ENHANCING SOIL HEALTH & BIODIVERSITY FOR ON-FARM CLIMATE RESILIENCE

PLATFORM RECOMMENDATIONS AT-A-GLANCE

- **Build on Successes and Lessons Learned in the Healthy Soils and SWEEP Programs**
- **Include an Agriculture Component in the 30x30 Biodiversity Initiative**
- **Catalyze the Widespread Deployment of Hedgerow Installation**

A CLIMATE PLATFORM FOR CALIFORNIA AGRICULTURE

This is one in a series of CalCAN policy briefs that describe approaches to moving California agriculture boldly and quickly toward a carbon-neutral and climate-resilient future. Together, they make up *A Climate Platform for California Agriculture*.

Access the full report at: calclimateag.org/ca-agriculture-climate-platform

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CalCAN
CALIFORNIA CLIMATE & AGRICULTURE NETWORK

INTRODUCTION

In 2022, California's severe multi-year drought conditions led to the fallowing of roughly 750,000 acres of agricultural land.[5] And then early in 2023, historic flooding devastated some of the state's most productive agricultural land, impacting livelihoods, rural communities, and farmworker homes. While this weather whiplash can be a natural occurrence in the arid West, climate change is increasing the severity and accelerating the frequency of these events. These climate impacts are laying bare the vulnerabilities of a highly engineered and aging water system and a decades-long lack of attention to agricultural soil health and biodiversity.

The scientific understanding of soil biodiversity is evolving quickly, as is the understanding of the relationship between soil health, carbon sequestration, and flood and drought resilience. A report called *Soil Biodiversity in California Agriculture*,[6] commissioned by the California Department of Food and Agriculture (CDFA) and released in July 2023, provides a thorough overview of the science of soil biodiversity as well as numerous recommendations for enhancing it. Several of the authors of that report also informed this solution chapter of the CalCAN Platform.

Practices for improving on-farm soil health and on-farm biodiversity—which are closely linked—offer potent, relatively inexpensive, and readily available strategies to help farmers and their neighboring communities cope with both droughts and floods while also mitigating climate change.

Bell bean cover crop at River Garden Farms showing complex root structure that builds soil carbon.

[5] Medellín-Azuara, J., et al. (2022). *Economic impacts of the 2020–22 drought on California agriculture.* Public Policy Institute of California.

[6] CDFA Belowground Biodiversity Advisory Committee. (2023). *Soil biodiversity in California agriculture: Framework and indicators for soil health assessment.*

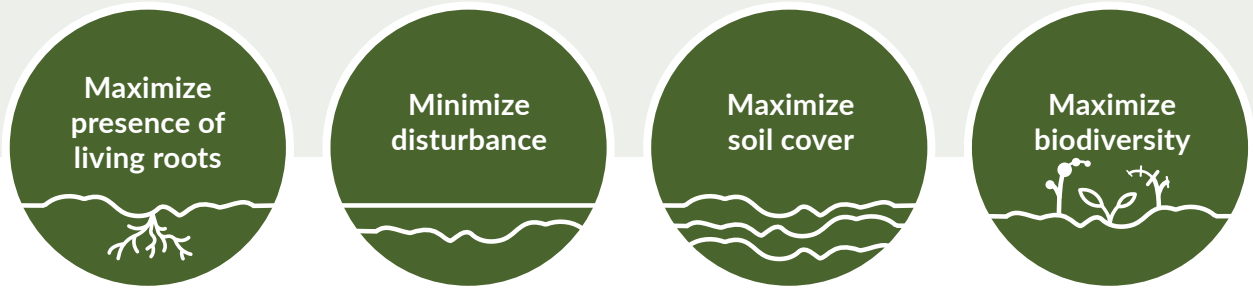
Soil organisms also play a large role in forming soil structure and enabling soil to act like a sponge and hold on to water. This makes more water available to crops during times of water scarcity and can improve water infiltration[7] and groundwater recharge. When heavy rains and floods come, the water is better absorbed by soil rather than eroding valuable topsoil and exacerbating infrastructure damage.[8] Diverse soil and plant communities can promote the formation of soil carbon,[9] reduce nitrogen losses,[10] and help suppress plant and soil pathogens.[11] And in good news for producers, soil health practices can increase profitability, as shown in a recent national study that found an average 42 percent increase in yields and a net farm income increase of $65 per acre.[12]

