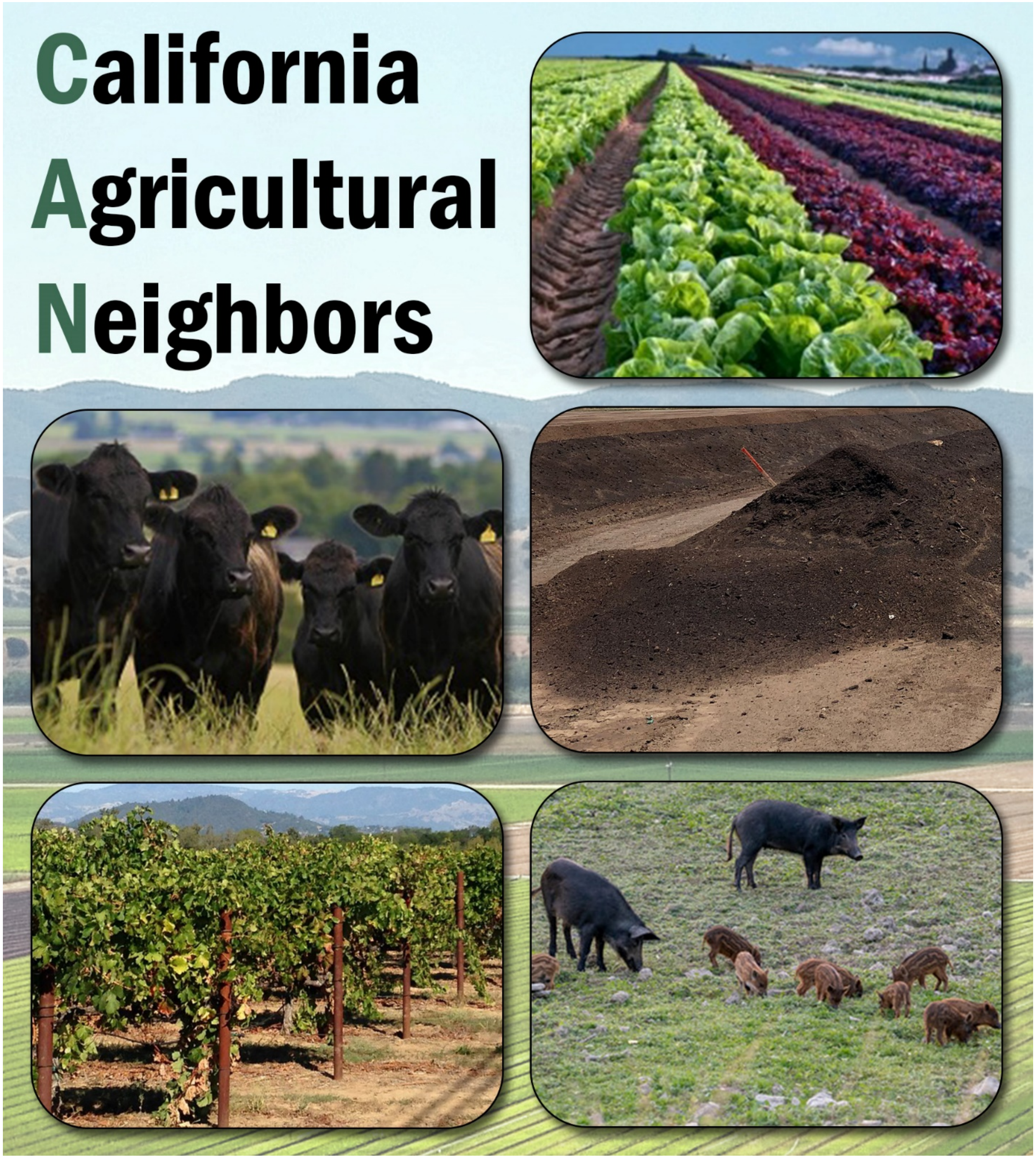


Neighbor-to-neighbor best practices to help enhance localized food safety efforts

Action Report – June 2022

CONTENTS

Suggested Citation:

California Department of Food and Agriculture and Monterey County Farm Bureau under direction of the California Agricultural Neighbors (CAN) Steering Committee. *California Agricultural Neighbors: Neighbor-to-neighbor best practices to help enhance localized food safety efforts.* Sacramento, California, 2022.

Note: The California Farm Bureau Federation was a funding partner in this effort.

EXECUTIVE SUMMARY

Food safety is a shared responsibility. Continued outbreaks of pathogenic *Escherichia coli (E. coli)* O157:H7 associated with leafy greens in the Salinas Valley of Monterey County, California, necessitated a robust response in order to protect public health through efforts shared among the food production, processing, and retail industry; the broader agricultural community; and local, state, and federal regulators. Beginning in January 2021, the agricultural community in the Salinas Valley came together in an effort known as California Agricultural Neighbors (CAN). Led by the California Department of Food and Agriculture (CDFA) and the Monterey County Farm Bureau (MCFB), CAN provided a roundtable opportunity to foster collaboration and discuss enhanced neighborly food safety practices when various agriculture operations such as leafy green fields, cattle ranches, vineyards, and compost sites are adjacent to one another.

Beginning with the proximity of farm and ranch practices that occur by season and month, the intersection of potential risk points came more into focus as discussions progressed within the CAN Dialogue Group. These potential risk points, along with input from subject matter experts, were utilized as a basis for communication and near-term actions in the form of a CAN Outcomes Table included in this report. A year-long commitment to joint learning, investment of time, and seeking sources of information led to further actions detailed in this report.

Following are major actions arising from the one-year CAN process. Action 1 can be accomplished by this group directly and Actions 2 through 4 will require a collaborative effort toward common goals:

1. **Action 1: Foster Neighbor-to-Neighbor Interactions and Conversations:** building a collaborative network necessary for collective input and impact, including the research capacity essential for continuous learning and focused local action. As part of the process leading to these actions, CAN established a common understanding of key terms; a move to fill knowledge gaps through building a vision for future efforts with recommendations, considerations, and opportunities; and, perhaps most importantly, recognizing that productive action toward common goals is dependent on the goodwill engendered by continued dialogue among those who are vested agricultural stakeholders in the Salinas Valley. More specifically these actions include:

    1.1. Sharing the CAN glossary of terms in order to help foster a common understanding of terms used in specific agricultural production practices.

    1.2. Collaborating with partnerships noted in the CAN Outcomes Table that foster a culture of awareness in specific categorical areas. Prioritization into near-term, mid-term, and long-term was done largely on a practicality basis using work group quantitative input related to probability of successful implementation and impact of implementation.

    1.3. Creating a Discussion Template as an immediate and valuable next step to the ongoing work of CAN. This will help support neighbor-to-neighbor dialogue about individual production practices and annual or other patterns of those events. This report presents action steps for good neighbor-to-neighbor communications on seasonal activities, outlines other action steps toward food safety integrity, and defines knowledge gaps that require further research and collaboration.

Several areas identified in the CAN Outcomes Table note that specific research would be needed in order to delineate the appropriate recommendations. A work group was formed composed of academia, industry, and government to explore a systemized approach (e.g., a roadmap) to filling these research knowledge gaps. The work group identified that progress towards near-term outcomes requires an end-to-end framework for near-term effort, adapted into future processes, and accounted for in resource needs (both personnel and funding) and future requests for these needs.

2. **Action 2: Build a Research Roadmap for the Salinas Valley:** The CAN process established a foundation of information that is available, and recognition of information that is needed, in key areas. The overall goal is to understand key landscape processes sufficiently to guide decision making at present and into the future. Processes represented in the research roadmap for which actions need to occur, include the following:

   2.1. Introduction of pathogenic *E. coli* to host populations, and re-introduction into the environment in a cycle that leads to continuing exposure and outbreaks.

   2.2. Amplification of pathogenic *E. coli* within host populations, following introduction, and through conditions that may allow for regrowth in growing lands and adjacent lands. Amplification may lead to increased exposure of leafy green crops to pathogens.

   2.3. Survival and persistence of pathogenic *E. coli* under various conditions that do not allow for amplification, but which do allow more time for transport opportunities and intersection with leafy green crops.

   2.4. Mechanisms of movement and transport of pathogenic *E. coli* across the landscape, including by air, water, animals, and machinery.

   Creation of the research roadmap requires recognition, prioritization, and sponsorship of research activities. Produce safety research has benefited from a long and productive partnership through sources such as the Center for Produce Safety (CPS), the Commodity Board Research Programs, the United States Department of Agriculture (USDA) National Institute of Food and Agriculture (NIFA) Food Safety Outreach Program (FSOP) and Specialty Crop Research Initiative (SCRI) programs, and the USDA Agricultural Marketing Services (AMS) Specialty Crop Block Grant program. The CAN group recognized the need to engage with these partners to champion and place priority on research roadmap topics.

3. **Action 3: Create a Quantitative Microbial Risk Assessment (QMRA) Framework**: Utilization of a Quantitative Microbial Risk Assessment (QMRA) Framework to support future directions. A framework such as QMRA allows organization of data in such a way that data gaps become evident. The quantitative aspect of QMRA also lends itself to modeling outcomes based on current knowledge to prioritize action, and sensitivity analysis to better

understand when more data is necessary for effective action. Specific steps to achieve a QMRA framework include the following.

3.1. Assess the current state of sponsored research underway and supported by various entities including CPS, USDA, FDA Center for Food Safety and Applied Nutrition (CFSAN), UC Davis Western Center for Food Safety, and CDFA. Compilation of ongoing research and research needs represented by those entities is a first step on the research roadmap.

3.2. Apply a QMRA framework to organize the data and ongoing research efforts to help prioritize research needs based on identified knowledge gaps where there is little to no working knowledge to populate the QMRA. The QMRA would also provide insights into the value of data gained through research in specific areas. The vast quantity of data currently available, augmented by data that might be collected, requires a structure with which to understand the applied value of the information and to identify data gaps.

4. **Action 4: Build and Maintain Capacity to Transfer Knowledge from Research into Applied Practice**: This recommendation includes support and (or) development of research programs and teams in the multiple disciplines needed for effective produce safety research, as well as encouraging relationships with research-sponsoring organizations. As the infrastructure for knowledge generation is nurtured to fruition, these actions evolve to include transfer of research knowledge into applied practice.

4.1. Research Capacity. Many key scientists who for decades have investigated topics relevant to produce safety are retired or are likely to retire soon. This creates concern that, despite many exceptional scientists entering in the field, there may not be enough backfill for those who leave the field. The research capacity outcome includes effort to right-size the needed depth and breadth of experts in order to fully support farmers, ranchers, and the balance of agriculture neighbors in the Salinas Valley. It also considers that experts will need to have a multidisciplinary approach in order to collectively foster food safety, food security, and environmental sustainability with a One Health goal of achieving target health outcomes.

4.2. Research Funding Sources. As the known list of research needs is identified and continues to be identified by way of the research roadmap, typical and non-typical funding sources and partnerships need to be pursued to support produce-specific research efforts. Typical partnerships are already described (above); non-typical partnerships may include U.S. Geological Survey (USGS) Water Resources Research Institutes, National Science Foundation Environmental Research and Education program, and U.S. Environmental Protection Agency (U.S. EPA) grant programs. The multidisciplinary needs of these Salinas Valley research efforts means that researchers from allied fields of study / specializations should be actively engaged, particularly specialists in climate and weather patterns that might impact produce safety in the Salinas Valley and researchers who are able to study wildlife populations, migration patterns, and STEC carriage rates.

4.3. Capacity to Transfer Knowledge. Agricultural extension has long been relied upon to provide not only research capacity, but also to provide advisors who translate research findings into applied recommendations and communicate those science-based recommendations to industry. Extension partners at land-grant universities, including in particular historically Black State colleges and universities and Tribal colleges, are valuable partners in these efforts. Non-traditional partners such as industry trade organizations should continue to be encouraged to fulfill this role.

The Salinas Valley has a diversity of crops produced, beyond leafy green crops, and the proximity of different agricultural land uses to each other is one factor that may account for the history of produce safety outcomes. There is a long-standing spirit of neighborly cooperation in the Salinas Valley evidenced by the strong family farm and ranch traditions spanning multiple generations. The Salinas Valley is known as a leader in food safety efforts related to leafy green production; providing this opportunity for dialogue and collaboration bridged the informational gap between various facets of production agriculture.

Across the next several pages, some key practical recommendations, considerations, and opportunities are outlined for each of the topic areas. Next step action items and partnerships are depicted alongside these recommendations. In some cases, knowledge gaps indicated where further research is needed (see **Action 2. Build a Research Roadmap for the Salinas Valley** section) or where deeper characterization is needed to prioritize the recommendation (see **Action 3. Create a Quantitative Microbial Risk Assessment (QMRA) Framework** section).The CAN stakeholder recommendations helped illuminate and apply information into the collective outcomes and action plan embodied in the four specific recommendations detailed in this *California Agricultural Neighbors: Neighbor-to-neighbor best practices to help enhance localized food safety efforts – Action Report*.

INTRODUCTION AND HISTORY OF CALIFORNIA AGRICULTURAL NEIGHBORS

Beginning around 2017, an increased number of leafy green product recalls followed by three investigative reports issued by the United States Food and Drug Administration (FDA) prompted a concerted effort on multiple levels throughout the agriculture community in the Salinas Valley. This brought added focus and awareness to food safety in a region that leads U.S. leafy green production and shares a diversified agriculture production environment. This effort, known as the California Agricultural Neighbors (CAN) emphasized the need and fostered an opportunity to explore new pathways to problem solving not previously pursued, considered, or researched from a collective and multidisciplinary vantage point. The outbreak incidents and associated reports indicated that additional food safety measures needed to be considered, including those related to adjacent land use.

Prompted by the findings of the FDA investigative reports, discussions began at the state and local level around the ideas that adjacent operations may not have a sufficient understanding of their neighbors' seasonal activities, and the importance and value of enhanced communication and awareness. In areas like the Salinas Valley, leafy green and vegetable crops grow adjacent to active rangeland cattle ranches as well as vineyards and other land uses that can attract or harbor wildlife that might carry pathogens. Many of these neighbors coexist without incident, but the increased food safety issues related to *E. coli* O157:H7 in leafy green products highlighted the need for further inquiry into neighboring farming practices and observations in the surrounding environment, using this local nexus as a focal point.

The 2021 work of CAN stemmed from a 2019 initiative, the California Good Agriculture Neighbors Workshops, which was led by the University of California, Davis, (UC Davis) Western Institute for Food Safety and Security (WIFSS) and the UC Davis, Western Center for Food Safety (WCFS) with funding and other support by the California Department of Food and Agriculture (CDFA). The workshop breakout sessions highlighted three key areas of notable next steps: 1) Research, 2) Communication, and 3) Outreach and Training. While some research has been conducted to support these efforts, and more is underway, there was an ongoing need to enhance local communication for the purposes of increased mutual understanding and problem-solving in the near term, and additional region-focused research to provide more options of science-driven solutions among the diversity of agriculture stakeholders in the Salinas Valley. The CAN Steering Committee and Dialogue Group were formed with three key goals in mind:

1) Identify practices for agriculture neighbors that can potentially help enhance food safety and improve public health and trust.

2) Document the broader challenges of the California regulatory landscape that impacts produce growers, cattle ranchers, vineyard managers, compost processors, and wildlife management differently, and that may result in regulatory silos with competing or conflicting demands with produce food safety practices.

3) Develop accurate messaging to enhance education and adoption of continuously improving food safety practices founded in science, while acknowledging that simple neighborly courtesy measures of communication can have beneficial, lasting impacts.

These goals were adopted to help guide the framework of the CAN Dialogue Group and to foster a collaborative approach to food safety, reduce the risks of pathogen contamination of produce, and strengthen neighborly practices that are supported by the current science.

CAN was formed to bring together all vested stakeholders within the agriculture community in discussions surrounding farm and rangeland management practices and potential risks for exposure to field-grown crops adjacent to rangeland, compost operations, or vineyards. These specific entities were the focus because they made up the primary interface in the Salinas Valley among agriculture operations in proximity to produce-growing fields.

Working cooperatively with agriculture associations CAN was able to bring together farmers and ranchers, researchers, food safety experts, and agency personnel to begin the process of understanding what practices occur during the production seasons. The process included a close and valuable working partnership with the California Leafy Greens Marketing Agreement (LGMA) technical subcommittee formed around adjacent land issues.

PROCESS AND PARTICIPANTS THROUGHOUT 2021

The CAN effort was led by CDFA and the Monterey County Farm Bureau (MCFB) and involved a year-long process. Candid discussion topics included food safety, farm and ranch practices, LGMA requirements of leafy green growers and handlers, and potential information gaps that require additional research and/or consideration.

