CSU The California State University

AGRICULTURAL RESEARCH INSTITUTE

2017 – 2018 Annual Report

INTRODUCTION

Dr. David W. Still
Executive Direcor

Some events are hard to ignore. Let's recap: over the last year, fires in California destroyed over 1 million acres, an area roughly the size of Rhode Island. Hurricane Harvey dumped nearly 61 inches of rain on the Houston coastal area (July 2017). At 120°F, Chino, CA reached temperatures normally seen only in Death Valley or Palm Springs (July 2018). The Rio Grande River dried to a trickle (August 2018). According to the National Oceanic and Atmospheric Administration (NOAA), 2018 is on pace to be the fourth hottest year on record, behind only 2015, 2016, and 2017. In fact, 17 of the last 18 warmest years on record have occurred since 2001. Climate scientists proclaim this is the "new normal", but as greenhouse gases continue to accumulate, the earth's temperature will also increase and heat waves will be hotter and longer in duration. The new normal will only be hotter.

The impacts of climate change in California are already evident: increased heat, drought and insect outbreaks, an increase in wildfires that burn hotter and are more destructive. Declining and unpredictable water supplies, however, may be the most impactful, far-reaching, and long lasting. By recognizing the potential impacts of climate change, we have some capacity to mitigate these effects to make agricultural and natural resource systems more resilient.

Agricultural Research Institute faculty and students are working on a wide range of projects to help mitigate the impacts of climate change. For example, faculty working on ARI-funded projects are assessing the effectiveness of recharging aquifers using surface canals. They are working to improve water use efficiency in several major California commodities (alfalfa, almonds, lettuce, onions, pistachios, tomatoes and wine grapes) using remote sensing, crop modeling, and breeding new cultivars. Other faculty projects seek to define the limitations of supplementing high quality irrigation water with saline water and "produced water" from the oil industry. If society is not able to reduce CO_2 emissions, sequestration is a plausible strategy to lower atmospheric CO_2. ARI faculty are evaluating methods to add organic matter to improve rangelands and increase carbon sequestration; working to reduce agricultural greenhouse gas emissions by developing best management practices that reduce nitrogen fertilizers, and by breeding crops to use less nitrogen.

The seriousness of climate change on California should not be underestimated. While we are witnessing the effects of climate change today, the problem facing the next generation is potentially even greater. I am optimistic they are up to the challenge. As you will read in this report, the students working on our projects are an impressive group. They are fully aware of the challenges facing agriculture, our environment, and our cities, and they are willing to engage in facing these problems and providing solutions. Our ARI students are developing a deep understanding of their discipline, they often engage in working with other disciplines and use multiple technologies in their research projects. They are also learning that research is incremental, not entirely tidy, and they learn they are the ones that have to solve problems – and they do. Not all of these students will have careers in agriculture, but they will all be well equipped to think independently and critically. Our society will be the ultimate beneficiaries of the work and knowledge of these students and the investments we make in them.

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MISSION

To support and fund applied agriculture and natural resource research within the California State University (CSU) system that improves the economic efficiency and sustainability of California agriculture.

VISION

California has diverse and abundant agricultural and natural resources. Through education and research, we envision the ARI being a valuable resource to the State on policy and informed decision-making based upon robust science to ensure the sustainability of California's agricultural economy and the preservation of its natural resources.

STRATEGIC OBJECTIVES

- Invest in applied research to address emerging and high-priority issues facing California agricultural and natural resource industries;
- Develop a highly-trained professional workforce for California agricultural and natural resource industries through student participation in research projects; and
- Communicate research results to industry stakeholders, scientists and the public.

Developing the next leaders in California agriculture

One of the key impacts of the ARI program is our investment in students and in the future of California agriculture. Faculty working on ARI-sponsored projects recruit and engage students in discovery-based research and mentoring to help guide students into careers and graduate schools. The diversity and talent of our students working on ARI projects is unparalleled. They come from every corner of the state and from almost every discipline. This year we highlight students from traditional agricultural backgrounds like animal and plant science, as well as students outside traditional agricultural fields. Two of our students profiled in this report have degrees in civil engineering and each of their projects are focused on using water more efficiently. Given the utter dependence of agriculture on a dependable supply of high quality water for irrigation, it is not surprising that so many of our projects and students are focused on water.

With almost 13,000 students majoring in 27 agricultural programs across the system, the California State University (CSU) enrolls more students in agriculture programs than any other higher education system in California. Of these, there are 9,500 students majoring in agricultural fields on the six ARI campuses (Figure 1. Distribution of agricultural majors across the California State University system, Fall 2017 enrollment data). In FY 17-18, the ARI dedicated 38% of our budget to provide support to 156 students through wages, stipends, and tuition reimbursements. Importantly, this allowed students to work in the lab or field on projects that are directly related to their major. Critical thinking goes hand-in-hand with science, and our ARI students learn science by doing science. Regardless of where these students go after graduation, this experience will be valuable for their success in any career.

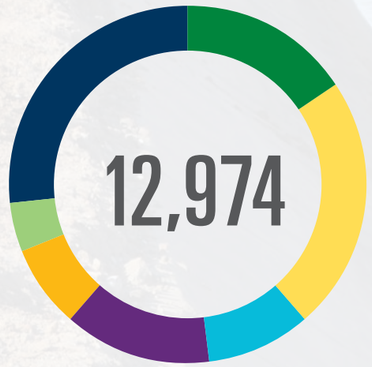


FIGURE 1. DISTRIBUTION OF AGRICULTURAL MAJORS ACROSS THE CSU
(Fall 2017 enrollment)

- **2,046** Cal Poly Pomona
- **2,999** Cal Poly San Luis Obispo
- **1,201** Chico State
- **1,742** Fresno State
- **982** Humboldt
- **558** Monterey Bay
- **3,446** Other CSU Campuses

STUDENT PROFILES

STUDENT PROFILES

Deeper learning and changed perspectives through research experiences.

As a program in undergraduate institutions, the ARI provides an unequaled opportunity for students to engage in research. Faculty involved students in 90% of their projects, often training several students. In fact, 577 students were involved in 114 projects during FY 2017 – 2108. Our undergraduate and master's students are engaged in research at the deepest and most technical levels – often doing the work that many postdocs and PhD students do at research universities. Students are often recruited in labs as a freshmen or sophomores and spend multiple years working on different projects and often with multiple professors.

Students involved with research projects receive training in science, and critical thinking is, well, critical, for a scientist to succeed. Critical thinking and science are best learned by doing. Both take many years of training and practice. Scientists are, in fact, life-long learners. Students have mentioned, many times, that being involved in research sparked a real interest in something and convinced them to pursue graduate school so they could learn more, and learn more deeply. They have remarked that they have learned they can, and must, teach themselves. This allows them greater opportunity to explore and make sure, to whatever degree possible, they graduate and move to a career that they enjoy.

MIGUEL ALVAREZ
CHICO STATE

Miguel Alvarez, a senior at Chico State, is working on a bachelor's degree in agriculture with an emphasis in agriculture crops and horticulture. He began college at Butte Community College (BCC) in 1994, but with little mentoring and without a clear idea of what careers were available, he decided to quit school and figure it out. He worked for Blue Shield of California for the next 13 years then decided to go back to BCC and study landscape design and installation. The core agriculture curriculum made him aware of how diverse agriculture is, and he developed an interest in insects and agricultural pest control. He took another break, then transferred to Chico State, still interested in agriculture and determined to obtain his degree.

Miguel became involved in a program for first-generation Hispanic students that provided agricultural research internships.

At Chico State, Miguel became involved in a program for first-generation Hispanic students that provided agricultural research internships. He selected a project led by Dr. Rich Rosecrance, a professor in the College of Agriculture with expertise in fruit tree physiology and plant mineral nutrition. Miguel is working on an ARI-funded project with Dr. Rosecrance to determine how different hedge-topping methods affect yield in olive trees. Topping olive trees keeps trees compact and manageable, reduces alternate bearing, and, if done properly, can increase yield. In this project, they have pruned trees in orchards to two heights, measured carbohydrate levels, bloom percentage, light penetration in the canopy and yield. They will determine the best time to prune to maximize flower buds and light penetration to optimize photosynthesis (carbohydrate production) since ultimately, carbohydrates are the energy source required to support flowers, fruit set and development.

Left, Miguel Alvarez, Right, Emily Hamblin

Miguel has worked on the project for the last three years and gained a great deal of practical knowledge regarding olive production. Miguel stated that being involved in research made coursework seem more meaningful, and he gained appreciation of the critical skills needed to manage a farming system. He believes it is important to find new and better ways of doing things and that need never ends. His project provided him with networking opportunities where he made many connections within the industry. Miguel commented that many things in the classroom seem theoretical, but, by being involved in research he could see if the theory matched what he observed in the field. If it did not, it made him realize something else could be going on and he would have to think about alternative explanations. A professional tip from Miguel: build your note taking abilities in the classroom – it will help you collect data and keep it organized.

Once Miguel graduates from Chico State, he would like to become a farm advisor, but he is also interested in working in the industry with almonds, walnuts, or perhaps wine grapes. His immediate goal is to get his pest control advisor's license, and he has not ruled out earning a master's degree. Whatever he decides to do, he has always liked research and improving things and is very thankful for the opportunity to work with Dr. Rosecrance.

JOSUE DUQUE
CSU MONTEREY BAY

Josue Duque is finishing an undergraduate program in biology at CSU Monterey Bay. He chose biology because he knew he wanted to do something in the sciences and biology. In high school, he took several biology classes; one of them was an AP environmental studies course that influenced him toward biology and systems biology.

Josue grew up in the Los Angeles suburbs, and one of the reasons he chose Monterey Bay was he wanted to live in a less populated area and attend a smaller school. Monterey has a good biology program and had a great location with ocean views! Josue was recruited to work in a research lab through his professor of an organic chemistry class, who mentioned a colleague was looking for a student with a good science and chemistry background to work on a project. That colleague, Dr. Haffa, an associate professor in the School of Natural Sciences at Monterey Bay, conducts research on biogeochemical cycles, especially as they relate to agriculture. Josue contacted Dr. Haffa, joined the lab, and has been working on projects for the last one-and-a-half years.

Josue is working with both Dr. Haffa and a NASA scientist, Forrest Melton, on an ARI project to develop best management practices to improve water and nitrogen use efficiency during production.The project involves a combination of field and lab work and is decidedly technology-driven. The team employs remote sensors to measure water and fertilizers, incorporate satellite images of plots to estimate crop growth, and sample the amount of greenhouse gasses generated from the field. Josue removes gas samples from PVC pipes that were inserted in the field and takes them to the lab for analysis. This part of the experiment, Josue said, has really kept him in shape because he has to finish taking samples from the tubes scattered across the field every fifteen minutes. Now, however, Josue says they are able to perform this type of gas and particle analyses in the field with an instrument fitted on a backpack, and he does not have to run around nearly as much. Josue described it looking like a "Ghostbuster backpack." Their group has conducted this type of nitrogen and greenhouse gas analyses projects in lettuce, strawberry, and broccoli fields.

Left, Josue Duque, Right, Jason Dexter

Josue commented that CSU Monterey Bay is really geared toward undergraduate research, and they have many programs to support student participation in research. He was able to think of ways he could apply the concepts that were being taught in the classroom to his fieldwork. This fall, Josue started his senior year, and he plans to pursue a Ph.D. program. He has not decided where he will go but he wants a project that will include both field and lab work. Ideally, he would like to find a program that combines cell biology with agriculture.

