Cover Page

CONSERVATION INNOVATION GRANTS

Final Report

Wild Farm Alliance

Title: Co-managing for Food Safety and Conservation Objectives in Specialty Crops: Preparing NRCS Conservationists and Technical Service Providers to Address New Challenges

Project Manager: Jo Ann Baumgartner

Timeframe Covered by the Report: October 1, 2010 – September 15, 2014

Agreement Number: #69-3A75-10-177

Date of Submission: December 12, 2014

Grant Agreement Deliverables Identified and Met

1. Conducted 145 grower surveys and interviews, and 24 farm visits including some with Spanish speakers, in CA, FL, and NY.
2. Referenced about 300 journal articles, university, and government publications in the *Co-managing for Food Safety and Conservation Objectives in Specialty Crops* technical note. Many of these addressed the role and risk of domestic and wild animals, and wildlife habitat in fresh produce growing regions.
3. The above-mentioned references also addressed the role of environmental factors influencing pathogen reduction in water, air and soil, and how conservation practices influence pathogen survival.
4. Created three conservation effects tables in the Technical Note (Tables 18, 20 and 22) that describe how conservation practices influence pathogen reduction in water, soil and air.
5. Produce a 96-page Technical Note with 7 figures, 22 tables, 20 photos, and one color illustration.
6. Evaluated food safety and conservation co-management educational needs, and developed and presented one webinar through NRCS, and presentations at two forums, two workshops and one meeting.
7. Rather than conduct separate TSP trainings, determined with NRCS input that the above outreach would serve their needs.
8. Created information in the form of frequently asked questions for a NRCS webpage and attached that to the technical note.
9. Attended the Soil Water Conservation Conference in Reno in July of 2013.
10. Submitted seven semi-annual progress reports and this final report.

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Executive Summary

NRCS Designated Priorities & Proposed Goals and Objectives
The designated priorities for this grant were natural resource concerns related to food safety in specialty crops. The project goal was to strengthen the capacity of NRCS, Technical Service Providers (TSPs), and specialty crop growers in addressing food safety and conservation co-management challenges. The objectives include producing a technical note on the co-management of food safety and conservation, developing and giving trainings for NRCS, Technical Service Providers (TSPs) and growers, and compiling a set of frequently asked questions for NRCS' website.

Accomplishments That Met the Goals and Objectives
Wild Farm Alliance (WFA) collaborated with farm organizations and their members, technical advisory committee members, consultants and NRCS staff to provide advice on how to best address emerging food safety issues in specialty crop production. This was done in part through grower surveys, interviews and farm visits coupled with an extensive literature review in order to create a technical note (including a set of frequently asked questions) on the co-management of food safety and conservation for specialty crops. This was also accomplished through the development of a webinar and several farm conference and meeting presentations. With NRCS input, a separate training for TSPs was determined not to be necessary.

Project Timeline
The project was planned to only take three years, but a no-cost extension was granted for a fourth year. This was required because NRCS hired Wild Farm Alliance's contractor Karen Lowell of L and L Consulting, who was co-writing the project's technical note, and that slowed the project down until we were able to reallocate our time to cover what she had not finished.

Beneficiaries of this Grant
NRCS personnel, TSPs and specialty crop growers benefit directly from this grant.

How Project Funds Were Spent
Project funds were spent as anticipated and no transfer among categories exceeded 10% except for one situation that was pre-approved by NRCS. The Personnel category had unspent funds from L and L Consulting in the Contractor category re-directed to it.

Methods Employed to Demonstrate Alternative Technology
Not applicable.

What Were the Quantifiable Physical Results from this Project?
The quantifiable physical results of this project include the technical note with the frequently asked questions that was created (Appendix 1), the webinar that given and continues to be posted on NRCS' website (Appendix 2), the notes on the technical advisory committee calls (Appendix 5), and the grower surveys and interviews that were conducted and the notes on the farm visits that were made (Appendix 6).

What Were the Economic Results of this Project?
This project will help specialty crop growers continue to benefits from the economic value of conservation practices while co-managing for food safety. Conservation practices such as those that support pollinators, beneficial insects and birds help to reduce pollination and pest control costs. Specialty crop growers in some states such as in California will continue to be able to meet water quality requirements with the use conservation practices, thereby avoiding fines for water pollution. Organic specialty crop growers will be able to continue to receive a premium since they will be able to comply with the requirements to conserve biodiversity and to maintain or improve their soil, water, wetlands, woodlands, and wildlife. Specialty crop growers in other eco-label programs, such as Salmon Safe and Fish Friendly Farming, will be able to continue to comply with those requirements as well.

Federal, State and Local Programs That May Be Used to Implement this Project
The following programs may benefit from and help to spread the information contained in the technical note and webinar: FDA's Food Safety Modernization Act program, USDA's Good Agricultural Practices (GAPs) and Harmonized GAPs programs, Produce Safety Alliance's Program (led by Cornell University, USDA and FDA), and many State food safety programs.

Major Findings
In order to best manage pathogens of the farm, the sources and transport of pathogens, and the biotic and abiotic factors that influence them must be understood. Conservation practices that address soil, particulate matter, water, and animal management can then be used to influence pathogen reduction. Using these conservation practices with GAPs in a multiple barrier approach can help to prevents pathogens from entering the farm, contaminating the crop, spreading from livestock operations to the crop, and moving out to the wider landscape.

NRCS staff can best work with specialty crop growers by collaboratively taking these steps:
Grower:
1. Strategically selects crop and field location.
2. Monitors for wild and domestic animals in crop field.

Conservationist assists grower in developing a plan for:
3. Reducing pathogens through water management.
4. Decreasing fugitive dust with pathogens through particulate matter management.
5. Diminishing pathogens through soil and manure management.
6. Lessening contamination through animal management.

Grower:
7. Determines what other GAPs are required, such as further controlling wildlife and domestic animals, a waiting between manure applications and next harvest, and water testing.
8. Develops a food safety plan that incorporates co-management of food safety and conservation practices and actions.

Conclusion
This project helps NRCS, TSPs and specialty crop growers have an understanding about the source, fate, and transport of food-borne pathogens and offers a systematic way for conservation practices to be used with GAPs check for addressing possible on-farm food safety concerns.

Introduction

Key Personnel and a Description of Their Qualifications

The key personnel of this project are Jo Ann Baumgartner of Wild Farm Alliance, Karen Lowell of L & L Consulting (before she was hired by NRCS), and Meaghan Donavan of WFA. Jo Ann has an M.S. in Environmental Studies, San Jose State University, and a B.S. in Soil and Water Science, University of California, Davis (1979). She has worked in agriculture since 1980: on a research farm, her own organic farm, and for nonprofit sustainable agriculture organizations.

Karen has a Ph.D. in Soil, Crop and Atmospheric Sciences, Cornell University, an M.S. in Agronomy, University of Maryland, and a B.A./B.S. in English/Psychology. She was the lead author of *Safe and Sustainable: Co-Managing for Food Safety and Ecological Health in California's Central Coast Region.*

Meaghan has a M.S. in Agriculture, Food and Environment, Tufts University, and a B.S. in Plant Science, Cornell University. She has worked on agricultural research projects in North and South America and has experience in agricultural policy at both the state and federal level.

What was the Project About?

The project focused on preparing NRCS Conservationists, Technical Service Providers and specialty crop growers to address emerging food safety and conservation co-management challenges.

Location of the Project

The project was focused on understanding food safety and conservation co-management challenges in three major specialty crop producing states—California, New York and Florida.

When Did the Project Occur?

The project began in October 2010 and ended mid September 2014.

How Was the Project Conducted?

WFA staff and contractors worked with farm groups to gain knowledge from their grower members, and with the Technical Advisory Committee to ensure a high quality, professional technical note was created and that similar trainings were given.

Project Goal and Objectives

Goal: The project goal was to strengthen the capacity of NRCS, Technical Service Providers (TSPs), and specialty crop growers in addressing food safety and conservation co-management challenges.

Objectives

- Producing a technical note to inform NRCS Conservationists about the types of food safety-driven management strategies that may adversely impact conservation objectives, and to advise NRCS Conservationists and TSPs as they work with growers implementing and maintaining conservation practices which may intersect with food safety.

- Evaluating food safety and conservation co-management educational needs of NRCS and growers, developing appropriate training materials, and conducting trainings with NRCS field staff and growers in California, New York and Florida.
- Determining which TSPs would benefit from increased food safety knowledge, and educating those TSPs in California, New York and Florida through trainings on co-management.
- Making co-management presentations at farm conferences, workshops and field days in the West, Northeast and Southeast.
- Compiling information for a NRCS webpage that answers frequently asked questions on the co-management of food safety and conservation.

Scope of Project Tasks

- Collect and review current and emerging data regarding food safety risk factors, with particular focus on domestic and wild animals, and wildlife habitat in fresh produce growing regions.
- Review research that explores how management of conservation practices may influence factors relevant for food safety.
- Hold Technical Advisory Committee conference calls to go over the project and receive input.
- Identify a) existing or potential food safety concerns related to conservation practice standards, and b) successful co-management and/or areas of conflict between food safety and conservation by:
    - Conducting surveys and interviews with growers in CA, NY, and FL.
    - Visiting farms in CA, NY, and FL.
- Incorporate information gained from farm visits, meetings and calls into draft technical note.
- Identify appropriate parameters to include food safety considerations in a Conservation Effects Table for NRCS Practice Standards.
- Produce final content for a technical note addressing the co-management of food safety and conservation and submit to NRCS.
- Evaluate food safety and co-management educational needs of NRCS field staff, TSPs and growers, and develop training materials.
- Make PowerPoint presentations at agricultural conferences and meetings in CA and FL.
- Present a webinar to NRCS staff, Technical Service Providers, and growers.
- Develop set of frequently asked questions and answers to be included in the technical note, and possibly used on NRCS national website.
- Submit seven semi-annual progress reports and a final report.

Business or Academic Relationships that Facilitated the Project

Farm groups and their members, technical advisors, and WFA's Board gave input that facilitated the development of this project. The farm groups helped with grower surveys and interviews, farm visits and reviews of the technical note. The Technical Advisory Committee (TAC) helped guide background literature research and content of the technical note through discussions held during four conference calls, and the WFA Board helped with overall guidance.

Substantial contribution was given by Trevor Suslow at University of California, Davis, William Boyd then of NRCS, and William Reck of NRCS. Others who gave input include: Andrew Gordus of California Department of Fish and Wildlife; Becky Weed of Thirteen Mile Lamb and Wool Company; Cathy Carlson then of Community Alliance with Family Farmers (CAFF); Dave Runsten of CAFF; Conrad Vispo of Farmscape Ecology Program, Hawthorne Valley; Dana Jackson then of Land Stewardship Project; Elizabeth Bihn of Cornell University; John Anderson of Hedgerow Farms; Jose Perez then of Florida Organic Growers (FOG); Travis Mitchell of FOG; Nathan Harkleroad and Kaley Grimland of Agriculture and Land-Based Training Association; Kate Mendenhall then of Northeast Organic Farming Association of New York, Inc.; Paul Robins of Resource Conservation District of Monterey County; Steve Warshauer of Beneficial Farm and liason for National Sustainable Agriculture Coalition; Vance Russell of National Forest Foundation. Additional assistance on the grower surveys and farm visits was given by Dan Botts of Florida Fruit and Vegetable Association, and Jeff Kubecka of New York State Fruit and Vegetable Association. In-kind match time from the above people, totals $58,601.

How the Project was Funded

NRCS provided a little less than half the funding of the project for a total of $137,510. The rest came from matching funds totaling $141,717. In-kind match made by farm groups and their growers, technical advisors, WFA Board and Karen Lowell totaled $58,601, as mentioned above. While this is less than the amount listed in our proposal, the cash match overcompensated for the in-kind shortfall. Cash match funds of $83,116 came from the following foundations and businesses: Cliff Bar Foundation $1,137, Columbia Foundation $16,397, Eddy Foundation $982, Imhoff Family Fund $15,000, Newman’s Own Foundation $21,180, Organic Farming Research Foundation $11,419, True North Foundation $10,000, United Natural Foods Foundation $2,000 and Veritable Vegetable $5,000. See Appendix 3 for the total income and expenses of the project and Appendix 4 for a breakdown of In-Kind match contributions.

Background

After the *E. coli* 0157:H7 spinach contamination of 2006 where five people died and many were hospitalized, specialty crop growers in California’s Central Coast region were caught between a rock and a hard place. In grower surveys conducted by the Resource Conservation District (RCD) of Monterey County in 2007[i] and again in 2009,[ii] growers reported pressure to reduce and/or eliminate wildlife either directly by hunting, fencing, poisoning or trapping, or indirectly by removing non-crop vegetation and water-bodies. Lowell et al (2010)[iii] found that many growers in this region reported they risked being unable to sell their crop if they did not comply with food safety requirements, which often directly conflicted with conservation practices.

While food safety illness has been traced to crops before, such as the Odwalla apple juice incident, [iv] there had never before been such extensive misguided perceptions of buyers that the removal of wildlife and their habitat could make food safer. In order to bring a better understanding of the issue, NRCS published *Reducing Risk of* E. coli *O157:H7 Contamination* in 2007 and *Food Safety* – E. coli *O157:H7* in 2008. That same year, Wild Farm Alliance published the policy paper *Food Safety Requires a Healthy Environment*, and in the following year the RCD published *Food Safety Considerations for Conservation Planners: A Field Guide for Practitioners*[v]. These along with the 2010 report by Lowell et al. gave this project a foundation from which to build on, but by themselves were not enough to help NRCS comprehensively address food safety and conservation objectives in specialty crops.

During this time, Congress passed the Food Safety Modernization Act requiring FDA to propose rules that establish science-based minimum standards for the safe production and harvesting of fruits and vegetables. FDA has since published proposed rules in 2013, and re-proposed rules in 2014. The final rules are expected in 2015. Since the rules address wild animals, manure and compost, they are relevant to the co-management of food safety and conservation.

Review of Methods

Physical Activities of the Project

The major components of the project are as follows:

- 145 grower surveys and interviews were conducted with the help of our agricultural partners in California (CA), New York (NY) and Florida (FL). The NY and FL data was collected in the first year of the project, where as the CA data was collected in the first three years. Partners included: Agriculture Land Based Association (ALBA), Community Alliance for Family Farmers (CAFF), Florida Organic Growers, Florida Fruit and Vegetable Association, Northeast Organic Farming Association, and New York State Vegetable Growers Association.
- 24 farm visits were conducted, including meetings with Spanish speaking growers, in California, Florida and New York. The NY and FL visits were conducted in 2011, and the CA visits were conducted from 2011-2013.We learned about the types of conservation practices used on their farms and the co-management challenges these practices sometimes posed in their regions with their crops and production systems.
- 4 Technical Advisory Committee conference calls were held to help assess and refine the direction of the project. These occurred in Sept. 2011, Mar. 2012, Jun. 2012, and May 2013.
- About 500 journal articles and government publications on current and emerging data that addresses the risk presented by domestic and wild animals, environmental factors that influence pathogen reduction in water, air and soil, and beneficial conservation practices used in fresh produce growing regions were collected and reviewed. These papers were amassed throughout the 4 years of the project. About 300 of these references were used in the final technical note.
- Using the above information, three conservation effects tables in the technical note (Tables 18, 20 and 22) were created that describe how conservation practices influence pathogen reduction in water, soil and air.
- The grower insights and the literature review were digested and compiled into the 96-page technical note with 7 figures, 22 tables, 20 photos, and one color illustration.
- The *On-Farm Food Safety and Conservation* Webinar was given on May 14, 2014 (see http://www.conservationwebinars.net/webinars/on-farm-food-safety-and-conservation). This

webinar was part of the Understanding Organic and Sustainable Agriculture Webinars series organized by USDA NRCS – East and West National Technology Support Centers and Oregon Tilth. According to NRCS' analyses, the number of participants during live webinar were 124, the number of participants that viewed the archived webinar were 86, and the total number of participants were 210. Of those, 95 received continuing education credits.

- 5 presentations shared information from this project between 2011-2014. These were given at the USDA Outlook Forum, Farm Food Safety Conservation Network Forum, two Ecological Farming Conference workshops, and an Agronomy Society of America Meeting. Besides making this project better known, many attendees gave useful input: USDA personnel underscored the need for pro-active co-management information, growers shared unique ways in which they deal with food safety and conservation situations, and scientists discussed their related research.
- In lieu of posting a set of Frequently Asked Questions on the NRCS website, these were included in an appendix of the Technical note.

Innovative Project

Through a grower survey and farm visits, conservation practices widely used by specialty crop growers were identified, and existing or potential food safety concerns related to these practices, as well as grower strategies to address concerns, were noted. This information, coupled with an extensive literature review and analysis, helped with the development of an innovative approach for addressing how conservation plans can interface with food safety Good Agricultural Practices (GAPs) in a multiple barrier approach.

Comparison of Innovative Part of Practices to Existing Practices

Currently, implementation of food safety Good Agricultural Practices rarely results in incorporating conservation practices that help to reduce food borne pathogens, or in mitigating conservation concerns. This project benefits farm food safety goals and conservation goals. Farms are safer when conservation practices help to reduce human pathogens in soil, water, air, and in animals. Impacts to natural resources are reduced when conservation practices are used to mitigate potentially harmful food safety practices.

Marketing An Alternative Product

Not applicable

What The Producer Had to Do Differently to Accommodate the Project

Not applicable

Location

Surveys, interviews and farm visits occurred in Florida, New York and California.

What Worked and What Didn't

The methodology of learning from most growers first and then reviewing the literature before writing the technical note worked well. While it wasn't planned, it was helpful to interact with some of the California growers who were surveyed and visited with later in the project because their input helped to refine our thinking.

Matching funds helped to create the technical note's illustration in 2013, which was also used in a Wild Farm Alliance/Community Alliance with Family Farmer publication. The process of working with NRCS to make that illustration technically correct during the middle of the project helped us to better understand NRCS' needs and to focus on how best to present the information.

What Would Be Done Differently in This Project If It Were to Start Over Today?

Ideally, we would not have requested a no-cost extension because we would not of had a personnel change caused by NRCS hiring one of the co-authors.

Discussion of Quality Assurance

Many wildlife pathogen prevalence papers initially reviewed were not used. The selection process was based on if the animals were in the United States; the number of animals sampled was at least 25; the samples were taken from the animal itself, not off the ground; the animals did not die of a disease; and the animals were not farm-raised or in a zoo. These parameters were chosen because:

- Most wildlife prevalence studies from other countries were about species that don't occur in the US.
- Prevalence data show percent of samples in which the target pathogen was found. Many studies have small sample sizes, and caution must be used when inferring risk from these small sample size prevalence rates; both 1/10 and 100/1000 positive test results will yield a prevalence rate of 10%, but the latter may provide more insight into environmental load of the pathogen and risk from the animal in question.
- Unless samples are collected directly from the animal, it is not clear whether each fecal sample reflects an individual or one of multiple samples from a single individual.
- Samples collected from an animal's gut, mouth, skin, and blood are more reliable than feces collected from the ground, where they may have been contaminated by other animal, wind, or water pathways.
- Animals dying of a disease have compromised immune systems that allow secondary infections (including human pathogens) to invade that may otherwise be under control in healthy animals.
- Wild animals that are farm-raised or in a zoo may be kept in less than ideal conditions that support their health.

Findings

The major findings in the *Co-Managing Food Safety and Conservation Objectives in Specialty*

Crops project are detailed below, and further explained in the Technical Note:

Food-borne Illnesses Attributed to the Farm are Not as Great as Thought

- The overwhelming majority of food-borne illnesses do not originate on the farm, but rather from any one of many sources or points along the supply-chain from farm to food preparation.

Pathogen Transport

- Pathogen routes to the farm include air, water, wild and domestic animals and humans.

There Are Only a Few Outbreaks Tied Directly to Water and Wildlife

- Only a few produce outbreaks have been traced back to irrigation water or wild animals as the confirmed source of pathogen contamination.

Wild Animals Have a Low Relative Prevalence of Human Pathogens

- Native wildlife has so far been found to have a low relative prevalence of carrying human pathogens. Even though the widespread risk appears low, pathogen prevalence in localized wildlife populations remains a concern.

Feral Pigs Have a Higher Level of Pathogens than Native Wildlife

- Current research suggests that non-native feral pig populations may have higher prevalence of many food-borne pathogens than populations of native wildlife.

Livestock Can Be a Source of Contamination

- Livestock can carry food-borne pathogens, sometimes at very high levels, and they can infect wildlife.

There are Biotic and Abiotic Factors that Influence Pathogen Reduction

- The major biotic factors that influence pathogen reduction include: sunlight/UV exposure, predation/competition/antagonistic microbial interactions, and harborage by biofilms, amoebas and algae.
- The major abiotic factors that influence pathogen reduction include: salinity, pH, nutrient sources, temperature, moisture and microscopic niches.

Pathogen Persistence in Soils is All Over the Board

- There is a broad range of pathogen persistence in soils from 7 days to 21 months.

The Following Conservation Practices Can Influence Pathogen Reduction:

<u>Water Management Practices</u>

- *Wetlands* [Constructed (656), Created Wetlands (658), Enhanced Wetlands (659), Restored Wetlands (657)].
- *Vegetative Buffers* [Field Borders (386), Filter Strips (393), Critical Area Plantings (342), Grassed Waterways (412), Vegetative Barriers (601), Tree and Shrub Establishments (612), Conservation Cover (327), Riparian Forest Buffer (391), and Riparian Herbaceous Buffer (390)].
- *Water Movement and Storage Practices* [Irrigation Water Management (449), Diversion (362), Waste Storage Facility (313), and Sediment Basin (350)].

<u>Particulate Matter Management</u>

- *Dust Mitigation Practices* [Air Filtration and Scrubbing (375) and Dust Control for Animals (371)].
- *Vegetation That Intercepts Fugitive Dust* [Windbreaks (380), Hedgerows (422), and Riparian Forest Buffers (391)].

Soil Management Practices

- *Manure Soil Management Practices* [Nutrient Management (590) and Composting Facility (317)].
- *Vegetative Soil Building Practices* [Cover Crops (340) and Conservation Crop Rotation (328)].

Animal Management Practices

- Integrated Pest Management (595).
- Wildlife Corridors.
- Prescribed Grazing (528).

The Multiple Barrier Approach Can Help to Comprehensively Reduce Pathogens on the Farm

- Conservation practice standards and Good Agricultural Practices (GAPs) can be used in a multiple-barrier approach to reduce the number of pathogens transported in and around the farm environment. This approach prevents pathogens from:
    - (a) entering the farm,
    - (b) contaminating the crop,
    - (c) spreading from livestock operations to the crop, and
    - (d) moving out to the wider landscape where they may lead to contamination.

How Conservationists Can Convert Co-management Knowledge to Action

- Conservation planners can assist growers by providing them with records of conservation practices that they helped plan or install. These records are documentation of expert conservation actions and do not constitute recommendations for food safety compliance by NRCS. Records can be kept with their food safety plans to show to their produce buyers, who in turn specify the acceptable audit scheme.
- The fundamental Co-Management steps to be taken by growers and conservationists for specialty crops includes:

Grower:

1. Strategically selects crop and field location.
2. Monitors for wild and domestic animals in crop field.

Conservationist assists grower in developing a plan for:

3. Reducing pathogens through water management.
4. Decreasing fugitive dust with pathogens through particulate matter management.
5. Diminishing pathogens through soil and manure management.
6. Lessening contamination through animal management.

Grower:

7. Determines what other GAPs are required, such as further controlling wildlife and domestic animals, a waiting between manure applications and next harvest, and water testing.
8. Develops a food safety plan that incorporates co-management of food safety and conservation practices and actions.

The above findings did support the goal of the project to strengthen the capacity of NRCS, Technical Service Providers (TSPs), and specialty crop growers in addressing food safety and conservation co-management challenges.

Conclusions and Recommendations

This project provides an understanding of the source, fate, and transport of food-borne pathogens and offers a systematic way for conservation practices to be used with GAPs for addressing possible on-farm food safety concerns. It will help specialty crop growers and conservationists better work together to reduce food borne pathogens on the farm and protect natural resources. NRCS conservationists knowledgeable about basic food safety issues will be in demand by growers as food safety requirements become more prevalent across the country.

Research Needs

Below are suggested research studies that would help to better understand factors that influence co-management:

- Determine the optimum composition of grasses for grassed waterways that best filter pathogens without needing to be mowed often.
- Study the fate of pathogens trapped in windbreak foliage.
- To better understand soil pathogen persistence, conduct studies in soils that have had many years of cover crops, and of compost applied to them; test some that were managed organically without chemical fertilizers and fumigants, and some with them.
- Compare the fate of pathogens in soil when manure is applied to them from grazing animals versus from those that are in concentrated animal feeding operations.

Identify Next Steps in Bringing this Information to the Field

On the federal level, it would be helpful for NRCS Headquarters to encourage their staff who work with specialty crop growers to review this technical note and watch the webinar. The agency would benefit from continuing to engage with the Produce Safety Alliance to make sure that the co-management of food safety and conservation is actively addressed, and to ask them to help spread this information. NRCS may want to encourage the USDA GAPs and Harmonized GAPs programs to allow their food safety auditors to receive continuing education credits for watching the webinar or reading the technical note. Additionally, NRCS may want to assist FDA in identifying a research agenda for better understanding pathogen persistence in soils amended with manure, and be involved with the conclusions they draw from that research.

On the State level, NRCS may want to share the technical note and webinar with agencies and marketing organizations that address food safety, such as State Health Department staff that work in agriculture, State Cooperative Extension Agents who work in food safety, and marketing mechanisms like the California and Arizona Leafy Green Marketing Agreements, the California Cantaloupe Program, the California Almond Board, and the Florida Tomato Committee.

Appendices

Appendix 1. *Co-Managing Food Safety and Conservation Objectives in Specialty Crops* Technical Note

Appendix 2. *On-Farm Food Safety and Conservation* Webinar

Appendix 3. Final Budget

Appendix 4. Breakdown of In-Kind and Cash Match

Appendix 5. Technical Advisory Committee Call Notes

Appendix 6. Summary of Farm Visits, Phone Surveys and Interviews

Appendix 7. Raw Survey Data of Florida Growers

Appendix 8. Raw Survey Data of New York Growers

Appendix 9. Raw Survey Data of California Growers

Appendix 10. Raw Data for Figures 4-7 in Tech Note

Appendix 11. List of Technical Note Photos, Citations and Captions

Technology Review Criteria

NA

References

[i] Resource Conservation District. 2007. A Grower Survey: Reconciling Food Safety and Environmental Protection. Salinas, CA: Resource Conservation District of Monterey County.

[ii] Resource Conservation District. 2009. Challenges to Co-Management for Food Safety and Environmental Protection: A Grower Survey. Salinas, CA: Resource Conservation District of Monterey County.

[iii] Lowell, K., J. Langholz, and D. Stuart. 2010. Safe and Sustainable: Co-Managing for Food Safety and Ecological Health in California's Central Coast Region. San Francisco, CA and Washington, D.C: The Nature Conservancy of California and the Georgetown University Produce Safety Project. http://www.producesafetyproject.org/admin/assets/files/wildlife.pdf

[iv] Whitmore, Arthur and Lawrence Bachorik. "E. Coli 0157:H7 outbreak associated with Odwalla brand apple juice products" (Press release). U.S. Department of Health and Human Services. 1996-10-31.

[v] Resource Conservation District of Monterey County. 2009. Food Safety Considerations for Conservation Planners: A Field Guide for Practitioners. Resource Conservation District of Monterey County, Salinas, CA. July 2009.

Appendix 1

Co-Managing Food Safety and Conservation Objectives in Specialty Crops

USDA NRCS Technical Note # xx

WILD FARM ALLIANCE

USDA
Logo

NRCS
Logo

Acknowledgments

This technical note was funded in part by the U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS). Support also came from: Cliff Bar, Columbia Foundation, Gaia Fund, Newman's Own Foundation, Organic Farming Research Foundation, Tompkins Imhoff Family Fund, True North Foundation, and United Natural Foods Foundation and Veritable Vegetable. It was produced by the Wild Farm Alliance (WFA) and written by Jo Ann Baumgartner of WFA, Karen Lowell then of L & L Consulting and now with NRCS, and Meaghan Donavan of WFA. Substantial input was given from Trevor Suslow at University of California, Davis, William Boyd then of NRCS, and William Reck of NRCS.

Others who gave input to parts of this publication include: Andrew Gordus of California Department of Fish and Wildlife; Becky Weed of Thirteen Mile Lamb and Wool Company; Cathy Carlson then of Community Alliance with Family Farmers (CAFF); Conrad Vispo of Farmscape Ecology Program, Hawthorne Valley; Dana Jackson then of Land Stewardship Project; Dan Imhoff of Watershed Media; Dave Runsten of CAFF; Elizabeth Bihn of Cornell University; John Anderson of Hedgerow Farms; Jose Perez then of Florida Organic Growers (FOG); Kaley Grimland of Agriculture and Land-Based Training Association (ALBA); Kate Mendenhall then of Northeast Organic Farming Association of New York, Inc.; Michele Jay-Russell of UC Davis; Nancy Flores of New Mexico State University; Nathan Harkleroad of ALBA; Paul Robins of Resource Conservation District of Monterey County; Rachael Long of Yolo County University of California Cooperative Extension; Steve Warshauer of Beneficial Farm and liason for National Sustainable Agriculture Coalition; Travis Mitchell of FOG; Vance Russell of National Forest Foundation; and Luana Kiger of NRCS.

Cover photos: Filter strip, S. Earnshaw; compost application, J. Redmond; European starlings with cows, APHIS; Campylobacter, CDC; clear water, NRCS; feral piglets, V. Dinets, University of Miami, Bugwood.org.

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1: Introduction to Co-Managing Food Safety and Conservation

1.1 Introduction

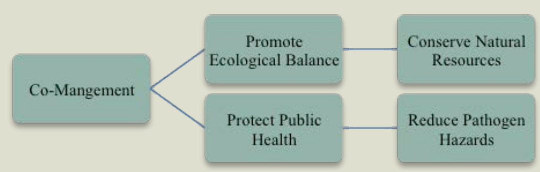
Building evidence over the past two decades and recent food-borne illness outbreaks have significantly influenced growers' production management and, as an unintended consequence, their conservation decisions in many of the specialty crop growing regions of the United States. On-farm food safety requirements by private industry or the government may be perceived as in conflict with conservation practices; too often the actions taken make this a reality. Consequently, agricultural food safety requirements, or independent actions taken to ensure compliance and continued market access, affect the work of conservation planners. As these requirements increase across the country, most conservation professionals will have to understand and address food safety issues to work toward implementing integrated solutions and removing obstacles.

J.A. Baumgartner

Conservation practices, like this vegetative buffer, can help reduce the movement of pathogens to specialty crop fields, but some produce buyers view these plantings as a food safety threat because they may attract wildlife.

This technical note helps conservation planners who work with specialty crop growers to co-manage food safety and conservation (see Figure 1) by understanding food safety risks in the growing environment, and by learning details of how specific management practices may reduce or increase food safety risk. Many of the vegetative conservation practices implemented by NRCS, such as filter strips, riparian forest buffers, windbreaks and wetlands, will likely help to reduce the risk of specialty crop contamination by pathogens that cause human illness, though limited specific data is available at this time. Non-vegetative practices used to control soil erosion, decrease runoff, and manage animal wastes also aid in lessening the movement of human food-borne pathogens across the landscape, thus reducing the risk of crop contamination. The *Healthy, Diverse Ecosystems Help Keep Pathogens in Check* illustration (Figure 2) provides a summary of these conservation practices and food safety Good Agricultural Practices (GAPs). GAPs help to identify and remedy potentially overlooked well-recognized areas of concern, such as creating a "no-harvest-zone" around feces in the crop field, not growing leafy green vegetables immediately adjacent to manure or compost piles, and not planting under bird roosts. While no on-farm practice (conservation related or otherwise) provides complete and conclusive protection against food-borne pathogens, implementation of NRCS conservation practices, with judicious monitoring, can support a farm's food safety management plan.

Figure 1 *Co-Management of Food Safety and Conservation*

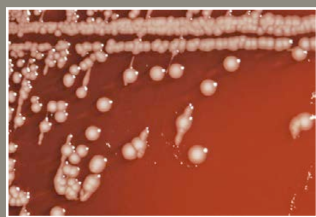


"'Co-Management' means farm system management approaches that respond to site-specific conditions by integrating cultural, biological, and mechanical practices that promote ecological balance and public health by conserving biodiversity, soil, water, air, energy and other natural resources, while also reducing pathogen hazards associated with food production." (National Sustainable Agriculture Coalition)

1.2 Food-Borne Illness Attributed to Produce and the Farm

By the time produce reaches the table in the United States, it may have encountered contamination from any one of many sources along the supply-chain from farm to food preparation. From 1998 to 2008, approximately 46% of the illnesses documented by the Center for Disease Control (CDC) were attributed to produce. Contamination could have come from the farm, processing, storage, or shipping. It could also have come from handling by a store, or poor preparation in a restaurant or home.

Center for Disease Control (CDC) Facts



CDC

From 1998 to 2008, about 46% of the illnesses documented by the CDC were attributed to produce. (Painter et al. 2013)

Of the food-borne outbreaks with identified causes that might come from the farm:

- *5% was reported between 1998 and 2008.* (CDC 2013 (a))
- *0.5% in 2009 and 2010.* (CDC 2013 (b))
- *1.3% in 2011.* (CDC 2014 (a))
- *0.1% in 2012.* (CDC 2014 (b))

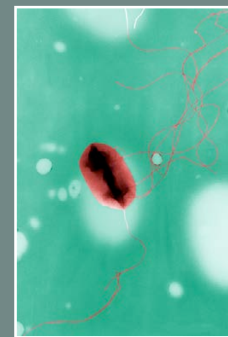
To understand how much food-borne disease may originate on the farm, it is helpful to look at the causes by which CDC tracks illnesses and outbreaks—defined as an occurrence of two or more illnesses in a population. CDC has only been able to identify approximately 40% of all the causes. Of disease outbreaks data with identified causes between 1998 and 2008, 5% might have come from the farm. CDC tracked farm causes using the category “Raw product/ingredient contaminated by pathogens from animal or environment (*e.g.,* Salmonella enteritidis *in egg, Norwalk* (Norovirus) *virus in shellfish,* E. coli *in sprouts*).” In the following four years, the percentage attributable to the farm decreased. Of the food-borne disease outbreaks with identified causes between 2009 and 2010, 0.5% might have come from the farm; in 2011, 1.3%, and in 2012, 0.12%. CDC’s category for farm causes changed to: “Foods originating from sources shown to be contaminated or polluted (such as *a growing field or harvest area*).” As indicated, the data are not sufficiently granular to differentiate between specialty crops and other farm products, such as eggs or meat, and 60% of the causes are not identified. While the percentage attributable to the farm could rise if the reporting mechanism for outbreaks becomes more refined in the future, this does give an indication that many of the outbreaks are coming from non-farm causes.

Agricultural crops eaten without a kill step, such as cooking, are associated with a higher risk of illness than those that require cooking, acidification, or other actions expected to reduce pathogen populations. Some types of produce harbor more optimal surface sites for pathogens to persist or avoid wash-disinfection, such as netted melons with rind crevices or the water-congested stem-scar region of tomatoes. Several studies provide evidence that minimally processed leafy greens, subjected to varying degrees of cutting or shredding, provide thousands of attachment sites, entryways, and nutrients for pathogen growth and survival. The Food and Drug Administration (FDA) classifies cut leafy greens as a “potentially hazardous food” that requires regulated time-temperature controls for food safety. When illness is traced back to the farm, it has often been to these types of crops. FDA has published specific on-farm food safety guidances for melons, tomatoes, sprouts, leafy greens, and fresh-cut lettuces and leafy greens to help reduce human illness.

1.3 Pathogens of Concern for Specialty Crops

The human body contains ten times more bacterial cells than human cells. Many beneficial bacteria in the gut help with digestion and immune responses. But not all microbes are beneficial. Ingesting contaminated food can allow pathogenic microbes to attach, invade, and reproduce in the gut, causing stomachaches and, in some cases, life-changing complications or death. Food-borne pathogens often have a low infectious dose, meaning that it only takes a few cells or infectious viral elements to cause illness in an individual. Because of this, washing produce to remove pathogens, while a good practice, cannot ensure safe consumption. The few pathogens that may remain after washing could still make someone sick, depending on the individual dose response.

This document covers the four bacteria, from human and non-human sources, most likely to contaminate U.S. specialty crops and cause illness—Shiga toxin-producing *Escherichia coli* (e.g., *E. coli* O157:H7), *Salmonella*, *Campylobacter*, and *Listeria* species. While better adapted to survive in the moist, anaerobic guts of their hosts, all may survive outside as well for different durations, depending on conditions. Uniquely, *Listeria,* a true environmental survivor, has many forms, though only two are pathogenic to humans.



Outbreaks of Shiga toxin-producing Escherichia coli*, such as* E. coli *O157:H7 pictured here, have been traced back to produce, including fresh-cut spinach, lettuce, and salad mix.*

E. H. White, CDC

This review includes a protozoan, *Cryptosporidium* species, because of its survival strategy, even though it is less likely to cause contamination. While the protozoan may persist in the environment longer than the others due to its ability to form an oocyst—a thick-walled protective spore—it usually only makes a few individuals, rather than large numbers of people, sick because it doesn't replicate outside the host.

Antimicrobial resistance in *E. coli* O157:H7, *Salmonella*, *Campylobacter*, and *Listeria* species sometimes appears in livestock, wildlife, and environmental sources, potentially making illnesses from these cases difficult to treat and even more of a health hazard. For more discussion about these pathogens, see Appendix I.

1.4 Food Safety Regulations, Guidances, GAPs, and Plans

Even though specialty crop farms have not caused the majority of produce outbreaks, growers must respond to today's heightened awareness of food safety on the farm. Many food buyers, state or regional commodity marketing agreements, orders, associations, and some government agencies require (under voluntary signatory or mandatory programs) specialty crop growers to follow specific food safety procedures, as well as to record the actions they take to implement these procedures. FDA proposed a regulation, *Standards for the Growing, Harvesting, Packing, and Holding of Produce for Human Consumption* (Produce Rule; expected to be final in 2015), under the 2011 Food Safety Modernization Act in order to help reduce food-borne illnesses and outbreaks from the consumption of fresh produce. FDA also published guidance for on-farm food safety in 1998 and more recent commodity specific updates. Some states have their own food safety standards and government audit requirements. Many public institutions, including military, hospitals, penitentiaries, and providers to schools under USDA programs, as well as private food buyers, require food safety plans accredited by third-party auditors.

Just as conservation programs call for an environmental assessment as part of the farm plan to identify areas or activities that impact a farm's natural resources, food safety policies call for a hazard analysis and food safety risk assessment as part of its food safety plan. This assessment done by the grower, ideally with the assistance of a food safety specialist, identifies areas or activities that may directly or indirectly expose crops to pathogen contamination. The plans are typically based on a set of GAPs developed by multiple stakeholders including industry, government, auditors, academia, and agricultural extension agencies. These GAPs usually focus on five categories of assessment, four of which are highly relevant for the co-management of food safety and conservation: (1) water quality, (2) soil amendments, (3) wild and domestic animals, and (4) the surrounding environment. The fifth, worker health and hygiene, is critically important but not a focus in co-management considerations. Co-managing for food safety and conservation involves managing non-crop vegetation, water bodies, soil amendments, and domestic animals and wildlife to minimize dissemination and persistence of pathogens on the farm and in the landscape. In a well-intentioned but misplaced effort to eliminate all risk of pathogen contamination, some GAP requirements by produce buyers, or the subjective misinterpretation of them by auditors, prove unintentionally counterproductive or indifferent to conservation goals.

1.5 Conflicts with Conservation Goals

When growers have to comply with multiple food safety requirements, they may aim for the highest common denominator, implementing the strictest food safety management practices to appease all buyers and regulating bodies. FDA, in its proposed Produce Rule supported by scientific reports, acknowledges that wildlife does not pose a universally significant food safety risk. The Produce Rule further acknowledges the difficulty and lack of certainty of quantifiable benefit in measures that attempt to exclude all wildlife, particularly birds, from farms. However, since wildlife feces is a recognized source of human pathogens and therefore perceived as a significant risk factor, wildlife—and the habitat that harbors it—is often a major focus of standards in food safety GAPs. While current GAP documents rarely target the direct removal of habitat or encourage the killing of wildlife, the observation of presence and perceived risk of wildlife and wildlife habitat can translate into a drop-off of sales, particularly when produce buyers refuse to buy the portion of a grower's crop that is located near wildlife habitat. This situation negatively incentivizes growers and has resulted in their removing conservation practices that support ecological functions critical to public health.

J. Couperus, Lighthawk 2008

In response to food safety pressures in the 5 years after the 2006 spinach contamination, about 13% of remaining riparian habitat was eliminated or degraded in the Salinas River Valley, such as this which is shown between the red lines.

In 2006, spinach contaminated with *E. coli* O157:H7, traced back to a farm on California's Central Coast, was cited as the cause of death of five people. While it was never determined how the spinach became contaminated, non-native feral pigs, contaminated irrigation water, and adjacent cattle operations were all considered potential sources during the official environmental investigation. Wildlife and the habitat it occupied were seen as a serious food safety risk with potential to transfer pathogens to the crop. Although research thus far has indicated that native wildlife has a low relative prevalence of carrying pathogens that cause food-borne illness in humans, localized conditions may create situations that cause concern, such as proximity to known domestic animal sources of key pathogens.

