## GRANTS PROGRAM: CENTER FOR PRODUCE SAFETY
## 2016 RFP Research Priorities Summary – October 20, 2015

The Center for Produce Safety sets its highest priorities in supporting research towards ready-to-use, data-based solutions or information which catalyze and support science-based actions and decisions to prevent or minimize produce safety vulnerabilities across the supply and marketing chain. To a significant degree, the sustainability of CPS to provide this resource and function demands that the greatest share of research award funds be allocated to investments in applied, practical, and knowledge gap–filling projects. These anticipated near-term research questions must be supported by longer-term fundamental research and limited objective proof-of-concept projects to explore novel solutions or to complete limited duration translation research of products or services of broad interest and adoption by the industry. While some priorities remain broad, other priorities are re-drafted for 2016 to capture and emphasize the input that CPS has received to more tightly focus the research question with specific anticipated data outcomes. With this mission in mind, the following priorities are provided as guidance to applicants to the 2016 CPS request for proposals. Research priorities are grouped in two parts: Part I – Core Produce Safety Research Objectives, and Part II – Commodity Specific areas provided by the Washington Tree Fruit Industry, California Fresh Fruit Association and the California Fresh Citrus Industry.

### Part I. Core Produce Safety Research Objectives

The following produce safety research objectives have been identified through solicitation of input from the produce industry as well as government and academic stakeholders. In addition, feedback from CPS research meeting participants and reviews of previously funded CPS grants and research outcomes were utilized to identify research objectives. The research objectives have been reviewed and revised by the CPS Technical Committee for the 2016 request for proposals (RFP). Core produce safety research objectives have been streamlined and prioritized for 2016 but research concepts and objectives not specifically listed will be considered. The desire for science-based advancements to bridge or close our knowledge gaps and practical technological solutions in risk reduction cut across all fresh fruit, vegetable and nut crops. Research that will enhance produce safety systems span all phases of production, harvest, cooling, packing, fresh-processing, storage, transportation, receiving and point-of-sale environments. These research objectives are typically broad in scope and are written with the intent to encourage creative approaches to research that will improve our understanding of potential produce safety hazards, risks and routes of contamination, and aid in development of more effective, science-based risk identification and characterization. In some cases, priority is given to very specific research topics and a structured set of anticipated outcomes that align with industry input for a public source of data to support preventive control validation or the efficacy of corrective actions to food safety risks. It is hoped that both approaches to solicit research proposals lead to increased knowledge and practical technologies that support evolving strategies and food safety management tools throughout the entire supply chain.

For 2016, the following core produce safety research priorities are provided as the focal point for program needs but are not intended to preclude submission of topics within the broadest context of produce safety. Importantly, details with background information about each of these identified research topics may be found on the CPS website at http://www.centerforproducesafety.org/. Principal investigators submitting a Concept Proposal are highly encouraged to review this information before submitting proposals. Principal investigators submitting a Research Proposal may also submit clarifying questions by telephone to (530) 554-9761 or by emailing the CPS Executive Director, Ms. Bonnie Fernandez-Fenaroli at bonnie@centerforproducesafety.org.

**1. Prerequisite Produce Safety Research**: Produce safety research requires expanded development of produce safety–specific research tools, techniques, materials and methods to address complex produce safety issues in the farm, adjacent farmscape and watershed environments, harvest operations, cooling facilities, packinghouses, re-pack operations, fresh-cut processing, transportation, distribution, retail or foodservice environments. While open to broad application of applied and more fundamental research proposals, specifically requested are research and development of tools and technologies regarding:

**1.1. Remote Sensing of Risk Factors**: Proof of Concept proposals are requested to develop baseline efficacy information and demonstration of data capture, analysis, and practical predictive modeling for the detection of presumptive risk of contamination and corrective action alert systems.

