CENTER FOR PRODUCE SAFETY

RESEARCH SYMPOSIUM

JUNE 18-19, 2019 · AUSTIN, TEXAS

cps CENTER for PRODUCE SAFETY

Welcome

Howdy Y'all! And welcome to Austin, Texas, the Live Music Capital of the world and one of my favorite cities of all time.

As a Texas grower/packer/shipper and CPS board member, I am honored that CPS has chosen the Texas state capitol as the host location of the 2019 Research Symposium.

With a population of over 1 Million, Austin is the 11th largest city in the US and the 4th largest city in Texas!! Yes, Texas is that big!! It is a diverse and eclectic city with the fastest population growth rate in the country, with over 20% growth between 2010 and 2017.

Austin is known as the music capital of the world. We also boast some of the most exciting chefs and restauranteurs in the country. It is a town of cultural diversity and creativity. In addition to the amazing music and food scenes, Austin is home to a massive tech sector. Some of the most innovative tech companies in the world, such as Google, Facebook, Amazon and Dell, have made huge investments in building out their businesses right here in Austin, Texas.

With all that being said, it makes perfect sense that the best and brightest minds in food safety would gather here to showcase cutting-edge science-based solutions that will help carry our industry forward!!

Again, welcome to our state Capitol and I hope you enjoy some great Texas hospitality while you are here.

Thank you,
Jimmy Bassetti

The Center for Produce Safety is delighted to showcase the 10th annual Research Symposium in Austin! This year's symposium is made possible by the generosity of many; please join me in thanking them all for their support.

Our sponsors help us to provide a world-class event. Many of these companies have supported this event for a number of years, if not for all of our symposia. We appreciate their continued help and trust to make each year's symposium better than the last.

Thanks also to our presenting scientists, moderators and panel members for the countless hours of preparation they have provided to ensure that our attendees have a rich and valuable experience. Their help to transfer new produce safety knowledge to the industry and other fresh produce safety stakeholders is invaluable.

Do you want to add to your food safety staff? Then I draw your attention to the students who are assisting CPS-funded researchers. These individuals work alongside principal investigators to collect samples, conduct tests, and gather data. All these students are being mentored by leading scientists while they learn about the produce industry – they could be coaching your next hire!

Later in this program, you will learn more about the visionary companies that have contributed to the CPS Campaign for Produce Safety, which provides core funding for our research. You will also learn about the leaders who volunteer to serve on our Board of Directors, Technical Committee, and Knowledge Transfer Task Force.

Finally, thank you to our attendees, and to all of us who are working together to *Fund the Science, Find Solutions and Fuel the Change!*

Sincerely,
Bonnie Fernandez-Fenaroli
Executive Director, Center for Produce Safety

Chairman's Welcome

Dear Friends,

Welcome to Austin and the Center for Produce Safety's 10th annual Research Symposium!

Austin is a symbolic choice to host this year's symposium. As the fastest-growing city in the United States, Austin emerged this century as a center for technology and business. This city embraces change, and welcomes the future. So, Austin is a fitting place for CPS to gather our unique public-private community to discuss produce safety change, and the future of produce safety.

CPS has embraced change in the last year, adopting a new strategic plan that literally hardwires produce safety change into our updated mission statement: **fund the science, find solutions and *fuel the change***. To get even more useable tools in industry's hands even more quickly, we've overhauled our research program and are working to better communicate what we know to industry.

Now it's your turn. Attending this symposium is not a passive act. As you listen to research reports here, ask yourself what you can take back to your business to fuel produce safety change. After you get home, comb through CPS's website to find out what else you can learn to fuel change. Our consumers deserve it, and so do all the people along our supply chain.

This symposium wouldn't happen without the generous support of our sponsors. Many have supported our events for multiple years. You'll find a complete list of sponsors in this program.

And did you know? Many of the volunteers staffing this year's symposium are graduate students who might one day conduct research for CPS.

Make plans now to continue the conversation with us at next year's Research Symposium. We will gather again June 23–24, 2020 in La Jolla, California. In the interim, visit CPS's website where you'll find a wealth of information and resources at www.centerforproducesafety.org.

Dave Corsi
Chair, Board of Directors
Center for Produce Safety

CPS CENTER *for* PRODUCE SAFETY

ABOUT CENTER FOR PRODUCE SAFETY

The Center for Produce Safety (CPS) is a 501(c)(3), U.S. tax-exempt, charitable organization focused exclusively on providing the produce industry and government with open access to the actionable information needed to continually enhance the safety of produce.

Agenda at a Glance

TUESDAY, JUNE 18, 2019

7:00 am – 8:00 am — **Registration, Continental Breakfast, Poster Session**

8:00 am – 8:15 am — **Welcome** – **Dave Corsi**, Chair, Center for Produce Safety
Sid Miller, Texas Agriculture Commissioner

8:15 am – 9:00 am — **Romaine Outbreaks – Perspectives and Moving Forward**

Panelists:
Dave Corsi, Wegmans Food Markets
Michael Robach, The Robach Group LLC
Mike Taylor, Stop Foodborne Illness, Meridian Institute
Tim York, Markon Cooperative

Moderator:
Cathy Burns, Produce Marketing Association

9:00 am – 10:00 am — **Romaine Outbreaks – How is Science Leading Us Toward Solutions?**

Panelists:
Samir Assar, US Food and Drug Administration
Natalie Dyenson, Dole Food Company, Inc.
Channah Rock, University of Arizona
Martin Wiedmann, Cornell University

Moderators:
Jennifer McEntire, United Fresh Produce Association
Bob Whitaker, Produce Marketing Association

Lightning Reports – What Lies Ahead in CPS Research

Simulation analysis of in-field produce sampling for risk-based sampling plan development. **Matthew Stasiewicz**, University of Illinois at Urbana-Champaign

Exploring the relationship between product testing and risk.
Emma Hartnett, Risk Sciences International

Towards a decision-support tool for identifying and mitigating on-farm risks to food safety. **Jeff McGarvey**, USDA ARS

10:00 am – 10:30 am — **BREAK**

10:30 am – 12:20 pm — **Research Session 1 – Agricultural Water**

Moderators:
Hank Giclas, Western Growers
Juan Anciso, Texas A&M AgriLife Extension

FSMA agricultural-water die-off compliance provisions benefit from condition-specific modifiers. **Renata Ivanek**, Cornell University

Application of chitosan microparticles to eliminate foodborne pathogens in agricultural water that contacts fresh produce. **Anita Wright**, University of Florida

Establishment of operating standards for produce wash systems through the identification of specific metrics and test methods. **Mabel Gil**, CEBAS-CSIC, Spain

Cyclospora: Potential reservoirs and occurrence in irrigation waters.
Gerardo Lopez, University of Arizona

Remotely-sensed and field-collected hydrological, landscape and weather data can predict the quality of surface water used for produce production.
Martin Wiedmann, Cornell University

Lightning Reports – What Lies Ahead in CPS Research

Development of a model to predict the impact of sediments on microbial irrigation water quality. **Charles Gerba**, University of Arizona

Cyclospora prevalence in irrigation water in fresh produce growing regions.
Gerardo Lopez, University of Arizona

12:20 pm – 1:40 pm **LUNCH**

1:40 pm – 3:30 pm Research Session 2 – Produce and the Environment

Moderators: **Suresh DeCosta**, Lipman Family Farms
Afreen Malik, International Food Safety and Quality Services

Engineering and ecological approaches reduce Pacific tree frog intrusion into leafy green agriculture. **Michelle Green**, University of South Florida St. Petersburg

The effects of storage conditions and the microbiome of non-traditional salad ingredients on the fate of *Listeria monocytogenes*.
Amanda Lathrop, California Polytechnic State University, San Luis Obispo

Use of raptors to prevent wild bird and rodent intrusion into fresh produce fields.
Paula Rivadeneira, University of Arizona

Scientifically valid corrective actions for multiple harvest shade-house production systems. **Trevor Suslow**, University of California, Davis

Establishment of vegetative buffer zones to reduce the risk of STEC and *Salmonella* transmission from animal operations to fresh produce on co-managed farms.
Sid Thakur, North Carolina State University

3:30 pm – 4:00 pm **BREAK**

4:00 pm – 5:00 pm

CPS Research Program – What's It All About?

Moderators: **Drew McDonald**, Taylor Farms
Bonnie Fernandez-Fenaroli, Center for Produce Safety

Lightning Reports – What Lies Ahead in CPS Research

Identifying competitive exclusion microorganisms against *Listeria monocytogenes* from biological soil amendments by metagenomic, metatranscriptomic, and culturing approaches. **Xiuping Jiang**, Clemson University

Modeling tools for design of science-based *Listeria* environmental monitoring programs and corrective action strategies. **Renata Ivanek**, Cornell University

A systematic review of *Listeria* growth and survival on fruit and vegetable surfaces: responding to critical knowledge gaps. **Laura Strawn**, Virginia Tech

Listeria monocytogenes growth potential, kinetics, and factors affecting its persistence on a broad range of fresh produce. **Xiangwu Nou**, USDA ARS Beltsville

5:00 pm – 7:00 pm

Symposium Reception

WEDNESDAY, JUNE 19, 2019

7:00 am – 8:00 am

Registration, Continental Breakfast, Poster Session

8:00 am – 8:15 am

Welcome Back – **Jimmy Bassetti**, J&D Produce

8:15 am – 9:15 am

General Session – How to Fuel Change

Panelists: **Donna Lynn Browne**, Naturipe Farms LLC
Suresh DeCosta, Lipman Family Farms
De Ann Davis, Church Brothers Farms
Walter Ram, Giumarra
Steve Warshawer, Winrock

Moderator: **Doug Grant**, The Oppenheimer Group

9:15 am – 9:35 am

Travel Grant Award Recipients

Moderator: **Tony DiMare**, The DiMare Company

9:35 am – 10:05 am

BREAK

10:05 am – 11:55 am

Research Session 3 – Development of Microbiological Tools

Moderators: **Jennifer McEntire**, United Fresh Produce Association
Stacy Stoltenberg, Hygenia

Metagenomics to identify viral indicators in the produce chain.
Gloria Sánchez-Moragas, IATA-CSIC, Spain

Listeria whole genome sequence data reference sets are needed to allow for improved persistence assessment and source tracking. **Martin Wiedmann**, Cornell University

Developing cross-assembly phage as a viral indicator for irrigation waters.
Kyle Bibby, University of Notre Dame

Detection, validation, and assessment of risks implied by the viable but non-culturable (VBNC) state of enteric bacterial pathogens in fresh produce.
Xiaonan Lu, University of British Columbia

Rechargeable antimicrobial and antifouling plastics for improved cleaning and sanitation of plastic bins and totes. **Gang Sun**, University of California, Davis

Lightning Reports – What Lies Ahead in CPS Research

Significance of sanitizers on induction of viable but non-cultivable (VBNC) foodborne bacteria and their survival and resuscitation in fresh produce.
Ana Allende, CEBAS-CSIC, Spain

Non-fouling food contact surfaces – prevention of biofilm and surface-mediated cross-contamination. **Boce Zhang**, University of Massachusetts Lowell

11:55 am – 1:00 pm

LUNCH

1:00 pm – 2:50 pm

Research Session 4 – Packing and Processing

Moderators: **George Nikolich**, Gerawan Farming
Matt Miles, Allan Brothers

Preservation of stone fruits by spray application of edible coatings with antimicrobial properties. **Kay Cooksey**, Clemson University

Mathematical modeling tools for practical chlorine control in produce wash process. **Daniel Munther**, Cleveland State University

Characterization and mitigation of bacteriological risks associated with packing fresh-market citrus. **Linda Harris**, University of California, Davis

Resolving postharvest harborage sites of *Listeria* protects Zone 1 surfaces.
Trevor Suslow, University of California, Davis

Control of *Listeria monocytogenes* on apple through spray manifold–applied antimicrobial intervention. **Meijun Zhu**, Washington State University

Lightning Reports – What Lies Ahead in CPS Research

Illuminating the role of whole genome sequencing in produce safety. **Kerry Cooper**, University of Arizona

Fate of different *Listeria monocytogenes* strains on different whole apple varieties during long-term simulated commercial storage. **Elliot Ryser**, Michigan State University