Surveys conducted by the Resource Conservation District (RCD) of Monterey County after the 2006 spinach outbreak found growers adopting environmentally destructive measures to comply with food safety audit requirements and to keep their markets. In 2007, 89% percent of growers managing 140,000 acres on California's Central Coast reported that they had actively discouraged or eliminated wildlife from crop areas. Growers began creating bare ground buffers around their crops, trapping wildlife, using poison bait stations, and fencing out wildlife. A later survey conducted by the RCD of Monterey County in 2009, showed that some of these reactionary measures had lessened. Research published in 2013 found that over a five-year period after the 2006 contamination, approximately 13% of the remaining riparian habitat in the region had been eliminated or degraded. If practices such as these occurred throughout all California croplands, estimates predicted that up to 40% of riparian habitat and 45% of wetlands in some of its counties would be impacted.

1.6 Addressing Food Safety and Conservation

Growers can achieve co-management of food safety and conservation in diverse situations, ranging from those whose markets demand the strictest food safety protocols, to those who are internally motivated to do the best they can at the least expense to the environment. Actions depend on how much preventive planning, monitoring, and exclusion they deem necessary. Using the multiple-barrier approach, growers can: (1) minimize the likelihood of pathogens entering the farm; (2) diminish likelihood of pathogens contaminating crops; (3) reduce the spread of pathogens to crops when livestock are on the farm; and (4) prevent pathogens from leaving the farm.

This document builds on the ongoing work by major research scientists, food safety regulatory agencies, and extension personnel, many of whom are already working on similar teaching tools, though not necessarily targeting food safety and conservation co-management strategies. This text includes key points learned from grower phone surveys and farm visits in Florida, New York, and California—such as how the diversity of production, climate, regulatory, landscape, and wildlife features influence specialty crop production management decisions. Many of the growers who participated in these interviews supported conservation measures and wanted to identify pathogen sources and the management practices they could use to help reduce the risk of pathogens that might contaminate their produce.

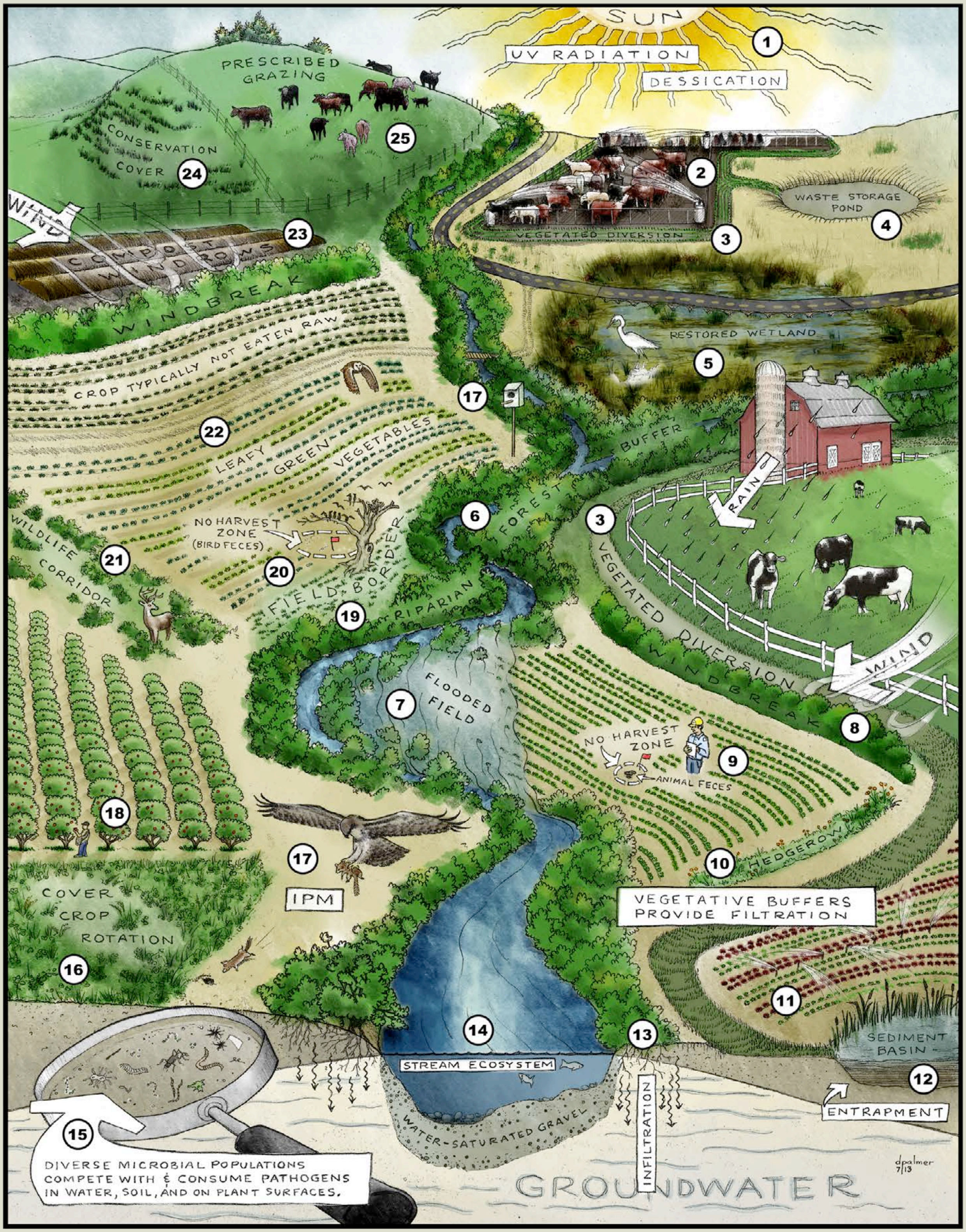
NRCS conservationists knowledgeable about basic food safety issues can help specialty crop growers implement co-management practices that benefit natural resources and biodiversity. Such skills will be in demand as food safety requirements become more prevalent across the country.

Specialty Crops

'Specialty crops' are fruits and vegetables, tree nuts, dried fruits, horticulture, and nursery crops (including floriculture). Eligible plants must be intensively cultivated and used by people for food, medicinal purposes, and/or aesthetic gratification to be considered specialty crops. Processed products shall constitute greater than 50% of the specialty crop by weight, exclusive of added water.

P. Greb

Figure 2 *Healthy Diverse Ecosystems Help Keep Pathogens in Check*



Key to Illustration: Healthy, Diverse Ecosystems Help Keep Pathogens in Check

Note: The Healthy, Diverse Ecosystems Help Keep Pathogens in Check *illustration* ***is not drawn to scale****; it serves as a visual summary of the conservation practices and food safety actions used to address food safety referenced in this document. These practices and actions do not provide complete and conclusive protection against food-borne pathogens on a given farm/ranch, and some vegetative conservation practices may attract wildlife that can vector pathogens. When implementing in-field practices to address food safety, one should take into account the conditions present on the farm/ranch and use this information to assess the effectiveness of a given practice in* ***reducing the risk of food-borne pathogen contamination*** *of crops.*

1. Sun: Ultraviolet (UV) radiation from the sun may inactivate recently deposited pathogens on the surfaces of soil and leaves, as well as in clear water. The sun also facilitates the desiccation of pathogens, which leads to pathogen reduction.

2. Dust from animal activity (371) is reduced with the application of water by sprinklers and with manure harvesting. Reducing emissions and removing manure proactively are cost-effective means of mitigating pathogen transfer.

3. Diversions (362) redirect water runoff from confined animal feeding operations to waste treatment and sedimentation lagoons, preventing the movement of waterborne pathogens to nearby farm traffic areas, fields, and waterways. Vegetated diversions also intercept organic matter and soil carrying pathogens in runoff from pastures and divert potentially contaminated water away from specialty crop fields. The diversions slow pathogen dispersal and provide a matrix for beneficial bacteria and protozoa that compete with and consume pathogens. Plants should be selected for low-flow filtering capacity and the ability for high flows to flow through the vegetation. Selection criteria should also consider how well air and sunlight can penetrate the vegetation, as the cool, moist, shaded interior vegetation may provide favorable habitat for pathogen survival. Otherwise additional maintenance will be required that regularly harvests and removes excess vegetation.

4. Waste storage pond (313) temporarily stores waste, such as manure runoff from concentrated animal feeding operations, thereby reducing pollution potential in the landscape. The waste storage pond should be properly designed and maintained to not overflow. Food safety Good Agricultural Practices (GAPs) recommend that the effluent from the ponds not be used on crops typically eaten raw. Monitoring of animal movement around the pond and between waste handling areas and crop fields should be a scheduled activity.

5. Restored wetlands (657) can considerably reduce pathogen transport by slowing the water, which increases the interaction time, and providing a matrix for beneficial microbes. The diverse plant and microbial community establishes desirable interactions that serve to limit pathogen persistence. Use of vegetation and designs that facilitate water moving slowly over long periods in the wetland allow the best chance for pathogen reduction in water draining from the wetland. The vegetation in the wetland may decrease the ability of UV light to reach the pathogens, which may increase survival. However, pathogens may be retained on vegetation. As water recedes, the pathogens that are retained on the vegetation may be exposed to sunlight and desiccation.

6. Riparian forest buffers (391) are vegetated areas along bodies of surface water, including streams, wetlands, and lakes. They may trap wind-borne pathogens on their vegetation and filter waterborne pathogens attached to suspended organic-soil particulates and other solids. The diverse plant and microbial community in the buffers encourages interactions limiting pathogen persistence.

7. Flooded field: Food safety GAPs recommend that crops typically eaten raw not be planted on lands that often flood. If and when a flood occurs, it may take time for pathogens present in the soil to die off. Depending on the frequency of floods, the field could be fallowed for a period, replanted to a cover crop, or possibly, permanently taken out of production with the restoration of riparian habitat.

8. Windbreaks (380) can trap dust containing pathogens and prevent it from entering specialty crop fields. Plants should be selected with foliar and structural characteristics that optimize dust/pathogen interception. If interior vegetation is too dense, it may provide a cooler, moister, and shadier environment, which may create a favorable conditions for temporary pathogen survival.

9. Evidence of animal intrusion in a crop field should be monitored. Food safety GAPs recommend that farmers monitor the crop for animal feces and signs of feeding, and if found, place a no-harvest buffer around the contaminated source, or take other measures to reduce risk of harvesting the contaminated crop. The following considerations all factor into determining the appropriate risk reduction actions taken: the type and number of animals; whether they are present intermittently or continually; if they are there because of food, a movement corridor, or live next to the crop; and if they are seen before planting or right before harvesting.

10. Hedgerows (422) may trap waterborne pathogens in their root systems and wind-borne pathogens on their vegetation. Shaded interior of the vegetation may provide favorable conditions for temporary survival of pathogen if too dense.

11. Irrigation (449): Food safety GAPs recommend using irrigation water sources that are adequately free of contamination. Management techniques that promote infiltration of the water into the soil can reduce runoff and may aid in reducing the movement of pathogens already present in the field. Techniques that aid in infiltration include soil quality management that increases porosity and improves structure, and irrigation management that keeps soil from becoming saturated.

12. Sediment basins (350) capture and detain sediment-laden runoff that may contain pathogens. Correctly designed, basins allow sufficient time for the sediment to settle out of the water. With moist, cool conditions, the basin may support the survival of pathogens. Having a sediment basin that dries down as rapidly as possible helps to alleviate these moist conditions and helps reduce pathogen survival. Moist sediment that is removed from the basin and put on cropland should be treated as contaminated, with an established time period similar to non-composted soil amendments between its application and the next crop's harvest.

13. Riparian forest root zone: The roots of the riparian forest promote water infiltration and provide biological activity. This helps divert pathogens from surface water, and encourages interactions with other soil microorganisms that can limit pathogen persistence.

14. Stream ecosystem: In a stream ecosystem where diverse microbial communities exist, they are thought to reduce pathogens by competition, parasitism, and predation. Clear water allows light to reach pathogens, which can lead to their reduction. Flowing water dilutes pathogen populations. However, some algae and protozoa may serve as an alternate host for pathogens, allowing them to live even when environmental conditions are unfavorable for their survival.

15. Diverse microbial populations compete with and consume pathogens in water and soil and on plant surfaces. When diverse microbial populations are present, beneficial microbes compete with pathogens for carbon and nitrogen, while others kill and consume them. Diverse microbial communities in water and on plants also compete for resources and/or consume pathogens. In some instances, biofilms—a matrix of bacteria and carbohydrates—can support beneficial microbes and in other cases harbor pathogens.

16. **Cover crops (340):** Rotating with cover crops increases soil organic matter and supports soil microbial communities that may aid in suppressing pathogens. Cover crops may also reduce the movement of pathogens in water runoff by trapping pathogens in their roots and leaves. They can be grown during a "waiting period" between events that might pose contamination risk (e.g., grazing, flooding or significant animal intrusion) and the planting of a crop typically eaten raw. Cover crops also reduce open soil, which helps reduce dust transmission problems.

17. **Integrated Pest Management (IPM) (595)** of vertebrates such as mice and squirrels can help control pest animals that enter crop fields. Having a few predatory animals, such as hawks or owls, on the farm is less of a risk than numerous prey species. A crop should not be planted directly under a raptor nest box or a roost, so that it is not contaminated with raptor feces. Farm traffic should not carry fecal droppings into the cropped area or equipment and storage yard.

18. **Harvesting orchard fruit** from the tree, not the ground, when it will be consumed fresh is recommended by Food Safety GAPs. Fallen fruit may have come in contact with animal feces.

19. **Field borders (386)** can intercept and reduce waterborne pathogens moving in overland flow from the field. This planting encourages infiltration and serves as a buffer between the field and the riparian vegetation.

20. **Tree bird roost:** Food safety GAPs recommend that a no-harvest zone be established under branches that hang over the field to ensure bird feces will not touch the crop.

21. **Wildlife corridors** allow wildlife to access resources (water, food, and cover) without having to cross crop fields or leave their preferred habitat.

22. **Crop placement:** Food safety GAPs recommend that leafy green vegetables or other crops typically eaten raw not be planted near manure stockpiles or composting facilities and windrows, or other areas of contamination, as pathogens may transfer to the field via water or wind.

23. **Compost (317):** Properly managed compost windrows heat up to a temperature that results in significant pathogen reduction. Compost itself supports beneficial organisms that compete with, inactivate, and consume pathogens. Unfinished compost or compost that has become re-contaminated could be a source of pathogens; thus, measures should be taken to prevent these below par composts from moving onto adjacent fields through wind or water. For information on proper compost management practices refer to "Chapter 2: Composting" in Part 637 of the USDA, NRCS National Engineering Handbook.

24. **Conservation cover (327)** is used to establish and maintain perennial vegetative cover to protect soil and water resources on land retired from agricultural production or land in need of permanent protective cover that will not be used for forage production. Perennial plants may trap windborne pathogens on the vegetation and waterborne pathogens in the root system.

25. **Prescribed grazing (528)** uses animals to manage vegetation. It also helps to increase water infiltration, reduce runoff, and prevent erosion. This aids in stopping the movement of pathogens in water runoff. Grazing animals are a reasonably foreseeable source of pathogens; thus, measures should be taken to prevent pathogens from the animals' feces from moving onto adjacent fields through wind or water.

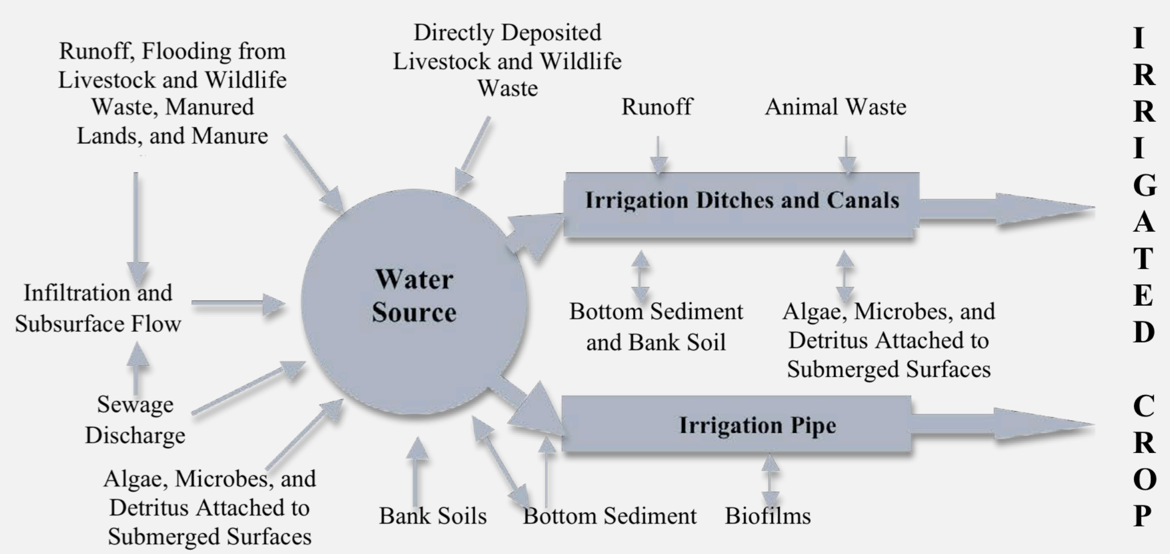
2: Pathogen Routes and Prevalence on the Farm

Successful co-management requires awareness and assessment of contamination pathways and prevalence (dynamic percentage of pathogens in a population) in order to plan, install and manage conservation practices with sensitivity to food safety concerns. Just as it is impossible to completely eradicate pathogens from the growing areas, it is impossible to predict with certainty when and where pathogens will occur. The high diversity of natural environments and the changing way in which pathogens react to them make prediction difficult. Typically pathogens move in water, on the wind, with animals, and through human actions. Prevalence of pathogens in wild and domestic animals can be assessed, but regional influences may cause significantly different outcomes. Prevalences serve as indicators of common risk potential rather than the foundation for sweeping generalizations at either extreme of absolute risk to absolute safety.

2.1 Waterborne Pathways

Water may carry pathogens to specialty crop production areas via numerous pathways, as shown in Figure 3. Manure applied to nearby lands, overflow from manure lagoons, runoff from manure and compost storage sites, and fecal matter deposited by livestock and/or wildlife throughout a watershed may be carried in surface runoff down slope to crop areas or to surface waters. Concentrated rainfall events can cause runoff, preferential flow, and flooding, which can quickly transport pathogens over large areas. Crops that come in contact with floodwaters are considered adulterated by the FDA regardless of ability to detect chemical or biological hazards.

Figure 3 *Process Affecting Microbial Quality of Irrigation Water*



Adapted from Pachepsky et al. 2011.

Groundwater irrigation sources may also become contaminated. Pathogen movement through the soil profile is largely controlled by soil structure and preferential flow channels, which are determined by the diameter and continuity of macropores in soil. Movement of pathogens through the soil profile to shallow groundwater supplies is possible with high rainfall/irrigation rates and very porous soils. Improperly managed or leaking septic systems may also present a risk, particularly those in close proximity to water sources used for irrigation or in areas where improperly percolating drain fields allow contamination. However, in many cases groundwater contamination is caused not by movement of pathogens through the soil profile, but rather by contamination around an active, or abandoned and unsealed, well-head or in the water distribution system.

In some areas of the country tertiary treated wastewater may be used as an irrigation water source. After going through primary and secondary treatment, wastewater is subjected to tertiary (advanced) treatment, which may include processes that use ultraviolet light and/or chlorination to maximize the removal of enteric bacteria, protozoan parasites, and human enteric viruses. While there are no federal standards for using tertiary treated wastewater for irrigation on crops, almost half of the states do have regulations of various kinds. California and Florida produce the most tertiary treated wastewater. As with municipal water sources, testing should ensure that these waters are safe for use; to date, no illness has been linked to the use of these reclaimed water sources in specialty crop production. If either municipal or tertiary treated waters are inadequately treated, these could present contamination risk.

Water may become contaminated by direct animal deposits or by bioaerosols in systems that employ irrigation ponds, reservoirs, ditches, and canals where either rainfall or surface runoff is used in distribution. Studies have found that the mammals and aquatic birds that inhabit wetlands can disseminate *Cryptosporidium, Giardia,* and other human pathogens. If waterfowl or other wildlife congregate in a wetland in large numbers, caution should be taken, as the water flowing out of the wetland may be contaminated with pathogens. Contact with pathogens attached to algae, bank soils and resuspended sediment in ponds, reservoirs, ditches, and canals may also lead to contamination. Pathogen concentration is frequently higher in sediments of water storage areas and waterways than in overlying water.

USDA NRCS

Water running off livestock yards may be contaminated with pathogens.

Disturbing these sediments may reintroduce pathogens into the water supply. Water transported through pipes interacts with biofilms—bacterial communities that establish on surfaces and create a protective extracellular matrix of polysaccharides—that may or may not harbor pathogens. Distribution systems handling reclaimed water have been shown to have an increased pathogen presence in these biofilms. Water unintentionally contaminated by pathogen sources during transport may end up in irrigation used on crops.

Only a few produce outbreaks have been traced back to irrigation water as the confirmed source of pathogen contamination. To make the link from water to humans, scientists have begun to use a DNA fingerprinting technique to compare the DNA of pathogens isolated from water samples collected at the suspected contamination site to that of the pathogens isolated from the contaminated crop and from the reported ill persons (Table 1). Many unconfirmed cases (not shown) have suggested that irrigation water may have been the source of contamination. These cases remain unconfirmed because there was no direct match between the outbreak strain and the strain found in the water; there was no direct use of the pathogen-laden water (groundwater was used for irrigation but pathogens were found in nearby river water); or potential environmental sources of the pathogens (animals, manure, and compost) near the water tested negative.

Table 1: Confirmed Outbreaks Associated with Irrigation Water			
Crop	**Pathogen**	**Irrigation Source**	**Farm Location**
Tomatoes (a)	*Salmonella* Newport	pond	Virginia
Lettuce (b)	*E. coli* O157:H7	small stream	Sweden
Shredded lettuce (c)	*E. coli* O157:H7	well water accidentally mixed with dairy lagoon water	California
Hot peppers (d)	*Salmonella* SaintPaul	holding pond used for irrigation water	Mexico
From: (a) Greene et al. 2008; (b) Soderstrom et al. 2008; (c) US FDA and CA Food Emergency Response Team 2008; (d) CDC 2008.			

2.2 Airborne Particulate Matter Pathways

Pathogens may enter the crop environment as bioaerosols—airborne particles that contain living organisms. Windborne particulate matter may include desiccated fecal matter with viable pathogen cells or dust/soil/debris with adhered pathogens. Such contaminated materials may originate from a variety of nutrient management systems, including manure lagoons, manure piles, and compost facilities. Locations with heavy fecal depositions where animals congregate, such as wild or domesticated animal loafing areas, pasture/range land, and large or small confined livestock operations, can also serve as sources of pathogen-containing bioaerosols. Additionally, vehicle traffic or farm equipment traversing these areas can send contaminated dust into the air.

Factors influencing the risk level of produce contamination include the distance between the contamination source and the produce field; particle size and buoyancy; wind intensity, speed, and direction; land surface topography; and physical features. Land applied with untreated wastewater and biosolids may contain persistent populations of pathogens. Winds may distribute fine droplets of contaminated water or particulates to adjacent areas. Some of these cases are described in more detail in Table 2. However, not all animal-generated bioaerosols cause contamination—for example, only non-pathogenic bacteria were found in the air next to fields where sheep grazed in a leafy green producing region of California.

Table 2: Selected Cases of Airborne Pathogen Contamination		
Types of Airborne Pathogens	**Location**	**What the Research Examined**
E. coli O157:H7 (a)	Colorado 6,000-head cattle feedlot	Airborne transport of *E. coli* O157:H7 from feedlot to various distances of leafy green crops.
Newcastle disease virus (b)	Pennsylvania poultry farms	Vegetative buffers in Pennsylvania reduced dust and respiratory virus transmission from commercial poultry farms.
Larynogtracheitis virus (c)	Delaware poultry farms	A four-fold increase in risk of poultry developing the disease for a farm located within the downwind plume of the farm with contaminated poultry.
E. coli O157:H7 (d)	Ohio fairgrounds	One hundred people were sickened when a dance was held in the same building that had earlier exhibited animals.
Many pathogenic *E. coli* strains (e)	Mexico City household and street dust	Intestinal infections caused by dust collected from indoor and outdoor environments was greater than thought.
E. coli O157 and *Salmonella* (f)	Texas cattle feed yards	Exposure to dust in the cattle load-out area of feed yards increased pathogen contamination of cattle hides.
Salmonella enteritidis (g)	Chicken houses	Infected hens in houses transferred disease to healthy hens via the air.
Bacteria, fungi, and dust (h)	Croatia laying hen houses	Free-range aviaries have higher content of airborne pollutants than the conventional cage system.
Several kinds of bacteria and fungi (i)	Egyptian dairy barns and beef sheds	Concentration and frequency of airborne microorganisms on cattle farms and their potential health hazards to farm workers.
Several kinds of bacteria and fungi (j)	Romanian dairy barns	Barn hygiene decreased airborne microbe concentrations.
Several kinds of bacteria (k)	Arizona agricultural fields	Wind is a possible mechanism for the aerosolization and off-site transport of land-applied biosolids.
Newcastle disease virus (l)	In the laboratory and in the open air	Vaccination of birds leads to a great reduction in the amount of virus liberated into the air.
Generic *E. coli* (m)	California leafy green fields near rangeland	Generic *E. coli* present in water was related to aerial transmission. Concentration increased by 60.1% for each 1 meter/second increase in wind speed and decreased by 3% for each 10 meter increase in the distance between the sample location and rangeland.
From: (a) Berry 2011 (interim report); (b) Burley et al. 2011; (c) Johnson et.al. 2001; (d) Crump et al. 2003; (e) Rosas et al. 1997; (f) Miller et al. 2008; (g) Holt et al. 1998; (h) Vucemilo et al. 2010; (i) Abd-Elall 2009; (j) Popescu 2011; (k) Baertsch et al. 2007; (l) Hugh-Jonesa 1973; (m) Benjamin et al. 2013.		

2.3 Wildlife Prevalence and Pathways

Pathogen Prevalence in Wildlife

Native wildlife has so far been found to have a low relative prevalence of carrying human pathogens. Even though the widespread risk appears low, pathogen prevalence in localized wildlife populations remains a concern.

While hundreds of studies have detected food-borne pathogens in wild animals, only a few to date have shown a direct relationship with human illness. In each of the cases in Table 3, the DNA patterns in the samples taken from animal feces were indistinguishable from those in the contaminated crop and the reported ill persons. Unconfirmed instances orange juice and the presence of a nearby toad, and with apple juice and deer in the orchard were not listed because there was no direct match of outbreak strain.

Table 3: Recorded Outbreaks Associated with Wildlife

Crop	Pathogen	Wildlife	Location
Spinach (a)	*E. coli* O157:H7	non-native feral pigs*	California
Straw-berries (b)	*E. coli* O157:H7	black-tailed deer	Oregon
Peas (c)	*Campylobacter jejuni*	sandhill cranes	Alaska
Carrots (d)	*Yersinia pseudotuberculosis*	shrews	Finland

* While feral pigs were found with the same DNA pattern of *E. coli* O157:H7 as that found on the spinach, so were nearby cattle and pasture soil, and water/sediments from a creek that may have contaminated the irrigation well.
From: (a) Jay 2007; (b) Laidler and Keene 2012; (c) McLaughlin 2008; (d) Kangas 2008.

More often, native and non-native wildlife that harbor food-borne pathogens have not been implicated in cases related to human illness outbreaks. These studies may simply determine that certain wildlife have the pathogen, or may discern how many carry the pathogen—the prevalence. The discussion below and in Figures 4—7 in Appendix II describe the prevalence found in wildlife.

It is helpful to understand that many biological factors and sampling methodologies influence the detection of pathogens in wildlife. If wildlife populations live near contaminated sources, they are much more likely to become infected or simply mechanically transport pathogens on their skin, fur or feathers. Just as with humans, animals tend to be more susceptible to pathogens depending on their health, stress level, age, and immunity. Some pathogens have no known virulence to the animal host but have serious consequences in a human host. The ability to detect pathogens in individual wildlife depends on the amount of pathogen it carries, the degree of activity and fitness of the pathogen, and the specific methods used to sample, recover, and detect the target pathogen. Sampling from the animal itself is a much more reliable indication of prevalence than sampling feces from the ground, which may introduce contamination or exposure to conditions that increase, decrease, or inactivate the pathogen. The pre-process handling and sample size is important for credibility—if too small, it may not accurately represent prevalence. As with any research, studies documenting pathogens in wildlife are snapshots that reflect the local conditions but do not necessarily give a comprehensive picture of pathogens in the landscape. For a more thorough discussion of the complexities of data interpretation, see Appendix II.

<u>E. coli *O157:H7 Prevalence in U.S. Native and Non-Native Mammal and Avian Species*</u>

Since cattle are considered the primary reservoirs of *E. coli* O157:H7 and possibly other *E. coli* pathogens, most wildlife studies examining its prevalence take place near cattle. Zero to less than 1% prevalence was found in deer, rodents, and in various other native mammals; and about 2% prevalence was found in elk and coyotes. The same low rate was found in songbirds (0–1%), non-native rock pigeons (0%), and European starlings (0–2%) that visited dairies or cattle feedlots. A few species have somewhat higher levels, including brown-headed cowbirds (about 3%), American crow (over 5%), and feral pigs (4–5%), possibly because they come in contact with the pathogen-laden organic matter more often. Brown-headed cowbirds eat seeds and insects from cattle feces, and American crows and feral pigs eat garbage and carrion. Pigs are also known to eat other animal's feces. As mentioned in Table 3, feral pigs were one of several possible *E. coli* O157:H7 sources in the 2006 spinach outbreak in California, and black-tailed deer were the source of this pathogen in a strawberry outbreak in Oregon. Figure 4 in Appendix II gives further details.

<u>Salmonella *Prevalence in U.S. Native and Non-Native Mammal and Avian Species*</u>

Feral pigs (>14%) presented twice the prevalence of *Salmonella* than any other wildlife species. Deer studies showed less than 3% prevalence with the exception of one study in Texas where deer shared rangeland with sheep and both had prevalences around 8%. Other wildlife prevalences were detected for raccoons (>7%), European starlings (0–7%), tule elk (4%), rodents (3%), and various other native mammals (4%) and birds (3%). As mentioned above, birds that feed on insects and seeds in manure, and scavenge or eat carrion seem to more often carry the pathogen. Due to the significant numbers of European starlings in one cattle feedlot, it was thought that the *Salmonella* contamination of the cattle's feed and water was related. Figure 5 in Appendix II gives additional details.

B. Higginbotham, TX AgriLife Ext. Service, Bugwood.org

Current research suggests that non-native feral pig populations may have higher prevalence of many food-borne pathogens than populations of native wildlife.

<u>Salmonella *Prevalence in U.S. Native Amphibians and Reptiles*</u>

Even though most human illnesses are caused by the "warm-blooded" *Salmonella enterica* subsp. *enterica*, all of the 1,500 "warm-blooded" and 1,000 "cold-blooded" *Salmonella* serotypes found in animals and the environment must be considered potentially dangerous. One-quarter of the "cold-blooded" *Salmonella* serotypes are now known to be human pathogens. People, especially children, often become sick after handling pet reptiles. Various studies have shown that, in nature, from one to almost 40% of amphibians, and from zero to almost 100% of reptiles carry *Salmonella*. Such a large range of prevalence suggests that the higher occurrences of this pathogen may relate to other contamination in the landscape. Figure 6 in Appendix II gives further information.

<u>Campylobacter, Cryptosporidium, *and* Listeria *Prevalence in U.S. Native and Non-Native Mammal and Avian Species*</u>

Feral pigs were found with high levels of *Campylobacter jejuni* in both their mouth and gut (40%), suggesting that contamination can come from pigs eating the crop as well as defecating on it. Different types of waterfowl (36%) have also been found at times to carry high levels of these pathogens, including Canada geese (4–16%), which carried antibiotic-resistant *Campylobacter.* Other wildlife known to carry *Campylobacter* include deer, raccoons, elk, skunks, squirrels, and California gulls. One study reported that most of *Campylobacter* serotypes found in gulls were not closely related to species commonly associated with human illness. As shown in Table 3, sandhill cranes carrying *Campylobacter* pathogens precipitated an outbreak traced back to peas. Figure 7 in Appendix II gives further details.

Feral pigs were found with a 5% prevalence of *Cryptosporidium.* Various rodent species were found to have 7% prevalence, while deer mice were found with a much higher of prevalence of 26%.

A preliminary study reported that the prevalence of rodents with *Cryptosporidium* is inversely related to the biodiversity present. It suggests that non-crop vegetation clearing and indiscriminate poison baiting led to the decrease of rodent species diversity and the increase of a single species (deer mice). As the single species proliferated, the interaction between individuals of that species increased, which may have caused an increase in pathogen prevalence in those individuals.

Listeria has been found in many types of mammals and birds, including deer, moose, elk, fox, raccoon, skunk, geese, and crows.

Pathogen Vectoring by Wildlife

Fecal matter contact with a crop, as when feral pigs or native wildlife come into cropped areas and defecate on or trample the crop with contaminated feet, is an obvious pathway of contamination, though not all fecal matter contains pathogens of human health concern. Pathogens may also be transferred when animals eat part of the crop or brush up against the crop with contaminated fur and feathers. Crops that grow close to the ground (e.g., lettuce, spinach) or are harvested from the ground (e.g., almonds, walnuts) are at higher risk of contamination.

Wildlife is universally present in growing areas, some more so than others depending on the surrounding environment, but not typically in high numbers. Animal movement is virtually impossible to completely control, and minute amounts of fecal matter contamination may escape notice during harvesting, allowing contaminated product to enter the supply chain.

At times, wildlife has been found to vector pathogens from areas of high pathogen concentration to crops. High concentration areas may include livestock operations, waste storage facilities, or landfills/dumps. These areas attract some species of mammals, birds, and insects, presenting unique co-management challenges because of the ease with which they may move around the landscape and the difficulty of restricting their access to crop areas.

Wild mammals that share rangeland with livestock may pick up pathogens and transport them to crops. Feral pigs on cattle rangeland in California especially pose a problem. While deer may also share grazing lands with cattle, they carry lower levels of pathogens than the pigs. Both deer and sheep grazing on rangeland have had somewhat similar elevated levels when compared to animals that do not share grazing areas. Birds feeding in confined cattle operations may, but not always, become infected with pathogens encountered there. Not all birds are equally likely to frequent areas with potentially high concentrations of pathogens. For example, arboreal chickadees are less likely to feed at a landfill than seagulls, and brown-headed cowbirds are more likely than chickadees to eat seeds and insects in manure. Understanding which wildlife frequent the growing area, as well as how far and where they forage for food beyond the farm, may guide risk assessment.

Filth flies, which breed or feed in animal wastes, carry some pathogens on their bodies and may present a risk. Researchers remain uncertain that the amount of contamination likely to occur via this pathway denotes a measurable risk, and note that pathogens deposited on an exposed crop surface in typical growing conditions may not survive for long. Other insects, for example bees, syrphids, leaf hoppers, and a range of other beneficial and pest insects may also visit produce fields, though because they are not specifically drawn to animal wastes, their activity does not elicit the same concern as a contamination pathway. Additionally, bees have been found to avoid flowers inoculated with *E. coli* pathogens, and bee propolis has toxicity factors that reduce survival of the pathogens bees might carry to the hive.

2.4 Domestic Animal Prevalence and Pathways

Pathogen Prevalence in Livestock and Companion Animals

Since many specialty crops may be part of a mixed crop/livestock operation, or may be grown near neighbors with livestock, it is important to understand the role livestock play in the spread of food-borne pathogens onto crops. For a thorough discussion, see *Introduction to Waterborne Pathogens in Agricultural Watersheds, USDA NRCS Nutrient Management Technical Note No. 9.*

USDA NRCS

Salmonella *and* Campylobacter *are most common in poultry.*

Livestock and companion animals can carry pathogenic *E. coli, Salmonella, Campylobacter, Listeria,* and *Cryptosporidium*. Some pathogens are more common in some animals than in others. Depending on their innate immunity, the virulence of the pathogen, and the nature of the infection, many animals remain asymptomatic.

E. coli *O157:H7 Prevalence in Domestic Animals*

Pathogenic *E. coli* is widespread in dairy and beef cattle in North America, whereas sheep are major reservoirs in Australia. Depending on the area, 7% to 100% of cattle operations may contain animals infected with *E. coli* O157:H7 (see Table 14 in Appendix II). Even in infected herds, relatively few individuals may carry the pathogenic *E. coli*. However, a small number can excrete large intestinal loads of the bacteria for long periods, while others may have a large load but excrete it quickly without being a constant source. Cattle in particular may carry pathogenic *E. coli* asymptomatically, tending to excrete it in the warm months of the year. A comprehensive USDA review indicates that grain-fed cattle in concentrated animal feeding operations have higher prevalence rates than those on pasture eating forage, even though both can be found with pathogenic *E. coli*.

Pigs, dogs, poultry, and bison raised for slaughter also harbor pathogenic *E. coli*. Horses and cats rarely carry it. Young livestock carry higher levels of pathogens than adults.

Salmonella *Prevalence in Domestic Animals*

Salmonella, most commonly found in poultry, can also be found in pigs, horses, and cattle. In studies of different layer chicken houses, the occurrence of *Salmonella* ranges from 7% to 68%. About 31% of the dairy herds studied had at least one cow with a positive *Salmonella* culture. In a multi-state study, 4.7% of the 2,496 environmental samples tested positive for *Salmonella*. Of the positive samples, 57.3% came from swine farms, 17.9% from dairy farms, 16.2% from poultry farms, and 8.5% from beef cattle farms (see Table 15 in Appendix II). *Salmonella* is seen in horses but not commonly in cats and dogs.

Campylobacter, Cryptosporidium, *and* Listeria *Prevalence in Domestic Animals*

Campylobacter is of most concern in poultry, but is also seen in cattle and other livestock. In one study, 90% of broiler chicken farms tested positive, and in another 100% of broiler cecal droppings were positive. Based on multiple studies, 34% to 51% of dairy cows test positive for these pathogens, while one study showed beef cattle prevalence at 5% (see Table 16 in Appendix II). Many of the other animals including sheep, dogs, cats, and pigs are susceptible to *Campylobacter* infection, though subspecies of the pathogen not typically found in human patients may be implicated.

Cryptosporidium parvum is known to infect cattle, sheep, goats, pigs, horses, geese, chickens, and turkeys. Some *Cryptosporidium* species found in animals appear to be host-adapted and rarely infect humans. *Listeria,* most commonly found in ruminants (sheep, goats, and cattle), occasionally occurs in dogs, cats, pigs, poultry, and other species. However, only *Listeria monocytogenes* is considered a human pathogen of significance.

Pathogen Vectoring by Domestic Animals

Like wildlife, free-range livestock, escaped livestock, and companion animals (dogs, cats, etc.) may contaminate specialty crops if they enter a field and defecate on the crop. Livestock and companion animals may transfer pathogens onto the crop through their saliva (by eating a crop) or through manure-soiled feet. Contamination may also occur when inadequate time elapses between when feces is left by grazing animals gleaning harvested fields and harvest of the next crop. More rarely, contamination occurs when growers use animal traction (e.g., horses or oxen) to work the field.

2.5 Human Pathways

While not the focus of this document, humans who do not take appropriate sanitary measures before harvesting or handling produce may also contaminate produce. Manure or other animal-based soil amendments brought onto the farm may create a direct pathway for pathogens. Humans may then unintentionally spread the pathogens if they do not change or wash boots after working with manure or animals, or properly clean produce-handling surfaces, equipment, and vehicles used to transport produce. Pathogen spread can be reduced if employees practice good hygiene, such as properly washing their hands after using the restroom, and do not come to work sick.

3: Environmental Factors That Influence Pathogen Reduction

Pathogen survival and growth depends on a number of biotic and abiotic factors. In general, pathogen numbers decline over time outside the host, usually with an initial steep decline followed by a small amount of lingering persistence, sometimes prolonged. Understanding this decline and recognizing the circumstances of the expected decline are critical elements of risk assessment and subsequent management in the specialty crop growing environment.

The major factors that influence pathogen reduction are summarized below. Tables 17, 19, and 21 in the Appendix provide further details on how these factors influence pathogens, specifically in water, soil, and air, respectively.

3.1 Sunlight/UV Exposure

UV radiation from the sun both dries and damages pathogens, typically leading to their quick reduction on the surfaces of soil, compost, manure, and leaves, as well as in clear, shallow water. Factors that compromise these beneficial actions—shade from vegetation, turbid water, algal mats that cover water, depth in the soil and manure—reduce the effectiveness of sunlight/UV exposure. Open orchard canopies foster sunlight/UV penetration to the orchard floor much more than dense, deeply shading canopies. Water without algae and suspended sediments fosters sunlight/UV penetration throughout the water column, but sunlight/UV only act as an effective biocide at shallow depths. Pathogens may also attach to macro-algae and persist both in the water and in dried mats on banks, riprap stones, or concrete. The effectiveness of sunlight/UV radiation in reducing pathogens in animal feces through heat and desiccation is related to the volume and surface area of the feces. For example, sunlight/UV radiation will reduce the total pathogen load in songbird feces faster than it will in cattle feces.

