Office of Environmental Farming and Innovation
California Department of Food and Agriculture
1220 N Street
Sacramento, CA 95814

December 15, 2017

Re: Conservation Crop Rotation Practice Proposal for Healthy Soils Program

Dear OEFI Staff,

Before the days of cheap and widely available synthetic fertilizers, insecticides, and fungicides, rotating crops was a necessary practice for maintaining soil fertility and reducing pest pressure. Crop rotation is still a core practice of organic agriculture for those reasons. There is broad consensus in the scientific literature that crop rotations have a litany of soil health benefits. An emerging body of evidence suggests that certain crop rotations can have a positive effect on net GHG emissions as well. We propose adding Conservation Crop Rotation as an eligible practice to the Healthy Soils program because the practice offers an opportunity to improve soil health, reduce GHG emissions, and sequester carbon in California's vast acreage of annual crop production, significant portions of which have limited or no crop rotation and/or are seasonally fallowed.

NRCS defines Conservation Crop Rotation (CPS 328) as "a planned sequence of crops grown on the same ground over a period of time… where at least one annually-planted crop is included in the crop rotation." NRCS includes cover crops as a potential crop in a rotation. Conservation Crop Rotation is part of the NRCS's Climate Change Building Blocks and is included in COMET-Planner.

In California, a few examples of crop rotations that would have climate and soil health benefits include:

1. Planting deep rooted crops (e.g. broccoli, brussels sprouts, cabbage, cauliflower, carrots, celery, peppers, or processing tomatoes) after shallow rooted crops (e.g lettuce and spinach)
2. Planting cover crops instead of annual, biennial, or triennial fallowing
3. Extending crop rotations from two crops (e.g. tomatoes-wheat) to three or more crops (e.g. tomatoes-safflower-corn-oats-bean)

In their synthesis of the literature on "Greenhouse Gas Mitigation Potential of Agricultural Land Management in the United States," Eagle et al. (2012) write: "Either diversification—replacing the main crop with a different crop for one or more seasons—or intensification— adding another crop to the annual (or biennial, triennial, and so on) cycle to increase the number of days during which crops are growing—can be used to increase total productivity or otherwise reduce GHG emissions from annual crop rotations."[1] They continue: "Crop species can vary significantly in growth patterns, biomass production, water requirements, and decomposition rates, all of which affect net GHG emissions. Therefore, many rotations could be adapted with alternative species or varieties of annual crops to promote soil C sequestration—increasing root and residue biomass, increasing root exudates, or slowing decomposition—or otherwise reduce emissions."[2] For example, diversification from a monocrop results in an average gain of about 0.04 Mt CO2e/acre/year.[3] In no-till cropping systems, diversified crop rotations can result in significantly higher gain, with soil organic carbon increases of up to 0.3 Mt CO_2/acre/year.[4]

Crop rotations can also be used to address nitrous oxide concerns from excess fertilizer. In 9 out of 10 trials on the Central Coast evaluating the impact of broccoli grown after lettuce, Smith et al. (2017) found that broccoli took up more nitrogen than was applied as fertilizer, effectively scavenging residual nitrate from the soil. [5] They conclude that planting broccoli and other deep rooted vegetable crops (which share a relatively long production season that allows roots to grow to a substantial depth, and modest seasonal N fertilization rates compared to their N uptake capacity) in rotation with shallow rooted, short growing season vegetables like lettuce and spinach (which have limited scavenging ability, and usually receive substantially more fertilizer N than they take up) can improve nitrogen use efficiency and delay and reduce nitrogen leaching. [6] Improving nitrogen use efficiency is one of the most effective ways to reduce nitrous oxide emissions.[7]

Replacing one rotation of a short season vegetable crop with a cover crop, as has been discussed as a strategy for nitrate pollution reduction and groundwater recharge in a pilot project in the Pajaro Valley of Santa Cruz County, would also reduce the GHG emissions associated with farm equipment and groundwater pumping.[8] The authors of the "Rotational Cover Crop Plan Economic Analysis" estimate that the carbon dioxide emissions associated with fuel use by farm equipment and energy use for groundwater pumping are between 12 and 63 times higher for growing a market crop than a cover crop.[9]