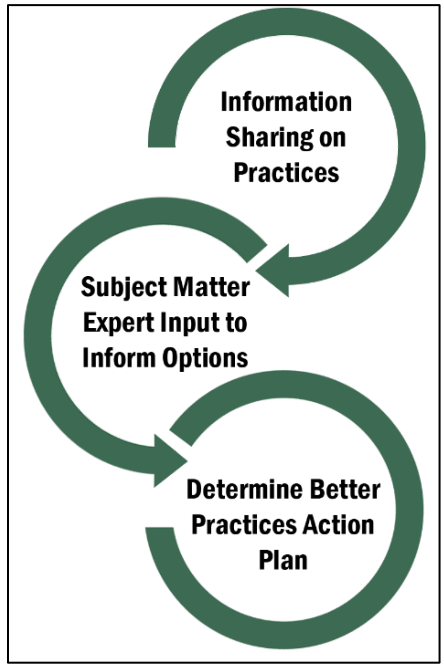


Figure 1: CAN process illustration.

CAN participants were added in a stepwise manner. First, a Steering Committee was formed of key stakeholders, primarily focused on the Salinas Valley growing and rangeland region. A larger Dialogue Group was then engaged to meet quarterly (at minimum) to review progress, offer suggestions and ideas, and work through some of the risk exposures (perceived or real). Finally, work groups that included experts from industry, academia, retail, and government came together in Summer 2021 to address topics on a more granular level. Their efforts were instrumental in the creation of the **CAN Outcomes Table** section in this document.

Beginning with the collection of farm and ranch practices that occur by season and month, the intersection of potential risk points came more into focus as discussions progressed within the CAN Dialogue Group. One such discovery was that wildlife management occurs differently on farms, ranches, and vineyards, often leading to differing management strategies required to reduce incidence and impact of incursions.

California Agricultural Neighbors: Neighbor-to-neighbor best practices to help enhance localized food safety efforts – Interim Report, issued in June 2021, detailed suggested management practices and actions that could occur during the remainder of the production seasons of 2021. While this was intended to be interim in nature until more information could be gathered, collated, and formulated into action steps, the guidelines offered in the report reminded agricultural neighbors of their shared responsibility for food safety.

For the interim report, five key areas of focus came into review, and action steps were developed and later ranked for probability of adoption, preventive impacts to food safety, and costs that might be incurred by agriculture entities to adopt and implement through the work group process. Action steps also were prioritized by near- and longer-term timelines for their implementation. This prioritization of potential outcomes and action steps contributed to the recommendations, considerations, and opportunities captured in this report. CAN continues to seek progress towards understanding and implementing practices that proactively manage risks to fresh produce and processed food products.

This CAN Action Report reflects the work and input of a diverse CAN Dialogue Group that was initially made up of 27 participants and expanded to 39 individuals throughout 2021 (See Appendix 1 for CAN Dialogue Group Participant list). Involvement from various sectors included:

- Agriculture production: leafy green growers, cattle ranchers, vineyard managers, compost processors (12)
- Academia: University of California (UC) Davis, UC Cooperative Extension (UCCE), and the UC Davis School of Veterinary Medicine (6)
- Associations: food production associations representing retail and consumers, agricultural industry associations and food safety organizations (13)
- Government: local, state, and federal government (8)

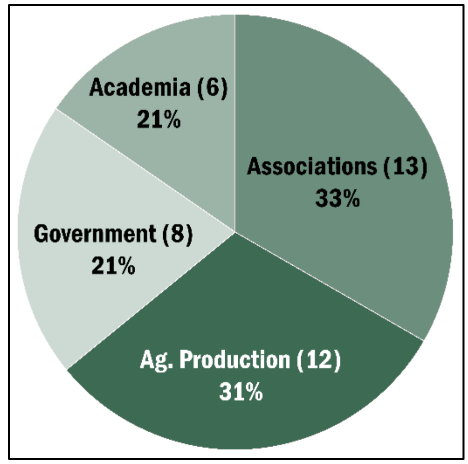


Figure 2: CAN Dialogue Group participants.

The Dialogue Group and a broader, invited Expert Input Group (composed of subject matter experts) focused on specific aspects of technical topics where the Dialogue Group identified a need for broader understanding in the context of potential related implications for food safety. These topics were further explored and addressed by way of [public webinar presentations](). In addition, a nine-member Steering Committee kept the overall process on track and on task. Throughout the process the meetings were coordinated by CDFA and MCFB and facilitated by Abby Dilley, RESOLVE. The goal was to create a safe space for sharing of practices, problem solving, and deliberations with a good faith effort in providing information, resolving challenges, and supporting near-term outcomes for recommended improved practices to enhance food safety.

- The Expert Input Group offered scientific resources to drill down to better understand and untangle complex issues to help inform the Dialogue Group and their recommended action steps.
- The Steering Committee helped draft meeting agendas, track progress on meeting goals and expectations, and engaged with other stakeholders (interested parties and key experts) to support the project's success as a full community effort and with implementation of the recommended action steps.
- Community Engagement via Town Halls occurred to create awareness about CAN and to share the Interim Report and Action Report; these also served to enhance food safety efforts through sharing the interim action insights.

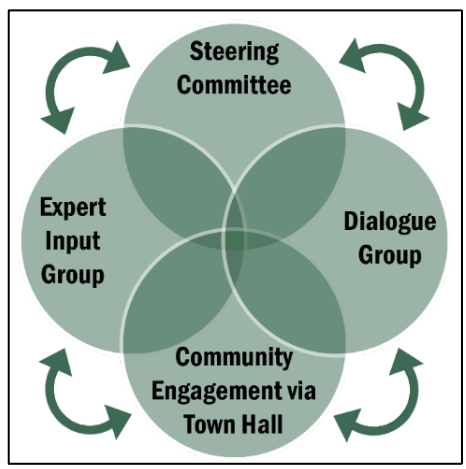


Figure 3: Communication and deliberation process of CAN.

Midway through the year, the Dialogue Group was expanded to include additional key industry members, academia, end-to-end supply chain engagement, and partners from Arizona Leafy Greens Marketing Agreement as valuable additions.

KNOWLEDGE BASE, COMMON LANGUAGE, AND ADJACENT EFFORTS

In order to achieve successful outcomes through CAN it was important to have end-to-end thinking. Meaning that **what** to do (actions) and **who** was going to do it (partners) couldn't be accomplished without consideration of **why** it was prioritized for attention (scientific risk assessment and (or) anecdotal report) and **how** it would be accomplished (research outcomes and implementation into practice). While the overall CAN process yielded a chart identifying near- and long-term recommendations, considerations, and opportunities (see the **CAN Outcomes Table** of this document), this section on Knowledge Base, Common Language, and Adjacent Efforts helps to offer context and a framework that lends itself to a process of continual food safety improvement.

Several areas identified in the CAN Outcomes Table note that specific research would be needed in order to delineate the appropriate recommendations. A work group was formed composed of academia, industry, and government to explore a systemized approach (e.g., a roadmap) to filling these research knowledge gaps. The work group identified that progress towards near-term outcomes requires an end-to-end framework for near-term effort, adapted into future processes, and accounted for in resource needs (both personnel and funding) and future requests for these needs.

Another aspect leading to successful outcomes was to establish clarity of scope and terminology during discussions. Specifically, work group discussions that led to various passages in this document included the term *E. coli* with specific meanings (and variations on those meanings) that sometimes resulted in confusion. To clarify the scope of CAN discussions (why the scope is limited to pathogenic *E. coli*), some of the different ways *E. coli* is described in this section are outlined here. The clarification of terms starts with what we mean by the word pathogen, followed by generic *E. coli* and different pathogenic types of *E. coli*. Other terms may be found in the Glossary in the **Additional Resources** section of this document.

- Pathogen: For the purpose of this report, the term pathogen refers to microorganisms that cause foodborne human illnesses and have in the past been linked to consumption of leafy green crops. Since nearly all past outbreaks associated with the Salinas Valley growing region have involved pathogenic *E. coli*, this document does not discuss *Salmonella*.
- Enteric pathogens and fecal-oral pathogens refer to pathogens that come from feces. They multiply (in some cases to high numbers) in the intestinal tract of people and warm-blooded animals including various domesticated animals, wildlife, rodents, and birds. Most produce-related foodborne pathogens are of this type. This information is important to explain why the scope of discussion about *E. coli* sources is generally limited to people and warm-blooded animals including cattle, and various wildlife species including deer, feral hogs, rodents, and birds.
- Generic *E. coli* is found in the gut of many people and warm-blooded animals. This is the reason generic *E. coli* are used to detect when fecal contamination might be present; it is

easy to measure and it is present in many sources of feces that might also contain pathogens. Only some *E. coli* are pathogens.

- One group of pathogenic *E. coli* is the Shiga-toxin producing *E. coli*, abbreviated STEC. The FDA Leafy Greens STEC Action Plan addresses risk from this grouping of pathogens. The STEC group is made up of several serotypes of *E. coli*. One STEC serotype, *E. coli* O157:H7 is the specific pathogen that has caused most detected outbreaks linked to consumption of leafy greens grown in the Salinas area. At a broader level, sometimes all of serotypes that start with O157 (including O157:H7 and other serotypes) are lumped together. At a finer level, FDA uses whole-genome sequencing to distinguish related strains of *E. coli* O157:H7 as part of FDA outbreak investigations.
- Although *E. coli* O157:H7 is the STEC serotype that causes most known outbreaks from leafy greens consumption, other STEC serotypes can also be important (especially the "Big Six" including *E. coli* O121:H19). *E. coli* O121:H19 recently caused a four-illness outbreak associated with Romaine lettuce, with last illness onset in November 2021.

The following three subsections of the report focus on ***why*** and ***how*** the CAN effort was launched, and leads to deeper discussion about opportunities for research, risk assessment, and knowledge transfer in later sections.

Historical Perspective: Outbreaks, Initiatives, and Regulations

The history of outbreaks linked to leafy greens, and the associated produce safety practices, continues to evolve. In the United States, *E. coli* O157 outbreaks were first linked to contaminated leafy greens in 1995. Later, studying a decade of investigations between 2009 and 2018, the FDA and Centers for Disease Control and Prevention (CDC) identified 40 foodborne outbreaks of STEC infections in the U.S. with a confirmed or suspected link to leafy greens. A report issued in October 2021 by the Interagency Food Safety Analytics Collaboration (IFSAC) outlined estimated percentages of foodborne *E. coli* O157 illnesses based on multi-year outbreak data in the United States. The IFSAC is a tri-agency group created by the CDC, the FDA, and the U.S. Department of Agriculture's Food Safety and Inspection Service (USDA-FSIS). IFSAC developed a method to estimate the percentages of foodborne illness attributed to certain carrier food items using outbreak data from 1998 through the most recent year (2019). While the report covers multiple pathogens, key results for *E. coli* O157 noted that in over 75% of *E. coli* O157 illnesses, food items categorized as Vegetable Row Crops (such as leafy greens) and Beef were implicated as carrier foods in the outbreaks, with Vegetable Row Crop foods having a significantly higher estimated attribution percentage than all other categories.

Because of recurring foodborne illness outbreaks associated with leafy greens consumption, FDA announced a set of actions to help enhance the safety of fresh leafy greens by publishing the 2020 Leafy Greens STEC Action Plan (LGAP). The LGAP, aimed to help prevent outbreaks caused by STEC, was designed to support an integrated food safety system and help foster a more urgent, collaborative, and action-oriented approach between the FDA and stakeholders in the public and private sectors. Helping to ensure the safety of fresh leafy greens is a shared responsibility that requires collaboration among many stakeholders in an agricultural ecosystem, often referred to as a One Health approach (see next subsection). The progress made during CAN is called out in the LGAP as action item #17, “Addressing Knowledge Gaps.”

The LGAP followed two other notable milestones. In 2007, following a tragic outbreak of *E. coli* that sickened over 200 people, California and Arizona farmers made an unprecedented commitment to protecting public health through the creation of their respective state Leafy Greens Marketing Agreements (LGMA). The programs’ goal is to assure safe leafy green products and confidence in the food safety programs of California and Arizona farmers.

At the heart of LGMA is a set of food safety standards that are implemented as common practices on leafy green farms throughout the state. LGMA created this unique and rigorous science-based food safety system working collaboratively with university and industry scientists, food safety experts, government officials, farmers, shippers, and processors. The system protects public health by managing potential sources and pathways of contamination and establishes a culture of food safety on the farm. LGMA members produce approximately 90% of the leafy green crops grown in the U.S. and are audited by USDA-licensed government inspectors.

This historical perspective is important because there have been several significant milestones achieved that have helped to improve food safety in fresh produce and specifically for leafy green crops. However, understanding risk and means of risk reduction continue to be a priority. The efforts of CAN and the model framework of the Dialogue Group helped establish focus on a local level to avoid overgeneralization of the reoccurring outbreaks and to address the specifics of a region and regional practices among agriculture neighbors. This framework created by CAN could be used as a roadmap for future efforts with other pathogens, such as Salmonella.

The current tools available to the industry each have their own characteristics and approaches: LGMA is very mechanistic and regimented in requirements and acceptability criteria; the Food Safety Modernization Act (FSMA) Produce Safety Rule requires a risk-based assessment and preventive approach. As such, words that cannot easily be objectively evaluated (e.g., adequate, necessary, appropriate) are used in the Produce Safety Rule in place of quantitative or other objective criteria from the LGMA system in order to bridge the gaps left from the audit approach. This CAN Action Report aims to represent the best of both worlds; safe harbors (e.g., objective criteria) along with the full systematic accountability (e.g., systems approach).

One Health Approach

While the efforts of CAN are unique to the Salinas Valley, the ideology of interworking systems are recognized beyond the work of CAN through One Health. A One Health approach recognizes that the health of people, animals, and the environment are intertwined. One Health is a collaborative, multisectoral, and transdisciplinary approach — working at the local, regional, national, and global levels — with the goal of achieving enhanced health outcomes by recognizing the interconnection between people, animals, plants, and their shared environment. Investigations of recent foodborne illness outbreaks associated with fresh produce consumption have indicated that presence of pathogens in broad proximity to the growing areas is a likely condition leading to fresh produce contamination.

The One Health approach is fundamental to a national effort called Healthy People. The Healthy People initiative helps guide health promotion and disease prevention efforts and improve the health of the nation. Released by the U.S. Department of Health and Human Services (HHS) every decade since 1980, Healthy People identifies science-based objectives with targets to monitor progress, motivate, and focus action. Healthy People 2030 (HP2030) is the current iteration of the Healthy People initiative. There are 21 objectives under HP2030; one of these is the reduction of foodborne illness. As a result, a food safety work group was formed within HP2030 and one focus has been opportunities to help reduce illnesses and outbreaks associated with Shiga toxin-producing *E. coli* (STEC) linked to leafy greens. Because some CAN efforts are interwoven with the objectives of HP2030, it was important to note the synergies in this report. In addition, insomuch as the CAN Action Report exemplifies the One Health approach the outcomes have applicability beyond leafy green commodities and STEC pathogens. The CAN process and One Health framework could be applied to other mixed agricultural systems.

At the Healthy People 2030 meeting held January 11-13, 2022, in Atlanta, GA, the sub-committee formed to focus on produce and STEC risk discussed baseline knowledge gaps, prevention and improved response, training and education, and root causes. The goal was to inform preventive measures on-farm and on-ranch. Presentations were provided on current processes and activities by the Centers for Disease Control and Prevention, the California and Arizona LGMA organizations, Western Growers Association, FDA, CDFA, International Fresh Produce Association, Romaine Task Force, Center for Produce Safety, and USDA. These presentations demonstrated that there are considerable efforts underway around produce safety and the risk evaluations of STEC in the environment that are relevant to the CAN effort as part of a continuum of STEC-related risk management efforts.

California Longitudinal Study (CALS)

The California Longitudinal Study (CALS) is focused along California's coastal growing region including the Salinas Valley, and started in 2020. It represents one California effort aimed to adaptively address the recent outbreaks of *E. coli* O157:H7 associated with leafy green crops. To accomplish CALS, the California's leafy green industry is collaborating with partners from California's cattle, viticulture, and compost industries, UC Davis WCFS, and state and federal partners. This new approach serves as a model to:

1. Offer an adaptive research strategy
2. Perform research on a large geographic area to better understand underlying causes of contamination in the production environment
3. Provide a scientific basis for recommendations
4. Offer information that guides the development of practical preventive controls
5. Assist in solution-oriented outcomes

The CALS effort should allow growers and affiliates in the agriculture industry to understand prevalence of human pathogens in and around leafy green crop growing environments. These data can bring awareness to leafy green growers and their farming systems and allow the industry to respond to that awareness with practices and measures that ultimately help prevent foodborne illness. The study enables sampling to be conducted in priority regions, with attention to seasonal/temporal changes. It also aims to provide an extensive data set to evaluate trends or changes over time, including metagenomics that may yield important clues to the changes taking place in the microbial community in response to the changing environment of the Salinas Valley.

