Center for Regenerative Agriculture & Resilient Systems

Annual Report 2021

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Climate change and soil loss threaten food production around the globe. Regenerative agriculture, with its robust, straightforward and cost effective practices, is uniquely poised to address these momentous threats to civilization. It has the ability to sequester significant carbon levels in the soil, leading to a healthier, more abundant and water efficient food supply.
The Future of Agriculture is Regenerative

The Chico State Center for Regenerative Agriculture and Resilient Systems (CRARS) is the first comprehensive university-based program devoted to regenerative agriculture in the United States. Our mission is to investigate, develop, demonstrate, and educate about regenerative practices that both restore and enhance the resiliency of living systems and communities. Our reach is local, regional, national, and global.

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Meet Our Team

Co-Founders & Faculty Affiliates

Cynthia Daley, PhD—Co-founder and Director; Organic Dairy Program supervisor; College of Agriculture professor

Tim LaSalle, PhD—Co-founder; Director of Research and Development; adjunct professor

Garrett Liles, PhD—Co-founder; faculty affiliate; soil scientist; College of Agriculture professor; director of RAD Lab

Lee Altier, PhD—Co-founder; faculty affiliate; organic vegetable cropping systems; College of Agriculture professor emeritus

David Johnson, PhD—Program Specialist in Research and Development; adjunct professor

Betsy Boyd, PhD—Faculty affiliate; College of Agriculture professor

Maria Giovanni, PhD—Faculty affiliate; College of Natural Sciences professor

Hossein Zakeri, PhD—Faculty affiliate; College of Agriculture assistant professor

Jamal Javanmardi, PhD—Faculty affiliate, Organic Vegetable Project director; College of Agriculture assistant professor

Jake Brimlow, PhD—Faculty affiliate; College of Agriculture professor

Logan Smith, PhD—Faculty affiliate; College of Agriculture assistant professor

Jeffrey Davids, PhD—Faculty affiliate; Civil Engineering, assistant professor
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Program Coordinator;
Manager, nutrient density lab;
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Drew Gilberti—
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Leadership Council

The Leadership Council’s purpose is to collaboratively think, plan, strategize, communicate, support and help create productive alliances that can significantly contribute to addressing these global needs. As leaders from the industry and aligned fields, the Council’s potential to advocate for the CRARS as a significant and primary contributor to help create a more resilient and ecologically healthy food production system is without limits.

CRARS Structure

The Center was established at Chico State in 2019 as a research and education center. Guided by the talents and experiences of the CRARS Leadership Council, executive director Cindy Daley oversees all aspects of the Center. Driven by an ethic of servant leadership and collaboration, Daley works with a diverse team of faculty, researchers, and staff to support and collaborate with farmers, ranchers, and community members through research, education, and networking. The University provides physical space, IT support, administrative support, University Farm access, and other resources, including consultation and collaboration to advance Chico State’s goals to achieve climate neutrality by 2030; remain responsive to additional sustainability needs; accelerate research and educational efforts to equip students, faculty, staff, and community members for a sustainable and resilient future.
Our New Mentor Farmers

The following farmers have now joined our list of mentors willing to help others in transitioning to regenerative methods:

• Jordon Lonborg, viticulturist at Tablas Creek Vineyard, biodynamically grown and regenerative organic certified wine

• Blake and Stephanie Alexandre, Alexandre Family Farm: certified regenerative organic dairy products and eggs

• Carrie Richards, Richards Grassfed: regenerative grassfed beef and pork

• Mimi Hillenbrand, 777 Bison Ranch: grassfed, holistically managed bison

• Thomas and Cody Nicholson Stratton, Foggy Bottoms Boys: grassfed dairy, beef, poultry, lamb, eggs, and wool products

• Alisha Taff, Rock Front Ranch: regenerative jujubes, quince, and honey

• Doniga Markegard, Markegard Family Grassfed: grassfed lamb, pasture-raised chicken and forest-raised pork
Graduate Students and Student Research Assistants

Graduate students in the interdisciplinary masters degree program are involved in research related to regenerative agriculture. Master’s thesis projects vary depending on the student, which can be of their own design or follow the design of a funded research project already underway. Student research assistants work on a variety of research projects initiated by CRARS.

Clair Beale: Research in use of cover crops in an olive orchard and the effects on water infiltration and runoff.

Gabrielle Hathaway: Research in greenhouse gas emissions and lifecycle analysis of organic grass-fed dairy systems.

