14 acres of existing vineyard planted to Pinot Noir and Chardonnay and 6 acres of riparian and wetland habitat. The philosophy and management plan of the vineyard property has been to combine sustainable conservation farming techniques with wetland enhancement and riparian restoration. The primary goal of the demonstration, as originally conceived, was to demonstrate cost effective vineyard practices that protect water quality and produce high quality wine grapes, to encourage broad adoption of such practices, and to provide education and assistance to growers and landowners. Beginning in 2015, the vineyard has been implementing programs funded by the

NRCS to develop the vineyard property as a demonstration site of drought resilient and climate mitigation farming practices.

Prior to RCD acquisition, the land had been intensively grazed and farmed for hay production for more than a generation. Adjacent reaches of Huichica Creek and seasonal wetland habitat areas within the parcel had been impacted significantly. Stream channelization, removal of riparian vegetation, draining and modification of the wetlands accompanied the historical agricultural operations within the Lower Huichica Creek Watershed. Since purchase of the property, the RCD has planted a demonstration vineyard, utilized conservation farming practices recommended by NRCS, and restored 1/2 mile of riparian habitat and over 4 acres of wetland habitat. The vineyard has served as a demonstration model for diverse cover cropping systems and conservation tillage practices that have been adopted around the Napa Valley and has further demonstrated the compatibility of riparian and wetland habitat in a productive vineyard setting.

Map. 1 Huichica Creek Vineyard Watershed Basin



Huichica Creek Vineyard Soil

The soil series at Huichica Creek Vineyard is Haire Loam, soil mapping unit 145 in the Napa County Soil Survey, USDA-SCS, 1978. The Haire soil is an Ultisol, a soil that is characteristic of a moist-warm climate, with an accumulation of clay minerals in the B horizon. The Haire loam soil at the vineyard property is characterized by silt loam and silty-clay loam in the top 18-24 inches, and heavy clay-argillic B horizons from 24 – 40 inches, and sandy clay loam 40+ inches in the C horizons. Soil analysis conducted in block F of the ranch resulted in a pH range from 6.6-7.0. Soil structure is sub-angular blocky to blocky in the A-horizons and columnar to prismatic in the B horizons. Percent organic matter content ranges from 4.8% in the A horizon to 2.8% in the B horizons, and organic carbon ranges from 2.8 % to 1.63% in the A and B horizon, respectively.

Permeability is generally slow in Haire loam soils. The effective rooting depth is generally 60 inches or more. The available water holding capacity is 3-6 inches. The soil gravel content varies throughout the property. Areas that have a high to extremely high gravel content will have greater permeability and a reduction in water holding capacity, compared to the areas with no gravel. In general, the water holding capacity is at the higher range as a result of abundant organic matter and a high clay content. The site frequently floods during large winter storm events, however, anaerobic soil conditions and mottling were not found in two soil pit analyses.

Soil resource issues as a result of vineyard production

Currently, throughout the majority of the vineyard, the soil within the drip zone, has high pH (7.9), moderately-high Sodium Adsorption Ration (SAR - 5.3), and higher than desirable sodium percentage (6.7%) occupying the cation exchange sites. These issues are caused by the well water quality, which has high pH, 8.2, and a very high adjustable SAR of 10.0. These issues are high enough to negatively impact plant growth, and low yields and poor plant health are notable throughout the vineyard, and many of the symptoms are characteristic of plant stress due to sodium. When SAR is high (generally 12+), soil physical problems arise and crops have difficulty absorbing water. In addition, there is substantial compaction issues in the non-tillage alleyways (cover crop middles).

Existing and Historical Carbon Beneficial Practices

Since the inception of the Huichica Creek Sustainable Demonstration, the Napa County RCD has restored and planted riparian vegetation on 1/2 mile of Huichica creek and allowed natives to establish naturally. Many non-native plants exist within the riparian zone, and the vineyard cover crop alleys and under the vine have many non-native weed species intermixed with the intentional cover crop. Below is an inventory of native riparian species provided by the Napa NRCS.