Preventive sanitation measures for the elimination of *Listeria monocytogenes* biofilms in critical postharvest sites. **Kay Cooksey**, Clemson University

2:50 pm – 3:20 pm **BREAK**

3:20 pm – 4:10 pm

Symposium Takeaways – Industry Leaders Provide Key Learnings

Panelists: **To be announced at the Symposium**

Moderator: **Bob Whitaker**, Produce Marketing Association

4:10 pm – 5:00 pm

CPS Challenges and Industry Opportunities

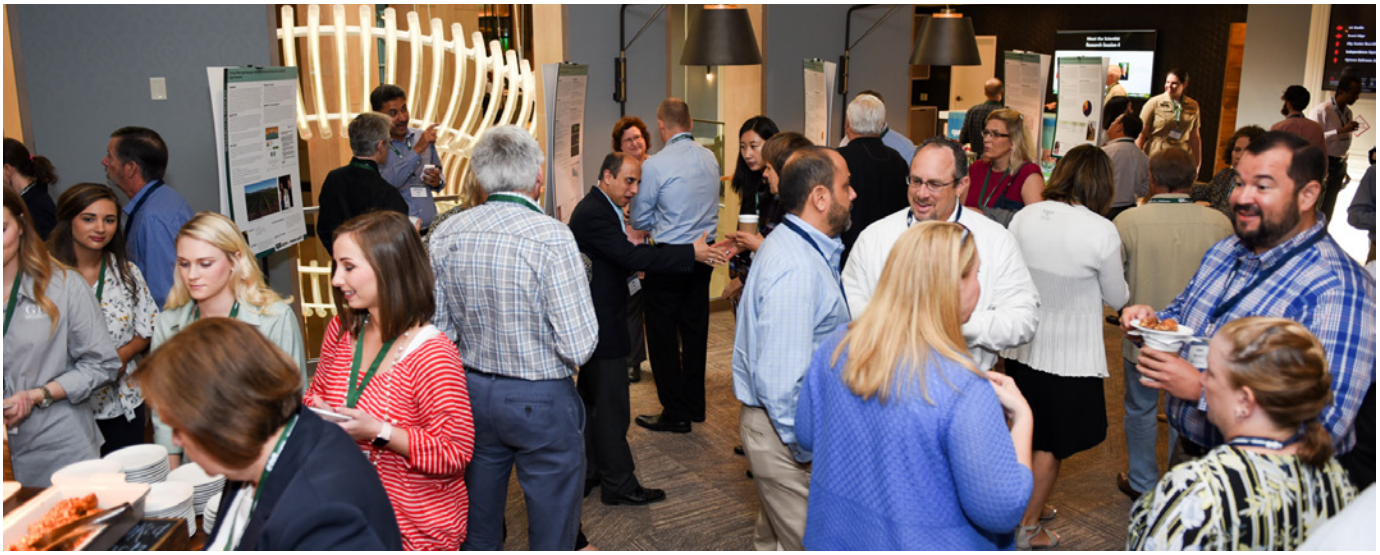
Executives share their vision for food safety in the fresh produce industry.

Panelists: **Tejas Bhatt**, Walmart
Dave Corsi, Wegmans Food Markets
Mark Mignogna, Sysco
Tim York, Markon Cooperative

Moderator: **Bonnie Fernandez-Fenaroli**,
Executive Director, Center for Produce Safety

5:00 pm – 6:00 pm

Closing Reception



Reception, 2018 Symposium

General Session

Asterisks with numbers denote Specialty Crop Block Grant Program support. Key on page 35.

General Session, 2018

RESEARCH SESSION

Agricultural Water

Project Title
FSMA agricultural-water die-off compliance provisions benefit from condition-specific modifiers

Principal Investigator
Renata Ivanek, PhD – Cornell University
ri25@cornell.edu

Project Term
January 1, 2018 – December 31, 2019

Non-Technical Summary
Recent Food Safety Modernization Act (FSMA) provisions for the protection of public health allow growers to use agricultural water exceeding the quantitative standards for indicator *Escherichia coli* if a pre-harvest waiting period after the last irrigation is applied, for a calculated number of days based on an assumed microbial die-off rate. There is an urgent need to validate the microbial die-off rate under standardized, multi-commodity and multi-regional conditions. Our objective is to establish die-off rates of a standardized set of indicators and attenuated pathogens on baby-spinach and lettuce in a replicated trial under field conditions in three different climatic regions. The estimated die-off rate, and the identified factors that affect it, will provide the foundation for a validated produce- and region-specific agricultural water die-off matrix for stakeholders to more effectively assess water quality and use. Our second objective is to develop a mathematical model of pathogen die-off under relevant environmental conditions and industry practices. The model will predict pathogen die-off under diverse conditions and indicate the conditions under which the regulatory matrix for pathogen die-off in agricultural water may be relied upon. Collectively, the results are expected to strengthen the FSMA regulatory matrix or demonstrate the need to modify it.

Funding
Center for Produce Safety

Acknowledgements
Co-PIs: Martin Wiedmann, PhD; Trevor Suslow, PhD; Ana Allende, PhD; Daniel Munther, PhD

Project Title
Application of chitosan microparticles to eliminate foodborne pathogens in agricultural water that contacts fresh produce

Principal Investigator
Anita Wright, PhD – University of Florida
acw@ufl.edu

Project Term
January 1, 2018 – December 31, 2018

Non-Technical Summary
Water used for irrigation or processing of produce has been implicated as a source of pathogen contamination that can persist in aquatic systems. Therefore, irrigation derived from surface water sources or flumes of wash water are often sanitized with disinfectants, such as sodium hypochlorite, chlorine dioxide, and peroxyacetic acid. However, these treatments are only margin-

ally effective and have potential toxicity. Thus, development of novel water treatment methods is needed. This project will examine the application of chitosan microparticles (CM) as a possible pre-harvest treatment in irrigation water and/or as post-harvest treatment in produce wash water. Chitosan is derived from chitin as the natural byproduct of seafood waste (shrimp and crab shells) and has applications for industrial waste water treatment as a flocculent. The potential of chitosan as a sanitizer is that it offers an economical, biodegradable and non-toxic alternative to toxic chemicals, and that it does not promote resistance to antibiotics. Chitosan is considered "generally recognized as safe," or GRAS, in other food applications, ensuring a high likelihood of acceptance for agricultural water applications. Studies will focus on reducing *Salmonella* and norovirus in natural water sources and on produce, and feasibility and cost-effectiveness of practical applications will be assessed.

Funding
Specialty Crop Block Grant*[4]; Center for Produce Safety

Project Title
Establishment of operating standards for produce wash systems through the identification of specific metrics and test methods

Principal Investigator
Ana Allende, PhD – CEBAS-CSIC, Spain
aallende@cebas.csic.es

Project Term
January 1, 2017 – December 31, 2018

Non-Technical Summary
The main objective of this project is helping producers to maintain the quality of the process water in commercial washing systems through control of water quality variables and the selection of adequate test methods for monitoring the process. Water disinfection is one of the most critical processing steps in fruit and vegetable production aimed at preventing cross-contamination. In the packinghouses and processing facilities, it is difficult to treat and maintain properly the quality of the process water because of the variability in the demand of disinfectant, the lack of operational limits and test methods to monitor the process, and the different commercial operations. This project will investigate the most common disinfection agents used in packinghouses and processing facilities. Four scenarios have been selected based on different water characteristics, including fresh-cut onions (excessive cell exudates, very high organic matter and turbidity), chopped lettuce (high organic matter and low turbidity), baby leaves (low organic matter and low turbidity) and peppers and tomatoes (low organic matter and high turbidity). Operational limits will be established commercial facilities and lab-scale experiments using inoculated foodborne pathogens. Results obtained should inform producers about the realistic expectations for controlling selected water quality variables in produce washing systems.

Funding
Center for Produce Safety

Acknowledgements
Co-PI: Mabel Gil, PhD – CEBAS-CSIC

Project Title
***Cyclospora*: Potential reservoirs and occurrence in irrigation waters**

Principal Investigator
Gerardo Lopez, University of Arizona
lopezg3@email.arizona.edu

Project Term
January 1, 2017 – December 31, 2018

Non-Technical Summary
Cyclospora has recently been implicated in outbreaks associated with U.S. produce imported from Mexico. Outbreaks have also been linked to drinking water. Information on the sources and occurrence of this organism are very limited. Currently, only humans and possibly primates are believed to be infected by this parasite. Our goal is to determine if produce in the United States is at risk of contamination from irrigation waters contaminated with human sewage (e.g., from faulty/leaky septic systems or compromised sewer pipes) and treated wastewater effluents that could potentially be discharged into surface waters

used for the irrigation of food crops. Our specific objectives are: a) to determine the occurrence of *C. cayetanensis* in irrigation waters in Arizona and Texas, which will allow a determination of any risk from *C. cayetanensis* and to identify areas of potential risk; and b) to determine the occurrence of *C. cayetanensis* in raw sewage and treated wastewater effluents in produce-producing areas such as Yuma, AZ and El Paso, TX, which will allow for an assessment of the incidence of *C. cayetanensis* infection in these communities. In addition, treated wastewater effluents are sometimes released into watersheds and could potentially impact irrigation waters. This study will determine if any risks exist from *Cyclospora* in irrigation waters from these two regions.

Funding
Specialty Crop Block Grant*[1]; Center for Produce Safety

Acknowledgements
Co-PIs: Paula Rivadeneira, PhD; Kelly Bright, PhD; Charles P. Gerba, PhD; Walter Betancourt, PhD – University of Arizona

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Project Title
Remotely-sensed and field-collected hydrological, landscape and weather data can predict the quality of surface water used for produce production

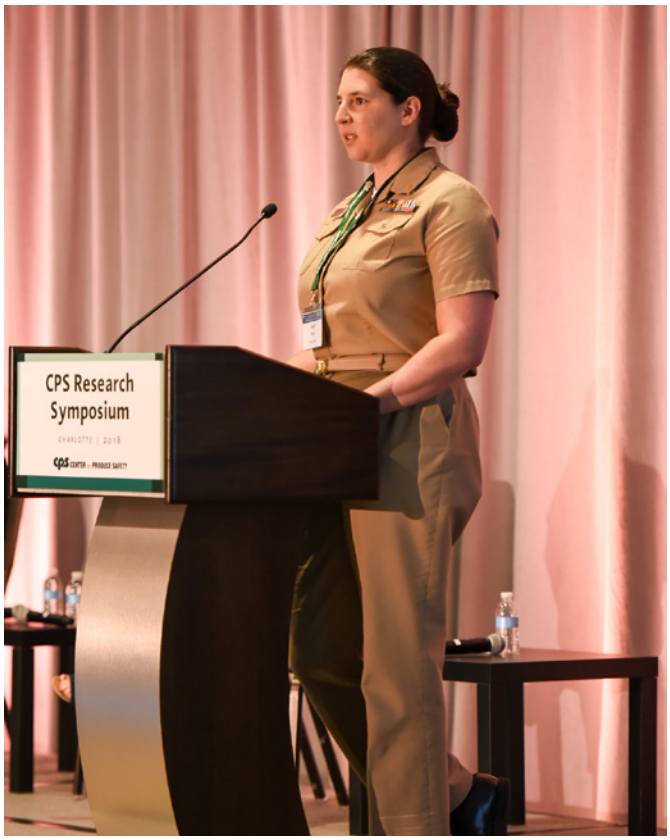
Principal Investigator
Martin Wiedmann, PhD – Cornell University
mw16@cornell.edu

Project Term
January 1, 2017 – December 31, 2018

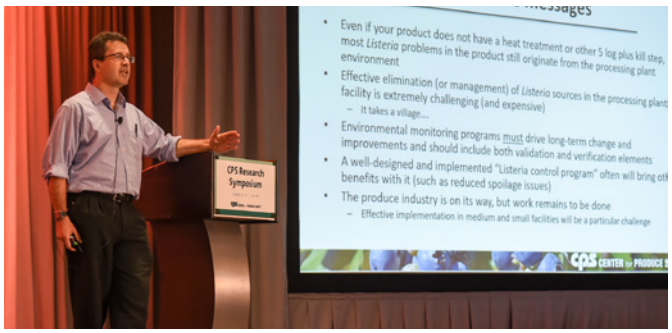
Non-Technical Summary
There is a clear need for the development of improved, science-based tools to help reduce pre-harvest introduction of microbial produce safety risks through surface water use. The purpose of this project is (i) to identify and prioritize spatial and temporal risk factors for microbial contamination of surface water, and (ii) to develop geospatial models that predict surface water microbial quality, which will be assessed by quantifying generic *E. coli* and testing for key pathogens (e.g., *Salmonella*). Spatial and temporal variation in water quality will be assessed by repeatedly testing multiple water sources over two years. Publicly available remotely-sensed data (e.g., predominant upstream land use) will be used to identify factors that are associated with elevated *E. coli* levels, and an increased risk of pathogen detection. Data collection will be performed in two produce growing regions (AZ and NY) to assess the robustness of our models and their translatability to other regions. These data and models will allow growers to identify times and locations where surface water sources are more likely to be microbially contaminated. This information will enable growers to better time water use, testing, and treatment to minimize produce safety risks associated with microbially contaminated surface water.