Increasing on-farm biodiversity using conservation plantings such as hedgerows, riparian buffers, windbreaks, silvopasture, agroforestry, and other conservation plantings also has a role to play in climate resilience and mitigation. All four of the principles for healthy soils (see sidebar) are provided by hedgerows, which also store carbon in their woody tissues. A recent study by UC Davis researchers found that plantings of hedgerows on the edges of farm fields in California can increase soil carbon on farms at a depth of one meter. The researchers offer an indication of how impactful the practice can be, stating that "assuming adoption rates of 50 to 80 percent across California for hypothetical field edges of average-size farms, and an identical soil organic carbon (SOC) sequestration potential across soil types, hedgerows could sequester 10.8 to 17.3 MMT CO2e or 7 to 12 percent of California's annual greenhouse gas reduction goals."[13] These plantings can also help limit erosion and mudslides while providing habitat for wildlife, pollinators, and beneficial insects.

Our interviews helped us to understand how improved soil health and increased biodiversity can provide resilience to drought and floods while also curbing climate change. The interviews also helped us to identify policy tools to scale up farming practices that achieve these co-benefits.

Healthy Soils Principles[14]

Healthy soils can promote soil ecosystem functioning and provide multiple benefits including improved water availability in soils and improved water infiltration. The main principles of soil health management include:



[7] Acevedo, S. E., et al. (2022). How does building healthy soils impact sustainable use of water resources in irrigated agriculture? *Elementa: Science of the Anthropocene, 10(1).*

[8] This NRCS video portrays the soil health benefits for flood control on the organic walnut orchard of farmer Russ Lester: USDA NRCS (2014, June 11). *Cover crops and water infiltration of soil.* AgNet West.

[9] Wagg, C., et al. (2021). *Diversity and asynchrony in soil microbial communities stabilizes ecosystem functioning.*

[10] Bender, S. F., & van der Heijden, M. G. A. (2015). Soil biota enhance agricultural sustainability by improving crop yield, nutrient uptake and reducing nitrogen leaching losses. Journal of Applied Ecology, 52(1).

[11] Schlatter, D., et al. (2017). Disease suppressive soils: New insights from the soil microbiome. Phytopathology, 107(11).

[12] Soil Health Institute. (2023). *Nationwide study on 30 U.S. farms shows positive economic impact of soil health management systems.*

[13] Chiartas, J. L., et al. (2022). Hedgerows on crop field edges increase soil carbon to a depth of 1 meter. *Sustainability, 14*(19).

[14] USDA NRCS. *Principles to manage soil for health.*

FINDINGS

Healthy Soils Increase Flood Protection and Groundwater Recharge

In our interviews with researchers working on agricultural solutions to the climate crisis, we discussed healthy soils as a climate resilience strategy. One researcher stated that "when it comes to floods, soils can really help." Cover crops can have a significant impact on water infiltration and the capture of water in agricultural soils. After two years of research on the benefits of cover crops in vineyards, researchers found deep percolation of water, and they found less nitrate loading in surface water runoff.[15] Improved water infiltration of soils can also contribute to improved groundwater recharge over time. Reduced tillage, plantings of perennial crops, cover crops, diversified crop rotations, as well as organic matter amendments like compost, biochar, and crop residues can improve soil structure and infiltration.[16,17]

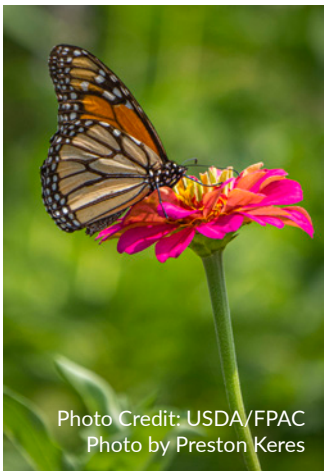
Salvador Prieto applying mulch to avocado and lemon orchards in Somis, CA.

