California (Regents of the University of California) Annual Report - FY2021

Report Status: Approved as of 07/08/2022

Contributing Organizations

Regents of the University of California

Executive Summary

Overview

In 2021, University of California Agriculture and Natural Resources (UC ANR) continued to adapt to pandemic-related conditions to optimize its operations, research and engagement across its locations and programs that aim to serve all 40 million residents of California. Despite ongoing changes, the UC ANR workforce has responded to increasingly complex issues such as wildfire resiliency, groundwater management, and working with small-scale farmers to navigate regulatory challenges and new markets.

UC Cooperative Extension (UCCE) staff and volunteers demonstrated their ingenuity and commitment to addressing COVID-19 by participating in a national campaign with Extension Foundation and the Centers for Disease Control that leverages Cooperative Extension networks to address adult vaccine hesitancy. Statewide programs such as the Expanded Food and Nutrition Education Program, the UC Master Gardener Program and CalFresh Healthy Living, UC contributed to community health by improving food security, nutrition and home gardening skills for families living in California's densely populated urban centers.

UC ANR continued to strengthen its commitment to diversity, equity and inclusion, or DEI, in all that we do. A new DEI Advisory Council will steer ongoing recommendations for improving how we operationalize DEI internally and in the communities we serve. We expanded DEI training and are working to implement best practices around equity in hiring. UC ANR recently recruited a Vice Provost, who will focus on DEI in our programs and work with academics to develop more inclusive scholarship, and a Director, who will focus on the DEI across our organizational culture.

In 2021, 150 UCCE Advisors were conducting research, outreach and education from locally based UCCE offices serving all 58 counties from 70+ locations throughout the state. Nine research and extension centers (RECs), located in a variety of ecosystems across the state, provide places for researchers to conduct field experiments and educational opportunities for the public. Approximately 560 affiliated Agricultural Experiment Station (AES) researchers were located at three campuses, and 120 UCCE specialists were located at six campuses, RECs and county offices.

UC ANR’s statewide programs and institutes continued work through and with our county offices and community partners. The statewide programs include UC California Naturalist, UC Master Gardener, 4-H Youth Development, Expanded Food and Nutrition Education, UC Master Food Preserver, Informatics and Geographic Information Systems, UC Integrated Pest Management, UC Sustainable Agriculture Research and Education, Agricultural Issues Center, and CalFresh Healthy Living, UC. The institutes are the Nutrition Policy Institute, California Institute for Water Resources, and UC Organic Agriculture Institute.

The state budget, signed by Governor Newsom in July 2021, included a historic increase for UC ANR. This revived UC ANR's budget to pre-COVID levels and provided an additional $32 million in ongoing funding that will restore our academic footprint across the state, adding up to 120 new UCCE Advisors and Specialists and more than 60 new positions for program support and operations. Our UC ANR locations

worked closely with community partners and stakeholders to identify positions that will address California's emerging and future needs, such as wildfire, drought and climate adaptation.

Critical Issue: Endemic and Invasive Pests and Diseases

Given this is a transition year between REEport and NRS, below we have added is a short summary of the potential impact for a REEport final project we want to highlight.

New methods to improve regulatory responses to plant diseases

Introduction of new plant diseases to an area, for instance huanglongbing in citrus, requires individuals, groups, and regulators to make decisions while uncertain of the future impacts. This can result in difficult decision-making processes for individuals and groups. Individuals could make rational decisions which result in wider damage to the group. Group decisions often rely on individuals understanding the benefits of collective action and willingness to contribute to the common good. The UC AES Plant Pathologist used decision theory and information theory to model decision making processes and responses. Based on aggregate outcomes at larger scales, the analysis suggested methods to improve regulatory responses to new disease diagnoses that could result in improved large-scale sustainability of agricultural production systems. (McRoberts) Accession #: 1011401

Critical Issue: Healthy Families and Communities

Given this is a transition year between REEport and NRS, below we have added is a few short summaries of the potential impact for REEport final projects we want to highlight.

Investigating the benefits of diversity in educational settings

The AES researcher investigated daily experiences with ethnic diversity among middle school youth and incorporated other target audiences such as teachers and administrators. The project generated changes in knowledge, including an increased understanding and appreciation for ways to capitalize on the positive effects of diversity in educational settings. School administrators, staff, and teachers also increased their awareness of how exposure to diversity might be important to adolescent development. Furthermore, undergraduate students, graduate students, and postdoctoral scholars from diverse backgrounds were provided opportunities to engage in this research, leading to professional development and publication opportunities. Positive impacts on participating graduate students' and postdoctoral scholars' workforce transition were also reported. (Adrienne Nishina) Accession #: 1012239

Understanding decision making to improve health

The UC AES Developmental Psychologist led an investigation on understanding how the effective use of nutrition information by individual consumers influences the consumption of healthy foods. Notable findings included: Motivation and knowledge are important in food choice and nutrition label use; however, individuals are often misled by large numbers on food labels, and that identifying servings per container is more important to the consumers targeted in this study than food label details. Relative to promoting knowledge acquisition to improve food label use and food choice, the team developed and promoted a variety of approaches, including nutrition tutorials and food label reading tasks that build label reading skills in areas where misunderstandings were most common. These efforts foster learning gains to improve health. (Miller) Accession #: 1010535

Global food preferences inform healthier product formulation

The UC AES researcher in food science and technology looked at consumer behavior on food preferences in three different countries. The study explores the influences of product and contextual variables on food choices, including family and culture. The knowledge generated by this project about consumer choice can be instrumental in marketing food products, including fresh fruits and vegetables, and develop strategies that partially swap less healthy ingredients with healthier ones with flavor- or sensory-enhancing qualities. These tactics can be used by food processors, restaurants and individual consumers to develop more nutritious recipes and can ultimately improve consumer behavior around diet-related health choices. (Jean-Xavier Guinard) Accession #: 1010421

Critical Issue: Sustainable Food Systems

For this Critical Issue there isn't a REEport final report that we want to highlight; but rather, a new partnership with the California Department of Food and Agriculture. Five Small Farms Community Educators were hired across the state as part of the California Underserved and Small Producers (CUSP) Grant Program. Created in 2021 with funding from the California State Legislature, CUSP is designed to facilitate direct assistance to individual small and mid-scale and socially disadvantaged farmers and ranchers including technical assistance in applying for economic relief grant programs, assistance with business planning and marketing strategies, and extension support with specialty crop production, regulatory compliance, and sustainable and climate smart agricultural practices.

Critical Issue: Sustainable Natural Ecosystems

Given this is a transition year between REEport and NRS, below we have added is a short summary of the potential impact for a REEport final project we want to highlight.

Novel research to inform conservation planning and wildlife management

The UC AES ecology researcher is generating new knowledge related to food and energy production on arid lands. This research includes novel investigations of the impacts of solar energy development on wildlife and regulating (biogeochemical processes, carbon sequestration) ecosystem services. This work will help inform conservation planning and wildlife management at the food-energy-water nexus. (Rebecca Hernandez) Accession #: 1010512

Critical Issue: Water Quantity, Quality and Security

Given this is a transition year between REEport and NRS, below we have added is a short summary of the potential impact for a REEport final project we want to highlight.

Developing more effective water conservation policies

With climate change, it is expected that droughts in California will become more frequent. The state has two options to address water shortages in the long run: construct new supplies and reduce demand. In the short run the state needs to introduce conservation policies to curtail demand. The effectiveness of these conservation policies hinges on how customers respond to them. This AES project conducted a series of field experiments and observational studies designed to test the relative conservation potential of price and non-price instruments. A paper was published that offers a one-stop shop to learn under what conditions water pricing may lead to conservation. In addition four randomized controlled trials were completed, which evaluated the effect of behavioral conservation instruments to encourage water conservation during times of extreme drought, and in disadvantaged communities. The new knowledge will help water conservation efforts be more effective. (K Jessoe) Accession #: 1010692

Merit and Scientific Peer Review Processes

Updates

None

Stakeholder Input

Actions to seek stakeholder input that encouraged their participation with a brief explanation

None

Methods to identify individuals and groups and brief explanation

None

Methods for collecting stakeholder input and brief explanation

None

A statement of how the input will be considered and brief explanation of what you learned from your stakeholders

Rebuilding the UC Cooperative Extension Programmatic Footprint

As described in our Plan of Work, UC ANR actively engages stakeholders in the process to determine the highest priority UC Cooperative Extension (UCCE) academic positions. The process includes consultation with internal stakeholders and strongly encourages engaging external stakeholders in the development of the position proposals. The UC ANR Program Council provides recommendations the UC ANR Vice President, who makes the final decision.

During the 2021 federal fiscal year, UC ANR continued to prioritize rebuilding the UCCE programmatic footprint to address California's emerging and future needs. Before the end of the federal fiscal year, 20 positions were released, which is on par with past position calls. What is even more significant, that we want to highlight, is that given the historic 2021-22 state budget increase the 2021 Call for Cooperative Extension Positions was launched in August 2021 to identify over 80 more UCCE Advisor and UCCE Specialist positions to be released over the next 12 months! The proposal development phase went until December 10, 2021, past the end of this reporting cycle.

We want to share little more about the 2021 proposal development process. For the UCCE Advisor positions, internal UC ANR programmatic leaders (i.e., County Directors, Research and Extension Center Directors, Statewide Program and Institute Directors, and Program Team Leaders) were designated position proposal submitters and were expected to seek stakeholder input and work collaboratively across UC ANR units to make the best use of submissions. For the UCCE Specialist positions, the UC campus Provosts and Chancellors were the designated submitters and encouraged to engage the UC ANR network to co-develop the positions on their respective campuses. A notable change this position call is that all ten UC campuses were invited to submit UCCE Specialist proposals. To date, UCCE Specialists were located on six of the ten campuses.

Highlighted Results by Project or Program

Critical Issue

Endemic and Invasive Pests and Diseases

Pest Management

Project Director

Katherine Webb-Martinez

Organization

Regents of the University of California

Accession Number

7000182

Increasing agricultural efficiency and profitability

In 2-3 sentences, briefly describe the issue or problem that your project addresses.

Pests, diseases, and invasive plants decrease California’s agriculture efficiency and profitability. Eight to ten exotic arthropods are introduced to California annually, with nearly 20% developing into invasive pests. In agricultural systems, pests reduce yields, render crops unmarketable, and negatively impact revenues. For example, fungicide use for mitigating grapevine powdery mildew accounts for 90% of the environmental cost of grape production. As California’s population increases, crop production must increase to meet the greater food demands despite lagging resources for detection. Science-based information is needed for growers, managers, and policymakers to develop practices and policies that sustain economic vitality while protecting environmental quality.

Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.

Viticulture & orchard systems

A UC Cooperative Extension (UCCE) Farm Advisor in the Central Sierra region organized a highly successful “Airblast 2021 Conference: Optimizing Canopy Sprayers” 2-day for 270 pesticide applicators, supervisors, growers, licensed professional applicators, Pest Control Advisors and anyone involved in spray application decision making in the orchard or vineyard. (Lynn Wunderlich)

UCCE took a network-based approach to address grapevine leafroll disease, one of grapevines' most economically consequential viral diseases worldwide. It causes negative impacts on plant health, fruit quality, and yield, equating to losses of $30,000 to $226,405 per hectare in California. The network-based approach disseminated best management practices and demonstrated the value of participatory research to disease management. (Monica Cooper)

A UCCE Advisor in Kern County continued to survey growers' vineyards and educate their staff about Pierce's Disease, which has plagued grapevines. (David Haviland) Additionally, UCCE Viticulture Advisors and Specialists conducted the Napa Grape Short Course, including field demonstrations. (Kari Arnold)

A UCCE Specialist at UC Davis conducted research projects directly funded by the grape and wine industry in response to new issues and direct requests from industry members. Topics include limiting the impact of grapevine red blotch virus, causing a disease for which there is currently no mitigation. Findings are disseminated through extension programs. (Anita Oberholster)

UCCE’s Walnut Workgroup teamed up to provide an online, 2-day course in 2019 combining several regional walnut days into one online series called the UCCE Virtual Statewide Walnut Series. The agenda covered fertilizer, pruning methods, irrigation practices, pests, and diseases. The series was well attended via zoom, with over 200 attendees each day. (Kari Arnold, Mohamed Nouri, Elizabeth Fichtner) UCCE also organized and hosted Quad County Walnut Institute (QCWI) extension meetings in Stanislaus County and neighboring counties, with over 100 attendees at each annual meeting. (Kari Arnold, Mohamed Nouri, Kamyar Aram)

A UCCE Specialist at UC Riverside conducted research on plant-parasitic nematodes, key soil-borne pests that reduce the productivity of perennial crops, including the susceptibility of pistachio rootstocks. These studies supplement investigations on almond, stone fruit, grape, and walnut rootstocks. Information was extended to farm advisors, crop consultants, pest control advisors, and growers. (Andreas Westphal)

UCCE continued work on brown marmorated stink bugs (BMSB) in Mendocino and Lake Counties. In May of 2020, the very first two BMSB adults in Lake County’s history were found in two of UCCE’s traps funded by the California Pear Board. Findings were extended in industry presentations and a magazine article. (Cindy Kron)

A UCCE Specialist at UC Riverside is the director of the California Citrus Clonal Protection Program (CCPP), which provides a safe mechanism for statewide introduction of different citrus varieties from any citrus-growing area of the world for research, variety improvement, or use by the commercial industry and citrus enthusiasts. (Georgios Vidalakis)

A UCCE Specialist with UC Davis located at UC ANR’s Kearney Agricultural Research and Extension Center (REC) extended science-based information at industry, farm advisors, workgroup meetings, and short courses in California. Attendees included growers, pest control advisors, farmers, field workers, and representatives of various agricultural industries. Topics included diagnosis and management of foliar, fruit, wood, and soilborne diseases affecting the fruit and nut crops. (Florent Trouillas)

Topsin-M® was studied in grapevines in the Coachella Valley by a UCCE Specialist at UC Riverside. Disease incidence, the number of replaced vines, and total and marketable fruit yield were measured. Trunk diseases incidence was about twice as high in the untreated block compared to the treated block. The decrease in marketable fruit was even more significant, with a drop from 10 kg per vine in the treated block to 5 kg per vine in the untreated block. (Philippe Rolshausen)

Agronomy & vegetable crops

A UCCE Specialist at UC Davis conducted research on endemic and invasive pest management in lettuce, safflower, melon, cotton, alfalfa, and rice. Research findings were shared with industry boards, growers, pest control advisors, and state agencies via presentations, reports, meetings, and individual consultations. (Ian Grettenberger)

UCCE academics continued work on weedy rice, which can cause yield reductions of up to 80% and quality downgrades. Weedy rice is the same genus and species as cultivated rice; therefore, herbicides used in rice do not control it. UCCE conducted a survey of weedy rice infestation in California rice fields and extended best management practices through farm calls, newsletters, field days, and courses. (Luis Espino, Whitney Brim-DeForest). In another rice pest management project, UCCE continued to maintain an armyworm monitoring network using pheromone traps in locations across the rice production area of the Sacramento Valley. This includes an email alert system to share the results weekly with more than 500 clientele. (Luis Espino)

A UCCE Advisor runs a plant pathology laboratory at the UC ANR West Side REC to help provide clientele with quick diagnoses, build relationships, conduct applied research with clientele, and extend research-based mitigation strategies. Long-term UCCE research on white rot of garlic identified an approach that consistently reduced the damage done by this soilborne fungus: application of a fungicide at planting at the trench where the garlic planting material is dropped. (Tom Turini)

UC ANR scientists work on various strategies to help growers reduce yield losses. In response to injury and yield reductions after applications of Roundup to a variety of alfalfa called Roundup Ready alfalfa within the Scott Valley region, researchers investigated the reason for crop injury and agronomic practices to reduce the risk of yield losses. One study found that applying glyphosate when the crop is no taller than 2 inches and avoiding glyphosate applications before frost events resulted in no crop injury. Findings were presented at the Siskiyou County Pest Management Seminar and other county, state, and national events. (Giuliano Galdi, Thomas Getts, Rob Wilson) In another alfalfa project, UCCE examined eight different herbicides and their application timing to identify efficient and sustainable control of noxious weeds. (Giuliano Galdi)

A UCCE Advisor conducted research trials on pesticide efficacy on the European asparagus aphid for USDA's Interregional Research Project No. 4 (IR-4) program. This program aids in registering pesticides on minor acreage and specialty crops. As older pesticides have been retired (disulfoton, chlorpyrifos), asparagus growers have been left with few options to control this highly damaging pest, which can result in the death of perennial asparagus crowns. (Brenna Aegerter)

A UCCE Specialist at UC Davis studied Verticillum dahliae, a disease to which lettuce was previously considered immune, but unfortunately became more prevalent after methyl bromide and chloropicrin use were discontinued. Affected lettuce fields have suffered near-total losses and commercially acceptable lettuce cultivars with resistance to Verticillium wilt are not yet available. Research was conducted to understand the biology of the pathogen and disease management. (Krishnamurthy Subbarao)

A UCCE Advisor researched beet leafhopper (BLH) and curly top virus (BCTV), a damaging insect and disease affecting processing tomato growers in the northern San Joaquin Valley and lower Sacramento Valley. Findings were shared widely with the tomato industry at extension educational meetings and were published in the Progressive Crop Consultant. The

advisor also identified processing tomato plants infected with Fusarium Race- 3 and provided information about the availability of resistant processing tomato varieties. (Zheng Wang)

A 3-year project evaluating the novel insecticide, Verimark, consistently reduced beet curly top virus incidence in tomatoes. Under moderately high disease pressure, Verimark treated transplants yields were 32% higher than those untreated. (Tom Turini)

A UCCE Advisor in the Capitol Corridor region continued a long-term study on disease-resistant rootstocks of fresh market heirloom tomatoes. These are a cornerstone crop in the region, and many varieties lack resistance to soilborne diseases. This is a persistent and increasing issue for organic growers with few organic management options. Preliminary findings have been extended to growers through two extension meetings and several one-on-one conversations. (Margaret Lloyd)

Briefly describe how your target audience benefited from your project's activities.

Participants gained knowledge of detection and control practices for invasive and endemic pests and diseases.

- Pesticide applicators who attended the Airblast 2021 Conference indicated they learned something they can use in their work (97% of 69 respondents). In an open-ended question about intended behavior change, respondents mentioned calibrating (26%) and using water-sensitive paper (26%), which were key learning concepts for improving spray operations. (Lynn Wunderlich)

- Over half of the Napa Grape Short Course participants who responded to a survey agreed they would in some way consider changing the way they grow or manage vineyards. (Kari Arnold)

- Through a survey, when asked how likely UCCE Virtual Statewide Walnut Series participants are to implement practices discussed in these meetings, 91% responded mildly likely to highly likely. (Kari Arnold)

- Through a survey QCWI attendees reported intended behavior change in the way walnuts are grown or managed (91%). (Kari Arnold)

- Pistachio growers increased their awareness of the susceptibility of pistachio rootstocks to nematodes and potential risks for plantings, as observed by UCCE. (Andreas Westphal)

- Clientele shared with UCCE their intent to follow recommendations for alfalfa weevil resistance management, increased understanding of using newer and more selective materials for management of cotton pests, increased knowledge of how to monitor and trap armyworms, increased knowledge of how drone applications of natural enemies can fit within leafy greens integrated pest management programs, and increased willingness to adopt novel monitoring and management tactics for cucumber beetles. (Ian Grettenberger)

Participants adopted prevention and detection practices for invasive and endemic pests and diseases.

- UCCE's work on weedy rice has resulted in a change of attitude within the rice industry: from perceiving a weedy rice infestation as something to be kept secret, to realizing the high risk of this pest and willingness to share where infestations occur. This change has allowed UCCE's field surveys to determine the extent (3,500 acres), severity, and location of all known weedy rice infestations, which will allow UCCE to evaluate the success of management practices that have been developed. If weedy rice is not addressed, farmers could be forced to fallow their fields using burndown

herbicides such as glyphosate. Additionally, farmers could experience increased production costs and poor grain quality, which may “bruise” the good grain quality reputation of California rice, potentially affecting trade. (Luis Espino)

Participants adopted recommended treatment and management practices for invasive and endemic pests and diseases.

- Participants of the network-based approach to grapevine leafroll disease reported in a survey that 89.6% and 88.4% had adopted at least one management practice for leafroll and red blotch disease, respectively. Furthermore, a median of 4 out of 5 best practices were adopted for leafroll and 3 out of 6 for red blotch disease. Participatory research demonstrated the value of leafroll disease management at the individual and regional scale. As a result, leafroll disease severity and negative economic impacts have decreased significantly in Napa County. (Monica Cooper)

- Several growers have used UCCE's research-based information to inform decisions related to minimizing the impacts of grapevine red blotch disease through roguing (removing vines). Research outcomes showed that this mitigation action makes more sense for high quality red varieties than white grape varieties. Data indicated that the quality impact on whites is lower than reds, although both experience a decrease in yield. Producers have used the data to limit the removal of white grapevines. Additionally, about 10-20 wineries have changed their cleaning and sanitation protocols after receiving technical assistance after UCCE's extension events. (Anita Oberholster)

- During 2021, the Citrus Clonal Protection Program’s budwood system registered 2,273 new users for a total of 5,850 overall users. Over 1,000 users placed 1,411 orders for 92,050 buds of 369 different citrus varieties. Therefore, this project not only has achieved measurable behavior change but has also reduced the risk of people smuggling desirable citrus varieties into California. (Georgios Vidalakis)

- UCCE’s recommendations on disease control have been broadly adopted in the field based on feedback to UCCE from industry leaders and stakeholders. These include the use of Thiophanate-methyl as a standard practice to protect pruning wounds against canker pathogens in almonds**.** (Florent Trouillas)

- Three garlic processors have adopted UCCE’s recommended white rot fungicide and application method, which has been shown in replicated studies to reduce damage by as much as 68%. Most fields are not as severely infested as the trial site, and not every acre is infested, so a smaller benefit would be expected. Even with a reduction of damage by 1%, the savings to the garlic industry in Fresno County would be $3.6 million per year, based on the 2019 Fresno County Ag Commissioner’s Crop Report. (Tom Turini)

- The data from Processing Tomato Advisory Board and Processing Tomato Variety Guide indicate a remarkable increase to nearly 70 Fusarium wilt Race- 3 (Fol 3) resistance processing tomato varieties for the 2022 season, compared to only 12 in 2018. According to the state’s processing tomato production data in 2021, 46% of the total tonnage was harvested from Fol 3 resistance varieties compared to 12% in 2018. In Stanislaus County, 54.3% of the total tonnage was produced by Fol 3 resistance varieties in 2021 compared to 5.7% in 2018. UCCE recommendations are impacting the tomato industry and favoring the advancement of more resistant cultivars that maintain healthy and sustainable food production. (Zheng Wang)

- Tomato growers have adopted recommended transplant treatment in the highest risk areas in Kings County, as observed by UCCE. This has the potential to save growers $2.5 million per year, assuming moderately high pressure over 2,000 acres annually at the prices, and average yields in the 2020 Kings County Ag Commissioner’s Crop Production Report. There are several materials that have consistently performed similarly to the malathion standard, but there is need for at least one more season of data. (Tom Turini)

Participants adopted strategies to maintain yields and reduce crop losses.

- Results from the Roundup Ready Alfalfa trials generated information on the maximum crop height at the time of Roundup application to reduce the risk of crop injury followed by frost. In conversations with extension participant growers, approximately 50% utilized this information to prevent yield loss in the 2019 growing season. (Giuliano Galdi)

- The commercial alfalfa cooperator benefitted from participating in the UCCE field trial by experiencing a significant difference in crop injury. Crop injury six days after herbicide treatment ranged from 0-100% and then improved over time. At 47 days after treatment, crop injury ranged from 0-12.5%. Besides improving weed control, applying herbicide in a timely way increases growers' profitability and makes agriculture more sustainable by avoiding unnecessary herbicide applications. (Giuliano Galdi)

Science-based information was applied to integrated pest management policy and decision-making.

- Due to the brown marmorated stink bug discoveries in UCCE's traps, the Agricultural Commissioner's offices in Mendocino and Lake Counties decided to fund the deployment of their own traps in urban areas of each county (three in Lake County, ten in Mendocino) to complement UCCE's trapping efforts in agricultural areas. This joint effort in county-wide trapping for BMSB increases the likelihood of early detection that can help prevent the establishment and economic damage. (Cindy Kron)

- Thanks to UCCE's work, the biological control product Vintec was registered in California for use against canker diseases of almonds. (Florent Trouillas)

- UCCE's European asparagus aphid research trials resulted in the new registration of sulfoxaflor, which will give growers an effective, reduced-risk option to control this pest. Additionally, this registration has been highlighted as an IR-4 Success Story. (Brenna Aegerter)

- Many seed companies utilized UCCE's research to develop elite cultivars resistant to Verticillium wilt in lettuce. (Krishnamurthy Subbarao)

Briefly describe how the broader public benefited from your project's activities.

Change in condition: Money saved.

- The UCCE-maintained armyworm trapping network has successfully promoted field monitoring and management of armyworms, as reported by Sacramento Valley clientele. In 2021, the trapping network showed that armyworm pressure during 2021 was low, confirming clientele observations and aiding in the decision to skip treatment when appropriate. This resulted in savings of $25 per acre. (Luis Espino)

- Processing tomato growers adopted UCCE's recommendations of replanting early in the season to reduce the chance of BLH feeding and BCTV infection. Some fields prevented up to $900 of losses per acre, an approximate yield reduction of 10 tons per acre, compared to growers' other fields that were not replanted. (Zheng Wang)

- The Capitol Corridor cooperating grower benefitted from participating in UCCE's on-farm study in disease conditions as the seven UCCE recommended rootstocks produced economically-viable disease protection. Additionally, extension of these initial findings has already prevented seven growers from abandoning tomato acreage, saving them thousands of dollars and preserving important marketing relationships for their whole business. (Margaret Lloyd)

- UCCE's grapevine field trial in the Coachella Valley measured gains in net returns from spraying Topsin® M 70WP in year 2 and beyond. They ranged approximately between $210,000–310,000 per hectare over 25 years in a scenario of 50–75% disease control. This translates to a gain of approximately $8,500–$12,500 per hectare annually. This work provides a benchmark about the long-term benefits of adopting preventative pruning wounds protection on trunk disease incidence, vineyard productivity, and economic return. (Philippe Rolshausen)

Change in condition: Reduced pest incidence.

- For over a decade, the program led to the monitoring of more than one million grapevines for Pierce's Disease and a mark and removal program that has resulted in the removal of tens of thousands of infected vines. The Pierce's Disease extension and removal efforts in UCCE Kern County have contributed to a low incidence of Pierce's disease county-wide, as indicated by data collected in UCCE's vineyard surveys. (David Haviland)

- UCCE's extension efforts, collaborative relationships, and monitoring survey contributed to measured reductions in weedy rice infestations. Only 20% of previously known acreage was still infested with weedy rice, meaning that about 80% of the known acreage was no longer infested. Weedy rice can have a substantial economic impact on the rice industry in California, reducing yields for impacted growers. Results of the greenhouse studies indicated yield losses of over 70% at high densities. (Whitney Brim-DeForest)

The measured outcomes reported above can improve the state's ability to prevent, control, and mitigate pests and diseases and create new opportunities for economic sustainability. For example, using mating disruption to reduce navel orangeworm increased the crop value in almonds by more than $250 per acre, which is more than twice the cost of using the technique. In these ways, UC ANR contributes to increased agricultural efficiency and profitability and the public value of promoting economic prosperity in California.

Describe and explain any major changes or problems encountered in approach. Additionally, note opportunities for training and professional development provided, how results have been disseminated to communities of interest, and any new details regarding what the project or program plans to do during the next reporting period to accomplish the goals.

Given we now have the NRS Results form and know how NIFA wants outcomes reported, we are reporting impact stories. Please note this is different than how we initially listed intended outcomes in the 2021 plan. We will edit our future plans to reflect the current reporting approach.

Biological Control of Aflatoxins and Ochratoxins Contaminating Pistachio, Almond, and Figs and Challenges in Implementation in Commercial Orchards

Project Director
T Michailides
Organization
Regents of the University of California
Accession Number
1020240

Progress Report

In 2-3 sentences, briefly describe the issue or problem that your project addresses.

Mycotoxins are toxic are toxic metabolites produced by certain molds. Pistachios, almonds, and figs are occasionally contaminated with either aflatoxins and/or in case of pistachios and figs with ochratoxins. The most toxic of the mycotoxins, and highly regulated worldwide, are the aflatoxins produced by fungi in the Aspergillus section Flavi, which include A. flavus

and A. parasiticus, the most common aflatoxin producing species found in California tree nut and fig orchards. The mycotoxins are strictly regulated by various governments because they bare very toxic. Our research aims to reduce aflatoxin contamination of these crops.

Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.