Tree		**Herbaceous**	
Aesculus californica	California buckeye	*Artemesia douglasiana*	Mugwort
Fraxinus latifolia	Oregon ash	*Bromus carinatus*	California brome
Juglans hindsii	Black walnut	*Conium maculatum*	Poison hemlock
Populus fremontii	Fremont cottonwood	*Elymus triticoides*	Creepign wild rye
Quercus lobata	Valley oak	*Foeniculum vulgare*	Fennel
Salix exigua	Sandbar willow	*Galium aparine*	Bedstraw
Salix laevigata	Red willow	*Juncus balticus*	Baltic rush
Salix lasiolepis	Arroyo willow	*Lepidium latifolium*	Perennia pepperweed
		Phalaris aquatica	Harding grass
Shrub		*Poa annua*	Annual blue-grass
Sambucus mexicana	Blue elderberry	*Raphanus sativa*	Wild radish
		Rumex crispus	Curly dock
		Salicornia pacifica	Pickleweed
		Schoenoplectus acutus?	Common tule
		Scrofularia californica	Bee plant
		Sonchus oleraceus	Annual sow thistle
		Typha sp.	Cattail

Four acres of wetland habitat was also restored from pastureland to native woody and herbaceous perennial cover. There is also a large population of non-native herbaceous vegetation that has colonized sections of the wetland.

Tree		**Herb**	
Salix laevigata	Red Willow	*Eleocharis macrostachya*	Creeping spike-rush
Salix lasiolepis	Arroyo willow	*Elymus triticoides*	Creeping wild rye
Shrub		*Epilobium brachycarpum*	Willow herb
Baccharis pilularis	Coyote brush	*Frankenia salina*	Alkali heath

	Pleuropogon californicus	Annual semaphorgrass

In addition, approximately 1700 square feet of native shrubs, sedges, forbs and wildflowers have been established as a hedgerow in the Northern corner of the property. Native species include, Redbud, Ceanothus, CA Coffeeberry, Toyon, Elderberry, Santa Barbara Sedge, Ribes, Sages, Penstemon, Santa Barbara Sedge, CA Yarrow, and CA Poppy.

Since the inception of the project in 1991, fourteen acres of pastureland has been planted to vineyard. Initially, the RCD attempted to farm all 14 acres under non-tillage practices. Due to poor vigor issues in some blocks, tillage was incorporated in every other row over a portion of the property. Approximately 11 acres are farmed in alternate row tillage, where the tillage rows are annually tilled and the permanent no-till rows remain untilled. The tillage rows are annually seeded with a standard plow-down green manure cover crop, which is disked and incorporated into the soil each spring. A diverse permanent ground cover has been established in the non-tillage rows. Many species include Zorro Fescue, Blando Brome, clovers native CA annuals, and CA perennial bunch grasses were attempted with limited success. Approximately 3 acres of vineyard has been under non-tillage practices for the lifetime of the vineyard and the permanent cover cropping efforts were very similar to the non-tillage rows in the alternate tilled vineyard blocks.

Left Photo; Huichica Creek riparian corridor in 1991 when the RCD purchased the property. Right Photo: Huichica Creek Riparian corridor from the same angle in December 2016.

Considering the carbon benefits of the restoration efforts and implemented soil health farming practices, using metrics from COMET-PLANNER and research, an estimated potential of 117.97 tons of CO2e has been sequestered or mitigated as a greenhouse gas per year. Table 1. below breaks down each practice and the estimated carbon dioxide reduction equivalent in metric tons per acre.

Figure 1. Estimated Carbon Sequestration and Greenhouse Gas Emission Reductions per year between 1991 – 2015.

Huichica Creek Sustainable Demonstration Farm Approximate Carbon Sequestration and Greenhouse Gas Emission Reductions 1991-2015 (tons CO2 equivalent per year)

NRCS Conservation Practice	Acres	Carbon Dioxide (CO_2) Per Acre Per Year	Nitrous Oxide (N_2O) Per Acre Per Year	Methane (CH_4) Per Acre Per Year	1yr - Metric tons CO_2e Reduction	20yrs - Metric Tons of $C0_2e$ Reduction
* Riparian Restoration (CPS 390)	4.70	*n/a	*n/a	0.00	76.80	1535.96
Conventional Tillage to Reduce Tillage (CPS 345)	11.00	0.13	0.07	0.00	2.20	44.00
Conventional Tillage to No Tillage (CPS 329)	3.00	0.42	-0.11	0.00	0.93	18.60
Cover Crop Establishment (CPS 340)	14.00	0.32	0.05	n/a	5.18	103.60
Nutrient Management - Repalce Synthetic N Fertilizers with Soil Ammendments (CPS 590)	14.00	1.75	n/a	0.00	24.50	490.00
Wetland Restoration (CPS 657)	4.00	1.81	0.28	n/a	8.36	167.20
				Totals	**117.97**	**2359.36**