**1.2. Validation of Surrogates for Preventive Controls**: Additional research, extending fundamental research on this topic already funded by CPS, is needed to specifically validate previously qualified non-pathogenic surrogates for use as geospatially relevant standards and research tools and for in-situ commercial operation validation studies. These qualified surrogates may be for general environmental risk, process-specific, intervention-specific, and/or commodity-specific applications.

**1.3. Closing Knowledge Gaps in FSMA Produce Rule-related Metrics**: Die-off of pathogens, primarily but not limited to bacterial pathogens, has proven challenging to confidently predict, particularly in preharvest environments and conditions. The proposed Produce Safety Rule provides a management option in which produce growers may apply an assumed die-off rate, based on limited studies, for pathogens between an irrigation or foliar-application event (using source water that does not meet the proposed statistically determined standards) and harvest, or between harvest and reasonably anticipated shortest storage and distribution interval prior to food preparation or point of purchase. A broad diversity of science-based assessments under tightly-controlled conditions are need to develop data and broaden knowledge critical to modeling die-off under conditions representative and reflecting the diversity of industry practices and environmental norms. CPS is requesting proposals designed to provide standardized, multi-regional projects that will provide foundational evidence for predictive modeling of pathogen die-off, which either strengthen and support current anticipated regulatory metrics for agricultural water or demonstrate the need for modifying this approach in view of clear limitations of these allowances in protection of public health.

**1.4. Developing Science-based Evidence for Principles of Co-management**: In many regions and, frequently, in operations under certified organic crop management, produce is grown on farmscapes in smaller production blocks and surrounded by woodlands or other wildlife habitat. As the anticipated Produce Rule or ancillary retail industry and direct–market buyer expectations engage a broader community of growers, this is likely to become an increasingly important business sustainability and management consideration. Although on-going research is addressing risk potential and mitigation characteristic of these numerous small-scale farms, CPS is committed to solicit complimentary research that identifies practical, economical and effective measures to divert or direct animal foraging and movement away from production areas, with minimal disruption of animal access or use of their habitat and also compliant with federal and local regulations and ordinances. For example: What is the quantitative effectiveness and cost:benefit of diversion and/or food source cropping to prevent deer intrusion into fresh produce fields and crop contamination with zoonotic pathogens?

**1.5. Evidence-based Standards for Produce Wash and Cooling Systems**: Despite recent efforts to consolidate current science into a guiding matrix and framework for validation, verification, and critical monitoring standards for microbiological quality of aqueous produce cooling, transport, wash, or postharvest treatment, there remains an immediate need to address practical data-supported issues of process control within a high

fidelity to commercial practices and current economic, training, or resource constraints. CPS, its international stakeholders, and commodity partners request diverse, limited or extended timeline proposals that collectively will further resolve the identification of critical factors which, individually or broadly, establish Water-based Process Controls Standard Validation by: 1. Metric verification and development; 2. Method verification and development; 3. Address multiple commodity types; 4. Incorporate multiple cooling, wash, or treatment systems and water quality variables.

**2. Indicators and Index Microorganisms**: Identify a singular or suite of culturable or non-culturable microorganisms, or biological or chemical markers that could quickly, easily and reliably indicate the presence or absence of human pathogenic viruses in agricultural inputs, within the on-farm agricultural environment, in/on produce commodities and in produce handling facilities.

**3. Factors Affecting Human Pathogen Persistence**: Related to Core Priority 1.3 – Research is needed to identify guidance principles to better predict the persistence and growth potential of human bacterial pathogens within the practical and realistic range of produce production, postharvest handling, and distribution environments to the point of purchase or food preparation. These principles should be generally transferable and translatable to diverse systems and scales of production and handling operations. Research results should include recommendations and/or guidance for system-wide preventive controls to reduce, control, or eliminate human pathogens in these environments and marketing channels. For 2016, CPS is specifically requesting research clearly elucidating:

**3.1. Human Pathogen Persistence in the Produce Production Environment**: Special attention is called to determining the prevalence, persistence and transference of *Cyclospora* to produce during production and in marketing channels. Concept Proposals which include clear evidence for the capacity to study survival and transference from endemic sources of *Cyclospora*-contaminated soil, water, or other environmental sources, whether on-site or in model systems, will be given priority.

