Carbon Cycle Institute

Memo

April 26, 2022

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Mendocino County Agricultural Climate Assessment - DRAFT

Introduction

The Carbon Cycle Institute (CCI), a California 501(C)3 organization with extensive climate science, policy, and planning experience in the agricultural sector, was asked to review and provide guidance on Mendocino County's efforts to quantify agricultural greenhouse gas (GHG) emissions and opportunities to advance climate-beneficial agricultural management practices. This document is intended to provide a broader context around agricultural climate action planning and emphasizes the many ecosystem service benefits provided by agricultural land stewardship. Because livestock grazing is identified as the primary source of agricultural emissions in Mendocino County, we offer a more detailed discussion of the nature of biogenic methane emissions and the role of livestock grazing as both a source of emissions and as an important tool for landscape carbon management and conservation more generally.

What is agriculture's role in climate change?

Each year, agricultural lands both emit greenhouse gasses (GHGs) into the atmosphere and draw down and sequester carbon dioxide (CO_2) from the atmosphere through photosynthesis. Sources of GHGs from agricultural lands include CO_2 from decomposition of plant biomass and soil organic matter, nitrous oxide from nitrogen fertilizer use, and methane from decomposition of plant biomass and soil organic matter in low-oxygen environments, such as cow stomachs and water-logged soils. CO_2 is sequestered through plant photosynthesis and stored in the form of plant biomass and soil organic matter. Other sources of GHGs from agricultural operations include combustion emissions from fossil fuel-powered farm equipment such as tractors and irrigation pumps.

Most sectors of the economy are net GHG emitters. Agriculture is the one sector, however, that can balance out or offset its own emissions through adoption of management regimes and practices that minimize GHG emissions while maximizing carbon sequestration in soils and perennial plants. Climate-beneficial agricultural management practices such as reduced tillage, cover cropping, replacement of synthetic fertilizers with compost, hedgerow and riparian plantings, etc., also provide important co-benefits that support healthy functioning ecosystems and on-farm climate resilience.

> ***Carbon Farming*** *is a whole farm approach to optimizing carbon capture on working landscapes by implementing practices that are known to improve the rate at which* ***CO_2*** *is removed from the atmosphere and stored in plant material and/or soil organic matter. Carbon farming is successful when carbon gains resulting from enhanced land management and/or conservation practices exceed carbon losses from the operation.*[1]

Ecosystem service benefits of agricultural lands

Agricultural lands are a mix of natural habitats and managed lands that provide a multitude of important environmental, public health, and economic benefits, including recharge for groundwater and instream flows, wildlife and pollinator habitat, scenic and recreational areas, sustenance for human populations, and a critical economic base for rural communities. Our natural and working lands play a fundamental role in regulating our climate by removing carbon dioxide from the atmosphere and storing it as carbon in soils, trees, shrubs, and wetlands. At the same time, natural and working lands are often the first to experience the impacts of climate change. With its long history of land use change and climate stresses, California's natural and working lands and the critical ecosystem services they provide, including their ability to sequester carbon from the atmosphere, are increasingly at risk.[2]

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[1] Carbon Cycle Institute 2021. What is Carbon Farming? https://www.carboncycle.org/what-is-carbon-farming/

[2] California Environmental Protection Agency, California Natural Resources Agency, California Department of Food and Agriculture, California Air Resources Board and California Strategic Growth Council. 2019. California 2030 Natural and Working Lands Climate Change Implementation Plan, January 2019 Draft. https://ww2.arb.ca.gov/resources/documents/nwl-implementation-draft

Protecting agricultural lands and increasing the adoption of climate-smart land management practices are core components of the State's climate strategy. To achieve the deep GHG reductions needed to avoid the most catastrophic impacts of climate change, the State of California is committed to boldly increasing its efforts to conserve, restore, and manage natural and working lands. The State's 2021 Budget alone provided $1.1 billion over two years for sustainable agriculture investments that support climate-smart agriculture, including $85 million for the California Department of Food and Agriculture (CDFA) Healthy Soils Program.[3]

Since 2016, California has invested over $123 million through the Department of Conservation's *Sustainable Agricultural Lands Conservation Program* to assist communities, including Mendocino County, in valuing and protecting the ecosystem service benefits, particularly climate regulation, of agricultural lands. According to the Department of Conservation, this level of investment in agricultural land protection could reduce the State's GHG emissions by 39.5 million metric tons of CO_2 over 30 years.[4]