Funding
Specialty Crop Block Grant*[1]; Center for Produce Safety

Acknowledgements
Co-PI: Channah Rock, PhD – University of Arizona



Kari Irvin (U.S. FDA CORE), 2018 Symposium



Martin Wiedmann (Cornell University), 2018 Symposium

RESEARCH SESSION

Produce and the Environment

Project Title
Engineering and ecological approaches reduce Pacific tree frog intrusion into leafy green agriculture

Principal Investigator
Michelle Green, PhD – University of South Florida St. Petersburg
mlgreen@illinois.edu

Project Term
January 1, 2018 – December 31, 2019

Non-Technical Summary
It's no secret that consumers expect perfection. In the case of produce, consumers expect a product that is safe for consumption and appealing to the eye. As the interface between wildlife and agriculture becomes increasingly intertwined, the challenge of providing high quality product to consumers becomes more difficult, with lapses in quality carrying massive financial repercussions to the producer. Our study will use an integrated approach to improve exclusion methods used to keep frogs from entering production environments. Engineers will improve on the traditional drift fence by testing new materials, designs, and deterrents to determine an optimal design for field sites. We will also test new thermal imaging technology to detect frogs in leafy green environments. From the biological perspective, we will test the efficacy of noninvasive acoustics to attract frogs away from ag-adjacent bodies of water, and will conduct targeted surveys to better understand local frog populations in leafy green production areas. Our study will provide novel data on fence design, frog detection, animal responses to deterrents and acoustic signals, as well as greatly increase our understanding of frogs and the leafy green environments they use. All components of our study integrate to provide a multifaceted approach to improving frog management.

Funding
Specialty Crop Block Grant*[3]; Center for Produce Safety

Acknowledgments
PI: Paul Davidson, PhD – University of Illinois at Urbana-Champaign; Co-PI: Jonathan Warner, PhD – Texas Parks and Wildlife Department

Project Title
The effects of storage conditions and the natural microbiome of nontraditional fresh-cut salad ingredients on the fate of *Listeria monocytogenes*

Principal Investigator
Amanda Lathrop, PhD – California Polytechnic State University, San Luis Obispo
lathrop@calpoly.edu

Project Term
January 1, 2018 – December 31, 2019

Non-Technical Summary
Recent outbreaks and recalls of produce due to *Listeria monocytogenes* contamination have increased the need to understand its potential for growth on fresh-cut produce at both ideal and abusive temperatures. Fresh-cut produce has provided an easy and convenient way for consumers to increase consumption of healthy foods. To meet consumer demands for "superfoods" and to create sustainable products by utilizing more of the whole plant, new salad blends have been developed from non-traditional fresh-cut salad ingredients. Many of these ingredients are not normally consumed raw or may not have even been widely consumed. New salad ingredi-

ents include beet greens, kale, Brussels sprouts, and shredded broccoli stalk. While researchers have investigated the growth of *L. monocytogenes* on common fresh-cut salad ingredients, like spinach and iceberg lettuce, research on these new salad ingredients is limited. This project will determine if and under what conditions *L. monocytogenes* will grow on non-traditional salad ingredients. This will be accomplished by placing a known number of *L. monocytogenes* cells on the selected produce and monitoring the population under ideal, abusive, and "real-world" storage conditions. Bagged salad producers will be able to use this data to develop management strategies to minimize food safety risk.

Funding
Specialty Crop Block Grant*[3]; Center for Produce Safety

Acknowledgments
Co-PIs: Jay Singh, PhD; Koushik Saha, PhD; Christopher Kitts, PhD – Cal Poly

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Project Title
Use of raptors to prevent wild bird and rodent intrusion into fresh produce fields

Principal Investigator
Paula Rivadeneira, PhD – University of Arizona
pkrivadeneira@email.arizona.edu

Project Term
January 1, 2018 – December 31, 2019

Non-Technical Summary
Wild animals, such as birds and rodents, carry foodborne pathogens that may be a threat to fresh produce crops. This project will determine if the use of falconry is an efficient and cost-effective natural way to deter birds and to control rodents in fresh produce fields. This project aims to: 1) Determine if the use of falconry at critical times in the growing season (post-sprouting and pre-harvest) decreases fresh produce crop loss due to contamination of crops from wild bird intrusion; 2) Establish wild native owl and kestrel programs that promote site fidelity to decrease rodent populations near fresh produce fields; and 3) Determine if the use of falconry on a large scale can be a cost-effective approach to bird and rodent deterrence compared with traditional methods. Falconers will fly captive-bred predatory birds from sunrise to sunset to deter birds, and we will control rodent populations by attracting native owls and kestrels to fresh produce fields by using nest boxes. We will also release native, rehabilitated birds in agricultural areas. We will measure the success of falconry using bird counts, pre- and post-rodent trapping, and documentation of food safety risks in fields with and without falconry.

Funding
Center for Produce Safety

Project Title
Scientifically valid corrective actions for multiple harvest shade-house production systems

Principal Investigator
Trevor Suslow, PhD – University of California, Davis
tvsuslow@ucdavis.edu

Project Term
January 1, 2018 – December 31, 2019

Non-Technical Summary
From 1996 to 2016, multiple outbreaks associated with consumption of shade-house or greenhouse grown fresh produce were reported, resulting in over 1200 illnesses, 260 hospitalizations and at least six deaths. Outbreak environmental investigations boldly underscored the need for science-based practices to prevent or respond to a detected contamination on multiple-harvest crops produced in enclosed cropping systems (protected culture). A common response to pathogen detection may be to destroy the remaining crop as the practical economic loss containment decision; however, a better knowledge foundation for pathogen die-off expectations and development of systematic sampling regimes has broad industry support. At this time, there is little science-based guidance for assessing the risk of contamination of fresh produce grown under protected culture. Closing this knowledge gap is critical to decision-making and application of validated corrective

actions in the case of pathogen detection in product or environmental samples. Our specific goal is the validation of die-off expectations for bacterial pathogens and corrective action options for shade-house grown crops. We propose also to evaluate corrective actions necessary to minimize the risk of transference and persistence of bacterial pathogens in the shade house. We anticipate a high degree of transferability to diverse protected crop culture systems.

Funding
Specialty Crop Block Grant*[3]; Center for Produce Safety

Project Title
Establishment of vegetative buffer zones to reduce the risk of STEC and *Salmonella* transmission from animal operations to fresh produce on co-managed farms

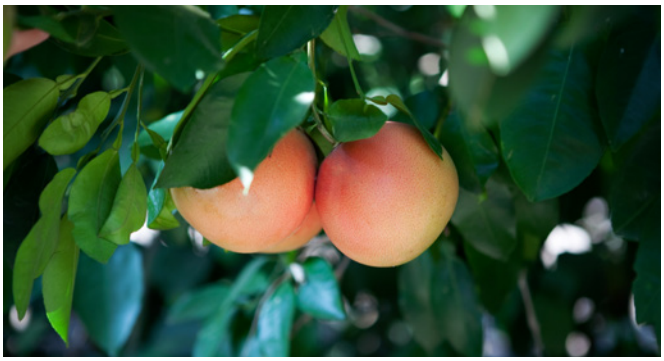
Principal Investigator
Sid Thakur, PhD – North Carolina State University
sthakur@ncsu.edu

Project Term
January 1, 2018 – December 31, 2019

Non-Technical Summary
To provide fresh, healthy and safe produce to consumers, we need to find effective and efficient practices that will allow us to continue farming with limited resources and land availability. Sustainable farming practices have, at their core, an integration of crops and livestock, recycling of nutrients and the well-being of humans and the environment. These farming practices increase crop productivity and environmental stewardship, although knowledge gaps exist on the presence and/or removal of a vegetative buffer zone (VBZ) between animal production areas (APAs) and produce fields and the potential relationship for pathogen transfer. This project will evaluate the effectiveness in reducing or eliminating movement of Shiga toxin–producing *Escherichia coli* (STEC) and *Salmonella* from APAs to adjacent produce fields by establishing a fast-growing and cost-effective VBZ between these areas within a 1–2 year growing season. Our project is unique and based on data collected from previous CPS- and USDA-funded projects. Our study will: 1) determine the risks associated with the presence of VBZ as barriers and/or sources of pathogen transmission between APAs and produce fields, 2) determine whether pathogen movement into produce fields increases with removal of the VBZ, and 3) determine if the proposed strategy is a tangible solution for growers facing these co-management practices.

Funding
Specialty Crop Block Grant*[3]; Center for Produce Safety

Acknowledgements
Co-PIs: Eduardo Gutierrez, PhD, and Chris Gunter, PhD – NCSU



RESEARCH SESSION

Development of Microbiological Tools

Project Title
Metagenomics to identify viral indicators in the produce chain

Principal Investigator
Gloria Sánchez-Moragas, PhD – IATA-CSIC, Spain
gloriasanchez@iata.csic.es

Project Term
January 1, 2018 – December 31, 2019

Non-Technical Summary

Detection of human pathogenic viruses in produce or irrigation water currently relies on culture-based methods of bacterial indicators, which frequently fail to correlate with the presence of enteric viruses. Culture-independent metagenomic approaches (i.e., massive sequencing) provide the highest resolution to analyze species diversity and will be applied to irrigation water, stools (which may contaminate agricultural and produce handling facilities by food handlers) and produce to search for new indicators. Our project goal is to identify viral species that correlate with presence/abundance of pathogenic viruses in irrigation waters and produce. Our specific objectives are: 1) Optimization of sample preparation procedure for viral metagenomics from irrigation water samples; 2) Determination of the viral community composition of samples previously analyzed that tested positive or negative for the presence of human pathogenic viruses; and 3) Identification of specific viral species or groups whose presence/abundance correlates with the occurrence of human pathogenic viruses in stools, irrigation waters and produce. The identification of meaningful viral indicator/s will allow the produce industry to simplify the control of enteric viruses by an easy and rapid procedure to detect and quantify the indicator, which in the short term will be implemented in the produce chain.

Funding

Center for Produce Safety

Acknowledgements

Co-PI: Jesús Rodriguez Díaz, PhD – University of Valencia

Project Title

***Listeria* whole genome sequence data reference sets are needed to allow for improved persistence assessment and source tracking**

Principal Investigator

Martin Wiedmann, PhD – Cornell University
martin.wiedmann@cornell.edu

Project Term

January 1, 2018 – December 31, 2019

Non-Technical Summary

Whole genome sequencing (WGS) is a powerful "genetic fingerprinting" tool for foodborne pathogens. Routine use of WGS to "fingerprint" *Listeria monocytogenes* from humans and foods has considerably increased the number of disease outbreaks detected and traced back to specific foods, including produce. WGS also is used to identify instances where a specific type of bacteria appears to survive ("persist") in a given food processing facility, indicating a particular food safety risk. However, our ability to interpret WGS data is hampered by (i) a lack of WGS data for bacteria from sources other than humans and foods and (ii) the need to better define how likely closely related bacteria can be found in different locations. In order to address these challenges, we will collect bacteria representing *L. monocytogenes* and other *Listeria* spp. from environmental sources throughout the US and perform whole genome sequencing on these bacteria. Comprehensive comparisons among these bacterial isolates along with isolates from produce-associated environments and human cases globally will be used to define similarity cut-offs that identify closely related bacteria and the likelihood of closely related bacteria occurring in different locations. This will facilitate more accurate use of these tools to address produce food safety issues.