**3.2. Human Pathogen Viability, Growth and Detection in Postharvest Handling and Distribution**: Special attention is called to determining the factors in bacterial pathogen stress responses during pre-harvest and postharvest handling and distribution conditions that favor reversion from a “viable but nonculturable” (VBNC) state to a detectable state in post-shipping surveillance, with a potentially corresponding elevated risk of illness when consumed.

**4. Understanding Produce Risks**: Industry practitioners and government regulators are limited in their ability to formulate truly science-based and risk-based produce safety best practices and policies. This limitation stems from their inability to integrate all the available information into a useable tool to assist in risk-ranking various hazards and routes of contamination and to most effectively deploy limited food safety resources. Specifically, development of qualitative and/or quantitative microbial risk assessment tools to aid in identifying and ranking produce safety risk factors comparing broad category operational assessments of risk to unique or regional operations. Research is needed to establish data fundamental for the development of a QMRA analysis that would lead to prioritization of preventive controls and interventions that optimally reduce public health and business risk.

**5. Proof of Concept Mitigation Technologies and Preventive Controls**: Proof of Concept proposals are requested to demonstrate the critical information needed to suggest longer-term investment in pre- and postharvest interventions that significantly reduce pathogens to non-detectable levels.

**6. New High Priority Objectives**:

**6.1.** CPS is requesting proposals for a comprehensive but limited timeline-scoping study to develop a White Paper consolidating the breadth of published research in the past 1.5 years of this RFP and all awarded research in the public domain, which should be systematically utilized in defining new priorities or directions in general RFP funding or specific research award placement for critical data needs. The proposal should be limited to a six-month period unless compelling justification is provided for a phased reporting approach, up to a one-year maximum.

**6.2.** Does application of approved and economically viable sanitizers achieve adequate and compliant disinfection of diverse fabrication and construction materials utilized in current packing, cooling and handling equipment and facilities?

**6.3. Development of Best Practice Guidance for Measuring Key Water Sanitizers**: Broad assessment of the variability in measurement of delivered and steady-state sanitizer dose across the fresh produce supply-chain and within the various scales of operation and diverse applications have taught us that meeting desired set-points and outcomes is harder to achieve for many commercial operations than bench-top testing would predict. Equally, reported sanitizer doses from preharvest to postharvest do not uniformly correlate with the expected outcomes in microbiological assessments of different bacterial groups in the treated water. While many systems are being used in good faith and according to standard, available protocols, it is clear that a greater understanding of in-practice dose measurement in relation to water quality constituents and commodity-specific parameters is needed to differentiate among practical Test Methods, which are sorely needed to define the required or allowable Accuracy and Precision. Whether compliance is determined by industry standards, customer specifications, or regulatory standards the protection of public health and the integrity of produce enterprises will increasingly require a greater level of performance in dose management and accurate documentation. CPS specifically requests a multi-state, multi-institution proposal to address the following Priority Objective:

Develop a matrix of Best Practice Guidance for measurement of sanitizer dose among various test kit options, which fit practical application expectations from small-scale to medium-scale applications on-farm to packinghouse, and determine the fully associated costs. A broad diversity of actual in-use water quality constituents must be included. Test kit performance in accuracy and precision must be compared to technical analytical measurement of constituents, temperature, pre and post microbiological profile, and dose, including but not limited to hypochlorites, chlorine dioxide, ozone, and peracetic acids. Comparative assessments among reasonably paired operations across multiple states, locations, crops, scale of operation, and seasonal conditions are expected. The anticipated outcome is the development of a concise guidance document, which better informs produce industry operations, audit-scheme holders and developers, regulators, and buyers of the realistic expectations for managing sanitizers in water-based applications, by measurement and treatment-adjustment, that fit the characterized performance in microbiological control of cross-contamination for their scale of operation and economic resources.