Clayton Handy: Research in walnut systems, cover crops, termination systems, costs of production

Raquel Krach: Research in almond orchard systems, cover crops and compost

Chloe Mahan: Student Research Assistant

Melvin A. Quezada Haro: Student Research Assistant

Cooper Davis: Undergraduate Research Assistant
Regenerative Agriculture Events 2021

This Way to Sustainability Conference XV, March 25-26, 2021, “Resilience from the Ground Up: Strengthening Diversity in Soil, Communities and Economies”

We had record-breaking attendance at this year’s conference which was held entirely online for the second year in a row. TWTS is a nationally recognized, student-run conference focusing on challenges, ideas, solutions and resiliency in planning our sustainable future. The conference has hosted 1,400 participants or more each year with a variety of respected professionals speaking on the many aspects of sustainability. The goal of the conference is to educate students, staff, and faculty, and community members; providing attendees an opportunity to network, discuss, and become more aware of pertinent environmental and social issues we all face.

The TWTS Conference brings expertise and experience from a variety of presenters in 7 tracks:

1. Environment, Land Planning & Natural Systems
2. Built Environments, Engineering & Waste Management
3. Health, Wellness, Diet & Nutrition
4. Sustainable Food Systems & Regenerative Agriculture
5. Entrepreneurship, Marketing & Supply Chain Management
6. Social Justice & Public Policy
7. Arts, Humanities & Creative Expression

2021 Presenters:

• **Leah Penniman, MA.** Author of *Farming While Black* and co-founder of Soul Fire Farm with the mission of ending racism and injustice in the food system. **Keynote:** “Uprooting Racism and Seeding Sovereignty in the Food System”

• **Katharine Wilkinson, PhD.** Principal writer and editor-in-chief for Project Drawdown. More recently she co-founded and leads The All We Can Save Project with Dr. Ayana Elizabeth Johnson in support of feminist climate leadership and co-hosts the podcast *A Matter of Degrees.* **Keynote:** “All We Can Save: Leading on Climate with Truth, Courage, and Solutions.”

• **Jennifer Atkinson, PhD.** Associate professor of environmental humanities at the University of Washington, Bothell. Leads seminars on “Eco-Grief & Climate Anxiety.” **Keynote:** “Eco-Grief & Climate Anxiety: In a time when there is so much bad news, how do we learn to cope?”

• **Bill Shireman, PhD.** President and CEO of Future 500 with a focus on ending polarization and crafting transpartisan solutions to climate change and other problems. **Keynote:** “In This Together: How to reach across the political and economic divide toward finding workable solutions to our climate crisis.”
Regenerative Agriculture Farm Tour Generated Excitement About Projects in the North State

Sheep grazing under the almond trees at Massa Organics.

On August 20, 2021, CRARS sponsored a Regenerative Agriculture Farm Tour & Field Day for 50 people who joined us to visit multiple sites engaged in innovative regenerative agriculture research and practices in Butte and Glenn Counties. It was an opportunity for members of the leadership of Chico State and key players in the greater community to engage with members of our own leadership council while sharing the impact and potential of this work.

Stops on the tour included:

**The University Farm.** Tour participants were introduced to research being done with the Organic Dairy Program, the composting site including fungal-dominant compost Johnson-Su Bio-reactors, the Organic Vegetable Project, the Soil Processing Area and Regenerative Agriculture Demonstration Lab, and the Farm’s new systems for regenerative standard and specialty mushroom production.

**North State Hulling Cooperative.** CEO Mayo Ryan provided a tour and shared their vision for a carbon neutral almond production facility. He showed off their innovative dryer system and master plan for a net energy metering system, biochar production, and composting facility. UC Davis associate professor Amelie Gaudin and Cindy Daley are working collaboratively on a transition program for North State Hulling Cooperative members.

**California Olive Ranch.** Ranch manager Clayton Handy discussed their participation in the Regenerative Agriculture Transition program and Jared Geiser from the Glenn County Resource Conservation District discussed the CDFA Healthy Soils Project taking place at this site. Cindy Daley also did a water infiltration demonstration with Chico State professor Garrett Liles.

**Massa Organics.** Racquel Krach discussed her master’s and CDFA Healthy Soils Project on the effects of compost application and cover crop planting on soil health, water use efficiency and crop production. She and Greg Massa provided a tour of their farm that employs an integrated system of rice, almonds and livestock.