Funding

Specialty Crop Block Grant*[4]; Center for Produce Safety

Project Title

Developing cross-assembly phage as a viral indicator for irrigation waters

Principal Investigator

Kyle Bibby, PhD – University of Notre Dame
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Project Term

January 1, 2017 – December 31, 2018

Non-Technical Summary

Ensuring high-quality irrigation water is necessary to protect the public when consuming minimally processed produce. The highest risk from

exposure to contaminated water is due to viruses; however, water quality is currently monitored using bacteria that are poor representatives of viruses. All previous viral indicators are limited by a low abundance (i.e., difficult to detect) in the environment. Recently, a bacteriophage (virus that infects bacteria) named "cross-assembly phage" (crAssphage) was discovered and shown to be more abundant than all other bacteriophages in the human gut combined. Investigations in the PI's research group have shown crAssphage to be highly abundant in sewage. As crAssphage is a virus, it will be a better representative of viral contamination in the environment. In this investigation, we will sample irrigation water and measure crAssphage, viruses, and indicators to demonstrate the correlation of crAssphage and pathogens. Also, we will determine how much sample volume is necessary to accurately measure crAssphage. The development of this viral monitoring tool will enable risk-managers to have an accurate and abundant indicator of viral contamination. This will ultimately provide greater protection of public health and improve consumer confidence in produce consumption.

Funding
Specialty Crop Block Grant*[2]; Center for Produce Safety

Project Title
Detection, validation, and assessment of risks implied by the viable but non-culturable (VBNC) state of enteric bacterial pathogens in fresh produce

Principal Investigator
Xiaonan Lu, PhD – University of British Columbia
xiaonan.lu@ubc.ca

Project Term
January 1, 2017 – December 31, 2018

Non-Technical Summary
More fresh fruits and vegetables are grown, sold and eaten today than at any other time in history. Unfortunately, outbreaks of food poisoning caused by pathogenic bacteria in fresh produce are also more common than in the past. Products are routinely analyzed to ensure that they are free of such bacteria, but some are very difficult to find because they do not grow on media used by quality control laboratories. These are known as "viable but non-culturable" (VBNC) bacteria. We will develop a new, inexpensive and easy-to-use method based on the well-known PCR reaction to make it possible for quality control laboratories to detect two important pathogens in fresh produce, *Salmonella* and *E. coli*, even when they are in the difficult-to-find VBNC form. The performance of the new method will be checked through field trials and pilot plant experiments with leaf lettuce. Information from these experiments will be used to reveal how likely fresh produce is to be contaminated with VBNC pathogens during production and after harvest. Therefore, this research will contribute to an important new laboratory method and key information to support on-going efforts by the industry to improve the safety of fresh fruits and vegetables.

Funding
Center for Produce Safety

Acknowledgements
Co-PIs: Pascal Delaquis, PhD, and Susan Bach, PhD – Agriculture and Agri-Food Canada; Jeff Farber, PhD – University of Guelph

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Project Title
Rechargeable antimicrobial and antifouling plastics for improved cleaning and sanitation of plastic bins and totes

Principal Investigator
Nitin Nitin, PhD – University of California, Davis
nnitin@ucdavis.edu

Project Term
January 1, 2018 – December 31, 2019

Non-Technical Summary
Sanitation of reusable plastic containers (RPCs) is a significant challenge and can lead to cross-contamination of fresh produce. These cross-contamination events can result in a foodborne disease outbreak as well as reduce the shelf life or quality of the product. To address this challenge,

this project is aimed at developing a rechargeable antimicrobial and antifouling plastic material and its evaluation for eliminating contamination of RPCs from various contaminating sources and reducing biofilm formation. The antimicrobial properties of this material can be recharged by simply using a diluted bleach solution. This novel material can be used as a rechargeable liner attached to existing RPCs and/or development of new RPCs with this novel plastic material. This novel material may also be used in combination with wooden bins. The proposed research plan will focus on *Listeria* as the target bacteria. To complement laboratory-based research, the project will also field test this material in improving sanitation of RPCs in fresh produce processing facilities as well as evaluate any impact on produce quality with extended contact. In summary, this research project addresses a significant unmet need in the industry to improve sanitation of RPCs.

Funding
Specialty Crop Block Grant*[5]; Center for Produce Safety

Acknowledgements
Co-PIs: Gang Sun, PhD, and Glenn Young, PhD – UC Davis

Kelly Bright (University of Arizona), 2018 Symposium

RESEARCH SESSION

Packing and Processing

Project Title
Preservation of stone fruits by spray application of edible coatings with antimicrobial properties

Principal Investigator
Kay Cooksey, PhD – Clemson University
kcookse@clemson.edu

Project Term
January 1, 2018 – December 31, 2018

Non-Technical Summary
Listeria monocytogenes is an important foodborne pathogen commonly found in the environment. Recent *Listeria* foodborne outbreaks have been linked to fresh produce, including stone fruits. Contamination of stone fruits is problematic since these products are usually consumed without heating. In addition, some surfaces associated with packing operations (brushes, peach rollers) are inherently difficult to sanitize. In the packinghouse, these fruits are covered (brushed) with a wax-based coating containing antifungal agents to prevent moisture loss and fungal infection. The project will develop and compare alternative coatings based on edible components that have antilisterial properties in addition to their physical barrier and antifungal role. The coatings will be formulated to contain safe antimicrobial agents, such as nisin, Listex P100, organic acids, and/or their combinations, and could be applied as a spray, thereby reducing the risk of cross-contamination in the packinghouse. Experiments will be performed in laboratory settings and validated in challenge studies with inoculated stone fruits. The goal is to formulate a coating that would prevent *Listeria* contamination on fruits and bacterial persistence on packing equipment. Results from this study will be used to provide improved pathogen control in addition to basic good agricultural practices, thereby helping fruit industry to produce safer produce for human consumption.

Funding
Specialty Crop Block Grant*[3]; Center for Produce Safety

Acknowledgements
Co-PI: Claudia Ionita, PhD – Clemson University

Project Title
Mathematical modeling tools for practical chlorine control in produce wash process

Principal Investigator
Daniel Munther, PhD – Cleveland State University
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Project Term
January 1, 2018 – December 31, 2018

Non-Technical Summary
Foodborne diseases associated with fresh produce continue to cause serious difficulties for public health in the United States. To offset this burden, the produce wash stage has received much attention as a critical control point. However, recent studies indicate a limited understanding of the dynamics of sanitizer control during washing. One problem is that the relationships between water quality constituents and sanitizer levels have only been described via experimental/correlative approaches or by risk models that are difficult to parameterize accurately. Accordingly, there is an urgent need to mathematically describe the fundamental dynamics that generate the observed relationships between sanitizer levels and water quality parameters. Based on such formulations, our long-term goal is to develop optimal sanitizer strategies that are easily automatable and adjustable to specific commodities and washing practices. The primary objective of this proposal is to develop data-informed modeling tools that quantitatively link easily measurable water quality parameters (e.g., turbidity/total dissolved solids) to commodity specific organic load and free chlorine consumption during recirculated wash conditions. Based on USDA experimental data and our recent modeling results, we hypothesize that by using our modeling tools, the industry can obtain reliable predictive capabilities that are not possible with correlations alone.

Funding
Center for Produce Safety

Acknowledgements
Co-PIs: Parthasarathy Srinivasan, PhD, and Chandrasekhar Kothapalli, PhD – Cleveland State University

Project Title
Characterization and mitigation of bacteriological risks associated with packing fresh-market citrus

Principal Investigator
Linda Harris, PhD – University of California, Davis
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Project Term
January 1, 2017 – December 31, 2018

Non-Technical Summary
After harvest, fresh oranges and lemons are sorted, washed and packed in packinghouses for further distribution and sale. Because green and blue molds result in significant losses of citrus fruit during storage and shipping, fungicides are often applied during packing. Recirculating drench applications are common because they significantly increase fungicide efficacy but they also provide an opportunity for cross contamination or movement of microorganisms throughout the facility, which can be a food safety issue if not appropriately managed. The overall goal of this project is to provide data that the California fresh citrus packinghouse industry can use to support the controls that reduce or eliminate foodborne pathogen cross contamination where citrus fruits are comingled or where recirculating materials come into contact with the fruit. A laboratory component will determine, for the most common fungicides, minimum compatible sanitizer concentrations that are effective in eliminating *Salmonella* and *Listeria monocytogenes*. The laboratory data will be verified in a pilot-scale citrus packing facility and the results of these studies will be used to prepare documents the industry can use to support the efficacy of their food safety practices.

Funding
Specialty Crop Block Grant*[1]; Center for Produce Safety

Project Title
Resolving postharvest harborage sites of *Listeria* protects Zone 1 surfaces

Principal Investigator
Trevor Suslow, PhD – University of California, Davis
tvsuslow@ucdavis.edu

Project Term
January 1, 2017 – December 31, 2018

Non-Technical Summary
The 2014-15 CA Agricultural Statistics Review places the combined value of oranges, lemons, and tangerines at over $2 billion dollars and all three are in the Top 15 Specialty Crops by value. Fresh whole citrus has not experienced an incident of recall, illness, or outbreak, and CA citrus production practices and regions appear to significantly limit the environmental risk of preharvest contamination. However, recent serious incidents involving the bacterial pathogen *Listeria monocytogenes*, associated with CA apples, have prompted proactive measures to more carefully assess postharvest risks and develop validated interventions for citrus system-wide. Confidentially enrolled handlers will participate in a detailed survey for indicator *Listeria* and *L. monocytogenes*. The outcome will be the development of model Environmental Monitoring Program (EMP) and guidance in establishing an environmental-zone Master Sanitation Schedule linked to EMP-outcomes for California fresh citrus packinghouses. The anticipated outcomes are expected to include a general overview and report card of the CA citrus packing environment, and identification of potential sources of *Listeria* related to industry growing regions and harvest/postharvest practices. Closing this knowledge gap will result in measureable improvements in reducing *L. monocytogenes* prevalence.

Funding
Specialty Crop Block Grant*[1]; Center for Produce Safety

Acknowledgements
Co-PIs: Adrian Sbodio and Janneth Pinzon-Avila – UC Davis

Project Title
Control of *Listeria monocytogenes* on apple through spray manifold–applied antimicrobial intervention

Principal Investigator
Meijun Zhu, PhD – Washington State University
meijun.zhu@wsu.edu

Project Term
January 1, 2017 – December 31, 2018

Non-Technical Summary
Listeria monocytogenes is listed by the Food and Drug Administration as a "pathogen of concern" and has been singled out on both ready-to-wash and ready-to-eat produce due to its nature as a true environmental species. The Pacific apple industry, led by Washington, suffered a significant loss of income following the *L. monocytogenes* outbreak traced back to a California packer. The final FDA Produce Rule and Preventive Controls Rule are challenging apple packers and handlers to develop specific efficacy data for their process controls. The apple industry has an immediate need to begin the process of science-based improvements in *Listeria* control during packing and subsequent storage. The overall goal of this project is to comparatively assess and validate critical operating parameters for registered, commercially practical, and legally allowed sanitizer(s) against *L. monocytogenes*, and to further seek to verify their efficacy on multiple apple packing lines. The project will develop information for apple producers about the practical efficacy of antimicrobial interventions under commercial packing conditions, resulting in tested and proven methods for spray bar intervention in fresh apples, which will fill critical knowledge gaps and will be crucial for addressing *L. monocytogenes* safety in fresh apples.