Use of metagenomics: Unlike traditional testing that detects one target (such as a pathogen test), metagenomics involves broad analysis of DNA from a sample to detect membership in a whole microbial community. Ecologists and other scientists can see widespread changes with this tool, including the unexpected, providing context to help better understand spatial and temporal characteristics of microbiomes in their environment.

INSIGHTS FOR MANAGEMENT OF STEC IN THE SALINAS VALLEY

Recurring outbreaks have forced the industry, government officials, and academic food safety experts to examine the food safety system through a different lens. Every effort toward fresh produce safety to date has helped lay a strong foundation to make California's produce some of the safest in the world. But when we face outbreaks, we are forced to reexamine every aspect of the system and ask ourselves what more could be done, what is known and unknown, and what measures grounded in science should come next. Recurrent outbreaks, despite considerable efforts to prevent outbreaks, illustrate the complexity of this issue and indicate that there is still more to understand about how Shiga toxin-producing *E. coli* (STEC) are introduced, amplified, and moved about in the Salinas Valley.

Several recurring themes continued to surface as the CAN Dialogue Group and varied work groups discussed opportunities on the leading edge of food safety. They hinge on changing the way we think about the problem. For decades, the systems have been built on a scoring mechanism representing pass or fail, percentages, and/or minimum scores. Those systems serve a purpose and place, but the reoccurring outbreaks emphasize the value of incorporating the One Health approach – an approach that fully appreciates whole system thinking and recognizes that the health of people, animals, and the environment are intertwined. This serves as the premise for the leading **Action 1: Foster Neighbor-to-Neighbor Interactions and Conversations** building a collaborative network necessary for collective input and impact, including the research capacity essential for continuous learning and focused local action.

As part of the process leading to these outcomes, CAN established a common understanding of key terms; a move to fill knowledge gaps through building a vision for future efforts with recommendations, considerations, and opportunities; and, perhaps most importantly, recognizing that productive action toward common goals is dependent on the goodwill engendered by continued dialogue among those who are vested agricultural stakeholders in the Salinas Valley.

By layering our thinking around this construct, it illuminates where there are opportunities and where gaps, unanswered questions, and missing tools still exist along with opportunities to bridge our learning.

Research and Prioritization Work Groups

Following the release of the CAN Interim Report, a Town Hall meeting, and a Subject Matter Expert webinar series, the Dialogue Group determined that there were still many unknowns that were likely to impede implementation of all recommended actions. The research objectives identified here help point out the necessary bridges to allow evaluation of research needs and actionable information for all stakeholders, including leafy green crop growers and adjacent land neighbors, in the region.

Work groups were formed to discuss research needs and prioritization. Overall, the work groups identified and recommended three key components to help build this end-to-end framework, which are discussed in full in later sections of this report.

But, fundamentally, and as a prerequisite condition, none of these three outcomes work without continued conversation among neighbors. Therefore, the graphic below notes the important neighborly partnership towards continuous improvement on near-term actions, some of which are already supported by science or practice.

The remaining Actions (Actions 2 through 4) reinforce the important foundation of neighbor-to-neighbor dialogue:

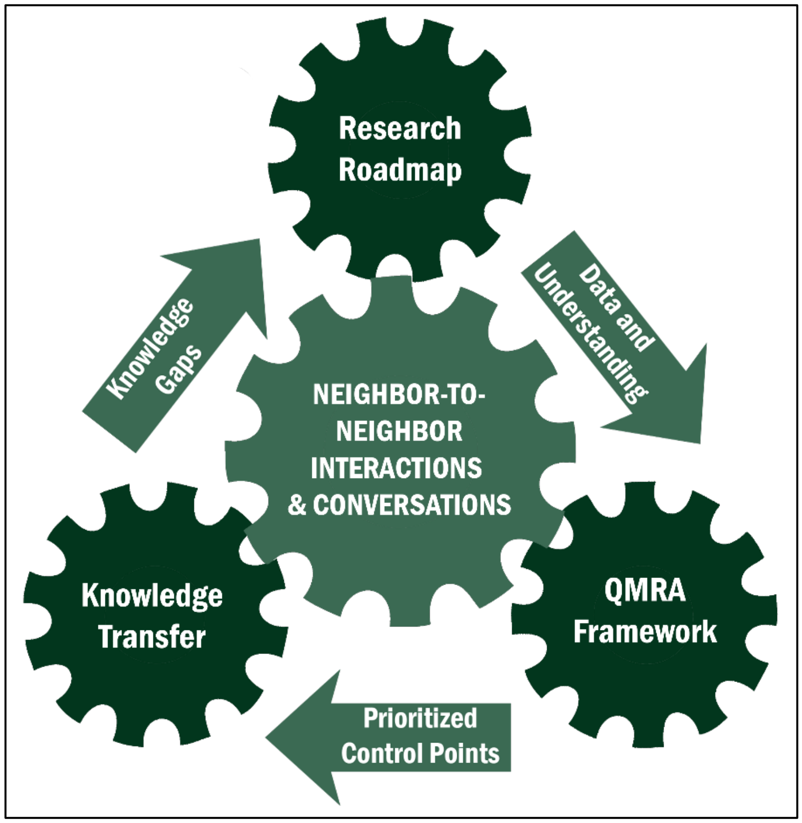


Figure 4: Relationship between the three key components of the end-to-end framework.

2) **Build a Research Roadmap for the Salinas Valley.** This Roadmap would aid collaboration to build **capacity** to fill knowledge gaps, develop a means to **fund** research to fill knowledge gaps, and represents a means to **prioritize and coordinate** knowledge-filling activities.

3) **Create a Quantitative Microbial Risk Assessment (QMRA) Framework.** This Framework would enable producers in the Salinas Valley to move toward the ability to prioritize risk factors and evaluate the benefit of addressing each. Efforts can be prioritized by evaluating which risk factors can be managed or mitigated through stepwise interventions.

4) **Build and Maintain Capacity to Transfer Knowledge from Research into Applied Practice.** This Capacity would help to right-size the needed depth and breadth of experts in order to fully support farmers, ranchers, viticulturalists, and the balance of agriculture neighbors in the Salinas Valley. It also considers that experts will need to have a multi-disciplinary approach to collectively foster food safety, food security, and environmental sustainability with a One Health approach to achieving target health outcomes.

Opportunities presented to this point for research, risk assessment, and knowledge transfer address the **why** and **how**. The CAN Outcomes Table (below) focuses on **what** and **who,** and is reflective of work group perspectives on actions and the partners to help accomplish important next steps. The working groups focused on the following topic areas:

- Collectively and Cooperatively Enhance Food Safety and Awareness
- Reduce STEC Pressure in the Environment
- Foster Good Agricultural Practices to Minimize STEC Transfer
- Evaluate Seasonal Wildlife and Management Effects on STEC Movement
- Enhance Operation Management, including with Contracted Companies

Across the next several pages, some key practical recommendations, considerations, and opportunities are outlined for each of the topic areas. Next step action items and partnerships are depicted alongside these recommendations. In some cases, knowledge gaps indicated where further research is needed (see **Build a Research Roadmap for the Salinas Valley** section, below) or where deeper characterization is needed to prioritize the recommendation (see **Create a QMRA Framework** section, below).

Prioritization into near-term, mid-term, and long-term was done largely on a practicality basis using work group quantitative input related to probability of successful implementation and impact of implementation. The work group determined that, while cost is a factor, produce safety activities should not be prioritized solely based on financial considerations.

Action 1. Foster Neighbor-to-Neighbor Interactions and Conversations

The CAN Dialogue Group spent considerable time developing a glossary in order to help foster a common understanding of terms used in specific agricultural production practices. See **Appendix 2 and 3** for a comprehensive list of these terms.

The Dialogue Group further recognized that a Discussion Template should be created as a valuable next step to the ongoing work of CAN. This will help support neighbor-to-neighbor dialogue about individual production practices and annual or other patterns of those events.

CAN Outcomes Table

CALIFORNIA AGRICULTURAL NEIGHBORS OUTCOMES*:
FOSTERING A CULTURE OF AWARENESS

Key to Prioritization Goals:
Near-term (2022)
Mid-term (2023)
Long-term (2024)

*Contains non-binding input to partnerships and relationships. CAN specifically acknowledges that the LGMA metrics revision process is proactive and responsive, and metrics are subject to revision as new information comes forward.

Collectively and Cooperatively Enhance Food Safety and Awareness		
Recommendations, Considerations and Opportunities	**Next Step Action Items**	**Partnerships**
Engage in a conversation with neighbors on the other side of the industry fence to know in detail their practices and the changes that occur throughout the year. Inform your neighbors of the various activities taking place in your operation for mutual awareness. Describe and communicate schedule of activities.	Better define the types of information that needs to be shared by neighbors; create supporting documentation including examples and templates that can be linked here.	Neighbor to neighbor
Establish neighbor-to-neighbor methods to notify the appropriate personnel about seasonal changes noted as important food safety factors to your operation. Establish a set meeting to discuss schedule and the communication chain to update throughout the season.	Define what the communication method looks like and how it will be implemented uniformly; create supporting documentation including examples and templates that can be linked here.	Neighbor to neighbor
Understand your neighbors' activities that occur during the off-season. Communicate what, where, and when activities occur.	Emphasize that off-season activities are important; create supporting documentation including examples and templates that can be linked here.	Neighbor to neighbor
Share data analytics and observations as possible. Localized information is more important than ever and can help identify issues and prevent potential problems as growers and ranchers continue to think of food safety as a shared responsibility. Monitor and describe animal presence, observations of activities, quantities, migration patterns and known activity areas.	Collect and share data that will lead the process and analysis of trends as well as long-term efforts and outlook.	Western Growers launched a shared data analytics platform called GreenLink™ in Fall of 2021; intended for produce growers, there is potential to inform conversations with neighbors and identify trends. Data tools have the potential to facilitate an objective view of a shared food system. Data sharing among all stakeholders should be promoted to better understand issues and find holistic solutions.

Reduce STEC Pressure in the Environment		
Recommendations, Considerations and Opportunities	**Next Step Action items**	**Partnerships**
Implement leafy green/rangeland/vineyard/compost best practices to minimize STEC introduction and amplification opportunities in the environment, as appropriate and feasible.	Support a holistic approach to address STEC prevalence in the environment that includes research needs. Work closely with the Center for Produce Safety and trade associations to consider current knowledge and define gaps and timing.	Interface with the LGMA metrics revisions process, based on contemporary data and research outcomes
Continue to invest in research trials that help inform the effectiveness of *E. coli* O157:H7 vaccines on rangeland cattle.	Continue to invest in research that helps inform agriculture on reducing STEC in the environment.	Research community
Understand more from subject matter experts and/or through research about feed additives (e.g., prebiotics, direct fed microbials, sodium chlorate) that have the potential to reduce shedding of *E. coli* O157:H7 in cattle; those that are scientifically validated to reduce shedding of *E. coli* O157:H7 specifically in rangeland cattle; and those models that can fully support the economic feasibility for neighboring operations should the science support their use and effectiveness.	Continue to seek proof of concept, update or create comprehensive objective talking points for what is known right now about this topic.	Research community

Foster Good Agricultural Practices to Minimize STEC Transfer		
Recommendations, Considerations and Opportunities	**Next Step Action items**	**Partnerships**
Consider developing and implementing visitor practices for any outside persons on the ranch, including why they are visiting or what they are working on.	Review how a visitor log can be implemented.	Ranch operations
Consider developing and implementing visitor practices for any outside persons on the farm, including why they are visiting or what they are working on.	LGMA requirement is in place to establish a visitor's policy. Clarify if there is a need to document visit reasons. Proposed changes to the LGMA requirements can be submitted to Western Growers for public vetting/review as part of a yearly process.	Farm operations
Neighbors should consider ways to reduce or eliminate manure material carried onto shared/common roadways that could carry pathogens (e.g., material that could potentially fall off of the transport vehicle undercarriage). This area requires additional research to help inform enhanced practices,	Coordinate the development of a best practices document to prevent further issues, including research of cleaning and sanitation practices.	Neighbor to neighbor; Research community

Foster Good Agricultural Practices to Minimize STEC Transfer		
Recommendations, Considerations and Opportunities	**Next Step Action items**	**Partnerships**
as well as including manure-related activities in the above sections on the communication of timing of these activities.		
Additional cleaning and sanitation of vehicles and equipment may be necessary by leafy green growers and harvesters during times of the year when local shared roadways experience seasonal traffic due to the transport of cattle or movement of soil inputs (manure) between facilities. (See Section IV for additional information). This is partially addressed in the LGMA metrics, but this area requires additional research to help inform enhanced practices.	Promote a risk-based approach to transportation patterns to support timing/need for more intense cleaning and sanitation.	Research community
Think about various crop and soil amendments that have long-term storage on the farm and how to address cleaning and sanitation in and around such storage tanks or areas of the farm where said materials are staged or stored.	Promote a risk-based approach to support more intense cleaning and sanitation based on data/research.	Farm operations
Consider security of vehicles and harvest equipment when idle for potential security exposures.	Evaluate and promote a risk-based approach to mitigate biosecurity concerns, bearing in mind the potential for intentional adulteration.	Farm operations
Actions taken to prevent the introduction of pathogens should be considered when moving vehicles onto and between leafy green farms. This includes personal vehicles, work crews, salespersons, contract company representatives, farm manager, etc.	LGMA requirement	Interface with the LGMA metrics revisions process, based on contemporary data and research outcomes
Movement of vehicles between or among mixed-type agriculture operations should undergo appropriate cleaning and sanitation prior to entering a leafy green field or location where harvest equipment is staged or stored (and rechecked when entering a leafy green field). Movement in and out of watershed areas - even if dry during the season - should be reviewed as well.	LGMA requirement is in place to establish cleaning/sanitation procedures. Clarify if additional detail is needed. Proposed changes to the LGMA requirements can be submitted to Western Growers for public vetting/review (yearly process).	Interface with the LGMA metrics revisions process, based on contemporary data and research outcomes

Foster Good Agricultural Practices to Minimize STEC Transfer		
Recommendations, Considerations and Opportunities	**Next Step Action items**	**Partnerships**
Ensure personnel clothing and footwear are clean before entering the farm.	LGMA requirement is in place to establish worker sanitation. Clarify if additional detail is needed. Proposed changes to the LGMA requirements can be submitted to Western Growers for public vetting/review (yearly process).	Interface with the LGMA metrics revisions process, based on contemporary data and research outcomes
Compost facilities with movement of raw feedstocks (manure) into a facility and finished product movement out of a facility should ensure no cross-contamination of vehicle ingress and egress, including roadways.	Consult with composter on impacts and costs and research opportunities.	Composters and research community

Evaluate Seasonal Wildlife and Management Effects on STEC Movement		
Recommendations, Considerations and Opportunities	**Next Step Action items**	**Partnerships**
Discuss your neighbors' wildlife management plan and strategies to address pressures; align management practices to reduce risk of conflicting objectives.	Create supporting documents that can be linked here, including examples and templates.	Neighbor to neighbor; Wildlife ecologists; Natural resources agencies and policy makers
Understand your neighbors' annual **seasonal management** events and communicate with one another when specific events are occurring and location. Continue to consider creative ways to foster ongoing communication among neighbors.	Create supporting documents that can be linked here, including examples and templates.	Neighbor to neighbor
Realize seasonal changes and the effect that weather has on grass availability for cattle grazing operations. Explore the timing and changes of practices that take place.	Incorporate knowledge related to weather impacts on grazing operations and develop mitigation strategies/best practices to mitigate STEC issues.	Ranch operations
Evaluate seasonal pressures (i.e., drought) and consider how this may change localized wildlife incursions (feral pigs, birds, rodents, et cetera).	Collaborate with wildlife agencies to identify and understand available data	Wildlife ecologists; Natural resources agencies and policy makers

Evaluate Seasonal Wildlife and Management Effects on STEC Movement		
Recommendations, Considerations and Opportunities	**Next Step Action items**	**Partnerships**
Recognize how individual industry management practices impact food safety and consider alterations for neighboring operations on both sides of the fence based on seasonal weather patterns and year-to-year changes (e.g., temperature, wind speed and direction, precipitation, flooding events). This type of information will be critical to help inform more streamlined future research efforts.	Continuation of the CAN Dialogue Group Ongoing data and information gathering, including identifying where research gaps exist	Research community; Neighbor to neighbor