3.2 Predation/Competition/Antagonistic Microbial Interactions

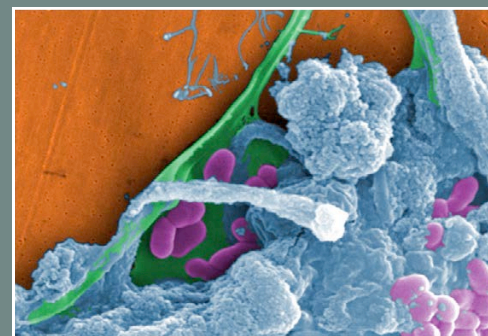
Diverse and abundant indigenous soil microbial populations generally decrease pathogen survival and reduce growth potential. Soil management practices that promote a robust native soil microbial community (e.g., high organic matter inputs from cover crops, manure, and compost; reduced tillage; infrequent fumigations) promote predation, competition, and antagonism. Laboratory work has demonstrated that pathogen survival time increases if native soil microbial communities are decreased through autoclaving or fumigation, although this relationship is not always straightforward. Studies employing variable degrees of soil pasteurization commonly result in a corresponding inversely proportional effect of bacterial pathogen persistence: the more severe the treatment, the greater the pathogen survival. Management practices that reduce the complexity of native microbial communities (e.g., fumigation) may create conditions favorable for prolonged pathogen survival, particularly if pathogens are re-introduced to this microbiological "vacuum" of limited microbial community density and diversity.

Native microbial communities effectively reduce pathogens in other media besides soil. Predation and competition for nutrients in water bodies is thought to reduce pathogen rates. Plants intercepting waterborne pathogens do so with the aid of biofilms, composed of microbial communities, which then help to reduce the pathogens. When biofilms form on the surfaces of leaves and roots, they may confer protection against pathogenic bacteria colonization, although in some instances, biofilms on plant surfaces may facilitate the survival and growth of pathogen populations. While predation, competition, and antagonism can play a significant role in enhancing food safety, they are insufficient for completely eliminating pathogenic contamination.

3.3 Harborage/Symbiosis

Although some biofilms may protect surfaces from pathogen colonization, others on living or inert surfaces—such as soil, vegetation, water, water systems, algae, and sediments—may serve as a reservoir for pathogens. While studies have proven the ability of many types of aquatic organisms to foster the survival of pathogens, the relative role of pathogens in water used for agriculture is currently unknown (see Section 2.1).

Pathogenic bacteria and protozoans may persist in biofilms, somewhat protected from environmental stressors such as UV radiation and predation. In sediments, biofilms may facilitate the capture and retention of pathogenic bacteria on individual and/or flocculated particles suspended in the water columns as well as in settled sediments. Amoebas and other protozoans grazing on bacterial biofilms may consume but not kill pathogenic bacteria and harbor the pathogens, thereby allowing them to persist or amplify even in unfavorable environmental conditions.



E. H. White, CDC

Biofilms are communities of microorganisms. Depending on the circumstances they may reduce or promote pathogen survival.

Evidence suggests that *E. coli*, *Campylobacter,* and *Salmonella* species may survive longer in a symbiotic relationship with algae, and in some circumstances their populations may amplify in association with algae. Nutrient-rich conditions that foster algal growth frequently occur in agricultural landscapes. Because algal blooms and algal mats may facilitate pathogen survival, management strategies should consider aquatic environments with abundant algae as possibly favorable habitat for extended pathogen survival.

3.4 Salinity, pH, and Nutrient Sources

Food-borne pathogenic bacteria generally survive well on soils with low salts and a neutral pH of around 6 or 7. Nutrients can support the growth of both pathogens and the microbes that compete with or predate upon them. Pathogens reduce more rapidly with low levels of bio-available carbon and nitrogen to consume, such as in clean water or sandy soils that typically contain less soil organic matter. The active area of the root zone that produces exudates can create a nutrient-rich environment for diverse microbial communities. For pathogens to survive, they have to compete with rival microbes for nutrients and avoid defensive antimicrobials produced by the plant. Different pathogens have different levels of ability to survive.

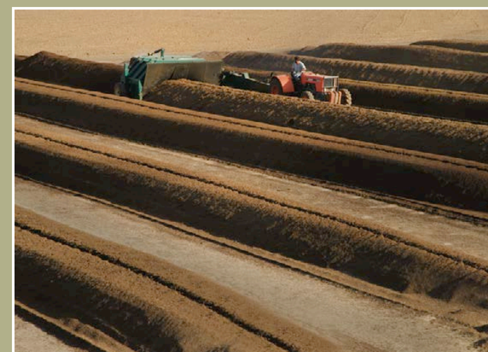
3.5 Temperature, Moisture, and Microscopic Niches

Lower temperatures tend to extend pathogen survival in soil and water, as there is less competition from native microbial populations. Cloud cover and increased moisture associated with cooler times of the year may also contribute to pathogen survival, though higher temperatures and humidity may favor growth on suitable substrates, including crops. Freezing temperatures by themselves cannot be assumed to inactivate most pathogens; however, rapid freeze-thaw cycles of weather can cause their reduction in the soil. Very high temperatures (> 55^{o}C/131^{o}F), such as those found in thermophilic composting processes, reduce most pathogen populations with sufficient exposure time.

4: Pathways and Persistence of Pathogens in Soils and Soil Amendments

4.1 Dynamic Influences of Soil Pathogens

Soil amendments of animal origin (e.g., manure, slurry, compost) serve as important soil fertility products for some growers, but may also serve as a pathway for produce contamination in the absence of appropriate management or treatment measures. Raw manure conveys higher risk than aged manure or finished compost.



USDA NRCS

Thermophilic composting can reduce the number of pathogens in manure.

The application method (surface applied vs. incorporated) and environmental conditions at the time of application influence pathogen survival and transport. Manure or other soil amendments exposed to a period of desiccation and UV radiation at the soil surface will have reduced pathogens present. Rainfall or irrigation events occurring shortly after manure application will likely release more pathogens. Manure composted using the full thermophilic process will carry reduced pathogen loads.

As outlined in Section 3, many factors influence pathogen survival. Yet food-borne pathogen persistence in the soil and manure is still not well understood. Most studies are compartmentalized and do not look at the whole dynamic picture—the fitness and virulence of pathogens, the interplay between indigenous microbes and pathogens, and the fixed features of soils, water sources, and climate. Many studies were conducted in labs, not in production fields. Even studies that do account for the majority of variables are only predictive of situations matching those same study conditions, not the entire scope of possible growing situations. Therefore it is difficult to accurately predict pathogen survival in the soil.

4.2 Range of Pathogen Persistence

Food-borne pathogens, with the exception of *Listeria*, are not part of normal indigenous soil microbial communities, and so are not perfectly adapted to them. Table 4 shows that in some cases pathogens can be reduced quickly, and in others they can be present for over a year. In several studies, survival related to whether the soil was sterilized—sterile soil lacks diverse populations of pathogen-suppressing microorganisms typically found in non-sterilized soil. Along these same lines, the presence of cover crops may influence the survival of indigenous soil microorganisms due to the support of increased microbial diversity. Different types of pathogens have different survival characteristics—*Cryptosporidium* oocysts typically persist outside of the host in soils or manure longer than bacteria. The type of the manure used, soil characteristics, and the rate of pathogens used for inoculation also influence persistence.

Table 4: Selected Cases of Pathogen Persistence in Soils and Manure		
Pathogen	**Pathogen Persistence**	**Relevant Details**
Salmonella	7 days (a)	*Salmonella* in land-applied manure survived for 7 days when sampled at 2 cm depth.
Salmonella	14–21 days (b)	Pig slurry containing *Salmonella* was incorporated into the soil.
E. coli O157:H7	25–96 days (c)	Fallow fields and fields planted with cover crops were amended with manure contaminated at a rate of 10^6 bacteria or cfu per gram (cfu/g) feces of pathogen.
E. coli O157:H7	28 days (d)	Pathogen was not detected on plant shoots after seven days but did survive in soil for up to 28 days.
Salmonella, *Campylobacter*, *Listeria, E. coli* O157:H7	<31 days (e)	Manure inoculated at levels of 2–5 log cfu/g was spread on land. *Listeria* survived longer than the other pathogens.
E. coli O157:H7	32–110 days (f)	Survival time varied with soil type.
Listeria	43 days (g)	Initial inoculation level of 5–6 log cfu/g was used in manure.
Salmonella and *E. coli*	50–70 days (h)	This was a multi-year field study in sandy loam soil. No contamination of vegetables was detected.
Fecal bacteria	56 days (i)	Poultry litter at 15 or 30 t/ac (recommended application rates for poultry litter typically is 2 t/ac).
E. coli O157:H7	>56 days (j)	Crisphead lettuce was grown in soil fertilized with manure inoculated at 4 log cfu/g. No contamination of lettuce observed. Study terminated at harvest; actual soil survival unknown.
E. coli O157	60 days (k)	Pathogen prevalence and densities were modeled probabilistically through the primary production chain of lettuce (manure, manure-amended soil, and lettuce).
Listeria, *Salmonella, Campylobacter, Cryptosporidium, E. coli* O157	64–128 days (l)	Initial inoculation of 6 log cfu/g; type of amendment used played large role in recovery. *E.coli* was not recoverable after 64 days, *Salmonella* or *Campylobacter* 120 days, *Listeria* sometimes persisted up to 128 days.
E. coli O157:H7	69–92 days (m)	A 3 log cfu/g *E. coli* was present at day 19; no *E. coli* recovered from radishes harvested at day 69 or from soil at day 92.
Listeria	90 days (n)	Time required for a 7 log reduction of the pathogen.
E. coli O157:H7	>99 days (o)	Soils amended with manure inoculated at rate of 10^8 to 10^9 cfu/g and then spread on grassland.
E. coli O157	105 days (p)	Samples of soil and sheep feces were collected from the campsite and tested for the presence of *E. coli* O157.

Table 4 (continued)		
Pathogen	**Pathogen Persistence**	**Relevant Details**
E. coli O157:H7	154–196 days (q)	Study used a rate of 10^7 cfu/g of pathogen. (Cattle with *E. coli* O157:H7 may shed the organism at levels ranging from 10^2 to 10^7 cfu/g; on rare occasion more.)
E. coli O157:H7	154–217 days (r)	Used a rate of 10^7 cfu/g of pathogen. Reduction rates changed based on crop grown in inoculated soils.
E. coli O157:H7, *Salmonella*	180 days (s)	90% reduction at 13 days, 99% at 33 days, low level survival to 180 days at project termination.
Salmonella	184 days, 332 days, and 405 days (t)	Pathogen survived 184 days in manure, 332 days in manure-amended non-sterilized soil, and 405 days in manure-amended sterilized soil.
E. coli O157:H7	226 days (u)	Used a rate of 10^7 cfu/g of pathogen and placed manure in sterile soil that did not support diverse microorganisms antagonistic to the pathogen. Pathogens declined more rapidly in non-autoclaved soil.
Cryptosporidium	1 year (v)	This pathogen is primarily transmitted to humans through water rather than soil.
Cryptosporidium	<1 year (w)	The oocysts of these protozoans typically survive for prolonged periods of time in the environment.
E. coli O157:H7	21 months (x)	Detected in a manure pile, not in soil that had a manure application.
From: (a) Gessel et al. 2004; (b) Baloda et al. 2001; (c) Gagliardi and Karns 2002; (d) Patel et al. 2010; (e) Nicholson et al. 2005; (f) Ma et al. 2011; (g) Jiang et al. 2004; (h) Cote and Quessy 2005; (i) Zhai et al. 1995, Dunkley et al. 2001; (j) Johannessen et al. 2005; (k) Franz et al. 2008; (l) Hutchison et al. 2005; (m) Mukherjee et al. 2006; (n) Girardin et al. 2005; (o) Bolton et al. 1999; (p) Ogden et al. 2002; (q) Islam et al. 2005, Himathongkham et al. 1999; (r) Islam et al. 2004; (s) Nyberg 2010; (t) You et al. 2006; (u) Jiang et al. 2002; (v) Peng et al. 2008; (w) Sorber & Moore 1987; (x) Kudva et al. 1998.		

4.3 Antimicrobial Resistance

Manure from livestock may contain antibiotics and similar drugs, also known as antimicrobial agents. Pathogens present in such manure typically have genetic traits for antimicrobial resistance; wildlife feces may also carry pathogens with antimicrobial resistance. This resistance can transfer to soil microbes, increasing the risk of *E. coli*, *Salmonella*, and other bacteria with low virulence traits becoming a health hazard by complicating medical interventions. Microbes that do not infect healthy people can sicken people with compromised immune systems, and antimicrobial resistance makes any illness more difficult to treat. The use of resistance-related antibiotics during initial treatments may allow symptoms and infection to worsen.

5: Conservation Practices That Influence the Reduction of Pathogens in Specialty Crops

Many specialty crop growers employ conservation practices in their efforts to protect water, air, and soil, as well as to support plants and animals. Understanding how some practices that contain vegetation, water or manure impact the fate and transport of pathogens is key in the co-management of food safety and conservation. Vegetation and water attract wildlife, and their presence near growing areas, while generally a low risk, may create co-management challenges. Managed correctly, manure is a beneficial component of the farm, but its high risk creates unique co-management challenges. Several conservation practices, as mentioned in NRCS' Conservation Practices Physical Effects worksheets, play a role in limiting the movement of pathogens across the landscape or in reducing their survival. The text below and supporting Tables in the Appendix (Tables 18, 20, and 22) describe how conservation practices may reduce pathogens in agricultural landscapes.

5.1 Water Management Practices That Encourage Pathogen Reduction

Vegetation may influence the fate and transport of pathogens in surface and groundwater. By acting as a physical barrier to pathogens carried in fecal matter, contaminated soil, or debris in runoff, vegetation may prevent pathogens from moving down slope to specialty crop production areas or surface waters. Organic matter in the soil, which supports diverse microbial populations that compete with and predate on pathogens, increases in the presence of vegetation. Soil structure and porosity also improves with vegetation, both of which increase water infiltration rates. The decreased pathogen presence and the improved infiltration reduce pathogen movement in surface runoff and to groundwater.

Wetlands

Constructed (NRCS Practice Standard 656), created (658), enhanced (659), and restored (657) wetlands may retain pathogens. Wetlands that allow water to move slowly through aquatic vegetation over long periods of time work best to decrease pathogen survival. Within the wetland, biotic and abiotic mechanisms—including predation, the release of antibiotics by other microbes, sedimentation, and multiple plant interactions—can contribute to pathogen reduction in water. Several explanations for the observation regarding the effect of vegetation have been offered: physical filtration, increased oxygen levels in the water column creating less favorable conditions for some pathogens, the presence of antagonistic rhizosphere interactions, adsorption of pathogens on biofilm-covered surfaces in contact with contaminated water. Root exudates of some aquatic plants may be toxic to some pathogens; conversely, these exudates may be a nutrient source to others.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Wetlands can be used to intercept and reduce waterborne pathogens.

Better interception of pathogens occurs in a constructed wetland than in a natural one due to less channeling and more uniform filtration. However, vegetation in a uniformly constructed wetland may decrease UV penetration whereas in natural systems with patchy vegetation, more UV radiation exposure may occur. When the water levels fluctuate, more susceptibility to UV radiation and desiccation may also occur to pathogens retained on vegetation above the water line. Large flocks of migrating waterfowl, runoff from adjacent lands, access by wildlife or domesticated animals, or other factors can cause water pollution in the wetlands at certain times of the year, possibly increasing pathogen loads and diminishing pathogen reduction mechanisms.

Vegetative Buffer Strips

Many livestock waste, pastureland, and riparian area studies have documented that vegetative buffers reduce bacteria and protozoan parasites. More recently, a study reported that vegetative buffers were important between produce farm operations and reservoirs of pathogens, such as livestock operations, ditches, and roads.

A review of 40 vegetative treatment systems found that efficacy depends on a good stand of dense vegetation with strong fall growth and well-established winter vegetative cover to provide optimum filtration. Regularly harvesting and removing excess vegetation alleviates the build-up of dense thatch layers, which may provide a moist, cool environment for pathogen survival and in some cases amplification. Grazing should not be used as a harvest option since the animals may contribute to the contamination. Uniform flow conditions are maintained by the prevention of channeling, and the traffic is minimized.

Filter strips (393), grassed waterways (412) and riparian herbaceous buffers (390) may reduce movement of pathogens in runoff, although regular harvesting that removes excess vegetation may be required for them to function optimally and to allow for desiccation of the pathogens. Other vegetative buffers such as riparian forest buffers (391), tree and shrub establishments (612), field borders (386), vegetative barriers (601), and conservation covers (327) may also intercept pathogens in runoff. When these practices contain taller woody vegetation, the understory herbaceous vegetation is less thick because of diffused light and root competition, which results in less capacity to intercept pathogens. However, unlike the herbaceous only buffers, these other practices would not become too thick and require regular harvesting of thatch to reduce the moist, cool conditions that support pathogen survival. Depending on the situation, it may be more appropriate to use vegetative buffers with woody vegetation, if regular harvesting is not possible.

Riparian buffers are critical because they may offer the last chance to filter pathogens in agricultural runoff before it enters waterways. The natural vegetation can reduce the momentum of surface runoff and can trap debris with pathogens. Steep-sided riparian areas and those compromised by bank erosion may require extra wide buffers and/or vegetation with deep root systems to help stabilize banks and provide more opportunity for effective riparian filtration.

Irrigation Water

Waterborne pathogens can be reduced by other practices besides those involving vegetation. Crop fields with recently applied manure or unfinished compost may harbor pathogens in the soil. By using irrigation water management (449) techniques, the water is applied at rates that minimize pathogen transport to surface and ground water.

Diversion

The use of a diversion (362), placed at approximate right angles to the slope with a supporting ridge on the lower side to capture runoff, can direct upland contaminated runoff from entering a specialty crop field. Diversions can also move water in agricultural waste systems.

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Terraced diversions, like the one pictured above, help divert potentially contaminated runoff water away from crop fields.

Sediment Basin

Sediment basins (350) help to trap sediments with attached pathogens in runoff, allowing them to settle out before reaching a waterway. In situations where soils are very porous, water that contains pathogens may infiltrate from the basin to groundwater. Care must be taken with the placement of excess sediments removed during catch basin cleaning. Since pathogens need moisture, allowing the sediments to dry out before removing them may support pathogen inactivation, although extended survival of low or localized populations is possible.

Waste Storage Pond

A waste storage facility (313) can temporarily store wastes such as manure, wastewater, and contaminated runoff that might otherwise pollute the watershed. If not managed properly, these ponds can leak or overflow.

5.2 Particulate Matter Management Practices That Aid in Pathogen Reduction

As Table 2 pointed out, windborne particulate matter may include desiccated fecal matter with viable pathogen cells, or pathogens adhered to dust, soil, or debris. Although NRCS does not currently recognize this as an air quality concern, it does address "fugitive dust." Mitigations used to minimize fugitive dust may provide the additional benefit of reducing pathogen transfer via air.

Dust Mitigation Practices

Specialty crop farms raising livestock in confined areas may need to reduce the generation of dust that could become a source of pathogens for crops. Air filtration and scrubbing (375) can help to capture fugitive dust particles in confined animal housing or other enclosed structures. Dust control for animals (371) can help to reduce particulate matter arising from animal activity on open lot areas, holding pens, corrals, working alleys, or other fugitive sources of particulate emissions. Practices can entail periodic manure harvesting and watering down areas of high animal activity. Managing animals on pasture with prescribed grazing (528) generates less dust and thus serves as an effective management tool to reduce the spread of pathogens.

Vegetation That Intercepts Fugitive Dust

Produce fields located close to livestock yards or adjacent to land with areas of high pathogen concentration (e.g., manure storage or uncovered compost) may benefit from vegetative barriers such as windbreaks (380), hedgerows (422), and riparian forest buffers (391) that intercept fugitive dust. Vegetative buffers can remove between 35% and 55% of downwind dust in the air. They work both by dropping particulate matter and by lifting dust into the upper air stream for greater diffusion. A preliminary study indicates that vegetative buffers similar to windbreaks significantly reduced the aerial transfer of pathogens between poultry houses. Use of plants not intended for human consumption reduces concern about the pathogens trapped in the plantings.

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In high wind situations, windbreaks surrounding the crop are sometimes needed to reduce the movement of fugitive dust.

When a vegetative buffer captures dust that contains pathogens, UV radiation may facilitate pathogen inactivation. Higher numbers of bacteria have been found on underside surfaces of leaves, suggesting UV radiation reduces survival on upper surfaces of leaves.

Canopy structure and leaf area influence UV penetration into the vegetation and may influence the fate of pathogens intercepted by vegetation. Dust deposited on vegetation may itself desiccate the pathogens; conversely, if enough moisture is present, it may serve to keep leaf surfaces moist and pathogens viable longer. Some evidence suggests that conifers work better than deciduous trees in high wind situations for providing dense foliage and interception. In the case of pesticide spray capture, the needle-like foliage of conifers captures two to four times more spray than broadleaves because the latter don't alter their leaf alignments in high winds.

5.3 Soil Management Practices That Influence Pathogen Reduction

Nutrient Management

Managing the amount, placement, and timing of manure applications through the nutrient management (590) practice helps to prevent harmful levels of pathogens from entering surface water and groundwater. Placing manure on fields that don't have significant runoff concerns, and limiting the amount of manure applied, reduces pathogen runoff. Thoroughly mixing manure with the soil may increase pathogen inactivation by exposing pathogens to desiccation, nutrient stress, and predation by native soil microbial populations, from which pathogens might be protected if they remain in intact clumps of manure.

Incorporating manure into the soil immediately (via injection or tillage methods) to reduce scavenging bird and fly contact with the manure may reduce risk. When feasible, given crop needs and land use options, applying manure in warmer, drier months may facilitate more rapid pathogen reduction as pathogens tend to survive longer in cool, moist conditions. Application on frozen ground may increase risk of pathogen runoff and wild bird exposure. If a rain event that may create runoff and erosion is forecast, or if high winds that may cause the production of pathogen-laden particulate matter are predicted, delaying the application can reduce the transfer waterborne and airborne pathogens.

Compost

Incorporating compost fosters long periods of pathogen inactivation due to its long-term effect of increasing microbial diversity in the soil from its slow release of nutrients. The composting facility (317) documentation can help in the planning and making of compost, and in preventing pathogens in unfinished compost from moving onto adjacent crop fields through wind or surface water or from polluting the groundwater.

Cover Crops and Crop Rotation

The planting of many types of cover crops (340) can greatly increase the activity and diversity of microorganisms in the soil. As mentioned in Section 3.2, soil microbial diversity is a major factor in decreasing pathogens through competition, predation, and antagonism. Some do have an antimicrobial effect on various microbes, including pathogens—for example, a mustard cover crop can reduce *Salmonella* pathogens. The use of conservation crop rotation (328) can also promote diverse soil microbial communities when organic matter is increased with high residue crops. Both cover crops and crop rotation can reduce dust and runoff that may contain pathogens from leaving the field.

5.4 Animal Management Practices That Help in Pathogen Reduction

Integrated Pest Management (IPM)

IPM (595) practices that use correctly placed raptor perches and owl boxes, rather than removing non-crop vegetation or using poison bait that may affect non-target animals, can help to reduce rodent populations that may carry pathogens. Management of refuge piles and other areas on the farm where rodents congregate, such as irrigation pipes stacked on ground, help to avoid population increases. Monitoring for rodents and other pests help to target suppression strategies that are used.

Wildlife Corridors
Because terrestrial wildlife may be in the growing environment, strategic use of wildlife corridors can help draw animals away from crop fields and reduce food safety risk. Many types of wildlife prefer to move in non-crop vegetation that provides their native food and a cover from predators. Giving wildlife access to a vegetated corridor may keep them from traveling through a crop field where they may cause unacceptable damage.

Prescribed Grazing
Prescribed grazing (528) can benefit widespread food safety goals. Grazing management encourages water infiltration and reduces runoff, both important since livestock may shed pathogens. Instead of concentrating animal feces in confined yards, grazing animals disperse their feces on landscapes managed to have a filtering capacity for any runoff that might make it to an irrigation source used by specialty crop growers. The dispersed feces are also subject to the sun's desiccation and UV radiation, which inactivates pathogens. However, there is very limited data available to base predictions of persistence under a diverse set of crop/soil/animal scenarios.

6: Multiple-Barrier Approach to Minimizing Food Safety Risk on the Farm and in the Watershed

Co-management of food safety and conservation objectives can be developed when keeping in mind what is known about pathogens and how they move and persist on the farm. Resource assessment and risk analysis are integral to farm planning. For optimum management, multiple barriers (blockades) reduce the number of pathogens transported in and around the farm environment. The multiple-barrier approach focuses on preventing pathogens from (a) entering the farm, (b) contaminating the crop, (c) spreading from livestock operations to the crop, and (d) moving out to the wider landscape where they may lead to contamination. If one barrier fails, others prevent contamination of crops and water supplies. Many of the barriers mentioned below in Tables 5—8 are also depicted in Figure 2.

Some of the management suggestions presented here, such as the value of composting to reduce pathogens, are based on benefits observed in well-controlled research. Other insight comes from the underlying understanding of functions known to affect pathogen fate and transport. For example, UV radiation can cause pathogen inactivation; therefore, practices that encourage the exposure of pathogens to sunlight and UV radiation may aid in reducing pathogen populations. Conservationists who assist growers with planning co-management practices should understand that growers must consider market factors when making management decisions. What works for a grower with one marketing outlet and a given set of regulatory pressures may not be acceptable to a grower in another set of circumstances.

6.1 Barriers That Intercept Pathogens at the Farm's Border

Conservation Practice Standards (CPS's) and Good Agricultural Practices (GAPs) as shown in Table 5 are barriers that filter or divert contaminated water, intercept fugitive dust and help to control non-native wildlife at the farm's perimeter. While the CPS's in the table are explained here and in the text of the three subsequent tables, the GAPs are more fully described since CPS's were covered in Section 5.

Table 5: Barriers That Intercept Pathogens at the Farm's Border

CPS's/ GAPs	*CPS Code(s)/ GAPs*	*# in Fig. 2*
I. Intercepting Waterborne Pathogen		
Conservation Cover	327	24
Critical Area Planting	342	
Diversion	362	3
Filter Strip	393	
Tree and Shrub Establishment	612	
Wetlands	656-659	5
II. Intercepting Particulate Matter with Pathogens		
Hedgerow	422	10
Windbreak	380	8
III. Discouraging Non-Native Feral Animals		
Deterring Feral Animals	GAP	
IPM	595	17

I. Intercepting Waterborne Pathogens

Vegetative buffer strips, diversions, and wetlands can be important management tools for intercepting waterborne pathogens at the farm's border. These conservation practices typically address runoff and flooding from livestock and wildlife waste, manured lands and manure stockpiles.

II. Intercepting Particulate Matter with Pathogens

Windbreaks and hedgerows placed along the farm's perimeter can intercept fugitive dust with pathogens blowing in from surrounding areas. This may be especially important when livestock are concentrated and manure is ground into the dust.

III. Discouraging Non-Native Feral Animals

Deterring Feral Animals

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Hawks and other birds of prey can help to frighten away pest birds, as well as reduce rodent populations.

Wildlife on the farm is inevitable, and in some cases desired. However, excluding non-native invasive animal species from the farm is good for conservation as well as for food safety. Non-native invasive species are the second major reason for biodiversity losses worldwide, and they sometimes carry pathogens. Controlling invasive species populations not only reduces potential food safety risks, but also opens up space for native species to thrive. Various non-toxic Integrated Pest Management (IPM) strategies exist for controlling populations of European starlings, house sparrows, rock pigeons, and Norway rats. Hawks and other birds of prey frighten away pest birds. Supporting healthy populations of predatory birds by installing perches and nesting boxes at the farm's border, or hiring falconers to visit the farm, can help disperse pest birds. Food safety GAPs recommend that nest boxes and perches be placed in locations that will not pose a food safety liability from bird droppings or leavings. Installing noisemakers and scare balloons may also frighten birds away. Placing food attractants in non-production edges of a farm may aid in keeping pests away from production fields.

Food safety GAPs recommend controlling rodent populations. Attracting raptors as mentioned above, as well as supporting healthy populations of terrestrial predatory wildlife, can help reduce the rodents. Removing features that attract rodents—brush piles, cull piles, puddles of standing water, and stacks of irrigation pipe—will also help. Installing vegetative cover to replace weedy annuals abundant with seeds that rodents may prefer can discourage these animals. The use of traps instead of poison baits near drainages and waterways will prevent water pollution.

Non-native feral pigs may present particularly challenging intrusion problems. Seeking out high-quality or favored food sources across broad territories, feral pigs may cause extensive damage by feeding on or trampling crops. They may also contaminate produce with their fecal matter. Food safety GAPs recommend trapping, hunting, or fencing feral pigs after obtaining proper permits. Temporary electrical fencing may dissuade less determined pigs, while short hog-wire fencing may be required in an area with a high population density. For added protection, running an electrified wire on the outside of the hog-wire fence, approximately 6 to 8 inches above the ground, may improve the fence's effectiveness. Feral pigs may travel up to 6 miles to reach a desirable forage opportunity. Close observation of movement patterns may help growers recognize food sources that attract feral pigs, allowing for efficient and effective fence placement.

6.2 Barriers That Reduce Likelihood of Pathogens Contaminating Specialty Crops

As shown in Table 6, there are many types of Conservation Practice Standards (CPS's) and food safety Good Agricultural Practices (GAPs) that help to reduce the possibility of crops becoming contaminated.

Table 6: Barriers That Reduce the Likelihood of Pathogens Contaminating Specialty Crops

CPS's/GAPs	***CPS Code(s)/ GAPs***	***# in Fig. 2***
I. Choosing Appropriate Sites		
Avoiding Nearby Contamination	GAP	22
Avoiding Frequently Flooded Land or Instituting a Waiting Period After Flooding	GAP	7
Planting Crops for Livestock	GAP	
Planting Fresh-cut Leafy Greens Away from Eroding and Sensitive Areas	GAP	
Avoiding Overhanging Vegetation	GAP	20
Avoiding Areas with Abundant Wildlife	GAP	21

I. Choosing Appropriate Sites

Avoiding Nearby Contamination

Food Safety GAPs recommend that land use history and environmental risk factors be considered before planting a crop. Areas near chicken pasture operations, sites adjacent to grazing livestock (including small numbers of horses, goats, or other non-working farm animals), and high-impact areas near troughs or water sources may require special consideration for risk mitigation. Fields next to large concentrated feeding operations present a higher risk because of the amount of manure and increased soil compaction that results in higher runoff rates. Increased risk may also occur near landfills, manure storage sites, and exposed compost facilities. The degree of risk depends on the proximity of the crops to the high-risk site, slope and direction of water flow, wind patterns, and environmental loading rate (if any) for pathogens. Large numbers of birds or insects moving from contaminated areas into cropped areas also increase risk of pathogen contamination.

Avoiding Frequently Flooded Land or Instituting a Waiting Period After Flooding

Lands that flood are often considered a higher food safety risk than areas not susceptible to flooding. Food Safety GAPs recommend that the flooded ground undergo a waiting period before it is considered safe for replanting. Risk from deposited sediment as well as saturation with waters of unknown quality are difficult to predict. FDA guidance, as well as many buyer guidances, cautions the use of flooded land without an adequate waiting period. Continual flooding may lead to lost productivity if an area must remain out of production for an extended period of time.

Planting Crops for Livestock

Farms that grow both specialty crops and animal feed can benefit from their operation's diversity by planting crops destined for livestock in areas of higher risk for pathogen contamination. For example, a grower who plans to plant hay or feed corn as well as specialty crops will plant the livestock feed rather than fresh-cut leafy greens next to a neighbor's cattle pasture. Choosing the location with the lowest risk of contamination can be an effective risk management strategy when growing specialty crops that will be eaten raw by consumers.

Planting Fresh-cut Leafy Greens Away from Eroding and Sensitive Areas

Produce buyers often perceive non-crop vegetation that may attract wildlife on the farm as a serious food safety threat. However, in many cases, conservation practices and natural habitat may actually help keep wildlife out of crop fields by providing an area of preferred food and shelter. Despite this, many produce buyers still require that specialty crops, especially fresh-cut crops such as salad mix, be separated from vegetative conservation practices and natural areas by bare-ground buffers, which incentivizes the removal of all non-crop vegetation. These requirements may pose significant challenges for on-farm conservation. The lack of non-crop vegetation in erosion-prone areas and along waterways with heavy nutrient and pesticide loading can cause significant impacts to the watershed. In some cases, configuring the crop fields so that roads serve as bare-ground buffers between crops and the conservation practice may satisfy food safety concerns. When markets demand the absence of conservation areas, planting the crop away from eroding and sensitive sites may alleviate some of the adverse impacts on soil, water, and wildlife resources.

Avoiding Overhanging Vegetation

Food safety GAPs recommend minimizing the risk of birds above row crops by reducing the likelihood that they will perch, roost, or feed in areas where their feces will fall on crops. Conservation practices that include trees, shrubs, or other vegetation may inadvertently attract and/or create perch areas for birds, thereby increasing the risk that birds will defecate into irrigation canals or on the crops below. Risk of fecal contamination can be reduced by not planting (or harvesting) crops directly under established vegetation. Mechanically harvested crops, such as baby spinach and spring mix, may also need to avoid physical hazards (i.e., acorns, stems) that could be included in the bagged product. Selecting conservation plants that have an upright instead of branching growth form can help minimize the loss of adjacent production area. Installing large branching trees and fruit bearing plants attractive to birds a distance away from specialty crops is another strategy to allow growers to balance conservation objectives with food safety risk management. Without non-crop vegetation, wild birds have been known to perch on anything they can find, including irrigation sprinklers positioned directly above the crop.

Avoiding Areas with Abundant Wildlife

Because wildlife is frequently drawn to vegetation and water, its presence in the farm landscape may create co-management challenges. Conservation planners can support co-management by helping growers understand how animals use these features, as well as how they move between conservation areas and crops. Animal intrusion into crop fields can be significantly reduced by taking wildlife movement patterns into account when planning crop-planting locations. Avoiding disruption of wildlife corridors allows animals to travel to needed resources without having to traverse crop fields. Avoiding locations with nearby frog habitat reduces entry of frogs into fields. This is especially important with certain crops, such as fresh-cut leafy greens, that are machine-harvested using blades that are close to the ground and are not as careful at avoiding small animals as with hand-harvests.

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Taking wildlife movement patterns into account when delineating fields reduces the need for wildlife to traverse through crops.

II. Preventing Pathogens from Coming in Contact with Crops:

Table 6 (continued)		
CPS's/GAPs	***CPS Code(s)/ GAPs***	***# in Fig. 2***
II. Preventing Pathogens from Coming in Contact with Crops		
a. Reducing Pathogens Through Animal Management		
Monitoring Animal Intrusion in the Crop	GAP	9
Deterring Wildlife	GAP	
IPM	595	17
b. Reducing Pathogens Through Water and Particulate Matter Management		
Sediment Basin	350	12
Diversion	362	3
Field Border	386	19
Grassed Waterway	412	
Hedgerows	422	10
Windbreak	380	8
Vegetative Barrier	601	
Monitoring Water Quality	GAP	
Irrigation Water Management	449	11
c. Reducing Pathogens Through Soil Management		
Nutrient Management	590	
Waiting Between Manure Application and Next Harvest	GAP	
Using Compost As an Alternative	GAP	
Compost Facility	317	23
Cover Crops	340	16
Conservation Crop Rotation	328	
Managing Contaminated Crop Sites	GAP	
Fostering Pathogen Desiccation in Soils and Sediment in Basins	GAP	12

a. Reducing Pathogens Through Animal Management

Monitoring Animal Intrusion in the Crop

Food safety GAPs recommend keeping animals out of the crop. Animal tracks, signs of feeding, feces in the crop, and downed fencing all signal that animals have passed through. Monitoring the crop itself for these signs and responding help prevent or minimize potential crop contamination. Monitoring adjacent habitat is unnecessary since signs found there are not an indication that animals are entering the crop. Many factors play into determining appropriate actions to reduce food safety risks to the crop, including the type and number of animals present; how long and with what frequency they enter the crop (Are they rushing through and eating a little or staying awhile and eating a lot? Has their presence been noted once or several times?); the purpose of their visit (Are they there because of food? Is this a movement corridor to water or food, including other crops or prey? Do they live next to the crop?); and when they are seen in relation to crop production schedules (Were they just seen before planting or did they appear right before harvest?). Monitoring may be especially important when factors such as drought or post-fire conditions lead to increased animal movement into crops.

Food safety GAPs recommend placing a no-harvest buffer around any contamination source in the field. No-harvest buffers are commonly established in operations, including those under the Leafy Green Marketing Agreement. Farm employees walk the fields and mark animal tracks and evidence of feeding or trampling, with the assumption that fecal contamination may be present but undetectable without extensive testing. Sometimes bare-ground buffers are used for easy monitoring of wildlife tracks, although these areas may be preferred passageways by some kinds of wildlife, and as mentioned above, there are natural resources concerns such as increased erosion associated with their use. It is common practice to use wire field flags of a specified color to mark off the no-harvest area, so workers harvesting the crop can easily identify them. The area of the buffer depends on many factors, such as whether feces landed nearby or contacted the crop, the size and type of the feces, whether rain or irrigation water has created a splash zone, and whether the harvestable portion of the crop grows close to the soil. Some GAPs recommend flagging a 5-foot radius around the contaminated area. For crops such as tree fruit and bush berries that do not have the harvestable portion close to the ground, food safety GAPs recommend that fruit with bird or other animal damage, or fruit on the ground, not be harvested.

Deterring Wildlife

If monitoring detects significant wildlife intrusion in the crop, actions will need to be taken. Many of the same non-toxic Integrated Pest Management (IPM) strategies used on non-native feral animals can be used for native wildlife. In addition, silt fencing may deter some types of small native wildlife such as ground squirrels and rabbits, which typically do not climb or enter something they cannot see over or through. Sprinklers activated by motion detectors, flashing red lights sensed as eyes, and judicious use of fencing may keep out larger wildlife. If fencing is deemed necessary, it should avoid obstructing wildlife corridors as much as possible, or should be placed around the crop fields rather than around the whole farm.

Frogs may present challenges for growers producing loose-headed lettuce or machine-harvested tender greens and tender-leaf culinary herbs. Some buyers suggest silt fencing around the perimeter of the crop to dissuade frog entry, but this strategy does not appear effective for fields immediately adjacent to water. As mentioned above, locating those crops away from frog habitat may reduce seasonal frog intrusion. Conservation planners should be concerned that some growers use copper sulfate to eliminate tadpoles in water bodies. Copper sulfate is typically used at low application rates to control algae growth in water bodies and is not labeled as an amphibian control product. Amphibians are in decline worldwide due to a multitude of challenges.

b. Reducing Pathogens Through Water and Particulate Matter Management

Vegetative practices within the farm can function as valuable barriers in protecting crops from waterborne and airborne contamination just as much as they can on the farm's border. On slopes that receive fresh applications of manure, vegetative terraces can reduce the runoff of contaminated water by allowing water to pond and infiltrate the soil. Diversions can catch and redirect the water away from the crop. Contaminated runoff flowing through grassed waterways may be filtered by the vegetation, and captured by sediment basins. Vegetative buffer strips adjacent to fields can intercept waterborne pathogens. Taller conservation plantings can intercept fugitive dust from compost and manure storage areas. Taking into account topography and prevailing wind patterns, conservation planners can help growers determine optimal placement of vegetation.

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Food Safety GAPs recommend that irrigation water meet good water quality standards.

Monitoring Water Quality

Food safety GAPs recommend that crops be irrigated with water that meets good water quality standards, and that the water be tested. The frequency of testing depends on past results, the type of crop grown and its harvest date. Streams, ponds, and basins that are managed to encourage clear water may allow more UV penetration, which may reduce pathogens. Maintaining low turbidity conditions may be particularly important in areas with high pathogen inputs, such as locations with contaminated runoff or sites where animals may contaminate water bodies. Low turbidity has the additional benefit of lessening the sediment load that could extend pathogen survival. Wildlife drinking from clean water sources will not pick up pathogens to later spread. Conservation planners can help growers with irrigation management to produce less runoff. They can also help develop a well-balanced nutrient management plan to reduce nutrient loads in drainage water systems. Together these management strategies decrease sediments and algae growth, which may support pathogen survival.

c. Reducing Pathogens Through Soil Management

Waiting Between Manure Application and Next Harvest

While incorporating manure in agricultural soils provides valuable fertility input, it may also present contamination risk. Food safety GAPs recommend and the USDA National Organic Program requires a waiting period between manure application and the next harvest to give the soil's indigenous microbial community time to inactivate pathogens. Nutrient management strategies that reduce the risk of using manure include managing the amount, incorporating it quickly and thoroughly, and timing applications based on season and predicted rainfall or high winds.