* Values generated from "Mitigating Greenhouse Gas Emissions through Riparian Revegetation", Lewis et al 2015. 16.34 MT CO2e/acre
All other values estimated by COMET-Planner USDA, 2014

Carbon Farm Plan Proposed Goals and Objectives

- Increase soil organic carbon to enhance, or improve the following
    - Improve cover crop productively and rooting depth
        - Convert tillage areas to non-tillage
    - Improve soil available water holding capacity
    - Reduce compaction and improve soil infiltration
    - Potentially buffer pH and Na issue in the drip zone (along with water treatment)
    - Enhance drought resiliency of vineyard and reduce irrigation inputs
- Enhance riparian, wetland vegetation, and insectary habitat

- Increase grapes yields to an average 4 ton/ acre.

Huichica Creek Sustainable Demonstration Vineyard Future Potential Carbon Beneficial Practices and Anticipated Outcomes

1. Riparian Restoration (NRCS Practice 390)
   Locations along the creek banks that are devoid of large riparian trees and shrubs will be planted and composed of species that are currently existing and thriving within the property riparian corridor. An estimated 2.76 acres of additional riparian acreage will be planted. At a rate of 16.34 tons of CO2e per acre per year, implementation of these practices provides for an estimated 901.97 tons of CO2e sequestered over a 20-year period (Lewis et al, 2015).

2. Hedgerow Planting (NRCS Practice 422)
   Approximately 0.15 acres of hedgerow planting is proposed along the main vineyard access road and Block F. At rate of 1.7 tons of CO2e per acre per year, an estimated 0.19 tons per year could be sequestered. Over a 20-year period there is a potential to sequester a total of 3.8 tons CO2e (COMET-Planner USDA, 2014).

3. Conventional tillage to Non-tillage (NRCS Practice 329)
   Currently 4 acres of vineyard are tilled annually. Current tillage practices include 2-3 disk cultivations to a depth of 10 inches for incorporating a green manure cover crop and reducing weed competition. At a rate of 0.31 tons of CO2e per acre per year for the practice of converting 4 acres from reduced tillage to non-tillage, an estimated 24.80 tons of CO2e could be sequestered over a 20-year period (COMET-Planner USDA, 2014).

4. Compost Application (NRCS Practices 484)
   Application of ¼ " of compost to 14 acres of vineyard. With the assumption that ¼ inch application of compost per acre is roughly 17 tons/ acre compost, and 25% of the compost mass composed of carbon, we estimate a potential 15.6 tons of C02e will be sequestered as result of each application. Application will occur every 3 years, with a total of 6 applications in 20 years, results in a total potential of 1310.4 tons of C02e could be sequestered. (17 tons compost is approximately 4.25 tons of carbon. One metric ton of soil carbon is equal to 3.67 metric tons of C02e).

5. Permanent Cover Crop Establishment (NRCS Practice 327)
   Conservation Cover metrics are used to quantify the transition from a plow down cover crop to a permanent no-till cover crop. The use of this metric also assumes enhanced productivity of the permanent cover crop that is already established. At a rate of 1.26 tons of CO2e per acre per year, a potential of 100.8 tons of CO2e could be sequestered in a 20-year period (COMET-Planner USDA, 2014).

6. Mulch Application (NRCS CPS 484)
   All vine row strips, the base of orchard trees, and hedgerows will be mulched with wood-based or straw based material. All vines that are extracted for replant, will be chipped, composed for one year, and applied as mulched throughout the property. We estimate approximately 4 acres of land will receive mulch application. At rate of 0.32 tons of C02e per acre per year, an estimated 25.60 tons CO2e will be sequestered over a 20-year period (COMET-Planner USDA, 2014).

7. Multistory Cropping (NRCS Practice 379)
   Approximately ¾ acre of grapes is being converted to a mixed apple orchard which will have an understory managed to replicate an oak-woodland savanna. Native plant populations will be established to the highest degree feasible. At rate of 1.71 tons of CO2e per acre per year, on ¾ acre an estimated 26.1 tons CO2e will be sequestered over a 20-year period (COMET-Planner USDA, 2014).

8. Windbreak / Shelterbelt Establishment (NRCS Practice 380)
   Remove one ¼ mile length row of vines in replant and establish a shelterbelt on at the windward fence line. At a rate of 2.09 tons of C02 per acre per year, an estimated 20.90 tons of C02 could be sequestered over a 20-year period (COMET-Planner USDA, 2014).