**Almendra Winery and Distillery.** A social hour with appetizers and cocktails was enjoyed by all who could attend.
Top left: Professor Garrett Liles explains what the soil sample monoliths indicate.
Top right: President Gayle Hutchinson and other participants walk through the nursery at the University Farm.
Bottom: CRARS director Cindy Daley, College of Agriculture Dean S. Patricia Stock, president Gayle Hutchinson, and staff research associate Seth Myrick in the Soil Processing Area on the University Farm.
Additional Virtual and In-Person Seminars and Workshops

Carbon Farm Planning Training

Self-guided online modules and four webinars on Tuesdays starting June 1, 2021 9-11:30 am.

This carbon farm planning training offered by CRARS and the Carbon Cycle Institute was for technical service providers and planners interested in carbon farm planning. Participants completed the online Carbon Farm Planning Curriculum, containing three modules. A webinar follows the completion of each self-guided module and associated task.

Soil Health Workshop: Cover Crops, Carbon & Drought for Growers & Partners

Tuesday, May 25, 2021, 9:30-11:30 am.

Participants learned about cover crops, compost, mulching, whole orchard recycling, and nutrient management at two different orchards in Glenn County. Sponsored by CRARS, Glenn County RCD, CDFA Healthy Soils Program, California Olive Ranch, Carbon Cycle Institute, and Patagonia.

Fava Bean Field Day

Friday, May 7, 2021, 1-12:00 pm.

Researchers, growers, and students presented the latest research on using fava beans as both a cover and cash crop. Participants learned about alley cropping in orchards and how to work with challenges. They also learned about the proportion to use in cover crop mixes and a variety of related ideas including fava bean cooking recipes.
CRARS is leveraging our applied research, hands-on educational programs, industry partnerships, and networks to investigate, develop, and rapidly disseminate important and progressive forms of agricultural production.

Innovative Applied Research

The CRARS is a global research center, demonstration and training site, and policy think tank working to usher in a brighter future. We develop, demonstrate, and disseminate techniques and practices that rebuild and enhance the resiliency of our living systems. Through on-farm research at sites around the world, we discover and test regenerative methods and share the outcomes via our website, workshops, and online journal.

With funding from multiple sources, we are working on validating Johnson-Su Biologically-Enhanced Agricultural Management (BEAM) research in corn, cotton, alfalfa, vegetables, and rangeland systems. BEAM combines a fungal-dominant soil inoculant with cover crops to enhance biodiversity. Each multi-year study is designed for peer-reviewed publication.

CRARS, University of California Cooperative Extension (UCCE) and five organic vegetable farmers are studying the impact of RA practices in organic vegetable production. With farmers leading their own experiments, we provide soil testing, nutrient density analysis, and farmer-to-farmer networking tools. A companion study, funded by the Agriculture Research Institute (ARI), is to study changes in the nutrient density of regenerative production systems vs. conventional practices in vegetables.

A series of research proposals support the study of regenerative cotton production. In collaboration with Guess Jeans, Bowles Farming, and Fibershed, we aim to reduce soil disturbance, improve water use efficiency, and eliminate synthetic inputs through regenerative practices. Five cotton producers participate in this work along with brands interested in developing regenerative cotton textile lines.

Engaged Outreach & Education

We seek to provide education and training to all who are involved in producing our food and managing our landscapes and to support the next generation of regenerative farmers, ranchers, and agricultural leaders. Phase I consists of:

- Interdisciplinary Master’s Degree in Regenerative Agriculture: We currently offer an interdisciplinary master’s degree program with an emphasis in RA.
- Professional Course Series for Technical Service Provider Training
- Agricultural Management Systems Learning Collaborative

Undergraduate research opportunities are currently available in the Regenerative Agriculture Demonstration Laboratory (RAD Lab), with additional proposals in development.

Farmer-to-Farmer Transition, Network & Educational Program:

We have developed a strategy for on-farm transition that builds upon proven techniques for achieving greater than normal rates of farmer adoption using a Communities of Practice (CoP) model that includes farmer-to-farmer mentorship/networking and collaborative on-farm research trials and demonstrations. We began the process with organic vegetables and the USDA Conservation Innovation Grant (CIG) (funded), and are expanding this approach to rangeland, almonds, walnuts, and cotton.