Josue was able to think of ways he could apply the concepts that were being taught in the classroom to his fieldwork.

GABE GOFF
HUMBOLDT STATE

In northwestern California, Oregon white oak and California black oak woodlands comprise important cultural, agricultural and working landscapes, and they support high levels of plant and animal biodiversity. Global warming and fire suppression over the last 100 years have contributed to the encroachment of conifers into mixed oak forests, leading to oak decline. A team of Humboldt State faculty and their students has begun a research project to examine the impact of the loss and degradation of oak woodlands in northern California. A recent graduate from Humboldt State's forestry program, Gabe Goff, will work on this project with Dr. Lucy Kerhoulas, an assistant professor specializing in forest ecophysiology in the Forestry and Wildland Resources program at Humboldt State.

Gabe is working on an ARI project to better understand how to restore Oregon white oak and California black oak woodlands.

Gabe grew up in Southern California, surfing, camping, and appreciating the environment. He attended San Diego State for a year and then transferred to a local community college. While on a family trip to northern California, Gabe was so impressed with the northern California coast that he transferred to Humboldt State. Gabe chose to major in forestry because he could study ecology and be outdoors. Focusing on forest management appealed to his hands-on nature and he thought this approach would allow him to get a good job after graduation.

Gabe took courses with Dr. Lucy Kerhoulas and reached out to see if he could work on one of her projects to gain research experience. Eventually his volunteer work turned into a paid job where he worked on an oak forest research project that became his senior project thesis and which he is expanding to serve as his master's thesis. The ARI project is

part of a broader effort involving multiple faculty studying oak woodland responses to conifer encroachment, conifer removal, and the effects of the recent severe drought. For their part of this project, Gabe and Dr. Kerhoulas will examine how growing space, competition and forest structure affect white oak health. Findings from this project will improve the cost effectiveness of management decisions that will foster resilient and sustainable woodlands into the future.

Like many students in the ARI program, Gabe indicated that his involvement in research contributed to understanding classwork and in turn, his classwork helped him better understand his research. For example, experimental designs are covered in classes, but they can be somewhat abstract. Working on this project allowed him to see how designs are applied to real-life situations and allowed him to collect data, analyze it and see how it all fits together. Using real data that he collected and analyzed led to a better understanding of statistics.

Gabe credits his father who provided support and encouragement in his quest to be a scientist. When Gabe finishes his master's program, he may take a little time off to travel, but he intends to land a job where he can use his skills and knowledge in field ecology to improve biodiversity and the planet. Importantly, Gabe continues to surf up north.

TAYLOR HERREN
CHICO STATE

Taylor Herren grew up in Pine Mountain Club, a small town nestled in the San Emigdio Mountains, surrounded by the Los Padres National Forest. Growing up, Taylor had always planned to go to veterinary school and attend college at Chico State, Cal Poly San Luis Obispo, or Cal Poly Pomona. In high school, she went to an open house at Chico State, thought that food and agriculture sounded more interesting than veterinary school and decided to attend Chico State. As an undergraduate, she became involved with community service work and started to realize that activities geared toward addressing food security really make a difference; she then fully transitioned to food systems.

Taylor realized the value of doing things to increase food security really makes a difference and she fully transitioned into studying food systems.

As an undergraduate, Taylor worked on an ARI-funded project with Dr. Cindy Daley, a professor in agriculture and Co-Director of the Regenerative Agriculture Initiative. The overarching objective of their studies was to evaluate the feasibility of using fodder (sprouted barley, in this experiment) as a replacement for grain in the dairy cow ration. If it worked, milk production would not be affected, and the dairies would save money, since feed is up to 65% of the cost of milk production. They developed large controlled environment chambers to germinate barley seeds, evaluated the nutritional profile of the sprouts and then substituted sprouts for grain in various amounts. Next, they examined sprout digestibility, assessed milk quality, and calculated the economic costs - including the environmental impact of the waste byproducts associated with growing the sprouts.

In addition to the research, Taylor did an internship with the California Department of Food and Agriculture (CDFA) under Secretary Karen Ross. Taylor helped develop the policy analyses of senate bills, including the highly visible hemp production bill. Taylor graduated with a bachelor's

degree in agriculture with an emphasis in animal science and followed this with an internship with the National Sustainable Agriculture Coalition in Washington D.C. There, she worked closely with the USDA and National Resources Conservation Service on analyzing the effects of public policy on agriculture and the environment. These experiences made Taylor realize the extent to which public policy drives spending of taxpayer dollars and the importance of basing policy on sound data and thorough analyses.

Taylor's college and internship experiences led her to complete an inter-disciplinary master's degree in which she examined the links among agriculture and food production, natural resource management, climate science, land use, and public policy. She has written a professional paper addressing regenerative approaches to improve rangeland and how public policies developed through the carbon cap-and-trade program that funded the healthy soils initiative can be used to support this research and improve sustainability and the resilience of public lands. Currently, Taylor is working as the project coordinator for the Regenerative Agriculture Initiative at Chico State, which is a collaborative research and education effort by Chico faculty with the purpose of lowering greenhouse gases through carbon sequestration and restoring ecosystem functions.

LOGAN KEARNAN
FRESNO STATE

Logan Kearnan is an undergraduate civil engineering student at Fresno State. Logan has always loved designing and building things and believes that engineering skills and knowledge can help solve the California water crisis. Further, Logan stated that water distribution projects have allowed agriculture to thrive in California, leading to the development of communities and industries that support agriculture. An engineer with knowledge in water distribution systems, he feels, would be able to live and work in almost any part of the world. Using this line of reasoning, Logan decided upon a career in civil engineering.

Logan decided to pursue a civil engineering degree because of his love for water distribution and he knows there is a lot of work you can do in agriculture in regards to solving the california water crisis.

Logan is working on his third ARI project with Dr. Dilruba Yeasmin, a research scientist in the Center for Irrigation Technology at Fresno State. Their current project uses ground-penetrating radar (GPR) technology to image roots. This technology directs radio waves into the soil and uses the return signal to gather information about what lies in the ground. Differences in material composition affects the return signal; as the instrument is moved across the field, the signals are recorded, the geographic coordinates noted, and an algorithm integrates this information into an image of the below-ground landscape. As a proof of concept, Logan first measured an oak tree outside the lab. It worked! Next they mapped roots of trees in an almond orchard on the campus farm. Logan said running the instrument and software was easy. The

From left to right:
Saravanakumar Somasundaram, Logan Kearnan, Dilruba Yeasmin

hard part was digging up all the roots to see how accurately they system placed the roots on the grid and to determine the lower limits of detection (i.e., what is the smallest root they could detect). According to Logan, "the soil in the Fresno State farms is like bedrock." They are now working with two different strength radars, one that detects large roots and the other that detects smaller roots. The two different images are superimposed to produce a more comprehensive representation of the tree root system. Currently, the instrument is pushed through the field on a cart where they can measure 35 to 40 trees within two hours.

Logan sees parallels between his fieldwork and hydraulics class in which he learned how water behaves as it moves through channels, pipes and the ground. Logan is also part of the Smittcamp Family Honors College, a highly selective program that provides mentoring, apprenticeships, and independent project opportunities to challenge students to achieve more and to help them develop leadership skills. In the summer of 2018, Logan started an internship with the engineering firm Provost and Prichard which gave him insight into what it would be like to be a professional engineer. Upon graduating, Logan would like to work for an engineering firm and eventually become a project or design manager. Another option would be a career with the United States Department of Agriculture or the National Resource Conservationist Service. Regardless of where he ends up, he is positive he will help in the national effort to conserve and distribute water resources effectively and efficiently.

SIERRA LAUMAN
CAL POLY POMONA

Sierra Lauman came to Cal Poly Pomona as a civil engineering student because she was unsure what she wanted to do but knew she was good at math and thought bridges were cool. After taking a few biology courses, Sierra decided to change her major to environmental biology because of her love for the outdoors, especially dirt and plants.

As an undergraduate student, Sierra started to help Dr. Erin Questad, an associate professor in biology at Cal Poly Pomona, on an ARI-funded project to increase the use of the southern California black walnut in landscapes. The native plant has lost 90% of its historic range, and one way to help ensure its survival is to use it as a specimen tree in landscapes. However, it produces a chemical that works as a natural herbicide – an obvious problem if one wants to have other plants in the landscape. Sierra worked with Dr. Questad and her graduate students on projects through two field seasons. She received training in ecophysiological research methods, including how to monitor soil and air temperature and take plant water potentials to measure water stress levels in native plants. The water potential readings had to be taken twice daily – once during the heat of the day and another reading, known as "pre-dawn water potentials," had to be taken at 3 a.m.!

Sierra added to her learn-by-doing education with an internship with the Arroyo Seco Foundation. She conducted vegetation surveys to assess rangelands for invasive plant species after which the Foundation hired her to propagate native plants. After graduating, Sierra started a master's program with Dr. Questad. She is interested in studying invasion biology and restoration ecology, and her master's thesis research will focus on propagule pressures (i.e., survival), which can be related to the rate of invasion. Native plants can be outcompeted by invasive species, and Sierra will focus on the competitive pressures that occur when the plant is trying to establish itself from seed. With global warming and shifting precipitation, we might expect those dynamics may change species composition over time with invasive species gaining a competitive advantage over the natives. But Sierra is interested in the reverse; can you discover the ecological principle associated with invasion to reinvade an invaded community and repopulate it with native species?

Sierra said that as an undergraduate she was very involved in research in the biology department, and felt added pressure to do well, especially when she takes a class with Dr. Questad. Sierra expects to have her master's completed by fall of 2020 and then wants to get her Ph.D. with a restoration ecology focus. Once she obtains her Ph.D., she aspires to have her own lab and teach at a university where she can bring academia and practical science together.

After graduating, Sierra started a new research project for her master's thesis focusing on invasion biology and restoration ecology.

PAUL MAWDSLEY
CAL POLY SAN LUIS OBISPO

Paul Mawdsley, the son of a chef, grew up in Austin, Texas with a passion for food and wine. Attending a family reunion in Paso Robles, his aunt mentioned he should check out the wine program at Cal Poly SLO. Until then, Paul thought he would major in medieval studies and go the University of Oregon - but they did not take a credit transfer from his high school and so he did not attend. Paul called this a blessing in disguise and could not be happier how this worked out.

Paul obtained an undergraduate degree in 2016 from Cal Poly, SLO in Wine and Viticulture with a concentration in Enology. After graduating, he took an internship with Craggy Range Winery in Hawkes Bay, New Zealand where he worked through the harvest. Paul has accumulated a wide variety of experiences at wineries, interning in Paso Robles, the Texas Hill Country in Stonewall and Round Mountain, and the historic (and famously good) Napa Valley winery of Chateau Montelena. At each winery, he learned about different grapes, how they are grown in different regions, how they behave differently when grown in these regions, and the different chemical profiles of the resulting wines. This wide exposure helped him decide what he wanted to do in his career.

For his master's thesis, Paul will be conducting research on a commercial winery that is helping in part by providing three acres and 2,500 vines.

As an undergraduate, Paul worked on two research projects, including one ARI-funded research project, with assistant professors Dr. Federico Casassa (enology) and Dr. Jean Dodson Peterson (viticulture). One project examined the relationship between grape yields and wine quality, investigating the oft-repeated paradigm of decreasing yields resulting in increasing grape and wine quality. In a second project, they were interested in the co-fermentation of red and white grape varieties to increase aromatic complexity and provide more stable wine color through the process of co-pigmentation. Paul presented his research results at conferences, thought this was fun, and decided to pursue a master's degree.