Using Compost As an Alternative

Food safety GAPs recommend that compost meet certain standards. When compost is made on the farm, specified composting procedures should be followed and documented. When purchased from a supplier, the compost should come with a certificate guaranteeing that it is free of pathogens. The use of the compost facility practice can help to keep the raw manure feedstuff, and the compost itself, from polluting air and water resources.

Composted manure is an excellent alternative to raw manure. To ensure that it heats up correctly, compost should have adequate moisture, a proper carbon to nitrogen ratio, and regular turning. During the heating process, high temperatures must be reached to reduce pathogens, but the compost should not get so hot that it kills off the compost's indigenous microbial community. This community helps to mitigate the growth of pathogens, should they be reintroduced. Adding compost to soil also supports soil conditions favorable for microbial populations, which in turn keep pathogen populations in check. While properly managed compost has the potential to reduce pathogen populations, care should be taken to limit moist conditions that could promote pathogen growth and to limit the reinoculation of pathogens into the finished compost.

Manure is considered a riskier compost feedstock, given that it is likely to contain pathogens. Non-manure compost feedstocks, such as green waste, may be less likely to contain pathogens. Caution should still be used, as it is possible for green waste to become contaminated with fecal material. Green waste may also contain other types of hazards, such as broken glass or heavy metals.

Some specialty crop buyers will not purchase crops produced on fields amended with raw manure. California's Leafy Green Marketing Agreement suggests a one-year waiting period between application of soil amendments with raw manure and the next crop. In these cases, conservation planners may be asked for assistance in implementing non-manure-based soil fertility practices, such as using nitrogen-fixing cover crops and non-manure-based composts.

Events that might introduce pathogens into a field include grazing, applying raw manure, spreading dredged sediments, flooding, or extensive fecal contamination by intruding animals. Planting cover crops after a contamination event allows for a longer waiting period between the contamination and the harvest of the next crop, giving more time for pathogen inactivation. This is especially important for higher risk crops such as fresh-cut leafy greens. A rotation of a low-risk crop (crops typically cooked or pasteurized before they are eaten) can also lengthen the time for pathogen die off. Cover crops and crop rotations limit the movement of pathogens in runoff water. Like compost, cover crops and rotations with high-residue crops increase soil organic matter and support robust soil microbial communities that may selectively exclude pathogens through predation, antagonism, and competition.

Managing Contaminated Crop Sites
When a large section of a crop is contaminated (e.g., through flooding or feces from a herd of feral pigs), it may be necessary to destroy that part unharvested. Since research suggests that pathogens may survive in the soil environment for an extended length of time following the incorporation of crop residues, mowing or undercutting the crop and allowing for desiccation of the plant material prior to disking and incorporation may allow for a reduction of pathogens. When a small amount of feces is found in the crop, after being cordoned off, as mentioned above, the feces is removed and disposed of out of the field or it is buried deeply.

Fostering Pathogen Desiccation in Soils and Sediment in Basins
Desiccation of pathogens contained in or on soil is a process that lends itself to management control. Allowing a crop field to fallow during the warm part of the year to dry out soils can reduce pathogen viability. Likewise, allowing sediment basins to dry as completely as possible provides pathogen control benefits. The design of a sediment basin can help drop sediments out of the water before they reach the main basin/pond. Designs that include a runway with a slight elevation decrease that is periodically cleaned out can have this effect. Trapping sediments in the runway makes them more susceptible to desiccation than if they fall out in the main basin. It also reduces sediment loads in the larger body of water. Although inactivation of pathogens may be hastened by drying periods, finer textured clay may retain sufficient water to support pathogen survival and may require more management to mitigate potential risk. Short intervals of wet/dry cycling may accelerate pathogen reduction in some soils.

In situations where specialty crop buyers will not purchase crops grown near non-crop vegetation because of the perceived threat of wildlife as significant food safety risks, water quality and soil erosion are concerns. The use of sediment retention basins to capture sediment and other contaminants before water is discharged to waterways can mitigate where significant areas of soil are bare. Since sediment basins themselves may be perceived to attract wildlife, developing an understanding of wildlife movement patterns around the site, and choosing vegetation to deter animal presence, can help. Depending on the wildlife present in the area, short vegetation in the sediment basin tends to dissuade mice, while tall vegetation tends to deter geese.

6.3 Barriers That Reduce Spreading Pathogens to Specialty Crops When Livestock Are on the Farm

The barriers shown in Table 7 can help to decrease the spread of pathogens to crops in diverse farm production systems that raise both crops and livestock.

Table 7: Barriers That Reduce Spreading Pathogens to Specialty Crops When Livestock Are on the Farm

CPS's/GAPs	***CPS Code/ GAPs***	***# in Fig. 2***
I. Livestock in and Near Production Areas		
Avoiding Contamination	GAP	
Prescribed Grazing	528	25
Waiting Between Fecal Deposits and Next Harvest	GAP	
Managing Animals Used for Traction	GAP	
II. Decreasing Pathogens Through Air and Water Management		
Air Filtration and Scrubbing	371	
Dust Control from Animals	375	2
Diversion	362	3
Waste Storage Pond	313	4
Using High Quality Water	GAP	
Hedgerows	422	10
Windbreak	380	8
III. Restricting Wild and Feral Animal Movement Between Livestock Areas and Crops		
Controlling Animals	GAP	
IPM	595	17

I. Livestock in and Near Production Areas

Avoiding Contamination

Placing food and water sources, as well as other features around which livestock generally congregate, away from specialty crop fields may help reduce the proximity of potential contamination sources to crop boundaries. Prescribed grazing can optimize infiltration and reduce runoff of water that may contain pathogens.

Waiting Between Fecal Deposits and the Next Crop

Animals that have access to crop production areas—livestock included as part of a pasture/crop rotation schedule or allowed to graze crop residues prior to the next planting—provide nutrients for crops while receiving sustenance. Food safety GAPs recommend a waiting period between fecal deposits and the harvest of the next crop, given that pathogen reduction in the soil takes time.

Managing Animals Used for Traction

Food safety GAPs recommend that when animals are included in crop management, such as growers using animal traction, standard risk assessment and management practices be developed to minimize contamination risk. These may include ensuring that no feces are deposited in the crop field after the crop has been planted, keeping animals distant from the crop, and avoiding moving animals through a production area close to harvest time.

II. Decreasing Pathogens Through Air and Water Management

When animals are confined in an area for any length of time, practices can be used to reduce fugitive dust and runoff containing pathogens.

Using High Quality Water

Food safety GAPs recommend that water from a waste storage pond should not be used to irrigate specialty crops typically eaten raw. This water is best used on crops grown for livestock.

III. Restricting Wild and Feral Animal Movement Between Livestock Areas and Crops

Controlling Animals

Animals that feed on livestock manure, or on the insects and seed found in it, may pick up the pathogens contained in manure. For this reason, Food safety GAPs recommend that measures be taken to reduce the presence of these animals if they have access to specialty crop fields. This recommendation also assumes that animal control measures will take place only after obtaining any necessary local, state, or federal environmental agency permits. IPM and other practices mentioned previously can be used. These measures serve to ensure that certain species of birds, rats, or feral pigs do not serve as mechanical vectors, tracking fecal matter from livestock feces, bedding, food, or water sources to crops or farm equipment. Tracking movement patterns and behavior of these animals can help land managers assess risk. Birds that are attracted in large numbers to a livestock operation for feed and water, who then perch on irrigation sprinklers or the crop itself, present a risk that must be managed.

6.4 Barriers That Prevent Pathogens from Leaving the Farm

In Table 8, the conservation practices shown can help to restrict pathogens from moving off the farm.

Table 8: Barriers That Prevent Pathogens from Leaving the Farm		
CPS's	***CPS Code(s)***	***# in Fig. 2***
I. Intercepting Waterborne Pathogens		
Filter Strip	393	
Riparian Forest Buffer	391	6
Riparian Herbaceous Buffer	390	
Sediment Basin	350	12
Wetlands	656-659	5

I. Intercepting Waterborne Pathogens

Many of the conservation practices that reduce the movement of pathogens onto the farm or into specialty crop fields can also be used to ensure that pathogens don't leave the farm to contaminate the larger landscape. Just as a wetland high up in the watershed can help to clean water before it reaches the farm, one may also help to treat runoff before it leaves the farm to possibly contaminate surface waters downstream. Sediment basins may function as one of the last barriers to capture pathogens in runoff on a farm that is not on a waterway, and riparian buffers make the last stand at reducing pathogens from entering streams. In this way, pathogen contamination risk reduction is practiced throughout specialty crop production systems.

USDA NRCS

Riparian buffers aid in reducing pathogens from entering waterways.

7: Converting Co-Management Knowledge to Action

7.1 Specialty Crop Food Safety Plans and Audits

It has become common practice for produce buyers to request food safety plans from the farms where they purchase produce. A food safety plan is the documentation and rationale of the management strategies a farm will take to address food safety risks. Major elements of any farm food safety plan include the personal hygiene of people on the farm, water purity and testing, use of soil amendments, land use history, neighboring issues, wild and domestic animals, and harvest. Food safety plans aid growers in proactively identifying and addressing food safety concerns to avoid making anyone sick.

Using the multiple barriers approach, conservation practices and GAPs are identified to address food safety risk on the farm and then translated into actions in the food safety plan—for instance, installing a diversion to redirect pathogen-laden water running off a livestock area so it does not contaminate a crop field, monitoring the diversion periodically, and taking corrective actions when necessary. These steps, along with the rationale that supports them, are written down in the food safety plan.

Many buyers also require a third-party food safety audit done either by a specific food safety auditor or by one chosen by the grower. If a grower sells to certain handlers, such as those in the Leafy Green Marketing Agreement, a third-party audit conducted by a specific government agency can be mandatory. The USDA Agricultural Marketing Service (AMS) offers food safety audits, as do some states. Many private auditing companies exist as well. Each auditing entity usually has a very specific checklist of GAPs and makes general observations. The purpose of the auditor's visit is to verify that the risk mitigation steps identified in the food safety plan are actually taken. Growers who fail to address mitigation steps or the record keeping identified in the plan lose points during the audit, resulting in mandated corrective actions. Losing too many points or having a critical major non-compliance will result in a failed audit.

The USDA AMS food safety audit, Harmonized GAPs (United Fresh Produce Association), and several other audit programs do not deduct points for the presence of non-crop vegetation near produce fields. However, the auditors of some food safety buyers will not allow a crop to be located near non-crop vegetation because of the perceived threat of wildlife intrusion. These buyers do not understand or do not accept current evidence about how conservation practices may help reduce food safety concerns. Growers can effectively advocate for their farming practices with food safety auditors by using risk assessment strategies outlined in the multiple-barrier approach and by explaining their rationale for management decisions that address those risks.

Conservation planners can assist growers by providing them with records of conservation practices that they helped plan or install. These records are documentation of expert conservation actions and do not constitute recommendations for food safety compliance by NRCS. Records can be kept with their food safety plans to show to their produce buyers, who in turn specify the acceptable audit scheme.

In addition to records, growers can provide their auditors with co-management training scenarios developed specifically for food safety auditors. These scenarios help explain how conservation practices work to address food

S. Earnshaw

NRCS planners can give growers records of conservation practices, such as a hedgerow or windbreak, so they can include them in their food safety plan.

safety concerns on farms or give examples of how auditors could respond to different risk situations. Two resources available are: The University of California's *Introduction to Auditor Resource Materials*, and Wild Farm Alliance's *Training Scenarios for USDA and Third Party Auditors on the Co-Management of Food Safety and Conservation as Well as Small- and Mid-Size Farm Concerns*. The latter publication offers USDA auditors continuing education units since many of them are not familiar with co-management concepts. These materials help growers address food safety without sacrificing responsible on-farm conservation measures.

7.2 Top Co-Management Concerns

Fostering public health is nothing new for conservation. Protecting natural resources and providing clean air and water thereby supports public health objectives. What has changed is the national focus on food safety and the perceived conflicts between wildlife habitat and food safety requirements.

Awareness, understanding, and management of on-farm food safety concerns in conjunction with conservation practices are evolving. Some buyers and food safety auditors who would formerly reject crops near conservation practices are now learning more about the value of conservation. Resource planners who assist growers in managing conservation practices with food safety in mind are helping to change that, but challenges still remain. While the food safety and conservation co-management strategies detailed in this document focus on pathogen reduction measures, not complete elimination strategies, they help growers reduce the risk of pathogen contamination in their specialty crops.

<u>Fundamental Co-Management Steps to Be Taken for Specialty Crops</u>

Grower:

1. Strategically selects crop and field location.
2. Monitors for wild and domestic animals in crop field.

Conservationist assists grower in developing a plan for:

3. Reducing pathogens through water management.
4. Decreasing fugitive dust with pathogens through particulate matter management.
5. Diminishing pathogens through soil and manure management.
6. Lessening contamination through animal management.

Grower:

7. Determines what other GAPs are required, such as further controlling wildlife and domestic animals, a waiting between manure applications and next harvest, and water testing.
8. Develops a food safety plan that incorporates co-management of food safety and conservation practices and actions.

The overwhelming majority of food-borne illnesses do not originate on the farm, but rather from any one of many sources or points along the supply-chain from farm to food preparation. This technical note provides an understanding of the fate and transport of food-borne pathogens and offers a systematic way to check for and address possible on-farm food safety concerns related to conservation. There is still much unknown in terms of looking at food safety from a reductionist perspective of single factors to seeing it from a holistic one. In general it is understood that conservation plays a vital role in farm production, food safety, and ecosystem functions. Specialty crop farms can manage for food safety and conservation without compromising natural resources.

Appendix I: Pathogens of Concern

Enteric bacteria naturally live in the healthy gut of animals and people and are necessary for good digestive health. Some enteric bacteria are pathogenic and if ingested may lead to gastrointestinal illness and, in some extreme cases, to life changing or fatal medical complications. This appendix focuses on four such bacteria—Shiga toxin-producing *Escherichia coli* (STEC), *Salmonella*, *Campylobacter*, and *Listeria* species—and a protozoan, *Cryptosporidium* species, which may also lead to severe gastrointestinal illness. These pathogenic bacteria are most likely to contaminate U.S. specialty crops from non-human sources (i.e., animals, water, soil, air). While the protozoan does not cause as many food-borne illnesses, it was included because of its unique survival strategy. The discussion that follows focuses on understanding attributes of each pathogen that may influence its fate and transport in the growing environment.

Escherichia coli species are present in the healthy animal gut and are frequently used as an indicator species to determine if fecal contamination has occurred. There are several types of pathogenic *E. coli*, among them Shiga toxin-producing *E. coli,* which may lead to severe and life-threatening Hemolytic-Uremic Syndrome (HUS), a disorder that occurs when the infection produces Shiga toxins that destroy red blood cells, causing kidney damage. Depending on the specific clinical symptoms of a patient's illness, an infectious pathogenic *E. coli* may be classified as a subset of Shiga toxin-producing *E. coli*—namely Enterohemorrhagic *E. coli* (EHEC). Other pathotoxigenic *E. coli* that do not cause HUS may also pose a serious risk to human health.

Among the Shiga toxin-producing *E. coli*, *E. coli* O157:H7 is a frequently identified strain in ill patients in the United States. However, numerous other strains may also be of human health concern and have been implicated in large outbreaks. Discussion of Shiga toxin-producing *E. coli* in this document is based on research that is predominantly focused on *E. coli* O157:H7, as this is the most frequently studied strain in the United States. Different strains of pathogenic organisms have been found to persist and behave differently both in the host and in the environment, so it is important to realize that more than one Shiga toxin-producing *E. coli* exists and all have unique characteristics that impact their virulence, survival, and multiplication.

Survival Outside the Host

Shiga toxin-producing *E. coli*, *Salmonella*, *Campylobactor*, and *Listeria* bacteria are well adapted to survive in the moist, anaerobic intestinal environments of their hosts, but all may survive outside their host as well. The protozoan parasite *Cryptosporidium* is likewise capable of surviving outside a host, and in fact may persist longer due to its ability to form an oocyst, a thick-walled spore that may survive for long periods of time. The oocyst may resist damage from environmental stressors such as desiccation, freezing, and scarce nutrient supplies more readily than bacterial cells. Survival times for pathogenic organisms outside of the host are highly variable and subject to environmental conditions as well as to specific characteristics of the pathogen.

Variable Expression of Traits

Several pathogens of human health concern have the ability to express a range of traits related to motility, virulence, and toxin production, among other factors. This variability impacts both direct human health risk and risk associated with pathogen survival outside of the host. For example, *Listeria monocytogenes* commonly occurs in the soil as saprophytic bacteria in decaying organic matter. When presented with certain environmental stressors, certain forms of *L. monocytogenes* may express varying traits influencing virulence, from wide-spread soil bacteria posing little human health concern to pathogenic bacteria capable of causing serious illness or death. *L. monocytogenes* can resist desiccation and grow in a wide range of temperatures and adverse conditions. *E. coli* bacteria also have a range of virulence factors that may or may not be active, leading to challenges in identifying risk presented by strains of the bacteria identified in the environment. For example, *E. coli* may carry but not express the genetic code to produce Shiga toxins.

Resistance to Antimicrobials

Antimicrobial resistance of pathogens is a human health concern because it is not only found in livestock and in soils with manure, but has also spread to wildlife. This resistance can be transferred among many types of soil microbes and can increase the risk of *E. coli*, *Salmonella*, and other bacteria with low virulence traits becoming a health hazard. Antimicrobial resistance makes any illness more difficult to treat. People with compromised immune systems, such as the young and the elderly, are particularly vulnerable. The Centers for Disease Control and Prevention (CDC), U.S. Food and Drug Administration (FDA), and World Health Organization (WHO) have recognized that human health and economic implications of resistance vary widely depending on antibiotics and pathogens of concern, and have concluded that feeding certain antibiotics to livestock for production purposes, to promote growth or increase feed efficiency, poses a public health problem.

Tables 9—13 give basic information about the pathogens considered in this document, including information about why each is considered important in food safety risk assessment in specialty crops.

Table 9: Pathogen Basics—Bacteria—Shiga toxin-producing *Escherichia coli*

Photo/ Description	**Forms of Most Concern for Human Health**	**Foods Associated with Illness**	**Additional Information**
 J. Haney Carr, CDC Rod-shaped, non–spore-forming gram-negative bacteria, facultative anaerobe	Common serotypes include O157, O26, O111, O103, O121, O145, and O45.	Commonly associated with beef, raw milk, and cheese; CDC recorded outbreaks in the following specialty crops: sprouts, leafy greens, hazelnuts, fresh spinach, apples, and grapes.	**Additional information:** ➢ Documented to survive freezing temperatures in soil. ➢ Survives better in sand, sediments, and soil than in water, but is relatively well adapted to survive in water (compared to other enteric pathogens). ➢ Appears to be less sensitive to UV radiation inactivation than *Campylobacter* or *Salmonella.* ➢ May survive and amplify outside the host.

Table 10: Pathogen Basics—Bacteria—*Salmonella* spp.

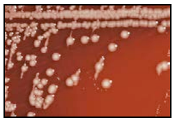
Photo/ Description	**Forms of Most Concern for Human Health**	**Foods Associated with Illness**	**Additional Information**
 CDC Rod-shaped, non–spore-forming gram-negative bacteria, facultative anaerobe	*Salmonella enterica* subsp. *enterica, found in* "warm-blooded" animals, is the most common cause of food-borne illness in the United States. While "cold-blooded" animals carry different types of *Salmonella*, all must be considered dangerous.	Commonly associated with chicken, eggs, and domestic turkey; CDC recorded outbreaks in the following specialty crops: peanut products, sprouts, cantaloupes, peppers, pine nuts, pistachios, mangoes, tomatoes, potatoes, onions, watermelons, leafy greens, blueberries.	➢ Widespread in the environment. At least some serotypes appear to be more resistant to environmental stressors and can resist inactivation by desiccation, starvation, freezing, and UV radiation better than some other pathogenic bacteria. ➢ Appears to be intermediate in its sensitivity to UV radiation in aquatic environments (more sensitive than *E. coli* but less sensitive than *Campylobacter*). ➢ Research indicates apparent ability to colonize plant surfaces. ➢ May survive and amplify outside the host.

Table 11: Pathogen Basics—Bacteria—*Campylobacter* spp.

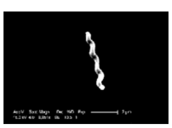
Photo/ Description	**Forms of Most Concern for Human Health**	**Foods Associated with Illness**	**Additional Information**
 J. Haney Carr, CDC Spiral-shaped gram-negative bacteria, micro-aerophilic facultative anaerobe	*Campylobacter jejuni* Many animals are susceptible to the infection of other *Campylobacter* subspecies, some of which are not typically found in human patients.	Chicken and other fowl are the most frequent source of contamination. Human illness most likely as sporadic cases (not outbreaks) leading epidemiologists to theorize that cases may be caused by cross contamination of produce with raw meat during meal preparation. CDC recorded outbreaks for the following specialty crops: leafy greens, root vegetable (unspecified), and tomatoes.	➢ Thermophilic organism with limited growth below approximately 30^{o} C (86^{o} F), though it may survive longer at lower temperatures (< 10^{o} C; 50^{o} F). May be damaged by freezing temperatures. ➢ Fairly vulnerable to inactivation by a range of environmental stressors; tends to be less persistent than *E. coli* O157:H7, *Salmonella* spp., *Listeria* spp., or *Cryptosporidium* spp. outside of the host. ➢ Appears to be highly vulnerable to inactivation via UV radiation. ➢ Protozoa may internalize *Campylobacter* and extend survival. ➢ Does not appear to amplify outside the host.

Table 12: Pathogen Basics—Bacteria—*Listeria* spp.			
Photo/ Description	**Forms of Most Concern for Human Health**	**Foods Associated with Illness**	**Additional Information**
 CDC Rod-shaped, non–spore-forming gram-positive bacteria, micro-aerophilic facultative anaerobe	*Listeria monocytogenes*	Commonly associated with turkey, processed meats, soft cheeses, raw milk and products made from it. CDC multi-state recorded outbreak for the specialty crop cantaloupe.	➢ Two forms, one a benign saprophytic bacterium in the environment, but when virulence genes activated, becomes pathogenic. ➢ Has strong resistance to desiccation, can grow in wide range of temperatures, including those commonly found in refrigerators. ➢ Nutrient limitations can induce starvation survival response in *Listeria monocytogenes* that enables long-term viability under environmental stress. ➢ Protozoa may internalize *Listeria* spp. and extend survival. ➢ May survive and amplify outside the host. ➢ Appears to persist in manure longer than *E. coli* O157, *Salmonella,* and *Campylobacter.*

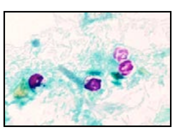
Table 13: Pathogen Basics—Protozoa—*Cryptosporidium* spp.			
Photo/ Description	**Forms of Most Concern for Human Health**	**Foods Associated with Illness**	**Additional Information**
 CDC Single-celled protozoan of the Phylum Apicomplexa	*Cryptosporidium parvum* and *C. hominis* (previously C. *parvum* genotype 1) are most frequently implicated in human illness. *C. canis* from dogs, *C. felis* from cats, *C. meleagridis* from birds, and *C. suis* from pigs may cause human illness, although they appear to be better adapted to their hosts and rarely affect people.	CDC recorded outbreak for one specialty crop, apples.	➢ Can't grow or replicate outside of host, but may persist in the environment as an infectious life stage (an oocyst) for a long time and remain capable of infecting a new host when ingested. ➢ Since it does not replicate outside the host, outbreaks where many people get sick are rare, and individuals are more at risk. ➢ Not all species infectious for humans. ➢ Oocysts may be filtered and retained in sediments; type of oxide coatings on sediment particles and nature of particles influence effectiveness of retention.

Table 9—13: Atwill et al. 2012; Brandl 2006; Byappanahalli et al. 2006; Center for Disease Control 2012; Czajkowska et al. 2008; Desmarais et al. 2002; US FDA 2012; Guan and Holley 2003; Hilton et al. 2002; Jiang et al. 2002; Kudva et al. 1998; McElhany and Pillai 2011; Nicholson et al. 2005; Sinton et al. 2007; Snelling et al. 2005.

Appendix II: Prevalence of Pathogens in Wild and Domestic

Evolving methodologies in collecting, analyzing, and reporting data, and the difficulties inherent in interpreting research results make precise risk analysis difficult. Nevertheless, the data are a useful element of risk analysis used to guide management decisions. The discussion of livestock and wildlife pathogen sources in Appendix II is not meant to be all encompassing, but rather to show the diversity of studies mainly occurring in the United States.

The current food-borne pathogen data on animals around the country and the world reflect snapshots of research in a range of settings and animal populations, rather than comprehensive understanding of pathogens in the environment, because thorough study is very difficult and expensive. Research has focused on assessing relationships between human illnesses and livestock, between human illnesses and wildlife, and increasingly on how wildlife and livestock may share pathogens. Wildlife science literature has also examined pathogens found in animal feces through wildlife surveys, and to a lesser extent how pathogens influence wildlife mortality rates. Before reviewing the information from current pathogen prevalence data, it is helpful to understand what the data measure, how they are collected, and their limitations.

Pathogen loading rate, prevalence, and sampling challenges

- Environmental loading rate of pathogens on the landscape is the most useful information for food safety risk analysis. It considers not only prevalence (percent of an animal population sampled that tests positive for a pathogen), but also the amount of pathogens per gram of an animal's feces, the amount of feces excreted per day by each animal, and population density. This type of data is currently scarce for wildlife species in particular.
- Prevalence data in this Appendix show percent of samples in which the target pathogen was found. Many studies have small sample sizes, and caution must be used when inferring risk from these small sample size prevalence rates; both 1/10 and 100/1000 positive test results will yield a prevalence rate of 10%, but the latter may provide more insight into environmental load of the pathogen and risk from the animal in question. Interpretation of data may be further complicated by the fact that total population size is often unknown, so it is not possible to know how well the population has been represented in any sample size.
- Unless samples are collected directly from the animal, it is not clear whether each fecal sample reflects an individual or one of multiple samples from a single individual.
- Samples collected from an animal's gut, mouth, skin, and blood are more reliable than feces collected from the ground, where they may have been contaminated by other animal, wind, or water pathways.
- Studies often only determine presence or absence instead of quantifying the amount of pathogen.
- Ease of pathogen detection increases with larger animals because ample samples may be collected from large fecal deposits.

Animal stress, age and immunity, and habitat

- Seasonal stress of some animals may result in the variability of pathogen shedding rates.
- Resistance to some diseases, such as *Salmonella*, *Campylobacter*, and *Cryptosporidium*, may increase as the animal host ages, perhaps due to immunity that is built from past exposure.
- If an area has a high background level of pathogens in the environment, animals in that region may reflect a similarly high pathogen load.
- Young animals tend to shed more pathogens than adults; for example, calves shed more than cows.

Human pathogens versus animal pathogens

- Improvements in pathogen testing methods now allow DNA fingerprinting to precisely identify pathogen serotypes implicated in human illness. Earlier work did not have this ability, and may have inaccurately identified certain organisms as pathogens of human concern, though it is now known they are adapted to specific animal hosts and present little risk to humans. This may be particularly relevant for pioneering *Cryptosporidium* studies. Thus, it is important to understand the methodology when reviewing literature or developing new research programs.
- Conversely, while some *Salmonella* studies report that pathogens are uniquely adapted for animal hosts, more recent work suggests they are also capable of infecting humans. Thus, unique adaptation to animal hosts does not exclude the possibility of human virulence unless research has specifically investigated that aspect.
- Many pathogen studies report all strains that may be able to infect humans, even in the absence of epidemiological studies showing that they have made people sick. This may be occurring in part because the pathogens may be evolving faster than research can identify them.

Pathogen presence, degree of activity, and fitness

- Before improved recovery and detection technologies and DNA fingerprinting, some studies may have under-reported pathogen presence.
- Other pathogens have been under-reported because of physician sampling, lack of illness reporting by sick people, lack of use of reporting systems, and pathogen sub-types not being included on mandated public health reporting lists.
- Modern genetic testing procedures determine if presumptive virulence gene(s) or a diagnostic pathogen marker gene(s) is (are) present, not if it is alive, in an inactive state, or dead. Non-viable pathogens, and/or remnant DNA of pathogens that were previously present, do not present risk, though they may help scientists understand pathogen pathways. In environmental samples, due to the low abundance, an enrichment step is generally required prior to detection, which virtually assures viability in PCR (Polymerase Chain Reaction) tests. This is often followed by cultural confirmation.
- Differential fitness among pathogens in competition with different background microbiota present in a sample can also impact pathogen growth sufficient to allow molecular detection and/or culturability.

A.II.1 Prevalence of Pathogens in Wildlife

Figures 4—7 present a snapshot of prevalence data in a range of animals from documented wildlife studies. The data were selected for inclusion if the animals were in the United States; the number of animals sampled was at least 25; the samples were taken from the animal itself, not off the ground; the animals did not die of a disease; and the animals were not farm-raised or in a zoo. This data may or may not mean that populations of the same species in other areas will show similar percentages of pathogens. Pathogen prevalence data is an area of active research, with increasing emphasis on collecting companion data to facilitate better understanding of environmental loading rates and pathogen pathways in the landscape.

E. coli *Pathogen Sources*

Prevalence of *E. coli* O157:H7 pathogens in native and non-native feral animals in the United States is depicted in Figure 4. The animals were in association with cattle in all but four of the studies (c, d, g, and p). No black-tailed deer in California coastal counties or white-tailed deer in Texas were found with *E. coli* pathogens, even though cattle and sheep were detected with the pathogens in the latter study. White-tailed deer in Louisiana and in the northeastern and southern states were found with a low *E. coli* pathogen prevalence, as were cattle in the south, although the *E. coli* had different genes encoding Shiga toxins.

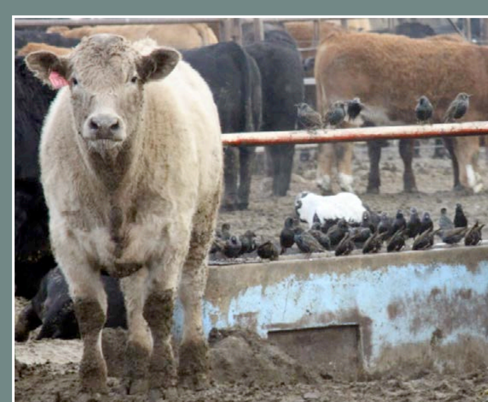
Other deer studies reporting animals without *E. coli* pathogens in California, and with them in Idaho, Kansas, and Nebraska were not shown in Figure 4 because of unacceptable data collection parameters. A link between pathogenic *E. coli* illnesses, strawberry consumption, and deer feces found on an Oregon strawberry farm was made with DNA fingerprinting techniques (see Table 3 Recorded Outbreaks Associated with Wildlife).

E. coli pathogens were also found in a few coyotes, tule elk, and a deer mouse (see Figure 4), but not in other rodents or various other wildlife (opossums, rabbits, skunks, ground squirrels, mice, or raccoons) in California Coast farmlands and rangeland. No *E. coli* pathogens were found in rodents in dairies and cattle feedlots in the Northwest.

Links between rodents and cattle have been established in European studies. *E. coli* strains with multiple antimicrobial resistances were detected in wild rodents originating from areas with high livestock density in Germany, suggesting a possible transmission from livestock to wild rodents.

Feral pigs were found with *E. coli* pathogens in California Coastal Counties in three studies (Figure 4), one of which also detected prevalence in about one-third of the cattle present. Although the definitive source of *E. coli* O157:H7 in the California 2006 spinach outbreak was never determined, feral pigs, cattle, pasture soil, water, and sediments were suspected. These non-native pigs may share the pathogens directly with the cattle, or indirectly through contaminated water and soil. Because they tend to preside in riparian areas and exist in high populations in this region, they may increase the spread of these pathogens through waterways.

Numerous bird species that frequent feedlots and farms with livestock have been found positive for food-borne pathogens, leading to speculation about the role of birds in the transfer and dissemination of this pathogen from livestock. Eight of the studies (Figure 4: a, f, j, k, l, m, n, o) looking at birds were conducted at cattle feedlots, dairy farms, or on rangeland and nearby produce fields to determine if birds acted as a significant carrier of *E. coli* pathogens, and two of those studies established that antibiotic resistance had developed in the pathogens found. European starlings near an Ohio dairy farm were found with *E. coli* O157, while those near a Kansas cattle feedlot were not in one study but were in another. One pigeon tested positive for *E. coli* O157 near a Wisconsin dairy farm, but the European starlings, sparrows, or turkeys also present did not. Rock pigeons near Colorado dairy farms were not found with *E. coli* pathogens, but *E. coli* virulence characteristics were detected. In California cattle ranches and nearby produce fields, American crows and brown-headed cowbirds were found with *E. coli* pathogens, but a large number of bird species (perching birds and wild geese) tested negative for *E. coli* pathogens in this region. Tundra swans tested negative for *E. coli* pathogens in Alaska. *E. coli* antibiotic resistance was reported in the gut flora of natural populations of Yellow-headed blackbirds in North Dakota (not shown).



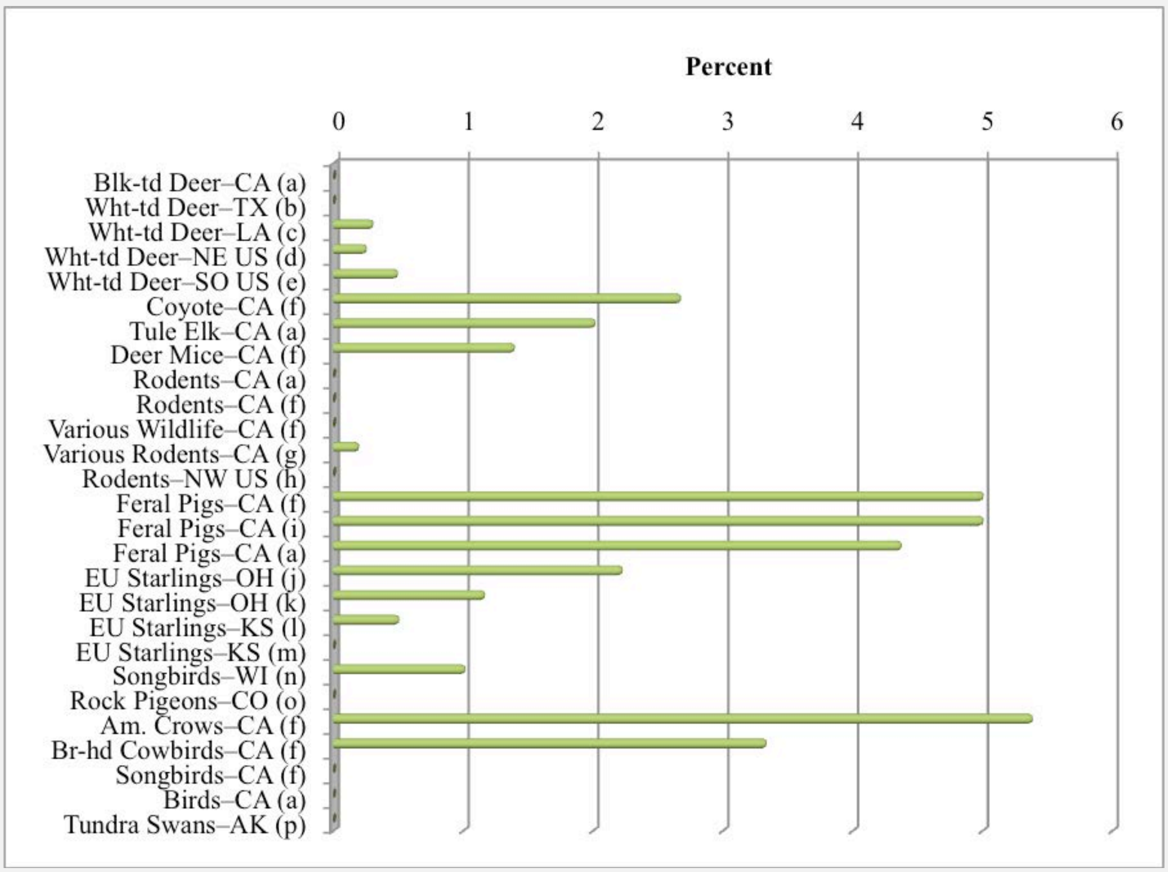
USDA APHIS

Birds that frequent farms with livestock have been found to test positive for pathogenic E. coli *and* Salmonella.

Figure 4 does not show invertebrate data. Of all the invertebrates, flies are most often associated with spreading diseases, especially since they are attracted to manure as a food source and developmental site, and can contaminate animal and human food through regurgitation, fecal deposition, or mechanical transfer. Flies collected at Midwestern state agricultural fairs where livestock were exhibited were found with *E. coli* pathogens. In Kansas, house flies in a cattle feedlot were found to carry antibiotic resistant *E. coli* pathogens, which they passed on to cattle, causing the researchers to conclude that flies play a role in disseminating the pathogen among animals and the surrounding environment. In California, flies were found to carry multiple strains of *E. coli* pathogens and may be able to transfer viable cells to spinach leaf surfaces. On the other hand, black soldier fly larvae were found to reduce the incidence of *E. coli* in dairy manure.

Other kinds of invertebrates have been the subject of *E. coli* pathogen tests. Slugs in a Scottish sheep ranch were found to carry *E. coli* pathogens. While bees weren't tested, a study showed how they tended to avoid flowers inoculated with *E. coli* pathogens. Bee propolis has toxicity factors that reduce survival of those pathogens that might make it to the hive.

Figure 4: *Percent of U.S. Native & Non-Native Mammal Colon and Avian Cloacal Swab/Tissue Samples with* E. coli *0157:H7 Pathogens*



From: (a) Gordus et al. 2011; (b) Branham et al. 2005; (c) Dunn et al. 2004; (d) Renter et al. 2001; (e) Fischer et al. 2001; (f) Jay-Russell et al. 2010; (g) Kilonzo et al. 2013; (h) Hancock et al. 1998; (i) Jay et al. 2007; (j) LeJeune et al. 2008; (k) Williams et al. 2011; (l) Gaukler et al. 2008; (m) Gaukler et al. 2009; (n) Shere et al. 1998; (o) Pedersen et al. 2006; (p) Milani et al. 2012.

The data presented in this figure were included if the animals were in the United States; the number of animals sampled was at least 25; the samples were taken from the animal itself, not off the ground; the animals did not die of a disease; and the animals were not farm-raised or in a zoo.

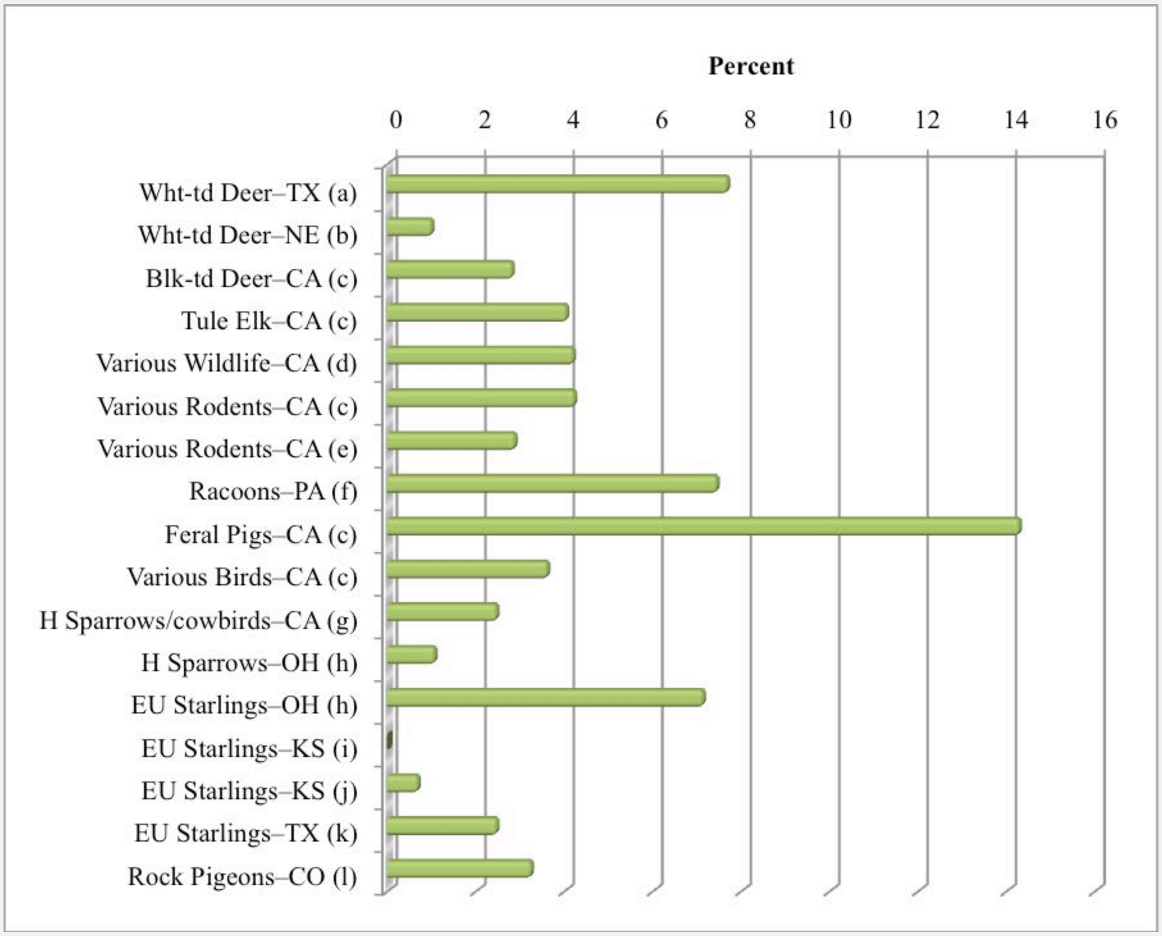
Salmonella *Pathogens in Mammals and Birds*

Figure 5 depicts prevalence of *Salmonella* in native and non-native animals in the United States. *Salmonella* was detected in white-tailed deer in Texas where they shared rangeland with sheep that had the similar pathogen levels, and in white-tailed deer in Nebraska. Some black-tailed deer and a few tule elk were found with *Salmonella* in California Coast farmlands and rangeland, as were various wildlife (coyote, skunk, opossum) and various rodents (deer mice, house mice, black rat, and ground squirrels). No *Salmonella* was detected in rabbits or raccoons in the California study, although raccoons have been found with *Salmonella* in Pennsylvania. Feral pigs roaming cattle rangeland and occasionally in produce fields of California were detected with a higher prevalence of *Salmonella*.