> *"California's natural and working lands—our forests, rangelands, farms, wetlands, coast, deserts, and urban greenspaces—sustain our economy, support our unique biodiversity, contribute to the global food supply, support outdoor heritage and provide clean water and air." Governor Newsom, Executive Order N-82-20* [5]

California's farmers and ranchers have a long history of working with state and federal agencies in enhancing and restoring conservation values on agricultural lands; for instance, integrating pollinator and wildlife habitat into farming operations and, in recent years, enhancing rates of carbon capture and storage through climate-smart management practices. It is important to note that the majority of public sector funding for restoration and conservation of natural resources on private lands is directly tied to agricultural land use and land ownership.

When agricultural land is no longer managed for agricultural production, there are often dramatic declines in land stewardship and landowner access to public sector conservation funding programs. Parcelization of large agricultural properties is also a leading contributor to habitat fragmentation and destruction. Keeping agriculture viable and resilient is as much a conservation strategy as it is an economic development goal.

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[3] State of California, 2021-2022 State Budget, Enacted June 21, 2021. https://www.ebudget.ca.gov/budget/publication/#/e/2021-22/BudgetSummary

[4] California Strategic Growth Council. 2022. Sustainable Agricultural Lands Conservation. https://sgc.ca.gov/programs/salc/vision/

[5] Newsom. 2020. Executive Order N-82-20. https://www.gov.ca.gov/wp-content/uploads/2020/10/10.07.2020-EO-N-82-20-.pdf

Agricultural Climate Action and Resilience Planning in Mendocino County

In 2019, the Mendocino County *Sustainable Agricultural Lands Committee,*[6] in partnership with the Mendocino County Agriculture Department, received a planning grant through the State's Department of Conservation to assess opportunities for agricultural climate mitigation. The planning grant also focused on identifying agricultural lands at highest risk of conversion to urban/residential development, as well as accounting for the GHG emissions impact and carbon loss if those lands were to be developed. A recent study by American Farmland Trust found that, on average, urban areas emit 58 times more GHGs per acre than California's farmland.[7]

The formal agricultural climate action planning process began with an inventory of estimated GHG emissions from agricultural land uses and the identification of climate beneficial management practices that, if widely adopted, would help the sector achieve long-term GHG neutrality, reducing emissions to the extent feasible while maximizing carbon sequestration rates to offset remaining emissions for the sector. Achieving carbon neutrality for a whole sector of the economy, particularly in rural counties, would require substantial public and private sector investments. It is anticipated that the development of a formal agricultural climate action and resilience plan, grounded in stakeholder participation and approval by the agricultural community and county board of supervisors, can be leveraged to secure millions of dollars in federal, state, and local technical assistance and funding support for Mendocino County agricultural producers.

Mendocino County Agricultural Emissions Inventory

As part of this planning study, Ascent Environmental conducted an inventory of the county's agricultural emissions (Table 1). Because no recent comprehensive countywide GHG emissions inventory data are available for Mendocino County, it is impossible to gauge the relative contributions of agriculture GHG emissions compared to other sectors in the county (e.g., transportation, urban/residential, etc.). We do know, however, that the agriculture sector in California accounts for only 7.6 percent of all GHG emissions in the State.[8] GHG emissions of many California counties are similar. For example in Marin County, agriculture accounts for 9 percent of countywide emissions.[9] For comparison, 2010 emissions

[6] Carol, would you like to list members here?

[7] Shaffer, S. and E. Thompson, Jr. 2015. A New Comparison of Greenhouse Gas Emissions from California Agricultural and Urban Land Uses. American Farmland Trust. https://climatechange.lta.org/wp-content/uploads/cct/2015/03/AFTCrop-UrbanGreenhouseGasReport-Feburary2015.Edited-May2015-1.pdf

[8] California Air Resources Board. 2021. California Greenhouse Gas Emissions for 2000 to 2019. https://ww2.arb.ca.gov/sites/default/files/classic/cc/ca_ghg_inventory_trends_2000-2019.pdf

[9] Marin County. 2020. Marin County Unincorporated Area Climate Action Plan 2030. https://www.marincounty.org/-/media/files/departments/cd/planning/sustainability/climate-and-adaptation/draft-climate-action-plan-2030.pdf?la=en

data for Mendocino County[10] indicate that agricultural GHG emissions were well below 10 percent of countywide emissions at that time.