This project supports the mission of the Agricultural Experiment Station by addressing the Hatch Act area(s) of: plant and animal production, protection, and health

Because mycotoxins are very toxic metabolites posing tremendous health issues to consumers and because they are regulated with tolerances set at a few to several ppb (parts per billion) our research aims to reduce contamination of California pistachios, almonds, and figs. All these crops are susceptible to contamination with aflatoxins produced by certain molds. Pistachio and figs are occasionally contaminated with either aflatoxins and/orochratoxins while almonds are contaminated solely with aflatoxins. The two species producing aflatoxins, A. flavus and A. parasiticus, and the species producing ochratoxin also are present in California orchards. In the past several years, we tested atoxigenic strains for reducing aflatoxin contamination. Most of the studies were done with the Atoxigenic strain of A. flavus (AF36). We were able to reduce aflatoxin positive samples by 40 to 55%. This strain now registered for used in pistachios (2012) and almond and figs (2017). In the summer of 2021, a second atoxigenic strain, NRRL 4828, under the commercial name Afla-Guard was registered for use in pistachio and almond. Currently in this project, we plan to determine what are the various factors limiting the effectiveness of AF36 Prevail in reducing aflatoxin contamination in nut crops and figs. In addition, we want to investigate whether the application of AF36 Prevail has any efficacy in reducing ochratoxin, which is another mycotoxin produced by several species of Aspergillus. Therefore, we plan to address the following five objectives: 1) to determine how the orchard environment affects the production and dispersal of spores of the AF36 and whether predators remove inoculum. 2) To evaluate changes in the microorganism populations on various nuts (infested by navel orangeworm, or early-split nuts) as affected by the application of AF36 Prevail in comparison with the microorganisms of nuts from

untreated orchards. 3) To find out if increasing the rate of AF36 Prevail product or applying it earlier in the season increases efficacy of the biocontrol product. 4) To evaluate effects of area-wide, long-term applications of AF36 Prevail. And 5) identify the fungi producing ochratoxins and determine the factors affecting ochratoxin contamination in pistachio and figs and whether the application of AF36 Prevail has any effect on levels of ochratoxins. We have been doing this research for years and we have the right personnel and methodologies to proceed with these studies.

For an effective reduction of aflatoxin contamination in crops, including pistachios, almond, and figs using the atoxigenic strain technology is necessary that the atoxigenic fungus applied in the soil be able to timely sporulate, and disperse to all parts of the canopy in risk of infection. Having an optimal sporulation of the applied product is essential for a successful dispersal of the atoxigenic strain and a successful displacement of toxigenic isolates. Soil moisture is one of the main factors influencing sporulation of the biocontrol product. To determine the best placement of the product, with respect to irrigation, for an optimal sporulation of the atoxigenic A. flavus biocontrol product AF36 Prevail® grains will be placed at different distances (from 25 to 250 cm) from the irrigation micro-sprinklers under field conditions. Both the sporulation of the A. flavus AF36 product grains and the soil water content will be periodically evaluated. Sporulation of AF36 Prevail® will also be tested under different temperatures in laboratory experiments. Predation will be checked by counting the changing number of grains per unit area and also recording the various insects and other organisms that may feed on seeds. To address objective 2, we will collect samples from AF36 Prevail treated and untreated fields, classify them at different categories, and evaluate the microorganism that may occur on these and

compared with the microorganism that occur on normal nuts in each treated and non-treated orchards. The samples will then be analyzed for aflatoxins and ochratoxins. Objective 4 is one of the most important goals in this project. We expect to have better efficacy when large areas are treated with AF36 Prevail and thus influence from untreated orchards is minimized. Samples from the area-wide treated regions and samples form untreated (control) areas will be compared by analyzing for aflatoxins and ochratoxins. In this way, we expect to find out whether the AF36 Prevail will influence the levels of ochratoxins, particularly in pistachios. Finally, in objective 5 we will focus on determining the various fungi that are able to produce ochratoxins on pistachios and figs and the factors (temperature, relative humidity, soil moisture) affecting the production of ochratoxins. In parallel in the laboratory, we will performed co-inoculation studies in which highly toxigenic strains will be co-inoculated with the AF36 Prevail strain and the inoculated nuts will be analyzed for aflatoxins and ochratoxins after one week incubation. After the completion of these studies, it will be much easier to answer question raised by growers on whether AF36 Prevail, in addition to reducing aflatoxins might also reduce ochratoxins.

Additionally, we continued analyzing pistachio library samples for aflatoxins and ochratoxins to compare and evaluate the effect of commercial application of AF36 Prevail® with that of other registered products (i.e. Afla-Guard GR). The results of these studies will be presented at the Statewide Pistachio Day, the American Pistachio growers Conference, and other county meetings.

Briefly describe how your target audience benefited from your project's activities.

This research will benefit the pistachio industry by reducing aflatoxin and ochratoxin contamination and therefore reducing the Rapid Alerts issued by the EU to reject loads exported to Europe.

The research will also benefit the almond industry by reducing aflatoxins and thus reducing the number of Rapid Alerts for almond loads exported to Europe. Similarly, the fig industry will be benefited by reducing of aflatoxin and ochratoxin contamination in California figs.

Briefly describe how the broader public benefited from your project's activities.

The general public will be benefited by consuming nuts and figs with lower risk of aflatoxin contamination and the general market by supplying products free or those will lower levels of aflatoxin and orchratoxin contamination

Describe and explain any major changes or problems encountered in approach. Additionally, note opportunities for training and professional development provided, how results have been disseminated to communities of interest, and any new details regarding what the project or program plans to do during the next reporting period to accomplish the goals.

Publications:

Moral, J.. Garcia-Lopez, M. T., Gordon, A., Ortega-Beltran, A., Puckett, R., Tomari, K., Gradziel, T., and Michailides, T.J. 2022. Resistance to *Aspergillus flavus* and *Aspergillus parasiticus* in almond advanced selections and cultivars and its interaction with the aflatoxin biocontrol strategy. Plant Disease 106: (https://doi.org/10-1094/PDIS-05-21-0892-RE).

Garcia-Lopez, M.T., Luo, Y., Ortega-Beltran, A., Jaime, R., Moral, J., and Michailides, T. J. 2021. Quantification of the aflatoxin biocontrol strain *Aspergillus flavus* AF36 in soil and in nuts and leaves of pistachio by Real-Time PCR. Plant Disease. (https://doi.org/10.1094/PDIS-05-20-1097-RE).

Changes:

Since Afla-Guard was registered, in 2022 we plan to compare AF36 and Afla-Guard effects in reducing aflatoxins in commercial pistachio orchards.

Dissemination:

The results were communicated to the in various communities, mainly with organized conferences, either by the University of California Extension Agents (farm advisors), and/or the industry boards. Also, multiple telephone responses were conducted when interested parties called to find information about the biocontrol of aflatoxins in all pistachios, almonds, and figs. In addition, we published a couple of popular magazine articles. Results were disseminated at the Statewide Pistachio Day (virtual presentation), there were approximately 300+ attendees and the presentation was entitled 'Aflatoxin management in Pistachios'.

Impact Statement (Optional)

Use this space to talk about the impact that this result had, in layman's terms. Adding comments here will **not** change the content in the highlighted result.

Research on biocontrol to improve food safety

California produces almost all the almonds, pistachios, and figs in the United States. These crops are occasionally contaminated with aflatoxin, a specific kind of toxin produced by fungi. Due to their toxicity, aflatoxins are strictly regulated worldwide, and food crops routinely tested. The aflatoxin-producing fungi are common in soil and the spores are airborne, which makes management challenging. The only reliable method of control is using strains that do not produce toxins to displace or exclude the aflatoxin-producing strains. The UC AES Plant Pathologist is studying two commercialized strains to document the best timing, rate, and placement. This new knowledge on how to achieve good biocontrol of aflatoxins will improve public food safety, and the marketability of these crops.

Closing Out (end date 09/06/2023)

Evolution, genetics,spread, and management of weeds in California

Project Director
Marie Jasieniuk
Organization
Regents of the University of California
Accession Number
1016401

Progress Report

In 2-3 sentences, briefly describe the issue or problem that your project addresses.

My project investigates the evolutionary, genetic, demographic, and/or physiological processes underlying the introduction, establishment, adaptation, and spread of weeds in California for the purpose of informing the design of effective, long-term weed management programs.

Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.

(1) Results of greenhouse, growth cabinet, and laboratory studies indicated that reduced susceptibility to glufosinate herbicide can evolve in Italian ryegrass (Lolium multiflorum) following repeated applications of even low rates of the herbicide. The magnitude of increase in resistance level is lower than that observed in response to repeated application of other herbicides at low rates but still points to the need for integrating non-herbicide weed control practices with the use of herbicides for the long-term management of Italian ryegrass in California.

(2) Results of review of the reproductive biology and herbicide resistance in Italian ryegrass in North America and globally clearly indicated that the species' self-incompatibility, extremely high outcrossing rate, and wind pollination has led to pollen-mediated gene flow as a mechanism by which herbicide resistance alleles can spread across an agricultural landscape. Further, Italian ryegrass readily hybridizes with other Lolium species (perennial ryegrass and rigid ryegrass) with the potential for resistance gene transfer across species boundaries. Results point to the need to intensely manage and isolate herbicide-resistant ryegrass immediately upon confirmation of resistance.

(3) As Reviewer of PRE-invasive plant risk assessments and Member of the Plant List Committee for PlantRight (https://plantright.org/), my activities have contributed to the identification and listing of ornamental plants that have a high risk of becoming invasive weeds in California. The information is provided to California nurseries not to sell any invasive plant on the PlantRight list and to consumers not to buy the listed species thus preventing the spread of invasive ornamental weeds in California.

Briefly describe how your target audience benefited from your project's activities.

Farm advisors, CE specialists, Pest Control Advisors (PCAs), and herbicide industry professionals have all been provided with the results indicating that reduced susceptibility to glufosinate can evolve in Italian ryegrass following repeated applications with even low rates of glufosinate. This target audience has also been informed of our recommendation that the control of Italian ryegrass in California requires an integrated weed management approach that includes non-herbicide practices. Hopefully, growers and land managers will be informed by this target audience. Results on the transfer of resistance alleles in Italian ryegrass are more recent thus communication of the weed management implications to the target audience is just beginning. The target audience for the work focusing on ornamental plants and their invasive potential in California includes nursery professionals, Master Gardeners, and the general public. Results of these plant risk assessments are communicated by PlantRight (https://plantright.org/) to this target audience.

Briefly describe how the broader public benefited from your project's activities.

Results of our studies on Italian ryegrass will benefit the broader public by ultimately leading to a reduction in pesticide inputs into the environment if farmers and land managers heed our recommendation to control Italian ryegrass using an integrated weed management approach as opposed to relying solely on herbicides for its management. Results of the plant risk assessments will benefit the broader public by informing them of the invasive potential of ornamental plants they choose to plant around their homes and use for landscaping.

Describe and explain any major changes or problems encountered in approach. Additionally, note opportunities for training and professional development provided, how results have been disseminated to communities of interest, and any new details regarding what the project or program plans to do during the next reporting period to accomplish the goals.

Beckie HJ, Jasieniuk M (2021) Chapter 12. Lolium rigidum and Lolium multiflorum. Pages 261-283 in Chauhan BS, ed. Biology and Management of Problematic Crop Weed Species. London UK: Elsevier Inc.

Jhala AJ, Beckie HJ, Mallory-Smith C, Jasieniuk M, Busi R, Norsworthy JK, Bagavathiannan MV, Tidemann BD, Geddes CM (2021) Transfer of resistance alleles from herbicide-resistant to susceptible grass weeds via pollen-mediated gene flow. Weed Technology https://doi.org/10.1017/wet.2021.82

Matzrafi M, Morran S, Jasieniuk M (2020) Recurrent selection with glufosinate at low rates reduces the susceptibility of a Lolium perenne ssp. multiflorum population to glufosinate. Agronomy-Basel 10:1288 https://doi.org/10.3390/agronomy10091288

Impact Statement (Optional)

Use this space to talk about the impact that this result had, in layman's terms. Adding comments here will **not** change the content in the highlighted result.

Understanding herbicide resistance in Italian ryegrass

Italian ryegrass (*Lolium multiflorum*) is an invasive annual grass that has spread across much of California, posing issues for both annual and perennial crop production systems. The UC AES weed scientist investigated how Italian ryegrass can evolve to develop reduced susceptibility to glufosinate by using controlled conditions with repeated low application rates of the herbicide. Italian ryegrass is wind pollinated and strongly outcrossing. This means that resistant genes can spread relatively easily through the ryegrass population. Additionally, Italian ryegrass can form hybrids with other perennial ryegrass and rigid ryegrass, potentially generating herbicide resistance genes across species. These features all point to the need to closely monitor and manage herbicide resistance in this invasive weed.

Closing Out (end date 09/06/2023)

Weed control programs for California flower, strawberry and vegetable growers

Project Director
Steven Fennimore
Organization
Regents of the University of California
Accession Number
1016438

Progress Report

In 2-3 sentences, briefly describe the issue or problem that your project addresses.

The goal of this project is to develop practical cost effective methods to contain or reduce the weed control expense of California vegetable and strawberry growers. We are evaluating chemical and physical control tools to manage weeds in these crops.

Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.

New methods of applying herbicides in lettuce. We are working on lettuce weed control systems that seek to improve labor and water use efficiency. Applying Kerb herbicide through the drip irrigation system saves water because drip irrigation is more efficient than sprinkler irrigation. Kerb applied to bed tops by spray application was compared to application through drip irrigation tape in two trials during 2021. These trials were conducted to support the request for a Kerb Special Local Needs label for California. The Kerb standard was spray applied at 3.5 and 5 pints per acre prior to planting. Following planting Kerb was applied at 3.5 and 5 pints/A by chemigation through buried drip irrigation tape just before lettuce emerged.

Major weeds present were annual ryegrass, common purslane, burning nettle and shepherds-purse. Both methods of Kerb application provided equally effective control of ryegrass, compared to the nontreated control. Kerb applied as a surface spray was more effective in controlling purslane, than the chemigation method and the nontreated control. This is due to purslane germinating at very shallow soil depths where the Kerb from the surface spray is applied. Neither Kerb application method provided effective control of burning nettle or shepherds-purse. No lettuce injury or yield loss was observed in either trial.

Cole crops. Tough herbicide (pyridate) at 0.47 and 0.62 lbs. ai per acre was evaluated on transplanted broccoli and cauliflower for post emergence weed control. Cauliflower tolerance to Tough was fair and broccoli tolerance was not acceptable. More work needs to be performed on these crops to determine if there are variations in crop tolerance by variety.

Strawberry research. Weed control under the plastic mulch in strawberry beds is labor intensive and expensive due to need for hand removal. Means to control weeds under the plastic are needed. Napropamide (Devrinol 50DF) herbicide was evaluated in “Cabrillo” strawberry at 2.0 and 4.0 lbs. ai/A, compared to the standard flumioxazin (Chateau 51WDG) at 0.1 lbs. ai/A. Devrinol, and Chateau were spray applied pre-transplant to the bed-top soil. At 29 days post-transplant Devrinol was injected through the drip irrigation system with WaterMaxx at 2.0 quarts product/A.

Devrinol applied preemergence controlled ryegrass at levels similar to Chateau. Devrinol applied post-transplant through the drip irrigation system was not as effective on ryegrass as Devrinol applied preemergence. Devrinol applied post-transplant by drip irrigation controlled common sowthistle similar to Chateau, and greater than that of Devrinol applied by preemergence spray. Devrinol applied at 2.0 and 4.0 lbs. ai/acre as a preemergence treatment caused early season stunting of strawberry plants; however, the plants outgrow this injury. Devrinol applied at 2.0 and 4.0 lbs. ai/A as a post-transplant drip injection causes early season stunting of the strawberry plant canopy; which persists, but does not worsen, as the season progresses. Devrinol appears to be safe on strawberry plants where applied as either a pretransplant bed-top spray or a post-transplant dripline injection.

Auto cultivators. We evaluated automated robotic cultivators that can perform many of the same activities as hand weeding crews. We evaluated three autonomous weeder machines: the Farmwise Titan cultivator, the Stout cultivator and the Dino weeder from NAIO, a French company. Auto cultivation carried out following lettuce thinning was compared with standard cultivation which leaves a 4 to 5-inch-wide band around the seedline. Hand weeding by commercial crews was measured to determine time to hand weed, and harvest evaluations were conducted to measure crop productivity. The Farmwise Titan removed 32 to 69% of the seedline weeds compared to 0% for the standard cultivator on commercial farms and 91% of the weeds in a field station study compared to 67% for the standard cultivator. Weeding times with the Titan ranged from 9.8 to 10.9 hours per acre compared to 11.2 to 23.4 hours per acre for the standard cultivator. The Stout cultivator removed between 53 to 99% of the weeds. On the field station study the Stout cultivator removed 89% of the weeds in the seedline compared to 0% for the standard cultivator. Hand weeding times on the field station were 30.4 hours for Stout compared to 78.3 hours for the standard cultivator. In a study at Gonzales, CA the Dino removed 60% of the weeds compared to 0% for grower standard. At that site hand weeding times were 7.4 and 11.9 hours per acre in the Dino and standard cultivator plots, respectively. At Hartnell, Dino removed 62% of the weeds compared to 42% for the standard cultivator. Hand weeding times were 17.8 and 30.5 hours per acre in Dino and standard cultivator treatments respectively.

Benefits to the target audience include water and labor savings from more efficient herbicide application methods. This benefit will be realized if a Special Local Needs label is granted in California for Kerb herbicide applications through the drip irrigation system. Our work on strawberry herbicides is designed to try to reduce the need for hand weeding labor under the plastic mulch.

Our work on robotic weeders provides our target audience with timely and accurate information about the newest automated weeders. These weeders reduce hand weeding times 30 to 60% which helps contain weed control costs for vegetable crops. The lack of laborers available to do hand weeding means that it is not always possible to remove weeds when necessary. These new auto weeders offer a more dependable method of weed removal and helps ensure that weed competition will not damage produce quality.

Briefly describe how your target audience benefited from your project's activities.

Benefits to the target audience include water and labor savings from more efficient herbicide application methods. This benefit will be realized if a Special Local Needs label is granted in California for Kerb herbicide applications through the drip irrigation system. Our work on strawberry herbicides is designed to try to reduce the need for hand weeding labor under the plastic mulch.

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Briefly describe how the broader public benefited from your project's activities.

The broader public benefits from increased water use efficiency in agricultural systems which helps shore up domestic water supplies. The public also benefits from improved food quality and safety. Improved quality results from making sure that weed competition is minimized. Improved food safety results from reduced human entry into the field.

Describe and explain any major changes or problems encountered in approach. Additionally, note opportunities for training and professional development provided, how results have been disseminated to communities of interest, and any new details regarding what the project or program plans to do during the next reporting period to accomplish the goals.

Rachuy JS and Fennimore SA (2021) Vegetable response to sulfentrazone soil residues at four planting intervals. Weed Technol. 35: 216–222. doi: 10.1017/wet.2020.100

Michuda A, Goodhue RE, Hoffmann M and Fennimore SA (2021) Predicting Net Returns of Organic and Conventional Strawberry Following Soil Disinfestation with Steam or Steam Plus Additives. *Agronomy* **2021**, *11*, 149. https://doi.org/10.3390/agronomy11010149

Kim DS, Kim S, Fennimore S. (2021) Evaluation of Broadcast Steam Application with Mustard Seed Meal in Fruiting Strawberry. HORTSCIENCE 56(4):500–505. https://doi.org/10.21273/HORTSCI15669-20

Impact Statement (Optional)

Use this space to talk about the impact that this result had, in layman's terms. Adding comments here will **not** change the content in the highlighted result.

Weeding with robotic technology

Despite advancements in technology, weed management remains an issue in many crop production systems, often requiring herbicides to achieve control. The UC AES research project helps California's vegetable and strawberry growers with weed management options, including efficacy assessments for new products or new uses for existing ones. The agricultural labor crisis makes manual weeding costly and difficult to schedule for many growers. While herbicides can provide one opportunity to alleviate this scarcity of labor, they can come with environmental concerns. The Specialist's research assesses the extent to which mechanical weeding can replace manual weeding and herbicide use, offering environmental and economic benefits for growers and consumers.

Development of integrated pest management strategy for pestiferous arthropods in urban settings

Project Director

Dong-Hwan Choe

Organization

Regents of the University of California

Accession Number

1015861

Development of integrated pest management strategy for pestiferous arthropods in urban settings

In 2-3 sentences, briefly describe the issue or problem that your project addresses.

My project addresses the insect pests that occur in and around urban / structural settings. In 2020, about 83 percent of the total population in the United States lives in cities and urban areas. The major goals of my projects are to investigate and develop principles and strategies contributing to effective insect / spider management in urban settings such as homes, apartments, commercial buildings, museums, and recreational areas. My project will also cover various pest problems in suburban - agricultural interface, which become more common situation as cities are expanding to the areas that were used to be agricultural land. By understanding pest biology, my project develops new IPM (integrated pest management) strategies and improves the current methods to minimize the impacts on non-targets and environments while achieving necessary level of pest suppression. In particular, I focus my effort to study several different groups of pestiferous insects / arthropod of urban importance: Argentine ants, bed bug, spider, termites, and wasps.

Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.

Argentine ant is ranked as one of the most important urban pests in California. Current control measures for Argentine ants typically include perimeter applications of insecticides around structures, resulting in problems with insecticide runoff and environmental contamination. Because ants exhibit strong innate trail-following responses, the trail pheromones and aggregation pheromones have great potential for attracting target ant species to toxic baits or insecticide-treated surfaces.

IPM strategies based on using trail pheromones to attract ants to point sources of toxic baits or treated surfaces will minimize pesticide runoff problems in urban waterways. We refer to this approach as the "lure-and-kill" technique. This "lure-and-kill" approach will improve the efficacy and target specificity of existing control methods by exploiting ants' innate trail-following behavior, while simultaneously providing environmentally and economically favorable IPM strategies. Supporting this goal, we plan to test the effect of (Z)-9-hexadecenal, a known pheromone component of Argentine ant, to the behavior of laboratory / field population of Argentine ants. Furthermore, I plan to develop effective pheromone formulations with a close collaboration with an industry collaborator, and develop protocols for incorporating the pheromone formulations with insecticide sprays for ant control. With these protocols, I also plan to conduct field studies to compare the efficacies of conventional approaches and our novel strategies, with the assistance of volunteering houses and cooperating Pest Management Professionals (PMPs). This work will provide a major advance in IPM strategy for control of pest ant species in urban settings by decreasing the overall amount of applied insecticide and reducing the potential runoff of pesticides in to urban waterways.

One of the more recent research projects involves biodegradable hydrogel matrix to deliver liquid bait for ant control. In previous research synthetic hydrogel compound (polyacrylamide) has been tested with some good amount of promise. However, polyacrylamide was persistent on the surface of the ground even after the ants consumed the liquid bait absorbed in it. The new project investigates the natural polymer compound that can be used for this bait delivery purpose. The natural / biodegradable hydrogel will be dissipating in the environment after being used as a carrier of an ant bait. In 2020-2021, we have been testing this biodegradable hydrogel bait with boric acid (as an active ingredient) to control Argentine ants in citrus groves (with a research fund from California Department of Pesticide Regulation).

Bed bugs continue to increase and plague many cities in America. Although some control methods exist, more are needed, especially those that pose minimal risk to humans and the environment. One project of bed bug is to understand their chemical ecology to exploit their behavior and use natural attractant compounds to develop a monitor / detection device that can be readily incorporated with a IPM practices to manage this pest. For the bed bug infestation, early and accurate detection is the key component for successful control. This goal will be addressed through four objectives: Objective 1. Conduct laboratory studies to identify the important behavior-modifying chemical cues for bed bugs. Objective 2. Determine whether the synthetic / standard chemical will increase bed bug's aggregation and retention once they contact a harborage substrate

treated with the chemical. Objective 3. Develop effective and economical methods of incorporating the chemical attractant(s) into novel monitoring tools for bed bug. Objective 4. Conduct field studies to directly compare our novel bed bug detector / monitor with conventional pit-fall traps and other types of active / passive monitors.

One of the recent projects on bed bug investigated the impact of entomopathogenic fungi to bed bug survivorship. Behavioral / chemical ecological interaction between bed bugs and entomopathogenic fungal species will be investigated. Since these biological control options have been receiving some good amount of interest from pest control industry , generating scientific data based on well-designed experiment will be able to provide realistic picture on this biological control options for bed bug control.

For termites, our goal is to study and exploit termite attractant pheromones to develop a functional Integrated Pest Management (IPM) approach to control drywood termites (Incisitermes spp.) in urban structures. This goal will be addressed through four objectives: Objective 1. Identify and synthesize the attractant / trail pheromones of western drywood termites, I. minor. Objective 2. Determine whether the synthetic pheromones will increase termites' contact with treated surfaces (liquid and dust). Objective 3. Develop effective and economical methods of incorporating synthetic pheromones into currently available insecticidal sprays or dusts.

Another recent development in our termite research is about utilizing botanical essential oil components as an adjuvant for structural heat treatment for drywood termite. This method can be effective in reducing the impact of “hard-to-heat” areas in the structure for the maximum control efficacy. The heat treatment is one of the non-chemical options that can be used to target relatively large portions of structure.

For wasps, our goal is to develop effective and economically viable baiting technology for western yellowjacket, Vespula pensylvanica. With their venomous sting and aggressive foraging behavior, the yellowjackets have been a continuing problem in many parks and other recreational area throughout the state. In collaboration with UC Cooperative Extension and Irvine Regional Park, we plan to monitor the activity level of yellowjackets using an active monitor with a chemical lure. Irvine Regional Park is located among a grove of oak and sycamore trees. The foothills and wilderness areas surrounding the park provide an ideal habitat for yellowjackets. With many picnic activities at shaded turf areas in the park, this park provides an excellent foraging setting for the local western yellowjackets. We plan to bait locations when the yellowjacket trap count was greater than a threshold level using chicken-based baits treated with a low rate of fipronil. Objective 1. Conduct continuous monitoring of yellowjacket activity throughout the year. Objective 2. Develop effective and economic methods of baiting yellowjackets in the park.

Accomplishments:

Several practical methods of incorporating the insect pheromones in the insecticidal sprays and insecticidal baits were tested and successfully established based on laboratory and field studies. Some of these technologies are currently patent-pending. Using several insecticides including volatiles essential oils and pyrethroids, out project was able to successfully demonstrate that bed bugs would show different levels of tolerance to these materials depending upon their feeding status.

Our study with bed bug exuviae elucidated that one of the major sources of volatile aldehyde pheromones in the bed bug's headspace volatiles. Laboratory experiment demonstrated that these aldehydes slowly evaporate from the shed exuviae, and the bed bugs respond to these volatiles by being arrested in the vicinity of the exuviae. Bed bugs have been tested with *Beauveria bassiana*, one of the most commonly adopted entomopathogenic fungi for pest management, in more realistic settings that mimics bed bug harborage sites.

Another important research done during the current project period was developing a new bed bug detection technique using chemical markers. In a collaboration with a major chemical company, my program has been involved in developing, testing, and calibrating the new technology to detect chemical signatures of bed bugs left on the substrates.

Termite research with heat treatment and botanical essential oil was conducted in the laboratory as well as semi-field conditions (at “Villa Termiti” at Richmond Field Station). The target species was western drywood termite. The laboratory study and field study outcome indicated that the volatile adjuvant can improve the current heat treatment protocols.

The use of protein-based bait for the area-wide yellowjacket control was successfully demonstrated by our field experiment. The novel substrates were also tested with the protein-based liquid bait to determine if these non-meat substrates can be used instead. The field data so far has been highly promising.

Briefly describe how your target audience benefited from your project's activities.

My clientele groups include:

Pest management professionals, general public, chemical pesticide manufacturer, state / federal regulators and agencies, pest management associations, environmental groups, housing management, school district, county-based urban IPM advisors.

Outcome dissemination and impacts for the communities of interest:

During the current project period, I have developed a robust extension program on the biology and management of urban pest arthropods. Central to my extension program is my leading role in organizing the UCR Urban Pest Management Conference (2011-current, with about 200 attendees annually). This longstanding annual meeting is well attended by pest management professionals throughout California and the Southwest United States, providing an ideal setting to communicate updates on scientific research and regulations to those how can immediately utilize the information. All of the educational materials and information are archived in the conference resource page developed and managed by me (http://ucanr.edu/sites/ucrurbanpest/Conferences/), allowing the conference attendees to freely access the resources anytime they need for continuing education and in- house training for their companies or agencies. In 2020-2021 project period, the conference was organized as a virtual one due to COVID-19 pandemic related limitations.

In addition to organizing the UCR Urban Pest Management Conference annually, I have been also active in co-organizing UCR Fumigation School with an industry collaborator. This is another unique educational opportunity for the pest management industry serving California. This event is typically held in November at UCR Extension.

In 2020-2021 project period, we continued provide another online education / outreach event — UCR Urban Entomology Fall Workshop Online. The demand on this type of online education was higher than ever because many of these types of event have been cancelled due to COVID-19 pandemic. This event provided some really new research updates on urban pest management to pest management professionals, and it was very successful with >70 participants.

Besides organizing these events, I have been also active in disseminating the results on urban pest management to clientele. During the current project, I have made more than 15 extension / research presentations on various topics of urban pest management to a wide range of audiences, including academics, pest management professionals, pest control advisors, landscape professionals, regulatory agencies, and the general public. I also regularly consulted on insect identification or pest control recommendations for local agencies or businesses, and provided technical advice to industry on product development or marketing.

In 2020-2021, impact of my outreach activities was evaluated using an indirect approach. We used a survey to assess the impact of the UCR Urban Pest Management Conference on behavior of our clientele group. The survey indicated that the impact of the conference is significant. For the question "As a result of participating in today's conference, I intend to apply at least one thing that I learned for what I do in urban pest management" (with 1 for strongly disagree and 5 for strongly agree), we got 4.9 (n = 271) in 2021 UCR Urban Pest Management Conference.

Briefly describe how the broader public benefited from your project's activities.

Throughout the current project, I have been continuously serving as a co-organizer for the Annual UCR Urban Pest Management Conference. We invite pest management professionals, pesticide / environmental regulators, pesticide companies, and the general public who serve in pest-related fields to provide the up-to-date scientific, technical, and regulatory information. In recent years, the conference had >200 registered attendees and more than dozen industry sponsors. Another important avenue for disseminating most up-to-date research data to the general public and professionals is an online extension publication (e.g., UCR Center for Invasive Species Research website) and trade magazine that is distributed nationwide (e.g., Pest Control Technology). I have been also maintaining several online resources including Choe Laboratory website (http://urbanpest.ucr.edu), Pesticide Usage Database (http://urbanpest.ucr.edu/pesticideuse/). I also have been providing numerous symposium / workshop presentations for continuing education of professionals or general public who work with pest-related issues.