Funding
Specialty Crop Block Grant*[1]; Center for Produce Safety

Acknowledgements
Co-PI: Trevor Suslow – UC Davis

Panelist Biographies

JUAN ANCISO

Dr. Anciso is an Extension Vegetable Specialist for the Texas A&M AgriLife Extension Service and is a Professor with the Texas A&M University System. Dr. Anciso has been employed with the Texas A&M University System since September 1989. His major goal has been to develop highly relevant programs impacting vegetable production in South Texas as well as statewide. He has focused on food safety educational programs and research since 1999 as food safety continues to be one of the vegetable industry's main concerns. Dr. Anciso has taught an HEB Produce Food Safety Training course since 2007 and is a lead trainer for the Produce Safety Alliance Grower trainings that began in 2017. He has participated in United Fresh's Produce GAPs Harmonization Initiative technical working group. Scholarly achievements include 27 peer-reviewed papers and over 100 extension publications and trial reports—eight of the papers have been research focused with on-farm produce safety practices and mitigation steps to include irrigation water. Dr. Anciso is the first Texas A&M AgriLife Extension employee to be elected to the Council of Principal Investigators at Texas A&M University.

SAMIR ASSAR

Dr. Samir Assar is the Director of the Division of Produce Safety, comprised of the Fresh Produce Branch, the Processed Produce Branch and the Produce Safety Network in the Food and Drug Administration's (FDA) Center for Food Safety and Applied Nutrition (CFSAN). The Division focuses on developing and implementing policies and programs related to enhancing the safety of both fresh and minimally processed produce. Since 2008, Dr. Assar has managed the development of FDA's policy, regulation and guidance on produce safety, including those mandated by the 2011 Food Safety Modernization Act. Dr. Assar provides strategic leadership in developing plans for research, training, and compliance activities that target a safe and abundant produce supply. He is committed to enhancing partnerships with produce safety stakeholders, including industry, consumers, federal, and state partners. He has collaboratively forged initiatives and agreements aimed at protecting public health both domestically and internationally, with an emphasis on ensuring the produce industry receives necessary food safety education, outreach and technical assistance. Dr. Assar received his M.S. and Ph.D. in Food Science from the University of Florida.

JIMMY BASSETTI

Jimmy Bassetti, with wife Diane, founded J&D Produce, Inc. in the Texas Rio Grande Valley in 1986. This family company, including sons James and Stephen, has grown to employ over 450 full- and part-time employees, and farms over 6,000 acres in the United States, Mexico and Peru. J&D markets their high-quality fresh produce under the Little Bear® Brand in both the U.S. and Canada. Jimmy attributes the company's success to the work ethic that his father, the "Bear" Bassetti, instilled in him as a young man: a work ethic dedicated to quality, integrity, honor and respect. Jimmy is the chairman of the Texas International Produce Association Executive Committee and a founding member of the Viva Fresh Produce Expo. Jimmy is also a member of the Vegetable Industry Advisory Committee at Texas A&M University. Through J&D Produce, Jimmy supports the Texas Vegetable Association, United Fresh Produce Association, Quebec Produce Marketing Association, Canadian Produce Marketing Association, and the Texas Onion Association, among others. Jimmy is dedicated to being part of the leading effort on educating consumers on the benefits of eating nutritious fruits and vegetables to reduce the rates of obesity, diabetes, heart disease and cancer, for an improved quality of life.

TEJAS BHATT

Serving as the Senior Director of Food Safety Innovations, Tejas Bhatt is responsible for the Blockchain initiative as well as other advancements in food safety for Walmart. Tejas' scope of responsibilities includes food safety innovations across Walmart's stores, Neighborhood Markets, and Sam's Clubs and their food supply webs. Accelerating the development, adoption and implementation of enhanced food safety innovations such as blockchain with Associates, food suppliers, industry partners, technology service providers and regulatory agencies also come under his purview. Prior to joining Walmart in 2018, Tejas was the Vice President of Science and Policy Initiatives at the Institute of Food

Technologists (IFT), and the Director of IFT's Global Food Traceability Center. In 2011, he was also one of the IFT leads to conduct the groundbreaking food traceability pilots with the U.S. Food and Drug Administration (FDA) under the Food Safety Modernization Act. In 2012, Tejas received the Center for Food Safety and Applied Nutrition (CFSAN) Leveraging Collaboration Award by the U.S. FDA. Tejas earned his B.Sc. in Computer Science and his M.S. in Interdisciplinary Food Science, both degrees from Purdue University. He has also earned a Certified Food Scientist credential from the International Food Science Certification Commission. He has authored or co-authored several peer-reviewed publications and book chapters, and has presented at numerous national and international conferences.

DONNA LYNN BROWNE

Donna Lynn began her career in produce food safety after graduating from Cal Poly SLO in 1989. Her first job was as research microbiologist at the Dole R&D Technical Center in San Jose, CA. She then moved on to positions with Safeway Manufacturing and Dole Fresh Vegetables as a Quality Supervisor, and then Manager. She then operated, for 8 years, a very successful business as a food safety consultant; her main clients were Taylor Farms and River Point Farms. Her current position is Director of Food Safety and Social Responsibility with Naturipe Farms LLC, which she has enjoyed for the past 6.5 years. She has always enjoyed working with farmers, directly helping them understand what is needed for true food safety. She holds a degree in Microbiology, MS in international food law, and has numerous food safety certifications (SQF, HACCP, GLOBALG.A.P, PCQI, FVSP etc.). She sits on the Center for Produce Safety Technical Committee, on the PMA and United Fresh Food Safety and Technology councils, and most recently has joined the Consumer Goods Forums where she works on the steering committee for the Sustainable Supply Chain Initiative (SSCI).

CATHY BURNS

Cathy Burns is CEO of the Produce Marketing Association (PMA). Prior to joining PMA in December 2013, she served as president of Food Lion, Harvey's and Reid's, and was a member of the Delhaize America Executive Committee. She previously served Food Lion as Chief Operating Officer, senior vice president of retail operations-north, and senior vice president of fresh merchandising, distribution, and quality assurance. Burns joined Food Lion from its sister banner, Hannaford Supermarkets, where she started as a part-time service clerk, completed the grocer's retail training program, and then held various leadership positions. She chairs the Board of Governors for Children's Miracle Network and the Board of Directors for Duke Children's Hospital and Health Center. Burns was named a 2007 Top Woman in Grocery by *Progressive Grocer*, was awarded *The Packer*'s 2008 Produce Marketer of the Year award, and was named one of *Supermarket News'* Power 50 in 2009, one of *Mass Market Retailer's* Most Influential Women in Mass Market Retailing in 2010, and a top-25 leader in the produce and floral industries by *The Packer* in 2018.

DAVE CORSI

Dave Corsi joined the Wegmans family 33 years ago, and in 1999 he became the Vice President of Produce and Floral Operations. Dave is responsible for procurement, merchandising, design, fixturing, pricing, and the Wegmans 170-acre Organic Farm operation. Dave currently serves as Chair of the Board for the Center for Produce Safety. Dave was recently presented the Produce Marketing Association's Bryan E. Silbermann Collaboration Award, being recognized as an individual for working with one or more people or organizations, including those outside the nominee's own organization, to realize mutually beneficial solutions to an industry issue. Dave has been a volunteer leader for 17 years with the PMA and during that time, he was the chair of the association in 2009. Dave led a taskforce for United Fresh in 2009 to create a Harmonized Food Safety Good Agricultural Practices Audit that is used today for many in our industry. In 2005, Dave was selected for the "Marketer of the Year" by Vance Publishing for his merchandising excellence, setting high standards for others to emulate, and for his leadership in the produce industry. In 2003, industry members nominated Dave and Wegmans as "Retailer of the Year" by Produce Merchandising Magazine. Dave served two consecutive terms as a member of the USDA Fruit and Vegetable Advisory Committee, from 2001 to 2005.

DE ANN DAVIS

As VP of Food Safety and Quality for Church Brothers Farms, De Ann's responsibilities include strategic development and implementation of food safety and quality programs across all farming, harvesting, and processing operations in the United States and Mexico. De Ann previously worked as Vice President of Quality and Food Safety at Earthbound Farm, and as Chief Food Safety Officer at Kraft Foods. On top of these achievements, De Ann has also worked in product safety and regulatory leadership roles at Alberto Culver, Kimberly-Clark, The Dial Corporation, and Procter &

Gamble. She obtained a bachelor's degree in Biology and Chemistry from San Diego's Point Loma College, and a Ph.D. in Biochemistry and Biophysics from Texas A&M University. De Ann Davis has been a Diplomate for the American Board of Toxicology since 1996. She was appointed to the USDA National Advisory Committee on Microbiological Criteria for Foods in 2018.

SURESH DECOSTA

Suresh DeCosta joined Lipman Family Farms as Director of Food Safety in April 2016. Prior to joining Lipman, he worked as food safety lead for agricultural products at McDonalds, national FSQA manager for Chiquita/Fresh Express, and product application scientist for SureBeam. Suresh is a recognized subject matter expert with the ability to lead cross-functional groups of suppliers, customers and produce industry representatives. His broad food science industry experience includes product development, beverage formulation, food irradiation, coffee blend management, good agricultural practices, and fresh cut processing. He leverages his holistic understanding of supply chain from farm to fork to mitigate food safety risks at each stage of the supply chain. Suresh uses his interpersonal skills to build consensus in technical and non-technical environments, which helps drive industry change. Suresh has served as the chairman of United Fresh Produce Association Food Safety and Technology Council and as a member of its board of directors, and is a member of the Center for Produce Safety Technical Committee. He has received multiple industry awards, including the UFPA technical award for his leadership in helping standardize agricultural food safety practices. Suresh received an M.S. in Food Science from Chapman University and a B.S. in Environmental Science from Slippery Rock University.

TONY DIMARE

Tony DiMare serves as vice president of The DiMare Company, an 90-year-old family produce business with growing, packing, and repacking operations, operating in Florida, California, Massachusetts, Pennsylvania, and Texas. Mr. DiMare began working for the family business in 1983 and is among the third generation of DiMares to do so. The DiMare Company believes strongly in industry organizations. Mr. DiMare is active in the industry and serves on several volunteer boards and committees. He is Chairman of the Florida Specialty Crop Foundation and is currently serving on the Board of Directors of the Florida Fruit & Vegetable Association, the Florida Tomato Committee, Florida Tomato Exchange, Florida Tomato Growers Exchange, and is Co-Chair of the University of Florida–Gulf Coast Research and Education Center (GREC) Advisory Council. In 2002, he was appointed by the Secretary of Agriculture to the Inaugural USDA Fruit and Vegetable Industry Advisory Committee. Also that year, he served on the Florida Agriculture Trade Advisory Committee for Congressman Adam Putnam. In addition to serving the ag community, Mr. DiMare also co-chairs the YMCA's South Shore Leadership and Advisory Council, is the co-founder and coordinator of the inaugural Florida Ag Expo, and serves on the board of directors for Farm Share, Inc., a not-for-profit organization working to fight poverty and alleviate hunger.

NATALIE DYENSON

Ms. Dyenson joined Dole as Vice President, Food Safety and Quality in October 2016. She has responsibility for food safety and quality programs globally for all divisions of Dole. Prior to Dole, she spent eight years in various senior director positions with Wal-Mart Stores, Inc., most recently leading food safety across 6,500 retail stores, 48 company-owned manufacturing facilities and 220 fresh distribution centers in 26 countries for Walmart's international division. Prior to Walmart, Ms. Dyenson spent eight years with Walt Disney Parks and Resorts, based out of Orlando, Florida, where she held various roles in food safety and public health supporting Walt Disney World, Disney Regional Entertainment, Disney Cruise Line and the Parks and Resorts business globally. Ms. Dyenson holds a B.S. in Microbiology from the University of Iowa and a M.P.H. in Infectious Disease Epidemiology and Biostatistics from the University of South Florida.

HANK GICLAS

Mr. Giclas serves as Senior Vice President of Strategic Planning, Science and Technology for Western Growers, a department he created and grew to help Western Growers become a leading trade association. This division now assists members with food safety, crop protection, environmental compliance, sustainability and a host of other areas where sound science and new technology must drive industry advancement, solutions and government policy. Mr. Giclas is also Executive Director for Western Growers' Center for Innovation & Technology, based in Salinas, California, and serves on many industry advisory boards and technical committees, including the Center for Produce Safety, Western Institute for Food Safety and Security, Coalition for Urban and Rural Environmental Stewardship, and the Specialty Crop Committee serving the National Agricultural Research Education, Extension and Economics Advisory Board. He received his B.S. from

The University of Arizona in Agricultural Education, and was a vocational agriculture instructor before coming to Western Growers.