To achieve this goal we have created or are in the process of implementing the following resources:

- A professional course series in RA that will be available on our website, free of charge. (Currently in planning.)
- A certificate program in RA, developed in collaboration with our mentor farmers, for producers or practitioners interested in receiving documentation of completed coursework. We continue to provide conferences and field days to promote RA within the industry.
- The RAD Lab supports farmers and ranchers with relevant soil analysis and nutrient density testing. ([www.csuchico.edu/regenerativeagriculture/soil-lab](http://www.csuchico.edu/regenerativeagriculture/soil-lab))
- Our website includes an extensive RA101 Learning Center, regenerative mentor-farmer information, and media resources. ([www.csuchico.edu/regenerativeagriculture](http://www.csuchico.edu/regenerativeagriculture))
Technical Service Provider Training: Assisting Producers with Resource Management Decisions

CRARS works with a large number of conservation partners to promote and support timely resource initiatives, including forest management, soil health, and water conservation efforts. Our conservation partners include Carbon Cycle Institute, California RCDs, UCCE, land trusts, NGOs, state and federal agencies, and independent agricultural consultants. The breadth of expertise presents a unique opportunity to enhance conservation delivery in California by increasing the availability of Technical Assistance (TA) to producers, using the proven framework of the NRCS conservation approach.

A coordinated training effort that capitalizes on network expertise can increase consistency, continuity and availability of Technical Service Provider (TSP) training to provide practice-specific workshops to increase design and implementation expertise; facilitate the integration of Conservation Activity Plans to develop robust implementation, management and monitoring strategies that are co-created by TSPs and practitioners; satisfy current demands for TA; and facilitate improved conservation outcomes and adoption.

To meet this opportunity, we have created a TSP Training Program to certify TSPs in specific resource categories. Participants will be required to:

- Complete NRCS AgLearn Courses
- TSP Orientation Course
- Conservation Planning Course, Modules 1-5
- Complete modules selected from the CRARS Professional Course Series
- Develop Conservation Activity Plans (CAPs) through resource category trainings in Soil Health Management, Nutrient Management, Grazing Management, Forest Management, Wildlife Habitat & Pollinator Habitat and Carbon Farm Plans
- Submit three operation-specific CAPs to be reviewed for each category of certification pursued

Project Goals, Objectives

The TSP Training Program is designed to increase support to farmers, ranchers and others who are interested in pursuing more effective resource management on their properties. Our objectives are to:

- Increase knowledge and implementation of resource management activities throughout California
- Create a responsive network of TSPs offering diverse experience and expertise
- Provide comprehensive guidance to ensure continuity from planning through implementation
- Make practical and effective use of existing financial and technical assistance mechanisms
- Support existing and future efforts by providing accessible training opportunities

Project Approach

Build on Science: We translate established conservation principles and create effective partnerships with producers and other collaborators to implement site-specific efforts in forest management, soil health and water conservation.

Value Producers: We create participatory learning environments that support and facilitate group learning and innovation, community building, the development of shared values and producer ownership of management systems critical to sustained conservation efforts.

Assess Progress and Outcomes: We assess the environmental and economic impacts of our work by analyzing soil samples, pest/pollinator data and economic data.

Impact: Systems-level Conservation Delivery to Reinforce the NRCS Conservation Planning Process

The TSP Training program offers a comprehensive, adaptive training opportunity that provides pathways for multiple layers of TSP certification, from addressing specific resource topics (e.g., grazing management and forestry management) to developing Resource Management System level conservation plans for farms, ranches and non-industrial timber lands. The program has potential to impact resource conservation planning throughout the Northern California region. Long-term, increased adoption of soil health practices will restore and regenerate thousands of acres of working lands.

The program builds on current certification pathways that deliver conservation planning process content, by adding the diversified expertise of training partners and the practical knowledge of producers, including individuals who have successfully implemented conservation plans and practices.
CRARS, in collaboration with the California Association of Resource Conservation Districts (CARCD), has begun the first phase of creating the Agricultural Management Systems Learning Collaborative (“The Collaborative”) to increase knowledge and enhance implementation support for the expansion of systems-based farm/ranch/forest management practices in Northern California production systems. Project activities will lay the foundation for ongoing, sustainable development that will continue to address identified stakeholder needs, as well as our long-term goals to build additional educational and leadership development capacity in systems-based agricultural management. Project activities are responsive to the results of a broadly disseminated Needs Assessment (113 responses analyzed). Our stakeholders include producers; agricultural professionals, including cooperative extension, California Resource Conservation District (RCD), and NRCS staff; and students enrolled in Agriculture, Natural Resources, Environmental Sciences, and Land Resource Management.

**Project Goals:** 1) Establish flexible non-credit bearing learning opportunities to address a broad range of stakeholder needs and interests; 2) Establish a cohort of Peer Mentors/Role Models in systems-based agricultural management systems; and 3) Provide additional participant-driven support mechanisms to promote and encourage sustained knowledge building/sharing and connections across the community.