Salmonella bacteria are found in birds, especially in scavenging or carrion-eating birds such as crows and gulls. Others birds are more susceptible, such as the perching birds that died from *Salmonella* in very large numbers at bird feeders in Great Britain (not shown). It is suggested that the prevalence is low in healthy perching birds because its presence would otherwise soon mean death.

Another study included in Figure 5 found that while a great number of bird species near cattle ranches and produce fields in California tested negative for *Salmonella*, there were various perching bird species that tested positive. House sparrows and brown-headed cowbirds had low prevalence of *Salmonella* near California dairies, while the cattle had much higher levels. In an Ohio study, house sparrows and European starlings were found with *Salmonella* at sites on or near dairy, poultry, or swine farms, or near human populations. European starlings were detected with antibiotic resistant *Salmonella* in one Kansas feedlots study but not in another. While starlings were found with low prevalence in Texas cattle feedlots, it was thought that the contamination of both the cattle feed and water troughs was significantly related to numbers of starlings present. Rock pigeons near Colorado dairy farms were found with *Salmonella* more often in the summer and fall than the winter.

Figure 5: *Percent of U.S. Native & Non-Native Mammal Colon and Avian Cloacal Swab/Tissue Samples with* Salmonella *Pathogens*



From: (a) Branham et al. 2005; (b) Renter et al. 2006; (c) Gordus et al. 2011; (d) Gorski et al. 2011; (e) Kilonzo et al. 2013; (f) Compton et al. 2008; (g) Kirk et al. 2002; (h) Morishita et al. 1999; (i) Gaukler et al. 2008; (j) Gaukler et al. 2009; (k) Carlson et al. 2011; (l) Pedersen et al. 2006.

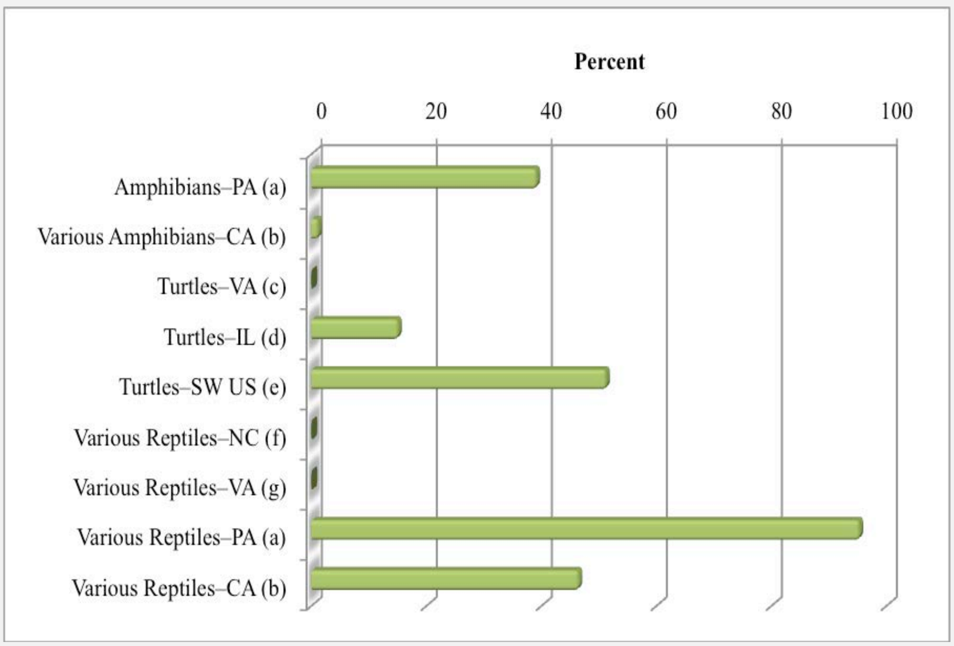
The data presented in this figure were included if the animals were in the United States; the number of animals sampled was at least 25; the samples were taken from the animal itself, not off the ground; the animals did not die of a disease; and the animals were not farm-raised or in a zoo.

Salmonella *Pathogens in Amphibians and Reptiles*

The amphibian and reptile research data in Figure 6 is shown separately from the other wildlife research in Figure 5 because it is not known how many of the "cold-blooded animal" *Salmonella* serotypes presented in this data are harmful to humans. All are assumed to be a risk, even though most cases of human illness arise from one "warm-blooded" type—*Salmonella enterica* subsp. *enterica.*

In nature, free-ranging amphibians were found with much more *Salmonella* in Pennsylvania than in California. Wild turtles in Virginia were absent of *Salmonella*, whereas those in Illinois and especially in the Southwest had higher prevalences. Various free-ranging reptiles in North Carolina and Virginia were not found with *Salmonella*, but others in Pennsylvania were. Various reptiles in California were detected with *Salmonella*. The large range of prevalence may be indicative that the higher occurrences of this pathogen are related to other contamination in the landscape. Reptiles are usually asymptomatic carriers, although once other diseases take hold, *Salmonella* can be a significant opportunistic pathogen contributing to their demise.

Figure 6: *Percent of U.S. Native Amphibian and Reptile Cloacal/Skin Swab/Tissue Samples with* Salmonella *Pathogens That May Have the Potential to Infect Humans*



From: (a) Chambers and Hulse 2006; (b) Gorski et al. 2013; (c) Brenner et al. 2002; (d) Readel et al. 2010; (e) Gaetner et al. 2008; (f) Saelinger et al. 2006; (g) Richards et al. 2004.

The data presented in this figure were included if the animals were in the United States; the number of animals sampled was at least 25; the samples were taken from the animal itself, not off the ground; the animals did not die of a disease; and the animals were not farm-raised or in a zoo.

Campylobacter, Cryptosporidium *and* Listeria *Pathogens*

Figure 7 depicts the prevalence of *Campylobacter* and *Cryptosporidium* pathogens in native and non-native animals in the United States. *Campylobacter* was detected in both the gastrointestinal tract and the oral cavity of feral pigs in produce fields and on rangeland with cattle in California Coastal Counties. In this same area (not shown in the figure), additional feral pigs and some native wild animals (birds, raccoons, coyotes), cattle, and goats were reported with *Campylobacter,* but not other wildlife (deer, skunks, squirrels, and deer mice). Migratory waterfowl was found with *Campylobacter* in Colorado, and Canada geese were detected with antibiotic resistant *Campylobacter* in North Carolina.

It is worth mentioning that deer, raccoons, elk, skunks, squirrels, and California gulls have been found with *Campylobacter*, although they were not shown in Figure 7 because of unacceptable data collection parameters. Most of *Campylobacter* serotypes found in the gulls in the last study were not closely related to species commonly associated with human illness. A direct relationship between ill persons who consumed peas in Alaska and *Campylobacter* pathogens found in sandhill crane feces was established with DNA fingerprinting techniques (not shown; see Table 3 Recorded Outbreaks Associated with Wildlife). *Campylobacter* was detected in flies, slugs, and ruminant feces that were collected from a single farm in Scotland over a 19-week period (not shown).

Feral pigs tested positive for *Cryptosporidium* in the California Coastal Counties, as did deer mice in two other studies (Figure 7). A thorough analysis was conducted in the deer mice study by calculating the environmental loading rate of the animals using the number of positive animals, daily fecal shedding rate, and the estimated population. This type of analysis can be most helpful with determining risk. As previously mentioned, most studies are only determining the prevalence in the animals.

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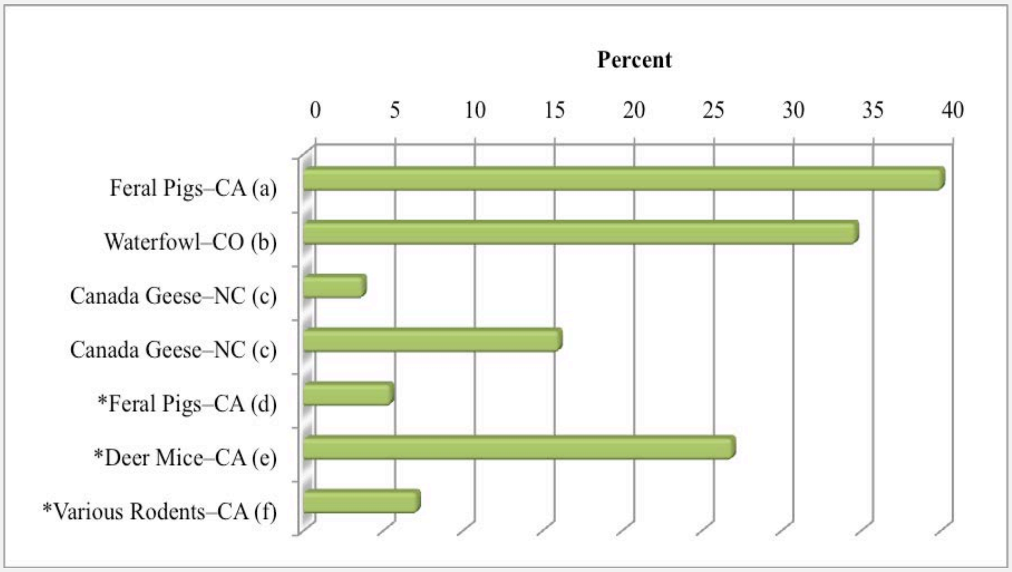
A study conducted in California suggests that a reduction in rodent species diversity may cause increased pathogen prevalence in the individuals that remain.

In the California 'various rodents' study (Figure 7), it was suggested that control efforts that potentially reduce biodiversity, such as non-crop vegetation clearing and indiscriminate poison baiting, might also decrease the diversity of rodent species. When diversity decreases, interaction between individuals of the remaining species increases, which may cause an increase in pathogen prevalence in those individuals.

Not shown in Figure 7 were incidences of *Listeria* detected in Roosevelt elk in California, fox in Illinois, raccoon in Connecticut, skunk in North Dakota, and a preliminary report of wildlife with *Listeria* in New York. Deer, moose, voles, mice, muskrats, shrews, otters, raccoons, and geese and other wild birds have been found with *Listeria* in Canada. Rooks were detected with *Listeria* in Sweden, Finland, and Germany, and crows in Japan.

Figure 7: *Percent of U.S. Native and Non-Native Mammal Colon and Avian Cloacal Swab/Tissue Samples with* Campylobacter *and* Cryptosporidium* *Pathogens*



*** Indicates *Cryptosporidium* studies.**

From: (a) Jay-Russel et al. 2012; (b) Luechtefeld et al. 1980; (c) Rutledge et al. 2010; (d) Atwill et al. 1997; (e) Li et al. 2012; (f) Kilonzo et al. 2013.

The data presented in this figure were included if the animals were in the United States; the number of animals sampled was at least 25; the samples were taken from the animal itself, not off the ground; the animals did not die of a disease; and the animals were not farm-raised or in a zoo.

A.II.2 Prevalence of Pathogens in Livestock

Food-borne pathogens can be present in livestock, often at higher rates than in wildlife. While the research regarding food-borne pathogens in livestock is extensive, Tables 14, 15 and 16 present snapshots of prevalence. These examples include *E. coli*, *Salmonella*, and *Campylobacter* in dairy and beef cattle, swine, and chicken layers and broilers. Some of the data looks at prevalence between livestock operations, and other data reports prevalence in the animals themselves.

Table 14: Examples of Research Investigation *E. coli* Prevalence in Cattle and Cattle Feces in Different Cattle Management Systems

Location	What the Research Examined	Cattle Management System	Prevalence Data
Wisconsin (a)	Prevalence of *E. coli* O157:H7 in calves (< 4 months) in dairy operations.	dairy	7.1% (5 of 70) of dairy farms tested positive and 1.8% of fecal samples from calves tested positive (10 in 560 calves).
Northwest United States (b)	Prevalence of *E. coli* O157 in fresh cattle fecal pats.	feedlots & dairies	100% (12 of 12) farms had herds tested positive for *E. coli* O157. Within the herds, 1.1%–6.1% of fecal samples tested positive.
The Netherlands (c)	Prevalence of *E. coli* O157 in dairy cattle feces. Samples obtained by rectal retrieval in dairy operations.	dairy	70% (7 of 10) of dairy farms tested positive for verocytotoxin producing *E. coli* O175. Within positive herds, the proportion of infected cattle varied from 0.8% to 22.4%.
California (d)	Prevalence of *E. coli* O157 in cattle feces. Samples collected from the animals or from the interior of freshly deposited feces.	cow-calf ranches	62.5% (5 of 8) ranches tested positive for *E. coli* O157. Within positive ranches, 0.7%–10.1% of fecal samples tested positive.
Switzerland (e)	Prevalence of *E. coli* O157:H7 in cattle.	dairy	25% (15 of 60) organic dairy farms and 17% (10 of 60) conventional dairy farms tested positive for *E. coli* O157:H7.
Midwestern United States (f)	Prevalence of *E. coli* O157 in lots of beef cattle originating from a single ranch or feed lot. Samples were obtained from colorectal tissues collected during processing.	beef processing facility	72% (21 of 29) of cattle lots tested positive for enterohemorrhagic *E. coli* O157. Within the positive lots, 7.7–100% of fecal samples tested positive.
Canada (g)	Prevalence of *E. coli* O157 in fecal samples from lots of beef cattle originating from a single ranch or feedlot, or from auction. Samples were obtained from the bagged off rectum collected during processing.	abattoir	19.5% of lots had at least one positive *E. coli* O157:H7 culture. The median within lot prevalence for *E. coli* O157:H7 was 0%.

From: (a) Faith et al. 1996; (b) Hancock et al. 1998b; (c) Heuvelink et al. 1998; (d) Benjamin et al. 2014; (e) Kuhnert, et al. 2005; (f) Elder et al. 2000; (g) Van Donkersgoed et al. 1999.

Table 15: Examples of Research Investigating *Salmonella* Prevalence in Livestock and Livestock Operations

Location	Animal	What the Research Examined	Prevalence Data
United States (a)	dairy cattle	Prevalence of *Salmonella* in dairy herds.	31% (30 of 97) of herds had at least one positive culture.
United States (b)	chickens—layers	*Salmonella* prevalence in layer houses.	7.10% of houses.
California (c)	chickens—layers	*Salmonella* prevalence in manure piles in layer houses.	68% of houses.
Multiple States (United States) (d)	swine, poultry, dairy and beef cattle	*Salmonella* prevalence in diverse environmental samples taken from diverse farming operations (swine, poultry, dairy and beef).	4.7% of the 2,496 environmental samples tested positive for *Salmonella*. Of the positive samples, 57.3% came from swine farms, 17.9% from dairy farms, 16.2% from poultry farms, and 8.5% from beef cattle farms.

From: (a) APHIS 2005; (b) NAHMS 2000; (c) Riemann et al. 1998; (d) Rodriguez et al. 2006.

Table 16: Examples of Research Investigating *Campylobacter* Prevalence in Livestock and Livestock Operations

Location	Animal	What the Research Examined	Prevalence Data
United States (f)	dairy cattle	Prevalence of *Campylobacter jejuni* in dairy cattle fecal samples obtained by direct rectal retrieval.	37.7% (786 of 2085) of samples tested positive.
United States (b)	diary cattle	Prevalence of *Campylobacter* spp. in dairy cattle fecal samples obtained by rectal retrieval.	51% (735 of 1435) of samples tested positive.
Washington State (a)	diary and beef cattle	Prevalence of *Campylobacter jejuni* in cattle fecal samples obtained by rectal retrieval or free fecal droppings.	34.1% (234 of 686) of samples tested positive.
California (c)	beef cattle	Prevalence of *Campylobacter* spp. in rectal fecal samples from adult beef cattle.	5% (20 of 401) of samples tested positive.
Not Specified (e)	chickens—broilers	Prevalence of *Campylobacter* spp. in broiler cecal droppings.	100% (20 of 20) of samples tested positive.
Not Specified (d)	chickens—broilers	Prevalence of *Campylobacter* spp. in broiler cecal material at broiler farms.	90% (9 of 10) of farms tested positive.

From: (a) Bae et al 2005; (b) Englen et al. 2006; (c) Hoar et al. 1999; (d) Stern et al. 1995; (e) Suslow et al 2003; (f) Wesley et al. 2000.

Appendix III: Factors that Influence Pathogen Reduction in Water, Soil and Air

Major environmental factors and conservation practices that influence the fate and transport of pathogens in agricultural landscapes are listed in Tables 17 and 18 for water, Tables 19 and 20 for soil, and Tables 21 and 22 for air resources.

Table 17: Environmental Factors that Influence Pathogen Reduction in Water

Factors	Resource Concern: Pathogens in Surface Water Fate and Transport of Pathogens in Surface Water
Sunlight/UV Exposure	**Exposure of water to UV radiation damages pathogens and typically leads to quick reduction.** • High intensity sunlight radiation decreased levels of cultivable fecal indicator bacteria in water. (Schultz-Fademrecht et al. 2008) • A study conducted in an outdoor laboratory setting found that inactivation rates of pathogens in water were higher in sunlight than in the dark. Pathogen inactivation was directly related to the amount of in solution (i.e., dose of sunlight). (Sinton et al. 2007) • In a simulated environment laboratory study, *E. coli* exhibited a strong sensitivity to sunlight. (Fujioka & Yoneyama 2002) • When subjected to strong natural sunlight, the exposure time required for the complete inactivation of pathogens suspended in water and stored in plastic bottles was 20 minutes for *Campylobacter jejuni*, 45 minutes for *Staphylococcus epidermis*, 90 minutes for enteropathogenic *E. coli*, and 150 minutes for *Yersinia enterocolitica*. (Boyle et al. 2008) • In surface waters, sunlight is the most important inactivating factor in determining the survival of *E. coli*, *Salmonella typhimurium,* and other bacteria. (Pachepsky et al. 2011)
	Turbid water may be associated with increased levels of pathogens, as compared to non-turbid water. • In coastal creeks, turbidity was positively correlated with the abundance of enteric bacteria. (Mallin et al. 2000) • During times of higher water turbidity, there was a general tendency toward higher densities of pathogens. (Wilkes et al. 2011)
	Shady conditions created by wetland vegetation may protect pathogens from UV effects. • Due to the shade created by emergent wetland plants, it is likely that sunlight plays a less important role in pathogen inactivation in wetlands than in animal waste lagoons. (Hill 2003)
Predation/ Competition	**Predation and competition by native microbial communities in water may increase pathogen reduction rates.** • Predation was thought the likely mechanism for the high removal of *C. parvum* in canal water. (Diallo et al. 2009) • Plankton may predate upon *C. jejuni* in aquatic environments. (McElhany & Pillai 2011) • Predation and/or competition for nutrients may affect the survival of *C. jejuni* and *E. coli* in aquatic environments. (Korhonen & Martlkalnen 1991)
Harborage	**Some protozoa and algae may host pathogens.** • *Campylobacter* spp. typically survived longer when co-cultured with golden algae *D. cartularies*, as well as three amoebas from the genus *Acanthamoeba.* (Axelsson-Olsson et al. 2010a) • When co-incubated with *Acanthamoeba polyphaga*, *C. jejuni* cells tolerated pHs far below their normal range. (Axelsson-Olsson et al. 2010b) • The water underlying mats of *Cladophora* (a green algae) had a significantly greater concentration of *E. coli* than the surrounding lake water. (Heuvel et al. 2010) • While it is documented that aquatic organisms a can aid in pathogen survival, the relative importance of their role in serving as a reservoir for pathogens is not currently known. (Pachepsky et al. 2011)

Table 17 (continued)	
Harborage	**Some biofilms may harbor pathogens.** • A laboratory experiment found that natural microbial assemblages [biofilms] occurring in a Pennsylvania stream showed seasonal differences in the retention of *Cryptosporidium* oocysts. (Wolyniak et al. 2010) • While river biofilms displayed indicator bacteria at two orders of magnitude higher than the surrounding water, the indicator bacteria made up only a minor fraction of the whole biofilm community. (Balzer et al. 2010)
Nutrients	**Nutrient availability is a factor in determining bacteria survival in water.** • *E. coli* could grow in autoclaved water taken from below a sewage outfall, but not in the water taken from above the outfall. Differences in nutrient content were considered the reason for the difference. (Pachepsky et al. 2011)
	Nutrients may influence competition with and predation of pathogenic bacteria. • Nutrients can cause an increase in competition and predation of pathogenic bacteria in water. (Pachepsky et al. 2011)
Temperature	**Lower temperatures tend to extend pathogen survival. Warmer temperatures, conversely, tend to decrease pathogen survival.** • Pathogen survival in water was enhanced by cooler temperatures. (Berry & Wells 2010) • While higher temperatures can prolong bacteria survival, these temperatures also favor the growth of organisms that predate upon bacteria. (Vymazal 2005)
Re-suspension	**Re-suspended sediments in irrigation water can be a source of pathogens.** • Activities that re-suspend sediments into the water, such as irrigation water intake from ponds, can elevate the concentrations of *E. coli* in water. (Pachepsky et al. 2011)
Biological Movement	**Livestock feces deposited on land may increase pathogens in surface water runoff.** • Higher concentrations of *E. coli* were found in irrigation tailwater when cattle were present in the pasture during irrigation than when cattle were not present. (Knox et al. 2008) • Water running off open livestock systems can contain contaminants including *E. coli*. (Koelsch et al. 2006) • Samples taken from lakes, streams, rivers, and ponds on California's Central Coast showed that areas of higher elevation where cattle were frequently observed grazing near the watershed were "hot-spots" for pathogen prevalence. (Cooley et al. 2014)
	Wildlife may degrade the water quality of irrigation water storage ponds. • Inputs by birds or other wildlife can degrade the quality of water in storage ponds. (Pachepsky, 2011)
	Human activity may degrade water quality, as runoff from urban areas a can be contaminated with pathogens. • A study looking at pathogens in runoff water found that urban runoff had the greatest percentage of total potential pathogens, when compared to agricultural and natural-area runoff. (Ibekwe et al. 2013)

Table 18: Conservation Practices That Influence Pathogen Reduction in Water	
Factors	**Resource Concern: Pathogens in Surface Water**
	Fate and Transport of Waterborne Pathogens in Water
Constructed (656), Created (658), Enhanced (659), and Restored (657) Wetlands	
Plant Emissions/ Exudates	**Wetland vegetation may create undesirable conditions for pathogens by increasing oxygen levels and secreting root exudates.** • Aquatic plants and algae may increase oxygen levels in the water, making undesirable conditions for pathogens. (Vymazal 2005) • Root exudates from aquatic plants may be toxic to some pathogens. (Vymazal 2005)
Water Movement/ Interception	**Wetlands greatly reduce the movement of bacteria in surface water, though some bacteria may still be present in wetland outflow.** • A two-year study showed that constructed wetlands were effective at removing various microbial populations from wastewater. The presence of vegetation slightly enhanced (approximately 0.5 log) the removal efficiency for most microbial groups. (Hench et al. 2003) • A small wetland used to treat runoff from a large agricultural area was able to retain ~70% of indicator bacteria with a hydraulic loading time of less than a day. (Diaz et al. 2010) • Looking at *E. coli* concentrations in irrigation tailwater above and below a wetland, it was found that the wetland decreased *E. coli* concentrations by approximately 40%. (Knox et al. 2007)
	Long residence time and low loading rates may improve wetland function, which may result in increased pathogen reduction rates. Conversely, short residence time and high loading rates decrease wetland function, which results in decreased pathogen reduction rates. • Hydraulic residence time (HRT) appeared to have the greatest effect on the removal efficiency of indicator bacteria. Longer HRTs tended to be more efficient in removing indicator bacteria than shorter HRTs. (Diaz et al. 2010) • A review of literature on constructed wetlands with emergent vegetation found that hydraulic loading rate (HLR), resultant hydraulic residence time (HRT), and the presence of vegetation are the primary factors that influence the efficiency of enteric microbe removal in constructed wetlands. (Vymazal 2005) • Natural wetlands often have channelized flow paths. When compared to a non-degraded reference wetland, a channelized wetland had shorter residence times and lower *E. coli* retention efficiency. (Knox et al. 2008)
Wildlife Consider-ations	**Wildlife may increase the concentration of pathogens in a wetland.** • Resident and visiting wildlife may play an important role in elevating levels of pathogens in wetland effluents. (Graczyk et al. 2009)
Field Border (386), Filter strip (393), Conservation Cover (327), Riparian Forest Buffer (391)	
Water Movement/ Interception	**Pathogens moving as free cells or attached to manure, soil, or other debris in concentrated and sheet flow can be greatly reduced by vegetative treatment systems such as field borders, filter strips, conservation cover, and riparian forest buffers when conditions are right.** • The likelihood of *Salmonella* and *L. monocytogenes* isolation in fields was significantly decreased if growers reported presence of a vegetative buffer zone, defined as a zone of at least 5 m separating the edge of produce fields from potential environmental pathogen reservoirs (e.g., forests, roads, waterways, livestock operations). (Strawn et al. 2013) • A review of vegetative treatment systems (VTS) used for managing runoff from open lot livestock systems determined that pollutant reduction is based upon two primary mechanisms: a) sedimentation, typically occurring within the first few meters of a VTS, and b) infiltration of runoff into the soil profile. Critical design factors include pre-treatment, sheet flow, discharge control, siting, and sizing. (Koelsch et al. 2006) • Grass filter strips measuring 9 meters in width trapped most of the fecal bacteria in surface runoff but did not reduce pathogen load enough to meet existing water quality standards. (Coyne et al. 1998) • Grass vegetated buffer strips reduced the total number of *Cryptosporidium parvum* oocysts discharged in overland and subsurface flow. An increase in rainfall application rate reduced the effectiveness of the buffers. (Tate et al. 2004)

Table 18 (continued)	
Water Movement/ Interception	• Each additional meter of vegetative buffer reduced *E. coli* discharge by 0.3 to 3.1 log (10). (Tate et al. 2006) • Reduction in the concentration of fecal coliforms, *E. coli*, and fecal streptococci in runoff were positively correlated to vegetative filter strip: drainage area ratio and negatively correlated to the depth of the rainfall event. (Mankin et al. 2006) • Vegetated filter strips reduced the amount of water running off test plots. The reduced runoff in turn reduced the surface transport of fecal coliform bacteria, while increasing the vertical transport of bacteria into the soil. (Roodsari et al. 2005) • Modeled scenario analysis suggests potential reduction (3–82%; median 35%) of *E. coli* concentrations in stream waters with riparian buffer strips by eliminating livestock defecation in and near streams, and by trapping of bacteria in the riparian vegetation. (Collins & Rutherford 2004) • Riparian buffer strips function similarly to vegetative treatment areas, but are more critical because they are the last control point before the pathogens enter streams. (Oliver et al. 2007) • A 24% reduction in fecal coliforms was documented for every ten meters of buffer length. (Lewis et al. 2010) • Vegetated buffers, ranging in width from 1 to 25 meters, generally reduced the median fecal coliform concentration in runoff water by more than 99%. (Sullivan et al. 2007) • Grassland buffers of 1.1 to 2.1 m width, with residual dry vegetation matter between 225 and 4,500 kg/ha, and land slopes of 5 to 35%, generated between 3.2 and 8.8 log retention of *Cryptosporidium parvum.* (Atwill et al. 2006) • One positive *E. coli* 0157:H7 result was found out of 60 freshly-cut hay samples from a 4.5 ha vegetative treatment system that received pond storage water from a cattle feedlot. Neither *E. coli* 0157:H7 nor *Campylobacter* spp. were recovered from hay following baling and storage. (Berry et al. 2007)
Size of Runoff Event	**Large runoff events can reduce the efficacy of vegetative buffer strips.** • To reduce the delivery of fecal microbes to waterways during large runoff events, grass buffer strips need to exceed 5 meters in length. It was also found that some of the microbes previously trapped by grass strips were remobilized and washed out during a later runoff event. (Collins et al. 2004) • Large storm events can flush *E. coli* from the soil. (Fenlon et al. 2000) • Excessive hydraulic loading rates and inadequate retention times may lead to poor filter strip performance. (Schellinger & Clausen 1992) • Manure slurry containing coliforms was applied to a 6-m vegetated filter strip (VFS) and bare ground plots. The VFS efficiency was found to be <95% in 25%, < 75% in 23%, and <25% in 20% of cases. The partial failure of VFS to retain coliforms was due to relatively long high-intensity rainfalls and low hydraulic conductivities. (Guber et al. 2009)
Temperature / Moisture	**The cool, moist, nutrient rich conditions of accumulated vegetation and litter in filter strips may increase pathogen survival.** • High levels of residual dry matter (4500 kg/h) in filter strips may provide a moist, cool, nutrient rich environment preferable for *E. coli* survival and multiplication. These conditions may have been the cause of increased discharges of *E. coli* in runoff water from filter strips with high levels of residual dry matter, compared to filter strips with lower levels of residual dry matter (225–900 kg/h). (Tate et al. 2006)
Maintenance	**Proper maintenance may be required to maintain vegetative buffer efficacy.** • Several maintenance issues are critical in VTA [Vegetative Treatment System] function: 1) a good stand of dense vegetation, 2) management practices that contribute to strong fall growth and well-established winter vegetative cover, 3) regular harvesting and removal (animal grazing does not represent an acceptable harvesting option), 4) prevention of channel flow, 5) minimizing solids accumulation, 6) uniform flow conditions, and 7) minimal animal traffic and limiting of vehicle traffic to dry conditions are critical. (Koelsch et al. 2006)

Table 19: Environmental Factors that Influence Pathogen Reduction in Soil	
Factors	**Resource Concern: Soil Contamination, Pathogens** **Fate and Transport of Pathogens in Soil**
Sunlight/UV Exposure	**Higher intensity UV radiation reduces survival of pathogens in soil.** • Pathogens near the soil surface died off quicker than what was reported in other studies that examined survival deeper in the soil, presumably because of solar radiation. (Gessel et al. 2004) • After dairy manure was amended to the soil, fecal bacteria numbers usually declined to pre-application levels in 2 to 3 months depending on soil temperature and potential exposure to desiccation and ultra violet light. (Stoddard et al. 1998) • Survival of *Escherichia coli* and a fecal streptococcus was studied in shaded and exposed outdoor soil plots. During summer and fall, the organisms survived twice as long in the shaded area. During winter and spring, survival in shade and exposed areas were very similar, which may be a reflection of the cool, wet weather, but it may also be partially explained by the reduced solar radiation from heavy cloud cover, shortened days, and low solar angle. (Van Donsel et al. 1967)
Predation/Competition	**Competition and antagonistic interactions decrease pathogens in soil.** • Death to *E. coli* occurs in soil by competition. (Bogosian et al. 1996) • Pathogen populations decline more rapidly in manure-amended un-autoclaved soil than in autoclaved soil likely due to antagonistic interactions with indigenous soil microorganisms. (Jiang et al. 2002) • Indigenous *Pseudomonads flourescens* (found in decaying organic matter) isolated in soil was very effective at inhibiting growth of *E. coli* O157:H7 at 25 degrees Celcius and was somewhat effective at suppressing it at 10 and 15 degrees Celcius. (Johannessen et al. 2005) • Survival of *E. coil* in soil was significantly influenced by the complexity of the microbial community. Survival of *E. coli* progressively increased with the reduction of microbial community diversity. (Liang et al. 2011) • Microbial community diversity affects survival of the human pathogen *Pseudomonas aeruginosa* in the wheat rhizosphere. (Matos et al. 2005) • Coliform populations often decreased faster when *E. coli* O157:H7 was added indicating possible competition between microflora. (Gagliardi and Karns 2002)
	Reduced competition in soil by fumigation increases long-term pathogen survival. • If soil is contaminated by *E. coli* pathogens, fumigation alone may not eliminate the pathogen, but it may cause a decrease in microbial diversity, which may enhance the survival of the pathogen. (Ibekwe et al. 2011 and Ibekwe and Ma 2011) • Fumigated soils foster *E. coli* O157:H7 growth. Soil systems with reduced biological complexity offer enhanced opportunities for invading microbial species to establish and persist. (van Elsas et al. 2007)
	Protozoa predation reduces pathogen survival in soil. • Decrease of *Salmonella* was related to growth of protozoa in the soil. (Garcia et al. 2010) • The survival of *Salmonella* has been shown to be influenced by predation by soil protozoans amongst others. (Jacobsen and Bech 2012) • The role of protozoan predation in *E. coli* population decline was demonstrated by the simultaneous increase of the indigenous amoeba counts and the decline of *E. coli* cell number. (Recorbet et al. 1992) • When the soil was inoculated with *E. coli* K12 strain, there was an increase of the protozoan numbers, and when the soil was amended with a eukaryotic inhibitor (which kills protozoa), the period of *E. coli* K12 survival was increased. (Sorensen et al. 1999) • Protozoans can decrease the number of pathogens present in soil. (Tate 1978)
Temperature/ Moisture	**High temperature and low moisture reduce pathogen survival in soil.** • Elevated temperatures, especially combined with drying conditions, will effectively increase die-off rates of enteric (human) bacteria. Lower temperatures appear to increase survival time. (Crane and Moore 1985) • Mortality of fecal coliform bacteria at the 0 to 5, 5 to 15, and 15 to 30 cm soil depths also correlated with decreasing moisture and increasing temperature in a curvilinear relationship. (Entry et al. 2000) • The rates of *E. coli* O157 decline in the susceptible sub-population were more rapid under higher temperature and low moisture conditions. The rates of decline in the resistant population were not significantly different across the range of temperature and moisture contents applied to soil cores during the study. (Ogden et al. 2001) • After the sunlight reduced the numbers of non-fecal coliforms in the soil, there was growth in numbers as a result of temperature and rainfall variations. (Van Donsel et al. 1967)

Table 19 (continued)	
Temperature/ Moisture	**Freeze-thaw cycles reduce pathogen survival in soil.** • Freeze-thaw cycles reduce bacterial populations. (Crane and Moore 1985) • Freezing and thawing of soil decreases survival of *Salmonella.* A late fall manure application will not increase the risk of contaminating vegetables planted the next spring, since further experiments showed that repeated freeze-thaw cycles were detrimental to the survival of *Salmonella* and *E. coli* in manure-fertilized soil. (Natvig et al. 2002)
pH	**Higher and lower pH reduces pathogen survival in soil.** • *E. coli* and *Salmonella* die-off increased with decrease in soil moisture and was minimum in a pH range of 6–7. Survival was adversely affected outside the pH range of 5.8–8.4. (Reddy et al. 1981) • Survival of *E. coil* appears to be better in more neutral to alkaline soil than in more acidic soil. (Sjogren 1994)
Soil Texture	**Heavy soil texture increases pathogen survival in soil.** • Survival of *Salmonella* and *E. coli* in farm fields depends on the soil, including the clay content (more clay, longer survival vs. more sand, shorter survival). (Barak and Schroeder 2012) • Presence of higher amount of clay in a clay loam, versus loam soils, may favor the survival of STEC (*E. coli*) O26. (Fremaux et al. 2008) • Data suggests that clay increases persistence and activity of *E. coli* O157:H7 and other coliforms. (Gagliardi 2002) • The time needed to reach the detection limit for *E. coli* O157:H7 for loamy sand, sandy loam, and silty clay was 32, 80, and 110 days, respectively. (Ma et al. 2011) • *E. coli* O157:H7 tainted irrigation water applied to various soil textures persisted longest in clay soils. (Ibekwe et al. 2004) • Compared with sandy soil, clay soil is of a finer texture and thus has smaller pore spaces that may protect adhered cells against predation or niche competition. (Barak and Schroeder 2012)
Nutrients	**Nutrient-rich environment increases pathogen survival.** • Excess nutrients foster *E. coli* growth in soil. (Byappanahalli and Ishii 2011) • High assimilable organic carbon and total nitrogen correlate with high survival of *E. coli* O157:H7 in soil. (Ma et al. 2012) • Survival of *E. coli* O157 was found to be greatest in soil cores containing rooted grass compared to just manure or slurry. (Maule 2000) • *Salmonella* can swarm around active root zone areas where there is a nutrient-rich environment from the root's exudates. These areas are also colonized by diverse bacterial communities. To survive, *Salmonella* may need to avoid defensive antimicrobials produced by the plant and compete with rival microbes for nutrients. (Barak and Schroeder 2012) • Diseased plant tissue may provide a nutrient rich and protected ecological niche for enteric (human) pathogens. However, this opportunity for growth is dictated by the nature of the pathogen's interactions with the resident plant microflora. (Brandl 2006) • Members of the *Enterobacteriaceae,* including *Salmonella* and *E. coli,* are facultative anaerobes, fermenting sugars to produce lactic acid and various other end products. Most also are able to use nitrate as an alternate respiratory chain acceptor under anaerobic conditions. (Brenner 1984)
Salt	**High salt levels reduce pathogen survival in soil.** • Higher electrical conductivity levels may produce shorter survival time of *E. coli* O157:H7 in soil. (Ma et. al 2012)
Harborage	**Some types of pathogens may be harbored by protozoa in soil.** • Ingestion of *Salmonella* by soilborne protozoa resulted in a large number of vesicles being released containing viable *Salmonella,* while ingestion by *Listeria* resulted mostly in death, with only infrequent *Listeria* being released. (Brandl et al. 2005)
Harborage	**Pathogens may be harbored by biofilms in soil.** • Biofilms enhance survival of *E. coli* in soil. (Abu-Lail and Camesano 2003) • Biofilm formation is one multi-cellular, aggregative behavior used by bacteria to successfully colonize plants. *Salmonella* strains with stronger biofilm-forming ability in vitro, have stronger adhesion and persistence on lettuce leaves. Biofilm formation is equally important for root colonization. (Barak and Schroeder 2012) • *E. coli* strains can create biofilms on soil that help restrict them from being transported in water. (Salvucci et al. 2009) • Bacteria frequently live in biofilms, which are surface-associated communities encased in a hydrated extracellular polymeric substance matrix that is composed of polysaccharides, proteins, nucleic acids, and lipids. Bacteriophages have been used for controlling biofilms on stainless steel. (Viazis and Diez-Gonzalez 2011)

Table 19 (continued)	
Antibiotic Resistance	**Antibiotic resistance can be transferred from manure to soil microbes.** • The environmental spread of antibiotic resistance can occur in soil bacterial populations. (Jechalke et al. 2013) • Evidence of increasing resistance to antibiotics in soil and other natural isolates highlights the importance of horizontal transfer of resistance genes in bacteria. The selective pressure for the spread of resistance genes correlates strongly with the clinical and agricultural overuse of antibiotics. (Nwosu 2001)

Table 20: Conservation Practices That Influence Pathogen Reduction in Soil	
Factors	**Resource Concern: Soil Contamination** **Fate and Transport of Pathogens in Soil**
Cover Crop (340)	
Species	**The relative length of pathogen survival in relation to cover crops.** • *E. coli* O157:H7 persisted a short time (up to 40 days) in soil with hairy vetch or with clover, and in soil with no plants; whereas it persisted more than twice as long (3 months) on alfalfa roots and on rye roots. (Gagliardi and Karns 2002) • Rye cover crops are usually grown in the winter for more than 3 months (Smith 2013) and alfalfa for a couple of years.
Anti-microbial Effects	**Compounds in some cover crops are harmful to pathogens.** • Glucosinolate compounds derived from cover crops in the Brassica family have an antimicrobial affect on *Salmonella* and to a somewhat lesser degree to *E. coli* O157:H7. (Patel 2013)
Microbial Diversity	**Soil Microbial Communities** • Cover crops can have a large impact on the size and activity of soil microbial communities. (Bolton et al. 1985; Fraser et al. 1988; Kirchner et al. 1993; and Powlson et al. 1987)
Compost Facility (317)*	
Sunlight/ UV Exposure	**Higher intensity UV radiation reduces survival of pathogens in compost.** • Higher light intensity in the summer was a contributing factor on the decreased survival of pathogens in compost versus lower light intensity in the winter, which increased survival. (Kim and Jiang 2010)
Competition/ Predation	**Competition decreases pathogens in compost.** • Bacteriophages (a type of virus) added to un-autoclaved dairy manure compost inoculated with *Salmonella* resulted in a greater reduction of the pathogen as compared to autoclaved compost due to competition. (Heringa et al. 2010) • Competition in non-autoclaved compost did not allow pathogens to grow, whereas autoclaved compost did. (Kim and Jiang 2010) • Indigenous microorganisms are critical for suppressing *E. coli* O157:H7 growth in compost. (Kim et al. 2011) • Pathogens did not survive when inoculated into stabilized compost but showed minimal die-off in sterilized compost. (Paniel et al. 2010)
	Protist predation reduces pathogens in compost. • Protist populations (protozoa and algae), not fungal populations, have the most dramatic effect on *E. coli* O157:H7 reduction. *E. coli* O157:H7 declined faster in untreated compost than in compost treated with cycloheximide. The chemical treatment was thought to kill the protists while leaving the fungal community unharmed. (Puri and Dudley 2010)
Microbial Diversity	**Soil Microbial Communities** • The use of compost has a long-term effect on soil microbial activity. (Ros et al 2006)
Moistu re	**With enough moisture, unfinished compost can increase pathogens.** • If there is a small number of *E. coli* O157 cells present and enough moisture, the pathogen can re-grow in the compost. (Kim et al. 2009)

Table 20 (continued)	
Temperature	**While high temperature reduces pathogen survival in compost, it doesn't necessarily destroy all.** • Elevated temperatures may not be lethal for all microorganisms, but may affect their efficiency and further contribute to the decrease in microbial activity. Some microorganisms form spores in response to excessive heating, and when more favorable conditions exist those spores can germinate. (USDA Part 637)
Nutrients	**A low carbon: nitrogen ratio in compost resulted in quicker reduction of pathogens.** • Compost preparations with an initial C:N ratio of 20:1 required a maximum of 4 days of storage before *Salmonella* was inactivated, whereas preparations with C:N ratios of 30:1 and 40:1 required more than 5 and 7 days of storage, respectively. (Erickson et al. 2009)
Maturity	**Making quality compost is dependent on whether it has matured enough to kill human pathogens but not excessively so that antagonistic microorganisms are not able to re-colonize.** • Immature compost serves as food for pathogens and increases disease even when biocontrol agents are present. On the other hand, excessively stabilized organic matter does not support the activity of biocontrol agents. (Hoitink and Grebus 1994) • Plant disease suppression is the direct result of the activity of consortia of antagonistic microorganisms that naturally re-colonize the compost during the cooling phase of the process. (Hadar and Papadopoulou 2012)
Technique	**The windrow method of compost making consistently reduces pathogen survival.** • Composts produced with windrow methods were of higher microbiological quality than were those produced with static pile methods, and point-of-sale bagged composts scored very high. More effort is required to improve hygiene consistency in relation to management practices. (Brinton et al. 2009)

* The assumption has been made that the compost from the compost facility will be used in accordance with the Nutrient Management (590) practice standard.