DOUG GRANT

Doug joined The Oppenheimer Group in 1995 as director of information technology and was recently promoted to Executive Vice President and Chief Operating Officer. His responsibilities include executive oversight for grower relations, IT, operations, quality control, transportation, food safety, the South American offices as well as Canadian operations. Doug is Chair of the Knowledge Transfer Task Force (KTTF), co-chair of the PTI (Produce Traceability Initiative) Leadership and Executive Council and serves as a member of the Romaine Traceability Task Force, the Center for Produce Safety Board of Directors and the PMA (Produce Marketing Association) Board of Directors and PMA Leadership Development Committee. As well, he has authored numerous white papers on key topics facing our industry. Doug is a past recipient of the Canadian Produce Marketing Association's "Produce Man of the Year" award, and he was featured among the 2012 Packer 25 industry leaders.

AFREEN MALIK

Afreen is Director of Technical Services at International Food Safety and Quality Services (IFSQS), a consulting firm that helps companies produce safe foods. IFSQS provides hands-on, practical, science-based food safety, quality, and environmental sustainability support, rooted in 20 years of experience in the food and agriculture sectors. Before consulting, Afreen worked with Ocean Mist Farms, Calavo Growers, and the California Department of Food and Agriculture. She has a B.S. in Biological Sciences from University of California, Santa Barbara, and a M.S. in Coastal and Watershed Science and Policy from California State University, Monterey Bay. Afreen is fluent in English, Urdu, Hindi, and Spanish.

DREW MCDONALD

Drew is the Vice President Quality & Food Safety at Taylor Farms, Salinas, California. He has over 20 years' experience in fresh produce and fresh foods. He oversees the quality and food safety programs across the food service, retail, and deli operations. Drew works with an impressive team developing and managing appropriate and practical quality and food safety programs for fresh food and produce products. Over the course of his career he has worked with growers and processors of fresh produce items all over the world. He currently serves on numerous food safety–related technical committees and has participated in the authorship of many produce food safety guidelines. Drew received his education from Lawrence University in Wisconsin.

JENNIFER MCENTIRE

Jennifer McEntire is VP Food Safety and Technology at United Fresh Produce Association. A food microbiologist by background, she has always worked in the Washington DC area, bringing the scientific perspective to food safety regulatory issues. She was previously Vice President of Science Operations at the Grocery Manufacturers Association, overseeing the microbiology laboratory, process authority team, and claims laboratory. She has also had roles as VP and Chief Science Officer at The Acheson Group and as the Senior Staff Scientist and Director of Science & Technology Projects at the Institute of Food Technologists. Jennifer McEntire earned a Ph.D. from Rutgers University and received a Bachelor of Science with Distinction, magna cum laude, in Food Science from the University of Delaware. She serves as an advisory board member of the Global Food Traceability Center, is on the Center for Produce Safety's Technical Committee, is a member of the International Association for Food Protection, and is on the steering and executive committees of the Food Safety Preventive Controls Alliance.

MARK MIGNOGNA

Mark Mignogna is Vice President of Food Safety and Quality Assurance for SYSCO Corporation. Prior to joining Sysco he graduated with a B.S. in Food Science from Rutgers University and held several Quality Assurance managerial positions at a major food manufacturer. He began his career at SYSCO in 1988 as Senior Manager, Quality Assurance. Mr. Mignogna has progressed through positions of increasing responsibility until reaching the position he now holds.

MATT MILES

Matt is the Facilities Manager at Allan Bros., Inc., a family-owned fruit company that grows, packs and ships apples, cherries, and wine grapes, located in Naches, Washington. The past 8 years at Allan Bros. have been a refreshing change from the previous 15 years in aerospace engineering enterprises like Boeing and GE. Involvement with the food and employee safety teams across the company, from growing the products to the packing and shipping operations, helps inform decisions on how to effectively reduce the risk to people

and product. Allan Bros. fosters a culture of continuous improvement, research, and development, and actively collaborates with academia and industry to improve processes, interventions, and design innovations. Matt received his B.S. in Mechanical Engineering Technology at the Oregon Institute of Technology in Klamath Falls, Oregon. He continues to receive his food safety education through a collaborative industry in Washington State and from a great many supportive people that tolerate his endless annoying questions!

GEORGE NIKOLICH

George Nikolich originally joined Gerawan Farming more than 30 years ago as the pest control advisor, agronomist and ranch manager. In 2009, George was promoted to Vice President of Technical Operations, overseeing Gerawan's compliance program for food safety regulations, quality assurance, postharvest handling, packaging, cooling, storage and transportation. George serves on the CA Fresh Fruit Association Board of Directors and the Center for Produce Safety Technical Committee, and is a member of the Food Science and Nutrition Advisory Committee at California State University, Fresno. George received his B.S. degree in Agricultural Science from California State University, Fresno, and his M.S. degree in Agronomy from the University of California, Davis.

WALTER RAM

Mr. Ram is Vice President of Food Safety at The Giumarra Companies and has been with Giumarra since 1995. He is responsible for food safety and regulatory affairs for Giumarra's 10 operating divisions, and is active in food safety and food defense work at the industry level. Giumarra is one of the world's largest table grape producers, and is a major supplier of over 60 fresh fruits and vegetables from 16 countries. His current industry activities include: Center for Produce Safety's Technical Committee; Produce Marketing Association Food Safety, Science and Technology Committee; Fresh Produce Association of the Americas Board of Directors; and Canadian Produce Marketing Association Food Safety Committee. Previous industry activities have included: chairman of United Fresh Produce Association's Food Safety and Technology Council; contributor and editor of Commodity Specific Guidelines for the Fresh Tomato Supply Chain; contributor to Commodity Specific Guidelines for the Melons Supply Chain; member of the steering committee for the National Mango Board; and Strategic Partnership Program for Agroterrorism (a joint government/industry program).

MIKE ROBACH

Mike is CEO of The Robach Group LLC, a recently formed food safety, quality and regulatory consulting group. Mike retired as Vice President, Corporate Food Safety, Quality & Regulatory for Cargill, based in Minneapolis, Minnesota, USA in the fall of 2018. He started out his career with Monsanto Company. Prior to joining Cargill, he headed up technical services for Conti Group's meat and poultry businesses. Mike is a graduate of Michigan State University and Virginia Tech. Mike is Chairman of the Board of Directors of the Global Food Safety Initiative (GFSI), past President and Founder of Safe Supply of Affordable Food Everywhere (SSAFE), and member of the U.S. Poultry and Egg Association's Research Advisory Committee. He is a member of the International Association of Food Protection, the Institute of Food Technologists, the American Society for Microbiology, and on the Advisory Board for Food Safety Tech & Food Safety Consortium. Mike is a member of the Wayne Farms Board of Directors and a member of the Clear Labs Board of Directors. Mike has worked with the World Organization of Animal Health (OIE), the Food and Agriculture Organization (FAO) and the World Trade Organization (WTO) on harmonized animal health and food safety standards. From 1995 through 2000, Mike was a member of the National Advisory Committee for Microbiological Criteria in Foods.

CHANNAH ROCK

Dr. Channah Rock is an Associate Professor at the University of Arizona in the Department of Soil, Water, and Environmental Science and also maintains a joint appointment as a Water Quality Specialist with UA Cooperative Extension. Dr. Rock is PI on several projects relating to microbial evaluation of water quality for the protection of public health as well as promoting water reuse as a safe and practical resource for the Southwest. She was extensively involved in assisting industry in the 2018 *E. coli* outbreak investigation initiated by the CDC and FDA involving romaine lettuce grown in Yuma, AZ. Additionally, Dr. Rock recently supported the CA and AZ LGMAs by providing science-based recommendations towards the revision of the Irrigation Water Metrics.

MIKE TAYLOR

Mike Taylor is a senior fellow at the Meridian Institute and co-chair of the board of Stop Foodborne Illness. Until June 2016, Mr. Taylor was FDA's Deputy Commissioner for Foods and Veterinary Medicine. He led the FSMA-mandated overhaul of FDA's food safety program and oversaw all of FDA's food-related

activities. Mr. Taylor served previously at FDA as Deputy Commissioner for Policy (1991–94) and at USDA as Administrator of the Food Safety and Inspection Service and Acting Under Secretary for Food Safety (1994–96). Prior to joining FDA in July 2009, he spent nearly a decade in academia conducting food safety, food security and public health policy research. In the private sector, Mr. Taylor founded the food and drug practice and was a partner in the law firm of King & Spalding, was Vice President for Public Policy at Monsanto Company, and served on the boards of the Alliance to End Hunger and RESOLVE, Inc. He is currently a member of the board of directors of Clear Labs, Inc. Mr. Taylor is a graduate of Davidson College and the University of Virginia School of Law.

ANGELA VALADEZ

Angela Valadez, a Chicagoland native, started with Publix Super Markets in 2013 as their Produce Food Safety Coordinator. She supported both Publix Fresh Foods Manufacturing and the Produce Retail Business Unit to continuously improve and strengthen food safety programs internally and improve the Produce Good Agricultural Practices associated with suppliers. In 2018, she was promoted as the new CQA Food Safety & Quality Assurance Manager for Supply Chain. In addition, she leads the CQA Supply Chain team who support Publix's business partners in corporate purchasing with supplier review and selection of Publix store brand products. She is an FSPCA lead instructor for FSMA's Preventive Controls for Human Food, the Produce Safety Rule, and Foreign Supplier Verification. She teaches internally to her industrial operation partners and externally with the University of Florida–IFAS. Prior to Publix, Angela held various food and plant science research and educational activities at formerly Silliker Labs in Illinois, USDA-ARS in Pennsylvania, and the National Renewable Energy Laboratory in Colorado. Angela earned her B.S. and M.S. from Purdue and Penn State Universities in Genetics, Microbiology, and Food Science, and a Ph.D. from the University of Florida in Food Science, specializing in produce food safety. Her dissertation focused on the risk of *Salmonella* for fresh market tomatoes during pre-and post-harvest practices.

STEVE WARSHAWER

Steve Warshawer is the food safety and value chain technical advisor to the Wallace Center at Winrock International. Wallace Center is a national leader in developing market-based solutions, support, and training programs for local and regional oriented food and farm businesses. In this role he applies learned experience from over 40 years in a variety of farm, food, and distribution businesses based at the diverse, very small family farm that he and his wife Colleen operate in the highlands near Santa Fe, New Mexico. In 2009 his commitment to assisting value chain partners gain new markets by meeting supply chain expectations led him to dive into the world of voluntary and regulatory farm food safety. As a novice he sought and gained insight from many specialty crop industry food safety and quality system professionals. Today he works as a member of the Technical Working Group of United Fresh Harmonized GAP initiative and serves on its Calibration Committee. He catalyzed and facilitated a collaborative initiative between the Wallace Center and USDA AMS/SCI to develop the ISO 9001 based GroupGAP Food Safety audit program. Through its "National Good Food Network" and related partnerships, Wallace Center initiatives continue to advance the understanding and implementation of scale-appropriate, science- and risk-based approach to food safety training and implementation for farms and food businesses in direct markets and short supply chains. Wallace Center is particularly focused on training, implementation, and, especially, data acquisition and reporting methods that are adapted to the needs of historically underserved communities and among socially disadvantaged and limited resource producers.

