Carbon Farming
Increasing Carbon Capture on California’s Working Lands

Photo by Paige Green

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Earth is a (bio)chemical battery where, over evolutionary time with a trickle-charge of photosynthesis using solar energy, billions of tons of living biomass were stored in forests and other ecosystems and in vast reserves of fossil fuels.

In just the last few hundred years, humans extracted exploitable energy from these living and fossilized biomass fuels to build the modern industrial-technological-informational economy, to grow our population to more than 7 billion, and to transform the biogeochemical cycles and biodiversity of the earth. This rapid discharge of the earth’s store of organic energy fuels the human domination of the biosphere, including conversion of natural habitats to agricultural fields and the resulting loss of native species, emission of carbon dioxide and the resulting climate and sea level change, and use of supplemental nuclear, hydro, wind, and solar energy sources.

The laws of thermodynamics governing the trickle-charge and rapid discharge of the earth’s battery are universal and absolute; the earth is only temporarily poised a quantifiable distance from the thermodynamic equilibrium of outer space. Although this distance from equilibrium is comprised of all energy types, most critical for humans is the store of living biomass.

With the rapid depletion of this (bio)chemical energy, the earth is shifting back toward the inhospitable equilibrium of outer space with fundamental ramifications for the biosphere and humanity. Because there is no substitute or replacement energy for living biomass, the remaining distance from equilibrium that will be required to support human life is unknown.

California—and the world—can only meet our GHG reduction goals by investing in our soils and working lands as major sinks for atmospheric carbon.

“A large fraction of anthropogenic climate change resulting from CO2 emissions is irreversible on a multi-century to millennial time scale, except in the case of a large net removal of CO2 from the atmosphere over a sustained period.”

– IPCC (2014)

The black line shows simulated decomposition of the compost following application to grassland soils. Gray circles show the monthly change in total ecosystem carbon, not including compost carbon. Values are averages across site characterizations, with standard error bars in light gray. Ryals et al, 2015. Ecological Applications, 25(2): 531–545.
What does Carbon Farming look like?

Clockwise from top left: stream restoration, planting of native trees and perennials (2), compost application on rangeland.
Riparian Carbon: The 4,419 metric tons of accrued carbon at the 1 km representative riparian restoration site, offsets the energy used by 1,478 homes or emissions from 3,411 passenger cars in one year.
How to Create a Carbon Farm Plan & Estimate Your Carbon Potential

Each agroecosystem offers unique GHG emission reduction and sequestration opportunities. A Carbon Farm Plan may include both, but focuses on carbon sequestration potential in soils and vegetation.

WHERE TO BEGIN?
1. Know your producer’s objectives
2. Understand your producer’s operations
3. Know your producer’s landscape
4. Understand your producer’s interest in Carbon Farming.

GENERAL FACTORS
- Resource Concerns
- Vegetation Types
- Special Status Species
  - Vegetation, Wildlife, Invasive Species
- Ecological Sites
  - Slope
  - Aspect
  - Soil
  - Elevation

EXAMPLES OF SITE-SPECIFIC FACTORS
- Erosion/ Sedimentation
- Coastal Scrub Protection/ Encroachment
- Oak Woodland Recruitment
- Bird Habitat
- Salmonid Habitat
- Invasive plants
- Slope ≥ 30% (Compost?)
- Soil C/OM

TOOLS FOR VIEWING THE AGRO-ECOSYSTEM THROUGH A CARBON LENS
- Ranch Maps
- Google Earth
- Web Soil Survey
- Ground Reconnaissance
- Producer input
- GIS
- Comet-Planner/Farm
CONTENTS OF A CARBON FARM PLAN

• Introduction
• The Carbon Farm Planning Process
• Ranch History
• Land Use
• Carbon Capture Potential
• Ecological Site Delineation
• Soils
• Grazing Plan
• Conservation Easement
• Potential Carbon Beneficial Practices
• Quantification of Greenhouse Gas Benefits of Plan Implementation (COMET-Farm and COMET-Planner results, CSU 2014, etc.)
• Summary
• Discussion
• Conclusion
• Monitoring and Record Keeping
• References
SOIL DATA

http://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm
SLOPE MAP FROM WEB SOIL SURVEY

Mechanical Treatment suitability used as a surrogate for slope.