Describe and explain any major changes or problems encountered in approach. Additionally, note opportunities for training and professional development provided, how results have been disseminated to communities of interest, and any new details regarding what the project or program plans to do during the next reporting period to accomplish the goals.

N/A

Impact Statement (Optional)

Use this space to talk about the impact that this result had, in layman's terms. Adding comments here will **not** change the content in the highlighted result.

Innovative ant control strategies protect water quality

The Argentine ant (Linepithema humile) is one of the most important urban pests in California, typically controlled by routine applications of insecticides around structure perimeters of homes, apartments, and businesses. However, insecticides have been known to runoff from the application site during irrigation and other outdoor watering, and can lead to environmental problems in urban streams, creeks, rivers, and lakes. The UC AES entomologist is exploring new Integrated Pest Management tactics that reduce the amount of insecticide applied but maintain their effectiveness. Another method is to use ants' scent cues to lead them to a bait station.

Critical Issue

Healthy Families and Communities

Improving Stability and Delivery of Food Derived Bioactive Compounds and Probiotics Using Bio-inspired Encapsulation Approaches

Project Director

Nitin Nitin

Organization

Regents of the University of California

Accession Number

1020134

Progress Report

In 2-3 sentences, briefly describe the issue or problem that your project addresses.

The projects aim to improve stability and delivery of bioactive compounds and probiotics using bio-based materials. These materials provide enhanced stability and affinity for the delivery of these bioactives.

Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.

Overall, this research project has developed innovative and sustainable bio-based approaches to improve stability and delivery of bioactive compounds. The list below illustrates specific innovations and approaches to achieve these goals

- Developed new food ingredient compositions based on clustering of cells to influence the rate of release of bioactives during digestion.
- Used spend biomaterials, such as grape pomace to encapsulate bioactives, improve stability of bioactives during storage and processing and demonstrate effectiveness of the spent pomace to deliver bioactives during simulated digestion
- Developed yeast and fungal biomass-based encapsulation of bioactives and evaluated differences in the release properties of bioactives from single and multi-cell bio-derived materials
- Developed a novel combination of polyphenolic and probiotics to improve stability of probiotics during gastric and intestinal pass and increase persistence of the probiotics in the gut. This innovation has resulted in filing of a provisional patent

Briefly describe how your target audience benefited from your project's activities.

1. The project addressed the unmet needs of the food industry by providing innovative and sustainable solutions to improve shelf life of active ingredients in food

2. The project specifically addressed the consumer and the industry need to enhance delivery of bioactives to improve human health.

3. The project also developed novel patentable innovations that can enhance the economic opportunity for the US industries in this field.

4. The project also developed solutions that provided value added solutions to the spent ingredients or inputs from the industry.

5. The results of the projects were shared with the target audience through presentations at scientific meetings, invited lectures and peer-reviewed publications

Briefly describe how the broader public benefited from your project's activities.

1. The project activities benefit the broader public by providing an improved food system with enhanced stability and delivery of bioactives

2. The project also provides a unique and an effective approach to enhance stability and persistence of probiotics in the gut. Gut health is one the leading health concerns among public and development of food based solutions to improve gut health has significant potential to benefit the broader public.

Describe and explain any major changes or problems encountered in approach. Additionally, note opportunities for training and professional development provided, how results have been disseminated to communities of interest, and any new details regarding what the project or program plans to do during the next reporting period to accomplish the goals.

Journal Publications:

1. F Dou, Y Lu, N Nitin, Yeast cell microcarriers for delivery of a model bioactive compound in skin, International Journal of Pharmaceutics 609, 121123, 2021

2. R Rai, C Merrell, W Yokoyama, N Nitin, Infusion of trans-resveratrol in micron-scale grape skin powder for enhanced stability and bioaccessibility, Food Chemistry 340, 127894, 2021.

3. Andrew P. Karman, Susan E. Ebeler, Nitin Nitin, Stephanie R. Dungan, Partitioning, solubility and solubilization of limonene into water or short?chain phosphatidylcholine solutions, Journal of the American Oil Chemists' Society 98(10), 2021.

4. Yixing Lu, R. Rai, N. Nitin, Engineering cell-based microstructures to study the effect of structural complexity on in vitro bioaccessibility of a lipophilic bioactive compound, Submitted (2022).

Impact Statement (Optional)

Use this space to talk about the impact that this result had, in layman's terms. Adding comments here will **not** change the content in the highlighted result.

Upcycled ingredients improve bioavailability and delivery of supplements

The UC AES researcher in food science and technology is working to develop new formulations that improve the bioavailability and delivery of nutritional supplements and probiotics. These formulations combine spent ingredients from food processing industries such as grape pomace or apple pomace with nutritional supplements or probiotic bacteria using a patented technology developed at UC Davis. In the case of nutritional supplements, it enhances the delivery of bioactive components to the gut. In probiotics, it enhances the survival of probiotic bacteria during digestion and enhances the persistence of these probiotics in the gut. These formulations also improve products' shelf life and stability during storage, helping to meet the needs of industry and consumers for more sustainable products that improve human health.

Nutrition

Project Director
Katherine Webb-Martinez
Organization
Regents of the University of California
Accession Number
7000181

Improving food security

In 2-3 sentences, briefly describe the issue or problem that your project addresses.

One out of ten Californians does not know where their next meal will come from. Of the four million Californians struggling with food insecurity, 1.2 million are children. Food insecurity for youth increases school absences and behavioral problems and reduces children's concentration and academic achievement. There is an ongoing need to increase participation in the CalFresh (SNAP) benefits program and connect families to additional resources such as the Women, Infants, and Children (WIC), USDA's Summer Food Service Program, and the broader charitable food network. As COVID-related shutdowns and economic challenges persist into a second year, these programs are a cornerstone for families' food security and physical health.

Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.

UC ANR's statewide programs provide academic oversight and local implementation of the Expanded Food and Nutrition Education Program (EFNEP), CalFresh Healthy Living, UC (CFHL, UC), and the Master Food Preserver Program. EFNEP and CFHL, UC use evidence-based curricula to deliver direct education on food security to participants across California. For example, in Alameda, Contra Costa, San Bernardino and Kern counties, EFNEP and CalFresh Healthy Living, UCCE educators provided a ten-part virtual series, UCCE Connects to You, in English and Spanish. Lessons focused on strategies to stretch the household food budget and provided information on COVID-19 related emergency food assistance programs. Some programs also demonstrated recipes for the food items parents received from local distribution programs. (CFHL, UC, EFNEP, Marisa Neelon, Chutima Ganthavorn)

To increase access to farmers market incentive programs and address barriers, UCCE in San Luis Obispo County convened partners through the EBT at Farmers Markets working group of the San Luis Obispo Food System Coalition. The workgroup includes partners from multiple sectors, including agriculture, government, private industry, and community-based organizations. The workgroup aims to increase the use of CalFresh at farmers markets to create equitable access to healthy food and support for local farmers. Partners collaborated to increase the visibility of farmers market incentives through social media, text messaging, materials distribution to local client-serving organizations, press releases, paid advertisements, and promotion at local food bank distributions and farmers markets. The workgroup applied for and received $30,000 in funding from the Danone Foundation to pilot a Farmers Market Navigator program to increase access to farmers market incentives among Hispanic and Latino customers who use CalFresh. (Katherine Soule, Shannon Klisch, Emily Dimond, Rosa Vargas)

A UCCE Specialist at UC Berkeley continued researching the impact of a nutrition course with an integrated teaching kitchen implemented in the college setting. Their study used a pre-post model to evaluate its effects on food security, nutrition, and students' self-efficacy related to food preparation and cooking. This year they improved the study design to include a comparison group (students who are not taking the class) in addition to the intervention group. In-person measurements of skin carotenoid as a biomarker of fruits and vegetable intake and blood pressure are being collected. (Susana Matias)

Briefly describe how your target audience benefited from your project's activities.

Participants learned how to increase food resources.

- Out of 248 parents that graduated from the virtual *UCCE Connects to You* series from EFNEP in Alameda and Contra Costa counties, 17% and 21% in those counties respectively improved in one or more food security indicators such as having enough money to buy food and having enough food to eat. (Marisa Neelon)

- Out of 128 JobTrain students in San Mateo County who participated in Plan, Shop, Save, Cook (PSSC) workshops with CFHL UC, 88% reported improvements, ranging from comparing unit prices more often (43%) to reading/using nutrition facts labels more often (60%). (Andra Nicoli, Mary Vollinger, Laura Vollmer, Elaine Silvers, Aileen Trujillo)

Change in condition: Participants improved food security.

- EFNEP surveyed nearly 1,400 participants statewide, and 13% of those adult respondents showed improvement in one or more food security indicators such as not eating less than you wanted so there was more food for your family or having enough money to get food for your family. (EFNEP)

- Out of 128 JobTrain students in San Mateo County who participated in Plan, Shop, Save, Cook (PSSC) workshops with CFHL UC, 28% of participants reported running out of food less often before the end of the month, suggesting they were more food secure after taking the course. (Andra Nicoli, Mary Vollinger, Laura Vollmer, Elaine Silvers, Aileen Trujillo)

- Of the 42 parents who participated in CFHL, UCCE Kern County programming, 30 parents participated in a post-survey. After attending the PSSC class series, 33% reported running out of food before the end of the month less often, indicating an improvement in families' food security. Ninety percent reported improvement in at least one of five food resource management behaviors (plan, prices, shop, think, facts). (Beatriz Rojas)

- Out of 216 study participants in the nutrition and cooking course study at UC Berkeley, 171 completed pre-and post-food security survey data. Respondents showed statistically significant improvements in food security, increasing those who indicated they were “food secure” at follow-up by 44%. The number of respondents indicating “very low food security” also decreased by 76%. Findings from the original evaluation study were published in two manuscripts in peer review journals in 2021. (Susana Matias)

Briefly describe how the broader public benefited from your project's activities.

Change in condition: Improved community food security.

- CFHL, UCCE in San Luis Obispo worked with extenders, school teachers, and staff at partnering school sites to harvest over 1,600 pounds of produce from school gardens. Produce was donated to school meal programs and local food pantries. (Katherine Soule, Shannon Klisch, Abbi Marrs)

- Since UCCE San Luis Obispo started convening the EBT at Farmers Markets workgroup, they have seen a 171% increase in CalFresh and Market Match redemption between 2017-2021, with a 49% increase occurring between 2020-2021. This has generated $386,000 in direct income to local farmers and farmers markets. In addition, the workgroup has supported two additional markets in launching their Market Match program and has advocated for and achieved a regional standard incentive amount of $15 from Paso Robles in northern San Luis Obispo County to Lompoc in northern Santa Barbara County. This regional standard simplifies communication to low-income clientele and ensures a meaningful and standardized food budget when clients shop at local farmers markets. (Katherine Soule, Shannon Klisch, Emily Dimond, Rosa Vargas)

Describe and explain any major changes or problems encountered in approach. Additionally, note opportunities for training and professional development provided, how results have been disseminated to communities of interest, and any new details regarding what the project or program plans to do during the next reporting period to accomplish the goals.

These measured outcomes showed learning and behavioral changes related to food resource management and informed decision-making that can lead to food policy changes at the local and state levels. They also demonstrate how UC's network of researchers and educators participate in cross-sector collaboration to address emerging food security issues. In this way, UC ANR's efforts contribute to the public value of safeguarding sufficient, safe, and healthy food for all Californians.

Improving individual and household financial stability

In 2-3 sentences, briefly describe the issue or problem that your project addresses.

Over the past two years, the COVID-19 pandemic significantly disrupted Americans' economic livelihoods through cascading shutdowns and layoffs. For example, between February 2020 and March 2021, the number of Americans unemployed for more than 27 weeks rose from 1.1 million (19% of unemployed workers) to 4.2 million (43% of unemployed workers). Resource management, particularly for families living below the poverty line, has been critical to making ends meet.

Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.

In partnership with communities and allied organizations, UC ANR conducts research and delivers education leading to improvements in food resource management practices.

The CalFresh Healthy Living, UC (CFHL, UC) State Office at UC Davis provided statewide oversight, leadership, and guidance for the CalFresh Healthy Living Program. UCCE academics and CFHL, UCCE supervisors offered local leadership and guidance in program implementation and evaluation. UC Cooperative Extension (UCCE) academics also provided oversight, leadership, and guidance for the Expanded Food and Nutrition Education Program (EFNEP) statewide programs. Curricula such as *Making Every Dollar Count* (MEDC), *Eating Smart Being Active* (ESBA), and *Plan, Shop, Save, and Cook* (PSSC) are designed to help adult participants gain the tools needed to take control of their money by teaching families food buying/budgeting skills and food resource management techniques. In Alameda and Contra Costa counties, for example, EFNEP educators provided a nine-part virtual series, *UCCE Connects to You!*, in English and Spanish, focused on strategies to stretch the household food budget and provided information on COVID-19 related emergency food assistance programs. They also demonstrated recipes for the food items parents received at their local distribution programs. (Marisa Neelon)

Briefly describe how your target audience benefited from your project's activities.

Participants learned about food resource management practices.

- In Alameda and Contra Costa counties, over 3,500 students participate in Youth EFNEP programming adapted to an asynchronous online learning format. A survey of 68 6th-8th graders showed that 49% percent of Contra Costa County respondents and 60% of Alameda County respondents reported improvements in food resource management skills. (Marisa Neelon)

Participants improved food resource management practices.

- Over 130 CFHL, UC participants statewide responded to a survey about their experience with the MEDC curriculum, with 66% reporting using tools learned at workshops to save money on food, 64% had made food last until they had

more money, and 49% had determined if using a coupon was better than buying store brand. (CFHL, UC)

- Over 400 CFHL, UC participants statewide responded to a survey about their experiences with the PSSC curriculum. They reported adopting food resource management behavior changes such as planning meals more often (65%), shopping with a list more often (65%), and comparing unit prices more often (60%). (CFHL, UC)

- Over 1,400 EFNEP participants statewide responded to a survey, with 97% showing improvement in one or more food resource management practices. (EFNEP) Local highlights include:
    - In Alameda and Contra Costa counties, 248 out of 371 parents graduated from the virtual *UCCE Connects to You!* series. Post-survey results show that 97% and 93% of participants in each county respectively improved food management skills such as planning meals before shopping, making a shopping list, and comparing food prices. (Marisa Neelon)

    - In Alameda and Contra Costa counties, over 3,500 students participate in Youth EFNEP programming adapted to an asynchronous online learning format. A survey of 285 6th-8th grade students showed that 49% percent of Contra Costa County respondents and 60% of Alameda County respondents reported improved food resource management skills. (Marisa Neelon)

    - Out of 20 *Eating Smart Being Active* participants in Humboldt and Del Norte counties, 64% improved food resource management practices after participating in the workshop series. (Dorina Espinoza)

    - Surveys from EFENP participants in Los Angeles County that participated in *UCCE Connects to You!* workshops showed that 98% of 268 participants improved in one or more food resource management practices. In Orange County, 99% of 108 participants improved food resource management practices. (Natalie Price)

Change in condition: Participants saved money.

- EFNEP graduates statewide averaged a $41.63 savings in their monthly grocery budget, which is a $500 savings per year. (EFNEP) Local examples include:
    - After attending the virtual *UCCE Connects to You!* series from EFNEP, families in Alameda County saved an average of $19 per month on food costs, and Contra Costa County families saved an average of $64 per month on food costs. (Marisa Neelon)

    - Families in Los Angeles and Orange County saved an average of $38.70 and $18.90 a month on groceries, respectively, after participating in EFNEP's workshop series. (Natalie Price)

Briefly describe how the broader public benefited from your project's activities.

The food resource management outcomes reported above improve individual and household financial stability. Longitudinal studies of EFNEP graduates indicate that they maintain positive behavior change two to six months after completing the program. In this way, UC ANR contributes to the public value of promoting economic prosperity in California.

Describe and explain any major changes or problems encountered in approach. Additionally, note opportunities for training and professional development provided, how results have been disseminated to communities of interest, and any new details regarding what the project or program plans to do during the next reporting period to accomplish the goals.

Given we now have the NRS Results form and know how NIFA wants outcomes reported, we are reporting impact stories. Please note this is different than how we initially listed intended outcomes in the 2021 plan. We will edit our future plans to reflect the current reporting approach.

Critical Issue

Sustainable Food Systems

Animal Production Systems

Project Director
Katherine Webb-Martinez
Organization
Regents of the University of California
Accession Number
7000178

Improving animal management, productivity and efficiency

In 2-3 sentences, briefly describe the issue or problem that your project addresses.

California ranks fourth in the nation in total livestock receipts, with over $12.3 billion (2019). It remains the largest dairy-producing state, accounting for about 19% of the nation's dairy product receipts (2019), and dairy is the state's top-producing commodity. Ranchers and dairy producers face many management and production challenges, like drought, water, and air quality regulations, and invasive species, as they strive to maintain their competitive edge. Forage crops linked to the livestock industry are an important economic driver in California's food-producing system. Although livestock is a high-value commodity, it can be challenging to be profitable at the ranch level. Ranchers or their family members often need to work off the ranch to make ends meet and keep the farm running. Simultaneously, there is the need to improve the ecological viability of these animal production systems, including conserving aquatic species and managing stress in sustainable aquaculture.

Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.

UC ANR partners with public, non-profit, and private groups to create and extend new knowledge about animal systems management for dairies and livestock operations.

The UC Cooperative Extension (UCCE) Aquaculture Specialist at UC Davis continues work on his fish slaughter and animal welfare program. This year slaughter technology was expanded to all sturgeon and paddlefish caviar farms across the US. Also, a demonstration was conducted of percussion stunning at the State of California Nimbus Fish Hatchery for State Fish Biologists. This technology will also be demonstrated to other state-run salmon fish hatcheries. (Jackson Gross)

A UCCE Dairy Advisor evaluated the efficacy of two experimental post-milking teat dip barrier products compared to a commercial post-milking barrier teat disinfectant in preventing new infections and maintaining good teat skin condition. She also took the opportunity to train the milkers on milking procedures and the importance of using teat disinfectants to prevent mastitis. (Daniela Bruno)

This UCCE Dairy Advisor continued animal health and welfare work through a selective dry cow therapy project. Behavioral data such as lying down/resting, walking, standing patterns, are collected via activity monitors and can be useful in determining a cow's health. For example, little to no movement could indicate the cow has a health issue. Other equipment sensors such as conductivity sensors could assist in identifying cows with subclinical mastitis that need antibiotics at dry off. She provided technical assistance to a dairyman using existing on-farm tools. (Daniela Bruno)

In Northern California, two UCCE beef herd health and production projects worked specifically to increase cattle weight gain, given calves' weight gain often is the difference in economic sustainability. These projects added an ionophore to a mineral supplement. The ionophore increases nutrient efficiency. The first project tested a low rate and found increased gains of 25 pounds added to solely salt and 50 pounds when added to a mineral supplement. These are a significant gain for a cost of roughly $1 per animal. A follow-up project is now looking at differing rates to target the most economical ionophore included in a mineral supplement. (Josh Davy)

A Livestock and Natural Resources Advisor working in the Central Valley has extended a local cow-calf cost study to new and existing ranchers so they can compare their operational budgets and make changes. (Rebecca Ozeran)

Livestock producers across California face increasing challenges related to large predators killing livestock due to increasing populations of large predators such as mountain lions, bears, and now gray wolves. Wolves have full legal protection from harm in California. While some non-lethal livestock protection tools work in limited circumstances, livestock raised on extensive rangeland systems is vulnerable to wolves. One potential means of mitigating this impact is via a compensation system by which losses documented by ranchers may be paid for by state or federal funding. The state allocated $3M to the California Department of Fish and Wildlife to compensate ranchers or livestock killed by wolves. However, there was no guidance on how the program would work, how livestock producers would be deemed eligible, or how livestock valued was provided. UCCE organized a meeting of local cattle producers to provide them an opportunity to voice their preference on how such a program might be structured. UCCE wrote a template of key discussion points to use in Lassen County so that other UCCE colleagues could also use it in their counties. (David Lile)

UCCE conducted the Water Diversion Monitoring and Reporting Training. This course provided knowledge and significant economic incentives to over 60 livestock producers. The training allowed clientele to be self-certified to report water usage and remain in regulatory compliance, versus employing a costly professional engineer to provide mandated reporting. To provide further assistance to property owners, site and office visits were provided to help them with complex reporting requirements and advised on implementing water monitoring systems to ensure regulatory compliance. (Tracy Schohr)

A UCCE Advisor in Modoc County organized several poultry extension events to address the increasing interest in producing and eating locally produced food. Technical assistance was provided to clientele wanting more information about proper production and processing of a small-scale poultry operation (~200 head/year). Additionally, information on state and federal direct meat sales guidelines is being shared with California State 4-H, California County Fairs, and local producers. (Laura Snell)

On the Central Coast, UCCE worked to improve the "Ag Pass" to soften future impacts of wildfire. The basic idea of the pass was to allow owners/operators of commercial farms and ranches limited, emergency access to areas that may otherwise be restricted to the public to protect or care for agricultural assets. In Ventura County, the local pass program had worked but with only moderate success because fire suppression resources and personnel from around the country were unfamiliar with it. UCCE is working to:

1. To help refine and reboot the program in Ventura County.

2. To establish a new program in Santa Barbara County.

3. To promote the adoption of this program statewide.

In December 2020, UCCE published a peer-reviewed document that serves as a “how-to” best practices guide for establishing community-based Ag Passes, which has been distributed throughout California, the nation, and globally. In July 2021, UCCE and the Santa Barbara County Agricultural Commissioner’s Office hosted the first 4-hour training and issued Ag Pass identification cards to producers, representing the culmination of 16 months of multi-agency planning and coordination. This provides a model to other counties throughout the state of establishing a program from scratch. (Matthew Shapero)

A rangeland forage production study is entering its 26th year. Each spring, forage samples are harvested to determine peak forage production. As a result of this work, colleagues across the state teamed up in Fall 2020 to begin a new statewide project that will utilize satellite imagery to quantify forage production across the state on annual rangelands. (Scott Oneto)

A UCCE Advisor in Tehama County increased individual technical assistance on forage production to rangeland managers due to the COVID-19 pandemic, which created a situation where individual, rather than group, contact with clientele was more feasible. (Josh Davy)

Briefly describe how your target audience benefited from your project's activities.

Participants adopted practices for more productive and sustainable animal management.

- The three California sturgeon farms have adopted percussion slaughter technology. They are the largest sturgeon farms in the nation, and make up 80% of the US sturgeon caviar industry. This effort has increased the welfare of 100,000s of California White sturgeon. In addition, the adoption of the technology also reduces workplace injuries for fish biologists. (Jackson Gross)

- The State of California Nimbus Fish Hatchery for State Fish Biologists adopted the percussion slaughter technology for the winter-run chinook salmon spawning period. This effort has increased the welfare of around 10,000 Chinook salmon this year. Use of this technology also reduces workplace injuries for fish biologists. (Jackson Gross)

- After implementing the new selective dry cow therapy (SDCT), the dairy that adopted this strategy decreased the proportion of culled cows or new clinical mastitis from 11% to 8% in cows on the SDCT group, which decreases antimicrobials use and thus decreases mastitis related costs to the producer. A successful implementation of this therapy on California dairies has the potential to decrease antimicrobial use, keeping animal health without losing productivity and efficiency. (Daniela Bruno)

- Through individual farm visits, new implementation of ionophore research results was observed. Full implementation has been shown to have economic benefit. For example, it is estimated that there are nearly 500,000 weaned calves grazing in California that would be applicable to this ionophore research. With approximately 25 lbs. of added gain per animal from the use of an ionophore, that could lead to potentially 12.5 million extra pounds of beef produced in California. At a conservative value of $1.20 per lb., that could contribute $15 million to the California economy. The use also protects the well-being of cattle. (Josh Davy)

- As a result of UCCE poultry extension efforts, two local producers are working to start selling locally raised poultry in the food hub in the coming year. (Laura Snell)

- As a result of individual technical assistance in land management, clientele adopted recommended varieties and practices pulled directly from UCCE research. For example, recommended clover was seeded on nearly 800 acres of rangeland and recommended perennial grass on another 200 acres. In another case, a cooperator implemented the researched weed control of barb goatgrass on over 500 acres of rangeland, two years in a row. These learning and behavioral changes have led to improving forage production on rangelands. (Josh Davy)

Science-based information was applied to animal production systems policy and decision-making.

- A consultant is using the cow-calf cost study as a basis for appropriate land lease pricing for grazing agreements. This work has potential impact on hundreds to thousands of acres of rangelands and irrigated pasture lands in Fresno County and beyond. (Rebecca Ozeran)

- The data from the rangeland forage production study is being used by ranchers, federal, state, local agencies, and other stakeholders to quantify forage production on an annual basis. This scientific approach gives ranchers a better understanding of available feed. The values are also used to document forage loss in years of drought or forage loss from other causes, which is critical for the USDA Farm Service Agency Noninsured Crop Disaster Assistance Program. (Scott Oneto)

- UCCE's proposed science-based information that was developed in collaboration with the Lassen County Fish and Game Commission, the Lassen County Board of Supervisors, and the Lassen County Deputy Chief Administrative Officer was adopted as a Lassen County Board of Supervisor‘s resolution requesting state funding to compensate ranchers whose herds have been affected by gray wolves. (David Lile)

- Approximately 70 ranchers across five counties participated in local discussions using the UCCE developed discussion points. UCCE subsequently summarized their responses which have been incorporated into the wolf compensation policy-making process. As there are now three active wolf packs in California and livestock depredations have occurred with all three, it is likely that a significant number of livestock producers will benefit from a fair and effective compensation program. (David Lile)

- In September 2021, when the Alisal Fire in Santa Barbara County severely impacted homes, property, agriculture, and transportation, the Ag Pass program worked seamlessly and allowed ranchers and orchardists to access their properties to evacuate livestock and irrigate. (Matthew Shapero)

- In October 2021, Governor Newsom signed AB 1103, a bill that provides a more formalized framework for counties throughout the state to institute Ag Pass programs. UCCE worked closely with organizations that supported the bill and testified to the Agriculture Committee of the California State Legislature on the merits and positive impacts of the program. (Matthew Shapero)

Change in condition: Money saved.

- Milkers learned to correctly identify cows with mastitis which decreased the number of cows in the hospital being treated. The decreased use of antibiotics, due to fewer cows in the hospital, leads to savings for the dairies. (Daniela Bruno)

- For the 60 Water Diversion Monitoring and Reporting Training attendees, it is estimated that they each saved at least $750 each year in consultant fees for regulatory compliance offered from the workshop, providing a local value of $45,000 annually. (Tracy Schohr)

Briefly describe how the broader public benefited from your project's activities.

The measured outcomes reported above demonstrate ranch-level advances, which help the state's overall improvement in animal management and production. California's total livestock and livestock products cash receipts went up nearly 5% from 2018 (California Agricultural Statistics Review 2019-2020). Thus, UC ANR contributes to the public value of promoting

economic prosperity in California and the ecological viability of the livestock industry.

Describe and explain any major changes or problems encountered in approach. Additionally, note opportunities for training and professional development provided, how results have been disseminated to communities of interest, and any new details regarding what the project or program plans to do during the next reporting period to accomplish the goals.

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Molecular Mechanisms Regulating Skeletal Muscle Growth and Differentiation

Project Director
Michael Mienaltowski
Organization
Regents of the University of California
Accession Number
1023827

Progress Report

In 2-3 sentences, briefly describe the issue or problem that your project addresses.

Broiler chickens have been genetically selected to grow quickly and efficiently such that fast-growing broiler chickens are more likely to display myopathies. Myopathies can lead to carcass condemnations, while others affect the aesthetic appearance, texture, and nutritional quality of the meat. Our research focuses on working to understand and then mitigate the pathophysiology leading to broiler breast myopathies.

Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.

Our research following the progression of white striping in broiler breast from hatching to market weight has verified those pathways involved in muscle growth and development but more importantly: (1) has discovered how muscle tissue structure and integrity changes from hatching to market weight (Objective 1); (2) has discovered the involvement of certain other molecular pathways involved in the pathophysiology of white striping, as well as the timing of when these pathways are predominant (Objective 2); and (3) has traced progression in the degradation of pectoralis major muscle over time from hatching to market weight (Objective 3).

Briefly describe how your target audience benefited from your project's activities.

The target audience for this research has been producers in the industry via the U.S. Poultry & Egg Association, physiologists and researchers in the field, and students and faculty at the University of California Davis. In this review year, two papers have been published in scientific journals: one conveying information about the progression of white striping in broilers over time, and another demonstrating the utility of cowpeas and sunflower meal as effective alternative sources of methionine in broilers. The research was presented at the Poultry Science Association Annual Meeting in July 2021. Additionally, in August 2021, an update on my research was sent to the U.S. Poultry & Egg Association, a poultry industry trade group who supports research. The research was highlighted on several poultry websites and in several trade magazines. Two students were trained in the laboratory during a portion of this review period for this project.

Briefly describe how the broader public benefited from your project's activities.

Dr. Mienaltowski was invited to present his work at the Poultry Science Association Annual Meeting in July 2021, which gave the research exposure to thousands of researchers and producers. The research was funded by the U.S. Poultry & Egg Association, which sent out the reports and updates Dr. Mienaltowski generated on the work. The reports were presented across the country on several poultry websites and in several trade magazines including The Poultry Site, WATT Poultry, poultryproducer.com, The Mid-Atlantic Poultry Farmer, and Timely Topics from the Delmarva Chicken Association. The

research marks the period in the broiler's life post-hatching in which pathology begins to be seen molecularly and cellular ahead of visualizing any gross pathology. The significance is that what we have found can be used to guide timing for interventions to reduce myopathies.