Table 1 2018 Mendocino County Agricultural Sector Greenhouse Gas Inventory. Prepared by Ascent Environmental in 2022.[11]

Agricultural Subsector	2018 Emissions ($MTCO_2e$/year)	Percent of Total Agricultural Emissions
Livestock (Enteric Fermentation)	60,848	79.3
Diesel Irrigation Pumps	8,132	10.6
Livestock (Manure Management)	2,725	3.6
Off-road equipment	2,682	3.5
Fertilizer application	1,401	1.8
Agricultural burning	944	1.2
Total	76,732	100

$MTCO_2e$/year = metric tons of carbon dioxide equivalent per year.

The agricultural emissions inventory found that approximately 79.3 percent of agricultural emissions in the county are associated with enteric fermentation from livestock grazing. This is perhaps not surprising given that grazed rangelands account for over 80 percent of agricultural land in Mendocino County. Direct GHG emissions from farm equipment, including irrigation pumps, represented approximately 14 percent of total emissions from the agricultural sector.

Agricultural GHG Emissions Reduction and Sequestration Measures

The climate action planning process provides a unique opportunity for the agricultural community to play a leadership role in shaping regionally-appropriate climate mitigation and adaptation strategies. By taking a county-wide approach to assessing climate-beneficial agricultural opportunities, participants can develop strategies needed to scale climate beneficial practices, including not only implementation funding but also addressing more systemic needs such as agricultural infrastructure, access to materials like nursery stock and compost, and technical assistance capacity.

[10] Mendocino County Resource Conservation District. 2017. Sustainable Agricultural Lands Strategy. Page 31. https://mcrcd.org/wp-content/uploads/2016/12/SALC-Final-Report_all-10.19.2017.pdf

[11] Ascent Environmental. 2022. Mendocino County Agricultural Sector GHG Emissions 2018 Inventory, Forecasts, and Measures Memorandum.

Importantly, implementation of agricultural mitigation measures in a climate action plan are entirely voluntary. And while adopting specific mitigation measures is not required, working together with county partners and local agricultural organizations to develop cogent agricultural strategies can lead to new funding streams to help producers adapt to and mitigate climate change.

Most of the agricultural practices considered in this study are located on vineyards and orchards (Table 2). In Mendocino County, these are some of the most intensively managed agricultural lands with higher inputs and greater access to water than many other agricultural lands in the county. As such, they represent unique opportunities for intensive climate-beneficial management, from nutrient management to cover cropping and agroforestry. However these lands are only a small proportion of the county's agricultural acres.

Rangelands, which make up a much greater land area in the county, are generally less intensively managed and pose unique challenges for implementing climate-beneficial practices. However, even relatively small per-acre carbon additions can significantly impact forage productivity, ecological health, and, if well managed, act as a net GHG sink.[12] It is therefore recommended that additional consideration be given to appropriate climate-beneficial rangeland practices based on feedback from ranchers and livestock managers across the county.

Table 2. Greenhouse gas emissions reduction and carbon sequestration measures for Mendocino County. Prepared by Ascent Environmental in 2022.[13]

Measure #	Measure description
Carbon Sequestration and Storage	
AG-1	Compost Application
AG-2	Conventional Tillage to Reduced Tillage
AG-3	Conventional Tillage to No-tillage
AG-4	Cover Crop Establishment
AG-5	Alley Cropping
AG-6	Vegetative Barriers
AG-7	Riparian herbaceous cover
AG-8	Riparian Forest Buffer
AG-9	Tree and Shrub Establishment
AG-10	Hedgerow Establishment
AG-11	Silvopastoral practice on pastureland
AG-12	Preservation of Agricultural Lands
AG-13	Support sustainable agriculture programs and climate beneficial farming practices.
AG-14	Support Local Agricultural Businesses
Livestock Management	

[12] Rotz, C. A. 2018. Symposium review: modeling greenhouse gas emissions from dairy farms. *Journal of Dairy Science* 101 (7): 6675–6690.

[13] Ascent Environmental. 2022. Mendocino County Agricultural Sector GHG Emissions 2018 Inventory, Forecasts, and Measures Memorandum.