Combining Soil Health and Deficit Irrigation Can Save Water, Improve Drought Tolerance

Our researcher interviewees cautioned that improving soil health as a drought mitigation strategy to achieve water savings is possible but complicated. In areas with sandy soils and low precipitation that start with low levels of soil organic matter (SOM), even a one percent increase in SOM can be challenging. Improved soil health can bolster the ability of soils to hold and retain water, but to reduce water use on irrigated acreage during times of drought, it is important to combine soil health practices with deficit irrigation strategies that delay irrigation without overly stressing crops. For example, in permanent crop systems such as orchards which cannot be fallowed during droughts, compost applications can increase soil water-holding capacity while also reducing evaporation, thereby limiting yield losses.[18]

Increasing On-farm Biodiversity Has Many Benefits but Insufficient State Action

Increasing biodiversity on farms using conservation plantings such as hedgerows and agroforestry can sequester carbon and deliver many co-benefits that create greater climate resilience. The researchers we interviewed noted that these strategies can also reduce the impacts of high wind and heavy rainfall that cause runoff and erosion on farms. Some farmers use conservation plantings to reduce erosion and mudslides following wildfires. Climate change is a factor in the decline of pollinator populations, so the habitats provided by hedgerows can help support them and protect yields in almonds and other crops dependent on pollinators. Climate change is also linked to changes in pest pressures, so conservation plantings can improve pest adaptation by increasing habitat for natural pest predators and decreasing reliance on agrochemical inputs.



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[15] Publication forthcoming. A recent overview of the role of soils in provisioning multiple environmental benefits, including flood tolerance can be found here: Keestra, S., et al. (2021). The role of soils in regulation and provision of blue and green water. *Philosophical Transactions of the Royal Society B: Biological Sciences, 376*(1834).

[16] Acevedo, S.E., et al. (2022). How does building healthy soils impact sustainable use of water resources in irrigated agriculture? *Elementa: Science of the Anthropocene, 10*(1).

[17] De Graaff, M., et al. (2019). *Chapter one - Effects of agricultural intensification on soil biodiversity and implications for ecosystem functioning: A meta-analysis.*

[18] Jahanzad, E., et al. (2020). Orchard recycling improves climate change adaptation and mitigation potential of almond production systems. *PLoS ONE 15*(3).

CDFA launched two promising new biodiversity-focused programs that made their first approximately $13 million in grants in 2022: (1) the Conservation Agriculture Planning Grants Program, providing grants for plans that will help farmers and ranchers identify actions for climate change mitigation and adaptation;[19] and (2) the Pollinator Habitat Program[20] to establish pollinator habitat on agricultural land.

The state's primary biodiversity roadmap report, *Pathways to 30x30 California*, focuses on how to improve biodiversity and address the state's biodiversity crisis[21] and notes the benefits of increasing biodiversity in agriculture, but does not include any biodiversity recommendations for croplands and rangelands. Several interviewees noted that this was a missed opportunity for the state to identify strategies to increase on-farm biodiversity to help meet our biodiversity goals.

Healthy Soils Program Is Popular but Limited in Impact

Since its inception, the state's Healthy Soils Program (HSP) has been oversubscribed, and we have heard from farmers in our network that it is a driver that can lead to new approaches to soil management with many benefits. However, several design changes are needed to increase its impact. The scientific literature makes clear that soil carbon sequestration—and more broadly, soil health— comes from stacking multiple soil health practices over several years (for example, combining cover crops, compost use, reduced tillage, and/or hedgerow installation). Changes in farming practices and irrigation methods that increase soil microbial populations and diversity need to be sustained for several years in order to see an impact. However, the grants are provided for only three years, and two-thirds of producers apply for funding for just one practice, the most popular of which is compost application.

The farmers whom we interviewed spoke about the importance of the HSP and State Water Efficiency and Enhancement Program (SWEEP), but also their limits given the three-year project timeline, limited unreliable annual budgets, and competition for funding. They told us that no one strategy or program is sufficient to support farmers in transitioning their operations to climate-resilient and smart operations and that a diversity of approaches is needed. They pointed to the importance of access to markets for their products, longer-term land security, and the need to support farmers for their ecosystem services over the long term. They also spoke about the importance of reaching those producers historically underserved by state and federal programs.