Describe and explain any major changes or problems encountered in approach. Additionally, note opportunities for training and professional development provided, how results have been disseminated to communities of interest, and any new details regarding what the project or program plans to do during the next reporting period to accomplish the goals.

1. Foster K, Mienaltowski M, Klasing K, King A. Production of broilers fed native methionine from sunflower seed meal and cowpeas. *EC Veterinary Science,* 2021 Feb 26;6.3:3-14. (https://www.ecronicon.com/ecve/ECVE-06-00367.php)

2. Vanhatalo OE, Henderson JD, De La Torre U, Garrity C, Pechanec MY, Mienaltowski A, King AJ, Mienaltowski MJ. Research Note: Evaluation of the incidence of white striping and underlying myopathic abnormalities affected by fast weight gain in commercially fed broiler chickens. *Poultry Science*, 2021 Apr;100(4):101020. doi: 10.1016/j.psj.2021.101020.

Meeting Presentation:

Tracking vascular inflammation associated with white striping in broilers using expression profiling. Michael J. Mienaltowski*, Ubaldo De La Torre, Oona Vanhatalo, Annie J. King Animal Science, University of California Davis, Davis, California, United States, Poultry Science Association Annual Meeting 2021, 7/19/2022-7/22/2022.

Report to U.S.Poultry & Egg Association: "Examining the Roles of Macrophages and Vascular Inflammation in Broiler White Striping" submitted 8/1/2021.

Plans for the next reporting period:

1. Publish a comprehensive functional genomics analysis of the pathophysiological progression of white striping from the data generated from the project described above.

2. Continue presenting findings from the research to producers, who are interested in the impact of pinpointing temporal windows of concern in the broiler's life.

3. Begin training a new graduate student, including using the knowledge from the above study to test dietary interventions to reduce white striping in broilers.

Impact Statement (Optional)

Use this space to talk about the impact that this result had, in layman's terms. Adding comments here will **not** change the content in the highlighted result.

New knowledge on raising poultry to feed a growing population

Producing sufficient food to feed a growing human population while staying within planetary resource limits is a grand challenge. Understanding the key processes in animal growth and development in order to increase the efficiency of production is one important element in sustainable food production. The research on skeletal and muscle development in chickens has led to important discoveries about the molecular pathways that can lead to muscle damage during growth. Not only is the work important in deepening our understanding of how muscle growth happens in this domesticated species, but it also has immediate practical significance in the formulation of poultry diets from plants such as cowpea and sunflower to ensure that required amino acids are provided by crop plants which can, themselves, be produced in sustainable production systems.

Assessing and enhancing the contributions of native bees to agricultural pollination

Project Director

Neal Williams
Organization
Regents of the University of California
Accession Number
1020216

Progress Report

In 2-3 sentences, briefly describe the issue or problem that your project addresses.

Bee pollination is critical to the production of much of the world's food crops. In North America, managed honeybees provide most of the agricultural pollination valued at over $15 billion annually.

Persistent disease, forage loss and other drivers have exposed the vulnerability of U.S. crop production because of its heavy reliance on this single pollinator. Native bees can also provide important pollination to numerous crops when their habitat and resource needs are met. However, we know relatively little about how wild bee communities respond to farm and landscape quality and how specific actions to reduce pesticide exposure and enhance habitat impact their populations and the pollination services they provide. This project seeks to fill key knowledge gaps and to inform management in these areas.

Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.

Our project seeks to assess the current quality of landscapes for managed and wild bees, as well as to guide actions at the farm scale and across landscapes to reduce threats to bee health (e.g., pesticide exposure risk) and improve habitat quality (forage and nesting resources).

Objective 1: Develop spatially explicit maps of pesticide loading and exposure risk for target CA agricultural counties.

We completed model development in 2020-21 and compiled new pesticide data from the California Pesticide Use Reporting Database (PUR) for 2020. Our models combined spatial loading data from the PUR with published data on the decay rates of specific active ingredients and models of bee foraging to predict expected exposure of bees to fungicides, insecticides, and herbicides over a target study area in Northern California. One manuscript from this work was published in 2021 and another is in revision. The first used spatially explicit PUR information and patterns of crop across all parcels in a county to test how cropping patterns impact the intensity of pesticide use. We revealed that pesticide use frequency and intensity on the same crop were lower for fields with higher surrounding crop diversity. The result suggests an important strategy to reduce pesticide intensity without changing cropped area. The second paper explores whether planting flower habitats (Objective 5) for bees may mitigate pesticide exposure.

We continued working to obtain pesticide residue data from sentinel honey bee colonies deployed across our landscapes and also identify pollen collected.

Objective 3: Test the ability of habitat plantings designed to support bee forage to also promote nesting habitat for wild bees.

We completed a manuscript for submission on our bee nesting project. Project results were also reported at the Entomological Society of America Meeting in Fall 2021.

Objective 4: Identify native wildflower species and mixes that best support wild bees and honey bees in agricultural contexts and can be used to benefit alternative functions, e.g., pest management for agriculture.

We integrated part of our work with a new USDA-NIFA funded project identifying the multi-functional benefits of cover crop plantings in almond orchards. Field planting started in Fall 2021 and we are now collecting data from the plots.

Objective 5: Refine strategies for the cultivation of native wildflower (so called pollinator habitat), specifically examine the importance of species diversity and seeding density. These variables may be used to develop reduced-cost wildflower mixes.

In additional to Objective 1 our greatest effort and progress has been toward this objective. Following interruption in the previous year from COVID restrictions, we collected data on flowering performance throughout 2021 season. This included multi-year metrics of plant establishment, floral cover and resistance to invasion by weedy plant species at replicated study plots. The design included three seed density treatments crossed by three seeding diversity treatments each replicated seven

times with a randomly selected species composition drawn from the regional pool of 40 California native flowering forbs. In fall 2021 we began analysis of how seeding density, seeding diversity and the choice of specific plant species impacted mix flowering and ability to support diverse wild bees and managed honey bees.

Briefly describe how your target audience benefited from your project's activities.

Our target audience includes beekeepers, growers, conservation managers and policy makers in California and more broadly. We have been working closely with commodity groups and conservation managers to provide insight from out Objective 1 data. Williams joined the new California Pollinator Coalition and serves on subcommittees for habitat planning and monitoring. He also presented work at the 2021 Orchard Bee Association meeting (Oregon State University). Through these efforts he has reached a range of beekeepers and grower groups. We were invited to submit a healthy landscapes proposal from the Almond Board of California and will continue to provide guidance to this grower group on habitat placement. Postdoc Vivian Wauters also presented our work on cover crop design and best management practices to the 2021 Almond Conference. The work has led to the new Cover Crop BMP for almond systems (see publications)

We also have ongoing discussions with grower cooperatives and the food industry who are working to increase sustainability of their supply chains. Our empirical and modeling work is informing pesticide reduction actions for several large groups.

Briefly describe how the broader public benefited from your project's activities.

Additional broader impacts for the public have been through a collaboration between the Williams lab and UC Davis Arboretum. We expanded our results from Objective 4 and Objective 5 and collected new data on horticulturally desirable traits for our plant species. We then create a set of new “plant profiles” that include information for cultivation of these species in horticultural contexts (for example for homeowner landscaping and gardens). Initially this has been done for 12 of our species that had highest horticultural value in addition to supporting pollinators. This effort reaches a much broader audience than our targeted agricultural work and increases awareness of the role of native plants in supporting pollinators as well as the existence and importance of these native pollinators in different landscapes. We will continue to work with the Learning by Leading program on the UC Davis campus to complete profiles for as many plants from our list as possible. In addition, we provided our results to the NRCS, a local landscaping company and two native seed suppliers who are using the information in developing plant materials for people of Northern CA.

Describe and explain any major changes or problems encountered in approach. Additionally, note opportunities for training and professional development provided, how results have been disseminated to communities of interest, and any new details regarding what the project or program plans to do during the next reporting period to accomplish the goals.

Publications:

Nicholson, C. C., Ward, K. L., Williams, N. M., Isaacs, R., Mason, K. S., Wilson, J. K., ... & Ricketts, T. H. (2020). Mismatched outcomes for biodiversity and ecosystem services: testing the responses of crop pollinators and wild bee biodiversity to habitat enhancement. *Ecology letters*, *23*(2), 326-335.

Nicholson, C. C., & Williams, N. M. (2021). Cropland heterogeneity drives frequency and intensity of pesticide use. *Environmental Research Letters*, *16*(7), 074008.

Stuligross, C., & Williams, N. M. (2021). Past insecticide exposure reduces bee reproduction and population growth rate. *Proceedings of the National Academy of Sciences*, *118*(48).

Wauters V, Gaudin A, Williams N, et al. 2021. Cover Crop Best Management Practices. Almond Board of California. URL: https://live-almonds-next.pantheonsite.io/sites/default/files/2021-07/Cover%20Crops%20Best%20Management%20Practices%20BMPs.pdf

Major Challenges and Problems:

Our greatest challenge has been in timely testing of pesticide residue from field-collected pollen samples. We have continued to deal with post pandemic supply shortages and personnel bottlenecks. Thus, we have yet to get final reside results to evaluate our spatial model predictions. Similar challenges with our pollen ID work slowed this element of the work too. These items relate to Objective 1.

Training:

This project provided training for 2 postdoctoral scholars. Uta Muller (Objective 4-5) received mentoring throughout the project on field research design and coordination. We have also been working with new statistical approaches to aid in selection of best performing plant species to use for pollinator seed mixes on farms. Charlie Nicholson (Objective 1) received mentoring throughout the project spatial modelling.

Impact Statement (Optional)

Use this space to talk about the impact that this result had, in layman's terms. Adding comments here will **not** change the content in the highlighted result.

Understanding pollination services for the sustainable production of specialty crops

A wide array of crops rely on bee pollination to produce the fruits and nuts that comprise important elements in a healthy diet. Many of these crops are pollinated by honeybees, but there are well documented threats to honeybee populations. The UC AES researcher is exploring the potential for native bees to provide some of the pollination services that currently rely on the honeybee. The work is important in exploring sustainable production of specialty crops and is using the detailed pesticide use records collected in California to model the potential exposure of bees to unintended effects from pesticides. In addition to revealing how the risk of exposure varies spatially, the work is also indicating potentially important connections between landscape scale crop diversity and reduced pesticide use, which in turn is expected to have positive benefits for bee health.

Enhancing Poultry Production Systems through Emerging Technologies and Husbandry Practices

Project Director
Maja Makagon-Stuart
Organization
Regents of the University of California
Accession Number
1021357

Progress Report

In 2-3 sentences, briefly describe the issue or problem that your project addresses.

Consumer and retail demands of the poultry industry have resulted in an expansion in a variety of production systems with differing constraints and knowledge base. The implication of these new systems on production and welfare outcomes is not clear, and is the subject of my research.

Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.

My research activities contribute primarily to project objective 2, “establishing and adopting husbandry practices to a changing industry landscape”. During the reporting period I contributed (as lead author) to a systematic review summarizing our knowledge about the way in which housing impacts duck welfare, and co-authored a paper summarizing our work on the utility of scatter feeding as an enrichment. Both studies contribute to our understanding of ways in which housing practices impact poultry welfare, and help identify further research gaps.

Briefly describe how your target audience benefited from your project's activities.

The systematic review is, to my knowledge, the first of its kind on a topic related to the impacts of housing of the welfare of ducks. The target audience includes researchers, duck producers, and individuals involved in setting policies. The paper identifies topics that have received the most attention, summarizes findings within each topical category, and identifies research needs. The implications of the current knowledge base and gaps for the feasibility of setting robust duck welfare standards are discussed. The study on the use of scatter feeding as an enrichment similarly targets researchers, producers, and individuals involved in setting guidelines and policies. We tested, and showed, that the practice of scatter feeding, recommended as promoting broiler welfare, has limited impacts.

Briefly describe how the broader public benefited from your project's activities.

The systematic review findings have been turned into an informational flier, which was discriminated as a research highlight to the Poultry Science Association's broad membership. Information from both studies has been integrated into courses taught at UC Davis, taken by undergraduate and graduate students.

Describe and explain any major changes or problems encountered in approach. Additionally, note opportunities for training and professional development provided, how results have been disseminated to communities of interest, and any new details regarding what the project or program plans to do during the next reporting period to accomplish the goals.

Wood, B., Rufener, C., Makagon, M.M., & Blatchford, R.A. 2021. The utlity of scatter feeding as enrichment: Do broiler chickens engage with scater fed items? Animals, 11: 3478

Makagon, M.M. & Riber, A.B. Setting research driven duck-welfare standards: A systematic review of Pekin Duck welfare research. Poultry Science, 101614

Impact Statement (Optional)

Use this space to talk about the impact that this result had, in layman's terms. Adding comments here will **not** change the content in the highlighted result.

Advancing knowledge on poultry management

The UC AES research project aims to raise poultry in economically viable production systems that also have high animal-welfare standards. The research team carried out a systematic review to assess the welfare benefits of scatter feeding, which entails spreading grain-based scratch feeds over a large area of ground to simulate how poultry species would find food under natural conditions. The study found that scatter feeding has a limited impact on animal welfare. Exploring these types of alternative feeding strategies helps advance the knowledge base on improving poultry management and welfare.

Organization, Regulation and Performance of Agricultural and Natural Resource Markets

Project Director
Rachael Goodhue
Organization
Regents of the University of California
Accession Number
1020150

Progress Report

In 2-3 sentences, briefly describe the issue or problem that your project addresses.

California's agricultural and natural resource markets are embedded in complex economic and physical systems. The interactions among market institutions and other characteristics, biological and physical systems, and government regulations and policies are important determinants of markets' economic performance, and market outcomes for producers, consumers, other stakeholders, and the environment. Many of the current issues facing the California agriculture and natural resource sectors are characterized by such interactions. A few examples include the effects of market power, including it affects how much growers benefit from commodity promotion programs; invasive species, including the development of management institutions; agri-environmental regulations, such as pesticide regulations intended to reduce air pollution; and the impacts of producer organizations, such as marketing orders, on producer, consumer, and public welfare.

Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.

During the reporting period work under this project focused on pest management, including pesticide use regulations. Pesticide use regulations are an important class of agri-environmental regulation in California, and the project estimated the cost of multiple proposed regulations. Notably, in response to our estimates of the cost of the initially proposed regulations on nitroguanidine-substituted neonicotinoid insecticides the California Department of Pesticide Regulation revised its proposed regulations to reduce the economic impact on agriculture.

Other work examined the economic viability of controlling soil pathogens in organic strawberry-vegetable rotation production systems and the impact of using steam for pre-plant soil disinfestation on net returns in organic and conventional strawberry production systems on yields and net returns.

Briefly describe how your target audience benefited from your project's activities.

State policymakers in the California Department of Food and Agriculture and Department of Pesticide Regulation are the major target audience for this project. As noted above, analysis conducted as part of this project induced revisions in proposed regulations to reduce the economic cost.

Briefly describe how the broader public benefited from your project's activities.

This project benefits the broader public in two ways. First, the cost of pest management in organic production systems influences the price of organic food. Identifying new, more cost-effective approaches can reduce the price.

Pesticide regulations are most generally implemented to protect human health and/or environmental quality. Understanding the economic cost to agriculture provides a more complete picture.

Describe and explain any major changes or problems encountered in approach. Additionally, note opportunities for training and professional development provided, how results have been disseminated to communities of interest, and any new details regarding what the project or program plans to do during the next reporting period to accomplish the goals.

Zavatta, M, J Muramoto, E Milazzo, S Koike, K Klonsky, R Goodhue, and C Shennan. 2021. "Integrating Broccoli Rotation, Mustard Meal, and Anaerobic Soil Disinfestation to Manage Verticillium Wilt in Strawberry." *Crop Protection* 146. https://doi.org/10.1016/j.cropro.2021.105659

Michuda, A, RE Goodhue, M Hoffmann and SA Fennimore. 2021. "Predicting Net Returns of Organic and Conventional Strawberry Following Soil Disinfestation with Steam or Steam Plus Additives." *Agronomy* 11, 149.

Goodrich, BK and RE Goodhue. 2020. "Are All Colonies Created Equal? The Role of Honey Bee Colony Strength in Almond Pollination Contracts." *Ecological Economics*. 177:106744. November.

Martin, F , S Fennimore, A Putman, M Matson, D Racano, F Melton, R Goodhue, P Henry, S Vougioukas, N Dorn, C Greer, O Daugovish, A Biscaro, and M Stanghellini. "Site-specific Soil Pest Management in Strawberry and Vegetable Cropping Systems." 2020 Methyl Bromide Alternatives Conference, November.

Goodhue, R, K Mace, J Rudder, T Tolhurst, D Tregeagle, H Wei, Y Zhang, B Grafton-Cardwell, I Grettenberger, SH Wilson, R Van Steenwyk, F Zalom, J Steggall. "Economic and pest management evaluation of nitroguanidine-substituted neonicotinoid insecticides: eight major California commodities." Prepared for the Department of Pesticide Regulation by the California Department of Food and Agriculture's Office of Pesticide Consultation and Analysis, the University of California, and the University of California Cooperative Extension. June 2021. *Evaluation of spring 2021 revised draft regulations*.

Goodhue, R, S Blecker, K Mace, H Wei, B Gress, E Zakowski, J Steggall. "1,3-Dichloropropene Overview, IPM, and Potential Yield Loss Report." Prepared for the Department of Pesticide Regulation by the California Department of Food and Agriculture's of Pesticide Consultation and Analysis and the University of California, Davis Department of Agricultural and Resource Economics. April 2021.

Goodhue, R, S Blecker, K Mace, Y Zheng, J Rudder, T Tolhurst, H Wei, B Gress, E Zakowski, and J Steggall. "Economic and Pest Management Evaluation of 1,3-Dichloropropene Pilot Mitigation Project." Prepared for the Department of Pesticide Regulation by the California Department of Food and Agriculture's Office of Pesticide Consultation and Analysis and the University of California, Davis Department of Agricultural and Resource Economics. April 2021.

Rudder, J, Y Zheng, K Mace, and R Goodhue. "Cost of Proposed Changes to Restricted Material Notifications of Intent for Growers and Applicators." Prepared for the Department of Pesticide Regulation by the California Department of Food and Agriculture's Office of Pesticide Consultation and Analysis and the University of California, Davis Department of Agricultural and Resource Economics. April 2021.

Training: Seven Ph.D. students and one post-doctoral scholar mentored.

Impact Statement (Optional)

Use this space to talk about the impact that this result had, in layman's terms. Adding comments here will **not** change the content in the highlighted result.

Understanding the multidimensional effects of policy changes

In an ideal world, the environmental, social, and economic aspects of sustainability would always align. In the real world, policies are necessarily focused on one or two at the expense of the other(s). Pesticide use regulations that restrict pesticide use are generally focused on reducing the environmental impact of agriculture and reducing the risk of exposure among farmworkers. Often these beneficial changes come with economic costs to growers. The UC AES researcher leads interdisciplinary efforts to study such trade-off effects in the implementation of California pesticide regulations with a view to helping policymakers better understand the multidimensional effects of policy changes. The work also helps agricultural stakeholders such as California's iconic strawberry producers document the economic impacts of implementing production practices that align with the changing regulatory environment.

Closing Out (end date 09/06/2023)

National Animal Genome Research Program

Project Director

Alison VanEenennaam

Organization

Regents of the University of California

Accession Number

1018277

Progress Report

In 2-3 sentences, briefly describe the issue or problem that your project addresses.

The National Animal Genome Research Program seeks to categorize and understand genomic variation in livestock species to enable improved approaches for genetic improvement. In this past year my laboratory has focused on improving methods for genome editing, and documenting the characteristics, health and well-being of genome edited cattle. Another focus of my program has also been on quantifying the public costs associated with delaying the adoption of breeding innovations in livestock breeding programs.

Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.

A major focus of my laboratory is exploring the use of genome editing in cattle breeding programs. In the past year we have used gene editing (GnEd) to explore the hornless (polled) phenotype in cattle. Horns can be dangerous, and their physical removal is undertaken to protect animals and their handlers. Dehorning is increasingly associated with animal welfare concerns. A naturally occurring dominant genetic mutation (Pc allele) comprised of a 212 bp duplicated DNA sequence replacing a 10-bp sequence at the POLLED locus, results in the hornless phenotype. This Pc allele is intergenic, and has been hypothesized to possibly affect regulation of nearby long non-coding RNAs. We hypothesized that either the 10 bp sequence missing in the Pc allele, or alternatively the expression of a long non-coding RNA (lincRNA#1) sequence results in the polled phenotype. GnEd of bovine embryos with CRISPR-Cas9 and dual guide RNAs was used to generate targeted, homozygous deletions at both loci independently. The resulting animals were identical to controls, signifying that the absence of these two genomic regions does not result in the polled phenotype.

Additionally, we undertook multiyear genomic and phenotypic analyses of six offspring of a dairy bull GnEd to be homozygous for the Pc allele. The offspring were heterozygous and polled as expected, and did not differ in their growth, health or development, nor the nutritional composition of their meat and milk, when evaluated against contemporary comparator controls. We further modelled how GnEd could be used to introgress the Pc allele in the US dairy cattle population by GnEd of elite artificial insemination bulls. Collectively, this research shows how the advent of targeted GnEd tools opens the way for hypothesis testing of putative gene function, and the rapid introgression of useful alleles into livestock breeding programs. We also worked on approaches to accelerate the delivery of genome editing reagents into livestock embryos using electroporation as an alternative to microinjection.

In contrast to GnEd crops, genomic alterations introduced by GnEd in food animals including targeted deletions and intraspecies allele introgressions (e.g. Pc) that could have been produced using conventional breeding, are currently considered unapproved new animal drugs by the US Food and Drug Administration. Drug approval is a lengthy and expensive process, limiting access of US researchers and small companies to employ GnEd in livestock improvement programs. We documented the economic costs resulting from delaying the adoption of genetic engineering and genome editing in livestock breeding programs.

Briefly describe how your target audience benefited from your project's activities.

Dissemination activities were dramatically curtailed this year due to the Coronavirus pandemic. I gave a total of 36 presentations to both domestic and international target audiences, the majority online.

1. “Emerging Technologies: Regulatory Oversight of Intentional Genomic Alterations in Animals”, Food Drug and Law Institute (FDLI) Online Conference 10/7/2020

2. “Genome Editing Applications in Animals” CRISPR in Agriculture Research, Syntego World CRISPR Day symposium (virtual) 10/20/2020

3. “Gene editing in livestock: promise, prospects and policy” Iowa State seminar (virtual) 10/21/2020

4. “Does a plant-based diet mean improved health for the climate, agriculture, and the population?” Grains and Health Symposia, Calgary Online Conference (virtual) 10/26/2020

5. “Agricultural animal transgenesis for food applications” Transgenic Technology, Israel, (virtual) 10/27/2020

6. “CAST Past Borlaug Communication Awardee Session”, CAST Annual Meeting online meeting 10/28/2020

7. “Using genome editing for livestock health”, ASAS-Southern Section Genetics and Genomics Webinar Series (virtual) 11/4/2020

8. “Genome editing applications in animals” Virtual Workshop in Genome Editing Technologies in Kenya,11/10/2020

9. “The importance of innovation to the future of beef production”, Wagyu Virtual International Conference, South Africa (virtual) 11/11/2020

10. “One-step generation of a targeted gene knock-in calf using the CRISPR-Cas9 system in bovine zygotes”, Centre for Genetic Improvement of Livestock (CGIL) Seminar, Department of Animal Biosciences, University of Guelph, Canada (virtual) 11/13/2020

11. “Genome editing in livestock”, National Center for genome editing in agriculture, Israel, (virtual) 1/14/2021

12. “Genome editing approaches to augment cattle breeding programs”, British Cattle Breeders Club Virtual Conference, England (virtual) 26/1/2021

13. How Can We Design a Cow to Better Meet Human Needs?” Virtual presentation to two high school classes in Minnesota at request of their science teacher; 2/3/2021 and 2/4/2021

14. “Science Communication: Navigating Controversial Issues”, UCD GSA/Science Says Science Communication Career Path, Virtual Seminar 2/8/2021

15. “Addressing Climate Change and Sustainability Through Innovation”, 2021 USDA Agricultural Outlook Forum, Virtual presentation 2/18/2021

16. “Current Status of Genome editing to Augment Cattle Breeding Programs”, Virtual presentation to the Board of the American Angus Association, 2/23/2021

17. “How Genes Advance Progress: Genomics' Role in Beef Sustainability?” Global Roundtable for Sustainable Beef virtual webinar, 2/26/2021

18. “Biotechnology, Genomics, and Reproduction: The Ultimate Ménage à Trois” Spring 2021 RPBO Seminar Series (Warnick Lecture), University of Florida, FL (virtual) 3/10/2021

19. “Polled genetics- ready for prime time?” Golden State Dairy Management Virtual webinar, 3/25/2021

20. “Animal Agriculture and Alternative Meats: Learning from Past Science Communication Failures” British Society of Animal Science, Virtual meeting, 4/13/2021

21. “Animal Agriculture and Alternative Meats: Learning from Past Science Communication Failures” University of California ANR Livestock and Dairy Program Team meeting, (virtual) 4/16/2021

22. “Gene Editing in Livestock: What is Gene Editing?” UC Davis Virtual Picnic Day, 4/17/2021

23. “Animal Agriculture and Alternative Meats: Learning from Past Science Communication Failures, Animal Agriculture Alliance Virtual meeting, (virtual) 4/28/2021

24. “Animal Agriculture and Alternative Meats: Learning from Past Science Communication Failures” Internet Lecture to University of Wyoming, (virtual) 4/29/2021

25. “Genome Editing in Animals”, Invited virtual lecture to “GMO & Biosafety” course, Brac University, Bangladesh (virtual) 5/5/2021

26. “Genetic Engineering of Livestock: The Opportunity Cost of Regulatory Delay”, Invited virtual lecture to Dalhousie University, Faculty of Agriculture Truro, NS, Canada (virtual) 5/6/2021

27. “Advanced Breeding Techniques Using Genomics, Reproduction, & Biotechnology” Invited virtual lecture to Cornell University, Faculty of Animal Science, Ithaca, NY (virtual) 5/11/2021

28. “Regulation of Gene Editing in Livestock”, Society for In Vitro Biology’s Virtual Annual Meeting, SIVB 2021: In Vitro OnLine 6/9/2021

29. “Gene Editing Today and in the Future”, Beef Improvement Federation Annual Research Symposium and Convention, Des Moines, Iowa 6/24/2021

30. “Comparative Evaluation of Human-edible Animal Products Derived from Offspring of Genome Edited and Control Cattle” 2021 ASAS-CSAS-SSASAS Annual Meeting and Trade Show, Virtual Presentation, 7/15/2021

31. “Gene editing in livestock: Science and policy” Academy of Veterinary Consultants (AVC), Amarillo, TX 8/6/2021

32. “Alternative meats: What are they and where are we now?” Academy of Veterinary Consultants (AVC), Amarillo, TX 8/6/2021

33. “Gene Editing in Livestock: What is Gene Editing?” Idaho State University Virtual Event, 8/21/2021

34. “Effective Science Communication to Raise Awareness on Animal Biotechnology”, The International Service for the Acquisition of Agri-biotech Applications (ISAAA) Impact of Gene Technology in Animal Agriculture and Food Production Virtual Workshop, 8/31/2021

35. “Genome Editing Opportunities in Livestock”, Royan Virtual Congress 2021, Iran (virtual) 9/3/2021

36. “The Interdependence of Sustainability, Innovation, & Science Communication Around Animal Agriculture” Agricultural Science Association (ASA) Ireland, (virtual) 9/10/2021

I continue to disseminate information thorough eBEEF. Reductions in beef genetics Extension specialists and outreach funding in the US led a group of beef genetics Extension faculty to coordinate their efforts and develop a national Extension program to meet beef producers and Extension educators’ needs in beef genetics programming. This effort, collectively called eBEEF, has utilized four platforms to provide these outreach efforts: Beef Improvement Federation, National Beef Cattle Evaluation Consortium, eBEEF.org website and the National Cattlemen’s Beef Association education program. Materials provided through eBEEF include the publication of a Sire Selection Manual, major contributions to the Beef Improvement Federation Guidelines for Uniform Beef Improvement Programs, 32 factsheets, 165 videos, over 18 train-the-trainer webinar series, 5 direct producer education webinars, and numerous in person educational programs. This collaboration has proved to be an effective model to provide beef genetics outreach programming to a national audience.

Briefly describe how the broader public benefited from your project's activities.

The public good of the genetic improvement of livestock is the clear reduction in the emissions intensity of animal-source foods that is an outcome of improved efficiencies. Improvements in livestock's input-use efficiency of grains will reduce the amount of land and other inputs needed to produce animal products. For example, animal breeders have tripled the feed efficiency (pound of meat per pound of feed) of broiler chickens (chickens raised for meat) over the last century. These productivity improvements have made chicken affordable for billions of people around the world, improving food security and reducing the environmental footprint of animal protein production. Milk production per cow in the U.S. has more than quadrupled over the last 75 years, allowing farmers to meet growing demand without a proportional increase in farm inputs. In fact, the U.S. dairy cattle herd has declined by more than half, from 25 million cows in 1944 to 9 million today, even as milk production has increased by 60%. As a result, the carbon footprint of a glass of milk today is one-third of what it was in 1944. In fact, the main beneficiary of genetic improvement programs in livestock is the consumer in terms of decreased cost of animal source foods. Additionally, using genome editing to avoid the need for dehorning or disbudding horned animals, addresses an animal welfare concern.