Enhance Operation Management, including with Contracted Companies		
Recommendations, Considerations and Opportunities	**Next Step Action items**	**Partnerships**
Ensure that contracted (non-agriculture entities) allowed on site follow similar safety protocols.	Develop current efforts and best practices for operational changes to create awareness and educate non-ag entities.	Operations and other stakeholders
Discuss with neighbors how they manage, store or handle raw materials (manure for compost) arriving or staged for pick-up and haul off.	Better define the types of information that needs to be shared by neighbor; create supporting documents that can be linked here, including examples and templates.	Neighbor to neighbor
Understand how neighboring facilities handle bulk raw or uncured material, and the timing of when the product is received and how long the material is on-site.	Understand issues with proximity to storage facilities and management of rodent populations feeding on raw materials; refer to Section I Fostering a Neighborly Culture of Awareness. Review existing practices/procedures.	Neighbor to neighbor
Identify other contractors that visit a farm or ranch and ensure they are aware of established protocols to prevent pathogen introductions, including those managing water systems, pesticide applicators, planting and weeding crews, thinning crews, etc.	Keep a record of those who visit each farm or ranch. LGMA 's general visitor requirement should be sufficient to address visitors' protocols. Clarify what additional information may be needed besides what is already collected.	Farm and ranch operations
Know what soil inputs are being applied, who is applying it and where, and what the input formulations consist of.	Improve knowledge of soil input ingredients.	Fertilizer manufacturers, composters, and farm operations (including contracted applicators)

Enhance Operation Management, including with Contracted Companies		
Recommendations, Considerations and Opportunities	**Next Step Action items**	**Partnerships**
Know the diligence of your harvest crew – what training they received about risks during harvest and how to respond, where they have been prior to harvest.	LGMA metrics requirement; in addition, design of equipment should be considered.	Interface with the LGMA metrics revisions process, based on contemporary data and research outcomes
Foster continuous improvement in hygienic design of equipment - equipment cleaning and sanitation and frequency.	Hygienic design is desirable to facilitate proper cleaning and sanitation and research is required to set standards and to make it actionable.	Research community; Equipment manufacturers; Equipment users (e.g., farm operations)
Identify the location where animals are fed or handled and may congregate in numbers.	Identify livestock or wildlife that may be congregating.	Farm and ranch operations; neighbor to neighbor
Discuss with your neighbors their routine annual cycle of management activities including general overview of practices: 1) what they are producing/growing and 2) activities close to direct neighbors, as well as 3) activities in the broader community of neighbors. In addition, management specifically for increasing food safety/reducing pathogens.	Collaboration of the CAN Dialogue Group Ongoing data and information gathering, including identifying where research gaps exist	Neighbor to neighbor
Periodically inspect and maintain operations by removing waste materials and reducing harborage of insect and rodent populations.	LGMA metrics requirement has general best practices.	Farm and ranch operations; Interface with the LGMA metrics revisions process, based on contemporary data and research outcomes
Monitor irrigation system for potential contamination by damage or unauthorized access, including areas where wildlife may inadvertently damage equipment and cause excess flows over fields.	LGMA metrics requirement has general best practices. Proposed FDA agricultural water requirement revisions also may impact next steps.	Farm operations; Interface with the LGMA metrics revisions process, based on contemporary data and research outcomes
Monitor set back distances and fencing for possible breaches by domesticated and feral animals and note any new or heavily used wildlife trails and migration or feeding/water-seeking patterns. Determine how monitored set back distances will impact operational costs for both farms and ranches.	LGMA metrics requirement; significant costs on ranch side of the fence. Find a holistic approach.	Neighbor to neighbor; Interface with the LGMA metrics revisions process, based on contemporary data and research outcomes

The following Actions 2 through 4 are based on the goodwill engendered by Action 1: continued dialogue among those who are vested agricultural stakeholders in the Salinas Valley.

Action 2. Build a Research Roadmap for the Salinas Valley

The Food Safety Modernization Act (FSMA) has reshaped our thinking and approach to food safety with a crucial shift of focus from response to prevention when it comes to foodborne illness. FSMA is inspection based and requires individual produce growers to make risk-based assessments and determine what preventive measures are appropriate for their unique operations. Growers, advisors, and those inspecting the growers are limited in their ability to effectively assess preventive measures unless they have a means to identify and prioritize the data needs of the grower (and rancher) and to fill those knowledge gaps with timely, coordinated effort.

One reoccurring theme in the CAN Dialogue Group was the desire to begin by identifying the needs of growers and ranchers in a localized region. This can happen in several ways; historically one of the most effective ways has been through the help of university cooperative extension researchers and advisors. This contingent has been extremely successful at helping to build California's agricultural capacity; however, the implementation of FSMA created extreme imbalance between the number of produce farms covered by the produce rule (estimated at 21,000 in California alone) compared to the sparse number of cooperative extension advisors and others who are able to assist. These farms are now motivated to seek help to meet the newly emphasized need to address produce safety risk factors. We are learning of the growing need at a field level and must explore the mechanics of addressing grower and rancher needs through timely research, when appropriate, and effective outreach and education based on scientific knowledge and data gained through historic, contemporary, and future research.

Shortly after the Interim Report was issued in June 2021, CAN hosted a series of webinars to learn more from Subject Matter Experts about what we know from decades of research. Strong ongoing partnerships exist between the university system, the Center for Produce Safety (CPS), USDA, and FDA, which have led to significant progress over the years in our knowledge around food safety. Yet, despite the progress we've made, throughout the CAN Dialogue Group process it was determined that fundamental research areas needed to be addressed before a recommendation, standard, or new practice could be implemented. Considering this, the work group charged with filling knowledge gaps found that, if the collective agriculture industry in the Salinas Valley is to move ahead in a progressive and collective manner, a near term adaptive research roadmap should be developed and utilized as a tool to elevate the localized research needs of agriculture operations in the Salinas Valley.

A research roadmap can serve as a tool to break intractable problems into subcategories to help with research planning and to specify milestones and pathways to those milestones. In one way, the process of CAN, using the CAN Outcomes Table, has helped to initiate the first step of this process by compiling a range of scenarios and noting where additional analysis or information is required before a decision can be made. In the CAN Outcomes Table, CAN has identified which areas represent near- and long-term needs. By utilizing a stepwise process of discussion, refinement, and prioritization (combining the likelihood of implementation, preventive control impact, and cost) we were able to examine theories (bias) held and reclassify established assumptions, noting where additional science was needed to bridge to an appropriate standard or practice.

One successful example of a collective and focused research collaboration is the Center for Produce Safety (CPS). Each year the CPS identifies its research priorities in collaboration with industry. As has been the practice and policy of CPS since its creation, these research priority areas and other areas of focus are shared within the narrative of the annual request for proposals. Some focus areas are open and broad, while others are more targeted and narrower in scope. In addition to this, CPS invites short duration projects to develop issue briefs that provide a technical state of the science, an assessment of practical research investment opportunities, and a projected timeframe for adoption or a maturing technological innovation. Through this means, there exists a strong opportunity for next-step collaboration with the work of CAN, using university researchers and advisors, and leveraging the pipelines and opportunities that exist through CPS to readily identify and support the practical scientific knowledge and data needs of the Salinas Valley.

Maximization of collaboration opportunities, and concurrent reduction of redundancy, is an additional important benefit of a research roadmap for the Salinas Valley. This comprehensive suite of knowledge gaps, that was identified and prioritized through collaboration with stakeholders, is intended to serve as a tool. This tool can assist research-funding organizations (e.g., FDA, USDA, CPS, and others) along with outreach-funding organizations (e.g., USDA National Institute of Food and Agriculture, Food Safety Outreach Program (NIFA FSOP)) in their efforts to generate and disseminate necessary information to propose and support concrete practices or operational decisions that make the most impact on risk to leafy green crops.

Currently, sponsored research is underway supported by various entities including CPS, USDA, FDA CFSAN, UC Davis WCFS, and CDFA. Compilation of ongoing research and research needs provided by those entities would be one important step to developing a research roadmap. The CAN work group devoted to filling knowledge gaps started the roadmap with the following summary of landscape processes related to STEC in the growing environment. This model helped to identify areas where better knowledge is likely to lead to better decision-making capability. This is not to say that the certainty provided by scientific research is the sole path forward. Individual producer practical observations and knowledge provide additional insights to disrupt the avenues of contamination and amplification.

Current Knowledge Gaps

This topic area identifies the information in the CAN Outcomes Table where foundational knowledge is not available and thus limits the ability to make a recommendation. The work group evaluated each respective section identified in the CAN Outcomes Table and discussed research questions as they applied to key landscape processes of: Introduction, Re-introduction, Amplification, Survival, and Transport of STEC in the environment. The following sections begin with some of the general questions that relate to multiple research question areas, followed by area-specific questions. This summary represents a beginning for the research roadmap and is by no means an exhaustive listing.

General Needs

A short-term goal for the nascent research roadmap is to compile scientifically relevant, actionable information about what researchers and others **are** looking at, **have** looked at, or **hope** to look at given financial support and other opportunities. The committee felt that it was important to establish prerequisite conditions to effectively address specific research questions, in pursuit of broader goals. These desired prerequisite conditions are 1) availability of motivated and qualified scientists, 2) who are enabled to work within a framework, 3) with sufficient broad-function data to accomplish research that fills gaps in scientific knowledge and conceptual understanding.

Research Capacity

Work group members voiced concern that even a comprehensive research roadmap and funding support have limited value if the capacity to conduct the scientific research, and apply the results to address practical problems, is lacking.

- Many of the key scientists who have been relied upon for decades to investigate topics relevant to produce safety have retired or are likely to retire soon. This creates concern that, despite many exceptional scientists entering in the field, there may not be enough backfill for those who leave the field.
- Agricultural extension has long been relied upon to provide not only research capacity, but also advisors to translate research findings into applied recommendations and communicate those science-based recommendations to industry. Extension partners at land-grant universities, including in particular historically Black state colleges and universities and Tribal colleges, are valuable partners in these efforts. Non-traditional partners should continue to be cultivated in this role.
- Produce safety research has benefited from a long and productive partnership through sources such as
    - The Center for Produce Safety
    - Commodity Board Research Funding Programs
    - The USDA NIFA FSOP and Specialty Crop Research Initiative (SCRI) programs
    - The USDA Agricultural Marketing Services (AMS) Specialty Crop Block Grant program

As the roadmap of research needs begins to develop, other funding sources and partnerships such as the United States Geological Survey (USGS) Water Resources Research Institutes, National Science Foundation Environmental Research and Education program, and United States Environmental Protection Agency (EPA) grant programs may also support produce-specific research efforts. In addition, the multidisciplinary needs of the Salinas Valley mean that researchers from adjacent specializations should be actively engaged, particularly specialists in climate and weather patterns that might impact produce safety in the Salinas Valley and researchers who are able to study wildlife populations, migration patterns, and STEC carriage rates. These needs were discussed at some depth in the CAN Outcomes Table, in particular the section about *Evaluate Seasonal Wildlife and Management Effects on STEC Movement*. Similarly, newly developed resources, such as the *Issue Briefs* on Adjacent Land Use and Food Safety prepared by Dr. Trevor Suslow for CPS in 2021, should be utilized as the research scope of the Salinas Valley is considered.

Establish a Framework to Apply Research Findings

The vast quantity of data currently available, augmented by data that might be collected, requires a structure with which to understand the applied value of the information and to identify data gaps.

- The work group engaged in extended discussion about risk thresholds, the fact that there is no quantitative risk threshold, and challenges that are introduced into the path forward by the lack of a clear target short of complete elimination of risk (which would be ideal but is not considered practical).
    - This led to a suggestion for alternative approaches, such as "safe havens" in which practices shift to always allow a certain separation in time or space between, for example, cattle transport activities and leafy green harvest activities.
- Even lacking a risk target, a framework such as quantitative microbial risk assessment (QMRA) would allow growers, researchers and policy makers to identify and focus on conditions that have the highest risk profiles. This was discussed in the context of how to identify unusual circumstances that might 1) indicate higher risk and 2) trigger initiation of risk-reduction strategies.
    - One example discussed of how QMRA outcomes might be applied was prioritized installation of risk based and targeted preventive controls. The recommended controls could be costly, but quantitative risk research data might be used to counter or support the idea that this was an important risk reduction measure during, for example, a particular season or at a particular location.
    - Work group members felt that if the projected outcome in risk reduction by disrupting the pathway of transport via tires were sufficient then growers could make the determination of whether expenditures were worthwhile.
- Narrowing in on research questions, the team converged on the benefit of a risk assessment framework and its potential use to use existing and forthcoming STEC prevalence information quantify and prioritize risk specific risk factors.
    - One vision could be to create a unified QMRA model for the Salinas Valley and use the outputs to drive risk reduction strategies. A QMRA or similar data- and process-based approach can avoid the trap of circular discussions based on partial knowledge and strong opinions.

- The adaptive risk management model of USDA researcher Dr. Alan Franklin was used as an example of successful application of this approach. Dr. Franklin's work is to manage the risk of disease to U.S. herds by focusing on risk related to wildlife transmission of pathogens to domesticated animals. Another example of successful application of a risk-model framework was Dr. Linda Harris' use of a QMRA approach in support of pistachio industry risk-reduction goals.

The work group felt that efforts to incorporate existing wildlife data, including STEC-carrying rates, into a formal risk assessment framework represents a viable path forward. This determination is further described in this report's **Action 3. Create a Quantitative Microbial Risk Assessment (QMRA) Framework**.

Broadly Functional Data Resources

Core data needs and untapped data that may be available in several topic areas represented a difficult-to-classify need because it supports multiple aspects of the research roadmap. Some examples follow.

- **Accessibility of weather and climate data**
    - The group recognized that understanding seasonality effects on STEC-related risk in the Salinas Valley is challenging. It proved difficult to identify an expert to discuss climate and climate impacts in the CAN subject matter expert (SME) webinar series. The work group concluded that cultivating an SME to work with the Salinas Valley should be a priority to support broad research goals.
    - Examples of how weather and climate data may affect risk include: better understanding the intersection of leafy green production, cattle herd management, and wildlife movement in response to drought conditions. Historic weather data provide a means to track relevant information and model trends to identify focus conditions, and associated timeframes and geographic areas.
        - Supporting data for an effort such as this might include meteorological data collection networks such as the California Irrigation Management Information System station network in Salinas Valley. The Salinas Valley includes stations 205, 113, 114, 252, 214, 116 moving south to north. Bay-coastal stations such as 129, 193, 229 may also be relevant.
        - Work group members noted that Integrated Pest Management weather data sets also may be available.
- **Root cause analysis and other environmental sampling data**
    - Pre-harvest testing being done by growers under LGMA could be used to evaluate conditions associated with STEC detection events. In particular, this effort might be supported by incorporation of lessons learned during root cause analysis done in response to STEC detection. These and other data are part of the Western Growers GreenLink™ collection.

        - Western Growers later added information that data collected within the platform are spatially related by grower, and will be anonymized and de-identified when published for general reporting or external use. However, the regional spatial relationships between data points remain visible to growers within a common region. Therefore, the platform includes potential for a grower to view various types of data, including observed animal intrusion data and pre-harvest testing data, on a geo-spatial basis.

    - STEC prevalence data collected during routine environmental sampling on private and public lands on the central coast during the California Longitudinal Study (CALS) are expected to provide value to multiple research efforts.

    - The FDA Coordinated Outbreak Response and Evaluation (CORE) Network data analysis focuses on the environment and seasonal weather patterns. These data may provide key insight into contributing factors associated with outbreaks.

- **Knowledge about the prevalence of STEC in animal reservoirs**
  Prevalence data has value for specific questions including the following:

    - Prevalence and persistence of STEC in cattle and other livestock manure at rangeland, confined, and other operation types (including hobby farms). Some of the substantial data that exist about prevalence in various manures could be compiled for the benefit of ongoing research.

    - Prevalence of STEC in wildlife and molecular characterization of isolates from wildlife and livestock to measure potential inter-species transmission and colonization (e.g., resident or transient).

    - Further understanding of how proximity of domesticated animals and wildlife affect pathogen carriage rates including the impact of set-back distances between produce and livestock operations.

However, work group members recognized that barriers to effective research into wildlife carriage rates include 1) the permitting process, 2) financial inducements such as scheduled hunts and tag income and 3) concerns that steps taken to manage nuisance birds like redwing blackbirds and starlings can result in collateral damage with other, more valued or sensitive species.

Some existing data about wildlife carriage rates is part of the USDA Specialty Crop Research Initiative-funded CONTACT study under Dr. Michelle Danyluk (University of Florida), with whom Dr. Michele Jay-Russell (UC Davis) shared data on wildlife prevalence for incorporation into a QMRA evaluation. Dr. Danyluk is utilizing Dr. Jay-Russell's data as one element of many to begin constructing a QMRA framework. CAN dialogue participants noted strong potential for the CONTACT project and its offshoots having extreme value to the work and next steps of CAN.