BOB WHITAKER

As Chief Science and Technology Officer for the Produce Marketing Association (PMA), Dr. Bob Whitaker oversees PMA's food safety, technology and sustainability efforts across the produce supply chain. This work focuses on delivering education content and connecting members to technical solution providers. Before joining PMA, Dr. Whitaker held various scientific and senior management positions at DNA Plant Technology Corporation, and senior operation and technical functions at NewStar Fresh Foods. Dr. Whitaker served as Chairman of the Board of Directors for the International Fresh-Cut Processing Association (IFPA), and was a board member for the United Fresh Produce Association. Dr. Whitaker has received a number of industry awards for achievement, has served on the USDA National Advisory Board for Microbial Criteria in Foods, the National Academies of Sciences Genetic Engineering Review Panel, and worked on a number of industry and government food safety and technology initiatives. He was named to the Executive Committee for the Center for Produce Safety (CPS) in 2007, and served as Chairman of the CPS Technical Committee from 2008–2013. Dr. Whitaker received his

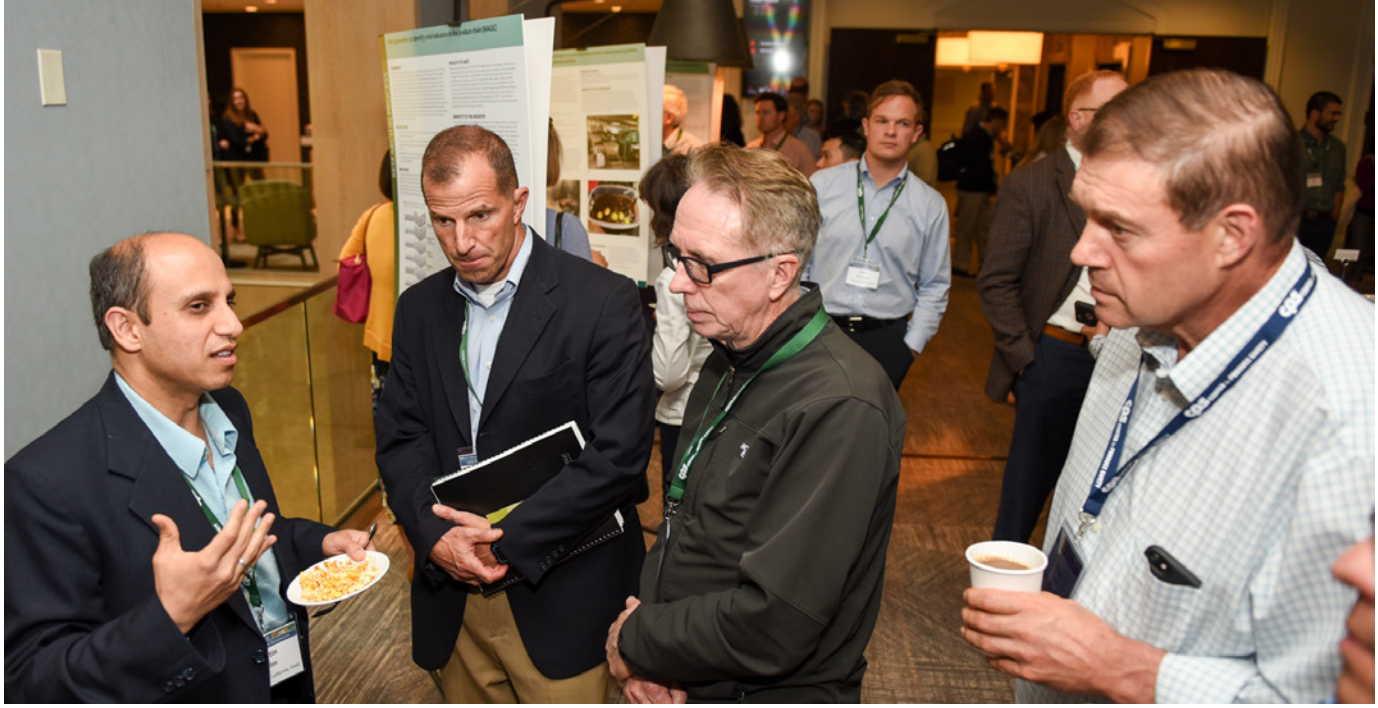
Ph.D. in Biology from State University of New York at Binghamton.

MARTIN WIEDMANN

Dr. Martin Wiedmann leads several initiatives and works to develop and communicate the scientific knowledge needed to prevent and control foodborne and zoonotic diseases caused by bacteria. Martin's academic programs focus on a comprehensive and interdisciplinary farm-to-table approach to food safety, and involve the application of a variety of disciplines (including microbiology and microbial genetics, population genetics, molecular biology, genomics, evolution and modeling) and collaboration from a variety of disciplines (economics, computer science, veterinary medicine, epidemiology and statistics) from many universities, state and federal health agencies, and trade organizations. His research program objective is to develop a better understanding of the pathogenesis, ecology, evolution, and transmission of bacterial foodborne and zoonotic diseases, and is currently focused on two model organisms, including *Listeria monocytogenes* and *Salmonella*. Martin Wiedmann received his Ph.D. from Cornell University, Ph.D. and Veterinary Degree from University of Munich, and has been awarded several honors. He is a Fellow of the Institute of Food Technologists (IFT), a Fellow of the American Academy of Microbiology (AAM), member of the International Academy of Food Science and Technology, and currently serves as co-director of the New York Integrated Food Safety Center of Excellence.

TIM YORK

Tim York is President of Markon Cooperative, Inc., a purchasing, marketing and logistics cooperative serving North America's leading independent foodservice distributors. Based in Salinas, California, Markon distributes produce to over 75 facilities in the United States and Canada. Tim has 40 years of experience in the produce and foodservice industries. He began his career in 1977 at H. Hall & Company, a grower/shipper of strawberries and mixed vegetables. Tim York joined Markon in 1985 as Purchasing Director, and he was promoted to his current position of President in 1990. Tim York has held numerous committee and task force positions, including Chairman of the Produce Marketing Association (PMA) (2002–2003) and Chairman of PMA's Foodservice Division (1994–1996); he is currently a member of the Canadian Produce Marketing Association Board of Directors.



Poster Session, 2018 Symposium

Poster Session

Simulation analysis of in-field produce sampling for risk-based sampling plan development [*6]

Contact **Matthew Stasiewicz, PhD – University of Illinois at Urbana-Champaign**
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Project Date January 1, 2019 – December 31, 2020

Summary Effective preharvest, field-level produce sampling is challenging because current practices typically yield few positive samples with fields rarely re-testing positive. Statistical theory suggests one reason is that detecting rare contamination events would require 100s to 1,000s of random samples, or targeting sampling towards higher risk locations in the fields. This project will develop and validate tools for the produce industry to evaluate existing and improved produce field sampling plans. Specifically, we will develop a simulation model of contaminated in-field produce and the process of picking samples. We will simulate fields in four regions of the US, contaminated by fecal deposits, irrigation water, or low-level soil bacteria. We will simulate convenience, generic, and risk-based sampling plans. Results will be used to communicate to growers the number and location of samples needed to achieve a known power to detect contamination. We will validate these simulations against academic literature, industry partner data, and field-trials of controlled contamination of spinach. Our goal is to provide tools for growers to (i) develop improved sampling plans, (ii) customize those plans to their individual fields, and (iii) quantify the performance and costs of the plan – all to better identify and manage preharvest food safety risks.

Exploring the relationship between product testing and risk

Contact **Emma Hartnett, PhD – Risk Sciences International, Canada**
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Project Date January 1, 2019 – December 31, 2019

Summary Risk to consumers is directly related to prevalence and concentration of pathogens in products. Sampling to determine if levels of pathogens are at acceptable levels is one approach adopted to manage the consumer risk. However, the relationship between different sampling options, and the reduction in risk provided by implementing those options has not been well described. We will develop a sampling-risk model that quantifies the relationship between product testing and the risk to consumers. This model will consider factors such as sample size (mass), number of samples, lot size, and many others. The result will be a series of tables and charts that describe the relationship between the factors and risk. Such analyses can be used to explore the efficacy of alternate risk management strategies, and help answer questions such as "If I increase the sample mass what is the impact on risk?" or "If I sample at point X instead of point Y, what will the benefit be?".

Towards a decision-support tool for identifying and mitigating on-farm risks to food safety *[6]

Contact **Jeff McGarvey, USDA ARS**
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Project Date January 1, 2019 – December 31, 2020

Summary Contaminated produce continues to be a leading cause of foodborne illness. Yet farmers still lack the ability to predict when their crops are at risk and lack effective strategies to manage those risks. While evidence is accumulating regarding the efficacy of many practices, results are often not made available to growers in a useable way. We plan to develop data-driven, pre-harvest tools to help growers predict and mitigate risks associated with foodborne pathogens. This tool will be based on existing literature and will be customizable to each farmer's unique management practices. We also will explore novel methods for suppressing pathogens, when they do occur on farms. Specifically, we will study how soil amendments and farm management affect the ability of feces-feeding soil bacteria to suppress pathogens (*Salmonella* and *Listeria*). Farmers, industry, and conservation organizations have expressed strong interest in making informed decisions about on-farm practices to improve produce safety without comprising environmental health. By combining literature syntheses with lab and field experiments, this project will provide growers with both new strategies for mitigating pathogen prevalence and an effective tool to assist growers in navigating decisions regarding the food safety/conservation "stale-mate."

Development of a model to predict the impact of sediments on microbial irrigation water quality *[6]

Contact **Charles Gerba, PhD – University of Arizona**
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Project Date January 1, 2019 – December 31, 2020

Summary Microbial contamination of surface water is a complex dynamic and influenced by many interacting factors (e.g., runoff into streams from rainfall). Sediments at the bottom of waterways have been shown to harbor 10 to 10,000 more fecal bacteria than surface waters, and when re-suspended may cause large increases in the overlaying water, resulting in increased risks of exposure to disease-causing microorganisms. However, their significance in manmade canals is unknown. The goal of this project is to determine under what conditions bacteria and viruses could be re-suspended from sediments found in manmade irrigation canals and to identify potential "hotspots" of accumulation of microbes in the canals. This information can then be used to design sampling strategies and irrigation events to minimize exposure of pathogens to crops.

Cyclospora prevalence in irrigation water in fresh produce growing regions

Contact **Gerardo Lopez, PhD – University of Arizona**
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Project Date January 1, 2019 – December 31, 2019

Summary In the United States, outbreaks associated with the protozoan intestinal parasite *Cyclospora cayetanensis* have been occurring almost every year since 2000, according to the Centers for Disease Control and Prevention. During May–August 2018, a total of 2,299 laboratory-confirmed cases of cyclosporiasis in 33 states were reported, and these people had no history of international travel. Only 761 of these cases were connected to two outbreaks associated with fresh produce, and the specific sources of contamination for the remaining cases were not determined. The disease can be transmitted by consumption of food or water contaminated with *C. cayetanensis*. The goal of this project is to close the scientific knowledge gaps and gain a better understanding of *C. cayetanensis* occurrence and prevalence in irrigation waters in fresh produce growing regions to help mitigate the cross contamination to fresh produce. The project will determine the prevalence of *Cyclospora cayetanensis* in irrigation waters using the new BAM Chapter 19b method for produce, with slight modifications. The project will help identify areas of potential risk associated with irrigation waters.

Identifying competitive exclusion microorganisms against *Listeria monocytogenes* from biological soil amendments by metagenomic, metatranscriptomic, and culturing approaches *[6]

Contact **Xiuping Jiang, PhD – Clemson University**
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Project Date January 1, 2019 – December 31, 2019

Summary *Listeria monocytogenes*, widespread in the environment, can contaminate many types of food products and result in deadly foodborne outbreaks. To reduce *Listeria* contamination of fresh produce, it is essential to understand the ecology of this pathogen where it inhabits. Compost has been used as biological soil amendment in agricultural practices for centuries as it provides readily available nutrients for plant growth and improves soil properties. Owing to the richness in microbial community, compost can also mediate suppression of plant diseases and human pathogens. In this proof-of-concept project, we will utilize the powerful high throughput sequencing approaches to understand microbial composition and functions at the whole microbial community level in a variety of composts (dairy- and poultry-waste based), and to identify competitive exclusion (CE) microbial species with antagonistic activities against *L. monocytogenes*, followed by CE isolation using culturing methods. Findings from this project will reveal the abundance and diversity of indigenous microflora in compost samples, identify and isolate potential CE microorganisms for future studies on biological control of *L. monocytogenes* in various ecosystems, such as soil, water, and produce processing plants. Ultimately, our study will provide biological tools to effectively control *L. monocytogenes* in produce growing and processing environments.