AG-15	Livestock Manure Management
AG-16	Explore methods to reduce enteric fermentation with feed additives
Farm Equipment	
AG-17	Incentives to switch to Tier 4 equipment
AG-18	Reduce fossil fuel consumption in field equipment
AG-19	Reduce use of fossil fuel consumption in irrigation pumps
Fertilizer Application	
AG-20	Optimize Fertilizer Use
Agricultural Burning	
AG-21	Reduce Agricultural Burning

We propose five additional recommendations for future development of the agricultural measures presented in Table 2:

- Consider opportunities for climate-beneficial practices on rangelands (see above)
- Consider the role of grazing management in fuel reduction and fire prevention in the context of avoided greenhouse gas emissions
- Consider opportunities for windbreaks in addition to hedgerows
- Review assumptions around timing and rollout of practice implementation when quantifying greenhouse gas benefits of practices
- Continue to engage the agricultural community in informing measures, targets and strategies for scaling climate-beneficial practices

The role of livestock grazing in relation to climate change

First, the important ecosystem service benefits, including climate regulation, habitat provision, and food production, provided by California's rangelands are a function of human management (e.g., ranch management) and natural ecosystem processes.[14] Livestock grazing operations are experiencing the effects of climate change first hand and their ongoing productivity and viability as businesses depend on adapting to the changing climate. Extreme drought, catastrophic wildfire, and record-breaking heat are reducing forage production and livestock productivity. At the same time, access to water and rising costs of other inputs are adding further economic strain. Opportunities to increase the economic viability and climate resilience of ranchland are directly tied to the long-term provision of ecosystem services, including carbon sequestration, provided by those lands.

Second, livestock operations are a source of emissions, primarily from the digestive systems of ruminant animals such as cows, sheep and goats (enteric methane) and from their manure (methane and nitrous

[14] Huntsinger, L. and J. L. Oviedo. 2014. Ecosystem services are social–ecological services in a traditional pastoral system: the case of California's Mediterranean rangelands. *Ecology and Society* 19 (1): 8.

oxide). In many rural counties where rangelands make up a majority of agricultural land, such as Mendocino County, the majority of agricultural GHG emissions are from grazing livestock. Although the livestock methane emissions estimated by Ascent Environmental as part of the county assessment are reasonable--estimates based on type and number of livestock in Mendocino County--two important caveats should be taken into consideration:

- Accounting for soil methanotrophs. It is well known that methanotrophic (literally meaning "methane-consuming") microbes at the soil surface play an important role in breaking down methane into CO_2.[15] One study found that methanotrophs in grassland soils reduced the methane emissions from grazing sheep by 3.1–8.6%.[16] However, methane reduction estimates were not included in the inventory due to a lack of regionally specific data.

- Comparing climate impacts of methane with CO_2. In order to compare the climate change impacts of different greenhouse gasses, the IPCC uses standard 100-year global warming factors (GWP_{100}) to convert GHG impacts into a common unit of CO_2 equivalents (CO_2e). The GWP_{100} of methane is 28, meaning that each metric ton of methane emissions is considered to have the same global warming impact as emitting 28 metric tons of CO_2, over a 100 year period. Methane is a potent greenhouse gas, but it does not last long in the atmosphere (12 years for methane versus several hundred years for CO_2), and the relationship between methane emissions over time and its impact on climate change can be very different from that of CO_2.

  Emerging research suggests that using the conventional GWP_{100} to convert livestock methane to CO_2e misrepresents livestock impacts on global temperature and emphasizes that it is changes in the rate of methane emissions that need to be considered in determining long-term warming potentials of methane, rather than simple annual methane emissions.[17] This research suggests that if the number of livestock in a region remains the same over time, the constant rate of methane emissions over time may cause little additional warming because methane produced each year is lost from the atmosphere at the same rate it is added. Utilizing this emergent understanding of methane emissions to evaluate Mendocino livestock methane emissions impacts on global warming would require an analysis of how livestock numbers have changed in Mendocino County over the past several decades.

[15] Murguia-Flores, F., S. Arndt, A. L. Ganesan, G. Murray-Tortarolo and E. R. C. Hornibrook. 2018. Soil methanotrophy model (MeMo v1.0): a process-based model to quantify global uptake of atmospheric methane by soil. *Geoscientific Model Development* 11 (6): 2009–32.