Table 21: Environmental Factors that Influence Pathogen Reduction in Air	
Factors	**Resource Concern: Air Quality – Particulate Matter with Pathogens**
	Fate and Transport of Pathogens in Air
Sunlight/UV Exposure	**Exposure to UV radiation both damages and dries pathogens and typically leads to quick reduction on leaf surfaces.** • UV radiation limits microbes in the phyllosphere. (Beattie and Lindow 1995) • UV radiation influences populations on leaf surfaces. (Newsham et al. 1997) • Higher numbers of bacteria have been found on lower surfaces suggesting avoidance strategies necessary for surviving UV radiation. (Sundin 1999) • Biological control agents, such as *Bacillus thuringiensis, Beauveria bassiana,* and nematodes on leaves have also been found to be affected by UV radiation. (Ignoffo 1978)
	Pathogen reduction from UV exposure in the shady areas of the permanent vegetation is related to dosage. • Canopy structure, leaf area, and, to a lesser degree, the brightness of the sunlight were found to influence UV penetration into vegetation more than the sun's angle. (Shulski 2004) • A biological dosimeter system using attenuated *E. coli* was created to measure microorganism activity in the canopy of grass. The *E. coli* was placed in cell suspensions within small plastic packets at different locations in turf grass, along with a miniature UV-B radiometer. Die-off was linearly related to UV-B dosage. (Yuen 2002)
Predation/ Competition	**Some native microbial communities on leaf surfaces increase pathogen reduction rates through competition, predation, and antagonism.** • *Enterobacter asburiae* repressed the growth of the *E. coli* O157:H7 when sprayed on leaf lettuce. (Moyne et al. 2011) • The reduction of *E. coli* O157:H7 numbers on spinach leaves by natural epiphytic bacteria show that native plant microbiota can be used for bio-control of food-borne pathogens. Fifteen different genera, the majority belonging to *Firmicutes* and *Enterobacteriaceae,* reduced growth rates of *E. coil* O157:H7 in vitro by either nutrient competition or acid production. However, other epiphytes—phylloepiphytic bacteria belonging to eight different genera—increased numbers of *E. coil* O157: H7 and may promote the persistence of enteric pathogens on the phyllosphere. (Lopez-Velasco 2012)
Symbiosis	**Other native microbial communities on leaf surfaces may facilitate the growth of pathogen populations.** • *Wausteria paucula* promoted *E. coli* O157:H7 survival on leaf lettuce. (Moyne et al. 2011)

Table 22: Conservation Practices That Influence Pathogen Reduction in Air	
Factors	**Resource Concern: Air Quality – Particulate Matter with Pathogens**
	Fate and Transport of Pathogens in Air
Windbreak (380)	
Interception of Pathogens	**Preliminary indication shows that vegetative buffers may intercept pathogens**. • Vegetative buffers (that function like windbreaks) were placed between poultry houses sprayed with two attenuated live vaccine strains and coops with pathogen-free chickens. The proportion of virus-positive serum samples was significantly greater from birds in the control (without the veg. buffer) than with the vegetative buffer in the last of three trials. It was thought that once the buffers had grown to a fuller and greater height, they would have functioned better to reduce the spread of pathogens (Burley 2011).
Aerodynamics of Dust Near Windbreaks	**How Windbreaks Reduce Dust Downwind** • Windbreaks reduce dust downwind by both dropping particulates and lifting emissions into the upper air stream for greater dispersion and dilution (Malone 2004).
Intercepti on of Dust by Buffers	**Vegetative buffers can be effective at reducing dust.** • Vegetative buffers can remove between 35%-55% of dust in the air (Luety 2004; Hernandez 2012; Malone 2004).
Plants Good at Interception	**Conifers are very good at interception.** • Conifers are better than deciduous trees for dense foliage (Straight 2007; Adrizal 2008) and interception. • The needle-like foliage of conifers captures two to four times more pesticide spray than broad-leaves because they don't alter their leaf alignment in high winds (Ucar 2003).

Appendix IV: Frequently Asked Questions

Note: These questions and answers were developed for posting on the NRCS website, along with Figure 2 and its key. The photos used above could also be used on the website.

A.IV.1 Pathogen Presence in Produce and on the Farm

1. **What types of pathogens typically cause food-borne illnesses in produce?**
   Shiga toxin-producing *Escherichia coli* (STEC), *Salmonella*, *Campylobacter*, and *Listeria* species are bacteria associated with large food-borne illness outbreaks in produce. *Cryptosporidium* species is a protozoan that can cause food-borne illness, although it usually only makes individuals ill. When ingested, these pathogens can cause sickness, life-changing medical complications or death.

2. **How do pathogens get on the produce farm?**
   Pathogens are carried to the farm by water and wind, and by livestock and wildlife that transport pathogens through feeding and depositing feces and when their skin, fur or feathers brush up against contaminated sources. Humans use manure with pathogens in produce fields and inadvertently spread contamination with boots and tools. People may also spread pathogens with improper hygiene practices when they themselves are sick.

A.IV.2 Natural Processes Affecting Pathogen Survival

3. **Are there natural processes growers can take advantage of that reduce pathogens on the farm?**
   Sunlight
   Allowing time for sunlight to hit feces left by grazing animals in row crop fields before tilling it in, and managing orchard canopies to let sunlight in on feces will help desiccate pathogens and reduce their survival. Effectiveness depends on how directly the pathogens are exposed to ultraviolet (UV) light and how well they dry out. With larger animals, such as cattle grazing un-harvested crops, a light disking to break up partially dried pats may accelerate pathogen reduction. It is important to minimize the potential for manure left on the surface to be carried to surface water during a significant rain or irrigation event.

   Clear Water
   When UV radiation is allowed to penetrate clear shallow water, pathogens won't survive long. If the water contains sediment or nutrients that cause algal blooms, UV radiation won't be as effective. Proactively protecting water quality by ensuring that irrigation water infiltrates the soil well, and excess fertilizers and eroded soils do not cause pollution and murky water will help. UV penetration can then effectively foster pathogen reduction.

   Vegetation to Intercept Pathogens
   Vegetative buffer strips planted in appropriate areas on the farm can help intercept airborne and waterborne pathogens and other pollutants to keep the water clean (see 3, 5, 6, 8, 10, 16, 19, 21, and 24 in Figure 2).

   Proper Composting
   High temperatures reduce pathogens, as do antibacterial compounds found in compost created by a process that purposely generates alternate cycles of high and low heat—through the correct mix

of carbon and nitrogen, moisture, and aeration through turning. The curing process at cooler temperatures allows the growth of suppressant microorganisms that tie up nutrients and can limit or outcompete pathogen re-growth, or growth following accidental re-contamination.

Soil Microbe Diversity
Farming practices that increase the native soil microbial community, such as high organic matter inputs of compost, cover crop rotations (see 16 and 23 in Figure 2), and reduced tillage, promote competition, predation, and antagonism of pathogens. On leaves and roots of plants, biofilms—bacterial communities that establish on surfaces and create a protective extracellular matrix of polysaccharides—may confer protection against pathogenic microbes, although they may do the opposite as mentioned below.

4. Are there natural processes or practices that harbor pathogens on the farm?
Pathogens may be sheltered from environmental stressors such as UV radiation and predation by biofilms. Protozoa sometimes consume bacterial pathogens without killing them. Algae may form a symbiotic relationship with pathogens. Wetlands can harbor pathogens when they are subject to runoff from adjacent lands or used by domestic or wild animals. Vegetative buffers can shelter pathogens when air and sunlight are not able to penetrate the vegetation, since cool moist shaded interior vegetation may provide favorable habitat for pathogen survival.

A.IV.3 Vegetative Conservation Practices

5. If growers obtain assistance with a vegetative conservation practice adjacent to a crop such as a riparian forest buffer that supports wildlife, will they be able to pass a food safety audit?
The OnFarmFoodSafety.org self audit, the USDA food safety audit, and several other audit programs allow for non-crop vegetation on the farm without losing certification or audit points. Global GAPs encourage habitat restoration. In writing the proposed Food Safety Modernization Act (FSMA) rules, FDA's perspective about wildlife habitat is that it does not expect growers to destroy habitat or otherwise clear farm borders around outdoor growing areas or drainages.

6. What should growers consider who have seen wildlife in vegetative conservation practices near their produce field?
Seeing wildlife in habitat is usually good, since the purpose of the habitat may be to support pollinators, migrating predators that eat rodents, and other creatures. Food safety Good Agriculture Practices (GAPs) suggest that a problem occurs when and if wildlife enters a field and damages the crop, and/or leaves feces behind that can contaminate the crop.

A.IV.4 Risk of Animals Near Produce

7. Do some animals pose a higher risk of contaminating produce with food-borne pathogens than others?
Humans and Domestic Animals Have Pathogens in Common
Livestock and companion animals can carry human pathogens, such as *E. coli*, *Salmonella*, *Campylobacter*, *Listeria,* and *Cryptosporidium* species. The pathogens might not make the host ill, but they can still cause severe human diseases. Some pathogens are more common in some animals than in others. Cattle often host *E. coli* pathogens, while poultry and pigs are common carriers of *Salmonella.* Poultry may often carry *Campylobacter*. Small ruminants, such as sheep and goats, are infected with *Listeria* more than other animals.

An animal's age and the season of the year may influence the pathogen level it carries. Young animals tend to carry higher levels of pathogens than adults. Seasonal stress may also result in higher levels. Cattle, for example, shed more *E. coli* in their manure during the summer than during the winter. Individual animals can be "super-shedders" in a herd with an overall low shedding prevalence.

Since livestock can be contained, the risk of contaminating crops with livestock manure depends on whether the manure is inadvertently transported into the produce fields via wind, water, wildlife, or people; or whether it has been applied directly on the field as a soil amendment without adequate composting or aging. Food safety GAPs recommend that an adequate time after application should elapse before planting and harvesting.

Native Wildlife Poses a Low Risk of Carrying Human Pathogens
Thus far, studies have shown that native wildlife has a low prevalence of carrying pathogens that cause human illness. The risk of extensive crop contamination from wildlife is small; however, it will never be zero.

Where wildlife lives and what it feeds on may influence pathogen levels. Birds, rodents, and feral pigs that live near areas with high levels of pathogens, such as landfills, feedlots, dairies, cattle ranches, or pig farms, may pose a greater risk of transferring pathogens than wildlife not associated with such areas. Some research shows that non-native feral pigs, which frequently share rangeland with cattle and eat cattle feces, carry food-borne pathogens at a higher rate than native wildlife.

Unlike livestock, wildlife cannot be contained or completely excluded from produce growing areas, so depending on the circumstances, it may pose a risk when in the production field. In writing the proposed rules for the Food Safety Modernization Act (FSMA), FDA suggested that the presence of wildlife in a production field is, in and of itself, not a significant food safety risk, though action needs to be taken if evidence of feeding or feces are found in a crop field.

A.IV.5 Actions Growers Can Take to Protect Their Crops

8. How can growers be sure that wildlife are not contaminating their crops?

Food safety GAPs recommend monitoring the production field next to the habitat for damage and feces can help determine if wildlife is coming in, thereby increasing risk (see 9 in Figure 2). By monitoring at a scheduled time, preferably in conjunction with the timing of other tasks, such as during insect pest scouting or before irrigation, and keeping records of the monitoring, growers can both reduce risk and have documents that support their farm safety program.

9. What steps should growers take if they see wildlife or its evidence in the production fields?

Food safety GAPs recommend that if growers find crop damage or animal feces, they should cordon off a specified area—the damaged/contaminated area plus a small percentage—so the risk of cross-contamination is removed from the growing area (see 9 in Figure 2). The size of the cordoned off area depends on the amount of feces, whether splash could occur from irrigation or rain, and how close to the soil the crop grows. A five-foot radius for overhead-irrigated crops is typically felt to be sufficient; for drip-irrigated crops in a dry season, a smaller area may provide sufficient buffering. Growers dispose of feces and the contaminated product away from the crop, sanitize the shovel or other equipment, wash hands afterward, and keep records of all actions taken.

Further crop assessments may be required to determine whether there are repeat visits by individuals or many animals, and whether they were feeding or just passing through. The number of wildlife in the crop is important—more intrusion equals higher contamination risk. In the proposed FSMA rules, FDA's perspective about crop contamination is that if the crop does not come in contact with manure, or in this case with wildlife feces, then it would not be covered in the rule. Hence, deer droppings in an apple orchard would not be covered. Of course, the apples should not be picked up from the ground.

10. Are predators of rodents acceptable on the farm?

It is better to have a few predators, such as hawks or bobcats, on the farm that help keep the rodent population in check, than numerous rodents that could cause more contamination (see 17 in Figure 2). Growers can attract hawks and owls to the farm with hawk perches and owl boxes, but should not plant directly under them. If four-footed predators are present near the production field, food safety GAPs recommend growers monitor the crop for feces periodically.

11. How can growers discourage unwanted wildlife?

Conserving habitat in wildlife corridors along waterways or other established routes may keep wildlife from crossing through the crop and contaminating it (see 21 in Figure 2). If wildlife, crop damage, or feces are continually found in the produce field, food safety GAPs recommend that corrective actions be taken. Removing animal attractants such as feed (culls or spilled grain), stacks of irrigation pipe and puddles of standing water may reduce intrusion. Projecting loud noises such as raptor or distressed bird calls, using scare balloons, flashing red lights sensed as eyes, or sprinklers activated by motion detectors may deter unwanted wildlife. Replacing weedy annuals abundant with seeds that rodents prefer with other non-crop vegetation may discourage rodents. Using rodent traps instead of poison baits near drainages and waterways will prevent water pollution.

Fencing may be necessary as a last, expensive resort. The type of fencing depends on the animals to be excluded. Short silt fencing can deter smaller animals, such as ground squirrels that tend not to climb something they cannot see over or through. Rabbit fencing, while a bit more involved, functions on the same visual barrier principle, tied to their natural avoidance behavior. Silt fencing is inconsistent in discouraging frogs and tends to be less effective in irrigated fields when immediately adjacent natural waterways. Short, moveable electric fencing can temporarily keep less-determined feral pigs out of a field; more permanent short hog wire fencing keeps more persistent feral pigs out. Tall permanent fencing, especially when electrified, can keep out deer. Fencing just the production fields, rather than the whole property, allows wildlife room to move through the farm for food and cover in neighboring lands. In the proposed FSMA rules, FDA does not expect growers to fence or otherwise exclude animals from outdoor growing areas.

A.IV.6 Crop Type and Location

12. Are some fields more suited than others to grow certain types of produce?

Nearness to Contaminated Sites

Since wind, water, wildlife, and people may transport pathogens to the crop from contaminated areas, such as dairy, livestock, or fowl production facilities, dumps, and compost piles, food safety GAPs recommend growers plant low risk crops near these areas and install a barrier between them (see 23 in Figure 2). The Center for Disease Control reports that leafy vegetables, tomatoes, and melons are associated with a high number of food-borne illness outbreaks. FDA has published guidances on leafy greens, tomatoes, and melons to help growers reduce risk. Depending on how these crops are grown and harvested, they may or may not be at higher risk. However, almost every year new commodities not previously recognized as vehicles for food-borne outbreaks are identified. Therefore, the prudent approach is to consider all crops for human consumption as potentially vulnerable to risk, even though many have natural risk-minimizing traits of growth habit and cropping practices. Growers may consider producing crops for livestock feed in areas of increased contamination risk.

Flooded Areas
FDA considers the edible portion of produce that has been flooded "adulterated," so fields subject to frequent flooding are better planted to crops not consumed by humans (see 7 in Figure 2). The best management for areas that often flood may be to convert them to conservation plantings, such as permanent field borders (see 19 in Figure 2) or riparian forest buffers (see 6 in Figure 2) that intercept pathogens in overland flow and encourage infiltration. The forest root zone along a river, stream, wetland, or water body helps reduce the movement of pathogens by slowing subsurface flow of contaminated water and providing for biological activity that can reduce pathogens (see 13 in Figure 2). For fields that don't often flood, food safety GAPs recommend growers institute a waiting period to allow pathogen reduction to occur before planting another cash crop. Cover crops can be a temporary solution.

Planting Away from Erodible and Sensitive Areas
Some produce buyers do not allow crops to be grown next to vegetative conservation practices and natural areas because of the perceived threat of wildlife contamination. Instead, they require bare ground buffers surrounding the crop, which can create conservation concerns. Crops destined for those markets should be planted away from eroding and sensitive areas to alleviate some of the adverse impacts on soil, water, and wildlife resources.

13. Can growers plant produce next to a compost pile?

When compost includes raw manure as a feedstock, food safety GAPs recommend growers take extra steps to ensure that crop contamination does not occur. Taking into account wind direction and speed, they locate the compost pile a safe distance away from the production field so unfinished compost cannot blow onto the crop and contaminate it. Growers may consider planting a windbreak to reduce the distance needed between the compost pile and the production field (see 23 in Figure 2). They should choose a location that allows water running off the site to be both contained and diverted away from traffic routes to the crop. When wildlife is attracted to compost feedstock, such as produce culls, it may explore or inadvertently step in raw manure and then move through the production field; keeping culls out of reach can reduce contamination risk. Food safety GAPs recommend growers ensure that any heavy equipment and hand implements used for making or handling the compost are cleaned and sanitized before use in the crop. They should train personnel involved in both compost and crop management in proper prevention and cross-contamination measures.

A.IV.7 Livestock Considerations that Reduce Contamination of Produce

14. What safety precautions should growers take when raising produce and livestock on the same farm?

In order to reduce the risk of livestock manure unintentionally contaminating the crop, livestock should be located downhill from the production fields, or runoff should be diverted away from the livestock yards with the use of a berm or diversion ditch (see 3 in Figure 2). Depending on the contamination of the diverted water, it may need to be contained in a waste storage pond or sediment basin (see 4 and 12 in Figure 2). Windbreaks and tall hedgerows can reduce dust blowing from livestock areas (see 8 and 10 in Figure 2). If wild birds are eating extra grain, growers can place the grain in a covered area that birds don't feel safe entering to discourage them.

15. Does prescribed grazing help to reduce pathogens in the environment?

Prescribed grazing disperses animal feces on the grazing lands where healthy stands of grass can help to filter pathogens (see 25 in Figure 2). While cattle both in confined operations (eating grain) and out on pasture (eating forage) can test positive for *E. coli* pathogens, a USDA comprehensive review indicates that populations of these pathogens are higher in grain-fed cattle. Additionally, confined operations concentrate feces and often increase animal vector occurrence, thereby increasing risk.

16. Can growers allow their livestock to graze in a fruit orchard or produce field after harvest?

Yes. Food safety GAPs recommend scheduling grazing to allow sufficient time for pathogens in any feces dropped to be significantly reduced by sunlight and other environmental factors. When ladders are used, harvesters may inadvertently walk in feces or contaminated soil, then climb up and down their ladders, contaminating their gloves; or they may accidentally place harvest containers on contaminated ground. While some standards do not address this issue, others suggest waiting 120 days between grazing and harvest. Food safety GAPs recommend growers assess whether any feces can be found five to seven days before harvest. It is a good policy to never pick fruit up off the ground since the fruit may have come in contact with animal feces (see 18 in Figure 2).

A.IV.8 Water for Irrigation

17. Do growers need to test their irrigation water?

The Produce GAPs Harmonized Food Safety Standards offered by USDA suggests that testing may not be warranted if past testing showed no high levels of fecal indicators, the crop will be not be eaten fresh, the harvest will not occur soon, and the water will not touch the crop. If any of these conditions do occur, initial baseline testing is recommended, along with a routine testing regime. Others recommend testing the water source at the beginning of the growing season for generic *E. coli*. If the water source is found to have high bacterial counts (e.g., > 500 *E.coli* /100 ml), growers should seek advice from local university extension personnel or farm consultants. Recommendations can vary depending on the situation. The quality of the water should conform to prevailing regulations.

A.IV.9 Manure Management

18. Can growers still use raw manure?

Pathogens that pose a serious food safety risk may be contained in raw manure. Some standards, such as those in the USDA National Organic Program (NOP), require that raw manure be incorporated into the soil not less than 120 days prior to the harvest of a product whose edible portion has direct contact with the soil, or not less than 90 days prior to the harvest of a product whose edible portion does not have direct contact with the soil. An intermediate recommendation from the USDA GAPs states that when raw manure is applied, it should be incorporated at least two weeks prior to planting, and a minimum of 120 days prior to harvest. Some marketing agreements, such as the one for leafy greens, suggest a one-year waiting period between application of soil amendments with raw manure and production of the next crop. Many standards recommend growers keep records of the composition of the manure and the time and method of application, and that they conform to prevailing regulations. If the suggested waiting periods are not feasible, the GAPs recommend using only properly composted manure.

19. Is manure-based compost acceptable to use in produce fields?

Composting is a treatment process that reduces the microbial hazards of raw manure. When done correctly, the composting process can kill most pathogens. Some food safety GAPs do not suggest a time period between compost application and other farming practices, while others recommend it be used only before planting, or applied at least 45 days before harvest. In all cases, it is a good idea for growers to record the dates that compost is applied to the field. If not completely composted, it should be treated like raw manure.

20. Can growers make their own compost, or should they purchase it?

Manure-based compost can be made safely on the farm with methodical management of the decomposing process. National Organic Program requires a specified carbon to nitrogen ratio of the compost feedstock, a temperature to be reached for a set number of days depending on whether using a static pile or a windrow, and a specified number of turnings when in windrows. Besides recording the compost's composition and the dates and methods of the compost treatment, some food safety GAPs also recommend that growers obtain residual fecal indicator and pathogen analyses of the compost. In all cases, growers must take care to ensure compost isn't re-contaminated with pathogens, and the composting process should conform to applicable federal, state, and local regulations.

Compost made solely with vegetative feedstock (i.e., no animal products) has fewer restrictions. Food safety GAPs recommend that feedstock not come from sources where hazards such as glass or heavy metals may be introduced.

Food safety GAPs recommend growers accept off-site or purchase commercial compost only when a letter of guarantee or certificate of pathogen analysis from the compost maker can be obtained. They should find out what the compost was made from (e.g., cattle or horse manure; spent mushroom compost; vegetable culls) and ensure that it was produced under conditions that do not pose a hazard.

Is aged manure okay to use?

Aged manure relies primarily on the passage of time to reduce pathogens. During the aging period, natural temperature and moisture fluctuations and UV radiation from sunlight will decrease the number of pathogens. The time needed will vary depending on the weather and on the type and source of manure. Food safety GAPs recommend that the growers who rely on the passage of time should ensure manure is well aged and decomposed before applying it to fields, in order to minimize microbial hazards. Most GAPs treat aged manure the same as raw manure.

21. Are there other ways to treat raw manure?

Some food safety GAPs approve of thermally or chemically processed manure. For instance, steam, ammonia, stabilized lime, and more recently biochars (a by-product of biomass conversion) are used to reduce pathogens in the manure. These GAPs recommend that growers take care not to accidentally re-contaminate sterilized manure with pathogens since beneficial microbes antagonistic to pathogens will be absent.

A.IV.10 Food Safety Plans, Audits and Inspections

22. What is the difference between a food safety plan, an audit, and an inspection?

A food safety plan is created by the grower, often in response to their produce buyer requesting a food safety audit. An audit uses a set of food safety GAPs to compare the plan to what is actually occurring on the farm. An inspection is carried out by a FDA or State health enforcement officer to check that the grower is complying with food safety regulations.

23. Do growers need a food safety plan and can conservationists help with that?

There are currently no federal regulations requiring a food safety plan. Several states may create their own food safety requirements. Many growers are getting ahead of the curve by creating their own food safety plan. Conservation planners can help by providing them with records of conservation practices to be included in their food safety plan. These records are documentation of expert conservation actions and do not constitute recommendations for food safety compliance by NRCS. These in turn may help the grower pass a food safety audit or inspection.

Appendix V: Glossary and Acronyms

Glossary

amplify/amplification: increase in number/increased numbers due to growth and cell division, replication of viral nucleic acids and encapsulation, or multiplication of a parasite in a host and production of increased spore number.

antagonistic: having the ability to inhibit the growth of another organism.

autoclave/autoclaved: an apparatus that uses superheated steam to sterilize media, instruments, soil, and so on/to treat in an autoclave

bare-ground buffer: a strip of ground cleared of all vegetation to leave nothing but exposed soil to serve as a buffer between wildlife habitat and crop fields.

bio-available carbon: carbon that is freely available, or extracellularly converted, to cross an organism's cellular membrane from the medium the organism inhabits at a given time.

biofilm: a complex community of microorganisms attached to a surface or associated with an interface. Biofilms can be found on leaf surfaces, in aquatic environments, in the soil, and on equipment or in water conveyance canals and pipes.

biological control agents: natural enemies of pest insects, weeds, and diseases; may be predators, parasitoids, or pathogens of the pest.

brassica: a plant of the genus *Brassica* (family Brassicaceae), includes mustard, cabbage, and broccoli**.**

coliform(s): gram-negative, rod-shaped bacteria typically found in the intestine, such as *E. coli*.

Concentrated Animal Feeding Operation (CAFO): According to the U.S. Environmental Protection Agency, CAFOs are agricultural operations where (a) animals are kept and raised in confined situations for at least 45 days in a 12-month period, (b) there is no grass or other vegetation in the confinement area during the normal growing season, and (c) meet certain size criteria.

cultivable: capable of growing on routine culture media in a laboratory.

dosimeter: a device that measures doses of radiation.

enteric bacteria: bacteria that live naturally in the healthy gut of animals and people.

epiphyte: an organism that lives on the surface of plants. In this technical note, the term refers to bacteria and other microorganisms that live on leaf surfaces.

epiphytic: living on plant surfaces.

exudates: liquid released from within a source, such as the roots of plants.

facultative anaerobe: an organism, such as a bacterium, that can grow with or without free oxygen.

fecal: relating to feces.

fecal shedding rate: the rate at which organisms are released from the host through its feces.

Good Agricultural Practices (GAPs): guidelines used by the agricultural industry to minimize and prevent contamination of fresh fruits and vegetables on the farm.

gram-negative bacteria: bacteria that stain pink, instead of purple, due to the fact that they have a thin layer of peptidoglycan on their cell walls that retains little of the purple dye used in the Gram staining method.

gram-positive bacteria: bacteria that stain purple due to the fact that they have a thick layer of peptidoglycan on their cell walls that retains the purple dye used in the Gram staining method.

Gram staining method: a method of differentiating bacteria into two large groups (gram-positive and gram-negative) based on the structure of their cell walls. Gram-positive bacteria have cell walls with a thick layer of peptidoglycan and stain blue/purple. Gram-negative bacteria have cell walls with a thin layer of peptidoglycan and stain red/pink.

horizontal transfer: the transfer of genes between different species by means other than traditional reproduction.

inactivation: to cause a pathogen (or other infective agent) to lose its ability to produce disease.

indicator bacteria: organisms that indicate the presence of fecal contamination (e.g., thermotolerant coliforms or *E. coli*).

indigenous: occurring naturally in a particular environment.

invertebrate: an organism that lacks a spinal column.

Leafy Green Marketing Agreement or California Leafy Green Products Handler Marketing Agreement (LGMA): the LGMA is a membership organization of leafy-greens handlers. Member companies comply with a mandatory audit program that certifies the farming operations they purchase from are implementing a dictated set of food safety practices. All these farming operations are subject to government audits to verify that these food safety practices are being met.

loading rate: the total number of pathogens excreted by a defined cohort of animals or released from an environmental point-source for a specific period of time.

macrophyte: typically refers to an aquatic plant, such as *Potomageton* (pond weed), that is macroscopic in size.

microbiota: the microscopic flora and fauna that live at a particular site.

microflora: the microscopic algae, fungi, and/or bacteria that live in a particular site.

no-harvest buffer: a zone established around animal tracks, evidence of animal feeding, animal trampling or animal feces in which no crop is harvested due to potential pathogen contamination.

oocyst: the environmentally resistant stages of protozoan, such as *Cryptosporidium*. During this stage of development the zygote is protected by a thick-walled cyst that allows it to survive outside the host; this facilitates the transfer of the protozoan from one host to another.

pathogenic: causing disease.

persistence: the ability of any microorganism, including infectious agents, to remain viable in the environment, on crops, or on inert surfaces.

predation: the act of preying upon (killing and eating) other organisms.

phylloepiphytic: living on the surface of plant leaves.

phyllosphere: the microenvironment immediately surrounding the aerial parts of plants, such as the leaves.

prevalence: the dynamic proportion of a population with infection or disease, often expressed as a percentage.

protozoan: motile and heterotrophic unicellular organisms, such as amoebas and paramecia.

residence time: the period of time a substance remains in a particular place.

retention time: the average period of time for which water resides in a wetland, lake, reservoir, or other body of water.

rhizosphere: the microenvironment immediately surrounding the roots of a plant. The population of microorganisms in this area is greater than in the rest of the soil.

saprophytic: describing an organism that obtains nutrients from decaying matter.

serotype: a group of microorganisms distinguished by a common set of cell surface antigens.

specialty crops: according to the USDA, specialty crops are "fruits and vegetables, tree nuts, dried fruits, horticulture, and nursery crops (including floriculture). Eligible plants must be intensively cultivated and used by people for food, medicinal purposes, and/or aesthetic gratification to be considered specialty crops."

streptococci: any bacterium from the genus *Streptococcus*—gram-positive bacteria that include many important human pathogens.

tailwater: water running off the lower end of a field resulting from normal irrigation practices.

tertiary treated wastewater: wastewater that has gone through a secondary treatment process, in which microorganisms degraded the dissolved organic material, and then a tertiary treatment process to remove inorganic nutrients, heavy metals, viruses, and so on from sewage by chemical and biological means.

thermophilic composting: a composting process in which one phase of the process takes place at temperatures exceeding 40°C (104°F).

thermophilic organism: an organism that requires/tolerates high temperature environments.

Ultraviolet (UV) radiation: electromagnetic energy with wavelengths that fall between those of visible light (violet) light and x-rays.

vector: any living organism that can carry a disease-causing organism.

vertebrate: an organism that possesses a spinal column, including mammals, reptiles, and birds.

virulence: the degree of pathogenicity of a microorganism as indicated by the severity of disease produced and the ability to invade the tissues of the host; by extension, the competence of any infectious agent to produce pathologic effects.

Acronyms

CAFO—Concentrated Animal Feeding Operation
CDC—Center for Disease Control
EHEC—Enterohemorrhagic *Escherichia coli*
FDA—United States Food and Drug Administration
GAPs—Good Agricultural Practices
HLR—Hydraulic Loading Rate
HRT—Hydraulic Residence Time
LGMA—Leafy Greens Marketing Agreement (or California Leafy Green Products Handler Marketing Agreement)
NRCS—U.S. Department of Agriculture, Natural Resource Conservation Service
STEC—Shiga toxin–producing *Escherichia coli*
USDA—U.S. Department of Agriculture
VTS—Vegetative Treatment System

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On-Farm Food Safety and Conservation

Jo Ann Baumgartner
Wild Farm Alliance
www.wildfarmalliance.org

WILD FARM ALLIANCE

Overview

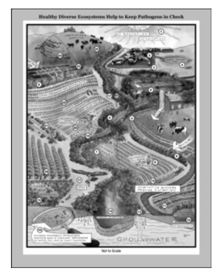
- Why Co-management of Food Safety and Conservation is Necessary
- Pathogen Routes and Prevalence on the Farm
- Factors that Influence Pathogen Reduction
- Persistence of Pathogens in Soils
- Conservation Practices that Influence the Reduction of Pathogens
- Multi-Barrier Approach to Minimizing Food Safety Concerns
- Converting Knowledge to Action

S. Earnshaw

WILD FARM ALLIANCE

Why Co-managing Food Safety and Conservation is Necessary

Healthy Diverse Ecosystems Help to Keep Pathogens in Check



www.wildfarmalliance.org

WILD FARM ALLIANCE

Food Safety Plans and GAPs

Good Agricultural Practices GAPs Address:

a) water quality,
b) soil amendments,
c) wild and domestic animals,
d) the surrounding environment, and
e) worker health and hygiene

WILD FARM ALLIANCE

Food-Borne Illness Attributed to Produce

- From 1998-2008, 46% of the illnesses documented by the CDC were attributed to produce.
- Causes include the farm, processing, storage or shipping; handling by a store, or preparation in a restaurant or home.

danieltaeger/123RF.com

WILD FARM ALLIANCE

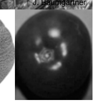
Food-Borne Illness Attributed to Produce from the Farm

- CDC can only identify 40% of the causes. Of those identified:
  - From 1998-2008, 5% might come from the farm.
  - From 2009-2010, 0.5% might come from the farm.

Foods More at Risk

- Raw vs. cooked
- Fresh cut ready-to-eat leafy greens
- Netted melons
- Tomatoes

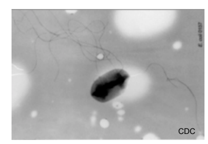




Bacteria in Us Would Fill a Half Gallon Jug

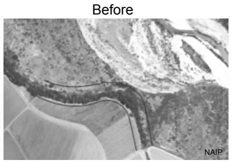
Pathogens of Concern for Specialty Crops

- Bacterial Pathogens
  - Shiga toxin-producing *Escherichia coli*
  - *Salmonella* spp.
  - *Campylobacter* spp.
  - *Listeria* spp.
- Protozoan Pathogens
  - *Cryptosporidium* spp.
- Pathogens with Antimicrobial Resistance

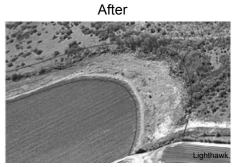


Conflicts with Conservation Goals

Before



After



After

Conflicts with Conservation Goals

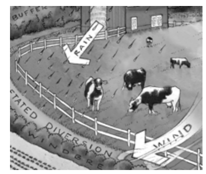
- In 2006, spinach contaminated with *E. coli* O157:H 7 caused the death of five people.
- In 2007, 89% percent of growers managing 140,000 acres on California's Central Coast reported that they had actively discouraged or eliminated wildlife from crop areas.
- Over a 5 year period after the contamination, about 13% of the remaining riparian habitat in the region had been eliminated or degraded.

Co-management of Food Safety and Conservation

Co-management means farm system management approaches that respond to site-specific conditions by integrating cultural, biological, and mechanical practices that promote ecological balance and public health by conserving biodiversity, soil, water, air, energy and other natural resources, while also reducing pathogen hazards associated with food production (National Sustainable Agriculture Coalition).

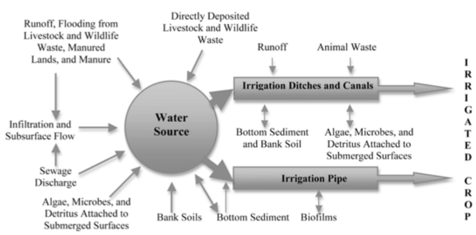
Pathogen Routes and Prevalence on the Farm

- **Waterborne Pathways**
- **Airborne Particulate Matter Pathways**
- **Wildlife Prevalence and Pathways**
- **Livestock Prevalence and Pathways**



Waterborne Pathways

Processes Affecting Microbial Quality of Irrigation Water



Adapted from : Pachepsky et al. 2011

Waterborne Pathways

Table 1

Confirmed Outbreaks Associated with Irrigation Water

Crop	Pathogen	Irrigation Source	Farm Location
Tomatoes (a)	*Salmonella* Newport	pond	Virginia
Lettuce (b)	*E. coli* O157:H7	small stream	Sweden
Shredded lettuce (c)	*E. coli* O157:H7	well water accidentally mixed with dairy lagoon water	California
Hot peppers (d)	*Salmonella* SaintPaul	holding pond used for irrigation water	Mexico

From (a) Greene et al. 2008; (b) Soderstrom et al. 2008; (c) US FDA and CA Food Emergency Response Team 2008; and (d) CDC 2008.

Airborne Particulate Matter Pathways

Table 2

Selected Cases of Airborne Pathogen Contamination

Types of Airborne Pathogens	Location	What the Research Examined
E. coli O157:H7 (a)	Colorado 6,000-head cattle feedlot	Airborne transport of *E. coli* O157:H7 from feedlot to various distances of leafy green crops.
Newcastle disease virus (b)	Pennsylvania poultry farms	Vegetative buffers in Pennsylvania reduced dust and respiratory virus transmission from commercial poultry farms.
Larynogtracheitis virus (c)	Delaware poultry farms	A four-fold increase in risk of poultry developing the disease if a farm was located within the downwind plume of the farm with contaminated poultry.
E. coli O157:H7 (d)	Ohio fairgrounds	One hundred people were sickened when a dance was held in the same building that had earlier exhibited animals.
Many pathogenic *E. coli* strains (e)	Mexico City household and street dust	Intestinal infections caused by dust collected from indoor and outdoor environments was greater than thought.
E. coli O157 and *Salmonella* (f)	Texas cattle feed yards	Exposure to dust in the cattle load-out area of feed yards increased pathogen contamination of cattle hides.
Salmonella enteritidis (g)	Chicken houses	Infected hens in houses transferred disease to healthy hens via the air.

Recorded Outbreaks Associated with Wildlife

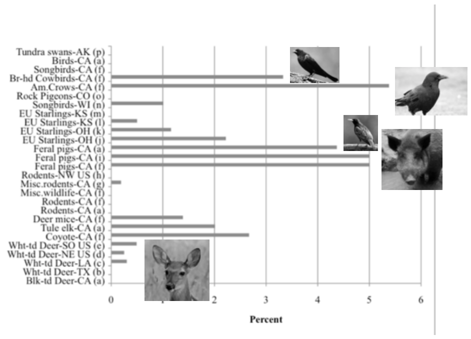
Table 3

Recorded Outbreaks Associated with Wildlife

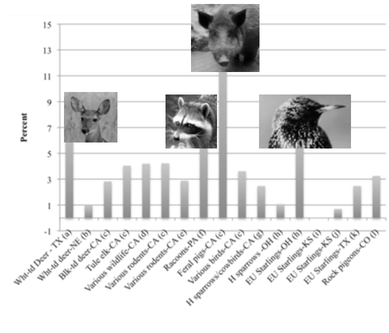
Crop	Pathogen	Wildlife	Location
Spinach (a)	*E. coli* O157:H7	non-native feral pigs*	California
Strawberries (b)	*E. coli* O157:H7	deer	Oregon
Peas (c)	*Campylobacter jejuni*	sandhill cranes	Alaska
Carrots (d)	*Yersinia pseudotuberculosis*	shrews	Finland

* While feral pigs were found with the same DNA pattern of *E. coli* O157:H7 as the spinach, so were nearby cattle and pasture soil, and water/sediments from a creek that may have contaminated the irrigation well.
From (a) Jay 2007; (b) Laidler and Keene 2012; (c) McLaughlin 2008; (d) Kangas 2008.