Another focus of my program has also been on quantifying the public costs associated with delaying the adoption of breeding innovations in livestock breeding programs. Along with economic colleagues we calculated the costs associated with delaying the commercialization of the fast-growing AquAdvantage genetically engineered salmon from 2002 through 2020, in 2020 USD. Various assumptions were needed to calculate these costs, such as a 4% interest rate and estimates of demand and supply parameters. We assumed salmon output was 30% higher for farms using transgenic salmon, so total production was 15% higher when 50% of farms adopt transgenic varieties. Under these assumptions, the estimated costs of regulatory delays ranged from $18 to $37 billion; our preferred estimate was $26 billion. These extra costs were paid by consumers (through higher prices) and producers (through higher production costs). The social costs of this regulatory delay extend well beyond the costs to current salmon consumers and farmers. Fast-growing salmon allows inland salmon production and, if adopted globally, could enable salmon production in developing regions far from coastal areas and with limited access to fish. Furthermore, adoption of this technology could provide additional incentives for the use of genetic engineering to improve the productivity of salmon and other fish, which could provide a valuable and affordable source of protein.

Our economic analysis suggested that modern biotechnologies they have been drastically underutilized in animal production systems. The pandemic shows that we are ready to take real risks, adopt new biotechnologies, and change our practices in order to save lives. Virtually all national academies of science suggest that modern biotechnology tools are as safe as traditional agricultural technologies, but we overregulate many of them because of hypothetical risks. Adopting more reasonable and flexible regulatory frameworks that would allow us to utilize the power of modern biology can improve the food system and the environment and enhance our resilience to future shocks to our global society.

Describe and explain any major changes or problems encountered in approach. Additionally, note opportunities for training and professional development provided, how results have been disseminated to

communities of interest, and any new details regarding what the project or program plans to do during the next reporting period to accomplish the goals.

Journal Articles – all acknowledged NIFA support

Van Eenennaam, A. L., F. De Figueiredo Silva, J. F. Trott, and D. Zilberman. 2021. Genetic Engineering of Livestock: The Opportunity Cost of Regulatory Delay. Annual Review of Animal Biosciences. 9:10.1–10.26 https://doi.org/10.1146/annurev-animal-061220-023052

Mueller, M.L., Cole, J.B., Connors, N.K., Johnston, D.J., Randhawa. I.A.S. and **Van Eenennaam, A.L.** 2021. Comparison of gene editing versus conventional breeding to introgress the POLLED allele into the tropically adapted Australian beef cattle population. Frontiers in Genetics. 12:593154 https://doi.org/10.3389/fgene.2021.593154

Owen, J.R., Hennig, S.L., McNabb, B., Mansour, T.A., Smith, J.M., Lin, J.C., Young, A.E., J. F. Trott, Murray, J.D., Delany, M.E., Ross, P.J., & **Van Eenennaam, A.L.** 2021. One-step generation of a targeted knock-in calf using the CRISPR-Cas9 system in bovine zygotes. BMC Genomics. 22, 118 https://doi.org/10.1186/s12864-021-07418-3

Kern, C., Y. Wang, X. Xu, Z. Pan, M. Halstead, K. Chanthavixay, P. Saelao, S. Waters, R. Xiang, A. Chamberlain, I. Korf, M. E. Delany, H. H. Cheng, J. F. Medrano, **A. L. Van Eenennaam**, C. K. Tuggle, C. Ernst, P. Flicek, G. Quon, P. J. Ross, and H. Zhou. 2021. Functional genome annotations of three livestock species provide a vital resource for comparative and agricultural research. Nat Commun 12, 1821 https://doi.org/10.1038/s41467-021-22100-8

Lin, J.C. and **A. L. Van Eenennaam**. 2021. Electroporation-mediated genome editing of mammalian zygotes. Frontiers in Genetics.12:56 https://doi.org/10.3389/fgene.2021.648482

Van Eenennaam, A.L. and S. J. Werth. 2021. Animal Board Invited Review: Animal Agriculture and Alternative Meats: Learning from Past Science Communication Failures. Animal. 15: 100360. https://doi.org/10.1016/j.animal.2021.100360

Deepak, S. S. Aly, W. J. Love, P. C. Blanchard, B. Crossley, **A. L. Van Eenennaam**, and T. W. Lehenbauer. 2021. Etiology and risk factors to bovine respiratory disease in pre-weaned calves on California dairies and calf ranches. Preventive Veterinary Medicine:105506. https://doi.org/10.1016/j.prevetmed.2021.105506

Impact Statement (Optional)

Use this space to talk about the impact that this result had, in layman's terms. Adding comments here will **not** change the content in the highlighted result.

Novel approach to dehorning cattle

Gene editing approaches offer the promise in crop and livestock breeding of being able to make extremely focused changes to traits to achieve specific beneficial outcomes. This research group has been exploring the possibility of using gene editing to produce hornless cattle. Dehorning cattle is currently done for health and safety reasons both for cattle themselves and also for livestock handlers. However, there are animal welfare concerns about the practice. Work in the Van Eenennaam lab has shown that targeted editing to a single gene can produce hornless offspring cattle which are identical in every other respect to offspring from comparative non-edited parents. In a novel and valuable interdisciplinary angle to the work, the group has also evaluated the economic costs resulting from delaying the introduction of gene editing into cattle breeding programs.

Agricultural Commodity Production and Distribution

Project Director
A Smith
Organization
Regents of the University of California
Accession Number
1013584

Progress Report

In 2-3 sentences, briefly describe the issue or problem that your project addresses.

This project will address the resilience of the agricultural production and distribution system by studying how (i) storage and transportation constraints affect the way that price shocks propagate around the globe, and (ii) how producers respond to price changes.

Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.

Here are four major goals of the project.

1) Model commodity price dynamics and thereby estimate how price shocks spread throughout the world.

2) Quantify how agricultural producers around the world respond to price shocks for multiple commodities.

3) Quantify how government policies such as biofuel mandates affect commodity markets.

4) Quantify environmental impacts of changes in agricultural production.

Towards Goals 1 and 2, my paper with Ghanem presents a modeling technique (SVAR) for estimating dynamic causal effects in agricultural and resource economics. We present an SVAR analysis of global supply and demand for agricultural commodities and illustrate the additional economic insights that the SVAR reveals. We estimate that demand responds similarly to one-year and longer-run supply changes, whereas supply responds differently depending on whether a price change is driven by poor weather last year or a jump in consumption demand.

Towards Goal 1, my paper with Adjemian shows that soybean tariffs during the US trade war with China reduced US soybean prices by $0.74/bu on average for about five months, and increasing Brazilian prices by about $0.97/bu, compared to what would have been observed without the tariff in place. Our price impact estimate is substantially lower than subsequent U.S. government “trade aid” payments to American soybean producers.

Towards Goal 1, my empirical paper with Bushnell and Hughes shows how transportation bottlenecks in North Dakota caused by increased transportation of oil by rail affected agricultural markets. We find substantial effects.

Towards Goals 3 and 4, I worked with Lark and other colleagues at the University of Wisconsin and at Kansas State University on comprehensive estimation of the environmental and land use effects of the Renewable Fuel Standard (RFS). We find that the RFS increased corn prices by 30% and the prices of other crops by 20%, which, in turn, expanded US corn cultivation by 2.8 Mha (8.7%) and total cropland by 2.1 Mha (2.4%) in the years following policy enactment (2008 to 2016). These changes caused enough domestic land use change emissions such that the carbon intensity of corn ethanol produced under the RFS is no less than gasoline and likely at least 24% higher.

Towards Goal 1, my paper with Ferguson presents a robust method for estimating the elasticity of demand for imported products. These methods can show how importing countries respond to price changes, thereby contributing to the picture of how price shocks reverberate.

Since May 2020, I have posted weekly blog-style articles on my website on various aspects of agricultural production, including numerous topics related to Goals 1-4. The articles are available at https://agdatanews.substack.com/ and https://asmith.ucdavis.edu/news.

Briefly describe how your target audience benefited from your project's activities.

The target audience for this project is:

1) Agricultural and environmental policymakers at the state and federal level

2) California farmers

3) Other researchers

State and federal policymakers are currently re-assessing biofuel policies, including the California Low Carbon Fuel Standard and the Federal Renewable Fuel Standard. Our paper on the environmental effects of the RFS will be a critical input to this process.

Researchers benefit from using the methods developed in my papers with Ghanem and Ferguson. They also benefit from the empirical estimates in the other published papers, which improve knowledge and thereby shape opportunities for future research.

Numerous of my blog posts have addressed topics relevant to California farmers.

Briefly describe how the broader public benefited from your project's activities.

I have developed a website to allow researchers and the public to easily view and download agricultural data. Although large quantities of data on agricultural production and distribution exist, they are often difficult to find if you don't know where to look, and if you find a source, it is often difficult to extract simple statistics from the data. Using the data apps on my website, users can view charts and maps of the data, and they can download the data for their own analysis.

The website is: https://asmith.ucdavis.edu/data

Currently, I have the following apps:

(i) US County Weather, (ii) Cropland Data Layer, (iii) California Crops, (iv) US Crops, (v) Low Carbon Fuel Standard, (vi) US Crop Insurance, (vii) Futures Convergence, (viii) World Trends for US Crops, (ix) US Export Sales Reports, (x) Ag Data Using R

Related, since May 2020, I have posted weekly blog-style articles on my website on various aspects of agricultural production. The articles are available at https://agdatanews.substack.com/ and https://asmith.ucdavis.edu/news. This activity has prompted numerous interactions with media and the public.

Describe and explain any major changes or problems encountered in approach. Additionally, note opportunities for training and professional development provided, how results have been disseminated to communities of interest, and any new details regarding what the project or program plans to do during the next reporting period to accomplish the goals.

Environmental Outcomes of the US Renewable Fuel Standard. Lark, T. J.; Hendricks, N. P.; Smith, A.; Pates, N.; Spawn-Lee, S. A.; Bougie, M.; Booth, E. G.; Kucharik, C. J.; and Gibbs, H. K. *Proceedings of the National Academy of Sciences*, 119(9): 1-8. 2022.

Estimating the Market Effect of a Trade War: The Case of Soybean Tariffs. Adjemian, M. K; and Smith, A. *Food Policy*, 105. 2021.

Import Demand Elasticities Based on Quantity Data: Theory and Evidence. Ferguson, S. M; and Smith, A. *Canadian Journal of Economics*. In press.

Causality **in Structural Vector Autoregressions: Science or Sorcery?.** Ghanem, D.; and Smith, A. *American Journal of Agricultural Economics*. In press.

Food vs. Fuel? Impacts of the North Dakota Oil Boom on Agricultural Prices. Bushnell, J. B; Hughes, J. E; and Smith, A. *Journal of the Association of Environmental and Resource Economists*. In press.

Impact Statement (Optional)

Use this space to talk about the impact that this result had, in layman's terms. Adding comments here will **not** change the content in the highlighted result.

Simplifying agricultural supply chain data

Supply and demand fluctuations in agricultural commodities in response to prices, costs and shocks to production remain a challenge for understanding global food production and supply. Recently, the COVID-19 pandemic affected the entire food supply chain from field to consumer, highlighting the need for better data solutions. The UC AES researcher is working with colleagues to address the resilience of the agricultural production and distribution system by studying how storage and transportation constraints affect global price shocks and how producers can respond to these price changes. The project will generate new web-based tools that allow farmers, decisionmakers and the public to extract easily accessible agricultural production data and summary statistics. This novel effort seeks to engage a wider audience in current issues in agricultural economics.

Plant Production Systems

Project Director

Katherine Webb-Martinez

Organization

Regents of the University of California

Accession Number
7000184

Improving access to positive built and natural environment

In 2-3 sentences, briefly describe the issue or problem that your project addresses.

There are documented health benefits of spending time in nature. Yet, a 2019 landscape and urban planning study found inequities in access to urban vegetation in communities that are more ethnically, racially diverse, and have lower income levels. Furthermore, 30% of Californian youth do not have parks, sidewalks, and community centers in their neighborhood, and 30% of adults do not meet physical activity guidelines. Adult and childhood obesity is a public health crisis for the state and nation, resulting in many negative health consequences.

Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.

UCCE academics provided leadership and science-based information for the statewide implementation of the UC Master Gardener Program. Volunteers delivered public education workshops on sustainable landscaping and edible gardening.

Briefly describe how your target audience benefited from your project's activities.

Target audience benefitted as part of community outcome below.

Briefly describe how the broader public benefited from your project's activities.

Change in condition: Improved access to positive built and natural environments.

- 76 participants of UC Master Gardener volunteer-led educational programs reported in a statewide survey that they applied the sustainable gardening practices they learned to over 510,000 square feet of school and community gardens. Gardening interventions have the potential benefit to the broader community. A 2016 nationwide study found that living near greenery may help you live longer due to less air pollution, more physical activity, more social engagement, and most significantly better mental health as measured by a lower prevalence of depression.

In this way, UC ANR improved access to green spaces and the outdoors for people and communities where they live, learn, work, and play. According to the Center for Disease Control and Prevention, you can burn up to 300 calories during just one hour of light gardening and yard work. In addition, research with students has demonstrated that just 30 minutes spent in nature after completing a stressful task improves their mood. The students who were studied exhibited lower levels of cortisol, the stress hormone. Collectively these efforts contribute to the public value of promoting healthy people and communities.

Describe and explain any major changes or problems encountered in approach. Additionally, note opportunities for training and professional development provided, how results have been disseminated to communities of interest, and any new details regarding what the project or program plans to do during the next reporting period to accomplish the goals.

Given we now have the NRS Results form and know how NIFA wants outcomes reported, we are reporting impact stories. Please note this is different than how we initially listed intended outcomes in the 2021 plan. We will edit our future plans to reflect the current reporting approach.

Improving food security

In 2-3 sentences, briefly describe the issue or problem that your project addresses.

One out of ten Californians does not know where their next meal will come from. Of the four million Californians struggling with food insecurity, 1.2 million are children. Food insecurity for youth increases school absences and behavioral problems and reduces children's concentration and academic achievement. Food insecurity is an issue in both urban and rural areas due to lack of availability of fresh produce and/or transportation issues. COVID-related shutdowns and economic challenges in the second year of the pandemic continued to exacerbate food insecurity.

Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.

UC Master Gardener volunteers provide the public with the knowledge and skills to increase their edible gardening success, reducing food loss and fostering the opportunity for garden grown fresh produce to be distributed in local communities. Science-based horticultural information is extended through educational workshops, demonstration gardens, phone advice, social media, newsletters, websites, and individual contacts. (UC Master Gardener Program)

A UCCE collaborative agriculture effort in community food security, specialty crops, orchards, and small farms worked with small growers in cities or at the edge of cities selling or distributing food produced in backyards, vacant lots, school gardens, and community gardens. UCCE Advisors co-organized a two-part workshop on orchard management for 49 local producers. Before the pandemic, the Second Harvest of Silicon Valley Food Bank estimated that one in four residents was at risk of hunger after the region's high cost of living was taken into account. During the pandemic, food insecurity increased, doubling the quantity of food and the number of people served by the food bank and its partners. (Lucy Diekmann, Kamyar Aram, Aparna Gazula, Phoebe Gordon)

Briefly describe how your target audience benefited from your project's activities.

Participants learned how to increase local food resources.

- Local producers who attended the UCCE series on orchards reported learning about orchard pests and diseases as well as nutrient, irrigation, and weed management, cover cropping, and compost application. This new knowledge about urban agriculture and local food production can help contribute to food security, access to healthy foods, and community resilience. (Lucy Diekmann, Kamyar Aram, Aparna Gazula, Phoebe Gordon)

Change in condition: Participants improved food security.

- 52% percent of 830 members of the public who participated in UC Master Gardener volunteer-led public education events reported that they applied gardening practices that reduced food loss in a statewide follow-up survey. (UC Master Gardener Program)

Briefly describe how the broader public benefited from your project's activities.

Change in condition: Improved community food security.

- Ninety members of the public, who participated in UC Master Gardener volunteer-led educational activities and who responded to the statewide survey, donated produce to community programs that distribute food to individuals in need of food assistance. (UC Master Gardener Program)
    - In Ventura County, over 450 pounds of fruits and vegetables harvested from UC Master Gardener sites were donated to local hunger relief agencies. (Jim Downer)

The measured outcomes reported above showed learning and behavioral changes related to growing practices that contribute to increased access to fresh produce. They also demonstrate how UC's network of researchers and educators participate in cross-sector collaboration to address emerging food security issues. In this way, UC ANR's efforts contribute to the public value of safeguarding sufficient, safe, and healthy food for all Californians.

Describe and explain any major changes or problems encountered in approach. Additionally, note opportunities for training and professional development provided, how results have been disseminated to communities of interest, and any new details regarding what the project or program plans to do during the next reporting period to accomplish the goals.

Given we now have the NRS Results form and know how NIFA wants outcomes reported, we are reporting impact stories. Please note this is different than how we initially listed intended outcomes in the 2021 plan. We will edit our future plans to reflect the current reporting approach.

Improving living and working conditions for California's food system and farmworkers

In 2-3 sentences, briefly describe the issue or problem that your project addresses.

In 2019 there were 22.2 million full- and part-time jobs related to the agricultural and food sectors – 11% of total U.S. employment. Migrant and seasonal farmworkers are a vital component of those jobs, yet they continue to live in poverty with poor health indicators and limited access to health care services. Farm labor conditions are intricately entwined with farmworker quality of life, farm profitability, and the socioeconomic vitality of agricultural communities. For example, recent labor shortfalls have reached as high as 20% in California, resulting in $3 billion in lost production. Agriculture, one of the most hazardous industries for workers, with over 75,000 injuries and illnesses reported annually across the U.S. Farmworker communities have been hard hit by the pandemic; crowded living and working conditions, low wages, and fear of deportation all contribute to high rates of COVID-19.

Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.

The COVID-19 pandemic brought to light the importance of essential workers in maintaining food system resiliency and, at the same time, worsened the inequities they face. In particular, farmworkers have experienced exacerbated challenges in maintaining healthy, safe, and sustainable livelihoods during the pandemic given dense living and working conditions, vulnerable legal status, and lack of equal protection under labor law. A UC Cooperative Extension (UCCE) Nutrition Specialist at UC Berkeley presented a talk titled, "In the middle of two pandemics: COVID-19 & chronic disease in farmworkers," as part of a webinar focused on "Farm Labor During the Pandemic: Critical links between Essential Work, Farmworker Health and Food System Resiliency." The webinar presented the key findings from a COVID-19 Farmworker Survey and other innovative efforts to adapt research, outreach, and policy work to improve farmworker living and working conditions in the pandemic context. The UCCE talk focused on increasing awareness of the farmworker population's dual risk: 1) high rates of transmission and 2) the high prevalence of pre-existing/chronic health conditions (e.g., obesity, diabetes, hypertension, etc.) that increase the risk of COVID complications. This activity does not yet have a measured outcome but it is included to illustrate Extension’s responsiveness to the pandemic. (Susana Matias)

A UCCE Specialist working on social justice in agriculture at UC Berkeley conducts evaluation research on social certification in agriculture. The researcher works with the Equitable Food Initiative (EFI) in its continuous improvement process to strengthen its social certification and workforce development program. EFI’s primary goal is to improve the working conditions of farmworkers in California and beyond. (Christy Getz)

Pesticide drift is a health concern for farmworkers, the surrounding farm and school communities, and the environment. A UCCE Advisor completed a 3.5-year project to train California pesticide applicators on recommended practices to reduce pesticide drift. She led a team of UC and industry professionals to deliver two hands-on training sessions and completed the online course development. (Lynn Wunderlich)

The UC Sustainable Agriculture Research and Education Program (UC SAREP) has a focus area on social equity to address inequities and racism in California's agriculture and food system. The program works to build capacity within extension. Guest speakers include professionals experienced in working with clientele who are people of color, farmers of color, and members of community-based organizations who interact with or would like to interact with extension professionals. In 2020-21, two webinars on serving farmworkers and farmers of color reached 135 real-time participants and many others who watched the recorded webinars later. (Sonja Brodt, Gail Feenstra, and Stephanie Parreira)

The UCCE Viticulture Advisor improved access to educational resources for vineyard workers and supported the professional development of the vineyard labor force, to promote equitable farm labor conditions and agricultural workforce development. (Monica Cooper)

Briefly describe how your target audience benefited from your project's activities.

Participants reported learning gains that are intended to lead to improved farmworker outcomes.

- Of the 78 attendees at the UC SAREP's webinars for those working farmworkers and farmers of color, 25 completed an evaluation survey and reported:
  - 100% said they gained new knowledge;
  - 96% indicated the webinar improved their awareness of the topic;
  - 84% said the webinar modified their opinions of the topic;
  - 80% said they are likely to use what they learned in future educational programming; and
  - 28% learned new skills.

Several attendees appreciated the suggestions to provide more outreach materials in the form of visual graphics and consider adding indigenous Mexican and Central American languages. For many farmworkers in California, Spanish is not their primary language. Many people asked about suggestions for organizations to partner with to engage with farmworkers effectively, and they appreciated the concrete suggestions provided by the panel. (Sonja Brodt, Gail Feenstra, Stephanie Parreira)

Farmworkers had learning gains intended to improve working conditions.

- Farmworkers gained knowledge in the areas of communication, leadership, facilitation, and technical viticulture information, specifically soil health and insect identification. These strategies help improve farm labor conditions to support agricultural resilience and promote a more inclusive and equitable food system. (Monica Cooper)

Participants adopted practices that lead to improved farmworker safety.

- A postseason follow-up survey found that 39% of 36 respondents, including Pest Control Advisers, growers, and pesticide applicators, adopted at least one recommended practice to reduce pesticide drift, improving farmworker working conditions and health. (Lynn Wunderlich)

Change in condition: Improved working conditions for farmworkers.

- The Equitable Food Initiative's (EFI) has implemented many of the evaluation-based recommendations from the 2017 UCCE report, improving the working conditions of farmworkers. Between 2017 and 2021, the number of EFI certified farms increased from 19 to 48 and, relatedly, the number of workers on certified farms from 10,000 to more than 57,000, magnifying the impact of UCCE's recommendations. (Christy Getz)

Briefly describe how the broader public benefited from your project's activities.

The measured outcomes reported above demonstrate changes to improve the working conditions for those working in the California food system, many of whom live in poverty and have poor health. In this way, UC ANR contributes to the public value of developing an inclusive and equitable society. These efforts also benefit the food system through workforce retention, improved safety, and product quality.

Describe and explain any major changes or problems encountered in approach. Additionally, note opportunities for training and professional development provided, how results have been disseminated to communities of interest, and any new details regarding what the project or program plans to do during the next reporting period to accomplish the goals.

Given we now have the NRS Results form and know how NIFA wants outcomes reported, we are reporting impact stories. Please note this is different than how we initially listed intended outcomes in the 2021 plan. We will edit our future plans to reflect the current reporting approach.

Increasing agricultural efficiency and profitability

In 2-3 sentences, briefly describe the issue or problem that your project addresses.

California is a national leader in agricultural production, leading the country in cash income received for agricultural products, with farms and ranches receiving more than $50 billion for their output. The state accounts for almost half the country's fruit and nut production and over half of vegetable production. The state's farmers and ranchers must innovate and adapt to technical, social, and environmental challenges to maintain the economic vigor of California's agricultural production. Factors such as high input prices (e.g., labor, fertilizers, and pesticides) and regulations affect the profitability of farm and ranch businesses. These factors often affect small-scale farmers more adversely, as many lack the resources or skills that larger farms have.

Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.

UC ANR creates and extends new knowledge about agricultural production from variety trials to post-harvest.

California is the nation's largest milling state for small grains. Cereals are integrated into most of the cropping systems in the state, and production is dispersed across a broad range of California agroecosystems, soil types and precipitation totals. The agronomic practices and information needs of the small grain stakeholders around the state are incredibly diverse. Although COVID restrictions hampered in-person field events, a UC Cooperative Extension (UCCE) Agronomy Specialist at UC Davis helped organize five virtual events and three small group gatherings. Activities included demonstrations of how to use the Nitrogen fertilizer management tools they developed, presenting their results from statewide small grain variety evaluations, and roundtable discussions of UCCE's work related to cropping system adaptation in the face of increasing water scarcity. Aggregate attendance at these events was more than 280 individuals and included growers, industry professionals, policymakers, agronomists, and other researchers. (Mark Lundy)

A UC Cooperative Extension (UCCE) CE Specialist of agricultural mechanization at UC Davis works directly with growers to test run the technologies developed at the Digital Ag Lab and solicits feedback for improvements. The major outputs include an interactive web application tool: myvirtualorchard.com, which is a free online application to visualize the results of aerial image analytics in the form of shapefiles and imagery. Users can analyze their within-field variability, define management zones, and export data. The first version of this web application was made available online. In addition, two methodologies

were designed and implemented for yield forecasting. The first approach for almond maps bloom density and estimates expected yield based on blossom conditions. Aerial RGB imagery was used to develop a deep learning algorithm to detect and count the number of flowers for each tree. The second method uses 3D modeling and simulation to estimate canopy-intercepted light, or photosynthetically active radiation (PAR), which is crucial for quantifying crop biomass development and yield potential. (Alireza Pourreza)

From 2018-2021, one UCCE research project explored the viability of adopting drip irrigation for organic and conventional spinach production to reduce loss from disease and input costs. Field experiments were conducted at the UC Desert Research and Extension Center and three commercial fields in the low desert of California. An overall effect of the irrigation system on downy mildew was observed. The disease incidence was two-to-five times lower in plots irrigated by drip compared to sprinklers. The findings were shared with growers and stakeholders through several media interviews, presentations in workshops/webinars, and extension and peer-review publications. (Ali Montazar)

An innovative UCCE research project on using biosolids for fertilizer continued. The data from the trials have provided valuable insights into what growers can expect when they use biosolids as an occasional substitute for synthetic nitrogen fertilizers. The findings provide a general picture of how growers can use biosolids to reduce fertilizer costs, utilize local sources of macronutrients, minimize leaching, and improve nitrogen efficiency in certain conditions. In 2021, the new knowledge was extended through a virtual field day and presentations. (Konrad Mathesius)

UCCE on-farm workshops in the Sierra Foothills continue to teach practical skills and knowledge. Peer-to-peer sharing of knowledge and experiences at these workshops results in the rapid adoption of new practices. In addition, on-farm research on pruning and mulching in five citrus orchards continues to provide important data on the impacts of mulch on soil temperature and moisture, microbial activity, and the impacts of tree stress on fruit drop. New knowledge on how to manage mulch throughout the year has been developed. (Cindy Fake)

Another UCCE orchard management effort focuses on developing and promoting best practices, including genetic, cultural, and chemical practices to reduce tree damage and loss. This information was extended through popular press publications and the media; the latter mostly related to walnut freeze. (Luke Milliron)

The Botryosphaeriaceae fungi and Phomopsis species are now widely distributed in walnut orchards in almost all walnut-growing regions in California. In 2021, a new spray program starting at bloom time provided a significant disease reduction compared to the grower's standard fungicide program. Research results will help walnut growers to avoid at least three fungicide sprays they were using at the wrong time, thus saving millions of dollars to the walnut industry and reducing the impact of pesticides on both human health and the environment. Further research is still ongoing to reduce the number of sprays. (Mohamed Nouri)

In the Central Valley, a UCCE research and extension project continued on rootstocks that can decrease boron toxicity. This came in response to growers asking how to properly manage this over-supplied, naturally occurring element in irrigation water, allowing more efficient use of California's scarce water resources. Research findings were extended through local meetings and the statewide meeting hosted by the Almond Board of California, and an interview with an industry news outlet. (Katherine Jarvis-Shean)

UCCE led attendees through a multi-county field tour extension meeting: Tree Fruit Orchard Tour, High-Efficiency Tree Architecture and Harvest Aids for Cherries, Pears, and Apples. This field tour provided fruit growers the opportunity to see platform harvest aide equipment in action. (Kari Arnold)

A UCCE Advisor responded to a farm call about apricots in Stanislaus County, which contains the greatest acreage for apricots in California with approximately 4,000 acres. Apricots have minimal research-based information on rootstocks and incompatibility. Thus, a nursery requested UCCE conduct a study and donate the trees. The apricot rootstock trial showed that two rootstocks are not compatible with the Patterson apricot cultivar; thus, these rootstocks will not be recommended for use in future Patterson cultivar orchards. The research aims to save nurseries and growers the cost of removing trees and future yield loss by providing information on compatible rootstocks. (Kari Arnold)

In 2021, a UCCE study on grafted watermelon continued after a 1-year hiatus due to COVID. The research investigated and compared the impacts of reduced plant population on grafted watermelon yield, fruit quality, and economic gains with the traditional production pattern. The findings generated optimal plant spacing and rootstock-scion combinations that could consistently out-yield non-grafted plants and maximize economic revenues. This new information was disseminated via extension activities, and a scientific journal article is under development. (Zheng Wang)

A UCCE Advisor in the Sacramento-San Joaquin Delta has had an annual field corn variety trial since 2013 and is the only UC researcher to trial corn varieties statewide. She has developed expertise in corn nitrogen management and is the principal investigator on a project to test nitrogen stabilizer efficacy in improving plant nitrogen uptake and corn yield. (Michelle Leinfelder-Miles)

A UCCE Agronomy Advisor presented on getting the most fertilizer value from manure during the UC Golden State Dairy Management Webinar, and on using N-Rich Reference Zones to guide nitrogen fertilizer management for irrigated Triticale in the San Joaquin Valley during the UC Small Grains: Alfalfa/Forages Virtual Field Day. (Nicholas Clark)

UCCE continued analysis of the evolution of conservation easements in the Northeastern region of California. The impetus stemmed from the Sierra County Board of Supervisors' concerns. A UCCE Advisor analyzed the terms of 38 deeded easements to develop a presentation that provided clarity for clientele on the value and drawbacks of selling a conservation easement on their land. Information has been provided to land trust staff and local agencies about restrictive easement language that can jeopardize the future viability of working landscapes. (Tracy Schohr)

Briefly describe how your target audience benefited from your project's activities.