To say Paul is busy is an understatement. While taking classes and conducting thesis research, he also works (full time) as a viticulture technician with a company managing about 3,000 acres of grapes in Paso Robles. For his master's thesis research, Paul will continue to work with both professors Casassa and Dodson Peterson. He will expand upon the yield manipulation study, conducting sensory and HPLC analyses of the co-fermentation wines. Paul published the first article detailing this research with Dr. Casassa and Dr. Dodson Peterson in July of 2018 in the journal *Fermentation*.

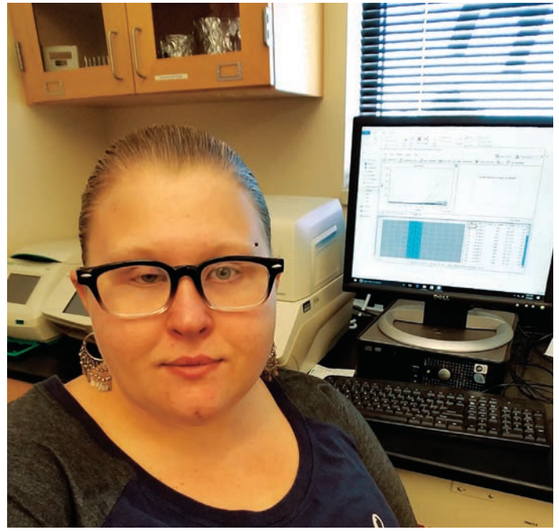
After Paul completes graduate school, he will obtain his Pest Control Adviser license in order to continue his career as a viticulturist. He hopes to continue with his present company working on the central coast. Eventually he would like to move to a cooler climate, or the exact opposite, move to Texas to be near his family. As he has always done, he will follow the opportunities.

CHELSEA NEWBOLD
CSU MONTEREY BAY

Raised in Alabama until she was five, Chelsea Newbold lived across the street from cornfields. For a very long time, this was her closest connection to agriculture. Chelsea's family later moved to Pasadena, CA. where her love for science began. In high school, she worked at Cal Tech on a project aimed at finding alternative metals for use in solar panels. She began her college career at Pasadena City College where she took classes to prepare her to be a nurse. She soon realized she was not a people-person and concluded that becoming a nurse probably was not for her. Never the less, she wanted a future in science and to work in a lab and decided to look into other science fields and colleges.

Chelsea transferred to CSU Monterey Bay where the agricultural seeds were sewn. She met Dr. Tim Miles, an assistant professor whose research focused on plant pathology. Prior to meeting Dr. Miles, Chelsea did not know this specialized field existed, but the transition from general biology to plant pathology was not difficult for her. Protecting crops against pests is important for food security, and as a self-described social activist, this aspect appealed to Chelsea.

The fact that plant pathology has an extraordinary effect on society appealed to Chelsea since she describes herself as a social activist.



Chelsea worked on an ARI-funded project with Dr. Miles that if successful, would help protect plants against the pathogen *Phytopthora cinnamomi*, of the most devastating plant pathogens in the world. In California, the pathogen causes severe root rot in avocados, threatening production. However, pathogens are difficult to identify in time to effectively apply control measures. The objective of their project was to develop a low-cost, rapid, DNA-based method to detect *P. cinnamomi*.

CSU Monterey Bay has a robust undergraduate research program that promotes a research culture that motivated Chelsea to get up and go to school every day. Chelsea could see the impacts of her classes on her research, and she shared her research with other undergraduates who were similarly excited about science.

Chelsea received her bachelor's degree and in Spring, 2018, entered a master's program in plant pathology at Oregon State University. She will study powdery mildew resistance to fungicides to help manage this disease in table and wine grapes. Although she has not made up her mind, she is considering earning a Ph.D. with the ultimate goal of becoming an extension agent. In the meantime, Oregon seems like a good fit for her, because she is close to home and working on a project where she can combine lab and field work and interact with growers.

JIM NORRIS
CHICO STATE

California has, by far, the largest agricultural economy in the nation, made possible by having a dependable water supply for agriculture. On average, farms in California irrigate more than 9 million acres using water diverted from rivers, lakes, reservoirs and groundwater. That water is delivered to farms through hundreds of miles of aqueducts (e.g., California aqueduct) and canals.

Jim Norris, a second year master's student in Civil Engineering at Chico State University, has always had an interest in water. Originally, he thought about going to UC Davis for a hydrology degree, but decided a civil engineering degree would let him study what he wanted while likely leading to more job opportunities. Jim is a returning student, having spent 10 years working in retail and then wholesale management. Jim started at Butte Community College and transferred to Chico State, received a bachelor's degree in civil engineering in 2016 and started a master's degree in civil engineering, specifically in hydrologic modelling.

Jim, a second year master's student in Civil Engineering at Chico State University, has always had an interest in water.

Jim is in an interdisciplinary master's degree program that combines agriculture, geoscience and engineering. He has two advisors: Dr. Eric Houk, a professor in the College of Agriculture with expertise in water and agriculture economics, and Dr. Steffen Mehl, a professor in the College of Engineering with expertise in modelling hydrologic systems, including flow and transport, surface water and groundwater interactions, parameter estimations and uncertainty. This program allowed Jim to see how different disciplines work together and how different areas of expertise can complement each other's expertise for the benefit of the project. Jim thinks that the interdisciplinary program

allows a student to learn more broadly than one would in the typical single-discipline master's program. Jim noted the effort and cooperation it took to establish the project: Jim first brought the project to the local water district and finding they, too, were interested in the project he took it to Dr. Mehl and Dr. Houk; they turned it from a modelling project into a real-world project and found funding.

Jim's project is a result of the situation in California in which prolonged drought has increased the reliance of agriculture on groundwater. Using a process called managed aquifer recharge (MAR), Jim's project is examining the feasibility of recharging groundwater by purposefully ponding water in existing irrigation canals. Since climate models predict increased extreme precipitation events, this could also be a method to capture and conserve excess surface water. Once they finish the field trials in the Orland-Artois Water District, they will model the impacts of the MAR on groundwater recharge. If successful, the state may use its network to recharge aquifers in other irrigation districts across the state.

Jim will graduate in December 2018 with a master's degree in Engineering and a master's in Business Administration. After graduating, he plans to work as a professional engineer. He realizes that with his engineering background, internships and research, and an MBA specializing in project management, he might work with the state, perhaps with the California Department of Water Resources.

VICTORIA SMITH
CAL POLY SAN LUIS OBISPO

Victoria Smith has always been interested in science and medicine. In high school, she shadowed her uncle, a veterinary pathologist at UC Davis, and thought it was the coolest thing. Raised in Las Cruces, New Mexico (go Aggies!), Victoria dreamed about going to California and applied to Cal Poly, San Luis Obispo. As a pre-vet major at Cal Poly, she intended to be a veterinary pathologist, and got a job working in a lab on an ARI-funded project that focused on cheese quality. Drs. Rafael Jimenez-Flores and Rodrigo Manjarin were examining genes in cows that affect citrate production in milk. In naturally ripened cheeses, citrate levels are intricately tied to the flavor of the cheese. When citrate is too high, the coagulation of properties in milk are poor, interfering in curding and texture of cheeses. They identified mutations in key genes and then looked at Holstein cows to see how those mutations affected citrate content.

Victoria has gained a lot of research experience in genetics and biochemistry as both an undergrad and master's student, which is unique.

Victoria started a master's program with Dr. Manjarin on his ARI project to study the effect of probiotics and high fructose supplementation on non-alcoholic fatty acid disease (NAFLD) using early weaning Iberian pigs as a translational model. High carbohydrate, low-fat diets are associated with NAFLD, an increasingly prevalent liver disorder in children that significantly increases the risk of developing long-term liver diseases. It is an open question to what degree high fructose contributes to these poor outcomes. In pig production, newborn pigs are weaned early to increase sow productivity, and the piglets are given sweeteners to increase their appetite. As a result, their gut microbiota becomes out-of-balance and they get diarrhea. Probiotics may help protect against diarrhea and result in better piglet health and growth. This research will help understand how diets and probiotics regulate gut-liver interactions so recommendations can be made that lead to better pediatric health and piglet growth.

Victoria started thinking about going to medical school so Dr. Manjarin suggested she do an internship in a lab doing human medicine to see if she liked it. During her junior year, she landed an internship with Dr. Douglas Burrin in the Children's Nutrition Research Center at the Houston Medical Center. There she worked on establishing the role of an essential amino acid, its metabolic precursor, and a signaling molecule (nitrous oxide) in the development of gastrointestinal (GI) abnormalities in premature infants. Victoria did a second internship in her senior year with Dr. Burrin.

Victoria gained valuable research experience in genetics and biochemistry as both an undergrad and master's student. She mentioned that when unexpected results appear in research, you have to think more about it and start reading scientific papers to increase your knowledge. Her research has taught her the value of persistence, patience, and how to troubleshoot.

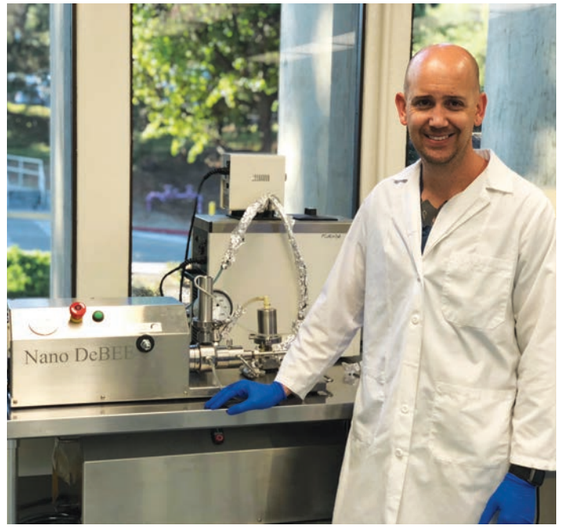
Victoria is applying to medical schools in California, along with Baylor, Harvard, and Yale. She wants to continue to study pathology because it is like unraveling a mystery by studying the clues and designing experiments to see if the results fit the hypotheses.

BENJAMIN STEINER
CAL POLY POMONA

As a community college student at Victor Valley, Benjamin Steiner found his love for chemistry. Throughout his undergraduate education, both at Victor Valley Community College and Cal Poly Pomona, Ben served as a teaching assistant, helping to run the chemistry labs at Victor Valley while later teaching nutrition courses during his master's program. By the time he transferred to Cal Poly Pomona, Ben's chemistry knowledge and lab skills were far above that of any undergraduate student.

When he transferred to Cal Poly Pomona, he enrolled in the dietetics program and dove right into taking the difficult and challenging upper level chemistry courses and other courses required by the dietetic curriculum. The chemistry courses convinced him this was exactly what he wanted to do for a career. When Ben started taking counseling courses, which are a part of the dietetics program, he learned how to convey the message to his clients to eat healthier. After taking these courses, he realized a career in dietetics would not encompass the level of science he envisioned. He decided to complete the dietetics program, but a desire for in-depth knowledge and the thrill of discovery appealed to him. He realized a master's degree in food science would be a better fit for him, and this could be the bridge between chemistry and dietetics.