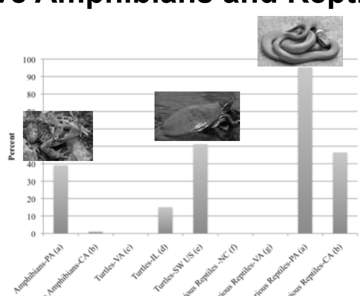
E. coli 0157:H7 Prevalence in US Native and Non-Native Mammal and Avian Species



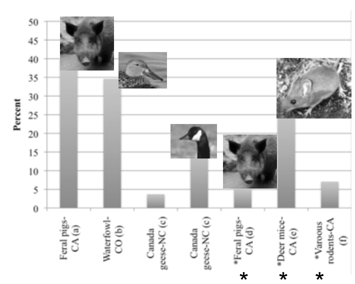
Salmonella Prevalence in US Native and Non-Native Mammal and Avian Species



Salmonella Prevalence in US Native Amphibians and Reptiles



Campylobacter and *Cryptosporidium** Pathogen Prevalence in US Native and Non-Native Mammal and Avian Species



Pathogen Vectoring by Wildlife

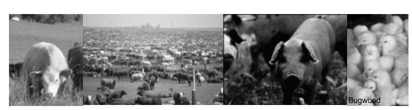
Prevalence of Pathogens in Livestock

E. coli 0157:H7

- **Widespread in cattle; higher in CAFOs than on pasture**
- **Also in pigs, dogs, poultry**
- **Higher in young than in adults**

Salmonella

- **Poultry**
- **Pigs**
- **Cattle**
- **Other livestock**



Prevalence of Pathogens in Livestock

Campylobacter
- **Most common in poultry**
- **Cattle**
- **Other livestock**

Cryptosporidium
- **Cattle**
- **Sheep**
- **Goats**
- **Pigs**
- **Horses**
- **Geese**
- **Poultry**

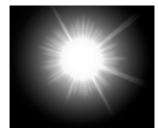
Listeria
- **Sheep**
- **Goats**
- **Cattle**
- **Other livestock**



For a thorough discussion, see *Introduction to Waterborne Pathogens in Agricultural Watersheds, USDA NRSC Nutrient Management Technical Note No. 9.*

Factors that Influence Pathogen Reduction

- **Biotic**
- **Abiotic**

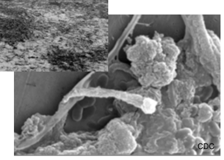



Biotic Factors - Microbial Interactions

- Predation
- Competition
- Antagonism

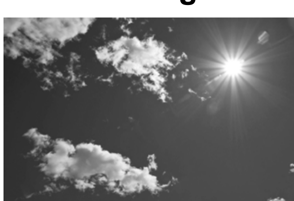
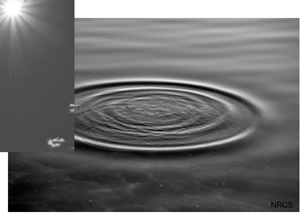
Biotic Factors - Harborage

- Biofilms
- Amoebas
- Algae



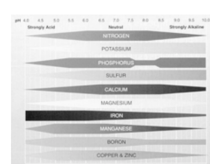
Biofilm

Abiotic Factors – Sunlight/UV Exposure

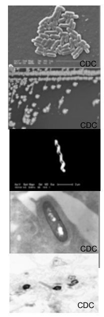
More Abiotic Factors

- **Salinity**
- **pH**
- **Nutrient Sources**
- **Temperature**
- **Moisture and**
- **Microscopic Niches**




Persistence of Soil Pathogens

- Examples of Pathogen Persistence
  - – *E. coli* O157:H7 (25 - 226 days)
  - – *Salmonella* (7 - 332 days)
  - – *Campylobacter* (31 – 64 days)
  - – *Listeria* (43 - 128 days)
  - – *Cryptosporidium* (<1 year)



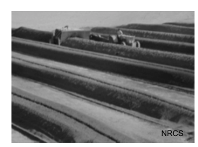
Five Minute Break for Questions

Conservation Practices that Influence the Reduction of Pathogens in Specialty Crops

- Soil Conservation Practices
- Water Movement and Storage Practices
- Vegetative Conservation Practices
- Animal Management Practices

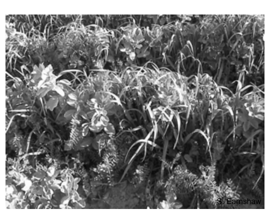
Soil Conservation Practices that Influence Pathogen Reduction

- **Manure Management**
  - – Nutrient Management (590)
  - – Composting Facility (317)
- **Dust Mitigation Practices**
  - – Air Filtration and Scrubbing (375)
  - – Dust Control for Animals (371)



Soil Conservation Practices that Influence Pathogen Reduction

- Cover Crops (340)
- Conservation Crop Rotation (328)



Water Movement and Storage Practices for Pathogen Management

- Irrigation Water Management (449)
- Diversion (362)
- Waste Storage Facility (313)

Water Movement and Storage Practices for Pathogen Management

Vegetation that Intercepts Waterborne Pathogens

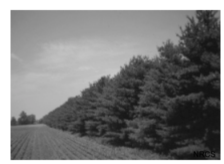
- **Wetlands**
  - Constructed (656)
  - Created Wetlands (658)
  - Enhanced Wetlands (659)
  - Restored Wetlands (657)

Vegetation that Intercepts Waterborne Pathogens

- **Vegetative Buffers**
  - Field Borders (386)
  - Filter Strips (393)
  - Critical Area Plantings (342)
  - Grassed Waterways (412)
  - Vegetative Barriers (601)
  - Tree and Shrub Establishments (612)
  - Conservation Cover (327)
  - Riparian Forest Buffer (391)
  - Riparian Herbaceous Buffer (390)

Vegetation that Intercepts Particulate Matter with Pathogens

- Windbreaks (380)
- Hedgerows (422)
- Riparian Forest Buffers (391)



Animal Management Practices that Help to Reduce Pathogen Presence

- Integrated Pest Management (595)
- Wildlife Corridors
- Prescribed Grazing (528)

Multi-Barrier Approach to Minimizing Food Safety Concerns on the Farm and in the Watershed

- **Barriers that Prevent Pathogens from:**
  - Entering the Farm
  - Contaminating Produce Crops
  - Spreading from Livestock to the Crops
  - Moving to the Wider Landscape

1st — Barriers that Prevent Pathogens From Entering the Farm

- Intercepting waterborne pathogens
- Intercepting particulate matter with pathogens

WILD FARM ALLIANCE

1st— Barriers that Prevent Pathogens From Entering the Farm

- IPM of non-native feral animals

WILD FARM ALLIANCE

2nd— Barriers that Reduce Likelihood of Pathogens on the Farm Contaminating Crops

Choosing the Appropriate Sites:

- Avoid nearby contamination*
- Avoid frequently flooded land or institute a waiting period after flooding*
- For riskier areas, plant crops for livestock*
- Mitigate food safety requirements*
- Avoid overhanging vegetation*

WILD FARM ALLIANCE

*Food Safety GAPs

2nd—Barriers that Reduce Likelihood of Pathogens on the Farm Contaminating Crops

Preventing Pathogens from Coming in Contact with the Crop:

- Monitor*
- Conserve wildlife corridors
- IPM

WILD FARM ALLIANCE

*Food Safety GAPs

2nd—Barriers that Reduce Likelihood of Pathogens on the Farm Contaminating Crops

Preventing Pathogens from Coming in Contact with the Crop:

- *Soil management practices that reduce pathogens*
  - Waiting period for manure*
  - Cover cropping and crop rotations
  - Nutrient management
  - Using compost as an alternative
  - Contaminated site management*
  - Pathogen desiccation in soils and sediments*

WILD FARM ALLIANCE

*Food Safety GAPs

2nd—Barriers that Reduce Likelihood of Pathogens Contaminating Crops

Preventing Pathogens from Coming in Contact with the Crop:

- Intercept pathogens before they reach the crop
- Mitigate water quality concerns caused by food safety requirements*
- Meet water quality standards*

WILD FARM ALLIANCE

*Food Safety GAPs

3rd—Barriers that Reduce Spreading Pathogens to Crops When Livestock are on the Farm

- Waiting period between fecal deposits and harvest*
- Conservation practices that keep pathogens from spreading in diverse farms
- Restrict wild and feral animals that move between livestock areas and crop fields*

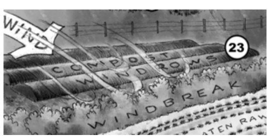
*Food Safety GAPs

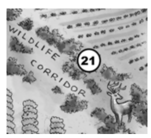
4th—Barriers that Prevent Pathogens From Leaving the Farm

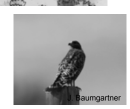
- Conservation practices that keep pathogens in check

Converting Knowledge to Action

- Specialty Crop Food Safety Plans and Audits
- Fundamental Co-management Concerns







Specialty Crop Food Safety Plans and Audits

- USDA AMS food safety audit program does not make growers loose points for non-crop vegetation near produce fields.
- Some auditors will not allow a crop to be located near non-crop vegetation.
- Growers can effectively advocate for their farming practices by explaining their rationale for management decisions that address any food safety risks.

Specialty Crop Food Safety Plans and Audits

- Wild Farm Alliance's *Training Scenarios for USDA and Third Party Auditors on the Co-management of Food Safety and Conservation* ***www.wildfarmalliance.org/resources/FS_Training_Scenarios.htm***
- University of California's *Introduction to Auditor Resource Materials* ***http://ucfoodsafety.ucdavis.edu/Preharvest/Co-Management_of_Food_Safety_and_Sustainability***

Fundamental Co-management Steps to be Taken

- Develop a food safety plan that incorporates co-management of food safety* and conservation,
- Manage manure for pathogen reduction,
- Strategically select crop and field,*
- Intercept contamination before it gets to the crop,
- Encourage diverse soil microbial populations,
- Monitor for wildlife and discourage significant intrusion,* and
- Manage water to reduce runoff with possible pathogens.

*Food Safety GAPs

Food Safety Without Compromising Natural Resources

www.wildfarmalliance.org

WILD FARM ALLIANCE

Acknowledgements

- USDA Natural Resources Conservation Service
- Private Foundations (Cliff Bar, Columbia, Gaia Fund, Farm Aid, Newman's Own, Organic Farming Research, Tomkins/Imhoff Family Fund, True North, and United Natural Foods)
- University of California Cooperative Extension
- Many other conservation and food safety technical experts
- Businesses (Veritable Vegetable and many farms in CA, FL, and NY)

WILD FARM ALLIANCE

Acknowledgements

Farm Organization Partners

FLORIDA ORGANIC GROWERS

Hawthorne Valley FARMSCAPE ECOLOGY PROGRAM

AGRICULTURE AND LAND-BASED TRAINING ASSOCIATION ALBA

CAFF COMMUNITY ALLIANCE WITH FAMILY FARMERS

NOFA-NY NORTHEAST ORGANIC FARMING ASSOCIATION OF NEW YORK

RCD MC RESOURCE CONSERVATION DISTRICT OF MONTEREY COUNTY

WILD FARM ALLIANCE

Wild Farm Alliance
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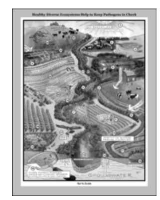
www.wildfarmalliance.org



WILD FARM ALLIANCE

Appendix 3 **Final Income and Expenses**

Income	NRCS Federal Share	Cash March	In-Kind Match	Total
NRCS	137,510.31			137,510.31
Cliff Bar Foundation		1,136.64		1,136.64
Columbia Foundation		16,396.95		16,396.95
Eddy Foundation/Philips		982.22		982.22
Imhoff/Community Foundation		15,000.00		15,000.00
Newman's Own Foundation		21,179.96		21,179.96
Organic Farming Research Foundation		11,419.37		11,419.37
True North Foundation		10,000.65		10,000.65
United Natural Foods		2,000.00		2,000.00
Vertitable Vegetable		5,000.00		5,000.00
Professionals			58,600.72	58,600.72
Total Income	**137,510.31**	**83,115.79**	**58,600.72**	**279,226.82**
Expense				
Payroll Expense	87,106.99	58,981.98		146,088.97
Postage and Delivery	127.86			127.86
Printing and Reproduction	92.62	167.97		260.59
Professional Fees				
Accounting/Bookkeeping	1,569.50	286.00		1,855.50
Artist		1,000.00		1,000.00
Editor	400.00			400.00
Farmers and Farm Groups	14,475.17		31,350.00	45,825.17
L & L Consulting	22,787.50	12,329.50	11,013.22	46,130.22
Surveyers	2,475.00	600.00		3,075.00
Technical Advisors			10,900.00	10,900.00
WFA Board Members			5,337.50	5,337.50
Rent	4,294.50	2,454.00		6,748.50
Supplies	548.95	100.32		649.27
Telecommunications	2,788.86	1,337.09		4,125.95
Travel/Meals/Conferences	843.36	5,858.93		6,702.29
Total Expense	**137,510.31**	**83,115.79**	**58,600.72**	**279,226.82**

Appendix 4 **Breakdown of In-Kind and Cash Match**

INVOICE #	In Kind Match Farm Groups	Tech Advisors	Karen Lowell	WFA Board	In-Kind Match Total	Cash Match	Total Match
1	$ 300.00		$ 912.50	$ 1,400.00	$ 2,612.50	$ 12,333.53	$ 14,946.03
2	$ 700.00	$ 2,000.00	$ 2,075.00		$ 4,775.00	$ 14,308.07	$ 19,083.07
3	$ 4,400.00	$ 500.00	$ 2,712.50	$ 975.00	$ 8,587.50	$ 16,357.01	$ 24,944.51
4	$ 12,550.00	$ 3,000.00	$ 1,362.50	$ 225.00	$ 17,137.50	$ 18,526.96	$ 35,664.46
5	$ 550.00	$ 500.00	$ 1,563.22	$ 262.50	$ 2,875.72	$ 274.50	$ 3,150.22
6	$ 300.00	$ 1,500.00	$ 2,387.50	$ 225.00	$ 4,412.50	$ 3,523.50	$ 7,936.00
7	$ 250.00	$ 800.00		$ 825.00	$ 1,875.00	$ 4,154.40	$ 6,029.40
8	$ 500.00	$ 500.00		$ 300.00	$ 1,300.00	$ 1,897.78	$ 3,197.78
9	$ 2,400.00				$ 2,400.00	$ 1,125.15	$ 3,525.15
10	$ 1,400.00				$ 1,400.00	$ -	$ 1,400.00
11	$ 200.00	$ 1,600.00		$ 1,125.00	$ 2,925.00	$ -	$ 2,925.00
12	$ 4,525.00				$ 4,525.00	$ 300.00	$ 4,825.00
13	$ 1,125.00				$ 1,125.00	$ 4,856.25	$ 5,981.25
14	$ 2,150.00				$ 2,150.00	$ 3,202.35	$ 5,352.35
15					$ -	$ 1,038.60	$ 1,038.60
16		$ 500.00			$ 500.00	$ 1,217.69	$ 1,717.69
Total	$ 31,350.00	$ 10,900.00	$ 11,013.22	$ 5,337.50	#######	#######	########

Farm Group
Need $26,600 Match

Estimate In-Kind Match

Farmer Groups	Farmer Survey-1 hour/survey	Number of Farmers Hosting Visit	Farmer Hours for Hosting Visit	Number of Farmers in Meeting	Hour of Farmers Participating in 2hr Meeting & driving 2 hours	Total Farmer Hours	Rate Per Hour	Total Farmer $
CA-CAFF	40	4	16	8	32	88	50	4400
CA-ALBA		4	16	8	32	48	50	2400
CA- RCD		4	16		0	16	50	800
FL-FOG	40	4	16	8	24	80	50	4000
FL- Fruit & Vegetable Assoc	40	4	16	8	32	88	50	4400
NY-NOFA	40	4	16	8	32	88	50	4400
NY-Farmscape	9		0	0	0	9	50	1800
NY State Fruit & Vegetable Assoc	40	4	16	8	32	88	50	4400
Totals						**505**		**26600**

Actual In-Kind Match

	Invoice 1/31/11	Invoice 4/31/11	Invoice 7/31/11	Invoice 9/30/11	Invoice 12/31/11	Invoice 3/31/12	Invoice 6/30/12	Invoice 9/30/12	Invoice 12/31/12	Invoice 4/30/13	Invoice 7/31/13	Invoice 10/31/13	Invoice 12/31/13	Invoice 3/31/14	Match red= short; blue= enough	
CAFF staff inkind match (Farm Aid)												$ 3,750.00	$ 1,125.00	$ 1,375.00		$ 6,250.00
Other CA			36			6		5			**2**	**10**		**16**	75	$ 3,750
CA-CAFF				7	11		5	5		22		5.5	18		73.5	$ 3,675
CA-ALBA									48						48	$ 2,400
CA- RCD											2				2	$ 100
FL-FOG			1	83						6					90	$ 4,500
FL- Fruit & Vegetable Assoc		2		62											64	$ 3,200
NY-NOFA			27	50											77	$ 3,850
NY-Farmscape	6	12		1											19	$ 950
NY State Fruit & Vegetable Assoc			24	30											54	$ 2,700
Total	**6**	**14**	**88**	**233**	**11**	**6**	**5**	**10**	**48**	**28**	**4**	**15.5**	**18**		**502.5**	**$ 31,375**
	300	700	4400	11650	550	300	250	500	2400	1400	200	775	900			

Cell E22-reported 18 hours too many (48-30) for farm visits (see their match letter - need to make up elsewhere

18 hours made up by farmers who gave input on illustration of tech note right before FDA comments were due

TAC Members

need $16,400 match

TAC Memb	Estimated	Hourly Rate	Invoice 1/31/11	Invoice 4/31/11	Invoice 7/31/11	Invoice 9/30/11	Invoice 12/31/11	Invoice 3/31/12	Invoice 6/30/12	Invoice 9/30/12	Invoice- 7/31/13	Invoice- 9/30/13	Invoice- 12/31/13	Match		
Andy Gordu	16	100		4		2		3	2		2			**13**	**$**	**1,300**
Anu Rangar	16	100						1						**1**	**$**	**100**
Betsy Bihn,DFS, Cornell		100				7		2			2			**11**	**$**	**1,100**
Brian Ander	16	100		1		2								**3**	**$**	**300**
Daniel Mountjoy		100			1	2	1							**4**	**$**	**400**
David Lewis	16	100				2								**2**	**$**	**200**
John Anders	16	100				2		1			2			**5**	**$**	**500**
John Hunt	16	100												**0**	**$**	**-**
Luana Kiger				1		1					2			**4**	**$**	**-**
Martha Rho	16	100												**0**	**$**	**-**
Michele Jay	16	100		1	1			2			2			**6**	**$**	**600**
Michael Mahovic						2		1	3	3	4			**13**	**$**	**-**
Nancy Flore	16	100				2		1			2			**5**	**$**	**500**
Phil Foster					1									**1**	**$**	**-**
Racheal Lon	16	100			1	2								**3**	**$**	**300**
Ray Weil, S	8	250												**0**	**$**	**-**
Richard Smi	16	100				0								**0**	**$**	**-**
Steve Gilma	16	100		4			2	1						**7**	**$**	**700**
Steve Warsl	16	100		6		2	2	2						**12**	**$**	**1,200**
Trevor Susl	16	100		3	1	2		1	3					**10**	**$**	**1,000**
NY-Wideman reseacher		100								1				**1**	**$**	**100**
Chicken research/hedge		100								1				**1**	**$**	**100**
William Boyd						2										
TAC Total	**232**		**0**	**20**	**5**	**30**	**5**	**15**	**8**	**5**	**16**			**104**	**$**	**8,400**
				2000	500	3000	500	1500	800	500	1600					**10400**

$15,000 Match Needed from the Board

	Estimated Hours	Hourly Rate	Invoice 1/31/11	Invoice 4/31/11	Invoice 7/31/11	Invoice 9/30/11	Invoice 12/31/11	Invoice 3/31/12	Invoice 6/30/12	Invoice 9/30/12	Invoice 6/30/13	Invoice 9/30/13			
WFA Board															
Dan Imhoff	28.5	75	3		2	0.5	0.5		2	2	1		11	$	825
Dana Jackson	28.5	75	3		2	2	0.5		3		4		14.5	$	1,088
Dan Kent	28.5	75	3		2		0.5				1		6.5	$	488
John Davis	28.5	75					0.5				1		1.5	$	113
Vance Russell	28.5	75	3		2		0.5	2	3	2	3		15.5	$	1,163
Becky Weed	28.5	75	3		2		0.5	1	3		3		12.5	$	938
Randy Gray	29	75	3.6		3	0.5	0.5						7.6	$	570
Dave Henson		75									1		1	$	75
Paula MacKay		75									1		1	$	75
	200		**18.6**	**0**	13	**3**	**3.5**	**3**	**11**	**4**	**15**		**69.1**	**$**	**5,333**

Wild Farm Alliance Co-management Technical Advisory Committee (TAC) Conference Call Notes

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September 26, 2011 Notes

Technical Advisory Members on Call- *Andy Gordus, California Department of Fish and Game; Brian Anderson, University of California; Dana Jackson, Land Stewardship Project; Daniel Mountjoy, Natural Resources Conservation Service (NRCS); David Lewis, Marin County UC Cooperative Extension; Betsy Bihn, Cornell University; John Anderson, Hedgerow Farms; Jose Perez, Florida Organic Growers; Karen Lowell, L & L Consulting; Kate Mendenhall, Northeast Organic Farming Association of New York; Michael Mahovic, FDA; Nancy Flores, New Mexico State University; Rachael Long, Yolo County UC Cooperative Extension; Richard Smith, Monterey County UC Cooperative Extension; Steve Warshauer, New Mexico farmer/liason for National Sustainable Agriculture Coalition; Trevor Suslow, UC Davis and William Boyd, NRCS*

See Highlighted Yellow Text for Decisions that Were Made on the Call

Overview of Project
Project Title: *Co-managing for Food Safety and Conservation Objectives in Specialty Crops: Preparing NRCS Conservationists and Technical Service Providers to Address New Challenges*

Length of Project: 3 year nationally funded NRCS Conservation Innovation Grant project

Goal: To strengthen the capacity of NRCS to assist specialty crop growers in the integration of new food safety requirements with resource conservation efforts.

Focus: FL, NY, and CA.

Deliverables: Technical Note and trainings

Audience: Primarily NRCS staff and the farmers they serve, but secondarily we are thinking the Technical Note could be used to inform food safety personnel about co-management.

Length of Technical Note: Target length is 20 pages, though it may be up to 30 pages.

Technical Note References: A selection of the most relevant references will be included. A separate document with the complete set of references will be created and made accessible on the web.

Farm Visits and Phone Surveys: Conducted in FL and NY (summaries were sent prior to the call); still completing them in CA. Complete results won't be published, they are helping to shape what will be included in the Technical Note. (Note: Fish emulsion was wrongly listed in the FL summary as a farming practice that may present a food safety risk. It is not a pathogen source because of the way it is processed which results in a low pH. Though when diluted with water of unknown quality it may become a food safety risk.)

Draft Technical Note Outline and References

Quickly reviewed the first two sections of the Technical Note Outline: #1 (Introduction) and #2 (What has been done, and what will this document add). Then went into more detail in rest of outline. The TAC was asked to point out what information was not in outline that should be included, and what is covered thoroughly elsewhere and doesn't need to be included.

3. Representative pathogens of concern in specialty crops. Main objective of this section is to describe and justify the choice of pathogens for focus in the document.

- Focus on the following list of pathogens:
    - Bacteria: Pathogenic *E. coli* / STEC, *Salmonella*, *Campylobacter* and *Listeria* (for now, this pathogen is included in the main focus list, but this may change after additional research is completed.)
    - Protozoans: *Cryptosporidium*
- Mention the following list of pathogens, possibly in a chart with the above pathogens, but don't focus on them:
    - Bacteria: *Shigella* (usually caused by failure in water systems)
    - Protozoans: *Cyclospora* (outbreaks usually occur outside the US)
    - Viruses: *Norovirus*, *Hepatitis* (both typically linked to contamination by human sources)

4. Sources of pathogens in the landscape. Main objective of this section is to identify major sources of pathogens in the landscape.

- Wild animals (and domestic animals and humans – but not the main focus)
- Move manure-based soil amendments to next section because they are not a source, rather addition of manure-based soil amendments represents a pathway for pathogens to reach crops.

5. Pathways of Contamination. Main objective of this section is to present an overview of the ways in which pathogens may come in contact with crops in the field setting, particularly as this relates to conservation practices.

- Direct contact with fecal matter (wild and domestic animals, bioaerosols, addition of manure or manure-based and non-manure-based soil amendments (e.g. compost), to cropland)
- Direct contact with contaminated water. Sources of water include runoff, floodwaters, and contaminated irrigation water. Include consideration of splash, dust abatement water, tailwater, and blended water.

6. Factors affecting fate and transport of pathogens in the landscape. Main objective of this section is to explain what factors impact survival, amplification, and movement of pathogens in the landscape. Where possible, use thorough, well-documented reviews on the topics in this section and avoid a lengthy text discussion here, relying instead on diagrams and summary tables to convey key information. In this way, the Technical Note can focus on those areas where reviews are lacking.

- Fate of pathogens in water. Include rainfall intensity and duration, and acknowledge settings on irrigation. Consider risk management impacts of conservation practices at the landscape level (e.g. use of wetlands high in the watershed to mitigate risk of pathogen movement to irrigation water sources).
- Fate of pathogens in soils and sediments
- Fate of pathogens on crops (mention, but don't make this a main focus) and on vegetation
- Fate of pathogens in manure and composted manure/composted greenwaste (not a main focus because this is already covered in another NRCS Technical note).

7. How conservation planners can help land owners/farmers minimize food safety risk associated with conservation practices. Main objective of this section is to connect risk analysis to specific aspects of conservation practices.

- Use Multi-barrier approach (1. Pathogen import to *growing environment*, 2. Cycle of pathogen amplification or proliferation in the *growing environment*, 3. Appropriate nutrient and waste management, and 4. Pathogen export or transport from the *source of contamination)*
- Create a table summarizing pathogen sources, pathways in the cropping environment, and factors controlling fate and transport.
- Create another table with beneficial conservation practice functions on one axis and pertinent NRCS Practice Standards on the other.
- The risk analysis will also alert conservation planners and others that farmers consider post harvest / market factors when making food safety management decisions.

8. Add new section: **How conservation planners can help land owners/farmers mitigate food safety practices**

- Address how food safety practices can create conservation problems (traps, rodent bait and other types of poison, copper sulfate used to treat ponds, fencing, lack of vegetation in erosion-prone areas), and discuss strategies to reduce adverse off-farm impacts.

March 26, 2012 Notes

Technical Advisory Members (TAC) on Call- *Andy Gordus, California Department of Fish and Game; Anu Rangarajan, Cornell University; Becky Weed, Thirteen Mile Lamb and Wool Company; Betsy Bihn, Cornell University; Cathy Carlson, Community Alliance with Family Farmers; Bill Reck, NRCS; Daniel Botts, Florida Fruit and Vegetable Association; Jo Ann Baumgartner, Wild Farm Alliance; John Anderson, Hedgerow Farms; Jose Perez, Florida Organic Growers; Karen Lowell, L & L Consulting; Luana Kiger, NRCS; Michael Mahovic, FDA; Michele Jay-Russell, UC Davis; Nancy Flores, New Mexico State University; Paul Robins, Resource Conservation District of Monterey County; Steve Gilman, Northeast Organic Farming Association of New York; Steve Warshauer, Beneficial Farm; Trevor Suslow, UC Davis; Vance Russell, National Forest Foundation; and William Boyd, NRCS.*

See Highlighted Yellow Text for Decisions that Were Made on the Call

On this call, the TAC gave feedback on Section 3 - Pathogens, Section 4 – Sources of Pathogens, and Section 5 - Pathways of Contamination. The next call will be spent reviewing the rest of the document, including Sections 1 and 2, which have not been sent out yet.

General Input on Technical Note:
Appropriate Content for Audiences: The Technical Advisory Committee (TAC) is tasked to make sure this technical note primarily covers what NRCS staff and Technical Service Providers (TSP) should know. The document will secondarily serve as a resource for others and so should use commonly understood terminology. The content should reflect the outline (also sent with this email) and not re-create the updated version of the NRCS Tech Note "An Introduction to Waterborne Pathogens in Agricultural Watersheds."

Glossary: Create a glossary section with one or two sentences for each word, and include a link to a website reference, when appropriate. The definition of "specialty crops" should be in the glossary with a link to the USDA website that provides the complete crop list.

Input on Section 3:
Viable But Not Cultureable: A question was posed on whether all pathogens covered in this document could be considered *Viable But Not Cultureable* (VBNC). It is thought that the four bacterial pathogens covered do not form spores and so may be VBNC, especially *Salmonella*. A couple of references were sent after the call. The concept of VBNC is not well understood and since it is still controversial as it applies to farm risk, any mention of VBNC will come with this caveat.

Pathogen survival times: Another question was asked about whether it would be beneficial to include a range, or possibly a table, of the pathogen survival times in the soil. The low end can be 30-60 days in dry conditions. The longest survival times reflect the worst-case scenarios. It was thought that the factors influencing pathogen survival are too complex to capture in a table, but that it would be important to show a range. Suggestions were also made to refer the reader to reviews by Van Elses on the survival of *E. coli* in the environment, and by Bowdman on manure pathogens.

Section 4: Sources of Pathogens

Complexities of Data: Keep the explanation on the complexities of data in Section 4, instead of putting it in the appendix. This helps to put the data in proper context.

Animal Specific Pathogens May Potentially Infect Humans: While there are many *Salmonella* pathogens that have not yet been linked to human illness, both CDC and FDA consider all of them as human pathogens, since they all have the potential to be pathogens. Currently, there are studies trying to figure out which versions of *E. coli* STEC are bad. FDA may be hesitant to make a determination on all STEC until more is known, but they seem to say all *Salmonella* are problematic. Therefore, the point will be made that all the STEC and *Salmonella* pathogens, whether or not they are animal specific, can potentially cause human illness.

Wildlife Figures: Re-scale the graphs to show less white space, and clarify that “percent” means “percent samples.”

Listeria: Check with Kendra Nightengale now at Texas Tech and Martin Weideman at Cornel about whether they know of *Listeria* wildlife studies in the US.

Section 5: Pathways of Contamination

Treated Wastewater: There have been no recent illnesses or outbreaks linked to tertiary treated wastewater applied to horticulture crops in US, although there have been some in other countries. California tends to have some of the strictest guidelines. Make sure the document points out that State guidelines may differ on the level of wastewater treatment required before application to crops, and if groundwater injection/recharge is allowed.

June 14, 2012 Notes

Technical Advisory Members on Call-
Bill Boyd, NRCS
Cathy Carlson, CAFF
Michael Mahovic, FDA
Trevor Suslow, UC Davis
Becky Weed, WFA Board
Dan Imhoff, WFA Board

WFA Staff on Call-
Jo Ann Baumgartner
Meaghan Donavan

See Highlighted Yellow Text for Decisions that Were Made on the Call

On this call, the TAC gave feedback on the co-management Illustration and Key, the Physical Effects ratings table (Table 7.2), the Multiple Barriers table (Table 7.1), the Glossary (Appendix 1) and Selected Resources (Appendix 2) of the *Co-managing for Food Safety and Conservation Objectives in Specialty Crops* document.

Input on the Glossary:
While there were no specific resources suggested for obtaining glossary definitions, it was recommended that we keep our audience in mind when writing the definitions to make the language appropriate for said audience.

Input on the Illustration and Key:
Reactions to the Illustration: Initial reactions to the illustration were discussed, which varied depended on point of view. To some all of the food-safety hazards in the illustration jumped out (i.e. wildlife, wildlife habitat, and confined animals near specialty crops), while others saw this as the title suggests, a healthy, diverse ecosystem.

Illustration Title: Change the part of the title of the illustration. The current title suggested to some that "healthy, diverse ecosystems PREVENTS ALL pathogen outbreaks." The new title should try to avoid giving this message, and instead convey that they can help to reduce but not eradicate all foodborne pathogens.

Illustration Key: Include more of the nuances of the different conservation practices in the key. For example, the waste storage pond may trap pathogens, but it needs to be maintained properly so it doesn't overflow, and wildlife should not be allowed to enter it.

Scale Disclaimer: Put a disclaimer at the bottom of the illustration stating that the drawing is not drawn to scale and that we are not recommending that one should have things squished together like they are in the illustration (i.e. CAFO right near specialty crops).

Input on Table 7.2 Ratings of Conservation Practice Components

Clarifying '-' and '+': It was suggested that the '-' and '+'s on the chart be explained in a more robust manner. One way to address this would be to actually give a definition for the '-' and '+'s. Another suggestion was to give items more details ratings depending on their effect on pathogen die-off (e.g. UV light might get +++, while root exudates might only get +) if research is available to strongly warrant that.

Referencing Research: Citing the sources for the ratings was also recommended, so that inquiring individuals could see how the research supported the rating.

Interplay Between Physical Effects: The interplay between the different physical effects was also brought up and how this interplay might affect the rating (e.g. how effective is a practice if there is a CAFO upstream vs. a clean, pristine mountain stream).

Input on Table 7.1 Multiple Barriers Approach

Chart Complexity: Make the Table less confusing and possibly relate it to on-farm situations. Some call participants found that the chart was complex and confusing, and favored removing the 'fate' and 'transport' columns and check boxes on the left of the table. Others thought that the columns should be kept, but replaced with on-farm problem situations, such as a CAFO located upstream.

Input on the Selected Resources:

None of the call participants had any additional recommendations for resources for the document.

May 29, 2013 Notes

Technical Advisory Committee Members on Call-
Kaley Grimland, ALBA
Cathy Carlson, CAFF
Dave Runsten, CAFF
Andy Gordus, CDFW
Betsy Bihn, Cornell University
Michael Mahovic, FDA
Scarlett Salem, FDA
John Anderson, Hedgerow Farms
Nancy Flores, NMSU
Kate Mendenhall, NOFA NY
Luana Kiger, NRCS
Jeanette Marvin NYVGA
Paul Robbins, RCD of Monterey Co.
Michele Jay-Russell, WIFSS, UCD

WFA Staff on Call-
Jo Ann Baumgartner
Meaghan Donovan

See Highlighted Yellow Text for Decisions that Were Made on the Call

On this call, input on the summary and tables covering the conservation practices and components that influence pathogen die off in water, air and soil was given by the TAC.

Announcement:
USDA's Ag Learn website now has an educational video providing information related to NRCS' *Waterborne Pathogens in Agricultural Watersheds* technical note updated by Rob Atwill, Luana Kiger and others.

How the Summary and Water, Air, and Soil Tables Fit Into the Larger Technical Note
The summary and tables are supported with more detailed explanations in the Fate and Transport Section of the technical note (see attached). In a few instances, new information contained in the tables still needs to be added to this section, but most has already been covered. When the Water, Air and Soil tables are laid out in the document, the summary will probably be broken down into shorter introductions for each table, and all will be placed in the appendix.

Audience
NRCS national decision makers and local field staff will be using this technical note. The annotated references in the Tables give the decision makers information they need to be confident that certain NRCS conservation practices can help reduce pathogens in landscapes containing specialty crop farms. Busy field staff will probably only have time to read the main sections of the technical note, and only glance at the tables.

How NRCS Works
NRCS assists farmers with conservation concerns, not with helping them grow a better crop.

Glossary
Make sure to add any new terms such as "residence time," and "loading rate" to the glossary.

Surface Water: Table and Summary Text
Since there are so many factors affecting the success of wetlands reducing pathogen survival, use a slightly less strong word than "greatly," as in "Wetlands greatly reduce the movement of pathogens moving in surface water."

Air: Table and Summary Text
Be clear that there is only one promising study that found windbreaks were able to intercept pathogens after the plants had grown tall enough, and that more research is needed.

Soil: Table and Summary Text
Point out that one study found the choice of cover crop influences how long pathogens are viable in the soil, not just that the pathogen persistence was similar to the length of time the cover crop was present before being tilled in.

Ask Trevor Suslow about student's analysis that pathogen survival was longer in organic soils than in conventional ones.

Mention that the National Organic Program temperature requirements for making compost are high enough to kill pathogens.

Summary of Farm Visits, Phone Surveys and Interviews

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Summary of Valuable Insights Gained

Most farms visited or surveyed:

- Must not adversely impact the natural values of wetlands or their adjacent areas
- Are adjacent to or surrounded by natural habitat
- Have soils with a vegetative cover
- Have abundant animals on and near the farm
- Have rare wildlife species present (e.g. alligators, Florida panthers and gopher tortoises)
- Use co-management strategies
- View wildlife as a low food safety risk

Many farms visited or surveyed:

- Use compost and make it themselves
- Raise livestock and/or have neighbors who raise cattle
- Use groundwater to irrigate and/or provide frost protection
- Use compost
- Use manure

Some farms/farmers visited or surveyed:

- Experience periodic flooding
- Use surface water to irrigate and/or provide frost protection
- Re-use tailwater irrigation
- Rotate livestock grazing into cropping areas
- Use practices to discourage wildlife
- Discourage wildlife because of crop damage, not food safety
- Receive assistance from NRCS for practices that address water quality and erosion.
- Are interested in food safety training

- Have written a food safety plan

Florida Farm Visits and Phone Surveys Summer 2011

Florida Farm Visits

8 Florida farmers were visited: 4 are members of the FL Fruit and Vegetable Association (FFVA) and 4 of FL Organic Growers (FOG). The following comments summarize observations from these 8 farms.

<u>Landscapes</u>

- Most farms are adjacent to or surrounded by natural habitat such as hardwood hammocks, dry prairie, pine flatwoods, and wetlands.
- Most soils are covered at all times because it rains there so much of the time. The grass and weeds are managed in the ditches and roadways by continually mowing and some herbicides.
- In general, all farms must not impact surface water flow in wetlands as a primary purpose. Farms can apply for a permit to conduct customary agricultural practices, if the primary purpose is not meant to impede or divert the flow of surface water, or adversely impact wetlands. Any disputes are settled by the FL Department of Agriculture. Much of FL's crop areas are low-lying and subject to flooding, often having been drained historically to allow for crop production. The wetlands function as retention areas allowing mitigation of pollution before water is discharged to surrounding surface waters. They also allow infiltration and groundwater recharge thereby reducing flooding problems downstream.
- Farmers are encouraged to have tailwater retention ponds if they don't have wetlands.
- One farm discharges into a creek from which a nearby community draws their municipal water supply.
- A couple farms have restored habitat that now supports more pollinators.
- Most farms report the presence of federally threatened alligators, and some have federally threatened gopher tortoises, or federally endangered panthers.

<u>Animal Presence On and Near Crop Production Areas:</u>

- Birds are attracted to crops. Examples include cardinals eating ripe tomatoes; egret individuals or flocks consuming insect pests depending on the season and crop; wild turkeys cleaning up leftover seed after a cover crop is tilled in; Muscovy ducks wandering onto farm from urban areas.
- Alligators are attracted to water sources, and farmers report that most water bodies have a proportionally sized alligator resident. Alligators move across cropland to seek new water bodies as they grow and/or are displaced by other animals. Since much of the cropland uses a series of canals to maintain drainage, these animals are commonly found throughout production areas.
- Large mammals are also reported in crops. Feral pigs, deer, coyotes and raccoons feed on many specialty crops and may also damage vine crops by trampling. One farmer reported a large wild rabbit population.
- Some diverse operations include chicken and cattle.
- One farmer captured feral piglets and is raising them in a pen.

Farming Practices That May Present Food Safety Risk

- Use of untreated surface water to irrigate.
- Use of untreated surface water for microspray frost protection.
- Re-use of tailwater to irrigate.
- Use of manure-based compost produced on-farm. Compost not necessarily produced with a documented pathogen reduction process (e.g. prescribed turning, heating, etc. management), nor is there pathogen testing of the finished product.
- Use of fish emulsion. *Fish emulsion was wrongly listed here as a farming practice that may present a food safety risk. It is not a pathogen source because of the way it is processed which results in a low pH. Though when diluted with water of unknown quality it may become a food safety risk.)*
- Farm fields situated in areas that experience periodic flooding.

Co-Management Strategies:

- Harvest practices avoid animal-damaged crops, and crops with fecal matter.
  Animals, such as deer, are attracted away from melon crops by planting a trap-crop, such as sweet corn
- Installing plantings around waterbodies that discourage animal activity in the water. For example planting thick, tall, grasses around a pond perimeter to discourage geese. Note this is a practice recommended in a 2011 Michigan Cooperative Extension document, Good Agricultural Practices for Food Safety in Blueberry Production: Basic Principles (2nd Ed.), that a grower uses.
- Hunting to reduce population density (e.g. rabbits and deer)
- Fencing larger wildlife, such as deer and raccoons, out of crops. An outrigger electric fence is used to discourage deer (a typical three line fence with an extra electrified line 12” away from this fence; also puts peanut butter attractant on fence).
- Keeping livestock such as cattle separate from crop fields
- Avoiding surface water irrigation contact with crop by use of drip irrigation, which minimizes splash.
- When both surface and well water are used, well water is only applied within 21 days of harvest.
- Using a pond/wetland that filters runoff before leaving the farm
- Cautious use of manure and manure products. For example, some growers do not use use raw or pelletized manure, or compost. Others use pasteurized poultry manure. Some who use manure and manure-based compost allow it to age for more than a year, or may apply farm-made manure only to cover crops.
- One farmer reports working with NRCS to create a small, on-farm compost production and storage facility.