Participants had learning gains and itend to adopt recommended practices for plant production.

- Of the 112 participants in the UCCE agronomy virtual field event, 22 individuals identified as growers or industry professionals participated in a post-event evaluation survey and rated their knowledge about the topics presented before and after the presentations. Topics included information on UC's statewide small grain variety evaluations, webtools available on the UC Small Grains RIC, how to use N rich reference zones to guide in-season fertilizer management, and the potential for biosolids as a fertilizer in California small grain crops. Across these topics, individuals indicated an average increase in knowledge of 22% before and after the presentations. Depending on the topic, between 62% and 84% of respondents indicated that they would likely use the information presented in their work (77% on average across topics). (Mark Lundy)

- Pre- and post-education surveys were administered to determine the shift in mindset and potential changes in future industry practices to further adopt digital agriculture. Growers, managers, consultants, crop advisors, educators, and the research community improved knowledge about the factors that influence grower decision-making, robust and scalable aerial and/or ground-based sensing tools to assess crop health and productivity, and precision-agriculture principles for high-resolution data-driven crop management. A total of 205 responses were received from four surveys conducted during this reporting period. The survey results showed that all audiences reported 10-85% (51% on average) the training material improved their knowledge. (Alireza Pourreza)

- Nine fruit growers learned hands-on techniques at the Cover Crops, Mulch, and Vegetation management workshop and reported:
    - 42% increased knowledge of soil and organic matter management;
    - 56% plan to seed a cover crop, compost plant residues, and plant insectary plants;
    - 44% will mulch their orchards and include those nutrients in their nutrient management plan; and
    - 44% plan to monitor soil moisture under mulch and adjust irrigation appropriately. (Cindy Fake)

- Of the 25 beginning farmers who participated in the Understanding and Improving Foothill Soils workshop, 63% reported increased knowledge of soils and the ability to manage soils. (Cindy Fake)

- Of the grape growers who participated in the Grapevine Stress Workshop, 91% of survey respondents (n=28) stated the intention to change one or more practices as a result of the workshop. (Cindy Fake)

- Of the 80 citrus growers in the citrus-growing area of Placer and surrounding counties, 72% now consider using mulch as standard practice and appreciate the benefits it provides in the Sierra Foothills variable climate. (Cindy Fake)

- Direct interactions with approximately 20 growers in San Joaquin County showed they have already changed their production practices responsible for spreading fungal pathogens in walnut orchards. In addition, growers plan to follow the new spray program in their orchards to control Botryosphaeria/Phomopsis disease in walnuts. (Mohamed Nouri)

- Of the 23 agricultural industry participants at the UC Small Grains Virtual Field Day who took an evaluation survey, 65% indicated an increase in their knowledge pertaining to the use of biosolids. Sixty percent indicated they were likely to use biosolids as a soil amendment. Biosolids reduce grower fertilizer costs, provide a slow-release nitrogen source, reduce nitrate leaching, close nutrient cycles, and feed soil microbial communities. (Konrad Mathesius)

- The 20 attendees on the Tree Fruit Orchard Tour expressed an increased knowledge of harvest mechanization (average score 4.2 on a scale of 1 to 5, with 5 being very much). (Kari Arnold)

- The Stanislaus County apricot grower participating in the study learned two rootstocks were incompatible and thus not to grow those. If this grower had planted these available cultivars, now knowing they were incompatible, he would have had to remove these trees. According to the UCDavis tree loss calculator for peaches (apricot tree loss calculator not available), a 2-year old peach tree was approximately worth $72 in replacement cost in 2009. If considering a 40 acre orchard consisting of 151 trees per acre, this would have cost $434,880 in replacement value. If considering all 4,000 acres of apricots in Stanislaus County, this would amount to $43,488,000. (Kari Arnold)

- Eighty-nine percent (17 of 19) of corn workshop survey respondents indicated that they learned useful information, and 15 intended to use what they learned in the next 12 months. (Michelle Leinfelder-Miles)

- Of the 41 attendees polled during the Dairy Management Webinar, 93% reported they gained information, and 90% said they would apply the information they gained. (Nicholas Clark)

- At the UC Small Grains Virtual Field Day, 22 poll respondents indicated gaining knowledge of how to use N-rich reference zone for in-season nitrogen fertilizer management in small grains. On average, respondents were very likely to use these learned practices in their commercial production. (Nick Clark)

Participants adopted recommended practices for plant production.

- Four growers and six researchers at UC Davis and UC ANR used the yield forecast technology in 2021. The insights from yield forecast technology help growers start thinking about field optimization to recover the low yield zones, avoid loss, and improve sustainability. Growers can estimate nitrogen and water demand per tree with a yield forecast map and manage accordingly. (Alireza Pourreza)

- One hundred and eighty-six specialty crop producers implemented one or more new soil management, water conservation, or pest management “best practices” on their farms. These include mulching, cover crops, nutrient management, soil moisture monitoring, irrigation scheduling, and pruning. These practices increase organic matter, build healthier soil, conserve water, and mitigate climate-change-induced plant stress. (Cindy Fake)

Change in condition: Participants have economic benefits.

- As a result of participating in research trials, a cooperative grower reported a considerable cost reduction of $300 per acre in conventional spinach under drip irrigation due to less/no water treatment applications for downy mildew control. In addition, a lower energy cost of $200 per acre is estimated for spinach produced under drip irrigation. Such savings demonstrate that drip irrigation has the potential for producing more profitable and efficient spinach in the California crop production system. (Ali Montazar)

- Growers' adoption of grafted watermelon continued to increase, which provides economic benefits given a reduction of cost for grafted transplants by up to 35% and an increase of net income by up to $2,500 per acre. The gross planting area of grafted watermelons in California increased from less than 250 acres in 2018 to over 1,500 acres in 2021, and this number keeps growing. On average, growers reported that successfully grafted fields could produce 15-25% more watermelons than the non-grafted fields per acre using the same amount of water and fertilizers. In addition, the plant population in grafted fields is about two-thirds of that in non-grafted fields, which lowers growers' input costs. (Zheng Wang)

- Growers reported thousands of acres were not damaged in the November 2020 freeze because of adopted best practices to reduce tree damage and loss. (Luke Milliron)

- Two clientele were better informed and decided the terms of their easement under negotiation were overly burdensome and did not align with terms from other land trusts with easements in the region. They decided to not enter into the perpetual contract, thanking UCCE for educating their family on a long-term decision that would have had significant negative economic and management impacts on their ranching operation for future generations. (Tracy Schohr)

Briefly describe how the broader public benefited from your project's activities.

Change in condition: Local economic benefits.

- Adoption of the almond rootstock for high-boron conditions has increased as measured by the sales of the best-suited rootstocks. The findings from the research trial suggest proper rootstock selection yields $3,871 more income per acre per year at prime production (2018 prices). Across the 5,000 acres of Yolo County's recent high-boron almond plantings, this is estimated to be a $20 million in annual increased yield. This value will grow as this research enables more almond orchards to be planted in these high boron areas. (Katherine Jarvis-Shean)

- One greenhouse manager explained the local economic benefit of UCCE helping connect local growers to local greenhouses. She has received orders to produce more than 500,000 grafted watermelon transplants, a total sale value of over $600,000, for the 2022 season, which is a 10-15 times increase compared to 2018 before the research and extension effort. Growers ordered all needed grafted plants from out-of-state nurseries in the past. California watermelon growers are now shifting transplant orders to local nurseries to save the shipping cost and prevent plant damage during long-distance transportation. (Zheng Wang)

The measured outcomes reported above strengthened diverse California farm businesses by helping to increase their economic returns given increased yield, reduced inputs, or improved business management and marketing. These outcomes contribute to increased agricultural efficiency and profitability and the public value of promoting economic prosperity in California. Statewide the sales value generated by California agriculture continues to increase. As last measured by the California Department of Agriculture, the sales value increased by more than one percent between the 2018 and 2019 crop years.

Describe and explain any major changes or problems encountered in approach. Additionally, note opportunities for training and professional development provided, how results have been disseminated to communities of interest, and any new details regarding what the project or program plans to do during the next reporting period to accomplish the goals.

Given we now have the NRS Results form and know how NIFA wants outcomes reported, we are reporting impact stories. Please note this is different than how we initially listed intended outcomes in the 2021 plan. We will edit our future plans to reflect the current reporting approach.

Increasing preparedness and resilience to extreme weather and climate change

In 2-3 sentences, briefly describe the issue or problem that your project addresses.

Increasingly extreme and erratic weather patterns caused by climate change threaten crop yields and farm profits across the state. Growers must continue to adapt to climate stressors, such as increased temperatures and occurrences of drought, and can aid in reducing climate change through their farming practices.

Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.

In partnership with the California Department of Food and Agriculture, the UC ANR Climate Smart Agriculture Educator team has provided hands-on assistance to over 200 farmers and ranchers through grant application assistance, workshops, field days, and events. Over 120 clientele were able to receive funding after receiving technical assistance and continue to receive support from UCCE in the implementation of climate-smart projects. (Dana Yount, Emily Lovell, Caddie Bergren, Nicki Anderson, Shulamit Shroder, Samikshya Budhathoki, Esther Mosase, Kristian Salgado, Valerie Perez)

A UCCE Advisor in the Delta region supported a growing rice industry by providing growers with production and pest management advice and guidelines to be successful. Collaborative extension efforts included presentations, blog articles, one technical report, and an article in an industry magazine with over 3,000 subscribers. (Michelle Leinfelder-Miles, Luis Espino, Whitney Brim-DeForest)

A UCCE Specialist at UC Merced conducted research to enhance agricultural resilience to climate and weather risks, with a focus on studying impacts of climate on various specialty and agronomic crops. Science-based information about managing risks and adaptive management practices was extended through workbooks, workshops, locally-relevant technical assistance, and policy engagement activities. (Tapan Pathak)

A UCCE Specialist at UC Berkeley and co-Principal Investigator from the Karuk Tribe continued their agroecosystem resilience work and long-term monitoring plots to assess the impact of climate change and land management on Karuk culturally significant foods and fibers. They developed and disseminated over 50 plant guides on cultural food, fibers, medicinal plants, invasive plants, and plant diseases to help with plant and disease identification. Additionally, new technologies and practices that integrate Western and Indigenous science perspectives were developed for Karuk Tribal government. Examples include a digital species distribution prediction model, mobile field data collection tools, knowledge databases, immersive visual tours, and 360-degree imagery of research plots in collaboration with the UC Informatics and Geographic Information Systems program. (Jennifer Sowerwine, Andy Lyons)

A UCCE Specialist at UC Davis conducted research projects directly funded by the grape and wine industry in response to new issues and direct requests from industry members. Topics include determining smoke exposure risk and mitigation options in the vineyard and winery. Findings are disseminated through extension programs. (Anita Oberholster)

Briefly describe how your target audience benefited from your project's activities.

Participants gained understanding of strategies to respond to climate change and extreme weather.

- UCCE observed through messages from clientele that the winegrape industry has increased their understanding of smoke exposure risk and the limitations of treatment options being sold to the industry, which potentially saves growers money and prevents issues from worsening. Additionally, growers now understand strategies for crop insurance for potential contract disputes and litigation, such as storing grape samples and conducting testing. (Anita Oberholster)

Participants adopted climate-resilient strategies.

- An outcome of UCCE's work in rice armyworm monitoring was the application of a reduced-risk, targeted pesticide on 1,000 Delta acres per year, which potentially reduces pollution caused by alternative, broad-spectrum pesticides. Furthermore, as UCCE helps Delta rice farmers be successful, the rice production system has the potential to sequester carbon and mitigate climate change as indicated by research that has shown that the flooded rice system staves off soil carbon loss, accreting 0.02-0.8 cm/yr (Deverel et al., 2017; Hatala et al., 2012). (Michelle Leinfelder-Miles)

Science-based information was applied to fire and climate-resilient policy and decision-making.

- The California Natural Resource Agency used science-based information from UCCE research and extension efforts in their report, which will guide the agency in future policy decisions. The UCCE Specialist served on the agency's expert advisory panel on expanding climate action through nature-based solutions, in response to an Executive Order by Governor Newsom. This demonstrates how UCCE engages in policy implementation. Anticipated impacts include protecting and restoring practices for carbon sequestration and accelerated climate-smart land management. (Tapan Pathak)

- UCCE's research findings were also used heavily in a report by the Delta Stewardship Council, a state agency, released in May 2021 called "Delta Adapts: Creating a Climate Resilient Future." This report is used to inform future work at the agency and provide guidelines and a toolkit for the local governments. Similarly, Butte County climate change vulnerability assessment and Berkeley Law reports also referred to this research for planning and policy recommendations. (Tapan Pathak)

- Karuk tribal community members shared that they intend to utilize the plant guides to supplement lesson plans on threats to cultural plants to be conducted in local schools and make them available in the Karuk Sípnuuk Digital Library. The Karuk Tribe's Tribal Heritage Preservation Officer utilized UCCE's shared information about the archeology

of project sites, which contributed to decisions regarding cultural management and protection of areas rich in artifacts. (Jennifer Sowerwine)

- More Karuk tribal community members and Karuk Department of Natural Resources staff are monitoring cultural plants for the effects of climate change as a result of UCCE's collaborative agroecosystem resilience work. Furthermore, these efforts have increased the long-term capacity of the Karuk Tribe to monitor the effects of land management and climate change on 20 culturally significant species beyond the end of the project. (Jennifer Sowerwine)

Briefly describe how the broader public benefited from your project's activities.

Change in condition: Reduced greenhouse gases.

- Through assisting awardees in the adoption of practices such as cover cropping, installing solar panels, and installing dairy manure solid separator systems, the 10 UC Climate Smart Agriculture Community Educator Specialists have collectively supported growers in reducing 33,000 MT/CO2 per year, as measured by California Air and Resources Board (CARB) Green House Gas Emission reduction calculator (SWEEP GHG Calculator on CDFA's website), and the HSP Comet planner tool. That's equivalent to removing 7,000 cars from the road per year. Furthermore, research shows that Healthy Soils Program practices such as compost application increases the amount of organic matter in soil, amongst numerous other benefits such as increasing the water and nutrient retention capacity of soils, providing a reservoir of nutrients for plants, improving aeration, improving water infiltration, reducing soil erosion, and supporting the abundance and diversity of soil organisms, which can improve plant health. Compost application is just one fundable practice farmers can implement to help reduce greenhouse gasses on their operation. (Dana Yount, Emily Lovell, Caddie Bergren, Nicki Anderson, Shulamit Shroder, Samikshya Budhathoki, Esther Mosase, Kristian Salgado, Valerie Perez)

The measured outcomes reported above demonstrate participants learning about and developing new management paradigms to address the challenges of a changing climate on agriculture and food systems. Adopting new strategies and policies informed by UC ANR's science-based research will help increase agricultural resiliency. In these ways, UC ANR contributes to building climate-resilient communities and ecosystems.

Describe and explain any major changes or problems encountered in approach. Additionally, note opportunities for training and professional development provided, how results have been disseminated to communities of interest, and any new details regarding what the project or program plans to do during the next reporting period to accomplish the goals.

Given we now have the NRS Results form and know how NIFA wants outcomes reported, we are reporting impact stories. Please note this is different than how we initially listed intended outcomes in the 2021 plan. We will edit our future plans to reflect the current reporting approach.

Critical Issue

Sustainable Natural Ecosystems

Investigating the effects of climate change on pollination services

Project Director

Nicole Rafferty

Organization

Regents of the University of California

Accession Number

1026313

Investigating the effects of climate change on pollination services

In 2-3 sentences, briefly describe the issue or problem that your project addresses.

This project addresses how pollination services are affected when plants and pollinators are subjected to warming, testing to what extent plant and bee phenology respond differently to the same environmental conditions. This research enables prediction of how pollination will be affected by future environmental change, allowing us to determine how likely environmental change is to disrupt species interactions and the provision of ecosystem services.

Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.

We secured all necessary supplies to successfully initiate the first iteration of this project in a newly constructed greenhouse facility at UC Riverside. This involves assembling 24 replicate foragaing arenas with both bees (*Osmia lignaria*) and our 3 focal plant species (*Phacelia campanularia*, *Collinsia heterophylla*, and *Nemophila menziesii*) in each arena to create experimental communities. We have secured greenhouse space in which to initiate 4 temperature treatments: ambient, +2 C, +4 C, and +6 C, with 6 replicate arenas (communities) per treatment. Thus, we achieved planning for the overall experiment, and in early 2022 we will begin collecting data on flowering and bee phenology (flowering onset, bee emergence), plant-pollinator interactions (visitation rate), and floral traits (nectar production, flower size). From April-July 2021, we also completed a smaller-scale pilot study to test many of our methods, using only 2 temperature treatments (ambient and +4 C). This results of this pilot study informed our methods, and we plan to submit the findings for publication.

Briefly describe how your target audience benefited from your project's activities.

We are in the process of disseminating results from our pilot study, which can help managers of commercial bee populations and conservation practictioners better understand how warming temperatures affect native wildflowers that provide important floral resources for bees and a native solitary bee species that is an economically and ecologically valuable pollinator of many orhard crops.

Briefly describe how the broader public benefited from your project's activities.

The crops (including various *Prunus* species such as almonds) that are pollinated by our focal bee species, *Osmia lignaria*, are an important part of the public food supply. Our project provides novel insight into how *O. lignaria* and key floral resources that this species relies upon will be affected by warming conditions, and therefore informs our ability to preserve critical pollination services.

Impact Statement (Optional)

Use this space to talk about the impact that this result had, in layman's terms. Adding comments here will **not** change the content in the highlighted result.

Exploring how temperature change affects plant-pollinator interactions

The UC AES researcher in community ecology is studying how changing environmental conditions, such as warming temperatures over time, may disrupt plant-pollinator species interactions. Using controlled greenhouse conditions, the experiment will expose native wildflowers and solitary bees to elevated temperatures to test how interdependent species respond to different levels of warming over multiple generations. The project will yield insight into how plant and bee phenology react to the same shifts in environmental conditions. This information can help bee managers and conservation practitioners better understand how warming temperatures will affect native wildflowers that provide ecologically and economically valuable resources for orchard crop pollinators.

Bolstering Resilience in California's Fire-Prone Rural and Agricultural Areas through Multi-scalar Landscape Management and Community Design Techniques

Project Director
Emily Schlickman
Organization
Regents of the University of California
Accession Number
1025191

Progress Report

In 2-3 sentences, briefly describe the issue or problem that your project addresses.

This project seeks to understand how landscape management and community design techniques might bolster resilience for rural and agricultural areas of California that are prone to wildfire. It presents a framework for managing and designing in the liminal area between wildland and rural land in California, and challenges what the future could hold forthis space.

Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.

This project has five primary goals: (1) shed light on the history of fire suppression and landscape management in California, (2) unpack how recent wildfire events have impacted rural communities and agricultural areas in the state, (3) identify areas of California where future management and design strategies could make a significant impact, (4) explore new technologies that could be employed in the field to democratize data about the potential effects of wildland fire and to inform future design and planning efforts, and (5) expand the toolbox for bolstering wildfire resilience by providing a multi-scalar matrix of tactics that have been employed and tested as best practices.

To help achieve the first goal, I presented on the topic to the UC Davis CAES Deans Advisory Council and to an interdisciplinary group of researchers focused on the intersection of art and fire. Additionally, I secured a grant through the Australian Department of Foreign Affairs and Trade which allowed me produce two exhibitions on the topic (one, of which, received an award). Lastly, I used my knowledge on the topic to contribute to a UC Davis CAES wildfire research fund proposal.

To help achieve the second goal, I conducted design research in the community of Vacaville, which was impacted by the LNU Lightning Complex Fires of 2020. Furthermore, I received a grant through the USDA Forest Service to conduct research on ten additional California communities that are particularly vulnerable to wildfire.

To help achieve the third goal, I published a research article that spatially analyzed higher-growth rural and agricultural communities in terms of their historical fire perimeters and wildland-urban interface areas. I also presented this work at an interdisciplinary conference focused on environmental design research.

To help achieve the fourth goal, I published a research article focused on prototyping an affordable and mobile sensor network for hyperlocal air quality. I also presented this work at a discipline-specific conference focused on digital technologies for landscape architecture.

To help achieve the fifth goal, I developed content for a forthcoming book, *Design by Fire: Resistance, Co-Creation, and Retreat in the Pyrocene*. The content included design case studies from fire-prone regions across the world.

Briefly describe how your target audience benefited from your project's activities.

The work produced over the last year was developed and shared with a number of key stakeholders. These included: the Vacaville Planning Commission, the USDA Forest Service, the California Native Plant Society, the College of Agricultural and Environmental Sciences at UC Davis, South East Arts, FieldScreen International, Moab Arts and Recreation Center, Fire School, the Environmental Design Research Association, the International Federation of Landscape Architects, the Council of Educators in Landscape Architecture, and the Digital Landscape Architecture association.

This target audience benefitted from the work by learning about: the history of fire suppression and landscape management in California, how recent events have impacted rural communities, areas across the state where future initiatives could make an impact, new technologies that could be employed to reduce risk, and techniques for bolstering wildfire resilience.

Briefly describe how the broader public benefited from your project's activities.

The work produced over the last year reached the broader public in a number of ways. First, the two peer-reviewed research articles were published in open-access journals to allow for a broader reach. The third article was published in a discipline-specific publication with a more professional reach. The work was also featured in two publicly-accessible exhibitions – one in-person and one online. Additionally, imagery from one of these exhibitions won an award from a California-based non-profit organization which was featured on their website and newsletter. Furthermore, with the specific focus on Vacaville, CA, residents of that community were engaged in the research process through outreach and planning commission meetings.

The broader public benefitted from the work by learning about: the history of fire suppression and landscape management in California, how recent events have impacted rural communities, areas across the state where future initiatives could make an impact, new technologies that could be employed to reduce risk, and techniques for bolstering wildfire resilience.

Describe and explain any major changes or problems encountered in approach. Additionally, note opportunities for training and professional development provided, how results have been disseminated to communities of interest, and any new details regarding what the project or program plans to do during the next reporting period to accomplish the goals.

2021 Publication List

Schlickman, E. (2021). Mapping the wildland-urban interface and historical fire perimeters to inform design and planning efforts in growing California communities. *Landscape Research Record*.

Schlickman, E. (2021). Prototyping an affordable and mobile sensor network to better understand hyperlocal air quality patterns for planning and design. *Journal of Digital Landscape Architecture*.

Schlickman, E. (2021). 7.17 seconds. *Ground Up Journal*.

Impact Statement (Optional)

Use this space to talk about the impact that this result had, in layman's terms. Adding comments here will **not** change the content in the highlighted result.

Community resilience models for living with wildfire

New models of resilient community design are critical for fire-prone regions engaged in rebuilding after wildfire, many of which are simultaneously experiencing an increase in new residents. The UC AES scientist in landscape architecture and environmental design is conducting a research project that seeks to incorporate a broader understanding of fire's natural presence, using art and education to connect with communities about the inevitability of wildfires and how to adapt to living in a fire-prone area. The project also aims to develop new strategies that provide community residents with affordable mechanisms for understanding their air quality at local and time-relevant scales.

Effects of land-use, roads and fences on wildlife ecology and management in California

Project Director

Justin Brashares

Organization

Regents of the University of California

Accession Number

1024114

Progress Report

In 2-3 sentences, briefly describe the issue or problem that your project addresses.

While the economic and non-economic values of wildlife are broadly appreciated, wildlife populations and communities continue to decline across the western U.S. as habitats, including lands critical for maintaining connectivity, are converted for agriculture, housing and other human uses. The goal of this project is to improve management of large mammals in the western U.S. through a rigorous, multi-year study of wildlife responses to land-use, roads and fences. Ultimately, an improved understanding of the impact of habitat conversion, roads and fences on wildlife movement will inform connectivity planning for conservation and wildlife management at large scales across the western U.S..

Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.

Our major activities during the 2021 project year focused on the application of two approaches: 1) study of wildlife movement using GPS collars to quantify the response of wildlife to human infrastructure, and 2) use of sensor arrays including wildlife cameras and accoustic recorders to measure changes in habitat use of hundreds of mammal, bird, and reptiles caused by human infrastructure.

GPS tracking

In 2021 we collected high-resolution movement data from GPS collars on 14 adult female black-tailed deer (*Odocoileus hemionus columbianus)* and 9 coyotes (*Canis latrans*). Collars were be programmed to take fixes every 5 minutes near fences and every 30 minutes elsewhere. Accelerometers recorded activity levels every 5 seconds. We are currently analyzing these data to measure behavioral responses and habitat use related to human infrastructure.

Camera Trapping

In 2021 we collected spatially explicit data from over3800 wildlife detections from 60 cameras and over 10,000 bird and bat detections from 40 accoustic sensors. We are currently analyzing these data to measure species occupancy and behavior associated with human infrastructure.

Other Progress

In addition to substantial data collection towards our goals and objectives, we also published and shared several results from this research. This included:

1) Gaynor et al. 2021. Contrasting patterns of risk from human and non?human predators shape temporal activity of prey. Journal of Animal Ecology

2) Kreling et al. 2021. Site fidelity and behavioral plasticity regulate an ungulate's response to extreme disturbance. Ecology and Evolution

3) Suraci et al. 2021. Disturbance type and species life history predict mammal responses to humans. Global Change Biology

4) McInturff et al. 2020. Fence ecology: Frameworks for understanding the ecological effects of fences. BioScience

Briefly describe how your target audience benefited from your project's activities.

We reached our target audience of researchers, wildlife and land managers and the general public through three types of activities:

1) Scientific publications: we published four high-profile papers during the study period resulting in over 10,000 views and 200+ media stories as of Jan 2022.

2) Research workshops: we organized and led two virtual workshops in 2021 that were attended by a total of 72 practioners representing state, federal, academic, ngo, foundation and other organizations.

3) Outreach talks: our team delivered 17 seminars and outreach talks on this work in 2021.

Briefly describe how the broader public benefited from your project's activities.

While our project was only recently initiated and has been impeded by COVID-related restrictions on travel and fieldwork, we have nonetheless produced several benefits to the broader public. First, our research on the impact of fences on wildlife has resulted in new policies on fence construction in three counties in California. Similar conversations about fence policy are

underway with representatives from four other CA counties and the states of Wyoming and Montana. Second, our study has provided new insights on the response of wildlife to fire and these insights are now being incorporated into state and federal strategies for mitigating the impacts of fire on wildlife populations and communities.

Describe and explain any major changes or problems encountered in approach. Additionally, note opportunities for training and professional development provided, how results have been disseminated to communities of interest, and any new details regarding what the project or program plans to do during the next reporting period to accomplish the goals.

Like many other projects, our progress was hampered by COVID-related restrictions on fieldwork. Nevertheless, we achieved 90% of our goals for 2021.

Impact Statement (Optional)

Use this space to talk about the impact that this result had, in layman's terms. Adding comments here will **not** change the content in the highlighted result.

Protecting wildlife communities from wildfire impacts

While the value of wildlife is broadly appreciated by the public, wildlife populations and communities are in decline across the Western United States as their habitats are altered or converted for human uses such as roads, fences, agriculture, and housing. The UC AES researcher is working to improve our understanding of how human infrastructure impacts wildlife movement, especially for larger mammals, and what types of habitat conservation strategies can help. This research will help inform conservation planning and wildlife management at large scales across the western United States, and has already informed local infrastructure decision-making related to postfire wildlife movement. It is also being incorporated into state and federal strategies for mitigating wildfire impacts on wildlife.

Forestry and Fire

Project Director
Katherine Webb-Martinez
Organization
Regents of the University of California
Accession Number
7000177

Increasing preparedness and resilience to extreme weather and climate change

In 2-3 sentences, briefly describe the issue or problem that your project addresses.

The associated effects of climate change are increasing the risk of extreme weather events that negatively impact California's ecosystems and communities. Because of our changing climate, rangelands, forests, peri-urban and urban areas are experiencing the effects of intense wildfires. In 2020, over four million acres burned, and over 10,000 structures were damaged or destroyed in California. Land managers and communities need effective response and adaptation strategies to prepare to deal with the growing risks. Communities need to be better prepared to mitigate the growing risks of hazards from fires, droughts, and urban heat islands. In summer, impervious surfaces in urban areas are often more than 50 degrees F higher than nearby surfaces shaded by trees and other vegetation, and low-income neighborhoods often have much lower urban tree canopy cover.

Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.