[16] Wang, X., Y. Zhang, D. Huang, Z. Li and X. Zhang. 2015. Methane uptake and emissions in a typical steppe grazing system during the grazing season. *Atmospheric Environment* 105 (March): 14–21.

[17] Allen, M. R., K. P. Shine, J. S. Fuglestvedt, R. J. Millar, M. Cain, D. J. Frame and A. H. Macey. 2018. A solution to the misrepresentations of CO_2-equivalent emissions of short-lived climate pollutants under ambitious mitigation. *NPJ Climate and Atmospheric Science* 1 (1): 1–8.

Third, managed livestock grazing plays a critical role in landscape carbon management.[18] Many of California's grassland soils have been degraded by over two centuries of invasion by annual grasses, presenting a vast opportunity to increase the carbon stored in these soils. Managing the timing and intensity of grazing on grasslands can increase grassland productivity, stimulate the deposition of carbon into the soil, and promote the growth of deep-rooted native and perennial species. Other important practices for both effectively sequestering carbon in grassland soils and increasing forage productivity include establishing perennial grassland species, strategically applying compost to grazed rangelands and using livestock to reduce wildland fire fuels and thus wildfire frequency and intensity. By enabling management of carbon on the landscape, managed livestock grazing on grasslands can more than offset its own emissions.[19]

What other roles does livestock grazing play in the county?

Livestock production is a critical component of the local agricultural economy, second only to fruit and nut crops, with a total annual value of $18,575,700.[20] County ranchland is often the first line of defense in managing wildland fires. Keeping the county's expansive grasslands and oak savannas in actively managed ranchland, with all that that entails, including maintenance of ranch roads, fuel breaks, and grazing and water infrastructure, is a key component of community wildfire protection.[21]

> *"Livestock grazing is the most effective, efficient way to manage California's grasslands on a landscape scale, particularly when the land is being managed with conservation objectives in mind."* [22, 23]

[18] Conant, R. T., C. E. P. Cerri, B. B. Osborne and K. Paustian. 2017. Grassland management impacts on soil carbon stocks: a new synthesis." *Ecological Applications* 27 (2): 662–68.

[19] Teague, W. R., S. Apfelbaum, R. Lal, U. P. Kreuter, J. Rowntree, C. A. Davies, R. Conser, et al. 2016. The role of ruminants in reducing agriculture's carbon footprint in North America. *Journal of Soil and Water Conservation* 71 (2): 156–64.

[20] County of Mendocino Department of Agriculture. 2019. Mendocino County 2019 Crop Report. https://www.mendocinocounty.org/home/showpublisheddocument/41892/637527094835730000

[21] Huntsinger, L. and S. Barry. 2021. Grazing in California's Mediterranean multi-firescapes. *Frontiers in Sustainable Food Systems* 5.

[22] Barry, S., L. Bush, S. Larson and L. D. Ford. 2015. Understanding working rangelands: the benefits of livestock grazing California's annual grasslands. ANR Publication 8517. University of California Agriculture and Natural Resources. https://anrcatalog.ucanr.edu/pdf/8517.pdf

[23] Hunstinger, L., J. W. Bartolome, and C. M. D'Antonio. 2007. Chapter 20: Grazing management of California grasslands; pages 233–253 in J. Corbin, M. Stromberg, and C. M. D'Antonio (eds.), Ecology and management of California grasslands. Berkeley: University of California Press.

Open rangelands, and the streams and rivers that flow through them, provide critical habitat for terrestrial and aquatic species. Leaving these lands unmanaged or removing them from agricultural production would severely limit opportunities for private and public sector investments in their conservation values, including habitat enhancement and restoration, vegetation management, fuels reduction, and carbon sequestration. Livestock grazing is an indispensable tool for landscape stewardship at scale.

Conclusion

California agriculture is already experiencing the effects of global climate change. Local and regional planning efforts, such as the one conducted by the Mendocino County Sustainable Agricultural Lands Committee, to identify at-risk agricultural lands as well as opportunities and strategies to advance regionally-appropriate agricultural climate solutions are a necessary first step in ensuring the continuing viability of agriculture, landscape ecosystem health, and the much-needed climate solutions these working lands have to offer.