At Cal Poly Pomona, Ben was introduced to Dr. Gabriel Davidov-Pardo, an assistant professor in the Nutrition and Food Science department. After discovering how much chemistry was used in Dr. Davidov-Pardo's research and how interesting he found it, Ben decided to join the research team. Dr. Davidov-Pardo also found Ben's lab experience very attractive, so it was a good match. Ben's project focused on stabilizing lutein, a carotenoid related to beta-carotene and vitamin A often sold as a botanical for eye health. Lutein is not particularly stable, and is also hydrophobic. Many pharmaceuticals have these properties and the solution is often to encapsulate the compound to improve stability and dispersion of the compound and to increase its release within the gastrointestinal tract. To further enhance these properties, other compounds can be added. In this case, Ben wanted to test if resveratrol or various "Maillard conjugates" could improve the stability of the encapsulated lutein. Simply put, Maillard reactions combine a protein and a carbohydrate, which together confer different, but complimentary, advantages to the encapsulated compound. Clearly, this project was all about chemistry!



Ben completed his degree in June 2018, but long before he defended his thesis, there was no question he wanted to pursue a Ph.D. program. In the fall of 2018, Ben started a Ph.D. program at Cornell in the Division of Nutritional Sciences with a molecular nutrition concentration. As someone who earlier never imagined he would even finish an undergraduate degree, he now says he cannot wait to teach at the university level.

Benjamin realized a master's degree in Food Science could be the bridge between chemistry and dietetics.

ALLEN VIZCARRA
FRESNO STATE

Allen Vizcarra received his undergraduate degree in plant sciences with a plant health option from Fresno State University. He is currently working on his master's degree. Allen comes from a family who farms almonds in Chowchilla, but when he first enrolled in college, his major was criminology. After taking a few plant science courses, he found that he really enjoyed them and could relate this information back to his farm. The turning point for him was a soil-water class during which he became fascinated with all the biological and physical processes going on in the soil.

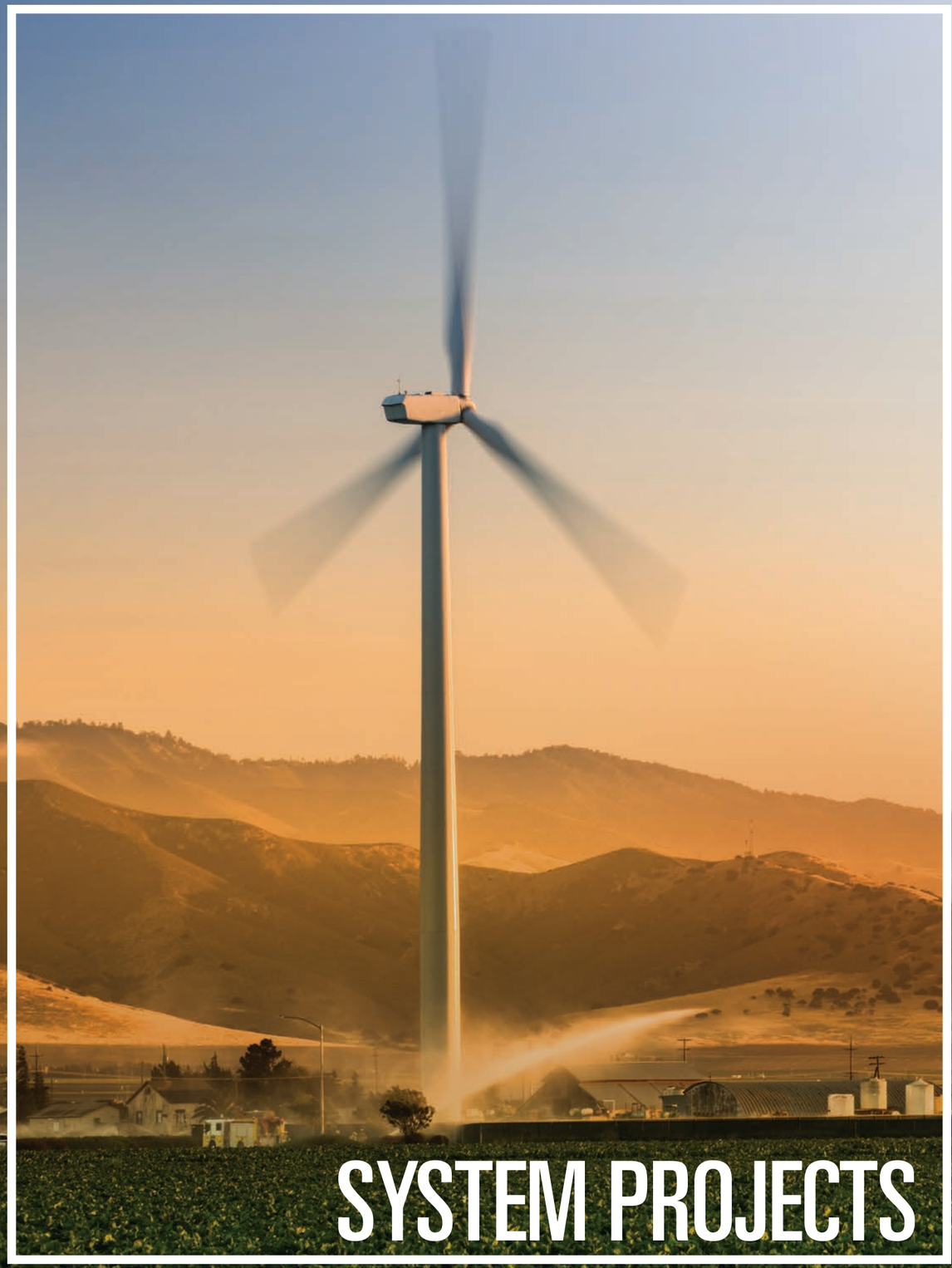
Allen is working on an ARI project with Dr. John Bushoven, Professor and Chair, of the Plant Sciences Department at Fresno State, and Dr. Bilruba Yeasmin, a Research Scientist at the Center for Irrigation and Technology. Their objective is to evaluate and develop ground-penetrating radar (GPR) technology to map plant root systems. Tree root systems are important to the health and growth of trees, but studying roots non-destructively and non-invasively is difficult. Allen states that roots carry a lot of information about the plant that could be used to understand the factors that determine a tree's architecture and plant health. However, if you disturb the soil to study roots, you are no longer studying a natural system and the roots may not grow as they would in their native state. This makes it difficult to conduct research and reach valid conclusions regarding how roots respond to water and fertilizers, knowledge that would be useful for agricultural production and crop management.

Allen aspires to become a farm advisor where he can help farmers use the local resources efficiently and sustain agriculture for the Central Valley well into the future.

Allen Vizcarra and Dr. Dilruba Yeasmin

Currently the team is ground-truthing the GPR technology, that is, making sure the roots are where the radar indicates they are. They have verified that the radar can detect roots larger than your pinky finger, map the roots in three-dimensional space, and can detect roots several feet down in the soil.

Allen currently works for the University of California cooperative extension. Once he graduates, Allen would like to be a farm advisor and help local farmers find the best solutions to their problems using their resources efficiently and help them sustain agriculture for the Central Valley well into the future. Allen believes cooperative extension fulfills an essential bridge between the work of research scientists and practitioners that is fundamentally important to support and sustain agriculture. Allen hopes to be an integral part in the agricultural industry and help propel the industry forward by providing the highest quality research, knowledge and tools for farmers to sustain California's world-class agriculture.



SYSTEM PROJECTS

SYSTEM PROJECTS

The CSU system contains talented faculty from diverse agricultural and non-agricultural disciplines who can contribute toward creating more resilient and sustainable food and agriculture systems in California. Solving the challenges facing agriculture requires diverse ideas, disciplines, and backgrounds. To access this pool of talented faculty and students, the ARI system competition was opened to the 17 non-ARI campuses. The FY 2017-2018 funding cycle marked the first time these campuses could directly apply for funding. Mulitple proposals were received from non-ARI campuses, and one of the three projects that received an award this year was from a non-ARI campus (CSU Los Angeles).

The FY 2017-2018 funded projects tackle long-standing issues with fresh appraoches For example, the persistence of pesticides in the soil, how best to raise poultry, and what to do with rice milling byproducts are issues as old as the industries themselves.

A team led by Dr. Nathaniel Jue will use metagenomics to characterize soil microbial communities and explore the biology underlying the ability for microbes to degrade pesticides. Animal welfare and economic efficiencies will be brought into the poultry production question in a project led by Dr. Katy Tarrant. The third project is led by Dr. Jing Zhao, who along with her team, will develop rice protein-based food products for humans to help add value for rice producers.

Also notable, is that each faculty member receiving the award is an assistant professor just starting their CSU career. The future of ARI research depends on identifying and supporting junior faculty who have a passion for research and who share our commitment to making California's food and agriculture systems more resilient and sustainable.

DR. NATHANIEL JUE
CSU MONTEREY BAY

Project Title: Microbes Relevant to Agricultural Specialty Crops Grown On California's Central Coast

Co-Investigators: Arlene Haffa (CSU Monterey Bay); Jonathan Geller (San Jose State)

ARI funding commitment: $296,090; Matching Funds: $360,498

Pesticides are widely used to control insects and diseases in crops. While there is great economic benefit to using pesticides, many persist in the soil. According to the California Department of Pesticide Regulation (CDPR), over 1 billion pounds of pesticides were sold in California in 2017. While a relatively small portion of these pesticides (<5%) are classified as cholinesterase inhibitors or as causing cancer or reproductive toxicity, their persistence in the soil is cause for concern. Pesticides can be degraded to less harmful compounds through exposure to sunlight, chemical degradation and by naturally occurring soil microbes. Precisely because microbes are diverse and possess the mechanisms to live in almost any environment (e.g., extremophiles), they offer a promising approach to mitigate residual pesticides in the soil.

The soil microbial community supports and perhaps drives agricultural and natural ecosystems. Through their role in nutrient cycling and maintaining soil structure, microbial communities are key to the overall health of agricultural soils. Because most microbes cannot be grown in the laboratory, a complete catalog of the organisms in the soil is far from complete. Instead, most of the microorganisms living in the soil can only be identified through sequencing the nucleic acids of the organisms present in soils and analyzing those data with bioinformatic algorithms to identify taxa. A team led by Dr. Nathaniel Jue will use metagenomics and bioinformatics to characterize the microbial communities associated with agricultural soils and wastewater. While Dr. Jue brings sequencing and bioinformatic expertise to the project, Dr. Arlene Haffa brings expertise in microbiology and bioreactor design and implementation, and Dr. Jonathan Geller is an expert in ecological genetics and biodiversity. Using a variety of sequencing techniques, P.I. Jue and his team will identify naturally occurring pesticide-degrading bacteria and discover genes and metabolic pathways that allow these bacteria to live in pesticide-laden soils. The team will use metagenomic sequencing to characterize microbial communities by sampling at pesticide-monitoring sites established by the CDPR. These sites are located along agricultural production areas and adjacent waterways in Salinas and Monterey and therefore have varying amounts of residual pesticides in the soil. The metagenomic data from these sites will allow Jue's team to characterize the microbial communities to understand the agroecology of these sites and draw inferences about the status of these production areas.

The data from this project will help develop bioreactors that will be used to mitigate pesticides in soils under agricultural environments. Their work should also help characterize microbial communities that are the hallmarks of a healthy soil ecosystem and develop soil management systems to help sustain agricultural production in the state.

Left, Arlene Haffa; Right, Nathaniel Jue.