- **Other broad data sets**
  If assembled, other data sets may enable understanding pathways, probabilities, and quantities of potential STEC transport pathways in the system including the following:
  - Potential pathway if equipment drives across the feces on a public roadway, then moves onto a farm
  - Timing of event sequences relative to harvest vehicle movement, such as along public roadways, in the leafy green crops cycle
  - Timing relative to cattle movement, or presence on or near roadways
  - Potential for amplification by regrowth following reintroduction of even minute quantities of the hazard to the growing environment
  - Potential for cross contamination, especially in areas where amplification by re-growth can occur
  - Effectiveness of interventions such as vehicle washes and tire scrubs
  - Fate and transport factors (e.g., how much is picked up by a tire or animal foot, distance traveled, die-off or growth over time during and after movement) which can vary seasonally and regionally

Research Related to Introduction and Re-introduction of Pathogens

In general, an enteric pathogen like Shiga toxin-producing *E. coli* (STEC) is not expected to be found in high numbers in the outdoor environment, separate from feces, because the pathogen is adapted to grow under conditions found in the gut of a person or warm-blooded animal. This means a persistent pathogen (e.g., *E. coli* O157:H7) likely is continually <u>re-introduced</u> into the outdoor environment. Examples of re-introduction processes are defecation by the host itself, or transport of fecal particles by equipment, air, or water.

A related concept is when a pathogen is introduced into an animal population (meaning that a herd of cattle or wildlife that did not originally carry *E. coli* O157:H7, for example, now does carry the pathogen). In this document, we try to clarify which meaning is intended through context or by using <u>introduction</u> into animal host populations and <u>re-introduction</u> into the environment.

Who sheds Shiga toxin-producing *E. coli* (STEC): Cattle are known to be a reservoir (natural host or carrier) of STEC. However, data show that STEC carriage by cow-calf herds is stochastic (e.g., sometimes STEC are present and sometimes they are not) and uneven (both the percent of a herd shedding STEC and the concentration of STEC shed in the manure).

The importance of cattle reservoirs compared with other possible reservoirs has not been clearly demonstrated. Huge numbers of birds and other wildlife, compared with rangeland cattle herd sizes (and differences in the amount of feces per day for these animals), hinders apples-to-apples comparison and ability to clearly evaluate assumptions about probability that STEC in the environment were shed by certain animal populations.

Research questions related to pathogen introduction and re-introduction address some of these processes. In the first CAN webinar series titled *Reservoirs of E. coli O157:H7 and other STEC*, researchers shared that we must be mindful of bias when comparing fecal material sample results among animal sources. This includes consideration of animal population density and the volume of fecal material tested. Wildlife fecal volume samples often underestimate the prevalence of pathogen when only small amounts of fecal material (e.g., bird or rodent droppings) can be gathered and tested. Comparatively larger amounts of fecal material can be gathered from cattle and pathogens are more likely to be detected in larger samples. Shedding, in the form of feces, by a person or animal host (of the pathogen) might result in a continual environmental re-introduction of the pathogen at potentially high levels. Close contact with feces from one animal by another animal can result in introduction then amplification (growth) of the enteric pathogen in the guts of the receiving population of animals such as a herd of cattle or a population of rodents, feral pigs, and/or deer. As these animals continue to defecate, they also re-introduce the pathogen into the outside environment in a continuous cycle.

Research questions in progress or needing to be addressed in this topic area include:

- Related to *E. coli* O157:H7 vaccine to reduce carriage rates in cattle:
    - Safety of *E. coli* O157:H7 vaccine in pregnant cows in a cow-calf operation. *(Dr. Gabriele Maier, UC Davis School of Veterinary Medicine and Dr. Michele Jay-Russell, UC Davis, Western Center for Food Safety are currently researching this topic)*
    - Efficacious antibody response at intervals using a Siderophore Receptors and Porins (SRP) vaccine at a two-dose regimen. *(Dr. Gabriele Maier, UC Davis School of Veterinary Medicine Extension and Dr. Michele Jay-Russell, UC Davis, Western Center for Food Safety are currently researching this topic)*
    - Do animal congregation settings concentrate STEC and introduce STEC to neighboring rangeland grazing cattle and wildlife that share the environment? Does this process allow re-introduction of STEC to the surrounding environment and further spread STEC from a potential source, despite confinement of animals?
    - A research topic following from feedlot-related settings is evaluation of whether 1) full implementation of the practices identified in the Beef Quality Assurance (BQA) program, along with 2) utilization of the *E. coli* O157:H7 vaccine, results in a decrease in introduction to nearby rangeland herds and environmental re-introduction rates around feedlots. The research outcome is whether BQA and vaccination efforts are effective when focused on feedlots and other location(s) that have confined animals.
    - Additional research is needed to better characterize livestock–wildlife interactions, and identify risk factors that induce fluctuations in herd prevalence (Benjamin et al, (2015). Such information would help further our understanding and perhaps address (introduction) and shedding (amplification) of STEC, including risk factors for sporadic "spikes" in prevalence. Questions include: Is the *E. coli*

O157:H7 vaccine effective at preventing rangeland introduction between same species animals (cattle to cattle) as new animals are added to the existing herd (stockers, feeders, bulls), if the new animals carry and shed STEC? The same question would apply in livestock-wildlife interactions where wildlife populations interact with livestock herds and those wildlife populations carry and shed STEC; is the vaccine effective at preventing introduction between different species (wildlife to cattle)?

- Related to feed and feed supplements:
  - Dr. Todd Callaway from University of Georgia shared with the CAN Dialogue Group current knowledge of feed supplements used for reduction of foodborne pathogen shedding in cattle. A question brought forward was: Is there an effect from feed sources and practices (e.g., certain types of supplemental hay or vitamin/mineral supplement barrels on STEC carriage rates for rangeland cattle operations)?
  - Which feed supplements or additives show the greatest effectiveness for reduction of STEC shedding in cattle? Has the effect been demonstrated in rangeland cattle operations?
- Related to non-cattle source introduction:
  - Would an *E. coli* O157:H7 vaccine administered to cattle help control transference between populations of other species? Would animal reservoirs other than cattle ultimately hinder the ability of vaccine interventions to decrease overall re-introduction of *E. coli* O157:H7 into the environment over long timeframes?
    - Pathogen spillover is not necessarily only from cattle to wildlife and humans – it is known to occur from wildlife to cattle populations. Reports in the scientific literature show that deer, feral hogs, and domestic hogs, in addition to cattle, can be reservoirs of STEC including *E. coli* O157:H7.
  - Does re-introduction to the environment explain year-over-year outbreaks and other detection events involving the same strain? Are those particular strains able to amplify in an environmental niche? Are we missing this possibility because of the intensive focus on manure and other feces?
  - Do facilities that aggregate and hold feces (including composting operations and wastewater treatment plants) contribute to re-introduction of STEC to the environment or introduction of STEC into wildlife populations?
- Translation of existing guidance for biosecurity and risk reduction in meat products into application for leafy greens**:**
  - Beef Quality Assurance program documentation including the BQA manual and the BQA field guide.

Research Related to Amplification of Pathogens

Amplification or multiplication refers to growth in the numbers of the bacteria. When managing risk, researchers talk about "populations" of bacteria rather than an individual cell. The population size increases when the bacteria in that population multiply. One bacterial cell will "grow" and then divide into two cells, then two becomes four, and four becomes eight, and so on. This is known as exponential growth.

Biostimulants and amplification: Organic farms in the Salinas Valley growing region use a diversity of input products as nutrient/ soil microbe biostimulant additions. These products include chicken pellets and fish emulsion (regulated under the Food Safety Modernization Act (FSMA) as biological soil amendments of animal origin) as well as (increasingly) non-animal-origin amendments that includes molasses. Molasses is a known bird attractant (especially crows and ravens) after application and irrigation. It is also an energy source that may increase pathogen growth potential.

It is also possible for amplification to occur outside of the animal's gut – but this only happens for pathogens that are bacteria, like *E. coli* O157:H7. For example, bacterial pathogens sometimes multiply in soil or water when nutrients are present and other conditions (especially moisture and warm temperatures) are right. Some non-pathogenic *E. coli* have been demonstrated to naturalize and gain the ability to persist and grow in the outdoor (non-gut) environment.

The working group converged on researchable questions having to do with 1) wildlife attraction and 2) amplification of low-level bacterial pathogens (either naturalized or re-introduced) by incorporation of soil amendments. Even if the soil amendment is not from animal manure, or if it is used as a biostimulant rather than as a nutrient source, the products typically include available carbon that can support bacterial growth. The group further clarified that untreated raw chicken litter and other untreated manure-based amendments are not used in Salinas Valley growing region practices.

Research questions to be addressed in this topic area:

- How does expansion of new and novel fertilizer materials, and resulting shifts in soil inputs, affect produce safety risk factors including amplification?
- Molasses and other carbohydrate sources continue to come up in discussion as both a soil probiotic and as a cattle feed supplement. Does use of molasses and other carbohydrate sources increase the possibility for STEC amplification in the agricultural environment? Does it increase the possibility of introduction into wildlife populations by exposing scavengers, drawn to undigested material in cattle feces, to STEC?
- How does incorporation of organic material such as molasses into drip irrigation water affect the availability/action of chemical treatments such as hypochlorite (bleach)? *(Dr. Channah Rock continues work on this topic as part of her research funded by the Center for Produce Safety (CPS))*.

- One result of this research might be a switch to apply biostimulants (that contain carbohydrates) as a side-dressing rather than through the drip lines.
- Application as side-dressing circles back to the question of wildlife attraction and potential, during cycles between outdoor and gut environments, for adaptation and naturalization of STEC to persist or even amplify in the outdoor environment.

Research Related to Survival of Pathogens

Microorganisms <u>survive</u> or <u>persist</u> if they are not rapidly increasing or decreasing in numbers, such as when numbers are decreasing slowly over the course of weeks or months. Survival in the environment is important for understanding fate and transport of pathogens after re-introduction to the environment with animal feces. For example, in the Salinas Valley growing region it might be important to know if *E. coli* O157:H7 <u>persist</u> long enough to be transported by seasonal rains into fields or water sources, or if the pathogens <u>survive</u> in dried material well enough to be transported in wind-blown dust.

Benefits of sanitation: This topic area is about <u>survival</u> as a separate but related topic to <u>amplification</u>. These research concepts are about measuring benefits of management and practices rather than basic research. Specific outputs from this topic area might include validated protocols for cleaning and sanitizing, frequency, and locations of sanitation activities. In other words, if an operation were to choose one piece of equipment and one method for cleaning and sanitizing, what would it be and how would they verify effectiveness?

The work group discussed nutrient/ probiotic formulations for crop production, and the perception that farm management companies may use them without knowing the totality of formulation ingredients and the concentrations. Survival is related to but different from <u>amplification</u> (discussed as the previous research topic). One step forward might be to conduct a survey in collaboration with an industry group, for example LGMA, to better understand what products are used by growers. This would be data aggregation rather than research.

Research questions to be addressed in this topic area:

- How do different soil amendments affect soil microbial ecology (including adjacent biofilm formation in the soil such as in drip lines) after exposure to the various amendment formulations? *(Dr. Michele Jay-Russell has a project with the UC Agriculture and Natural Resources (ANR) Desert Research Center in Imperial to study chicken pellets and potential for regrowth of pathogens).*
    - The working group noted that the "starter" pathogen population might be endogenous (e.g., naturalized or from resident animal populations) or exogenous (e.g., introduced with the chicken pellets).
- Regarding equipment cleaning and sanitization, existing research demonstrates that cross contamination of pathogens can occur by way of harvest equipment during the harvesting process *(Dr. Channah Rock did [a 2019 study with support from CPS](#) that*

demonstrated the extent to which contaminated harvest equipment can spread pathogens during harvest):

- What are the biggest risk factors? What is the priority control point to effectively reduce those risks? *(This work is currently being prioritized and researched by industry).*
- What are the current best practices, and what are the barriers to improvement?
- What specific equipment is, for example, National Sanitation Foundation-certified that it can/has the ability to be cleaned?
    - In some cases, such equipment may not exist or conversion to equipment that incorporates sanitary design might be prohibitively expensive (a long-term investment not a short-term switch). In this case, where are best practices most effectively applied in the near-term?
    - If equipment conversion is determined to be cost prohibitive, could specific infrastructure grants or cost-share dollars be identified as a possible solution?

Research Related to Movement or Transportation of Pathogens

While some bacteria can move limited distances by themselves, especially in water, these distances are restricted on a human scale (i.e., bacteria can move millimeters but not kilometers by themselves). For movement more than millimeters, other carriers are usually at play. For example, bacteria can be carried by moving water or in the wind via air particles (e.g., dust) or by a fomite (a solid material or object that can carry bacteria; like the sole of a shoe, gloves, or a tire).

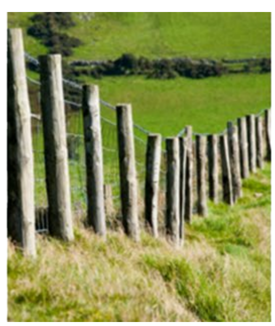
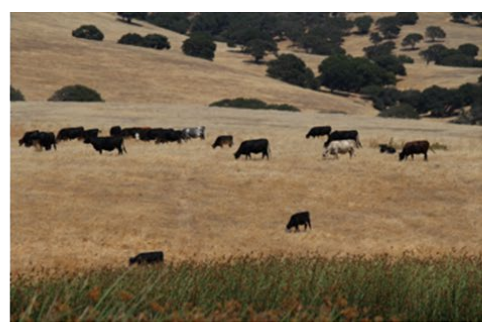
Muck in the treads: The Salinas Valley is flanked by two mountain ranges, on the west by the Santa Lucia Range and on the east by the Gabilan Range. In some parts of the valley there are narrow, shared roadways that lead from the valley floor and into the mountains. These roadways are shared by agriculture vehicles that attend to the daily activities of the crop, ranch, and other businesses in that region.

Managing risks necessarily includes aspects of risk assessment to prioritize risk factors, and a food safety culture of trained workers who can reduce the probabilities of risk factors going undetected/unmanaged. This framework could also help to get ahead of shifts in risk profiles from changes in practices, such as the Covid-era practice of abandoning shared transportation (e.g., buses) and having harvest crews arrive in many personal vehicles (e.g., more tires, more pathways travelled to the field, less control over cleanliness/sanitation). There continues to be ongoing work in this area with subject matter experts and a helpful resource to this topic includes the CPS STEC Issue Brief #1 on seasonality and moving vehicles, which were categorized as a moderate risk.

Vehicle cleaning and sanitation (including harvest equipment and farm management activities) were a topic of discussion in this section because of the potential that may exist for vehicles in the area to move or transport pathogens during shared roadway timeframes. Some roadways have more concentrated traffic flow with neighboring agriculture activities in proximity to one another due to where the road is situated and how it services neighboring operations in the particular region as a conduit for people, machinery, and transportation of livestock or raw materials destine for compost.

Research questions to be addressed in this topic area:

- The work group consensus was that this topic could be effectively addressed utilizing a quantitative microbial risk assessment (QMRA) framework. The framework would help to organize the variables and utilize information such as probabilities that localized shared roadways may result in contact between STEC in manure or other feces and vehicle tires that enter leafy green fields. A series of specific questions follows:
    - What are the relevant variables (e.g., how much manure, source of manure) and probabilities (e.g., production status of nearby fields, like being close to harvest) and are corresponding data available?
    - What is the baseline risk, in comparison to other risk factors, and how best to reduce the risk?
    - Can a qualitative, less-intensive approach result in the same actionable outcomes? In other words, does it require a QMRA to evaluate whether presence of manure on a road that leads into a growing area should be dealt with?
- The general scope of the topic was further divided into two topic areas:
    - Single issue of shared use of roadways, and the extent to which manure on the roadways is a priority problem.
    - How to appropriately manage equipment/worker risk factors? This topic area references back to points in amplification and survival in the sense that it contains both a strong element of sanitation requirements and would benefit from the use of a QMRA framework.

Path Forward Toward the Research Roadmap

In summary, there is an opportunity to systematically incorporate and elevate the research priorities and needs that come from local input. This input can be captured on an annual basis from growers and ranchers, farm advisors, University of California Cooperative Extension (UCCE), state Departments of Agriculture, and associations or member organizations. Currently, the organization that most closely models this prioritization and solicitation described is the Center for Produce Safety. Yet, the requirements and compliance dates of the Food Safety Modernization Act rules have created a catalyst where we are seeing the growth of data needs to help address local food safety practice decisions. This also creates a growing need for technical assistance subject matter experts to help interpret data and implement risk-based best practices. The inventory of produce farms in California is about 21,000. This number represents farms of all sizes with over half being small and very small-scale farms, often with diversified agricultural practices. These inventory numbers exemplify the need for technical assistance, which continues to grow. An increasing number of highly specific research questions need attention, coordination, and prioritization for local agricultural communities.