**Project Objectives:** 1) Develop four online courses in Agricultural Systems and Soil Health Management that will serve as a foundation for multiple education and outreach pathways; 2) Identify, support, and assess the experiences of 10 paired teams of Northern California producers and RCD Technical Assistance Providers who will serve as Peer Role Models and Mentors; and 3) Add value to existing CRARS outreach and assistance efforts through community-driven workshops and an online AMS Collaborative Network.

Medium- and Long-term Outcomes of the AMS Collaborative Project beyond the funding period include: 1) Create an institutionally-approved 21-credit certificate program available to regional and national audiences; 2) Establish an undergraduate program and online master’s program in systems-based agricultural management; and 3) Sustain the AMS Collaborative through continuing partnerships, collaborations and projects.
California is the nation’s leading agricultural producer by total receipts, generating over $50 billion in 2019, far exceeding the number two leading state of Iowa ($27.5 billion). By sheer size and productivity, California has significant potential to contribute to working lands conservation efforts.

However, climate change, diminishing soil health, low implementation of conservation efforts, and lack of knowledge and/or access to information, training, and assistance with systems-based agricultural management have left us less resilient and more vulnerable to economic and environmental threats.

CRARS has developed this four-course professional series to support the expansion of systems-based farm, ranch, and forest management practices on California working lands, and foster conversation and innovative, collaborative strategies to address current and future threats and opportunities for California agricultural production. The courses are:

- Systems Theory and Practice
- Soil Health Systems
- Science & Practice of Ecological Forest and Range Management
- Farm/Ranch Planning & Design

**Course Structure:**

- Fully online for flexibility and convenience
- Lectures and coursework (5-6 hours per week) completed at participant’s own time and pace
- Weekly, one-hour live-online discussions with participants and faculty
- Pass/No Pass quizzes to gauge mastery of the content
- Certificate of completion given at the end of each course

Participants can take any number of individual courses, or take all four to complete the series.

**Program Faculty:**

Cynthia Daley, PhD.; director of the Center for Regenerative Agriculture and Resilient Systems; Rawlins endowed professor for environmental literacy; professor College of Agriculture, Chico State

Garrett Liles, PhD; associate professor of agriculture, Chico State

Don Hankins, PhD; professor of geography and planning, Chico State

Priya Tuvell, M Agr; CRARS program manager

Mollie Aschenbrener, MAGD; professor and lead teacher, educator and graduate coordinator, College of Agriculture, Chico State
Awarded a Regional Conservation Partnership Program Grant from the USDA

CRARS, in collaboration with 12 other conservation partners, has been awarded a coveted Regional Conservation Partnership Program award totaling nearly $7 million for 2020-21 through the USDA's Natural Resources Conservation Service.

The Center and its conservation partners were awarded $6,995,463 to support “Soil Health Management Systems for Northern California,” a five-year project designed to help orchard/vineyard, rangeland, dairy and row crop producers in Northern California build food and fiber production resiliency to counter climate change challenges. The grant will fund four California Resource Conservation District Hub positions to support the development of producer-based Soil Health Management Plans, implementation strategies and protocols in three distinct regions in Northern California. The project integrates carbon farm planning activities and will report on economic and social outcomes in addition to conservation outcomes. It also supports Agriculture Communities of Practice to disseminate adaptive management knowledge, training and exchange of ideas. Working together, CRARS will build plans that conserve and regenerate soil while sequestering carbon and building resilience through water use efficiency.

"The Regional Conservation Partnership Program is public-private partnership working at its best," said Terry Cosby, acting chief for USDA’s Natural Resources Conservation Service (NRCS). "These new projects will harness the power of partnership to help bring about solutions to natural resource concerns across the country while supporting our efforts to combat the climate crisis.”

Conservation partners work in collaboration with NRCS to help farmers, ranchers and forest landowners throughout the nation implement systems that conserve water and soil resources, improve the health of wildlife habitats and increase climate resilience. These projects offer impactful and measurable outcomes so the NRCS is investing $330 million in 85 locally driven, public-private partnerships to protect agricultural viability in the face of climate change. The award received by CRARS is one of these projects.

CRARS conservation partners include:

- California Association of Resource Conservation Districts
- The California Department of Food and Agriculture
- Carbon Cycle Institute
- Fibershed
- Glenn County Resource Conservation District
- Humboldt Resource Conservation District
- Lassen Resource Conservation District
- Lassen County Farm Bureau
- Mendocino County Farm Bureau
- Mendocino Resource Conservation District
- Modoc Resource Conservation District
- University of California Cooperative Extension
Cover crops have become increasingly popular in California because of their contributions to improved soil health, and cool season cover crops have sparked interest as a result. Of the cool season pulses used in cover crop mixtures, fava bean (*Vicia fava* L.) and pea (*Pisum sativum* L.) express high nitrogen fixing capacity and have strong potential to reduce grower reliance on nitrogen fertilizers. These legumes are also popular food and protein sources around the world because of their contribution to reducing health issues associated with high cholesterol, diabetes, and cardiovascular disease. This makes them a potential secondary cash crop that could at least defray the cost of adding them as a cover crop.