A UCCE Specialist at UC Merced established a long-term partnership with the USFS Pacific Southwest Research Station through The Kings River Experimental Watersheds (KREW) Project. One study evaluated how forest thinning affects streamflow and forest mortality and, for the first time, demonstrated that water made available from thinning, a recommended forest management practice, can either be taken up by remaining trees (provide drought resilience) or flow downstream. These results provide key insights to forest and water managers with different management outcomes. For example, forest managers may look to increase drought resilience, while water managers may be more interested in maximizing water supply. Findings were presented at several meetings. (Safeeq Khan)

A team of UCCE Advisors, UC faculty, and USDA Forest Service scientists continued monitoring the growth and health of twelve species of underplanted but promising heat, drought, and pest-resistant landscape trees in a 'climate-ready landscape tree' research study at UC Riverside. After applying adequate water during the establishment period, the irrigation system was turned off to determine how the trees would perform under extremely dry conditions. Despite the trees showing drought stress, most species recovered by January 2021 due to late fall/early winter rainfall. Results of this study were shared with over 1,500 arborists and other 'green industry' professionals via webinars. and seminars. (Janet Hartin, Jim Downer, Darren Haver) A UCCE Advisor also partnered on a state grant with the Inland Empire Resource Conservation District, the CA Climate Action Corps, the City of Redlands, University of Redlands, Esri, and other groups to provide over 400 of the drought, heat, and pest-resistant "climate-ready" trees identified in the study to residents of neighborhoods with low canopy cover and a neighborhood sports park. A "Trees for Tomorrow Start Today" workshop brought together over 300 municipal planners, city foresters, wholesale and retail nursery growers, landscape architects, home-owner association leaders, and UC Master Gardeners to discuss how to work together to enhance tree canopy cover in vulnerable neighborhoods. (Janet Hartin)

UCCE Advisors developed data on livestock and rangeland infrastructure loss from fire during the Santa Clara Unit (SCU) lightning-complex fire, which was the 3rd largest fire in California's history. (Sheila Barry, Theresa Becchetti) A UCCE Advisor in Placer, Nevada, Sutter, and Yuba Counties continued to extend information about rangeland drought and wildfire mitigation strategies and support the six targeted grazing businesses he helped expand or establish. (Dan Macon)

A UC Cooperative Extension (UCCE) Advisor in Los Angeles and Ventura Counties conducted extension events related to maintaining fire-resistant landscapes around structures in wildland/urban interface areas, habitat recovery post-fire, and fire-related debris flow events and residential preparation for fire. Clientele includes land and public agencies, environmental NGOs, and residents and groups that represent them, such as fire safe councils. In particular, the Southern California Fire Symposium reached over 350 individuals. (Sabrina Drill)

A UCCE Advisor in Plumas, Sierra, and Lassen Counties served on the incident management team for Prescribed Fire Training Exchanges, known as TREX. This included growing and developing the Plumas Underburn Cooperative, delivering organized prescribed fire and fuel management workshops, facilitating learning networks, and supporting forest manager and landowner efforts in hazardous fuel reduction. TREX events reached 100 land managers and landowners. In another project, the advisor continued to deliver wildfire preparedness information and assist communities in completing assessments for Firewise USA, a national recognition to empower communities on defensible space, home hardening, and evacuation planning. The advisor also developed a reporting tool to support Firewise communities. (Ryan Tompkins)

A UCCE Advisor developed and facilitated activities with the Central Coast Prescribed Burn Association (CCPBA), which includes nearly 500 ranchers, farmers, tribal members, land management agencies, academics, students, people who live at the wildland-urban interface, and anyone else interested in prescribed burning. The association purchased a burn trailer and equipment, developed and collected pre-treatment data, built relationships with the California Department of Forestry and Fire Protection (CAL FIRE) and other agencies, and provided consultation for prescribed burns. The CCPBA's work was extended through three Firelighter trainings, including a virtual presentation about the benefits of prescribed burning. Furthermore, the advisor engaged in policy activities by writing letters, presenting to elected officials, and participating in two legislative hearings. (Devii Rao)

A UCCE Advisor in Santa Barbara and Ventura Counties conducted policy engagement work related to vegetation management and bringing back prescribed burns on rangelands, which had ceased in the last fifteen years. After the widespread devastation of the Thomas Fire, the political climate provided a unique opportunity to resume burning in the counties. The advisor provided leadership to re-establish the Santa Barbara County Range Improvement Association, develop open channels of communication between public agencies, and form a new Prescribed Burn Association that will bring training and fire to Ventura County residents. (Matthew Shapero)

A UCCE Specialist at UC Berkeley continued a long-term study, Adaptive Management Experiment, for which prescribed burns are an important component. Additionally, the Specialist set up field sites for research burns and mentored researchers who collected data on the impact of multiple prescribed fires on the ponderosa pine. (Robert York)

Briefly describe how your target audience benefited from your project's activities.

Participants gained understanding of strategies to respond to climate change and extreme weather, like wildfires.

- Southern California Fire Symposium reported in retrospective pre/post surveys increases in understanding of how aquatic habitat is affected by fire (75%), how vegetation and fire regime interact (60%), how fire changes wildlife communities (53%), what drives post-fire type conversion (52%), how soil, water, and air are affected by fire (46%), the importance of habitat connectivity in fire affected ecosystems (45%) and how human health is impacted by fire (42%). (Sabrina Drill)

- CCPBA members shared in a post-training survey how the CCBPA has helped facilitate attitude change toward prescribed burns. One participant stated that the CCBPA helped with “democratization of returning fire to land management, normalizing fire in the community, building tolerance for fire and smoke in surrounding communities, getting CAL FIRE and other fire districts comfortable with the use of prescribed fire and specifically relinquishing control of all things fire.’ (Devii Rao)

- Firelighter workshop participants shared that they would use the information they learned to establish fire lines around their property, identify safety zones and escape routes, improve pump and fire hose setups, apply information while participating in prescribed burns, and continue to volunteer in support of prescribed burns. (Devii Rao)

Participants adopted climate-resilient strategies, like prescribed burning.

- During a site visit with legislative staff, one CCPBA member said that she had three neighbors who had not been supportive of prescribed burning, but after hearing CCPBA presentations, they are now more comfortable with it. After attending a webinar about the CCPBA, one of these neighbors agreed to allow the expansion of a burn unit to include a small portion of her property. (Devii Rao)

Science-based information was applied to fire and climate-resilient policy and decision-making.

- Federal counties were able to declare federal emergencies and provide evidence to CAL FIRE of the SCU fire’s potential impact by using UCCE’s data. This supported the deployment of 450 to 500 firefighters to suppress the fire. (Sheila Barry)

- Three new communities completed their assessment and received Firewise recognition status in 2021, and three additional communities initiated Firewise assessments and plans due to receiving UCCE technical assistance and support. These communities serve over 3,000 rural residences and, in 2021 alone, contributed over 5,600 volunteer hours of Firewise work and $235,000 of investments in wildfire preparedness. (Ryan Tompkins)

- The National Fire Protection Association adopted the use of UCCE’s Online Firewise Reporting tool, which supports 30 Firewise communities across Plumas and Sierra Counties. In 2021, the tool documented over 14,000 hours of community Firewise volunteer hours and over $1.5 million of community investment in wildfire preparedness across two rural northeastern California counties. (Ryan Tompkins)

- Cal Poly used information from UCCE's prescribed burn efforts to inform their decision to reassess policies and allow the CCPBA to conduct a joint CAL FIRE/CCPBA burn at Swanton Pacific Ranch. One professor at Cal Poly had been trying to get approval from the university to conduct prescribed burns at Swanton Pacific Ranch for over ten years with no success. This burn will set the stage for future prescribed burns and associated prescribed-burn research on Cal Poly lands. (Devii Rao)

- UCCE's policy engagement activities contributed to the passing of SB 332, which will make California a gross negligence state for suppression costs associated with prescribed fire. A potential impact of SB 332 is that more people will be comfortable with and therefore conduct prescribed burns on their properties as they will not be required to pay CAL FIRE for suppression costs if a fire escapes, as long as possible they meet certain safety standards. This can potentially make our communities safer, improve livestock forage, and improve habitat for a variety of native plant and wildlife species. (Devii Rao)

- The Placer County Water Agency, Yuba Water, The Nature Conservancy, other utility companies, and nonprofits have used UCCE's Kings River Experimental Watershed project findings to convince their rate payers to implement active forest management policies. This demonstrates how UCCE contributed to attitudinal shifts from the "timber grab for water" and focusing on downstream benefits alone to a multi-benefit framework that includes improving forest health and building forest resilience to drought. (Safeeq Khan)

- The US Drought Monitor and USDA California Climate Hub utilized qualitative and quantitative data from UCCE and other rangeland professionals to inform the US Drought Monitor drought decision-making process. Local, state, and federal agencies use the USDM to trigger disaster declarations, determine eligibility for relief programs, and activate regional drought responses. These coordinated, regular reports from UCCE and partners have provided important data to national and regional mapping efforts on drought conditions and impacts across California's rangelands. (Leslie Roche)

- The California Natural Resource Agency utilized many of UCCE recommendations on how to more effectively incorporate freshwater in its "Pathways to 30x30" policy framework in response to an Executive Order by Governor Newsom. (Ted Grantham)

Briefly describe how the broader public benefited from your project's activities.

Change in condition: Climate resilient land.

- The six targeted grazing practitioners reduced fuel loads on more than 5,000 acres in the Sierra foothills and northeastern Sacramento Valley with assistance from UCCE. (Dan Macon)

- UCCE technical support for the Plumas Underburn Cooperative and local California prescribed training exchange (Cal-TREX) event in the northern sierra region educated 51 participants on local fire ecology, science, and management and contributed to the implementation of eleven community prescribed fires in Plumas County. (Ryan Tompkins)

- UCCE's direct organizational and policy engagement led to a significant increase in the number of prescribed burns in Santa Barbara County on 1,149 acres since 2018, 493 of which were during FFY2021, and planned implementation of training burns in Ventura County. (Matthew Shapero)

- The Watsonville Slough Farm used information from UCCE's prescribed burn efforts to inform their decision to co-organize a 6-acre burn on their farm. This resulted in the UCCE Advisor's first prescribed burn and the opportunity to provide CCPBA activities at a live burn. (Devii Rao)

- UCCE's research contributed to an additional 150 acres of land on the western slope of the Sierra Nevadas being treated with prescribed burn to build resilience, sustain heterogeneity, and contain wildfires around communities. (Robert York)

- The Chino Basin Water Conservation District is now planted with four UCCE-recommended, climate-resilient tree species (Chilopsis linearis 'Bubba,' Prosopis glandulosa' Maverick,' Pistacia' Red Push,' and Parkinsonia' Desert Museum' Palo Verde). Ongoing research through 2021 confirmed that the trees continued to grow in circumference, despite the spring 2020 drought when the recycled-water irrigation system was turned off. (Janet Hartin)

- Over 400 'climate-ready landscape trees' identified in the UCR study of drought, heat, and pest-resistant species were provided gratis to residents of low tree canopy neighborhoods and a municipal sports park frequented by youth. UC Master Gardeners in San Bernardino County are ensuring that ecosystem benefits of the trees (shade, cooling urban heat islands, enhancing habitat, reducing energy use, etc.) are realized long-term by providing ongoing tree care information via seminars, community meetings, and at community parks. (Janet Hartin)

The measured outcomes reported above demonstrate participants learning about and developing new management paradigms to address the challenges of a changing climate. Adopting mitigation strategies and new policies informed by UC ANR's science-based research will help increase forest, rangeland, and community resiliency and decrease the impact of fires. In these ways, UC ANR contributes to building climate-resilient communities and ecosystems.

Describe and explain any major changes or problems encountered in approach. Additionally, note opportunities for training and professional development provided, how results have been disseminated to communities of interest, and any new details regarding what the project or program plans to do during the next reporting period to accomplish the goals.

Given we now have the NRS Results form and know how NIFA wants outcomes reported, we are reporting impact stories. Please note this is different than how we initially listed intended outcomes in the 2021 plan. We will edit our future plans to reflect the current reporting approach.

Managing for multiple ecosystem services within California rangelands

Project Director
Loralee Larios
Organization
Regents of the University of California
Accession Number
1023122

Managing for multiple ecosystem services within California rangelands

In 2-3 sentences, briefly describe the issue or problem that your project addresses.

Land managers and agencies that are leading long term management efforts of natural resources often must balance multiple management objectives. However, comparing trade-offs among multiple management decisions is complicated given the uncertainty of outcomes due to ongoing and projected stressors of drought and invasive species.

Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.

Over the past year, we have worked on a variety of components to this project. We have continued the ongoing long term monitoring of the plant community at the study site of the Carrizo Plain National Monument, while our collaborator continued the monitoring of the endangered Giant Kangaroo Rat. Tracking plant and animal dynamics in the grazed and ungrazed study areas will help inform how conservation efforts are impacted by grazing. Additional we are running a seedbank study to see how native species persistence and the long-term resilience of these rangelands may be impacted by ongoing drought. We

initiated a project forecasting the potential spread of the invasive species Sahara mustard that currently invades dryland areas. These multiple efforts will provide insight to the complexity in managing for invasive species and native persistence in a rangeland system.

Briefly describe how your target audience benefited from your project's activities.

These efforts are currently in progress, so we have not shared any findings with our target audience. However, we do have a continued dialogue with the Bureau of Land Management that oversees the study site to share with them our yearly activities.

Briefly describe how the broader public benefited from your project's activities.

The three current research activities are still underway, and we have not disseminated any findings. However, we anticipate sharing results from these activities at academic conferences and land managers in regional monitoring meetings in the coming fiscal year.

Describe and explain any major changes or problems encountered in approach. Additionally, note opportunities for training and professional development provided, how results have been disseminated to communities of interest, and any new details regarding what the project or program plans to do during the next reporting period to accomplish the goals.

During this period research activities were still slowed due to the impacts of the COVID-19 pandemic. Notably, work was limited to activities that could be carried by a single individual due to restrictions with occupancy restrictions in indoor spaces.

In the coming fiscal year, the project activities will include 1) analysis of the long-term plant community dynamics to evaluate how native and exotic plant species respond to experimental drought treatments, 2) completion of seedbank greenhouse study and the start of data analysis, 3) presentation of the species modeling efforts at an international conference with plans to draft a manuscript of the analyses, and 4) begin outreach and engagement with target audience.

Impact Statement (Optional)

Use this space to talk about the impact that this result had, in layman's terms. Adding comments here will **not** change the content in the highlighted result.

Managing California rangelands for multiple ecosystem services

Rangelands are the primary resource for livestock grazing, as well as support diverse native plant and animal species and provide many key ecosystem services such as food production and habitat for pollinators. Managing land for a variety of ecosystem services often involves complex trade-offs between forage production, invasive species and native species persistence. The UC AES scientist in plant ecology is conducting research to provide decision support methods that can identify solutions to these complex trade-offs. Findings are currently being shared with federal land managers to help inform invasive plant and native plant management, and future work will be shared with land managers and land management agencies. This research will help inform conservation planning and land management on public rangelands.

Linking forest dynamics and climate change to manage Southern California forests

Project Director
Marko Spasojevic
Organization
Regents of the University of California
Accession Number
1023123

2021 Progress report

In 2-3 sentences, briefly describe the issue or problem that your project addresses.

Our goal is to gain more insights into the process influencing forest health in Southern California. This work is don ein teh San Jacinto Forest Dynamics plot located on the west slope of Mt. San Jacinto in Southern California . Research at the San Jacinto FDP will focus on four complimentary areas: 1) spatial variability, 2) species interactions, 3) ecosystem functioning and forest health, and 4) linking Southern California forest dynamics into regional and global frameworks

Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.

As of June 2020, all free-standing stems of woody species greater than 1 cm diameter at breast height (DBH) within the 4ha SJFDP have been tagged, identified, measured, and mapped following CTFS-ForestGEO protocols (Condit 1998). The 4ha SJFD currently includes 100 20x20m quadrats, 4,684 main stems (stem number ranges from 11 to 95 perquadrat with a mean of 44) and a total of 18 species (Fig. 2). Species richness varies from 3 to 11 species (mean = 6.72) per quadrat. We have additionally measured 13 environmental variables (soils nutrients and topography) across the 4ha SJFDP. Our initial analyses (distance-base redundancy analysis with variation partitioning) have examined the factors underlying spatial variation in biodiversity (β-diversity) among quadrats across the SJFD. We have found that the environment explained 1.3**%** of the variation in β-diversity, spatially structured environmental variables explained 16.9**%**, spatial processes explained 41.7**%**, and 40.1**%** of the variation in β-diversity was unexplained. These patterns suggest that variation in biodiversity among quadrats is largely driven by spatial processes associated with the long history of fire suppression and drought in this forest.

In the summer of 2021, we assessed drivers of the variation in seedling composition (individuals under 1m in height) in 256 1m2 seedling plots across the central 64 quadrats of the 4ha SJFDP (4 seedling plots per quadrat). We found a significant mismatch between adult and seedling composition in the SJFDP based on a perMANOVA of Bray-Curtis dissimilarity. Forthe adult community, we found 18 species across the 4ha SJFDP including a mix of pines, oaks, and manzanitas common to this mid-elevation forest. For the seedling community, we found only 11 species and that oaks made up 75**%** of all seedlings while only making up 45**%** of the adult community. Seedling composition was not strongly predicted by any of our measured variables with 25.8**%** explained by adult composition, 11.8**%** explained by a combination of our other variables, and 62.4**%** of the variation in seedling composition unexplained. These results suggest that this forest is primed for change with pines likely to experience strong demographic stochasticity from the low numbers of individuals and weak species sorting, and oaks becoming the dominant species in this forest. These patterns suggest a potential shift in the composition of the forest from a mixed Oak-Conifer forest to an Oak dominated system. This change in the composition of the forest can have important ramifications for carbon storage, as Oaks are slower growing than Pines, as well as implications forthe rest of the plants and animals that depend on these species.

in December 2021 we installed 20 automated dendrometer bands (Environmental Measuring Systems, Brno, Czech Republic) on 10 individuals of *Quercus kelloggii* (a drought tolerant species) and 10 individuals of *Pinus ponderosa* (a drought avoiding species) as these two species are showing variable recruitment and Pines have been dying more than Oaks. These dendrometer bands will measure diameter every 30 minutes for the next year. We plan to download data after the first three months and every three months thereafter to assess both water stress (short term changes) and growth (long term changes). We chose the 10 individuals of each species to differ in neighborhood composition where some individuals with dendrometer bands had a neighborhood with a higher ratio of conspecifics (neighbors of the same species). This approach allows us to examine how neighborhood composition influences biomass production across two species with very different strategies for coping with drought.

Briefly describe how your target audience benefited from your project's activities.

Our work to date provides useful information for land managers seeking to manage these forests. The mismatch we found between adults and seedlings suggest a potential shift in the composition of the forest from a mixed Oak-Conifer forest to an Oak dominated system. This change in the composition of the forest can have important ramifications for carbon storage, as Oaks are slower growing than Pines, as well as implications for the rest of the plants and animals that depend on these species. To better understand these dynamics, we plan to 1) resurvey seedling plots in 2022 and every otheryearthereafter for survival and growth, 2) place 100 seed traps to across the SJFDP understand how seed inputs impact forest demography, and 3) place temperature data loggers to characterize thermal limitation to seedling survival.

Moreover, our fine scale measurements of tree growth (dendrometer bands) coupled with a planned re-survey of all stems will allow me us assess how ecosystem functions (i.e., biomass production, carbon storage) are influenced by short- and long-term changes in the environment. This summer we plan to: 1) place more automated dendrometer bands on a broader range of species and individuals, and 2) prepare for conducting a complete resurvey of the 4ha SJFDP in 2023.

Briefly describe how the broader public benefited from your project's activities.

Our results will provide greater insights into the dynamics of a forest at the wildland urban interface where many people recreate. In addition, this last summer we participated in the UC-Riverside Natural Reserve internship where we recruit an undergraduate with an interest in Forestry to conduct summer research in this plot. They successfully complete the seedling survey and are returning to re-survey the seedling plots this summer. This project also supported 1 graduate student in research on Forest dynamics. We are also hosting an Environmental Data Initialize summer intern this summer to create data pipelines for the climate data associated with our Forest Plot. Finally, we hosted a student chapter of the Ecological Society of America's Strategies for Ecology Education, Diversity and Sustainability program who had a field trip to the site. This group include undergraduates underrepresented in STEM, many of whom had never been to this type of forest before

Describe and explain any major changes or problems encountered in approach. Additionally, note opportunities for training and professional development provided, how results have been disseminated to communities of interest, and any new details regarding what the project or program plans to do during the next reporting period to accomplish the goals.

Research was still slowed by impacts of COVID-19

Impact Statement (Optional)

Use this space to talk about the impact that this result had, in layman's terms. Adding comments here will **not** change the content in the highlighted result.

Tracking and explaining forest species composition changes

The UC AES faculty is conducting a long-term study to track changes in species composition in Southern California forests. The study has found evidence for an ongoing shift in composition from the ponderosa pine to an increased dominance of the California black oak. This type of change has implications for carbon sequestration and will also influence how wildfires burn in the future. The study investigators are working to identify physiological mechanisms responsible for these shifts so that forest managers can identify solutions to mitigate negative environmental impacts.

Closing Out (end date 09/06/2023)

Understanding Particulate Matter Pollution from Biomass Burning Activities in California

Project Director
Q Zhang
Organization
Regents of the University of California
Accession Number
1016612

Progress Report

In 2-3 sentences, briefly describe the issue or problem that your project addresses.

Biomass burning (BB) activities, such as wildfires and residential wood combustion (RWC), are one of the largest sources of airborne particulate pollutants in California. A thorough understanding of the emission and atmospheric aging of particles from various BB sources is necessary for achieving a quantitative assessment of the environmental impacts of fires in the state.

Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.

We performed field and laboratory studies and integrated data analysis to study the emission and processing of biomass burning aerosols in the California's Central Valley. Specifically, our 1) improved speciation and characterization of biomass burning organic aerosols (BBOA) using state-of-the-art aerosol instruments including a Soot-Particle High-Resolution Time-of-Flight Aerosol Mass Spectrometer (SP-AMS); 2) investigated the impacts of residential wood burning curtailment on aerosol pollution in the Central Valley using highly time- and chemically-resolved aerosol data collected by the PI's group during previous and ongoing field projects; and 3) investigated photochemical processing and evolution of BB aerosols from residential wood burning and wildfires. These studies improve process-level understanding of carbonaceous aerosol emissions from BB sources and their atmospheric aging processes in the troposphere.

Briefly describe how your target audience benefited from your project's activities.

The target audiences for this project include state policy makers, scientific communities on aerosol research, climate change, environmental health and toxicology, and atmospheric chemistry, and the general public. The activities of this project produced results that allow them better understand the air pollution problems in the California's Central Valley, which is a region of an agriculture-oriented economy and a high population of Hispanics and Latinos. Thus, our project's activities serve a population group who tends to be socially, economically, and educationally disadvantaged.

Briefly describe how the broader public benefited from your project's activities.

Wildfires and residential wood combustion have become an important threat to air quality and public health in California by increasing the amount of particulate matter (PM) in the air. Our activies from this project result in a quantitative understanding of the amount of fire smokes emitted and the atmospheric processing of these pollutants in the Central Valley of California. This knowledge benefits the broader public by supplying information that can be used to evaluate and improve air quality models and may contribute to the development of effective air pollution regulatory policies.

Describe and explain any major changes or problems encountered in approach. Additionally, note opportunities for training and professional development provided, how results have been disseminated to communities of interest, and any new details regarding what the project or program plans to do during the next reporting period to accomplish the goals.

Publications:

Sun, P., Farley, R. N., Li, L., Srivastava, D., Niedek, C. R., Li, J., Wang, N., Cappa, C. D., Pusede, S. E., Yu, Z., Croteau, P., and Zhang, Q.: PM2.5 composition and sources in the San Joaquin Valley of California: A long-term study using ToF-ACSM with the capture vaporizer, Environmental Pollution, 292, 118254, https://doi.org/10.1016/j.envpol.2021.118254, 2022.

Impact Statement (Optional)

Use this space to talk about the impact that this result had, in layman's terms. Adding comments here will **not** change the content in the highlighted result.

Environmental tradeoffs of wood smoke for home heating

The use of biomass from California forests can produce positive climate and forest restoration benefits, but the tradeoffs of using wood for home heating versus other sources is not entirely understood. The UC AES researcher in environmental toxicology is comparing smoke emissions from wildfires to residential burning to better understand the impact of residential wood burning in the Central Valley. Since wood burned in the Central Valley may increasingly come from forests of the Sierra Nevada, there is a link between this research and forest ecology and management. While there may be some negative impacts from residential burning on air quality, the saved emissions from reducing fuel that is available for wildfires may be substantial.

Working Landscapes

Project Director
Katherine Webb-Martinez
Organization
Regents of the University of California
Accession Number
7000176

Enhancing community economic development

In 2-3 sentences, briefly describe the issue or problem that your project addresses.

California needs community economic development approaches to foster economic resilience and vigor across its working landscapes, especially now, given the severe economic effects of the COVID-19 crisis. The state's working landscapes span fishing to agriculture and ranching and from mining to renewable energy. In 2018, the nine working landscape segments paid

workers $85 billion in earnings and generated $333 billion in sales. Collectively, these segments contribute significantly to the state's economic vitality and account for more than 1.5 million jobs and nearly 70,000 business establishments. In particular, small producers face challenges managing costs, marketing, and understanding and complying with regulations.

Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.

UC ANR's efforts focus on California's agriculture, ranching, and forestry sectors to identify opportunities for economic development through innovation and entrepreneurship while also fostering environmental and social sustainability.

UC Cooperative Extension (UCCE) works to support new farming businesses. Due to the pandemic, virtual workshops and peer support events were primary delivery methods until small-group, in-person workshops were held in spring 2021. Peer-to-peer learning is a critical component of the training, which results in the rapid adoption of new practices and improvements in farm and ranch profitability, so in-person workshops are critical for many participants. Thirty-two new and beginning farmers participated in three virtual/hybrid farm business courses (Start a Farm, Beginning Farming Academy, Intro to Commercial Citrus Production). These courses included guidance and requirements for starting an agricultural business, learning to assess resources and conduct market research, and an introduction to basic farm economics and key regulations. Eleven prospective farmers and ranchers participated in a 2-part "Start a Farm" webinar to learn about farm business. The Foothill Farming Website provides important business information and tools for producers. In 2020-21, 54% (26,559) of visitors to the site focused on the Farm Business pages. (Cindy Fake, Dan Macon)

A UCCE program in the Sierra Foothills incorporates agricultural business viability elements into natural resources and livestock production programming, including working with new and aspiring producers to build hands-on animal husbandry skills and practical knowledge that will increase both efficiency and profitability. In 2020-21, there was a combination of in-person workshops, one-on-one consultations and ranch visits, and virtual programming (webinars, videos, and podcasts). (Dan Macon)

UCCE provides information on agricultural tourism to foster opportunities for farmers and ranchers to diversify their operations and expand their revenue sources to help them stay in business. In 2021, the statewide UC Sustainable Agriculture Research and Education Program (SAREP) conducted an agritourism intensive course through webinar series and in-person workshops. (Gail Feenstra)

UCCE is the research partner on the French Meadows Project in the Middle Fork of the American River Basin, measuring and modeling water, carbon, and forest health benefits of watershed restoration. The field sites are used as a living laboratory for extension. Working with the Nature Conservancy, Sierra Nevada Conservancy, American River Conservancy, Place County Water Agency, Placer County, and US Forest Service, this award-winning project has developed and demonstrated a collaborative model for watershed restoration. (Safeeq Khan)

A UCCE Specialist at UC Riverside is the director of the California Citrus Clonal Protection Program (CCPP). This was the first program of its kind in the world with roots in the 1933 discovery of the first citrus virus by Dr. H. S. Fawcett, who was part of the Citrus Experiment Station established in 1907 at UC Riverside. CCPP provides a safe mechanism for introduction into the state of citrus varieties through methods such as in vitro variety therapy and disease diagnostics to propagate healthy citrus trees for the growing California citrus industry and all Californians. (Georgios Vidalakis)

Briefly describe how your target audience benefited from your project's activities.

Participants learned or planned to utilize innovation and entrepreneurial strategies.

- The 11 participants who completed the evaluation survey for the 2-part "Start a Farm" webinar reported:
    - 100% increase in knowledge of agriculture rules and regulations,

- 75% increase in ability to assess resources,
- 38% increase in understanding of economic principles, and
- One or more key actions to start their farm business that they would complete within 30 days. (Cindy Fake, Dan Macon)

- The seven Beginning Farming Academy participants reported:
  - 100% will analyze the start-up costs for their operation within six months,
  - 80% of respondents will develop a budget for the enterprise within six months,
  - 60% will develop a recordkeeping system for their operation within six months, another 20% within a year, and
  - 80% will analyze capital purchase costs and returns within one year. (Cindy Fake, Dan Macon)

- The 18 new and beginning farmers who participated in the farm business courses reported:
  - 64% increase in their knowledge of farm business practices,
  - 100% increase in their knowledge of farm economics and ag marketing, and
  - Three key actions that they needed to take within the next 6 months to get their farm business started. (Cindy Fake, Dan Macon)

- The 15 new/prospective citrus growers who participated in the Introduction to Commercial Citrus Production course reported:
  - increasing their knowledge of citrus nutrient management by 90%
  - citrus production and orchard management by 82%
  - citrus pest management by 71%. (Cindy Fake)
- Ninety-four producers improved their understanding of the financial, human, legal, and marketing risks associated with their operations generally. (Dan Macon)

- Of the 68 farmers and others who participated in UC SAREP's Agritourism and Direct Sales webinar series, 87% reported increased their knowledge of direct sales options from the webinar series. (Gail Feenstra)

- All of the direct sales in-person workshop participants reported increased knowledge of agritourism and direct sales. (Gail Feenstra)

Participants implemented innovation and entrepreneurial strategies.

- From the 40 new citrus varieties that completed therapy and testing during this reporting period, 19 varieties were introduced by large California citrus producers that invested $190,000 towards the cost of the introduction. This means that the California citrus industry believes that 19 varieties have commercial potential. Thousands of agricultural jobs will be maintained or created in the next few years as these varieties are propagated, grown in the field, and come to production. (Georgios Vidalakis)

- Twenty-five producers developed capital purchase plans (i.e,. for items that cost $5,000 or more and have a useful life of more than one year) or other financial plans that will enable their operations to continue in the event of climate change impacts. (Dan Macon)

- Nineteen producers identified key risks to their operations related to increasing climate uncertainty. (Dan Macon)

- Ten producers developed and implemented financial analysis and recordkeeping systems, including enterprise analysis, cash flow, and profit and loss. This improved business decision-making and helped improve profitability. (Dan Macon)

- Podcast listeners reported implementing new management practices, including grazing management, animal health management, and business management. Ultimately, improved livestock management leads to greater profitability, improved resource management, and improved animal welfare. (Dan Macon)

- Of the 63 participants in the 2021 agritourism intensive, 24 took steps to start or expand their agritourism business, and 12 implemented at least one element of their new marketing strategy. This promotes economic prosperity among farmers and ranchers participating in agritourism (Rilla et al., 2011). (Gail Feenstra)

Briefly describe how the broader public benefited from your project's activities.