9. Wetland Restoration and Enhancement (NRCS 657)
   The restoration proposal includes incorporating large shrubs and small trees of the perimeters, and planting wetland grasses in the more prominent inundated locations. Using windbreak (CPS 380) metrics, at rate of 2.09 tons of C02 per acre per year, an estimated 167.20 tons of C02 could be sequestered over a 20 – year period.

Table 2 estimates the additional carbon sequestration and GHG emission reduction potential from the implementation of the NRCS Conservation Practices listed above. Using COMET-PLANNER and published regional research, we estimate a potential of 66.22 tons of CO_2 equivalent sequestered or mitigated as greenhouse gas emissions per year for the entire property. COMET-Farm Tool will be used to quantify actual changes as projects are implemented.

Figure 2. Estimated Annual Carbon Sequestration and Greenhouse Gas Emission Reductions Associated with Implementation of Suggested Conservation Practices.

Huichica Creek Sustainable Demonstration Farm Approximate Carbon Sequestration and Greenhouse Gas Emission Reductions 2016 - Future (tons CO2 equivalent per year)

NRCS Conservation Practice	Acres	Carbon Dioxide (CO_2) Per Acre Per Year	Nitrous Oxide (N_2O) Per Acre Per Year	Methane (CH_4) Per Acre Per Year	1yr - Metric tons CO_2e Reduction	20yrs - Metric Tons of $C0_2$e Reduction
* Riparian Restoration (CPS 390)	2.76	*n/a	*n/a	0.00	45.10	901.97
Hedgerow Planting (CPS 422)	0.15	1.42	0.28	0.00	0.26	5.10
Conventional Tillage to No Tillage (CPS 329)	4.00	0.42	-0.11	0.00	1.24	24.80
Permenant Cover Crop Establishment (CPS 327)	4.00	0.98	0.28	n/a	5.04	100.80
**Compost Application (CPS 484)	14.00	15.60	n/a	0.00	218.40	1310.40
Mulching (CPS 484)	4.00	0.32	n/a	n/a	1.28	25.60
Multistory Cropping (CPS 379)	0.75	1.71	0.03	0.00	1.31	26.10
Windbreak/ Shelterbreak Establishment (CPS 380)	0.50	1.81	0.28	n/a	1.05	20.90
Wetland Restoration (CPS 657)	4.00	1.81	0.28	n/a	8.36	167.20
				Totals	**282.02**	**2582.87**

* Values generated from "Mitigating Greenhouse Gas Emissions through Riparian Revegetation", Lewis et al 2015. 16.34 MT CO2e/acre

** Assumption: 6 application of 1/4 inch compost in 20 yrs. 17 tons compost = 15.6 MT C02e reduction/acre/yr
All other values estimated by COMET-Planner USDA, 2014

Below, Map 3 spatially identifies current land use practices and proposed conservation practices that have been identified by the NRCS to result in carbon sequestration and or greenhouse gas reduction. Table 3 illustrates the relative potential impact each practices is estimated to have, as a proportion to each other.