A team led by professor Hossein Zakeri and postgraduate researcher Kyle Brasier has launched an extensive research program to study the potential benefits of these crops in northern California. They collaborate with researchers in the Departments of Food Science and Business at Chico State, USDA-ARS in Pullman, UC Davis, Fresno State, and the Crop Development Center at University of Saskatchewan in Canada. They also work closely with local producers including Lundberg Family Farm, Terra Nux LLC., and Chico Flax. The program has provided numerous opportunities for undergraduate students to conduct research on legume species for healthy soils and foods. Following is the list of the team’s active and upcoming projects:
1. **Screening Fava Bean Germplasm**, funded by CDFA (2018-2021): This project aimed to identify fava bean genotypes that are suitable for cover cropping. The project outcomes resulted in securing a second CDFA grant to test the findings of the first project.

2. **Cover Crop Project**, funded by CDFA (2020-2023): The project aims to study the performance of small seeded fava bean genotypes in cover crop mixes. Currently, bell bean (a fava bean variety that has large seeds) is grown in cover crop mixes. Replacing bell bean with small-seeded fava will save in seed costs and make it much easier to plant the seed mix with a grain drill. One pound of bell bean yields about 450 plants while small-seeded genotypes can produce over 1000 plants. This project is an extensive collaboration between Chico, Fresno, Pomona, NRCS at Lockeford, Vilmorin Seed at Monterey, and Arizona State. The team just finished planting trials at these locations, and Chico State will lead to complete them all.

3. **Pea Nodulation Project**, funded by Saskatchewan government (2019-2021). This was a collaborative project with the Crop Development Center at University of Saskatchewan, and involved screening a pea population that has been created to improve nitrogen fixation of field pea. We were specifically interested to see if the population can be used for cover crop.

4. **Fava Bean as Food Crop**, funded by Western SARE (2019-2023). This project is seeking approaches that can help in promoting fava bean as a food crop. Field trials were concluded last fall and samples are still processing. The outcomes include varieties that can produce fresh pods and also improve soil nitrogen.

5. **Alley Cropping in Young Orchards**, funded by ARI (2020-2023). This project aims to promote alley cropping as a sustainable farming practice in California. In this project the team works with farmer Dax Kimmelshue in Durham, CA. Preliminary observations were presented at the American Society of Agronomy conference in Salt Lake City. They showed that alley cropping is less likely to impact water availability of orchard tree and tree water status.

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**Alley Cropping in Young Orchards: Soil and Tree Water Status**

*Kelsey Delano, Brian Halley, Kyle Brasier, and Hayoung Zober* - Department of Plant Science, California State University - Chico

**Figure 1:** Average mobile number of inoculated and non-inoculated yellow bean

**Figure 2:** Average daily soil moisture of the alley cropped (right) and bare land (left) during July 2021

**Figure 3:** Average leaf water potential of walnut trees in the alley cropped (right) and bare land (left) during July 2021

The former grew a range of 50 to 125% across beans between 1- and 2-year-old root systems during 2015-2018. Average production area, including fertilizer, pesticides, plantings and harvesting equipment, was about 5600 ha. On average, bean yield was 2000 lb/ha in these years, resulting in an average gross sales of about $35,000/ha. The cost benefit of growing beans between trees was about $39/ha which was divided between the grower and orchard owner based on a leasing agreement between the two. Soil moisture and leaf water potential also within a narrow range in the alley cropped and bare land; however, both parameters fluctuated more due to irrigation across the non-inoculated areas than in the inoculated ones.

**Introduction**

Every year, large amounts of California almonds are grown in orchards. Various rottnet's such as fire blight and nematodes can be a significant problem in the orchards. In 2015, the grower dedicated land for two experiments where almonds and yellow bean were planted in two fields. 1) Soil moisture was measured by soil moisture sensors from the depths of 45 cm and within 7% of water in available water in both crops and bare land. 2) Soil moisture and leaf water potential were measured weekly by a pressure chamber from the same tree in planted and bare areas. 3) Soil moisture and leaf water potential also within a narrow range in the alley cropped and bare land; however, both parameters fluctuated more due to irrigation across the non-inoculated areas than in the inoculated ones.