DR. KATY TARRANT
FRESNO STATE

Project Title: Evaluating environmental enrichment structure design and implementation for conventionally-raised broiler chickens.

Co-Investigators: Shawna Weimer (Purdue University); Darin Bennet (Cal Poly, SLO); Sara Shinn (Fresno State)

ARI funding commitment: $343,196; Matching Funds: $360,000

Over the last two decades, American dietary preferences have shifted from beef to chicken. Americans, on average, consumed about 64 pounds of chicken and 275 eggs in 2017. California raises millions of chickens each year, and California consumers are increasingly concerned about standards of farm animal care and welfare. Paths to increase animal welfare have sometimes been voluntary and at other times it is a result of legislative action. For example, California Proposition 2 and AB 1437 redefined minimum standards for laying hen confinement and banned the sale of eggs that do not conform to Proposition 2 standards, respectively. Other welfare initiatives are likely to advance, and research addressing animal welfare is needed to provide data to help guide public policy and provide best management practices for industries.

Conventional production methods produce chicken protein at minimal costs. An affordable price-point after implementation of additional welfare standards is a key consideration in selecting enrichment methods. Dr. Katy Tarrant, an assistant professor in animal science at Fresno State University is conducting research in improving welfare standards in broiler chicken production. The goal is to strike a balance that materially improves animal welfare but is economically viable for the producer to sell chicken at a price point that is affordable to consumers. Along with her collaborators from Purdue University and

Foster Farms, Dr. Tarrant will develop and evaluate enrichment platforms for production facilities. The platforms will be evaluated using multiple health parameters described in the Welfare Quality Assessment protocol for poultry, along with measures of physiological and behavioral changes in the chickens. During the second phase of the study, she and her team will assess the ease of installing and maintaining these structures and assess the economic outcomes of large-scale implementation.

Consumers will provide the ultimate measure of the success of improving animal welfare. For example, egg prices increased ~22% after implementation of Proposition 2 but egg consumption did not decrease in response to the price increase. In the last stage of her study, Dr. Tarrant will implement a customer survey to understand purchasing behavior and willingness to pay for chicken raised at a higher welfare standard.

DR. JING ZHAO,
CAL STATE LOS ANGELES

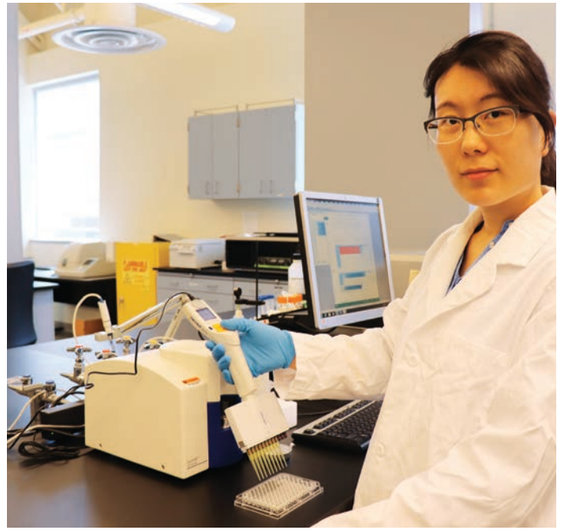
Project Title: Improving the functionalities and applications of rice protein ingredients

Co-Investigators: Changqui Liu, San Diego State University; Yao "Olive" Li, Cal Poly Pomona

ARI funding commitment: $150,000; Matching Funds: $165,681

Food scientists often create new products from food byproducts, adding value to the commodity, improving profits, and lowering food waste. In California, rice is a leading commodity worth $800 million annually. During rice milling, the bran (i.e., aleurone and pericarp of the seed) and husk (lemma and glumes) are separated from the rest of the seed, and what is left is largely the starchy endosperm. The waste products (rice bran and cracked grains) are used in animal feed and sold at relatively low prices.

A team led by assistant professor Dr. Jing Zhao of California State University, Los Angeles, will work to transform rice bran and rice protein into protein-rich food products. Many steps, however, lie between the raw materials (rice bran and rice dreg flour) and a finished product that will be accepted by consumers and commercially marketed. Dr. Zhao, with expertise in food chemistry, will use different extraction methods to maximize yield and maintain properties of the rice protein that allow development into a rice-based food product. She will characterize the physicochemical and functional properties of the different rice bran protein concentrates. Dr. Changqi Liu, an expert in protein chemistry, will provide the chemical and amino acid analyses of the different protein



concentrates. The team will use the food engineering and processing expertise of Dr. Olive Li to help develop pasta-based products from the different rice protein concentrates. Dr. Li's group will substitute a portion of pasta flour with different rice protein concentrates. Different extrusion methods will be used to change the physical, textural and organoleptic properties of the finished product – i.e., pasta fortified with rice protein. Finally, a sensory panel team will evaluate the different pasta formulations and the shelf life of the products will be measured.

"If a product is well received by the taste panel and has an acceptable shelf life, there is potential to develop and market new products. Consumers will benefit from new and healthy products while the value of rice bran would increase.

STRATEGIC OBJECTIVES

STRATEGIC OBJECTIVE 1

Invest in applied research to address emerging and high-priority issues facing California agricultural and natural resource industries.

During FY 2017-2018, ARI expenditures across the six ARI campuses totaled $3.911 million. These funds were matched with another $4.092 million from industry, state and federal sources to support these ARI projects. Research budgets are commonly organized into six categories that include salaries, benefits, equipment, travel, supplies and "other". Note that the ARI does not allow indirect costs to individual grants, and thus no indirect cost category is used. The greatest portion (55%) of the ARI budget was used to support the collective effort of faculty, students, post docs and technicians to conduct ARI research (Figure 2). Lab supplies and "other" (primarily payments to outside vendors and contractors) comprised 17% and 12%, respectively, and were the second and third highest expenditure categories. Nine percent of the ARI budget covered benefits (primarily for faculty), while 4% and 3% of the budget was directed toward travel and equipment, respectively (Figure 2). The budget from FY 2017-2018 was similar to last year's budget, with slight deviations. Compared to last years' budget, salary expenditures declined by 7% and supplies and "other" categories increased by 4% and 8%, respectively.

Campus expenditure data of the six budget categories are given to provide an overview of how each campus expended their allocation (Figures 3A to 3F). The expenditures are a composite of faculty budgets and reflect, to a degree, how research is implemented on each campus. The data indicate appreciable inter-campus variation in expenditures within the six categories. For example, overall, 55% of the ARI budget was spent on salaries, but salaries ranged from 31% to 70% of the total campus budget for CSU Monterey Bay and Chico State, respectively (Figure 3A). While benefits are often a large percentage of a total compensation package for faculty, benefits averaged across all campuses were only 8% and ranged from 6% to 13% (Figure 3B). Supplies varied by nine-fold across the six campuses (range of 3% to 27%; Figure 3C) while both Humboldt State and Cal Poly Pomona used 6% of their campus budget to purchase equipment (Figure 3D). Other direct costs include sub-contracts to other campuses (for example, Monterey Bay, 53%), or outside services, like sequencing or isotope analyses (for example, Pomona, 20%; Figure 3E). A relatively small portion (4%) of the overall budget was used to support travel to conduct research in the field and attend meetings. This varied from a low of 1.7% to 6.5% of the campus budget for Monterey Bay and Humboldt, respectively (Figure 3F).

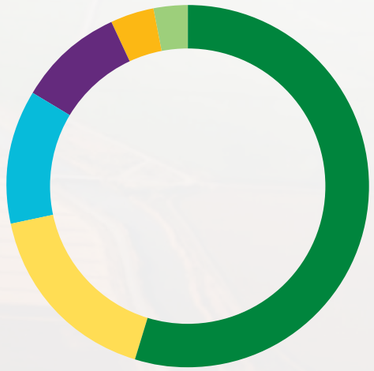


Figure 2.
Expenditures for the ARI program during FY 2017-2018 across the six Member and Associate campuses in support of the ARI research mission to conduct applied research in agriculture and natural resources.

- **$2,143,959** Salaries 55%
- **$660,246** Lab Supplies 17%
- **$468,905** Other 12%
- **$374,348** Benefits 9%
- **$154,524** Travel 4%
- **$109,160** Equipment 3%

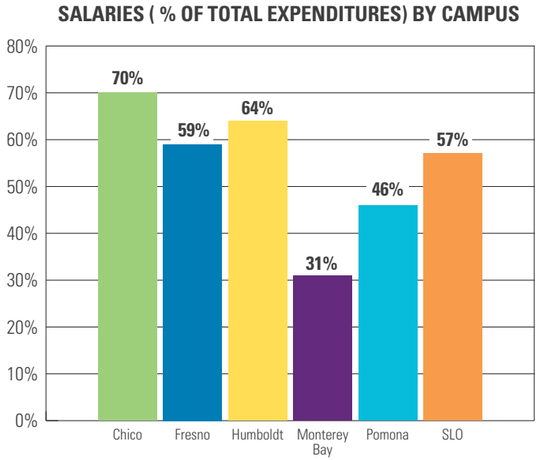


Figure 3A. Salary expenditures, by campus.

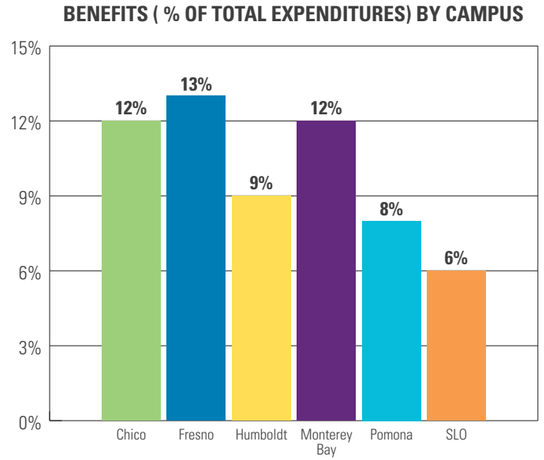


Figure 3B. Benefit expenditures, by campus.

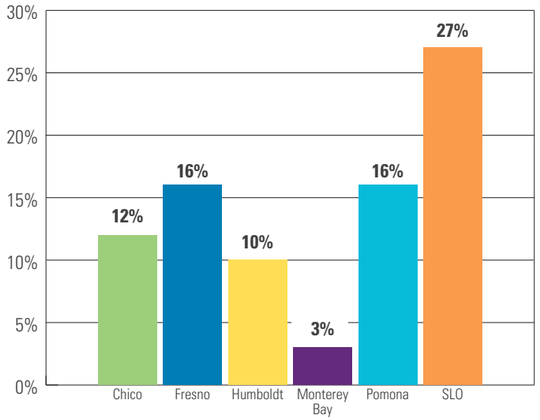


Figure 3C. Supply expenditures, by campus.

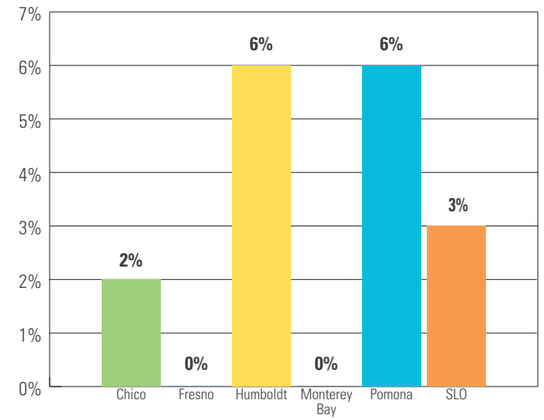


Figure 3D. Equipment expenditures, by campus.