MAP. 2 Carbon Farm Plan Map

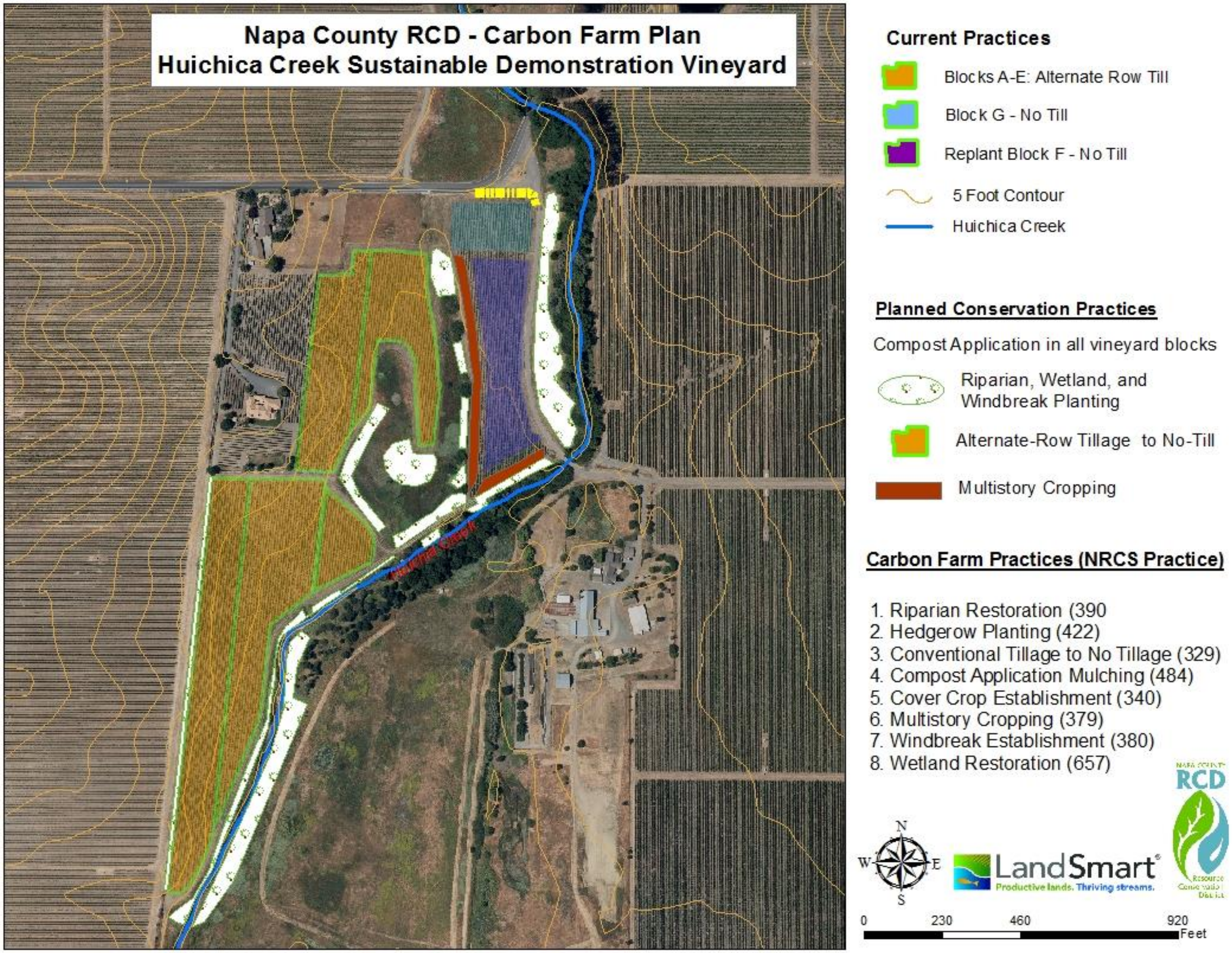
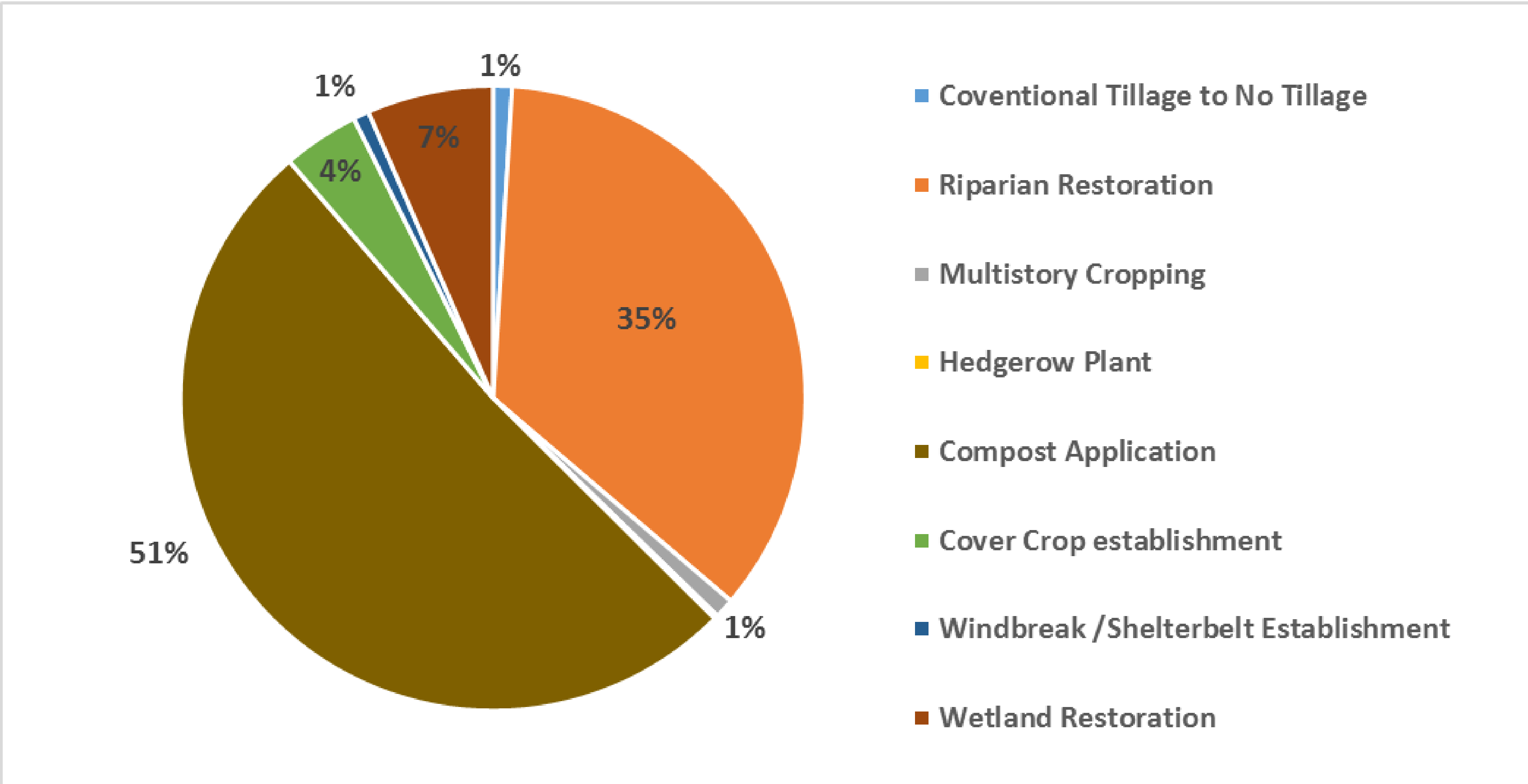