To collectively advance the food safety knowledge and technical assistance support available to California's produce growers in localized regions, appropriate staffing numbers and resources are needed for UCCE. This includes ongoing research and technical assistance funding for broad food safety practices that apply to many, specific local/regional needs, and/or commodity specific needs.

CAN has attempted to aggregate a large number of the immediate research priorities in one place. But there is a need to formalize this system as a future practice. The CAN process is one way to characterize what we know and place it on a framework (see, for example, the QMRA section below). Once the framework is in place, a next step could be to revisit the research roadmap annually and determine, in collaboration with a collective of organizations, how it needs to be updated and where contemporary research priorities should focus.

Action 3. Create a Quantitative Microbial Risk Assessment (QMRA) Framework

A structural hurdle was encountered during several conversations among CAN Steering Committee members, within the Dialogue Group, and during work group deliberations. Specifically, discussion participants were challenged to make "apples-to-apples" comparisons and prioritize information related to pathogen detection, pathways of pathogen transport, and contributing factors to past outbreaks that are determined during investigations. The research work group concluded that creation of systematic framework such as quantitative microbial risk assessment (QMRA) enables information from many sources to be combined and relationships among risk factors and control points to be evaluated.

To put it more concretely, using language borrowed from [Dr. Don Schaffner at Rutgers University](), a QMRA framework allows deliberations to move past application of best professional judgement that is often based mostly on when and where a pathogen is detected. Instead, QMRA incorporates probabilities and allows data-driven prioritization of risk-management practices. The risk factors in a particular setting are prioritized in a QMRA framework by combining detection/pathogen presence with probability/opportunities for pathogen to get onto covered produce. A simplified conceptual illustration follows, populated with notional information; representative values used for the example calculation were replaced with descriptive classifications for presentation to avoid over-interpretation. A real QMRA model would have values, a much more sophisticated framework, and the information provided would be scientifically rigorous, supported by research reports and survey data. One peer-reviewed example QMRA analysis, relevant to this effort, was published in 2020 by Dr. Channah Rock and other colleagues in Arizona *Review of water quality criteria for water reuse and risk-based implications for irrigated produce under the FDA Food Safety Modernization Act, produce safety rule*.

Example of Quantitative Microbial Risk Assessment (QMRA) Framework			
Measurement	**Herd A**	**Herd B**	**Crow flock**
Number of individuals (n_source)	Smaller	Larger	Very large
Probability individual carries STEC (P_STEC)	Moderate	Nil	Very low
Mass feces per day per animal (m_feces)	Larger	Larger	Very small
"Direct deposit" hit rate on target field (P_direct)	Nil (fenced out)	Nil (fenced out)	Low (discouraged)
Probability of individual feces transfer to field (P_indirect)	Lower (adjacent, wildlife carried)	Very low (distant, wind carried)	Nil (no mechanism)
Mass of individual feces transferred to field given transfer (m_transfer)	Smaller (wildlife fur)	Minute (dust)	Entire mass (whole dropping)
Calculated cells STEC per gram (surviving transfer) (C_STEC)	Moderate (less if older)	Lower (die-off in drying)	Higher (fresh deposit)
Units product affected by each transfer event (per acre) (n_contam)	Low	Entire field	Low
Calculated cells STEC per leafy green harvest unit	Low but present	Nil	Low but present
Units affected (per acre)	Very few	Entire harvest	Few

In the table above, a QMRA type evaluation would tell an operations manager the following:

- Some individuals in a small herd of cattle (herd A) carry STEC. A small amount of feces can be carried from the range land into the growing field by wildlife. Using notional estimates and a fictional scenario, a few units of produce might be contaminated with small amounts of infectious STEC on a given day.

- No individuals in a larger herd of cattle (herd B) carry STEC. A small amount of feces can be carried from the range land into the growing area in the form of dust. Since herd B does not carry STEC there is no contamination in from this herd. If herd B were carrying STEC, however, a large number of produce units could be affected.
- A few individuals in a flock of crows carry STEC. Though these birds are discouraged from the field, some birds access the field and, when they defecate, it sometimes directly hits growing produce. Using notional estimates and a fictional scenario, several units of produce might be contaminated with small amounts of infectious STEC on a given day.

An operations manager could use information like this to prioritize operational decisions to most effectively reduce risk. Since in this illustration more product is contaminated by birds than cattle, and the level of contamination is similar, the manager might prioritize control of the crows over control of wildlife that have access to both the field and herd A as their first risk reduction move.

In reality, a QMRA is unlikely to be done for each leafy green growing operation. Instead, scenarios such as the illustration would be used to develop and refine general concepts. If research were to show that interventions such as vaccination or modification to feed practices on nearby animal operation lands reduced the probability of *E. coli* O157:H7 amplification and transfer to the leafy green crop, then that information could be used to make decisions about risk reduction interventions targeting domesticated animals. Similarly, research could show that interventions targeting domesticated animals were less effective than interventions directed toward a wildlife population, which also may carry *E. coli* O157:H7. In this situation, that information could be used to make risk-based decisions targeting wildlife management.

This illustration was made to demonstrate how a QMRA framework can provide information that guides practical transfer of knowledge into operational decisions, through risk-based prioritization of STEC control points. The illustration also provides some indication of how data-intensive a fully developed QMRA framework can be. During application of the QMRA framework, data gaps will inevitably become apparent. The process of filling data gaps is already begun through the Western Growers GreenLink™ data set, which demonstrates the commitment of leafy green growers to contribute knowledge toward solutions. These data, and data provided by ongoing research and other data-collection efforts, can be used to further refine and develop the research roadmap to provide relevant, applied information into the risk reduction system put forward in this report.

Action 4. Build and Maintain Capacity to Transfer Knowledge from Research into Applied Practice

The need for shaping and encouraging a culture of food safety has never been more profound. Implementation of the Food Safety Modernization Act (FSMA) has challenged us in more than one way. Sets of rules can be readily implemented, but fostering behavioral change is a longer endeavor. Food safety work is a process of continual improvement based on knowledge gained, insights implemented, and processes refined.

Thus far, two of three key components to modeling a successful outcome – a Research Roadmap and using QMRA – have been discussed. A third component is to transfer this knowledge into applied practices; this is easier said than done. Technical assistance is necessary in order to facilitate knowledge transfer, grow our understanding, and to help shape behavioral change over time.

Some of those who are key to helping facilitate knowledge transfer and technical assistance include: industry associations, commodity groups, non-profits serving a specific group of growers, and partners in the university systems. In particular, the University of California Cooperative Extension (UCCE) has years of experience working with farmers, ranchers, environmental groups, and many others to identify concerns and innovate solutions that support productive agriculture, healthy ecosystems, and prosperous communities throughout California.

Rooted in every California county, UCCE specialists connect the campus to the people they serve. It is a two-way link. UCCE researchers provide science-based strategies and solutions, and local communities help scientists understand what issues to address, find working landscapes to use in their research, and circulate findings back to the field. Together, UCCE and local communities build a better future for California agriculture and the consumers fed by California growers.

UCCE has experienced years of declining funding revenues, causing a drastic loss in funded Farm Advisor positions. In the 2021-2022 California state budget, a funding augmentation was approved to fill vacant positions and replace retiring Farm Advisors. The research ability of Farm Advisors remains constrained as it will take significant effort and time to backfill these positions. For growers and ranchers of the Salinas Valley who depend upon Farm Advisors for specific projects, there remains a void in capability for locally focused research projects that address food safety priorities. This specific area needs to continue to be revived with funding and expertise. In particular, approximately 21,000 covered farms that are subject to the FSMA Produce Safety Rule in California will benefit from strengthening, and in some areas reviving, UCCE-based programs.

Private funding for research projects and in-field testing are also critical to filling knowledge gaps, specifically for locally identified risks and concerns. Each project will need to be tailored to the specific needs of the farm or ranch (either locally or regionally), to ensure that the best possible science is utilized when formulating potential practices or food safety measure requirements. Private funding will play a key role in helping to identify and manage these specific projects and their complementary aims among the local agricultural community.

COMMUNICATION, FUTURE DIRECTION, AND NEXT STEPS OF CAN IN 2022

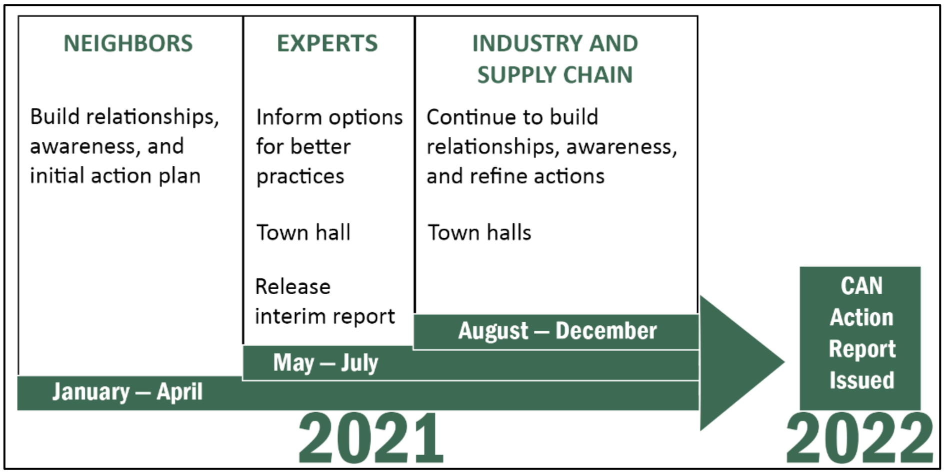


Figure 5: Timeline of CAN efforts leading to CAN Action Report.

The initiative of CAN has been unique and a pioneering effort to bring together diverse sectors of the agriculture community. In the process, we have built understanding and respect, while engaging in exploration of options for change that are critical to all to address food safety in the Salinas Valley. The CAN dialogue has created an opportunity to show the way for more ambitious objectives. The process has reinforced and otherwise informed why it has been critical to approach this effort locally, in a stepwise fashion, with a focused, measured, and balanced approach. Realizing that while food safety is the primary driver, this conversation cannot be fully effective without proper consideration given to food security and environmental sustainability while keeping scientific knowledge and/or data and societal needs centric to the discussion.

As discussed, this effort has been stepwise and collaborative throughout 2021. Additionally, the engagement of an ever-broadening roster of stakeholders, starting with neighbors, expanding to subject matter experts (SMEs), and then including the broader industry and supply chain helped build upon and reinforce key opportunities and their prospects or limitations to practical applications. As such, the CAN Dialogue Group finds value in this endeavor and plans to continue to meet throughout 2022 to build upon the collaboration.

Several areas noted throughout this report fostered successful outcomes based on partnerships and ongoing structured dialogue and support. These are partnerships among neighbors and with those entities that help support growers, ranchers, and the agriculture industry. The CAN Dialogue Group has expressed the desire to continue fostering the working relationships established in 2021 through ongoing dialogue, information sharing, and implementation of this CAN Action Report throughout the coming year. CAN will continue to meet regularly to address action items in the report, foster ways to continue to support agriculture neighbors, share relevant food safety work through webinars or material dissemination, and discuss new and emerging issues that involve localized collaboration with the agriculture community (e.g., FDA and the proposed revisions to the agriculture water requirements under the Produce Safety Rule). This ongoing local partnership will help ensure that implementation of the CAN Action Report maintains progress and remains progressive.

Bureaucratic Externality Challenges

CAN participants noted that we do not work in isolation. There can be other entities with conflicting objectives that create challenges to promoting food safety measures and practices. Just as we have worked toward the goal of bringing physical agricultural neighbors together, we also must proactively work to bring adjacent organizations and bureaucracies together.

Many regulatory programs such as the Irrigated Lands Regulatory Program and wildlife protection programs promote on-farm and on-ranch practices that can be inconsistent with solutions to food safety security. Some sustainability practices can be inconsistent with recommendations made for on-farm and on-ranch practices to reduce produce safety risks. Though beyond the scope of this report, interested readers may wish to learn more about managing the priorities of various programs and initiatives through, for example, the peer-reviewed publication *Evolving food safety pressures in California's Central Coast region* and the CDFA report *Food safety and sustainable agricultural practices: Conflicts and their effects on policy and programs in California*.

Coordination of diverse agency objectives related to water and other environmental resources is necessary to ensure that food safety practices can be incorporated and implemented without risk to compliance with other rules or other conflict with the objectives of other entities.

Economic Viability

Farming and ranching have been a part of California's landscape since long before California achieved statehood. With the most agricultural sales in the U.S. (about $50 billion), including almost $22 billion in exports, California plays an outsized role in feeding the growing population of the world. This abundance was built on the backs of farming and ranching families that run generations deep not only in the Salinas Valley growing region, but across the state. These families take great pride in the bounty produced and strive for the highest food safety standards with a focus towards being good stewards of the land today and for future generations to come. Food safety has grown in complexity, especially when layered with additional expectations on the agricultural community, including food security and environmental sustainability.

There is a finite amount of arable land in the world. With growing scarcity of water, increased input and labor costs, and regulatory demands, California farmers strive to meet the food security needs of the nation by producing nutritionally dense produce grown to the highest standards of food safety and sustainability, while maintaining an affordable and accessible price point to all consumers. Similarly, ranchers graze the nearby hillsides in the Salinas Valley growing region that are not suitable for crop production. These hillsides serve an important function as rangeland to fulfill dietary needs for protein and as natural working lands for the state.

These three pillars of agriculture—food safety, food security, and farm sustainability and stewardship—are in tension and require careful attention and collaboration. The existence of this tension was a primary driver of the CAN formation, with food safety a primary driver of the conversation. The CAN process reinforced the message that proactive food safety outcomes, even when they are a primary goal, cannot be the sole topic of discussion. The CAN group found that actions to enhance food safety were sometimes not economically feasible nor sustainable by a grower or rancher. Growers and ranchers must simultaneously make decisions with separate goals in mind, because many factors affect the profitability for farms to continue creating food for consumers. If growers and ranchers cannot produce food sustainably, then the domestic supply chain suffers.

Because of the need to balance all three pillars of agriculture, the work group discussed the importance of models and practices that can fully support the economic success of neighboring operations, including those that fall outside of the requirements of the FSMA Produce Safety Rule. The important criterion was that science supports the use and effectiveness of these practices. Given this context, there may be space to explore a new voluntary program to eligible landowners and agricultural producers that could provide financial and technical assistance to help implement practices in support of food safety, as part of a One Health approach.

As we reflect on the challenges that brought the CAN Dialogue Group together and navigate the changes before us, we should not, and in some instances we cannot, separate the conversation of food safety, food security and sustainability, and economic viability.

Opportunities, Considerations, and Action Steps

The work conducted by the CAN Dialogue Group in 2021 has fostered a deeper understanding among Salinas Valley agriculture neighbors of the agronomic practices that commonly take place throughout the year. It should be noted that each operation is unique. Each makes decisions informed by practices in the growing or ranching region within the Salinas Valley, or based on the entity-specific business structure. We also have recognized that measures to enhance food safety require a layered approach; each layer adds an important element, and therefore reduces the risk of pathogen contamination. There is no one solution that addresses environmental pathogens, but several measures that when combined are known to yield effective results.

Through the series of meetings with the CAN Dialogue Group, CAN Workgroup, and industry experts, the following areas became collective themes of discussion, recommendations, or consideration. It is important to acknowledge that while this is an Action Report, the scope of food safety is vast and the Dialogue Group did its best to note the areas one should consider and to provide a degree of prioritization. As such, some areas lend themselves to ease of implementation, while other areas are notably more challenging.

CAN Action Recommendations

Food safety is a shared responsibility, and the complexities are evident and illustrated throughout the report. Yet, it is evident that the pathway forward toward enhanced food safety awareness, action, and understanding. The CAN process created the foundation for success including enhanced communication among neighbors and the community at large. It also allowed for sharing of scientific insights and translation to more targeted action steps and interventions. In summary, the future action steps of CAN include four key areas:

1. **Foster Neighbor-to-Neighbor Interactions and Conversations.** This can be supported locally through industry and association meetings, workshops and webinars, and shared information and updates. These efforts will be promoted as part of the ongoing work of CAN to develop a Dialogue Template, and while leveraging the CAN Outcomes Table for specific action and key partners.
2. **Build a Research Roadmap for the Salinas Valley.** This Roadmap would aid collaboration to build capacity to fill knowledge gaps, develop a means to fund research to fill knowledge gaps, and represent a means to prioritize and coordinate knowledge-filling activities. Currently, sponsored research is underway supported by various entities including CPS, USDA, FDA CFSAN, UC Davis WCFS, and CDFA. Compilation of ongoing research and research needs provided by those entities would be one important step to developing a research roadmap.
3. **Create a Quantitative Microbial Risk Assessment (QMRA) Framework.** This Framework would enable producers in the Salinas Valley to move toward the ability to prioritize risk factors and evaluate the benefit of addressing each. Efforts can be prioritized by evaluating which risk factors can be managed or mitigated through stepwise interventions. The vast quantity of data currently available, augmented by data that might be collected, requires a structure with which to understand the applied value of the information and to identify data gaps.
4. **Build and Maintain Capacity to Transfer Knowledge from Research into Applied Practice.** This capacity would help to right-size the needed depth and breadth of experts in order to fully support farmers, ranchers, and the balance of agriculture neighbors in the Salinas Valley. It also considers that experts will need to have a multidisciplinary approach in order to collectively foster food safety, food security, and environmental sustainability with a One Health goal of achieving target health outcomes.