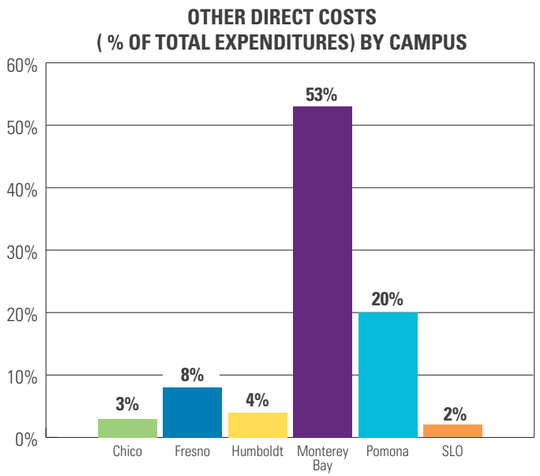


Figure 3E. Other direct costs, by campus.

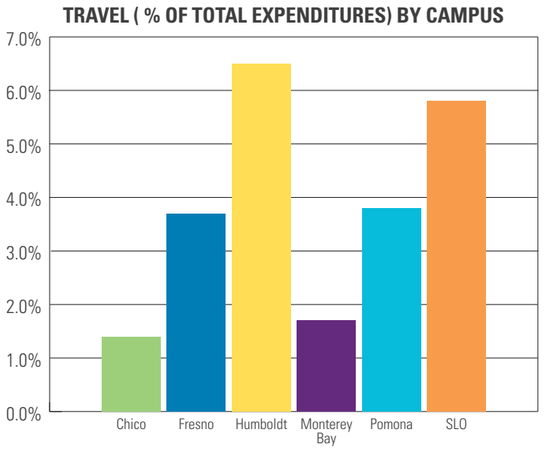


Figure 3F. Travel expenditures, by campus.

Salary expenditures totaled approximately $2.4 million across the six campuses and were categorized and tracked to differentiate among tenure-track faculty, postdocs/technicians and different types of student support (Figure 4). Three campuses (Humboldt, Monterey Bay and SLO) reported no (or essentially zero) release time for faculty during the academic year (Figure 5A). Instead of release time, most faculty opted for additional employment, which averaged 17% across the six campuses and ranged more than six-fold, from 6% to 37% of the total budget (average 17%; Figure 5B). Most faculty employ students to assist with research projects and this allows students to get more involved with their discipline. On average, the campuses allocated 18% of their budget to support students through wages, and that ranged from 7% to 24% (Figure 5C). While land grant and research universities often provide tuition reimbursements to support graduate students, mostly PhD students, only two campuses, Monterey Bay and SLO, provided significant student support through tuition reimbursement with expenditures of 15.3% and 6.7% of their total budget (Figure 5D).

A few laboratories have postdoctoral scientists or technicians supported, in part, with ARI funds. These scientists often participate in student training and typically conduct the highly technical components of the research. This year, approximately 6% of the total ARI expenditures provided financial support to those scientists, with a range of 0% (Chico State) to 19% (Humboldt State; Figure 5E). While expanding the technical capabilities of the research to the benefit of the project, at the same time, this opportunity provides experience, training, and often teaching opportunities to enhance the career of those scientists as they seek permanent positions.

The salary category "other" represents 3% of the salary expenditures and captures those employees that did not fall neatly into a well-defined category, for example, those that worked on a project, either intermittently or less than a full-time basis. This category was primarily used by Chico State and Fresno State (Figure 5F).

Figure 4.

Detailed salary expenditures for the ARI program during FY 2017-2018 summarizing the six ARI campuses, including system funding.

- **$721,821** Faculty AE 34%
- **$709,666** Student Salaries 33%
- **$257,324** Faculty Release 12%
- **$247,324** Tech/PD/Adjunct 11%
- **$103,917** Tuition Reimbursement 5%
- **$103,907** Other i.e. Intermittent Salaries 3%

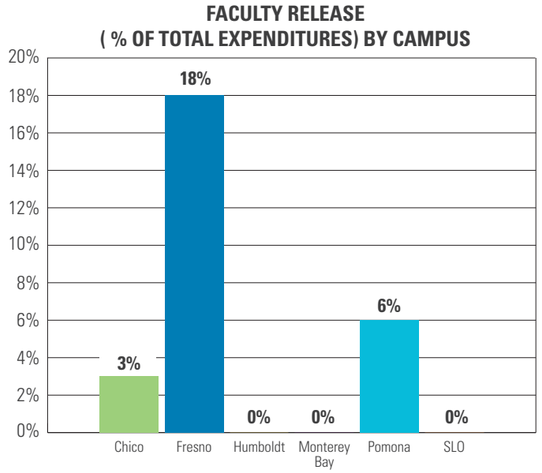


Figure 5A. Faculty release, by campus.

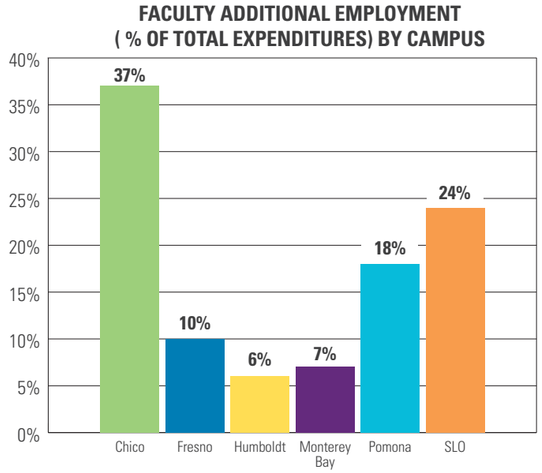


Figure 5B. Faculty additional employment, by campus.

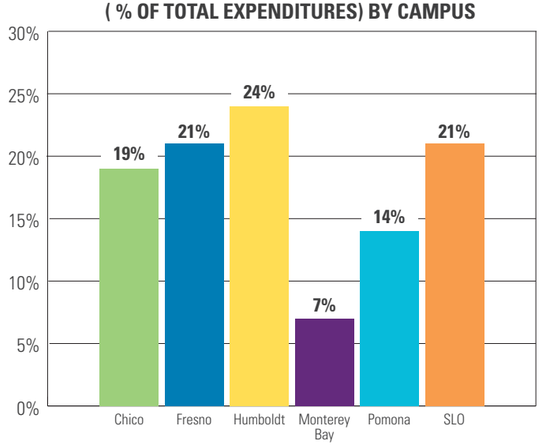


Figure 5C. Student salaries, by campus.

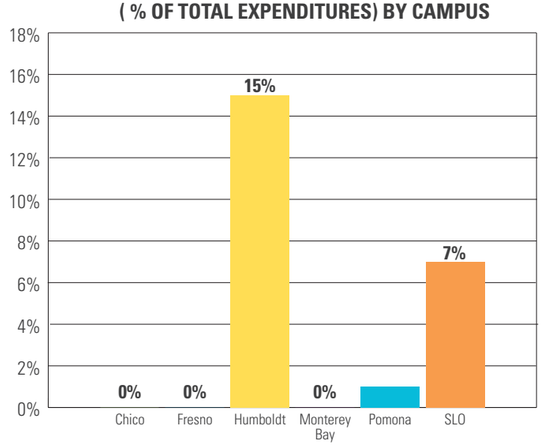


Figure 5D. Tuition reimbursement, by campus.

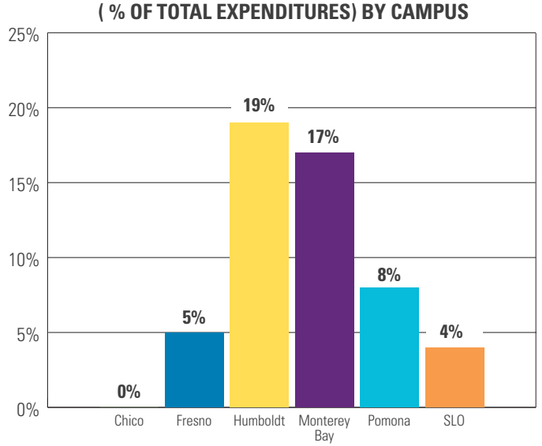


Figure 5E. Salaries paid to technicians, postdocs (PD) and adjunct faculty, by campus.

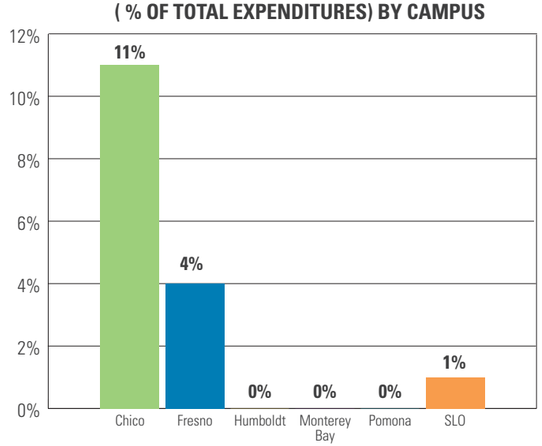


Figure 5F. Other, intermittent, by campus.

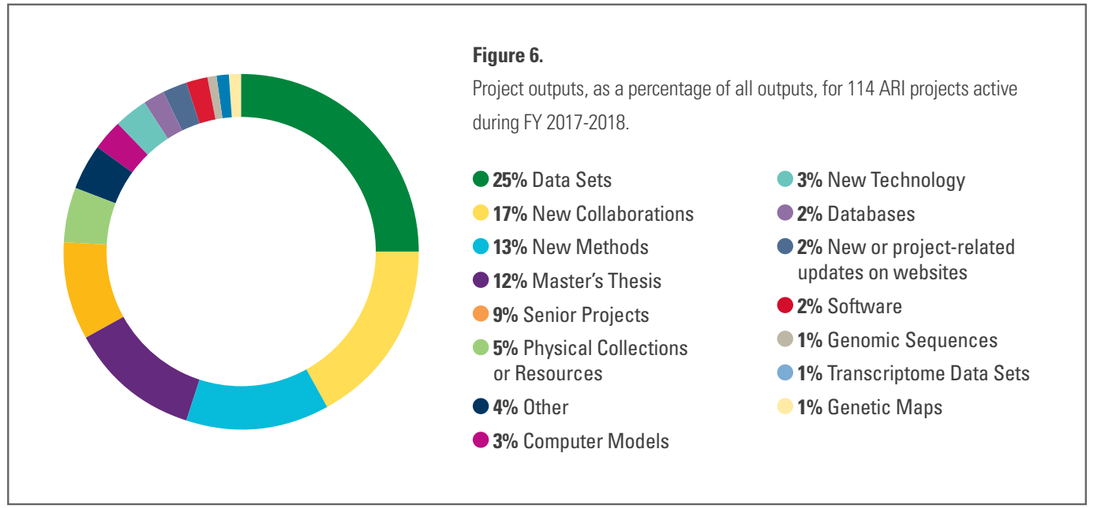


Figure 6.
Project outputs, as a percentage of all outputs, for 114 ARI projects active during FY 2017-2018.