**6.4.** Define system-wide and system-specific probabilities of *Listeria monocytogenes* for transference from non-food–contact surfaces and areas (Zone 2 to 4) to food-contact surfaces and products.

**6.5.** Develop a detailed design and comprehensive cost analysis of a large-scale daily water reconditioning and re-use system for water-use efficiency and conservation in primary packing operations, with data developed specifically in relation to food safety process controls and routine verification and monitoring of physicochemical and microbiological constituents. Close alignment and participation with a company

collaborator is essential, but anticipated engineering design elements and management outcome principles should be broadly transferable regionally and to comparable scale commodities.

**6.6.** Much empirical and anecdotal information has been circulated among the produce industry regarding the efficacy of various EPA-labeled, non-labeled, and GRAS compound preharvest surface sanitizers to significantly reduce risk when applied several days preharvest, especially on leafy greens and pole-tomato fields. Definitive data is need to guide the industry to informed decisions regarding the cost:benefit of this practice for any science-based assessment of these formulations, alone or in comparative studies.

**6.7.** Industry input has identified the need to validate an approved process for removal of fruit waxes and lusters applied to whole produce, which will significantly improve the efficacy of sequential pre-slice treatment in mechanical removal and sanitizer lethality of entrapped pathogens during minimal processing for fresh-cut products.

## Part II. Commodity Specific

### 1. Pacific Northwest Tree Fruit

NOTE: Different from research awards solely supported by CPS, all projects under the Pacific Northwest Tree Fruit PIR must include a strong written, oral and web-based outreach component to better assess current practices and, as necessary, provide science-based knowledge to improve practices and decision-making industry wide.

Pacific Northwest Tree Fruit (PNTF) research objectives are as follows:

**1.1. Agricultural Water**: Agricultural water is used in various ways for tree fruit production in the Pacific Northwest. Among other uses, it may be applied for overhead sprinkler orchard irrigation and to apply fruit and foliage crop protection sprays on apple, pear, cherry and other stone fruit (apricot, nectarine, peach, and plum). To reduce damage from sunburn in apples, agricultural water may be applied by overhead sprinkler irrigation (also called overhead cooling). In these cases, agricultural water directly contacts fruit throughout the growing season. It is currently unclear if there is a public health risk associated with the use of agricultural water that is contaminated with human pathogens when used in a manner that directly contacts tree fruit in the orchard. The successful proposal will clearly identify and demonstrate how the proposed research objectives will advance, rather than duplicate or be limited to derivative model research, existing or in-progress studies identifiable in the public domain. Specifically, additional research is requested to:

- Determine how long human pathogens will persist (survive, die and/or grow) on tree fruit that have been directly sprayed in the orchard with agricultural water containing human pathogens. Special consideration should be given to the development of fruit inoculation protocols (materials and methods) that will yield meaningful, repeatable and applicable results for tree fruit grown in the Pacific Northwest.
- Determine the rationale and reasonably acceptable criteria for a “safe” preharvest time interval, relative to variable climatic/environmental factors during crop maturity, for agricultural water application based on current production practices, agro-ecological growing conditions and anticipated human pathogen persistence on tree fruit in the Pacific Northwest. What factors must be considered in establishing a standardized decision-tree or matrix for the required preharvest interval following foliar contact with a potentially contaminated water source?