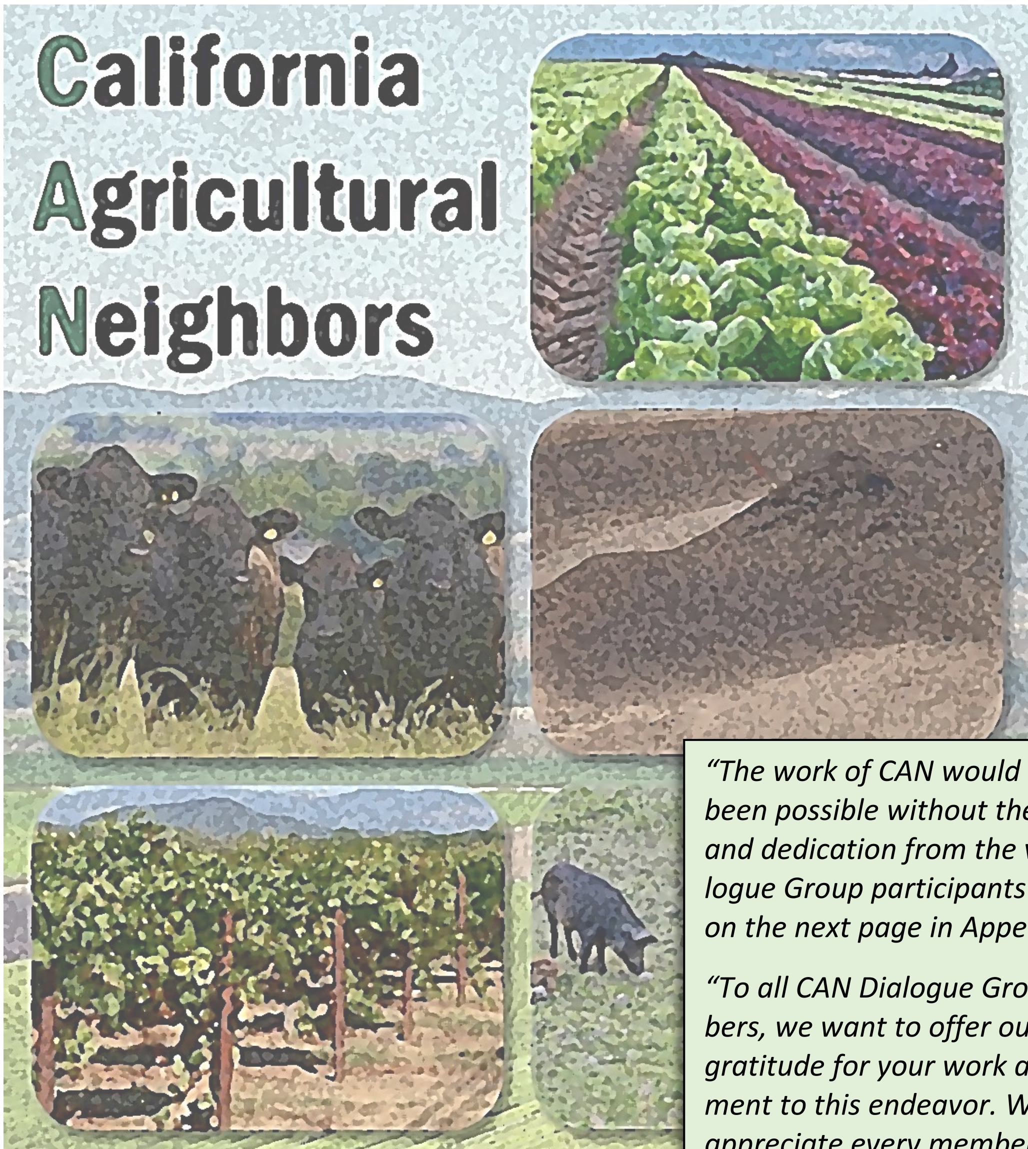
The work of CAN will continue through 2022 to address many areas brought forward in this report and to build upon the relationships and opportunities as a community and world-renown growing region of California.

While this can fully be appreciated as a complex challenge and a collective journey, the process of CAN dialogue enhanced a shared appreciation for food safety. This appreciation included how complex understanding microorganism contamination is; how much information is available; and, how much more information is needed. And, through sharing information and encouraging cooperation, some actions can be taken that are practical. This endeavor and journey started with small steps – by talking to one another – and has created a vision for walking together. Eventually – through the research capacity development and by expanding the cooperative network of neighbor-to-neighbor dialogue – we can run together making significant strides into the future of food safety. The more work accomplished on both fronts, the better we all will do.

ADDITIONAL RESOURCES

For additional resources, including webinar links and the interim report, visit the Monterey County Farm Bureau web site:

www.montereycfb.com/index.php?page=ca-ag-neighbors



"The work of CAN would not have been possible without the willingness and dedication from the various Dialogue Group participants identified on the next page in Appendix 1.

"To all CAN Dialogue Group members, we want to offer our sincerest gratitude for your work and commitment to this endeavor. We deeply appreciate every member of the team and your investment of time and expertise is unmatched and appreciated. Thank you for your help to advance our collective food safety efforts."

Sincerely, Norm and Natalie

Appendix 1: CAN Dialogue Group Participants

Natalie Krout-Greenberg, *California Department of Food & Agriculture* (co-lead)

Norm Groot, *Monterey County Farm Bureau* (co-lead)

Abby Dilley, *RESOLVE* (facilitator)

Dominic Adam, *Adam Bros. Farming*

Sara Arsenault, *California Farm Bureau*

Rob Atwill, *University of California, Davis, School of Veterinary Medicine*

Michael Brautovich, *Gabilan Ag Services/Keith Day Company*

De Ann Davis, *Western Growers Association*

Melissa Duflock, *San Bernardo Rancho*

Jeff Farrar, U.*S. Food & Drug Administration*

Dirk Giannini, *Christensen & Giannini*

Kurt Gollnick, *Scheid Vineyards*

Henry Gonzales, *Monterey County Agricultural Commissioner*

Jim Gorney, *U.S. Food & Drug Administration*

Linda Harris, *University of California, Davis, Food & Science Technology*

Kate Horstmann*, *Foster Farms*

Bill Hsu, *Yum Brands*

Michele Jay-Russell, *University of California, Davis, Western Center for Food Safety*

Annette Jones, *California Department of Food & Agriculture, State Veterinarian*

Kavishti Kokaram*, *California Department of Food & Agriculture*

Sharan Lanini, *Sharan Lanini Consulting*

Gaby Maier, *University of California, Davis, School of Veterinary Medicine*

Mason Mallroy, *Mallory Ranch Cattle Company*

Drew McDonald, *Taylor Fresh Foods*

Ann Muriu, *HEB*

Steve Patton, *California Department of Food & Agriculture*

Colby Pereira, *Braga Fresh Family Farms*

Jack Rice, *California Cattlemen's Association*

Taylor Roschen, *California Farm Bureau*

Carla Sanchez, *California Department of Food & Agriculture*

Vicki Scott, *Arizona Leafy Greens Marketing Agreement liaison*

Mark Shakespeare, *WalMart*

Vic Smith, *JV Smith Companies*

Don Stoeckel, *California Department of Food & Agriculture*

Trevor Suslow, *University of California, Davis, Emeritus Extension Research Specialist*

Ken Tate, *University of California, Davis, Rangeland Watershed Sciences*

Mike Taylor, *STOP Foodborne Illness*

Christopher Valadez, *Grower-Shipper Association of Central California*

Anita Varga, *California Department of Food & Agriculture*

Matthew Viohl*, *California Farm Bureau*

Scott Violini, *Monterey County Cattlemen's Association*

Kirk Wilbur, *California Cattlemen's Association*

Craig Winn*, *Scheid Vineyards*

Tim York, *California Leafy Greens Marketing Agreement*

**New member, 2022*

Appendix 2: Glossary of Report Terms and Usage

Terms in this portion of the Glossary reflect words that are important for understanding aspects of this Action Report. Some of the terms reflect the specific usage in this document (not annotated) and others are marked to indicate the source of the definition as used by industry.

Adjacent Lands †	Land within a proximity that could potentially affect safe production of leafy greens. *CAN note: In the Action Report, proximity includes situations where production (irrigated) fields share a fence or are within radius of rangeland that could potentially affect safe production of leafy green crops. Adjacent lands are positioned such that they may affect the prevalence of STEC at growing lands. There is not a strict distance relationship between adjacent lands and growing lands because use of the term is conditional on STEC transport pathways.*
Aerial Application †	Any application administered from above leafy greens where water may come in contact with the edible portion of the crop; may be delivered via aircraft, sprayer, sprinkler, etc.
AFO †	Animal Feeding Operation (AFO) are agricultural operations where animals are kept and raised in confined situations. An AFO is a lot or facility (other than an aquatic animal production facility) where the following conditions are met: • Animals have been, are, or will be stabled or confined and fed or maintained for a total of 45 days or more in any 12-month period, and • Crops, vegetation, forage growth, or post-harvest residues are not sustained in the normal growing season over any portion of the lot or facility. Less than 1,000 animal units does not meet the requirements of a CAFO.
Amplification, of STEC	Growth in the numbers of the bacterial pathogen, such as STEC. Amplification can occur within the host gut, resulting in shedding with the feces and re-introduction of the pathogen to the environment. Amplification can also occur in the non-enteric environment, under favorable conditions, resulting in re-growth of the bacterial pathogen outside of the host.
Animal Hazard †	Feeding, skin, feathers, fecal matter, or signs of animal presence in an area to be harvested in sufficient number and quantity to suggest to a reasonable person the crop may be contaminated.
Animal Unit †	There are three approaches to defining an animal unit: • cow-calf unit, • 1,000 pounds of live weight of any species, and • on an energy basis.

† California LGMA Commodity Specific Food Safety Guidelines for the Production and Harvest of Lettuce and Leafy Greens, Glossary (version 02 August, 2021)

	CAN note: In Salinas Valley rangeland production, an animal unit (AU) is considered to be the equivalent of 1,000 pounds of "live" animal weight.
Application Interval †	Means the time between application of an agricultural input (such as a soil amendment) to a growing area and harvest of leafy greens from the growing area where the agricultural input was applied.
Branding	Marking of cattle for ownership; usually with a hot branding iron. Cattle are grazing in large pastures and may be brought in a day or two ahead of time to facilitate ease of gathering and less stress to the animals. These animals are in a smaller area for approximately one day.
Breeding of Cattle	The natural act of insemination of cows for pregnancy; bulls are generally kept in separate pastures until time to join with the cows for breeding. There is no substantial concentration of these animals; breeding just adds a few numbers to the existing herds. Central Coast introduction is generally a 90-120 day period. Bulls are put with the cows in November and December and are taken out in April and May.
Buffer Zone Grazing	Setback area from fence that borders production fields. This would be an agreement between the grazers and the irrigated operations; food safety managers monitoring and negotiate these arrangements. LGMA metric (Table 0) is a 30-foot buffer from operations characterized as AFOs, grazing lands, or hobby farms. In the Salinas Valley buffer zones range up to 800-feet. These buffer areas create a habitat for smaller species that can infiltrate the leafy greens production areas when left unmanaged.
CAFO	Concentrated Animal Feed Operation. CAFO, as defined by the United States Department of Agriculture, is an intensive animal feeding operation in which over 1,000 animal units are confined for over 45 days a year. An animal unit is equivalent to 1,000 pounds of "live" animal weight.
Calving	References a cow giving birth to a calf. Cows graze in the natural settings and are not confined to smaller areas; birth takes place in these areas, generally; the only exception may be first calf heifers that could be brought into a smaller pasture so they can be watched more closely in case they need assistance calving; after calving they are turned out with the larger group. General timeframe on calving is 90 days; months of September to February.
Carbohydrate †	Ingredient for soil amendments and crop inputs that could improve growth of bacteria.
Carriage Rate	The fraction of individuals in a population that carry a target pathogen, such as STEC. Closely related to the term prevalence.

† California LGMA Commodity Specific Food Safety Guidelines for the Production and Harvest of Lettuce and Leafy Greens, Glossary (version 02 August, 2021)

Co-Management †	An approach to conserving soil, water, air, wildlife, and other natural resources while simultaneously minimizing microbiological hazards associated with food production.
Compost †	Compost is the product manufactured through the controlled aerobic, biological decomposition of biodegradable materials. The product has undergone mesophilic and thermophilic temperatures, which significantly reduces the viability of pathogens and weed seeds and stabilizes the carbon such that it is beneficial to plant growth. Compost is typically used as a soil amendment but may also contribute plant nutrients.
Composting †	Means a process to produce compost in which organic material is decomposed by the actions of microorganisms under thermophilic conditions for a designated time period (for example, 3 days) at a designated temperature (for example, 131 °F (55 °C)), followed by a curing stage under cooler conditions.
Congregation	A gathering or coming together at a central location, such as a water trough, feeder, supplement block, or other attractant. Congregations of animals may have adverse effects to riparian areas, pastures, plant health, other species, geomorphological characteristics. Variables such as timing, duration, and frequency of grazing, stocking rate, and animal distribution is subject to ranch management control, including water trough placement.
Covered Produce	Fresh fruits and vegetables for which production and harvest practices are regulated under the Food Safety Modernization Act (FSMA) Produce Safety Rule with a goal to enhance produce safety.
Cow-Calf Operation	An operational method of raising beef cattle in which a permanent herd of cows is kept by a rancher to produce calves for later sale.
Crop Input †	Crop inputs are materials that are commonly applied post-emergence for pest and disease control, greening, and to provide organic and inorganic nutrients to the plant during the growth cycle.
Cross-Contamination †	The transfer of microorganisms, such as bacteria and viruses, from one place to another.
Culling the Herd	Livestock graze in larger pastures until being herded to a smaller field for ease of handling and then brought to the corral for processing or shipping. Not all cattle are shipped on the same day; there may be multiple groups brought to the same corral over a period of a week or two depending on the marketing of the animals and availability of the veterinarian for pregnancy checking or semen checking of bulls.
Enteric Pathogen	Pathogens that come from feces, generally residing in the intestinal tract of people and warm-blooded animals.
Escherichia coli **(*E. coli*)** †	*Escherichia coli* are common bacteria that live in the lower intestines of animals (including humans) and are generally not harmful. *E. coli* are frequently used as an indicator of fecal contamination but can be found in nature from non-fecal sources.

† California LGMA Commodity Specific Food Safety Guidelines for the Production and Harvest of Lettuce and Leafy Greens, Glossary (version 02 August, 2021)

	CAN note: The term "generic E. coli" is used in the Action Report to clarify when the usages refers to E. coli as an indicator of fecal contamination, compared to when the usage refers to pathogenic E. coli such as Escherichia coli O157:H7.
***Escherichia coli* O157:H7**	One serotype of *E. coli*, responsible for multiple outbreaks of food-borne illness associated with leafy green crops. *E. coli* O157:H7 is a type of Shiga-toxin producing *E. coli* (STEC).
Fecal-oral pathogen	See enteric pathogen.
Food-Contact Surface †	Those surfaces that contact human food and those surfaces from which drainage, or other transfer, onto the food or onto surfaces that contact the food ordinarily occurs during the normal course of operations. ''Food-contact surfaces'' includes food-contact surfaces of equipment and tools used during harvest, packing and holding.
Food Safety Assessment †	A standardized procedure that predicts the likelihood of harm resulting from exposure to chemical, microbial and physical agents in the diet.
Food Safety Professional †	Person entrusted with management level responsibility for conducting food safety assessments before food reaches consumers; requires documented training in scientific principles and a solid understanding of the principles of food safety as applied to agricultural production; in addition this individual must have successfully completed food safety training at least equivalent to that received under standardized curriculum recognized as adequate by the Food and Drug Administration.
Grazing	Grazing refers to the consumption of standing forage (edible grasses and forbs) by livestock or wildlife, while browsing is the consumption of edible leaves and twigs from woody plants (trees and shrubs) by larger-hoofed animals.
Grazing Capacity	Quantifies the amount of available forage for grazing animals on a given site, expressed in pounds or tons of forage produced. May be described in Animal Unit Months (AUMs) or Animal Unit Days (AUDs).
Grazing Intensity	A relative and general term usually expressed as light, moderate or heavy. Intensity of use strongly affects a site's response to grazing. Two variables – stocking rate and length of grazing period(s) - are the principal controls that can be prescribed to achieve the grazing intensity desired for a site.
Grazing Periods	The length of time that grazing animals occupy a specific land area.
Grazing Season	The time period, during a year, when grazing is feasible or practical. In low-elevation California, the grazing season can be year-around.