RECOMMENDATIONS

Build on Successes and Lessons Learned in the Healthy Soils and SWEEP Programs

There was a consistent refrain among interviewees that while HSP and SWEEP are popular and valued, it is time to consider the next stage of their evolution. Just as with other sectors of the economy (for example, energy or transportation), a transition toward climate resilience and mitigation requires longer-term, consistent, sizable investments. Producers typically operate with five-year business plans, and science tells us that reliable improvements in soil organic matter and carbon sequestration may take five to ten years, a time frame that should be supported with grants to give farmers time to see a return on investment. They should be encouraged to adopt multiple practices and supported to maintain them.

Include an Agriculture Component in the 30x30 Biodiversity Initiative

Pathways to 30x30 California mentions the value of on-farm biodiversity strategies—but it stops there. Ignoring the significant and wide-reaching potential of practices on farms and ranches to preserve aboveground and belowground biodiversity is a missed opportunity. CDFA, the California Natural Resources Agency (CNRA),

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[19] For more on the Conservation Agriculture Planning Grants Program, see https://www.cdfa.ca.gov/oefi/planning/

[20] For more on the Pollinator Habitat Program, see https://www.cdfa.ca.gov/oefi/php/.

[21] 30x30 California, see page 31.

and the Department of Conservation (DOC) should convene stakeholders to evaluate the current status of on-farm biodiversity in California, consider barriers to adoption of greater aboveground biodiversity,[22] set actionable, measurable targets for accelerating on-farm biodiversity, and identify the resources needed to achieve these targets. This process should build on the recommendations in CDFA's *Soil Biodiversity in California Agriculture*,[23] including these important actions:

- Integrate soil biodiversity assessment into CDFA's HSP and tackle barriers such as the scarcity of soil testing labs and the lack of a cost-effective soil test for farmers to use
- Run a pilot program within the HSP, selecting a subset of projects that relate soil biodiversity indicators with complementary measurements of soil health
- Build capacity in the public and private sector to provide services and training for soil biodiversity analysis and assessment
- Develop an Adaptive Management Framework that allows farmers and agricultural practitioners to dynamically respond to changing conditions and uncertainties in their farming systems

Catalyze the Widespread Deployment of Hedgerow and Agroforestry Installation

In September 2023, CalCAN and other agriculture and environmental advocates provided recommendations to the California Natural Resources Agency in response to its call for public comment on target setting as required by AB 1757. Based on available opportunities and feasible implementation rates, we recommended the following targets for conservation plantings: 290,000 acres of silvopasture by 2030 and 22,100 acres of riparian forest buffers, plus 380,000 acres of hedgerows and windbreaks by 2040.[24]

CDFA's new Pollinator Habitat Program[25] provides resources to farmers interested in adding hedgerows, agroforestry, and other conservation plantings to their operations. This program could be expanded to develop a workforce capable of greatly scaling up conservation plantings on farms and ranches across the state. Providing skilled professionals to plant appropriate species and maintain them for the first few years as they get established would likely increase farmer willingness to participate and would increase the success of the plantings and protect the state's investments in this climate solution. This program could be connected to or modeled on the California Conservation Corps that provides workforce training for on-farm conservation and could partner with Resource Conservation Districts and Point Blue Conservation Science.

Sheep used to remove mature cover crops and add manure for soil fertility in a new orchard.

[22] There is good research on these issues that can be reviewed with stakeholders, including a recent Central Coast study on agriculture's adoption of biodiversity strategies: Esquivel, K. E., et al. (2021) The "sweet spot" in the middle: Why do mid-scale farms adopt diversification practices at higher rates? *Front. Sustain. Food Syst.*, *5*.

[23] CDFA Belowground Biodiversity Advisory Committee. (2023). *Soil biodiversity in California agriculture: Framework and indicators for soil health assessment.*

[24] See this CalCAN blog for more details on these targets and their rationale.

[25] CDFA. *Pollinator Habitat Program.*