- Identify how intrinsic and extrinsic factors (e.g., production practices and agro-ecological conditions) influence the persistence of human pathogens, and resistance to postharvest removal, on tree fruit that have been directly sprayed in the orchard with agricultural water containing human pathogens. Developing a model system to systematically evaluate the intrinsic and extrinsic factors that may affect the risks associated with the diverse production practices and agro-ecological growing conditions encountered in the Pacific Northwest is encouraged. The successful proposal will clearly identify and demonstrate how the proposed research objectives will advance, rather than duplicate or be limited to derivative model research, existing or in-progress studies identifiable in the public domain.
    - Based on recent events related to apple food safety concerns, we would like to specifically know: (a) Do natural openings of the fruit (pedicel-end, calyx-end, lenticels) differentially harbor human pathogens or provide protected sites not penetrated by current practical technologies? (b) What unexploited technologies will consistently reduce the pathogen load if problematic anatomical, physicochemical, or topographical locations are identified?
- Assess and characterize the microbial quality of agricultural water systems in the Pacific Northwest regions where the agricultural water is used in such a manner that it directly contacts tree fruit in the orchard. Special consideration should be given to identification of intrinsic and extrinsic factors (e.g., time of year) that influence the microbial quality of agricultural water.
- Quantify the economic impact of reduced crop yield and fruit quality if production practices have to be altered considerably to comply with the FSMA regulations.

**1.2. Development of Qualitative or Quantitative Microbial Risk Assessment**: Develop models describing the likelihood of fruit contamination through common uses of agricultural water. Develop supporting data to assess the risk associated with the use of agricultural water that has been contaminated with human pathogens when directly applied to fruit in the orchard. The successful proposal will clearly identify and demonstrate how the proposed research objectives can be achieved by accessing existing or in-progress studies identifiable in the public domain, and be coordinated integration of studies in PNTF Objective 1.1.

**1.3. Tree Fruit Packinghouse and Storage Operations**: Tree fruit are routinely sorted, washed and packed for further distribution and sale in packing facilities. Cherry fruits are frequently run through a hydrocooler to remove field heat and thus aid postharvest fruit quality retention. Tree fruit packinghouse operations provide an opportunity for packers to reduce microbial loads of human pathogens on tree fruit but conversely provide an opportunity for tree fruit to be contaminated by cross-contact with contaminated water or food-contact surfaces. Specifically, research is needed to:

- Determine how effective current packinghouse preventive controls are in reducing the potential for food-contact surface-to-fruit and water-to-fruit cross contamination in packing lines and hydrocoolers. Specific emphasis should be given to identifying and ranking niches, harborages and food-contact surfaces that are likely to transfer human pathogens to fruit during packinghouse operations, according to risk, and determining if there are more effective equipment designs or material options available.
- Determine how effective current packinghouse preventive controls are in reducing the number of human pathogens on fruit as they proceed through packinghouse operations (e.g., antimicrobials in the dump tank, soap, wash, brushes, rinse, and heat). Special emphasis should be given to identifying packinghouse operations and operating variables that maximize the reduction of human pathogens on tree fruit. Investigation of water disinfectants that may effectively be used under current packinghouse operating conditions and practices is encouraged, particularly alternatives to chlorine.

- Develop a protocol (materials, methods, and criteria) to easily validate and verify that tree fruit packinghouse preventive controls are effective and performing as anticipated.
- Determine the fate of human pathogens, including *Listeria monocytogenes*, on fruit surfaces during common storage periods and when employing common storage practices, with special emphasis on technologies that may reduce the persistence of human pathogens in storage.
- **Special Emphasis Project – DPA and Fungicide Application Methods**: Apple fruit are routinely drenched with a solution containing one or both of: a) diphenylamine (DPA) to prevent scald development during long-term cold storage; or, b) a fungicide to control fruit decay in long-term cold storage. The most commonly used fungicides are Mertect (thiabendazole), Penbotec (pyrimethanil), and Scholar (fludioxonil). It is currently unclear if there is a public health risk associated with re-circulation/re-use of the drench solution if human pathogens were to be introduced into the drench solution. Alternative application methods include fogging of antioxidants or fungicides into the storage room, or continuous treatment with ozone while fruit is being stored. The successful proposal will clearly identify and demonstrate how the proposed research objectives will advance, rather than duplicate or be limited to derivative model research, existing or in-progress studies identifiable in the public domain. Specifically, research is needed to:
    - Determine if DPA/fungicide drench solutions have the potential to serve as a vector of drench solution-to-apple contamination for human pathogens. Special emphasis should be given to determining the likelihood of such contamination, and identifying factors that may limit or enhance the potential for such contamination events.
    - Determine the potential for persistence, growth and/or proliferation of human pathogens in DPA/fungicide drench solutions and how this may affect the potential for fruit contamination.
    - If necessary, develop effective, real-time and cost-effective means of monitoring, controlling, reducing, or eliminating human pathogens in drench solutions.
    - Investigate the survival of human pathogens on fruit when treated with alternative, non-drench based methods of antioxidant and fungicide delivery to fruit such as fogging or ozone pulsing.