**Methodology**

Soil moisture and leaf water potential in 2015 and 2016 were obtained from the grower. In June 2015, the grower dedicated land for two experiments where almonds and yellow bean were planted in two fields. Soil moisture was measured by soil moisture sensors from the depths of 45 cm and within 7% of water in available water in both crops and bare land. Soil moisture and leaf water potential were measured weekly by a pressure chamber from the same tree in planted and bare areas. The experiment was conducted from June 1, 2015, to May 30, 2016.

**Results**

- **Figure 1:** Average mobile number of inoculated and non-inoculated yellow bean
- **Figure 2:** Average daily soil moisture of the alley cropped (right) and bare land (left) during July 2021
- **Figure 3:** Average leaf water potential of walnut trees in the alley cropped (right) and bare land (left) during July 2021

**Conclusion**

- **Inspection of yellow bean plants** showed little effect of the plant infection, most likely because of the presence of indigence in the soil.
Improving Soil Carbon Capture and Water Use Efficiency in the Palo Verde Valley

The Metropolitan Water District transports, stores, and distributes water to a large portion of Southern California, including the counties of Los Angeles, Orange, Riverside, San Diego, San Bernardino, and Ventura. The CRARS is conducting a five-year research program designed to increase Metropolitan’s knowledge of regenerative agriculture and carbon sequestration opportunities. The project contrasts regenerative land management methods to the current conventional practices used by Metropolitan, and contrasts cash crop (alfalfa) productivity between the two systems.

Conventional fallowing practices involve multiple and repeated tractor passes, which comes with climate, fuel, maintenance, depreciation, and labor costs, while also causing damage to soil structures. Collectively, this has led to the need for increased inputs—fertilizer, herbicide, insecticide, and fungicide applications—thereby increasing production costs. While these inputs have increased productivity in conventionally managed production systems, they do so with reduced profits due to the cost of the inputs, and at great cost to the environment. Soil degradation and topsoil erosion is compromising the planet’s ability to produce sufficient food to feed the world’s population, with scientists estimating that we may have as few as 60 years of topsoil left.

In an effort to reduce or eliminate these impacts, the CRARS is studying the effects of summer and winter cover crops, fungal-dominant inoculant, and no till practices. The potential benefits of the project include improved water use efficiency, improved carbon capture, increased net profit, reduced agricultural greenhouse gas emissions, and long-term soil health and fertility benefits that will leave a soil legacy for the next generation.

Project Design

The research is based on a randomized block design with three replications of two contrasting treatments. The first is a conventional fallow system with full tillage and no water application. The second is a regenerative fallow system including winter and summer cover crops seeded with a no-till drill at 60# per acre with minimal irrigation to maintain a living root system all year round. Block 1 will follow a three-year fallow contrast, Block 2 a four-year fallow contrast, and Block 3 a five-year fallow contrast.

The regenerative fallow seeding began in October-November 2020. It was terminated with a roller crimper and a summer cover crop was planted in May-June 2021.
Soil Carbon Accrual Project Using Flux Tower Technology in Multiple Locations

Led by CRARS, the Soil Carbon Accrual Project is a collaboration of more than 10 scientists from two continents coming together to measure the effect of regenerative agriculture on soil carbon in multiple locations over multiple years using flux tower technology. Despite considerable evidence that soil, when well managed, can be a significant carbon sink, conventional methods of measuring soil carbon only capture single measurements at any one time, leading to what seems to be misleading impressions that the soil respires as much CO₂ as it captures.

Flux towers measure the flow of CO₂ continuously (both respiration and accrual). Data from the flux towers and new soil probe technology will be correlated with data from satellite soil carbon estimates and conventional laboratory analysis of soil core samples. The intention is to get a comprehensive technical view and verify which technical measurements are most accurate and efficient. It will also provide an opportunity to evaluate the level of significance soil carbon accretion can play in mitigating GHG levels with much more certainty, thus providing scientists, farmers and policy makers with clear information to use to choose the most effective paths forward to address climate change.

The 3-5 year project is designed to holistically compare carbon cycling associated with the standard system (full tillage; herbicide; fertilizers; pesticides and no cover) to a regenerative system (multispecies cover crops; no-till or strip-till/vertical till, and crop rotations) in a robust replicated plot design to quantify the impacts on soil carbon accrual (net carbon flux), soil microbial diversity, water use efficiency, soil health, forage nutrient density, and economic return.

In the past, coordinated deployment of multiple flux towers (also known as eddy covariance (EC) towers) has been cost-prohibitive. The current project will leverage new lower-lost EC technology to replicate EC data collection across a range of agroecosystems representative of the major growing regions of the United States and other places in the world.