† California LGMA Commodity Specific Food Safety Guidelines for the Production and Harvest of Lettuce and Leafy Greens, Glossary (version 02 August, 2021)

Green Waste †	Any plant material that is separated at the point of generation contains no greater than 1.0 percent of physical contaminants by weight. Green material includes, but is not limited to, yard trimmings …, untreated wood wastes, natural fiber products, and construction and demolition wood waste. Green material does not include food material, biosolids, mixed solid waste…. It may also include material from a centralized facility as long as that material was kept separate from the waste stream prior to receipt by that facility and the material was not commingled with other materials during handling. *CAN note: definition abridged from full LGMA text for clarity.*
Growing Lands	For purposes of the CAN Action Report, growing lands includes land used to grow fresh produce, including leafy green crops, but does not include vineyard lands.
Harvesting †	Activities that are traditionally performed on farms for the purpose of removing leafy greens from the field and preparing them for use as food; does not include activities that transform a raw agricultural commodity into a processed food. Examples of harvesting include cutting (or otherwise separating) the edible portion of the leafy greens from the crop plant and removing or trimming parts, cooling, field coring, gathering, hulling, removing stems, trimming of outer leaves of, and washing.
Harvest Equipment †	Any kind of equipment which is used during or to assist with the harvesting process including but not limited to harvesting machines, food-contact tables, belts, knives, etc.
Hazard †	Any biological, physical, or chemical agent that has the potential to cause illness or injury in the absence of its control.
Heat Treated Soil Amendment †	Soil amendments and crop inputs that have been physically heat treated and dried in accordance to standards issued by the USDA. *CAN note: this definition relates to raw animal manure; alternative treatments are recommended for reducing or eliminating pathogens. Processed manure products must be treated so that all portions of the product reach a minimum temperature of either 150 degrees Fahrenheit for at least one hour or 165 degree Fahrenheit, and are dried to a maximum moisture level of 12 percent.*
Host, Human or Animal	In the context of the CAN Action Report, which focuses on a fecal-oral pathogen (STEC), a host (human or animal) is capable of supporting the long-term growth of STEC in the lower intestinal tract and sheds STEC in its feces.
Indicator Microorganisms †	An organism that when present suggests the possibility of contamination or under processing.
Introduction, of STEC	The process by which a human or host animal of an enteric pathogen such as STEC is exposed to the pathogen. Following introduction, the pathogen may be amplified within the gut of the host animal and pass to other individuals in the same herd or population. The term

† California LGMA Commodity Specific Food Safety Guidelines for the Production and Harvest of Lettuce and Leafy Greens, Glossary (version 02 August, 2021)

	introduction is used to describe situations where a herd of cattle or group of wildlife that did not originally carry *E. coli* O157:H7, for example, now does carry the pathogen at detectable prevalence.
Listeria †	Any of a genus (*Listeria*) of small, gram-positive, rod-shaped bacteria that do not form spores and have a tendency to grow in chains and that include one (*Listeria monocytogenes*) that causes listeriosis.
Manure †	Animal excreta, alone or in combination with litter (such as straw and feathers used for animal bedding) for use as a soil amendment.
Microorganisms †	Yeasts, molds, bacteria, viruses, protozoa, and microscopic parasites and includes species having public health significance and those subjecting leafy greens to decomposition or that otherwise may cause leafy greens to be adulterated.
Pathogen †	A disease-causing agent such as a virus, parasite, or bacteria. *CAN note: In the CAN Action Report, the focus is on pathogens that cause illness in humans. The specific pathogen on which this report focusses is Shiga-toxin producing Escherichia coli (STEC).*
Persistence, of STEC	The length of time for which STEC or other pathogen remains detectable or demonstrates a specific removal. Example usage includes phrases such as “This study also provides multi-regional baseline data relating … development of potential risk mitigation strategies to reduce pathogen persistence in soils amended with BSAAOs” (Ramos et al, 2021)
Pest †	Any objectionable animals or insects, including birds, rodents, flies, and larvae.
Prevalence, of STEC	The frequency with which STEC or other pathogen is detectable in a relevant unit such as animals, herds, or manure. Usage of this term includes, for instance, the prevalence of STEC in the herd was measured as a percentage of individuals from which samples were obtained. Closely related to the term carriage rate (within a population of animals).
Re-introduction, of STEC	The process by which an enteric pathogen such as STEC is continually brought into (re-introduced to) a non-enteric environment. Examples of re-introduction processes are defecation by the host itself, or transport of fecal particles by equipment, air, or water.
Research Community	A collective term that includes all areas of agricultural and food safety research, including public and private universities; regional, state and federal agencies; and, other public and private entities engaged in research targeting farm and ranch practices and food safety risks.
Reservoir, of STEC	A natural host or persistent carrier of a pathogen. The term ‘reservoir’ is often used to refer to the host of a pathogen, such as STEC, that is re-introduced into the environment of concern (such as growing lands or packing houses).

† California LGMA Commodity Specific Food Safety Guidelines for the Production and Harvest of Lettuce and Leafy Greens, Glossary (version 02 August, 2021)

Riparian Area †	A vegetated ecosystem along a waterbody through which energy, materials, and water pass. Riparian areas characteristically have a high-water table and are subject to periodic flooding and influence from the adjacent waterbody. These systems encompass wetlands, uplands, or some combination of those two landforms. They will sometimes, but not in all cases, have all the characteristics necessary for them to be also classified as wetlands (USEPA 2005)
Risk Mitigation †	Actions to reduce the severity/impact of a risk.
Salmonella †	*Salmonella* is a Gram-negative facultative rod-shaped bacterium in the same proteobacterial family as Escherichia coli, the family Enterobacteriaceae, trivially known as "enteric" bacteria. Salmonellae live in the intestinal tracts of warm, and cold blooded, animals. In humans, *Salmonella* is the cause of two diseases called salmonellosis: enteric fever (typhoid), resulting from bacterial invasion of the bloodstream, and acute gastroenteritis, resulting from a foodborne infection/intoxication.
Sanitary Facility †	Includes both toilet and hand-washing stations.
Sanitize †	To adequately treat cleaned surfaces by a process that is effective in destroying vegetative cells of microorganisms of public health significance, and in substantially reducing numbers of other undesirable microorganisms, but without adversely affecting the product or its safety for the consumer.
Serotype, of *E. coli*	A naming convention based on detectable proteins on the surface of a bacterial cell (antigens). Serotypes of *E. coli* are named based on an O-type antigen and an H-type antigen. Usage includes, for example, *E. coli* O157:H7.
Serogroup, of *E. coli*	A grouping of serotypes. Usage includes, for example, the O157 serogroup of *E. coli* that includes all associated H serotypes.
Shedding	A term used to describe excretion levels of an organism such as a bacterium or virus from a host animal. In this context, it refers to excretion of *E. coli* O157 in cattle feces.
Shiga-Toxin Producing *E. coli* †	Bacteria found in the environment, foods, and animal and human intestines that produce a potent disease-causing toxin. The serogroup most commonly identified and associated with severe illness and hospitalization in the United States is *E. coli* O157; however, there are over 50 other serogroups that can also cause illness.
Shipping Unit/ Equipment †	Any cargo area used to transport leafy greens on the farm or from the farm to cooling, packing, or processing facilities.
Soil Amendment †	Elements added to the soil, such as compost, peat moss, or fertilizer, to improve its capacity to support plant life.
Stocker Cattle	Introduction of additional animals to existing herd. Density on the grazing lands increase somewhat because these animals are smaller in frame (2 of these type to 1 cow/calf generally). The pasture grasses are utilized to increase weight gain on this particular group; generally grazed the same as a cow/calf but for a shorter period of

† California LGMA Commodity Specific Food Safety Guidelines for the Production and Harvest of Lettuce and Leafy Greens, Glossary (version 02 August, 2021)

	time (generally introduced to grazing in November to April) and mostly grazed during the green, wet season. Salinas Valley producer involvement is limited to only a few operations that do this.
Stocking Density	Number of animals per unit area of land at any one point in time. Can be expressed as Animal Units (AUs) per acres.
Stocking Rate	The number of animals grazing the available forage for a given period of time. It is expressed as Animal Units (AUs) per time period. Following units apply to cattle: weaned calf to yearling 0.6 unit; steers and heifers (1-2 years) 1.0 unit; mature cows with or without calf 1.0 unit; and mature bulls 1.3 units.
Supplemental Feed	Additional hay or grains provided to supplement natural grass. Cattle are usually fed in large pastures in several different areas; and are not fed in the same area every day on the same pasture as it will kill and damage the grass and soil. Most ranchers will rotate the feeding zones for this reason. In the Central Coast Mediterranean climate, this is a general practice because the grass is dry and contains low energy value in the fall of the year (September -November) and the cows need some additional energy (supplemental hay) to support the calf.
Supplemental Molasses/Salt	These items are distributed throughout pastures to benefit the animals and keep them in a rotational basis within large pastures. Cattle will concentrate around such areas, much the same as a watering trough. These areas are selected to minimize damage to soil and grasses.
Survival, of STEC	The ability to persist in the non-enteric environment. Environmental conditions may result in ability to grow (see also amplification) or only to survive (see also persistence). A population can be characterized as 'surviving' in an environment if concentrations do not rapidly increase or decrease.
Synthetic Soil Amendments	Any soil amendment and/or crop input that may be refined, and/or chemically synthesized, and/or transformed through a chemical process, such as gypsum, lime, sulfur, potash, ammonium sulfate, etc.
Tailwater	Excess run-off water (surface flow) which is generated (and may be collected) during the process of irrigation.
Transport, of STEC	The movement of pathogens, such as including bacteria and viruses, from one place to another. In this report and usage, transport could be by various carriers including rain, wind, animals, and equipment. Related to cross-contamination which more specifically relates to transfer from one contaminated item to another.
Transporter †	The entity responsible for transporting product from the field; LGMA guidelines apply only to handlers and cover production through harvesting.
Vaccinations	Providing medicinal supplements and disease prevention "shots" to animals, usually at the time of branding.

† California LGMA Commodity Specific Food Safety Guidelines for the Production and Harvest of Lettuce and Leafy Greens, Glossary (version 02 August, 2021)

Validated Process †	A process that has been demonstrated to be effective though a statistically based study, literature, or regulatory guidance.
Validation †	The act of determining whether products or services conform to meet specific requirements.
Verification †	The act of confirming a product or service meets the requirements for which it was intended.
Visitor †	Any person (other than personnel) who enters your field/operations with your permission.
Water Distribution System †	Distribution systems -- consisting of pipes, pumps, valves, storage tanks, reservoirs, meters, fittings, and other hydraulic appurtenances - to carry water from its primary source to a lettuce and leafy green crop.
Water Source †	The location from which water originates; water sources can be municipal, well or surface water such as rivers, lakes, or streams.
Water System	A source of agricultural water, the water distribution system, any building or structure that is part of the water distribution system (such as a well house, pump station, or shed), and any equipment used for application of agricultural water to covered produce during growing, harvesting, packing, or holding activities. *CAN note:* FDA Proposed Water Rule text
Water Treatment †	Any process that improves the quality (safety) of the water to make it more acceptable for a specific end-use.
Water-Direct Application	Using agricultural water in a manner whereby the water is intended to, or is likely to, contact produce (including leafy greens) or food-contact surfaces during use of the water.
Water-Potable	Water that is safe to drink or to use for food preparation without risk of health issues; municipal water supply systems must meet strict standards for portable water supplies.
Weaning	The practice of separating calves from their source of milk. Weaning calves reduces the nutrient requirements of the cow. It will allow the cow to transfer nutrients previously going to milk production to her own body function, improving her own condition and preparing for the next calving.

† California LGMA Commodity Specific Food Safety Guidelines for the Production and Harvest of Lettuce and Leafy Greens, Glossary (version 02 August, 2021)

Appendix 3: Glossary of Terms to Foster Neighbor-to-Neighbor Conversations

Terms in this portion of the Glossary reflect words that are important for neighbors to understand each other in the context of the operations on neighboring land. This understanding of terms in common usage for an industry or agricultural sector is essential to effective communication.

These terms, and those captured within Appendix 2, will continue to serve as helpful references as neighbor-to-neighbor Discussion Templates **(Action 1: Fostering Communication Among Neighbors)** are developed in the 2022 ongoing work of CAN.

Ancillary Equipment †	Temporary storage equipment for fertilizers such as third-party storage tanks, pony tanks, etc.
Animal By-Product †	Parts of an animal including organ meat, nervous tissue, cartilage, bone, blood, feathers, and excrement. This also include worm castings, guano, and other animal-based products and excrements.
Antimicrobial Water Treatment †	A physical, energetic, or chemical agent, applied alone, in combination, or as a sequential process, to achieve and maintain a defined microbiological water quality standard.
AUD	Animal Unit Days.
AUM	Animal Unit Months.
Available Forage	Forage produced less the amount of residual dry matter (RDM) desired. There is no baseline developed on RDM; RDM should be measured for an entire pasture.
Biosolids †	Solid, semisolid, or liquid residues generated during primary, secondary, or advanced treatment of domestic sanitary sewage through one or more controlled processes. *CAN note: the LGMA definition goes on to define Class A and Class B biosolids.*
Blue Valves (Water) †	Pipes which are used as a closed conveyance system for moving agricultural surface water from water source to irrigation systems or reservoirs for agricultural use.
Browsing	Similar to grazing.
Closed Delivery System (Water) †	A water storage or conveyance system which is fully enclosed and protected such that water is not exposed to the environment from the water source to the point of use.
Fecal Coliforms †	Coliform bacteria that grow at elevated temperatures and may or may not be of fecal origin. Useful to monitor effectiveness of composting processes. Also called "thermotolerant coliforms."

† California LGMA Commodity Specific Food Safety Guidelines for the Production and Harvest of Lettuce and Leafy Greens, Glossary (version 02 August, 2021)

Flooding †	The flowing or overflowing of a field with water outside a grower's control that is reasonably likely to contain microorganisms of significant public health concern and is reasonably likely to cause adulteration of edible portions of fresh produce in that field.
Ground Water †	The supply of fresh water found beneath the earth's surface, usually in aquifers, which supply wells and springs. Ground water does not include any water that meets the definition of surface water.
Parts per Million †	Usually describes the concentration of something in water or soil; one particle of a given substance for every 999,999 other particles.
Parts per Billion	Describes concentration of substances in water or soil; one particle of a given substance for every 999,999,999 other particles (PPB).
Process Authority †	A regulatory body, person, or organization that has specific responsibility and knowledge regarding a particular process or method; these authorities publish standards, metrics, or guidance for these processes and/or methods.
RDM	Residual Dry Matter; mulch or the dead plants above the soil surface, beneficial to controlling erosion and has a direct effect of composition of range plants.
Sediment †	Undissolved organic and inorganic material transported or deposited by water.
Surface Water †	Water either stored or conveyed on the surface and open to the environment (e.g., rivers, lakes, streams, reservoirs, etc.). *CAN note: The FDA version of this definition goes on to say that surface water does not include any water that meets the definition of ground water.*
Water, Agricultural	Agricultural water, abridged from the United States Food and Drug Administration definition, is water … (that) is intended to, or is likely to, contact covered produce or food contact surfaces, including water used in growing activities (including … water used for preparing crop sprays …) and in harvesting, packing, and holding activities (including water used for washing or cooling harvested produce and water used for preventing dehydration of covered produce).
Water Treatment System	An add-on to agricultural water system that improves the quality and safety of the water to make it more acceptable for a specific end use. The water treatment system may treat multiple farm fields, water sources or batches of water as defined by the water system definition.
Wildlife Control	Wildlife control rules are set by the California State Fish and Game Commission. As such, ranchers and livestock operations must adhere to those rules of which the process of tags and depredation requires time and is costly. The method of control is up to the individual landowner.

† California LGMA Commodity Specific Food Safety Guidelines for the Production and Harvest of Lettuce and Leafy Greens, Glossary (version 02 August, 2021)