ARI Outputs and Activities

The diversity of projects is reflected in the titles of the 114 active projects supported by the ARI during FY 2017-2018. The most common activity across the ARI project landscape was "analyzing data", reported in 76% of the projects, followed by "conducting experiments", reported in 69% of the projects, with a range from 84% (Pomona) to 40% (Chico). Collaborations among scientists helps drive new technologies and methods that are needed to solve problems. This is especially true with interdisciplinary collaborations between faculty trained in agriculture and those from allied disciplines that can support agriculture. These include engineering, data science, artificial intelligence, sociology, etc. Toward that purpose, 17% of the projects reported establishing new collaborations and 13% reported developing new methods (Figure 6). In addition, in 21% of the active projects, students used ARI supported research to fulfill their degree requirements, either through senior projects (9%) or a master's thesis (12%; Figure 6).

STRATEGIC OBJECTIVE 2

Develop a highly-trained professional workforce for California agricultural and natural resource industries through student participation in research projects.

Students working on ARI projects learn research skills and use critical thinking to solve problems. This approach prepares our students for careers in the California agriculture and natural resource industries.

A strength of the ARI is that students receive training in critical thinking skills. Discovery-based research provides the best format for students to practice critical thinking, and this is best learned through practice. Each student who is deeply involved in a research project will learn first-hand that research projects do not always go as planned, that problems have to be solved, and they will likely need to read the literature to help them figure things out and interpret results observed in the experimental data. Research produces data, generates new ideas, tests standing hypotheses, and develops new knowledge and hypotheses. Our students are involved in every aspect of the research, and critical thinking is part of each stage. Thus, research is a value-added component to their education, and one not easily duplicated through other avenues. Students involved in research are far more likely to graduate, have higher grade-point averages, enroll in graduate school, be employed in a major-related career, and obtain an advanced degree.

Most faculty recruit and train students to work on their ARI research projects. A majority (81%) of the ARI projects trained or supported students, with a total of 469 undergraduate students receiving science training, ranging from 9 students at Monterey Bay to 189 students at Cal Poly SLO (Figure 7A). A total of 108 graduate students worked on ARI projects, ranging from 4 at Monterey Bay to 37 at Cal Poly Pomona (Figure 7B).

As part of their training, students are involved in experimental design, obtaining and analyzing data, presenting at conferences, and gaining experience in writing a peer-reviewed manuscript. In fact, 19 students were co-authors on 13 of the papers published by ARI researchers this year. The research culture is further instilled in students when they participate in professional or grower conferences. This year, 45% of the projects reported that a total of 51 students attended or presented their ARI-sponsored research results at a conference or symposium. Ideally, research generates new ideas and new information that is not in text books or has not made it to a publication. In 54% of the projects, the knowledge and information generated in ARI-sponsored projects was brought into the class room, enhancing instruction and keeping both students and faculty engaged, motivated, and informed. Across the CSU system, almost 75% of CSU students work more than 20 hours per week, mostly off-campus and often in a job not related to their field of study. Student salaries comprised 18% of the ARI FY 2017-2018 expenditures and were used to support 179 students at an average wage of $3,965 per student.Students received almost 53,000 hours of paid training across all six ARI campuses (Figure 7C). Students who get involved in ARI projects are often engaged in research that takes place on-campus, and most importantly, gain knowledge and experience that are directly relevant to their future career. Faculty reported a higher number (577) of students who were trained in their projects than were supported by a wage. The higher figure represents those students who volunteered and were not paid, and it also includes students who worked on multiple ARI projects and were therefore counted multiple times.

The CSU is one of the most ethnically and racially diverse university systems in the U.S. More than one-third of the CSU's entering freshmen are among the first generation of their families to attend college and 60% are students of color. Of the 114 assessments returned, faculty reported they employed first-generation students on 39 projects (34%). While faculty of 19 projects affirmed they had not hired first-generation students on their project, another 59 (52%) indicated they never had that conversation with their students.

Students under-represented in the sciences (Hispanic, African-American, American Indian, Alaska Native, Native Hawaiian, and other Pacific Islanders) were employed in 51 (45%) of the projects according to faculty-reported data. Another 25 projects affirmed they had not hired under-represented students, and faculty reported that for 25 (22%) projects, they never had that conversation with their students.

By working on ARI projects, students are able to spend time with faculty outside the classroom. Importantly, they may ask and receive advice from faculty about careers or how to get into a graduate program. For many first-generation college students, these faculty may be their best or only resource for this information. Many of our faculty are themselves first-generation students and can personally relate to the student's background.

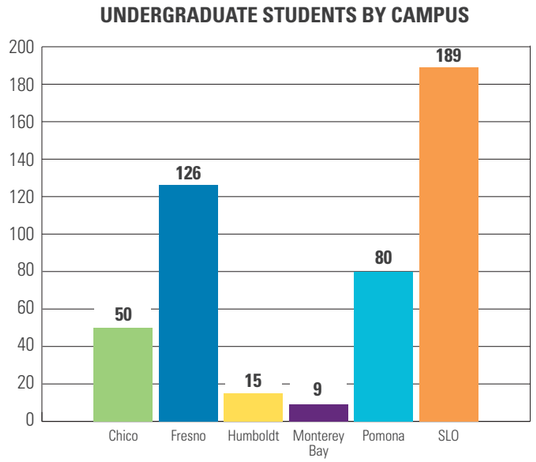


Figure 7A. Number of undergraduates trained, by campus.

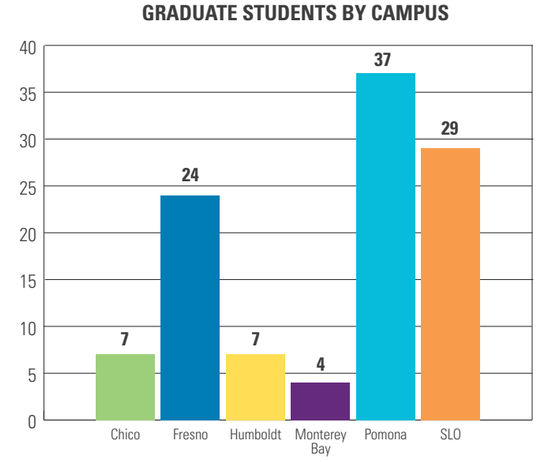


Figure 7B. Number of graduate students trained, by campus.

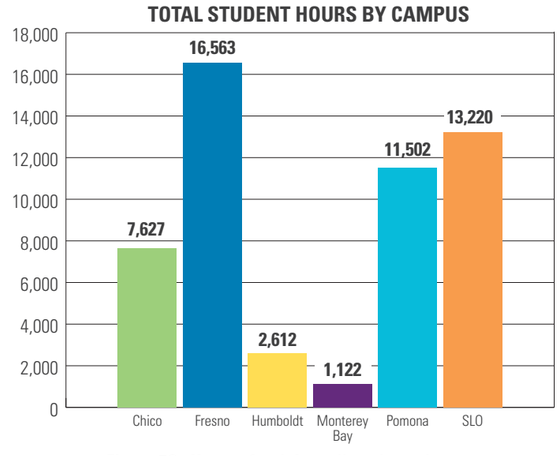


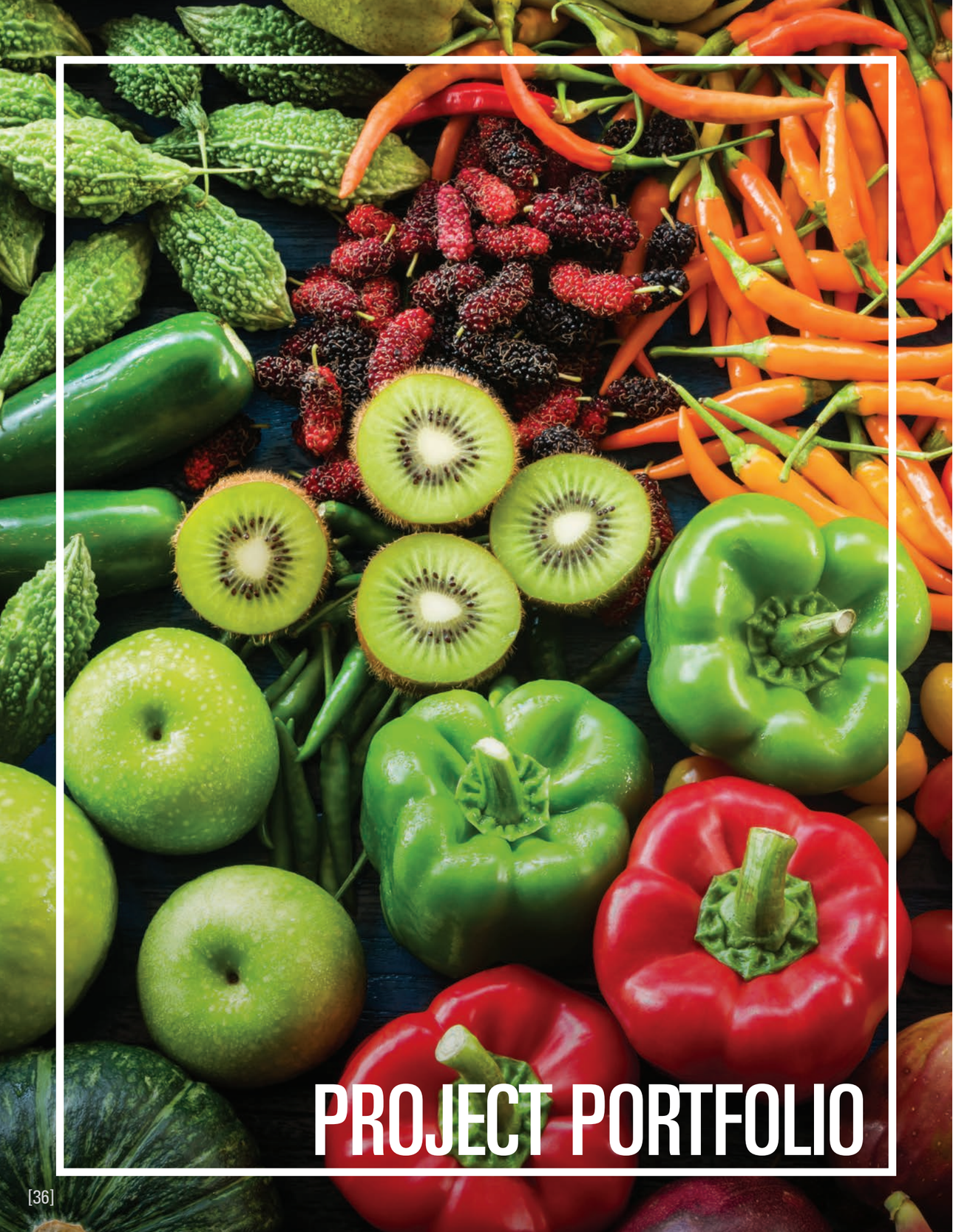
Figure 7C. Hours of training, all students, by campus.

STRATEGIC OBJECTIVE 3

Communicate research results to industry stakeholders, scientists and the public.

A total of 13 peer-reviewed manuscripts were published as a science journal paper, book chapter, book or trade journal for publication during this reporting period. Faculty presented 157 posters or made oral presentations at scientific meetings, industry meetings, or symposia. Clearly, professional discipline-specific conferences attended by faculty and students allow exchange of scientific ideas. During these meetings, faculty are exposed to a wide array of new ideas and advances in technologies. Importantly, these meetings are a great networking opportunity allowing faculty to make collaborations and students often establish a connection with a professor from another institution and end up in their lab for graduate school. While many industry personnel attend professional society meetings, many more attend industry meetings. It is during these meetings where practical and actionable knowledge and ideas from ARI projects find their largest audience.