Figure. 3 Relative Impact of Proposed NRCS Conservation Practice Standards



By analyzing the potential carbon sequestration as a relative proportion of each proposed practice from the pie chart we can see that the most effective conservation practices for capturing carbon at the Huichica Creek vineyard is through compost application. Riparian restoration has the second greatest potential, followed by wetland restoration.

Soil-Water and Carbon Connection

The Natural Resource Conservation Service suggests that a 1% increase in soil organic matter (SOM) results in an increase in soil water holding capacity of approximately 1-acre inch, or 27,152 gallons of increased soil water storage capacity per acre. A 1% increase in SOM represents roughly 20,000 pounds of organic matter, or 5 short tons of organic carbon.

An estimated 7 acre feet of additional water storage capacity associated with soil carbon increases at Huichica Creek Vineyard property can result from the implementation of the Carbon Farm Plan. After 20 years of implementation of each proposed practice, the assumption can be made that there will be a potential to store 7 more acre feet of water, every year in the top soil.

Additional Climate Beneficial Practices with Potential Carbon Sequestration and Emission Reduction Impacts

Biochar

Six tons of biochar has been applied within the vine row and incorporated to a depth of 6 inches to 1.5 acres in block F. Although currently, there is no accepted C-sequestration or C02e reduction quantification of biochar, many farmers, agencies, resources organizations, and academic researchers are recognizing biochar has a soil amendment that has many benefits to soil health and is a significant carbon amendment that may lead to additional soil carbon sequestration for decades. An estimated potential of 26.5 metric tons C02e reduction per acre per year, has been calculated using the CAPCOA GHG Rx Protocol, with an application rate of 4 tons of biochar to the acre, to all 14 agricultural acres at HCV.

Sheep grazing management plan

Grazing sheep throughout the vineyard during the vine dormancy season can have many beneficial impacts to reducing carbon emissions, and potentially contribute to building organic matter in the soil, enhancing the site soil carbon storage. The sheep grazing would reduce our need for mowing, herbicide application under the vine, and under the vine mechanical weed cultivation. Currently, 2-3 tractor passes are made each year to mow the vineyard cover crop, one pass for herbicide application under the vine, and an additional 1-2 passes with in under the vine cultivator for organic weed management. This is a total of 4-6 tractor passes per year, that potentially could be eliminated. The production and shipping of herbicide alone has a carbon life cycle that could be considered in the CO_2e reduction calculations. In addition, sheep excrement throughout the vineyard may reduce the need for compost and fertilizer applications, further reducing the carbon footprint of the operation.

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