This project is not fully funded, but initial preparation for the first year of trials is already underway.

The photo above shows the CRARS team at the location in Blythe, California in the Palo Verde Valley.
Bruce Burnworth

Bruce Burnworth is a civil engineer who had a dramatic change in fortune after investing in 2019. Inspired by David Johnson’s research with BEAM (Biologically Enhanced Agricultural Management) and by Elon Musk’s announcement of a Carbon Capture XPRIZE, Burnworth has decided to invest considerable effort to combat climate change through the promotion of healthy soil biomes using the BEAM approach. He intends that widespread adoption will extend the data collection necessary to determine results in various applications. His Healthy Soil Biomes, Charitable LLC is a not-for-profit entity with a mission to accelerate the world’s transition to sustainable agriculture using restoration of soil microbiology as a driving factor.

At the moment Healthy Soil Biomes is working to spread the word about how soil microbiology matters to farm resiliency and increased profitability, food security, and carbon sequestration. Burnworth is pulling together an alliance of organizations devoted to the science of soil and climate change. His organization also provides information for farmers and the general public about how to make a Johnson-Su Beam bioreactor and use it to improve their soil.

One of the tools Burnworth wants to use to make information-sharing more engaging is a tool called Storyfile. By using video technology to prerecord answers to a variety of potential questions in an interview format with a real person, users have what feels like an interactive experience with that person. Burnworth is hoping this approach might help potential adopters get the help they need in a more engaging way than a typical FAQ page. CRARS director Cindy Daley has collaborated with Burnworth and the Storyfile team to create the first Storyfile project focussed on helping farmers and ranchers find answers to some of the questions they might have when first starting out.

Natasha Lilly, DVM, CVA

Natasha Lilly is a mother of three children, and a holistic and regenerative-minded veterinarian and acupuncturist with a special interest in companion animal nutrition and equine medicine. She lives in California, where she co-operates a working ranch, runs a veterinary practice and serves as an adjunct professor at California Polytechnic State University, SLO. She’s part of the Royal Animal Health University and Animal Diet Formulator team and recently became a Director of the College of Integrative Veterinary Therapies, CIVT. Lilly says she thrives on exploring solutions for big world challenges that can be appreciated best through the eyes of nature. This led to a partnership and start of the company, Animal Diet Formulator, where she works alongside top leaders and researchers in pet food nutrition globally, in addition to her involvement in regenerative agriculture practices through CRARS. She questions conventional practices when they limit success and enjoys discovering and providing solutions where possible in more natural medicines and modalities through education and exemplary practice that is needed for true health.
The Carbon Cycle Institute’s (CCI) mission is to “stop and reverse global warming by advancing natural, science-based solutions that reduce atmospheric carbon while promoting environmental stewardship, social equity and economic sustainability.” As one of the key organizations working to support the adoption of carbon farming in the United States, CCI has been developing a model framework for land management using data from the COMET-Planner and COMET-Farm tools and over 80 years of soil conservation experience. The process is called Carbon Farm Planning and utilizes a whole-farm approach to develop comprehensive farm plans for maximizing on-farm carbon capture, and enhancing important ecosystem functions such as providing wildlife habitat, increasing water quality and storage, and supporting biodiversity. CCI provides training and educational programs for farmers and ranchers, technical service providers, conservation agencies and organizations, and policy makers. They also provide training for Carbon Farm Planners and support community and national policies that promote the spread of this work.

CRARS has developed a strategic partnership with the Carbon Cycle Institute (CCI) to increase training and education opportunities in regenerative agricultural practices for students, producers, and conservation planners and agency staff. These opportunities support agricultural workforce development and will accelerate the development and implementation of Carbon Farm Plans throughout Northern California.

Two USDA-funded programs (described elsewhere in this report) have been recently awarded to CRARS to support this priority. Through the first, awarded through the National Institute of Food and Agriculture (NIFA) Non-Land Grant Colleges of Agriculture (NLGCA) program, CRARS is developing a series of online courses in regenerative agriculture. These courses contribute to undergraduate education, as well as to professional development for conservationists and natural resource management professionals. Through the second, recently awarded through the Natural Resource Conservation Service (NRCS) Regional Conservation Partnership Program (RCP) program, CRARS will lead a collaborative effort with partners across the Northern California region to provide technical assistance and financial support to producers to implement conservation plans with a focus on soil health to increase carbon sequestration among other benefits.
Special thanks to our sponsors, donors, and grant partners.

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California Department of Food and Agriculture
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