**2. California Fresh Fruit Association**

The California Fresh Fruit Association (CFFA) is seeking proposals to address the following questions related to postharvest handling and survival and growth of human pathogens on peaches, plums, and nectarines grown in the San Joaquin Valley of California, with special emphasis on developing greater risk reduction knowledge towards preventive controls for *Listeria monocytogenes*.

Successful proposals will clearly identify and demonstrate how the proposed research objectives will advance, rather than duplicate or be limited to derivative model research, existing or in-progress studies identifiable in the public domain. Furthermore, proposals that may result in anticipated benefits to industry in a one-year timeframe will be given priority consideration

**2.1.** How well do human pathogens survive and grow on the surface of fresh, whole stone fruit, and how are survival and growth affected by fruit finishes (mineral and vegetable oil-based waxes), postharvest fungicides, and the conditions found during commercial cooling, storage and transportation?

**2.2.** How does time, temperature, moisture, organic debris, fruit label adhesives, wax residues (mineral and vegetable oil-based waxes), and postharvest fungicides affect the survival and growth of human pathogens on common stone fruit packinghouse food-contact surfaces?

**2.3.** Are there commercially viable alternatives to the current industry practices of dewatering fruit with sponge rollers after washing and the use of brush beds to uniformly redistribute applied wax and fungicide after dewatering? If yes, how do those alternatives compare to current industry practices with respect to the harborage and transfer of human pathogens?

**3. California Fresh Citrus Industry** (current focus on orange and lemon packinghouse operations)

Industry priorities are to develop data-based knowledge that address postharvest preventive controls and provide a science-based foundation for corrective actions aimed at identified food safety risks that are specific to the California fresh citrus industry. The immediate goal is to generate practical qualitative and quantitative operational tandards for industry guidance in the form of Recommended Packinghouse Practices. Research is requested to:

**3.1** Characterize the potential for survival, transfer, or movement of validated surrogates for human bacterial pathogens within a packinghouse, with emphasis on areas where product lots are comingled (e.g., float tanks, drench systems) and systems where water or waxes are recirculated/reused.

**3.2** Identify and validate realistic, cost-effective intervention strategies that control, reduce, or eliminate human bacterial pathogens in recirculated/reused solutions and that can be applied within the broad range of California citrus packinghouses.

**3.3** Determine the potential for growth of human bacterial pathogens on citrus fruit from harvest to pre-shipping storage under typical and sub-optimal conditions.

**3.4** Using naturally-occurring nonpathogenic bacteria as indicators of efficacy, determine the effectiveness of current packinghouse preventive controls for reducing the number of potential human pathogens on citrus fruit as they proceed through commercial packinghouse operations, by a comprehensive assessment of process variability within and among different packinghouses and among different varieties of citrus fruit.

**3.5** Develop a quantitative matrix of options and validation protocols for the most effective methods for cleaning and sanitizing harvest and postharvest fruit-contact surfaces and handling equipment.

**3.6** Develop a detailed baseline spatial mapping profile, among confidentially enrolled handlers, towards the development of a model Environmental Monitoring Program (EMP) and guidance in establishing an environmental-zone Master Sanitation Schedule linked to EMP-outcomes for California fresh citrus packinghouses.