Map used to determine accessibility for tractor driven compost equipment.
SLOPE MAP (DEM)

VEGETATION MAP
SOIL ORGANIC MATTER (SOM/2=SOC)
PRIORITY COMPOST APPLICATION SITES

Based on slope, access and baseline SOM

Estimated total = 635 acres
CRITICAL AREA PLANTINGS

Total Acres: 25.55

Top: Aerial Assessment (Google Earth), Right: Ground Truth
RIPARIAN SYSTEMS

Riparian Forest Buffer: 38 acres (Comet-Planner)
Riparian Restoration: 27 acres (2.3 stream miles)
(Quantification per D. Lewis et al, UCCE 2015)
OTHER POTENTIAL CARBON BENEFICIAL PRACTICES

Prescribed Grazing: 766 acres
Windbreak Establishment: 10.78 acres (+)
Silvopasture Trial: 2.73 acres (+)
Using Comet Farm Planner to estimate your carbon potential

LOCAL DATA IF AVAILABLE:
UCCE Creek Carbon: D. Lewis et al 2015
Land Reclamation – Currently Mined Land
(Conservation Practice Standard 544)

NRCS Practice Information
DEFINITION: Reclamation of currently mined land to an acceptable form and planned use.

PURPOSE:
• Prevent negative impacts to soil, water and air resources in and near mined areas
• Restore the quality of the soils to their premining level
• Maintain or improve landscape visual and functional quality

CONDITIONS WHERE PRACTICE APPLIES:
This practice applies to currently mined land. It includes the identification, removal, stockpiling and replacement of soil materials, and revegetation. This practice also applies to nearby non-mined areas adversely affected by the mining activities.

COMET-Planer Practice Information
COMET-Planner estimates for reclamation of mined land are constructed from two scenarios. For dry/semiarid climates, the assumption is herbaceous planting and soil carbon changes are estimated using cropland set-aside literature. For moist/humid climates, the assumption is woody planting and biomass carbon sequestration and soil carbon changes were estimated using values from tree/shrub establishment.

Approximate Carbon Sequestration and Greenhouse Gas Emission Reductions *

<table>
<thead>
<tr>
<th>Practice</th>
<th>Climate zone</th>
<th>Carbon Dioxide (Mg CO₂ eq ac⁻¹ y⁻¹)</th>
<th>Nitrous Oxide (Mg CO₂ eq ac⁻¹ y⁻¹)</th>
<th>Methane (Mg CO₂ eq ac⁻¹ y⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land Reclamation – Currently Mined Land (CP 544)</td>
<td>Dry/semiarid</td>
<td>1.05 (0.68 – 1.40)</td>
<td>Not estimated</td>
<td>Not estimated</td>
</tr>
<tr>
<td></td>
<td>Moist/humid</td>
<td>1.90 (1.02 – 3.65)</td>
<td>Not estimated</td>
<td>Not estimated</td>
</tr>
</tbody>
</table>

*Positive values indicate reductions in greenhouse gas emissions and negative values indicate increases in greenhouse gas emissions. In moist/humid climates, woody biomass carbon estimates were derived from empirical models of woody biomass carbon accumulation in NRCS agroforestry prescriptions that used tree growth increment data from the U.S. Forest Service Forest Inventory and Analysis (FIA) program and allometric equations to allocate biomass carbon to tree components (Paustian et al. 2012, Merwin et al. 2009). Only herbaceous planting was assumed for dry/semiarid climates. Soil organic carbon estimates were based on North America sandy soils (Eve et al. 2014) as a proxy for disturbed soils. These estimates are not meant to apply to any specific site conditions but rather represent the range of expected values to be found over broadly defined climate regions and conditions and reflect the assumptions stated.

Links to NRCS Practice Standard Summary Information
COMET-Planner
Carbon and greenhouse gas evaluation for NRCS conservation practice planning

A companion report to
www.comet-planner.com

http://comet-planner.nrel.colostate.edu/COMET-Planner_Report_Final.pdf
CALCULATED CARBON POTENTIAL

Estimated CO2e Sequestration Potential:
Average Annual = 1,193.5 MT
20 Year = 45,063 MT
If the state’s combined 46 million acres of grasslands, pastures and arable lands achieved even a modest 1% increase in SOC in the plow layer alone, the associated water holding capacity increase would be roughly 6.6 million acre feet and the CO2e sequestered would be 1.5 Billion tonnes.

Assumptions:
• Based on the plow layer (top 6.7” of soil) only; including deeper soil strata will increase potentials accordingly;
• 1% increase in SOM results in 1 acre-inch increase in soil water holding capacity;
• 1% increase in SOM represents 0.5% increase in SOC;
• 1 metric ton (2,200 lbs) of soil C represents 3.67 metric tons of CO2e;
• 1% increase in (plow layer only) SOC is about 10 short tons or 9 metric tons SOC/acre.

Good News:
California, and the World, can meet our GHG reduction goals if we dramatically reduce emissions and invest in our soils and working lands as major sinks for atmospheric carbon.