Intensification through crop rotations – i.e. keeping plants in the ground and photosynthesizing more days per year – is also a way to improve soil health and sequester carbon. Shorter fallow periods can lead to increased biomass inputs and reduced decomposition rates,[10] which has positive soil carbon implications. In a 10-year cropping study from Texas, Franzluebbers et al. (1998) showed that each additional month of cropping during a year resulted in increased soil organic carbon at a rate of 0.11 Mt CO_2e/acre/year. Sherrod et al. (2003) found that eliminating summer fallowing maximizes carbon sequestration, with soil organic carbon increasing 20% in the 0-10cm depth in a rotational continuous cropping system when compared to a wheat-fallow system.[11]

For dry/semiarid climates, COMET-Planner averages soil carbon sequestration rates from eliminating summer fallow and adding perennial crops to rotations to arrive at an average estimate of 0.26 Mt CO_2e sequestered/acre/year (with a range of -0.18-0.71).[12] COMET-Planner also estimates that nitrous oxide emissions from these practices average to zero. The studies that COMET-Planner uses to arrive at these estimates are largely based in Midwest grain cropping systems and rotations, so the tool would likely need to be refined to reflect California crops and crop rotations. But given the emerging evidence around the climate benefits of the practice, as well as the clear soil health benefits (discussed below), Conservation Crop Rotation merits fine-tuning in the COMET-Planner tool.

Conservation Crop Rotation has myriad soil health and ecological benefits. The NRCS Conservation Practice Standard for Conservation Crop Rotation states that the practice can be applied to support all of the following purposes:

1. Reduce sheet, rill, and wind erosion
2. Maintain or increase soil health and organic matter content
3. Reduce water quality degradation due to excess nutrients
4. Improve soil moisture efficiency
5. Reduce the concentration of salts and other chemicals
6. Reduce plant pest pressures
7. Provide feed and forage for domestic livestock
8. Provide food and cover habitat for wildlife, including pollinator forage, and nesting

One example of the soil health benefits of extended crop rotations comes from the USDA Agricultural Research Service's Farming Systems Project (FSP), which provides long-term comparisons of three organic cropping systems—a two-year, three-year, and six-year organic rotation – and two conventional cropping systems—one utilizing no-till and another utilizing chisel tillage. Results from the project support an association between system performance, soil health, and crop diversity, with lengthening crop rotations improving agronomic, economic and environmental performance.[13]

Another example is from Karlen et al. (2006), which found that extended crop rotations that included at least three years of forage crops in the corn belt of the Midwest had the highest soil quality rating based on a variety of soil health indicators (BD, WSA, pH, TOC, MB-C, and Mehlich extractable P), with total organic carbon being the most sensitive indicator. [14] Based on the results, they concluded that "more diverse and extended crop rotations would improve the sustainability of agriculture throughout the region."[15]

Practicing an appropriate crop rotation is also an effective and practical management tool for reducing pest and disease pressure, especially the root rot pathogens of many crops.[16] Adding broccoli into a strawberry rotation and incorporating the broccoli residue can be an effective tool in the management of Verticillium wilt in both conventional and organic strawberry production systems.[17] Crop rotation has also been shown to be effective in reducing soil inoculum levels of Fusarium wilt in fields planted with lettuce.[18]

Eagle et al. (2012) suggest that "environmental and productivity issues (e.g., weeds, diseases) may provide the greatest incentive for diversification." [19] That may be true, but that incentive alone has thus far failed to sufficiently drive diversification in California annual crop production. Between the well-established soil health benefits of Conservation Crop Rotation, the emerging evidence of climate benefits from cropping intensification and strategic diversification, and the vast acreage in annual crop production in California, we believe Conservation Crop Rotation merits an incentive in the Healthy Soils Program and a refinement of COMET-Planner's tool for California-based GHG benefit quantification.

Sincerely,

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[2] Ibid.

[3] Ibid.

[4] Ibid.

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[9] Ibid.

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