Change in condition: Jobs created.

- The French Meadows watershed restoration project partners have appeared on various forums highlighting the role of UCCE research in changing the pace and scale of forest restoration in California. UCCE's continued engagement with research, education, advocacy, and fundraising resulted in 4,500 acres of forest restoration within the 28,000 acres of federal and private land. In the previous two seasons, this project generated jobs for over 200 contractors and removed 4 million board feet of timber to a local mill, and more than 2,500 tons of biomass to local renewable energy facilities which contribute to the local economy, and help offset restoration costs while generating 4,100 MWh renewable energy for 500 homes. (Safeeq Khan)

These aforementioned measured outcomes demonstrate changes that improve the economic, environmental, and social sustainability of California's working landscapes. For example, increased agritourism demonstrates enhanced community economic development and contributes to promoting economic prosperity among farmers and ranchers participating in agritourism (Rilla et al., 2011). In this way, UC ANR contributes to the public value of promoting economic prosperity in California.

Describe and explain any major changes or problems encountered in approach. Additionally, note opportunities for training and professional development provided, how results have been disseminated to communities of interest, and any new details regarding what the project or program plans to do during the next reporting period to accomplish the goals.

Given we now have the NRS Results form and know how NIFA wants outcomes reported, we are reporting impact stories. Please note this is different than how we initially listed intended outcomes in the 2021 plan. We will edit our future plans to reflect the current reporting approach.

Improving management and use of land

In 2-3 sentences, briefly describe the issue or problem that your project addresses.

Public and private land in California is managed for a wide variety of uses. Challenges include loss of productive working landscapes, human and wildlife conflicts, protecting water quality, living in fire-prone areas, and a better understanding of ecosystem services. Research and extension are needed to help land managers and owners balance the social, economic, and ecological benefits.

Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.

UC ANR activities focus on management strategies concerning livestock, wildlife, and land maintenance.

A University of California Cooperative Extension (UCCE) Advisor in the Central Sierra region continued to disseminate information on a recent research project about chemical control recommendations for the invasive weed, oblong spurge (Euphorbia oblongata). With no prior, effective control strategies in place, this plant has continued to expand its range. After the Butte fire of 2015, this plant has rapidly spread in wildland areas throughout the burn. After several herbicide trials, the UCCE Advisor developed a treatment method that provides nearly 100% control. Information was presented to local clientele, UC Master Gardener groups across the state, several government agencies, and professional societies. (Scott Oneto)

UCCE Advisors collaborated with the National Park Service's national office to update a basic grazing plan for Pinnacles National Park, located in San Benito and Monterey Counties. The update included providing clarification and adding several points in response to questions from the national office. UCCE determined sampling methods, trained contractor and park staff, and obtained input from ranchers. (Devii Rao and Leslie Roche)

A UCCE Specialist's lab at UC Berkeley spearheaded several testing approaches for pathogen detection in plants, fruits, plant products, oaks, and timber. These include generating composite samples, training dogs and using sniffing jars, and sampling air spora. Furthermore, the lab developed the first polymerase chain reaction (PCR) test to be officially used by a nation (USA) to detect a regulated pathogen. That test was a standard PCR test for the detection of Phytophthora ramorum. (Matteo Garbelotto)

A research project was conducted between a UCCE Advisor, a UCCE Specialist at UC Riverside, a professor at UC Riverside, and other collaborators to develop baiting strategies to control yellowjacket wasps in recreational areas using minimal amounts of toxicants. Two of the sites in this project are located within Orange County Parks: one in Irvine Regional Park and one in Caspers Wilderness Park. Yellowjackets are a pressing problem in these two parks during the summer when they become particularly abundant and prevent the public from safely using the campgrounds and other outdoor facilities. Monitoring traps and experimental baiting stations were set up throughout both parks. (Beatriz Nobua-Behrmann, Dong Hwan Choe, Mike Rust)

A UCCE Advisor and her team monitored Orange County Parks' trees for emerging tree pests and provided science-based management advice. Orange County Parks manages 60,000 acres of parkland and open spaces with 40,000 inventoried trees, valued at $184 million. Invasive tree pests, like the invasive shot-hole borers, have already affected many of those trees resulting in big ecological and economic losses. (Beatriz Nobua-Behrmann)

A UCCE Advisor in Modoc County continued to address the overpopulation of wild horses on public and private lands, affecting wildlife populations, rangeland health, and short and long-term livestock productivity. The once native perennial grass-dominated rangeland is being turned into bare ground and annual invasive grasses. In the last few years, UCCE has targeted education to policy makers to continue wild horse gathers and developing strategies to place gathered horses in good homes, and developed the 2019 Colt Challenge, which results in 150 horses going home with 4-H and Future Farmers of America youth, family, and friends. (Laura Snell)

Briefly describe how your target audience benefited from your project's activities.

Science-based information was applied to land management policy and decision-making.

- As a result of UCCE's oblong spurge efforts, the Amador County Agricultural Department decided to pursue grant funding to implement a county-wide control program informed by UCCE research. This weed poses significant harm to the natural environment as it forms dense stands and outcompetes native and desirable vegetation in riparian areas, roadsides, grasslands, and oak woodlands. This plant is poisonous to animals and can cause severe dermatitis and eye injury. (Scott Oneto)

- The National Park Service used information provided by UCCE to inform their approval of experimental grazing on 75 acres, which is a major step forward in thinking, where grazing becomes a conservation tool instead of a threat. This project is expected to result in an additional 75 acres of grazed land and potentially improve rangeland management and increase ecological sustainability of landscapes. (Devii Rao, Leslie Roche)

- PCR tests are routinely used in California now for all regulated pathogens on all crops, after UCCE advocated for this and designed the first test ever used, as observed by UCCE. This impact is in the billions of dollars nationally. Additionally, entities in the European Union have adopted the airspora sampling approach and PCR tests to identify Heterobasidion in conifers, as observed by UCCE. The impact is equivalent to millions of Euros in savings. (Matteo Garbelotto)

- The first PCR test designed by the UCCE Specialist's lab was used to identify immediately the first introduction of the EU1 lineage of Phytophthora ramorum in California, providing a much-needed early alert that may substantially have helped the state to slow down its spread. Del Norte County used this information to inform their decision to lead an eradication effort. (Matteo Garbelotto)

- UCCE's research findings, best management practices, and diagnostic approaches have been used to make restoration decisions by entities like National Parks, the UC Berkeley Botanical Garden, the California Native Plant Society, East Bay Regional Parks, Marin Open Space, Santa Lucia Preserve, Air Force, and San Francisco Recreation and Parks. This has saved tens of millions of dollars from using infected plants, as observed by UCCE. For example, in 2021, the lab contributed to 3,087 oaks being protected via the removal of infectious bay laurel and chemical and cultural treatments. The average success of treatments was 95%, with a range of success between 75 and 100%. The mean cost per tree treatment was $175.00, with the cost per large monumental tree being as high as $1500 per tree. The value of the effort is estimated at $4,287,500.00. (Matteo Garbelotto)

- East Bay Regional Parks, Bay Area Townships, and others are now using information from UCCE in their long-term management plans for over 1,000,000 Acacias and Eucalyptus trees in the East Bay region. (Matteo Garbelotto)

Briefly describe how the broader public benefited from your project's activities.

Change in condition: Improved managment and use of land.

- During the summer of 2021, Irvine Regional Park and Caspers Wilderness Park had a 50-88% measured reduction in the number of yellowjackets captured in traps after baiting. This project allowed UCCE to test the efficacy of control methods in a field situation while also providing a solution to local partners and improving the use of natural areas by the general public. (Beatriz Nobua-Behrmann)

- As a result of UCCE's tree monitoring program and adoption of best management practices recommendations, 80% of Orange County Parks have shown a steady reduction in the number of infested reproductive hosts during the last two years. Some of the parks, like Peters Canyon Regional Park and Mile Square Regional Park, show particularly favorable trends with reductions of 16% and 25% respectively in the number of infested trees during the last year. (Beatriz Nobua-Behrmann)

- Modoc County's wild horse population decreased from 20 times the appropriate management level to about half due to UCCE's collaboration and perseverance in the last few years. Furthermore, this decrease has resulted in almost all producers returning to summer grazing and resuming the use of their allotment per a multi-use mandate of public land that supports the local economy. (Laura Snell)

The aforementioned measured outcomes demonstrate how UC ANR has contributed to improvements in land management policies and practices that can maximize the benefits that managed lands provide. In this way, UC ANR contributes to the public value of protecting California's natural resources.

Describe and explain any major changes or problems encountered in approach. Additionally, note opportunities for training and professional development provided, how results have been disseminated to communities of interest, and any new details regarding what the project or program plans to do during the next reporting period to accomplish the goals.

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Increasing diversity, inclusiveness, and cultural competency in California's workplaces

In 2-3 sentences, briefly describe the issue or problem that your project addresses.

California is the most diverse state in the nation by many standards, including race/ethnicity, languages, and socio-economics. It is a minority-majority state, where no single ethnic group forms a majority of the population. However, more than half of the children in California are Latino. The median annual income for Latino, Native American, and African American households in California is well below the state median income. This income gap correlates to opportunity gaps in critical areas like access to high-quality youth development programs and early college preparation. California continues to be challenged by social, health, and economic inequities.

Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.

UC ANR builds cultural competency skills, implements community-centered programs, and develops proactive policies to increase diversity and inclusiveness. UC ANR engages in intentional efforts to ensure that all members of the public have equitable access to UC ANR resources. UC ANR academics live and work in communities building trust and credibility to solve

local problems together through research, outreach, and education.

The UC Sustainable Agriculture Research and Education Program's (SAREP) focus area on social equity that addresses inequities and racism in California's agriculture and food system includes engaging UC ANR colleagues to further DEI-advancing efforts within the organization. Lessons learned in implementing diversity, equity, and inclusion measures in Extension, are published in blogs and articles geared toward the Extension audience. (Sonja Brodt, Gail Feenstra)

UC ANR's statewide California Naturalist program continues its efforts to broaden participation and address Justice, Equity, Diversity, and Inclusion (JEDI) in the program. The program established a framework for operationalizing its JEDI efforts using a Four "R's" approach: 1) investing in Relationships, 2) focusing on local and cultural Relevance in our content, 3) breaking down barriers to Recruitment or access, and 4) promoting individual and program Responsibility and accountability. During this period, the program initiated a new demographic data collection approach using course evaluations for course participants and registration for events. (Gregory Ira)

A UCCE scientist working in the UC ANR statewide Agricultural Issues Center was the lead on a $1M grant from the National Institute for Health for community-based participatory research. A course in human subject research ethics was developed so that the community researchers could receive their CITI certifications. (Karen Jetter)

A UC Cooperative Extension (UCCE) Specialist located at UC Berkeley served on the California FarmLink Board and helped establish a new Diversity, Equity, and Inclusion (DEI) Committee to assess and develop principles and best practices for DEI for this organization. They developed a survey that was administered to like-minded non-profits assessing the status of DEI principles, practices, challenges, and successes the organizations had with implementing DEI practices. The report California FarmLink DEI Assessment: Policies, Principles and Practices of DEI and Inclusive Governance within the California Non-profit Agricultural Services Sector was presented to the organization and at the Eco-farm conference. (Jennifer Sowerwine)

Briefly describe how your target audience benefited from your project's activities.

UC ANR academics, staff, and volunteers learned skills to better engage diverse audiences.

- UC SAREP's webinars on working with farmworkers and farmers of color provided useful networking connections and contributed to growing the membership of a newly formed UC ANR Diversity, Equity, Inclusion, and Justice Program Team, which currently counts 44 members from across UC ANR. (Sonja Brodt)

UC ANR better engages communities historically underrepresented in its programs.

- As a result of the California Naturalist program operationalizing the *4R* framework, the following outcomes have been achieved:
  - *Relationships:* New partnerships were established with the California Tribal College and the Anahuacalmecac School, and Audubon Center at Debs Park.
  - *Relevance:* Course content is made locally and culturally relevant through co-design of the course syllabus.
  - *Responsibility:* Program team members pursue professional development, including completing the Intercultural Development Inventory (IDI) training.
  - *Recruitment*: 31.8% of all course participants (258 of 812) received either full or partial scholarships to eliminate cost barriers to participation. (Gregory Ira)

- Results from the first year of the California Naturalist Climate Stewards courses show promising results for Hispanic and non-white participation: 31% Hispanic (39% in 2019 CA Census); 4% Black (7% in 2019 CA Census); and 13% Asian (16% in 2019 CA Census). (Gregory Ira)

- Community researchers from three Northern California Tribes: The Mechoopda Indian Tribe of the Chico Rancheria, the Grindstone Indian Rancheria of Wintun-Wailaki Indians, and the Round Valley Indian Tribes were engaged. Two clinics, the Northern Valley Indian Clinic, Inc, and the Round Valley Indian Health Center, also collaborated with this project. All community and clinic partners, 40 people total, were able to pass the course to be certified to conduct research with human subjects on federally funded projects. (Karen Jetter)

Briefly describe how the broader public benefited from your project's activities.

Change in condition: Workplaces are more inclusive.

- California FarmLink organization increased the adoption of new DEI principles and practices and increased diversity of the board in both racial and farmer representation. (Jennifer Sowerwine)

These measured outcomes demonstrate how UC ANR has strengthened its internal capacity to do effective outreach to diverse audiences to have participants better reflect the state's diversity. UC ANR increased access to opportunities and created environments where different kinds of people can thrive and succeed. In this way, UC ANR contributes to the public value of developing an inclusive and equitable society. The UC Berkeley Hass Institute of Fair and Equitable Society finds California ranking in the top quarter amongst the states for inclusiveness. However, the state dropped from fifth to twelfth in the nation between 2018 and 2020, indicating there is still much work to do.

Describe and explain any major changes or problems encountered in approach. Additionally, note opportunities for training and professional development provided, how results have been disseminated to communities of interest, and any new details regarding what the project or program plans to do during the next reporting period to accomplish the goals.

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Critical Issue

Water Quantity, Quality and Security

Water Resources

Project Director

Katherine Webb-Martinez

Organization

Regents of the University of California

Accession Number

7000183

Improving water use efficiency

In 2-3 sentences, briefly describe the issue or problem that your project addresses.

More than nine million acres of farmland in California are irrigated, representing roughly 80% of all water used for businesses and homes. The state faces challenges to meet its water demands. As the state's population expands and agricultural water uses are curtailed to meet new sustainable groundwater management guidelines, there can be an expected decrease in water availability and increased competition between urban, environmental, and agricultural water uses. These issues create a need to identify new solutions to improve water use efficiency on agricultural lands and the urban sector in and around homes to meet increasing demands.

Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.

UC ANR conducts research projects throughout the state to identify more efficient water practices and extends them to growers, managers, decision-makers, and the public to transform how Californians use water.

A UC Cooperative Extension (UCCE) Advisor, Agricultural Experiment Station (AES), and other UCCE collaborators conducted a statewide walnut water use efficiency project in Stanislaus and Tehama Counties to provide regional information for the central portion of California. These trees are often damanged from typical industry over-watering. The walnut irrigation applied research project indicates that a grower could save approximately 868,928 gallons per acre, per year, by starting irrigation in May or June, rather than starting when most growers typically do in March or April. (Kari Arnold)

A UCCE Specialist at UC Davis monitored evapotranspiration in three cherry orchards over three years. This information provided specific crop coefficients for irrigation in sweet cherry orchards and could also identify the potential for regulated deficit irrigation in the post-harvest period. (Susana Suvocarev)

A UCCE Advisor in San Diego County offered six webinars on irrigation scheduling based on evapotranspiration, irrigation system performance, and runoff management. Two seminars were offered twice, once in English and once in Spanish. The advisor also collaborated with greenhouse and outdoor container nurseries to conduct an applied research project on sprinkler head efficiency. Pressure, wind speed, and distribution uniformity were measured. (Gerry Spinelli)

A UCCE Advisor in Butte, Glenn, and Tehama Counties conducted collaborative research and extension efforts on orchards, including topics like irrigation management. They focused on the plant-based pressure chamber technique that directly measures tree water status and irrigation needs. (Luke Milliron)

A UCCE Advisor in Monterey, San Benito, and Santa Cruz Counties continued research to develop accurate models for estimating crop water use of coastal crops and efficiently scheduling irrigation of these crops using evapotranspiration weather data. This information was used to expand the CropManage online application to additional commodities so that growers can efficiently schedule irrigations from weather data available from the California Irrigation Management Information System (CIMIS). Results were disseminated widely to clientele through presentations, newsletters, blogs, and trade journal articles. (Michael Cahn)

A UCCE Advisor in San Joaquin County and a UCCE Specialist at UC Davis collaborated on campus-based research trials and extensive soil and tissue sampling in commercial tomato fields to improve understanding of water and nutrient dynamics in drip-irrigated tomatoes. The results of this work fed directly into the development of two different decision support tools whose development was led by the UCCE Specialist and another UCCE Advisor in Monterey County. The first is CropManage for tomato: a computer-based tool for growers to aid in irrigation and nutrient management decisions. The second is a simple online tomato nitrogen budget calculator. These tools are publically available online, and information was extended to growers and consultants via numerous extension presentations and a newsletter article. (Brenna Aegerter, Daniel Geisseler, Michael Cahn)

UCCE county-based academics and community education specialists in Santa Cruz and Santa Clara Counties delivered trainings and technical assistance to support small farmers' understanding of the requirements of and submitting Healthy Soils Program (HSP), State Water Efficiency and Enhancement Program (SWEEP), and Agriculture Resilience Incentive (ARI) grants. These grants assist growers in implementing practices that improve soil health and water-use efficiency. (Qi Zhou)

A UCCE Advisor conducted a nitrogen (N) study at UC ANR's Desert Research and Extension Center and on 14 commercial fields of leaf lettuce, romaine lettuce, head lettuce, and processed onions. The N uptake curve and N needs and removal coefficients information were developed for these commodities. The findings were disseminated to growers and stakeholders through articles, training presentations, and media interviews. The data and demonstration trials were used to adapt the CropManage online irrigation and nutrient management decision support tool for carrots, as well as continued efforts to adopt CropManage for the low desert crops initiating with onions, different types of lettuce, spinach, and alfalfa. In another project, the advisor conducted extensive field measurements in 53 commercial fields over the last three-year for 11 agricultural commodities, including alfalfa, carrots, onions, Klein grass, date palm, lemons, olives, sugar beets, spinach, sunflowers, and wheat. The findings provide evidence about the benefits of the residual of energy balance method, water use sensors, and soil moisture sensors specifically in southern California and potentially provide significant benefits to the region by supporting enhanced water and nutrient use efficiency and drought resilience information for profitable and sustainable crop production. Findings were shared with cooperative growers, local irrigation and water districts, and in several articles. Lastly, the advisor studied seven commercial date palms with different soil types and conditions, canopy features, and irrigation practices for the major date cultivars in the region. Information on date palm's best irrigation management practices was developed and disseminated in collaboration with the CA Date Commission. (Ali Montazar)

A UCCE Advisor evaluated processing tomato deficit irrigation influence on soil salinity levels. In a replicated three-year applied research study with a cooperating grower, sub-surface drip irrigations' influence was evaluated in a commercial field. The results showed no apparent impact on salinity within the soil. Furthermore, the study reinforced that on the clay loam soil, there is no negative impact on yield or quality of tomatoes due to the reduction in applied water. Ongoing findings were shared with the cooperating grower. (Tom Turini)

UCCE was part of an effort to help qualify range managers do their own water reporting to meet California regulations, which can often be cumbersome for livestock managers to comply. The reporting includes both stock water ponds and irrigation diversions. Extension efforts included classroom certification and a hands-on water measurement field meeting. (Josh Davy)

A UCCE Specialist at UC Riverside and his water team conducted landscape irrigation field trials to investigate the effects of irrigated turfgrass and groundcover species irrigation on CO_2 emissions, cooling benefits, and water conservation. Findings were extended information through their website and Twitter account, which act as a clearinghouse to reach a diverse audience. (Amir Haghverdi)

A UCCE Specialist at UC Riverside analyzed residential water consumption in California and found that it fell dramatically in the past three decades. These reductions result from various water-conservation policies and other efforts by state and local water managers. The specialist also partnered with multiple regional water agencies to investigate the effectiveness, costs, and unintended consequences of conservation programs (e.g., rebate, lawn replacement, education, and pricing programs) effectiveness using household-level water use data. Results have been widely disseminated through workshops, water agencies board meetings, professional conferences, and reports. (Mehdi Nemati)

Briefly describe how your target audience benefited from your project's activities.

Participants demonstrated learning gains and intend to adopt recommended irrigation practices.

- Both collaborating Stanislaus County walnut growers have expressed a desire to change their irrigation practices and begin using the pressure chamber for better irrigation management. If half the county acreage adopted the practice, this would amount to 15,640,704,000 gallons saved on an annual basis. Furthermore, the tree mortality rate due to over-irrigation would decrease. (Kari Arnold)

- In an end-of-session survey, San Diego webinar participants reported that they plan to adopt tools presented about evapotranspiration-based irrigation scheduling and distribution uniformity (88% of 27 survey respondents). (Gerry Spinelli)

- The cherry grower that hosted UCCE's evapotranspiration experiment shared that they intend to continue implementing an irrigation schedule using UCCE's crop coefficient measurements. (Susana Suvocarev)

- As a result of the UCR Water team's extension efforts, clientele enhanced their knowledge about urban irrigation best management practices and potentially increased urban water use efficiency and resilience to climate change and variability, as observed by UCCE. (Amir Haghverdi)

Participants adopted recommended irrigation or other water and soil management practices.

- Cooperating nurseries benefitted from participating in UCCE's applied research project by adopting a new sprinkler head that was more efficient than the growers were using. Additionally, the nursery staff was trained to continue using the new sprinkler. (Gerry Spinelli)

- Evidence of grower adoption of plant-based irrigation management continued. For example, after working with a grower for a couple of years, he reported he had adopted best management practices recommended by UCCE across 500 acres. The grower also reported that his trees looked healthier and noted, "I should have listened to you and started a year earlier." This anecdote shows that adoption requires a year-after-year repeated extension to the same clientele to get adoption. (Luke Milliron)

- Grower use of CropManage increased significantly during the past three years. More than 27,000 acres per year of lettuce were managed using the online decision support tool. Additionally, 7,700 acres per year of broccoli, cauliflower, celery, and strawberries were also managed using this CropManage. This online application provided more than 2,500 recommendations per month during the growing season in 2019. Field trials testing the CropManage have demonstrated that growers can reduce average water use in celery and cauliflower production by more than 40% without sacrificing yield and quality. (Michael Cahn)

Science-based information was applied to water use policy and decision-making.

- The California State Water Resources Control Board (SWRCB) utilized UCCE findings and recommendations on the effectiveness and consequences of water conservation programs in the implementation of "Making Water Conservation a California Way of Life'' regulations, in response to Governor Brown's Executive Order B-37-16 issued in May 2016. UCCE recommendations were also used by Elasonor valley, Eastern and Western municipal water districts to develop and implement conservation programs. (Mehdi Nemati)

- Through UCCE's water use research and technical services, the water management agency in Pajaro Valley made progress in achieving half of the water conservation goal outlined in their basin plan. Additionally, the California Strawberry Commission redirected resources towards developing an irrigation education program using the protocols developed under UCCE's irrigation efficiency program. (Michael Cahn)

- Tomato irrigation growers adopted the use of CropManage software, demonstrated by data showing that 727 tomato irrigation recommendations were made in the first two growing seasons that the software included tomato information. (Brenna Aegerter)

- As a result of UCCE technical assistance, 26 small growers were awarded HSP, SWEEP, or ARI grants, totaling over $478,000 and affecting over 200 acres of farmland. Growers used the grant funds to replace leaking pipes, valves, and inefficient pumps to improve irrigation efficiency and water-use efficiency as well as purchase and apply compost, mulching, and sawdust to their farm to improve soil quality. (Qi Zhou)

Briefly describe how the broader public benefited from your project's activities.

Change in condition: Water saved.

- Cooperative carrot growers who switched furrow irrigation to sprinkler irrigation in nearly 500 acres and followed best irrigation and nitrogen management practices developed by this study conserved 0.8-acre feet per acre water (20%) and reduced N fertilizer application by 17%. Cooperative onion growers who switched furrow irrigation to drip irrigation and adopted the findings of this study conserved nearly 1.7 acre-feet per acre of water, increased yields by 21%, and reduced N fertilizer application by more than 32% (Ali Montazar)

- As a result of collaborating in an irrigation study, one cooperative grower found that water use efficiency improved by 18%, puffy skin diseases of date fruits reduced, and fruit quality improved overall. (Ali Montazar)

- Eight date growers in the low desert adopted recommended irrigation management and developed tools in date palms, achieving higher fruit quality and conserving water by 15%. This provides a better understanding of crop water use and best irrigation management practices in date palms. (Ali Montazar)

- As a result of the tomato deficit irrigation influence study, the cooperating grower began applying 25% less water from approximately 50 days pre-harvest and 50% less from 30 to 15 days preharvest. He uses this schedule on approximately 5,000 acres of processing tomatoes annually. At an average evapotranspiration rate of 2.0 inches per week, this schedule resulted in a water savings of an estimated 2.4 billion gallons of water over the last five years. (Tom Turini)

- Exams in water measurement workshops demonstrated increased knowledge in water use efficiency. Operators shared that they could more easily comply with water regulations because of UCCE's efforts and developed a greater understanding of the amount of water diverted. Prior to developing water measurement skills through UCCE's hands-on learning activities, their efficiency level was unknown to them. Weather stations throughout California provide insight into the amount of water used by particular crops. By matching water use to diversions, managers can develop priorities for improving irrigation on the land they manage. In addition, without these skills producers would have been forced to hire an engineer to design and implement their reporting system, which would have cost them thousands of dollars. (Josh Davy)

These aforementioned measured outcomes demonstrate how water users better understand and adopt water use efficiency measures to help California reduce its water demand while maintaining crop yields. Ultimately, improved water management will increase water cost savings, reduce water usage, benefit the end-user, and reduce groundwater over-pumping in California. For example, it was estimated in 2019 that California growers could save approximately $147 billion gallons of water per year by using California Irrigation Management Information System (CIMIS) weather data to inform more efficient water practices (Zilberman, et al., 2019). Thus, UC ANR contributes to the public value of protecting California's Natural Resources.

Describe and explain any major changes or problems encountered in approach. Additionally, note opportunities for training and professional development provided, how results have been disseminated to communities of interest, and any new details regarding what the project or program plans to do during the next reporting period to accomplish the goals.

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Microirrigation: A Sustainable Technology for Crop Intensification and Improved Crop Productivity

Project Director
Amir Haghverdi
Organization
Regents of the University of California
Accession Number
1021158

Microirrigation: A Sustainable Technology for Crop Intensification and Improved Crop Productivity

In 2-3 sentences, briefly describe the issue or problem that your project addresses.

The western USA is generally arid and subject to droughts while home to some of the largest cities in the nation. In southern California, the demand for landscape irrigation is significant, and enhancing irrigation efficiency is a critical water conservation approach, given its high population and dependency on water transportation from other regions.

Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.

The last year of a three-year (2019–2021) irrigation research trial was conducted to evaluate the response of bermudagrass to soil moisture sensor (SMS) based deficit irrigation treatments and assess the efficacy of Acclima smart controller for autonomous irrigation scheduling in southern California. The irrigation levels applied were based on upper and lower soil moisture thresholds and ranged between 25% and 97% of reference ET (ETo). The controller was also programmed to implement two irrigation frequencies, i.e., restricted (3d/week) and on-demand (7 d/week) irrigation. Normalized difference vegetation index (NDVI) and turf temperature data were collected weekly during the summer irrigation season to evaluate the response of bermudagrass to irrigation treatments. We also measured soil salinity, sodium adsorption ratio (SAR), and infiltration rate before and after the summer irrigation season. There was a significant effect of irrigation levels and irrigation frequency restrictions on NDVI for all three years, while turf temperature was significantly affected in 2020 and 2021. On-demand irrigation resulted in 3.4% lower turf temperatures over the study period than restricted irrigation while maintaining slightly better visual quality. Although soil salinity oscillated with the seasonal cycles because of leaching observed due to winter rainfall, both salinity and SAR increased as the study progressed.

Briefly describe how your target audience benefited from your project's activities.

Multiple presentations were delivered by the research team to disseminate the results of this work to the research community. Social media, website posting and extension publication, and Youtube videos were generated to research a broader audience.

Briefly describe how the broader public benefited from your project's activities.

Available water resources in urban areas are limited in the southwestern USA which makes water conservation a vital goal to achieve in near future. The significant water consumption by the urban irrigated landscape sector in the region puts pressure on already limited resources and therefore the research-based information developed in this project and outreach activities conducted by the research team are of critical importance to save water in urban areas.

Impact Statement (Optional)

Use this space to talk about the impact that this result had, in layman's terms. Adding comments here will **not** change the content in the highlighted result.

Irrigation strategies to conserve Southern California water

The Western United States is generally arid and subject to drought, while also being home to some of the largest cities in the nation. In Southern California, the demand for landscape irrigation is significant, and enhancing irrigation efficiency is a critical water conservation approach given the region's high population and dependency on water from other regions. The UC AES researcher conducted the final year of a three-year research trial that examined on-demand smart irrigation controllers that monitored soil moisture. The trial evaluated the efficiency, reliability and ease for these controllers that can help save water in urban irrigated settings such as parks, schools and private homes.

Type	Projects / Programs
Projects / Programs without a Critical Issue	**0**

Not Provided