Faculty from a total of 18 projects (16% of the 114 projects in which assessments were received) reported they participated or hosted a total of 30 field days or workshops for industry and the public. These faculty estimated that over 2,028 people received information or instruction by attending these events. These outreach activities are important since they directly target the growers or ranchers that are the direct consumers of this knowledge and whose practices may benefit from this ARI-generated data and information.



PROJECT PORTFOLIO

ARI RESEARCH PROJECT PORTFOLIO

ARI faculty conducted research to address the most pressing issues facing California agriculture and natural resources.

The diversity of research being conducted by ARI faculty and students is impressive. While the majority of the projects funded during the last year were centered on water issues, they also included improving food security, improving nutrition, developing new products and applying new technologies to solve long-standing problems in water and fertilizer management. Faculty participating in the research were from colleges of agriculture, business, engineering, humanities and science. Many of the projects utilize collaborations between disciplines as well as colleagues from the University of California, the USDA and other federal and state agencies. It is hard to escape the fact that many of the projects are in response to the effects of global warming and climate change on California's natural resources, agriculture and food systems. Opportunities and challenges lie at every step of the process of protecting our natural resources and ensuring a resilient food system.

Principal investigators of 78% of the 114 projects strongly agreed that ARI funding allowed them to create new knowledge and establish new collaborations. Faculty in 40% of the projects created the initial data that is needed to seek other funding, especially from federal agencies and another 27% of the faculty reported they used ARI-funded projects to help meet tenure and promotion requirements. Faculty almost unanimously report that ARI funding helped improve their research capabilities through improving their grantsmanship and by receiving additional training. In summary, the data indicate that faculty enjoy the opportunity to conduct research and see the ARI as an important vehicle that allows them to both teach and conduct research. In fact, 74% of the faculty reported that ARI funding was a contributing factor in their decision to accept CSU employment at the time of hire, and 86% indicated that ARI funding is a contributing factor for them to remain at the CSU.

Table 1. Funding amounts, average duration of award, average total funding commitment and the average funding per year for each campus or system competitions for FY 2017 – 2018.

Campus or System	Average duration (Years)	Average total funding commitment	Average funding commitment / year
System	3.0	$373,993	$124,664
Chico	2.2	$244,080	$110,946
Fresno	2.2	$101,622	$45,555
Pomona	1.1	$26,806	$24,369
San Luis Obispo	2.2	$84,461	$38,144
Humboldt	2.6	$45,818	$17,622

During FY 2017 – 2018, 50 campus and two system competitive grants were awarded across Member and Associate campuses. Although the ARI receives state allocations on a year-to-year basis, the ARI conditionally commits funding projects for up to three years. The average funding duration of a system project for FY 2017-2018 awards was three years and with an average total commitment of $373,993, which is an average yearly commitment of $124,664 (Table 1). The average project duration for campus projects awarded during FY 2017-2018 was 2.1 years with a range of 1.1 to 2.6 years (Pomona and Humboldt, respectively). Although Associate ARI campuses are funded through the Chancellor's Office, these campuses, awarded multi-year projects, a first, for these campuses. There are many advantages to multi-year projects: they help faculty build program capabilities; provide program and project continuity; allow a Principal Investigator to spend more time working on research rather than writing grants; and, lower work-loads for proposal review committees and administrators. The average annual campus funding per project ranged from $17,622 to $110,946 for Humboldt and Chico, respectively, while average total funding ranged from $26,806 to $244,080 for Pomona and Chico, respectively (Table 1).

RECIPIENTS OF FY 2017-2018 ARI GRANTS

SYSTEM

Project Director	Project Title	Duration (Years)	2017-18 Allocation	Total ARI Commitment
Brar, Gurreet	Determination of long term threshold limit for using saline water on pistachios	3	$104,788	$298,114
Cassel Sharma, Florence	Lysimetric determination of evapotranspiration coefficients for drip-irrigated vegetables	3	$149,921	$449,871
	total:		**$254,709**	**$747,985**

CHICO

Project Director	Project Title	Duration (Years)	2017-18 Allocation	Total ARI Commitment
Houk, Eric	Local food in northern California: estimating consumer preferences and cost minimizing food budgets	2	$47,251	$95,780
Carroll, Christine	Fact or fiction: benefits and costs of food labeling in California	1	$5,000	$5,000
Ataie, Feraidon	Improving alkali activated metakaolin properties using rice straw ash	2	$14,684	$29,440
Rosecrance, Rich	Tree hedging and topping management strategies to optimize yield in table olive orchards	3	$45,185	$136,405
Chao, Michael	Comparison of nutrient composition, quality, and sensory differences among dorper, domestic commercial crossbred and australian commercial lamb meat	1	$17,508	$17,508
Houk, Eric	Improving water management through managed aquifer recharge using surface water canals	2	$64,673	$113,725
Daley, Cindy	Effects of compost on soil health, pasture productivity, and carbon sequestration in rangeland grazing systems	3	$68,307	$194,669
Ataie, Feraidon	An extensive study on utilization of rice straw ash in concrete	3	$35,794	$84,944
	total:		**$298,402**	**$677,471**

FRESNO

Project Director	Project Title	Duration (Years)	2017-18 Allocation	Total ARI Commitment
Ashkan, Shawn	Development of variable rate irrigation techniques to optimize application of water and nutrients	2	$38,388	$74,376
Ellis, Margaret	Development of a DNA extraction method from epidemiologically meaningful amounts of soil for quantification of nematodes using quantitive PCR	2	$20,915	$42,979
Goorahoo, Dave	Airjection irrigation impact on oxidative stress in vegetable and on soil nitrogen cycle gene communities	3	$61,995	$185,985
Gu, Sanliang	Using internet of things and big data analytics to improve WUE in vineyards	3	$27,500	$87,500
McKeith, Amanda	Investigation of the best practices to innoculate whole muscle and ground beef and pork products	2	$15,000	$30,000
Nambiar, Arun	Non-thermal plasma applications in agriculture	1	$21,088	$21,088
Sethuramasamyraja, Balaji	Real-time mitigation of nitrate leaching potential in vegetable crops using autonomous feedback control system	3	$80,377	$192,744
Van Zyl, Sonet	Identification and durability of novel sources of resistance to Pierce's disease and its effect on berry color development	2	$48,442	$96,884
Van Zyl, Sonet	Evaluation of OR-151 as a plant growth regulator and biostimulant to enhance color development and uniformity in red seedless table grapes	2	$25,000	$50,000
Vang, Kaomine	Utilizing real time plant stress indicator to improve water use efficiency in almonds	2	$66,778	$133,556
Yeasmin, Dilruba	Almond water stress and yield analysis through soil, plant and image based technologies for sustainable almond production	2	$60,077	$111,654
Brar, Gureet	Effects of saline irrigation on soil characteristics and on pistachio trees grown under microplot and field conditions	2	$72,957	$145,914
Cassel Sharma, Florence	Crop water requirements for Onion (*Allium cepa* L.) production in semiarid climates	3	$49,469	$148,407
	total:		**$587,986**	**$1,321,087**

HUMBOLDT

Project Director	Project Title	Duration (Years)	2017-18 Allocation	Total ARI Commitment
Kerhoulas, Lucy	Encroached oak woodlands	2	$68,899	$68,899
Johnson, Matt	Barn owls - pest control	3	$22,727	$22,727
Kelly, Erin	Politics of forest biomass	3	$52,499	$52,499
Byrne, Kerry	Assessing drought on livestock	2	$39,511	$39,511
Vergara, Sintana	ARI biomass pile emissions	3	$45,454	$45,454
	total:		**$229,090**	**$229,090**

POMONA

Project Director	Project Title	Duration (Years)	2017-18 Allocation	Total ARI Commitment
Bhandari, Subodh	Precision agriculture using UAV-based remote sensing technology and machine learning	1	$75,000	$75,000
Brundage, Cord	Establishment of a poultry facility at Cal Poly Pomona for testing the efficacy of vaccines for avian respiratory aspergillosis	2	$30,930	$35,691
Cullen, Eileen	Food safety on California urban farms: Harnessing biological soil amendment microbial activity without increasing risk of microbial foodborne illness	1	$60,000	$60,000
Davidov-Pardo, Gabriel	Development of high protein, high fiber gluten-free extruded pasta using pulse flour fractions	1	$10,000	$10,000
Elam, Marcus	Berry anthocyanin-rich diet for the prevention or retarding of ovariectomy-induced bone loss	1	$8,351	$8,351
Fox, Aaron	Does fall resource availability enhance pollinators and biological control insects on urban farms?	1	$10,000	$10,000
Gekara, Ondieki	Determining nutritional benefits of *Cleome gynandra* and medicinal value of its phytochemicals against *Haemonchus contorts* and other enteric pathogens in goats	1	$9,796	$9,796
Sharma, Bharti	Understanding flower development, maturation and dehiscence in columbines for horticultural purposes	1	$15,594	$15,594
Singh, Harmit	Effect of the enzymatic treatment of tomato juice on the extraction of lycopene content from tomato waste.	1	$30,705	$30,705
Still, David	Breeding lettuce for increased nutritional content under low water and nitrogen inputs	1	$12,920	$12,920
	total:		**$263,296**	**$268,057**

SAN LUIS OBISPO

Project Director	Project Title	Duration (Years)	2017-18 Allocation	Total ARI Commitment
Chiu, Yiwen	Dynamic life-cycle analysis: New model development and testing on agricultural impact assessment	3	$57,861	$141,033
Dodson Peterson, Jean	The effect of crop reductions timing and whole cluster addition on chemical and sensory aspects of cool climate in cv. Pinot noir wines	2	$20,000	$40,000
Garner, Lauren	Improving sustainable fertilization practices for pomegranate through leaf nutrient concentration evaluation and fertilizer trials	3	$37,412	$114,058
Ivors, Kelly	Investigating plant-soil microbial interactions and host resistance in commercial strawberry cultivars for low input soilborne disease control	3	$98,484	$217,137
La Frano, Michael	Utilization of calibration and internal standards for the quantitation of nutrients in foods and metabolites in the body	1	$5,000	$5,000
La Frano, Michael	Utilization of metabolomics analyses to investigate biomarkers of gestational diabetes mellitus	1	$20,000	$20,000
Lazcano, Cristina	Closing the loop: Evaluating the availability and suitability of agricultural organic waste materials as fertilizers in San Luis Obispo County	1	$5,000	$5,000
Lin, Kevin	Promoting California grown specialty crops at international trade shows	2	$13,333	$18,333
Manjarin, Rodrigo	Effect of probiotic and high fructose supplementation in pediatric NAFLD and early weaning of pigs	3	$89,735	$216,386
Pilolla, Kari	Strawberries and health: Is the way to the heart through the gut?	3	$24,554	$108,029
Reaves, Scott	Metabolic/proteomic profiling in type 2 diabetes and effects of dietary nutrients and exercise	2	$47,063	$94,598
Rees, Gordon	Genesis and management implications of mollic soils in forest vs. grassland settings	2	$20,000	$40,000
Tubeileh, Ashraf	Application of bio-fertilizers to improve soil and plant health in organic and conventional crop production systems	3	$36,619	$122,881
Volpe, Ricky	The economic impacts of the California grocery industry: regulation, market structure, and food safety	2	$20,000	$40,000
	total:		**$495,061**	**$1,182,455**

ACKNOWLEDGEMENTS

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