Modeling tools for design of science-based *Listeria* environmental monitoring programs and corrective action strategies *[7]

Contact **Renata Ivanek, PhD – Cornell University**
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Project Date January 1, 2019 – December 31, 2019

Summary Well-designed environmental monitoring programs for *Listeria* as a strategy to identify and eliminate *Listeria monocytogenes* risks are essential for the produce industry and are increasingly mandated by both regulatory agencies and buyers. Along with this, industry needs science-based tools to implement responses to *Listeria* detection that are both appropriate for a specific facility and its unique processes and effective in reducing risk of contaminated products. As it is not practical to test out different corrective actions and sampling strategies in a given facility, our objective is to use computer modeling to identify the optimal approaches for a particular setting. Specifically, a model we have previously developed will be adapted to fresh produce processing facilities and validated with sampling data collected through an on-going project. Simulations with validated models will characterize various corrective action and monitoring schemes for their ability to detect and control *Listeria* in the unique settings of different facilities. As a result, the project will provide industry with science-based resources for selecting appropriate corrective action approaches and demonstrating the equivalency of different sampling strategies in their unique facilities.

A systematic review of *Listeria* growth and survival on fruit and vegetable surfaces: responding to critical knowledge gaps *[9]

Contact **Laura Strawn, PhD – Virginia Tech**
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Project Date January 1, 2019 – December 31, 2019

Summary There are critical knowledge gaps regarding the risk of *Listeria monocytogenes* on intact fruit and vegetable surfaces (i.e., whole fruit and vegetable commodities that are not cut or processed). This is of particular concern as outbreaks have occurred from intact produce, such as whole cantaloupe and stone fruit. Since it is widely accepted that *L. monocytogenes* may be present in produce production environments, data are needed on *L. monocytogenes* behavior on whole produce, after harvest, when handled/stored at typical and abuse conditions over typical shelf life (and beyond). This project will determine *L. monocytogenes* growth and survival potential on intact whole produce commodities and develop quantitative risk models for selected commodities that demonstrate growth or significant survival potential. These goals will be achieved using a three-pronged approach of i) investigating prior information (systematic literature review), ii) filling critical data gaps (*L. monocytogenes* growth/survival experiments), and iii) developing risk models to assist the industry in managing the risk from *L. monocytogenes* contamination. Knowledge will be created on which whole produce commodities support *L. monocytogenes* growth and/or survival potential at various handling and storing conditions observed along the supply chain.

Listeria monocytogenes growth potential, kinetics, and factors affecting its persistence on a broad range of fresh produce *[6]

Contact **Xiangwu Nou, PhD – USDA-ARS**
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Project Date January 1, 2019 – December 31, 2020

Summary *Listeria monocytogenes* (*Lm*) is one of the most dangerous foodborne pathogens, and is widespread in the natural and food production environments, including soil and water. It also has a unique ability to grow at refrigeration temperatures. In recent decades, *Lm* has been implicated in several produce-associated foodborne outbreaks and become a major concern for the fresh produce industry. In developing guidelines to effectively manage risks of *Lm*, both FDA and the fresh produce industry urgently need information on the potential and the underlying factors of *Lm* growth on a large variety of fresh produce. In this project, we will examine *Lm* growth potential and kinetics on a broad range of whole and fresh-cut vegetables and fruits, under typical pre-market storage and/or retail display conditions as well as under elevated abusive temperatures. We also will investigate how the nutritional and physiochemical characteristics of produce and the microbial community on produce affect *Lm* growth.

UA Ag Water app-language expansion and practical grower-inspired improvements

Contact **Channah Rock, PhD – University of Arizona**
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Project Date January 1, 2018 – December 31, 2018

Summary Currently, growers face substantial challenges in meeting the revised FDA Food Safety Modernization Act requirements, specifically the agricultural water regulations. Over the past year, our research and extension team has received tremendous feedback on the usefulness of the Ag Water app for both the evaluation of local water quality as well as to meet the FSMA requirements (calculating Statistical Threshold Value, Geometric Mean, and die-off requirements). Whether the Ag Water app is used as a training tool to help growers and food safety managers better understand water quality or as a resource to meet the FDA FSMA regulations, updates are required to meet grower needs as well as reach the broadest stakeholder group possible (including Spanish speakers). The main objective of this project is to improve functionality of the Ag Water app, based on real-world grower feedback, as well as to deploy a fully functioning Spanish version of the app and associated on-line tools developed by the University of Arizona.

Significance of sanitizers on induction of viable but non-cultivable (VBNC) foodborne bacteria and their survival and resuscitation in fresh produce

Contact **Ana Allende, PhD – CEBAS-CSIC, Spain**
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Project Date January 1, 2019 – December 31, 2020

Summary Washing is a key intervention step for fresh fruit and vegetables to remove dirt, foreign materials, tissue exudates from cut surfaces and microorganisms. Sanitizing agents are needed to maintain the microbial quality of the water and prevent cross-contamination of the product. Several CPS-funded projects have been focused on the efficacy of disinfection treatments using standard plate count procedures to determine the bacterial inactivation. However, foodborne pathogens are able to develop a stress resistance mechanism that enables them to enter into a temporary state of low metabolic activity in which cells can persist for extended periods without division, called the viable but non-cultivable (VBNC) state. There is a pending need to determine the capability of water disinfection treatments to induce the VBNC state of foodborne pathogens in process wash water, particularly when optimizing the sanitizer dose. This project will evaluate the ability of foodborne bacteria in the VBNC state, present in the process wash water, to attach to the surface of fresh produce during washing as well as the conditions needed to survive and recover from VBNC to culturable state during storage. Data obtained will provide us with better understanding on the role of sanitizers in the induction of VBNC foodborne bacteria.

Non-fouling food contact surfaces – prevention of biofilm and surface-mediated cross-contamination *[6]

Contact **Boce Zhang, PhD – University of Massachusetts Lowell**
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Project Date January 1, 2019 – December 31, 2020

Summary Post-harvest preventive control is a critical research topic for the produce industry because post-harvest handling is an essential stage in the supply chain regarding food safety. A practical preventive control will not only make a great impact on public health but also on the produce industry's long-term profitability. Despite previous interest in fouling of mainstream FDA-approved food contact substances (FCS), there has not been a comprehensive evaluation of non-fouling properties of any FCS, or the practicality of industrial sanitization procedures for the produce industry. We propose to fill this gap and develop an applicable post-harvest preventive control approach to enhance the non-fouling properties of FDA-approved FCS against *Listeria monocytogenes* (*Lm*) biofilms. We will: 1) evaluate non-fouling properties of existing FDA-approved FCS; 2) enhance FCS performance by simple and cost-effective physical/topographical modification without altering the chemical composition; 3) evaluate whether the top-performing FCS are compliant with sanitary designs for the fresh produce industry; and 4) validate the findings at a fresh-cut processing pilot plant. Project outcomes will provide scientific information that will support sanitary design of packing, holding, and processing equipment/devices, coatings, and coating modifications to simplify cleaning/sanitization, and to prevent pathogen attachment and biofilms on FCS for new and retrofitted equipment.

Illuminating the role of whole genome sequencing in produce safety *[6]

Contact **Kerry Cooper, PhD – University of Arizona**
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Project Date January 1, 2019 – December 31, 2020

Summary Whole genome sequencing (WGS) is rapidly becoming the gold standard for foodborne outbreak investigations by public health agencies around the world. However, as WGS continues to be developed as a tool it needs to be refined to maximize its potential, and thus reach the ultimate goal of speeding up investigations. The goal of this project is to provide data to public health agencies like the FDA to improve the use of WGS as an outbreak investigation tool. Overall, this project will help to refine WGS as a tool for outbreak investigations for public health agencies to use during outbreaks. Furthermore, this project can be used by the produce industry to implement WGS for internal source tracking to identify "resident" versus "transient" pathogens, sources of contamination for either, and a better understanding of the breakdowns or gaps in prevention, thus improving produce safety by closing these gaps.

Fate of different *Listeria monocytogenes* strains on different whole apple varieties during long-term simulated commercial storage *[8]

Contact **Elliot Ryser, PhD – Michigan State University**
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Project Date January 1, 2019 – December 31, 2020

Summary The microbiological safety of whole and sliced apples has been called into question during the last seven years due to multiple recalls for *Listeria monocytogenes* (*Lm*) and a high-profile outbreak of listeriosis from caramel apples. Most recently, whole Gala and Honeycrisp apples were recalled in December 2017 due to *Lm* contamination, suggesting extended survival of this pathogen. Consequently, this two-year project seeks to determine the fate of *Lm* on apples during long-term simulated commercial storage. Some of the key questions to be answered include: 1) Do different foodborne outbreak strains of *Lm* differ in their ability to survive on apples; 2) Does *Lm* survival differ when apples are contaminated from water versus direct contact with equipment surfaces (crates, brushes); 3) Does the physiological state of *Lm*, specifically whether cells in the inoculum harvested from a planktonic (i.e., broth) culture vs. from a biofilm (i.e., solid surface) impact *Lm*'s subsequent fate on apples; 4) Does storing apples in air versus a controlled atmosphere (low oxygen and low carbon dioxide) affect *Lm* survival; 5) Does the variety of apple (Gala, Granny Smith, Honeycrisp), region in which the apples are grown (Washington State, Michigan, Pennsylvania), and growing season affect how *Lm* attaches and survives on apples; and 6) Does apple waxing affect *Lm* survival? Answers to these and other questions will assist the apple industry in minimizing the *Lm* risks associated with current apple growing and packing practices.

Preventive sanitation measures for the elimination of *Listeria monocytogenes* biofilms in critical postharvest sites *[6]

Contact **Kay Cooksey, PhD – Clemson University**
kcookse@clemson.edu

Project Date January 1, 2019 – December 31, 2019

Summary *Listeria monocytogenes* is an important foodborne pathogen commonly found in the environment. Recent *Listeria* foodborne outbreaks have been linked to fresh produce including stone fruits. Contamination of stone fruits is problematic since these products are usually consumed without heating. In addition, some surfaces associated with packing operations are inherently difficult to sanitize. In the proposed research, these surfaces will be characterized and inoculated with *Listeria monocytogenes* in fluid chambers for biofilm formation. Biofilms will be treated with sanitizers commonly used in the stone fruit packing industry. Results from this study will provide improved pathogen control in addition to the basic good agricultural practices, thereby helping fruit industry to produce safer produce for human consumption.

Managing *Listeria* risk in fresh produce using predictive models

Contact **Don Schaffner, PhD – Rutgers University**
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Project Date January 1, 2019 – April 30, 2019

Summary Many foods are perishable and require time/temperature control throughout their shelf life. In many cases this control is required to ensure quality, but in an uncertain number of situations, it may also be required for food safety (to control foodborne pathogen growth). This issue is often discussed by fresh produce producers and buyers and is now exacerbated by several federal regulations and policies, including the Preventive Controls Rule and Sanitary Transportation Rule. While research funded by CPS may eventually provide definitive laboratory-based information to guide these discussions, there is an urgent need for short-term science-based parameters on this topic. This project will focus on the pathogen most likely to grow at the temperature range of interest (*Listeria monocytogenes*) and will use "off-the-shelf" computer models in the form of ComBase Predictor. The objective will be to produce a report with a series of time and temperature tables, comparing relative risk of *Listeria monocytogenes* growth for different conditions to guide science-based risk management decisions.

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[*1] **2016 RFP:** California Department of Food and Agriculture (CDFA) SCBGP support through Grant 16-SCBGP-CA-0035.

[*2] **2016 RFP:** Florida Department of Agriculture and Consumer Services (FDACS) SCBGP support through Grant USDA-AMS-SCBGP-2016.

[*3] **2017 RFP:** CDFA SCBGP support through Grant AM170100XXXXG011.

[*4] **2017 RFP:** FDACS SCBGP support through Grant USDA-AMS-SCBGP-2017.

[*5] **2017 RFP:** Washington State Department of Agriculture (WSDA) SCBGP support.

[*6] **2018 RFP:** CDFA SCBGP support through Grant AM180100XXXXG003.

[*7] **2018 RFP:** FDACS SCBGP support through Grant AM180100XXXXG046.

[*8] **2018 RFP:** WSDA SCBGP support.

[*9] **2018 RFP:** Texas Department of Agriculture (TDA) SCBGP support.

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