Strategies Some Farmers are Not Willing to Implement

- Won’t fence because crop area is too big
- Won’t take out habitat (they are currently restoring it)
- Prescribed buffer area around feces (the width should be left up to the farmer)

Farm Conservation Practices and Management That Benefit Public Health

Encourages Bio-Control / Pollination

- Egrets consume grasshoppers
- Predatory insects eat several types of pest insects

- Bees provide pollination services

Manages Water Quality and Quantity

- Retention areas
- Conservation of wetlands
- Vegetative cover on soil

Manages Soil Health

- Cover crops
- Compost

Florida Phone Surveys

Affiliation/Size/Crops/Markets/NRCS Contact For Farmers Surveyed

- 47 Florida farmers were surveyed: 14 are members of the FL Fruit and Vegetable Association (FFVA) and 34 of FL Organic Growers (FOG).
- About one fifth of farmers surveyed crop more than 1,000 acres; a quarter 1,000 acres or less, another fifth 100 acres or less, and a third were less than 10 acres.
- Many of farmers surveyed grow multiple crops, about a third grow blueberries, citrus, and cucurbits; a quarter tomatoes, eggplant, and peppers; a fifth brassicas; a sixth salad greens, sweet potatoes, and strawberries. Lesser amounts of various other specialty crops were also grown.
- About half of farmers surveyed sell to national and regional markets. Over a third sell to retail or direct market. A few sell internationally, to processors, or grow for contract.
- Almost one third of farmers surveyed have received NRCS support for practices that predominately address water quality and erosion.

Natural Habitat

- Almost all farmers surveyed have natural areas on their farms (native trees and shrubs, ponds, wetlands grassed areas, or hedgerows), and half of these said they comprised a significant amount of their farm (equal to or greater than a quarter of the farm).
- Two thirds of farmers surveyed said their crops were surrounded by a significant amount of natural habitat as well (equal to or greater than a quarter of the farm).

Water

- One eighth of farmers surveyed said their fields flooded periodically from overland flow or waterways over-topping their banks.
- Almost all the farmers surveyed use ground water, and a fifth also use surface water.

Manure/Feces

- About half of farmers surveyed use compost, and half of those make manure-based compost themselves. Most of the manure is from poultry or horse operations.
- One eighth of farmers surveyed use un-composted poultry manure.
- About a third of farmers surveyed also raise cattle, pigs, sheep, goats, and chickens, some of which rotate grazing into cropping areas.
- Half of farmers surveyed said they have neighboring farm operations that graze livestock, the majority of which is cattle, but there are a few horses too. These are typically small grazing operations.

Wildlife Species Present

- About three-quarters of farmers surveyed report deer and songbirds,
- Half of farmers surveyed report feral pigs, alligators, raccoons, snakes, corvids and raptors,
- A third of farmers surveyed report coyotes, bobcats, foxes, possums, ground squirrels, mice, waterfowl, and shorebirds,
- Several of the farmers surveyed report armadillos, wild turkeys, bears, and federally endangered Florida panthers.
- A few of farmers surveyed report, skunks, rabbits, otters, iguanas, turtles, skinks, and federally threatened gopher tortoises.

Evidence of Wildlife and/or Their Signs on the Farm

- Over half the farmers surveyed see wildlife in their crop fields, some also see their signs, such as tracks, digging, and a few see fecal matter.
- Three quarters of the farmers surveyed see wildlife in tree and shrub lines and in natural areas.
- About a third of the farmers surveyed see wildlife around water bodies and in wildlife corridors.
- A few farmers surveyed report seeing wildlife around cull piles and compost.

Perceived Food Safety Risk Areas

- One fifth of the farmers surveyed consider workers high risk, one fifth say they are medium risk, and the rest say low risk.
- One fifth of the farmers surveyed consider water and compost high risk, although most of the others feel they are low risk.
- The majority of farmers surveyed view wildlife as a low food safety risk, though some view wildlife as a medium food safety risk. Only a few farmers consider wildlife a high food safety risk.
- Almost all farmers surveyed consider natural areas a low food safety risk.

Practices Put in Place That Address Food Safety

- One quarter of the farmers surveyed have written a food safety plan, while a few more have thought about writing one.
- Several farmers surveyed have fenced out wildlife and/or removed wildlife by trapping, hunting, or using poison. One farmer uses lights, noisemakers to deter wildlife. Another planted food far from crops to attract wildlife away.
- A couple farmers surveyed planted windbreaks/hedgerows to serve as a barrier to reduce movement of airborne pathogens, redirected water away from crops, or stopped growing crops where wildlife are commonly seen.
- A couple farmers surveyed don't harvest crops where there are signs of wildlife.
- Several farmers test water and a few chlorinate surface water before using for irrigation.
- One fifth of the farmers surveyed felt these practices mentioned in this section helped to reduce food safety risk, while a couple said they were done to satisfy a buyer and didn't change the risk.

Need for Food Safety Training

- Over a third of the farmers surveyed said they would be interested in food safety training for growing and harvesting fresh produce.

New York Farm Visits, Phone Surveys and Interviews 2010-2011

New York Farm Visits

- 8 New York farms were visited: 4 are members of the New York State Vegetable Growers Association (NYSVGA) and 4 of Northeast Organic Farmers Association of New York (NOFA-NY), and 1 is a member of both. In addition, 2 other NYSVGA farmer members met with us at their packing facility. The following comments summarize observations from these 8 farms.

<u>Landscapes</u>

- Most farms are adjacent to or surrounded by natural habitat such as open and forested uplands, barrens and woodlands, riverine, and wetlands.
- Most soils have a vegetative cover because of New York's humid, temperate climate and average rainfall of 47 inches per year.
- All farms must not adversely impact the natural values of wetlands or their adjacent areas, without first obtaining a permit.

<u>Animal Presence On and Near Crop Production Areas</u>

- Birds are attracted to crops. Examples include starlings and blackbirds in corn; migratory geese in fields; seagulls moving from Great Lakes, to landfills, and to fields being tilled. Geese are resident in swampy areas. Birds increase in numbers as beavers extend ponds.
- Mammals are also reported in crops. Deer are commonly reported in crop areas throughout the state. Both moose and bears are occasionally seen. Bears may be attracted to bee hives. Raccoons and coyotes consume corn. Rabbits and woodchucks eat leafy greens. Moose like soybeans. Dogs follow farmers around.
- Some diverse operations include pastured chickens, milk cows, hogs, cattle, and sheep.

<u>Farming Practices That May Present Food Safety Risk</u>

- Rotation of pastured chickens with vegetable crop production
- Use of untreated surface water for overhead irrigation, including some with upstream dairy and cattle grazing runoff in it, some with treated municipal wastewater in it, and some from ponds with beavers present.
- Ditches and ponds receive runoff with nitrogen, and algae mats formed in them may harbor pathogens.
- Application of raw manure (including liquid manure) to specialty crop production fields.
- Use both raw and composted dairy manure in a minimum-till operation.
- Aged manure stored next to vegetable production area.
- Neighboring dairy farms are permitted to spread manure on land adjacent to specialty crops.

<u>Co-Management Strategies</u>

- Harvest practices avoid animal-damaged crops, flag evidence of animal intrusion and crops with fecal matter. Some farmers report monitoring for animal activity when scouting for insect pests and plant disease. Some farmers also have a standard operating procedure (SOP) to record all monitoring activities.
- Most animal control is done because of crop damage, not food safety.

- Birds are discouraged with balloons moved regularly to keep them guessing, and with flashy tapes and propane "poppers." Many farmer report shooting crows, geese and ducks to keep them from settling in crops.
- Strategies mentioned to discourage deer include installing electric fencing, by increasing the height of a canal berm so that they won't cross it, and by hunting. One farmer reported that often it was enough to just kill one deer because that made the others skittish.
- One farmer traps raccoons. Another moved bats out of a storage facility into bat boxes on the outside of the structure.
- Some farmers keep livestock, such as cattle and sheep, are not allowed to graze vegetable fields, and instead are given culls/waste to eat.
- Farmers are aware that use of surface water increases risk. One farmer used to irrigate from ponds but now uses municipal water, which is costly. Another farmer only runs surface water through a drip irrigation system, which minimizes splash. A third farmer reported that his surface water is drip irrigated and well water is sprinkle irrigated. Most test surface irrigation water periodically.
- Many farmers report they have installed vegetative buffers along streams. A typical example was a 25' vegetative buffer along streams to filters runoff before leaving the farm.
- Cautious use of manure and manure products. For example, one grower used to use raw chicken manure, but now applies chicken compost 120 days before harvest, and uses pasteurized chicken pellets when fertilizer is required closer to harvest. A couple of farmers use raw turkey manure, and liquid dairy cow manure, but apply it in the fall when a planting cover crop. Another couple of farmers wait one year between applications of compost or manure.
- Farmers are considering whether areas are appropriate to farm. One farmer reports not growing higher risk crops, such as leafy greens, tomatoes and melons in several of his small fields (2-5 acres) that are surrounded by woodlands. Another farmer stopped growing vegetables on land next to natural area because too much pressure from deer and raccoons.

Evidence of Conflicts Between Food Safety and Conservation

- Removal of wild turkey and native bumblebee habitat, which also served as a buffer for adjacent wetlands
- Removal of a hedgerow in the middle of a crop field
- One farmer reported that he was considering enrolling in programs to conserve greenspace and plant a hedgerow, but decided against them because of concerns that it would create problems with his food safety audits.
- Farm Conservation Practices and Management That Benefit Public Health

Encourages Bio-Control / Pollination

- Coyotes help to keep deer, rabbits and woodchucks from becoming too numerous.
- Placement of bat boxes on outside of barn done to encourage Big Brown bats that consume the brown stink bug.
- Farmer reports Colorado potato beetle overwinters in woodlands next to crop and wild turkeys pick them off in the corridor between the trees and the crops. He intentionally leaves harvested rye seed for them to scavenge.

- Predatory insects eat several types of pest insects.
- Farmer reports working with Cornell University to study native bee pollination services.

Manages Water Quality and Quantity

- Riparian buffers
- Conservation of wetlands
- Vegetated cover on soil

Manages Soil Health

- Cover crops
- Compost
- No-till

Manages Crop Health

- Extensive set of windbreaks keep crops from getting sandblasted in a windy region.

New York Phone Surveys

Affiliation/Size/Crops/Markets/NRCS Contact For Farmers Surveyed

- 51 New York farmers were surveyed: 24 members of the New York State Vegetable Growers Association (NYSVGA) and 27 of Northeast Organic Farmers Association of New York (NOFA-NY).
- Over one fifth of farmers surveyed crop more than 1,000 acres; almost a third were 1,000 acres or less, over a quarter 100 acres or less, and a sixth were less than 10 acres.
- Many of farmers surveyed grow multiple crops, about half grow brassicas, corn, cucurbits, tomatoes, about a third grow alliums, beets, carrots, legumes, peppers, potatoes, salad greens; a quarter eggplant and lettuces; a fifth spinach; and a sixth pome fruit. Lesser amounts of various other specialty crops were also grown.
- About one fifth of farmers surveyed sell to national markets, half to regional markets, and half sell to retail or direct market. A few sell internationally, to processors, or grow for contract.
- A little less than half of farmers surveyed have received NRCS support for practices that predominately address erosion, water quality, and native plants and wildlife conservation.

Natural Habitat

- Almost all farmers surveyed have natural areas and/or non-crop areas on their farms (native trees and shrubs, woodlots, ponds, wetlands grassed areas, or hedgerows). Half of these said they comprised a significant amount of their farm (equal to or greater than a quarter of the farm), and another quarter said they comprise about one tenth of the farm.
- Over half of farmers surveyed said their crops were surrounded by a significant amount of natural habitat as well (equal to or greater than a quarter of the farm).

Water

- One quarter of farmers surveyed said their fields flooded periodically from overland flow or waterways over-topping their banks.
- About half of farmers surveyed use ground water, half surface water, and half rely on rain.

Manure/Feces

- About half of farmers surveyed use compost, and almost half of those use manure and make the compost themselves. Most of the manure is from poultry or cattle operations, while some is from horse and pig farms.
- Almost half of farmers surveyed use un-composted cattle manure; a few use pig, horse and poultry manure.
- About half of farmers surveyed also raise cattle, pigs, sheep, goats, and chickens, half of which rotate grazing into cropping areas and/or use their manure in farming operations.
- About half of farmers surveyed said they have neighboring farm operations that graze livestock. These are typically small cattle grazing operations, but there are a few horses also.
- Almost a third of farmers surveyed said they have neighboring confined livestock operations, predominately dairies, but a couple chicken farms are nearby.

Wildlife Species Present

- Almost all farmers surveyed report deer,

- Around half of farmers surveyed report geese and ducks, corvids, songbirds, raptors, raccoons, foxes, coyotes, snakes, and mice,
- A third of farmers surveyed report possums, ground hogs, ground squirrels, and frogs,
- A quarter of farmers surveyed report gophers, voles, shorebirds, wild turkeys, and salamanders,
- A few of farmers surveyed report bears, wolves, cougars, bobcats, feral pigs, moose, weasels, minks, rabbits, muskrats, nutria, river otters, skunks, chipmunks, cranes, turtles, toads, and lizards.

<u>Evidence of Wildlife and/or Their Signs on the Farm</u>

- Almost three-quarters of the farmers surveyed see wildlife in their crop fields, some also see their signs, such as tracks, digging, and a few see fecal matter.
- Over three quarters of the farmers surveyed see wildlife in tree and shrub lines and in natural areas.
- About half of the farmers surveyed see wildlife around water bodies.
- A few farmers surveyed report seeing wildlife around barns/buildings, cull piles and compos, and in wildlife corridors.
- One farmer surveyed reported seeing turkeys and geese eating seeds out of manure.
- One farmer surveyed reported it was hard to keep birds out of the sweet corn.

<u>Perceived Food Safety Risk Areas</u>

- One fifth of the farmers surveyed consider workers high risk, one quarter say they are medium risk, and the rest say low risk.
- One quarter of the farmers surveyed consider contamination from water high risk, although most of the others feel it is low risk.
- The majority of farmers surveyed view wildlife as a low food safety risk, though some view wildlife as a medium food safety risk. Only a few farmers consider wildlife a high food safety risk.
- Almost all farmers surveyed say natural areas are a low risk.

<u>Practices Put in Place That Address Food Safety</u>

- One third of the farmers surveyed have written a food safety plan, and one third have thought about writing one.
- One third of the farmers surveyed have fenced out and/or removed wildlife by trapping, hunting, or using poison. One farmer uses reflectors and human hair to deter wildlife and another bombs woodchucks. Several farmers manage wildlife primarily for economic reasons, not for food safety.
- A few farmers surveyed removed habitat to discourage wildlife presence near crops.
- One farmer surveyed stopped growing crops where wildlife is commonly seen.
- A few farmers surveyed monitor for animals and will not harvest contaminated areas. A couple test irrigation water. One grower reported he waits several months after spreading manure before planting.
- One third of the farmers surveyed felt the practices mentioned in this section helped to reduce food safety risk, while a couple said they were done to satisfy a buyer and didn’t change the risk.

<u>Need for Food Safety Training</u>

- Over half the farmers surveyed said they are interested in food safety training for growing and harvesting fresh produce.

New York In-Person Farmer Interviews

Interviews Conducted by Collaborator Hawthorne Valley Farmscaping Ecology Program

Note: Due to farmer interviews already scheduled by Hawthorne Valley, one of this project's farm organization collaborators, we decided it would be more efficient to include co-management questions into their process than ask the growers to participate in two separate querries.

During the fall of 2010, in-person farmer interviews relating to various aspects of vegetable management were conducted with 19 vegetable growers in NY's Columbia County as part of a larger study looking at use of ecological management techniques. While not specifically related to food safety, some questions were designed with that issue in mind. In addition to that, preliminary food safety questions compiled by Wild Farm Alliance were asked of eleven growers, nine of whom were also part of the group of 19 interviewed earlier.

<u>Highlights From These Interviews:</u>

- The majority of farms had livestock as part of their operation or on adjacent land.
- Manure, often composted, was an important fertilizer on the organic operations being used on at least 12 of 19 farms.
- All respondents had deer and mice, and most had groundhogs (90%), rabbits (90%), and birds (turkeys, geese and crows - 90%).
- Wildlife was most commonly noticed in open crop fields (90% of respondents), followed by hedgerows and riparian areas (80%), and around structures (60%) and water bodies (60%).
- Fencing and trapping were used by more than 90% of the growers to control wildlife.
- Dogs were employed by nearly three quarters and hunting by nearly two thirds of respondents.
- Less common control measures included noise making, ashing, repellants, balloons or pans, and habitat removal (usually the removal of brush piles or the mowing of some cropside areas).
- These attempts at controlling wildlife were generally described as "sometimes effective", although most seemed to feel that control was adequate.

California Farm Visits and Phone Surveys 2010-2013

California Farm Visits

Eight California specialty crop farms were visited. Three were visited early on in the project and they helped to inform the initial writing of the Technical Note. Since the others were visited after the first draft of the Technical Note was written, they helped to refine what was written.

One of the more interesting visits was to the large organic farm whose processing plant was implicated in the 2006 *E. coli* 0157:H7 spinach contamination. This visit helped us see that even hyper-aware salad mix operations can co-manage their food safety mandates with conservation, if they are so inclined. When farming next to a riparian area, they use a 30' dirt road between it and the crop so that wildlife tracks can be seen. Additionally, they train all their employees, from irrigators to harvesters, to look for wildlife tracks into their production fields, and wildlife feeding or feces in the fields themselves (instead of searching the habitat), and hence they know which areas rarely have problems and others areas that require more constant monitoring. While this type of co-management can only be used on large farms where 30' dirt roads are possible, it does show that some types of co-management strategies are being incorporated even in high-risk fresh-cut leafy green crops.

At the ALBA farm visits and meetings with Spanish speaking farmers, we learned how food safety auditors are having the farmers cut overhanging tree limbs, so that birds won't drop feces on the crop. Because they have a serious ground squirrel problem, they were also trimming up some of their hedgerows in order to better see the squirrel holes.

It was interesting to see one of the CAFF farmers use portable electric fencing to keep out exotic non-native pigs. In other areas of California, these pigs have been found with 5% prevalence of *E. coli* 0157:H7 and 15% *Salmonella*. The farmer suggested we might want to include electric fences in the Technical Note illustration. Another CAFF farmer suggested adding more people, including a washing station outside an outhouse, and a foot cleaning station near a compost pile in the illustration. The farmer who spoke at the EFA conference with Wild Farm Alliance staff reported her success at convincing her USDA Good Agricultural Practices auditor that hedgerows were okay and that she shouldn't loose audit points over the use of weeder geese in their apple orchard, especially since the pickers don't use ladders and hence would not be tracking the goose feces on ladders they handle. This farmer suggested adding weeder geese to the Technical Note illustration. One farmer in the Salinas Valley reported financial hardship due to buyers not wanting to purchase salad mix crops near his hedgerow and grassed hillside; he can only find buyers for broccoli, which does not have as high a value.

California Surveys

Affiliation of Farmers Surveyed

- 47 California farmers were surveyed: 21 members of the Community Alliance with Family Farmers (CAFF) were surveyed using SurveyMonkey. In addition, 16 participants of the Ecological Farming conference and 10 of a CAFF/WFA Food Safety Modernization Act meeting filled out surveys.

Natural Habitat

- Almost all farmers surveyed have natural areas and/or non-crop areas on their farms

Food Safety Plan

- Most either follow Good Agricultural Practices or have a food safety plan and/or

Practices that Address Food Safety Risks

- Many described how they value conservation practices such as pollinator habitat, hedgerows and windbreaks, and some mentioned how these helped them to manage for food safety.
- One grower detailed how he uses a hedgerow between his compost yard and his cropped field to increase safety, and that his "thermophilic aerobic produced compost, with manure as a feedstock, is an important part of his soil building and fertility program."
- A couple other farmers mentioned that swales, berms, and ditches were important for directing non-irrigation water away from crops.
- A few said they use buffer zones, and one was "discontinuing the use of fencing, trapping and bait stations due to evidence showing they are not effective in preventing possible contamination."
- Several reported the use of floating row covers to keep wildlife off their crops near hedgerows and other non-crop vegetation, and a few reported periodically monitoring their crops for animal feces.
- A couple farmers mentioned how they value of wildlife corridors.
- One grower of a mid-sized farm said that the corridor "dramatically reduced the pressure from wildlife – especially deer."
- Another grower of a very large salad mix operation reported that they protect habitat along rivers and creeks and streams, instead of encouraging wildlife to venture into farm fields when such buffers are removed. These descriptions help to confirm that many of the issues addressed in the Technical Note, and its illustration are appropriate.
- Below are further farmer comments:
    - Utilize windrows to prevent wind drift from adjacent grazing animals
    - Wash all produce with city water
    - Farming with no chemicals
    - Increase soil biodiversity
    - Fence out animals and use a floating row cover; scare away crows
    - Installed windbreaks and conserve riparian habitat
    - Stopped using fencing, trapping and bait stations because not effective and instead use buffer zones
    - Removed wildlife by trapping, hunting or using poison to kill them
    - If bird poop is found on a kale leaf, the leaf is picked off and dropped on the ground so that the poop doesn't enter the wash water
    - Stopped growing crops where wildlife were commonly seen
    - Removed habitat to discourage wildlife presence near crops

Food Safety and Farm Conservation

SurveyMonkey

1. Your name (person filling out survey):

		Response Count
		30
	answered question	30
	skipped question	18

2. From what list did the farmer contact come from:

	Response Percent	Response Count
Florida Organic Growers (FOG)	**70.8%**	**34**
Florida Fruit & Vegetable Association (FFVA)	29.2%	14
Northeast Organic Farming Association of New York (NOFA-NY)	0.0%	0
New York State Vegetable Growers Association (NYSVGA)	0.0%	0
Community Alliance with Family Farmers (CAFF)	0.0%	0
other CA list	0.0%	0
	Other (please specify)	2
	answered question	48
	skipped question	0

3. Demographic Information

	Response Percent	Response Count
Name:	**100.0%**	**48**
Company or Farm:	**100.0%**	**48**
Organic or Conventional?	97.9%	47
State:	97.9%	47
Email Address:	33.3%	16
Phone Number:	**100.0%**	**48**
	answered question	**48**
	skipped question	**0**

4. How many acres do you farm?

	Response Percent	Response Count
10 acres or less	**34.1%**	**15**
100 acres or less	20.5%	9
1,000 acres or less	25.0%	11
> 1,000 acres	20.5%	9
	Other (please specify)	23
	answered question	**44**
	skipped question	**4**

5. What type of specialty crops do you grow? (Vegetable Row Crops)

	Response Percent	Response Count
Alliums (garlic, onions, leeks, green onions)	24.0%	6
Artichokes	0.0%	0
Asparagus	4.0%	1
Beans, peas, legumes	24.0%	6
Beets	12.0%	3
Brassicas (cabbage, broccoli, cauliflower, Brussel sprouts, turnip, radish)	40.0%	10
Carrots	12.0%	3
Celery	8.0%	2
Corn	16.0%	4
Cooked greens (kale, collards, chard)	20.0%	5
Cucurbits (summer and winter squash, cucumbers)	**56.0%**	**14**
Eggplant	48.0%	12
Lettuces	24.0%	6
Peanuts	0.0%	0
Peppers (green, hot)	40.0%	10
Potatoes, Sweet Potatoes	32.0%	8
Salad greens (arugula, endive, parsley, radicchio, spinach)	32.0%	8
Spinach	12.0%	3
Tomatoes	44.0%	11

	Other (please specify)	16
	answered question	**25**
	skipped question	**23**

6. What types of specialty crops do you grow? (Fruit Row Crops)

	Response Percent	Response Count
Blueberries	**84.2%**	**16**
Cranberries	0.0%	0
Grapes	10.5%	2
Kiwis	0.0%	0
Raspberries	5.3%	1
Strawberries	36.8%	7
Other (please specify)		12
answered question		**19**
skipped question		**29**

7. What types of specialty crops do you grow? (Orchard Crops)

	Response Percent	Response Count
Avocado	6.7%	1
Citrus (orange, grapefruit, tangerine, lime, lemon)	**93.3%**	**14**
Nuts (almonds, walnuts, pecans, pistachios)	0.0%	0
Pome fruit (apples, pears)	0.0%	0
Stone fruit (cherries, plums, peaches)	13.3%	2
	Other (please specify)	8
	answered question	**15**
	skipped question	**33**

8. Do you also raise livestock?

	Response Percent	Response Count
No. Skip to question 10.	**81.1%**	**30**
Cattle	8.1%	3
Pigs	2.7%	1
Sheep	5.4%	2
Goats	2.7%	1
Chickens	13.5%	5
	Other (please specify)	6
	answered question	**37**
	skipped question	**11**

9. If livestock is part of your operation, do you:

	Response Percent	Response Count
Rotate grazing/cropping areas	**85.7%**	**6**
Feed culls to the animals	28.6%	2
Use manure in operations	28.6%	2
Other (please specify)		3
answered question		**7**
skipped question		**41**

10. Are there any natural and/or non-crop areas on your farm, and if so what kinds?

	Response Percent	Response Count
Native trees and shrubs	**64.3%**	**27**
Woodlots	31.0%	13
Hedgerows and tree lines	33.3%	14
Grassed areas	38.1%	16
Vegetated ditches	21.4%	9
Ponds	40.5%	17
Rivers/streams	9.5%	4
Springs/Wetlands/Bogs	35.7%	15
Other water bodies	7.1%	3
Other (please specify)		11
answered question		**42**
skipped question		**6**

11. And if there are natural areas/vegetation on your farm, what percent of the farm do they compromise?

	Response Percent	Response Count
0	5.9%	2
<1%	11.8%	4
about 5%	14.7%	5
about 10%	11.8%	4
about 25%	**29.4%**	**10**
>25%	26.5%	9
	Other (please specify)	16
	answered question	**34**
	skipped question	**14**

12. What percent of your crops are surrounded by natural areas/vegetation?

	Response Percent	Response Count
0	5.7%	2
<1%	8.6%	3
about 5%	8.6%	3
about 10%	17.1%	6
about 25%	17.1%	6
>25%	**42.9%**	**15**
	Other (please specify)	15
	answered question	**35**
	skipped question	**13**

13. Do fields flood periodically?

	Response Percent	Response Count
Yes	26.1%	12
No. Skip to question 14.	**73.9%**	**34**
	Other (please specify)	4
	answered question	**46**
	skipped question	**2**

14. What is the source of the flooding?

	Response Percent	Response Count
Water collects in flat farmland because drainage is poor	**50.0%**	**4**
Overland flow from upland areas	**50.0%**	**4**
Waterways over-top their banks	37.5%	3
	Other (please specify)	7
	answered question	**8**
	skipped question	**40**

15. Have you ever received NRCS (Natural Resource Conservation Service) support for conservation practices, such as:

	Response Percent	Response Count
Erosion control	53.8%	7
Water quality protection	**76.9%**	**10**
Native plants and wildlife conservation	15.4%	2
Invasive species control (like feral pigs)	7.7%	1
Native insect support	0.0%	0
	Other (please specify)	18
	answered question	**13**
	skipped question	**35**

16. How do you harvest:

	Response Percent	Response Count
By hand	**95.7%**	**45**
By machine	19.1%	9
Other (please specify)		6
answered question		**47**
skipped question		**1**

17. How do you market your product?

	Response Percent	Response Count
Direct	41.3%	19
Retail	34.8%	16
Wholesale (Regional)	45.7%	21
Wholesale (National)	**54.3%**	**25**
Wholesale (International)	15.2%	7
Sell to Processor	10.9%	5
Grow for Contract	4.3%	2
Other (please specify)		10
answered question		**46**
skipped question		**2**

18. What is your source of water?

	Response Percent	Response Count
Rain water	31.1%	14
Surface water	22.2%	10
Ground water	**91.1%**	**41**
	Other (please specify)	7
	answered question	**45**
	skipped question	**3**

19. Do you use compost?

	Response Percent	Response Count
Yes	45.7%	21
No. Skip to question 7.	**54.3%**	**25**
	Other (please specify)	2
	answered question	**46**
	skipped question	**2**

20. Is the compost?

	Response Percent	Response Count
Made on the farm	**52.4%**	**11**
Purchased from other business	**52.4%**	**11**
Other (please specify)		1
answered question		**21**
skipped question		**27**

21. Is the compost manure based?

	Response Percent	Response Count
Yes	**57.1%**	**12**
No. Skip to question 7.	42.9%	9
Other (please specify)		4
answered question		**21**
skipped question		**27**

22. What is the source of manure?

	Response Percent	Response Count
Manure is from a large animal operation	**50.0%**	**6**
Manure is from a small animal operation	**50.0%**	**6**
	Other (please specify)	4
	answered question	**12**
	skipped question	**36**

23. What type of animal manure is used?

	Response Percent	Response Count
Cattle	18.2%	2
Pig	0.0%	0
Poultry	**54.5%**	**6**
Horse	45.5%	5
	Other (please specify)	2
	answered question	**11**
	skipped question	**37**

24. Do you use un-composted manure to improve fertility, water holding capacity, soil tilth/structure, and microbial communities? (note: NOP requires application to be 120 days before harvest)

	Response Percent	Response Count
Yes	14.0%	6
No. Skip to next page.	**86.0%**	**37**
Other (please specify)		4
answered question		**43**
skipped question		**5**

25. What type of un-composted manure is used on your fields?

	Response Percent	Response Count
Cattle	0.0%	0
Pig	0.0%	0
Poultry	**100.0%**	**5**
Horse	0.0%	0
Other (please specify)		4
answered question		**5**
skipped question		**43**

26. Are there livestock grazing or corralled on neighboring farms?

	Response Percent	Response Count
Grazing	**51.1%**	**23**
Confined spaces	2.2%	1
No. Skip to next page.	46.7%	21
Other (please specify)		3
answered question		**45**
skipped question		**3**

27. What kinds of animals are in those operations?

	Response Percent	Response Count
Cattle	**84.0%**	**21**
Pigs	0.0%	0
Sheep	0.0%	0
Goats	4.0%	1
Chickens	0.0%	0
Horses	24.0%	6
Other (please specify)		2
answered question		**25**
skipped question		**23**

28. If yes, would you describe those operations as large or small (take shorthand on size, hundreds vs thousands)?

	Large	Small	Response Count
Cattle	20.0% (4)	**85.0% (17)**	20
Pigs	0.0% (0)	0.0% (0)	0
Sheep	0.0% (0)	0.0% (0)	0
Goats	0.0% (0)	0.0% (0)	0
Chickens	0.0% (0)	0.0% (0)	0
		Other (please specify)	4
		answered question	**20**
		skipped question	**28**

29. What large to medium-sized wildlife is present near the growing area?

	Deer	Moose	Feral pigs	Coyotes	Bobcats	Fox	Raccoon	Possum	Res C
Large - Medium Sized Mammals	**76.7% (33)**	0.0% (0)	51.2% (22)	39.5% (17)	37.2% (16)	39.5% (17)	55.8% (24)	39.5% (17)	
								Other (please specify)	
								answered question	
								skipped question	

30. What small-sized wildlife is present near the growing area? (Small mammals in field, not rats near buildings)

	Gophers	Mice	Voles	Ground squirrels	Groundhogs	Nutria	Response Count
Small Mammals	24.0% (6)	**64.0% (16)**	8.0% (2)	60.0% (15)	4.0% (1)	4.0% (1)	25
					Other (please specify)		18
					answered question		**25**
					skipped question		**23**

31. What birds are present near the growing area?

	Crows and ravens	Geese and ducks	Hawks and owls	Shorebirds	Songbirds	Response Count
Birds	55.6% (20)	50.0% (18)	75.0% (27)	41.7% (15)	**83.3% (30)**	36
					Other (please specify)	23
					answered question	**36**
					skipped question	**12**

32. What amphibians and reptiles are present near the growing area?

	Frogs	Salamanders	Lizards	Snakes	Alligators (in FL)	Response Count
Amphibians and Reptiles	57.6% (19)	12.1% (4)	36.4% (12)	**75.8% (25)**	57.6% (19)	33
					Other (please specify)	17
					answered question	**33**
					skipped question	**15**

33. Where do you most often see wildlife or their signs?

	Animal	Fecal matter	Digging	Tracks	Response Count
In crop fields	**81.8% (27)**	15.2% (5)	33.3% (11)	51.5% (17)	33
In non-crop vegetation, tree and shrub lines, natural areas	**97.3% (36)**	27.0% (10)	13.5% (5)	40.5% (15)	37
In barns/buildings	**83.3% (5)**	0.0% (0)	0.0% (0)	50.0% (3)	6
Around water bodies	**100.0% (19)**	21.1% (4)	10.5% (2)	36.8% (7)	19
Around brush piles	**100.0% (2)**	50.0% (1)	50.0% (1)	**100.0% (2)**	2
Around cull piles and compost	**100.0% (7)**	14.3% (1)	28.6% (2)	28.6% (2)	7
In wildlife corridors	**93.8% (15)**	31.3% (5)	25.0% (4)	37.5% (6)	16
				Other (please specify)	11
				answered question	**44**
				skipped question	**4**

34. Based on your own awareness of food safety risk factors, and/or information/guidance from buyers and/or food safety auditors, what is your understanding of the degree of food safety risk posed by each of the following:

	High	Medium	Low	Response Count
Water	20.0% (9)	6.7% (3)	**73.3% (33)**	45
Wildlife	8.9% (4)	15.6% (7)	**75.6% (34)**	45
Natural areas/vegetation	2.3% (1)	4.5% (2)	**93.2% (41)**	44
Compost	22.9% (8)	8.6% (3)	**68.6% (24)**	35
Workers	22.2% (10)	24.4% (11)	**53.3% (24)**	45
			Other (please specify)	12
			answered question	**45**
			skipped question	**3**

35. If you have identified food safety issues on your farm, what have you done? If you haven't, skip the next question.

	Response Percent	Response Count
Thought out a food safety plan	15.0%	3
Wrote a food safety plan	**60.0%**	**12**
Removed wildlife (by trapping, hunting or using poison to kill wildlife)	35.0%	7
Fenced out wildlife	30.0%	6
Removed habitat to discourage wildlife presence near crops	10.0%	2
Planted windbreak/hedgerow barrier to reduce movement of airborne pathogens	5.0%	1
Redirected water to discourage wildlife movement near crops	5.0%	1
Stopped growing crops where wildlife are commonly seen	5.0%	1
	Other (please specify)	30
	answered question	**20**
	skipped question	**28**

36. In your opinion, did these steps to discourage wildlife presence on a farm reduce food safety risk?

	Response Percent	Response Count
Yes	**71.4%**	**10**
No	14.3%	2
They were done to satisfy a buyer or food safety professional and didn't really change food safety risk.	14.3%	2
Other (please specify)		17
answered question		**14**
skipped question		**34**

37. If food safety audits have been done on your farm, who conducted them?

	Response Count
	30
answered question	**30**
skipped question	**18**

38. Would you be interested in a food safety training for growing and harvesting fresh produce?

		Response Percent	Response Count
Yes		43.5%	20
No		**56.5%**	**26**
		Other (please specify)	19
		answered question	**46**
		skipped question	**2**

39. For Florida: If interested, who would be the right organization to do that training?

Florida Organizations

	FOG (Florida Organic Growers)	FFVA (Florida Fruit and Vegetable Association)	University of Florida's Food Safety and Quality Program	Florid He Hyg
Organization	**37.5% (6)**	25.0% (4)	**37.5% (6)**	

Private Industry

	Food safety auditors	Buyers
Organization	0.0% (0)	0.0% (0)

Federal Government

	FDA	USDA Natural Resources Conservation Service	USDA Ag Marl GAPs I
Organization	0.0% (0)	**50.0% (1)**	**50.0**

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40. For New York: If interested, who would be the right organization to do that training?

New York Organizations

	NOFA (either presenting or co-sponsoring)	NYSVGA (either presenting or co-sponsoring)	New York Dept of Health	Cornell Unive
Organization	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)

Private Industry

	Food safety auditors	Bu
Organization	0.0% (0)	0.(

Federal Government

	FDA	USDA Natural Resources Conservation Service	USDA
Organization	0.0% (0)	0.0% (0)	

41. For California: If interested, who would be the right organization to do that training?

CA Organizations

	CAFF (Community Alliance with Family Farmers)	ALBA (Ag Land-Based Association)	Monterey Resource Conservation District	California Public I
Organization	0.0% (0)	0.0% (0)	0.0% (0)	0.0%

Private Industry

	Food safety auditors	
Organization	0.0% (0)	

Federal Government

	FDA	USDA Natural Resources Conservation Service	U
Organization	0.0% (0)	0.0% (0)	

42. Who else should we talk to that knows a lot about food safety and agriculture in your area? (take names and contact information, if they have it)

	Response Count
	25
answered question	**25**
skipped question	**23**

43. From what list did the farmer contact information come from?

	Response Percent	Response Count
NOFA- Northeast Organic Farming Association	0.0%	0
NYSVGA - New York State Vegetable Growers Association	0.0%	0
FOG - Florida Organic Growers	**50.0%**	**12**
FFVA - Florida Fruit and Vegetable Association	**50.0%**	**12**
CAFF - Community Alliance with Family Farmers	0.0%	0
Other California databases	0.0%	0
	Other (please specify)	1
	answered question	**24**
	skipped question	**24**

44. Demographic Information:

	Response Percent	Response Count
Name:	**100.0%**	**26**
Company or Farm:	96.2%	25
Organic or Conventional	88.5%	23
State:	92.3%	24
Email Address:	38.5%	10
Phone Number:	88.5%	23
	answered question	**26**
	skipped question	**22**

Appendix 8

Food Safety and Farm Conservation

1. Your name (person filling out survey):

	Response Count
	24
answered question	**24**
skipped question	**27**

2. From what list did the farmer contact come from:

	Response Percent	Response Count
Florida Organic Growers (FOG)	0.0%	0
Florida Fruit & Vegetable Association (FFVA)	0.0%	0
Northeast Organic Farming Association of New York (NOFA-NY)	**52.9%**	**27**
New York State Vegetable Growers Association (NYSVGA)	47.1%	24
Community Alliance with Family Farmers (CAFF)	0.0%	0
other CA list	0.0%	0
	Other (please specify)	1
	answered question	**51**
	skipped question	**0**

3. Demographic Information

	Response Percent	Response Count
Name:	**100.0%**	**51**
Company or Farm:	**100.0%**	**51**
Organic or Conventional?	**100.0%**	**51**
State:	98.0%	50
Email Address:	47.1%	24
Phone Number:	98.0%	50
	answered question	**51**
	skipped question	**0**

4. How many acres do you farm?

	Response Percent	Response Count
10 acres or less	18.0%	9
100 acres or less	28.0%	14
1,000 acres or less	**32.0%**	**16**
> 1,000 acres	22.0%	11
	Other (please specify)	22
	answered question	**50**
	skipped question	**1**

5. What type of specialty crops do you grow? (Vegetable Row Crops)

	Response Percent	Response Count
Alliums (garlic, onions, leeks, green onions)	41.3%	19
Artichokes	2.2%	1
Asparagus	17.4%	8
Beans, peas, legumes	41.3%	19
Beets	34.8%	16
Brassicas (cabbage, broccoli, cauliflower, Brussel sprouts, turnip, radish)	54.3%	25
Carrots	34.8%	16
Celery	10.9%	5
Corn	54.3%	25
Cooked greens (kale, collards, chard)	47.8%	22
Cucurbits (summer and winter squash, cucumbers)	**63.0%**	**29**
Eggplant	26.1%	12
Lettuces	30.4%	14
Peanuts	0.0%	0
Peppers (green, hot)	39.1%	18
Potatoes, Sweet Potatoes	34.8%	16
Salad greens (arugula, endive, parsley, radicchio, spinach)	34.8%	16
Spinach	21.7%	10
Tomatoes	54.3%	25

	Other (please specify)	24
	answered question	**46**
	skipped question	**5**

6. What types of specialty crops do you grow? (Fruit Row Crops)

	Response Percent	Response Count
Blueberries	55.6%	5
Cranberries	0.0%	0
Grapes	22.2%	2
Kiwis	0.0%	0
Raspberries	**66.7%**	**6**
Strawberries	55.6%	5
	Other (please specify)	11
	answered question	**9**
	skipped question	**42**

7. What types of specialty crops do you grow? (Orchard Crops)

		Response Percent	Response Count
Avocado		0.0%	0
Citrus (orange, grapefruit, tangerine, lime, lemon)		0.0%	0
Nuts (almonds, walnuts, pecans, pistachios)		0.0%	0
Pome fruit (apples, pears)		**100.0%**	**9**
Stone fruit (cherries, plums, peaches)		66.7%	6
		Other (please specify)	8
		answered question	**9**
		skipped question	**42**

8. Do you also raise livestock?

		Response Percent	Response Count
No. Skip to question 10.		**56.5%**	**26**
Cattle		21.7%	10
Pigs		15.2%	7
Sheep		8.7%	4
Goats		6.5%	3
Chickens		26.1%	12
		Other (please specify)	13
		answered question	**46**
		skipped question	**5**

9. If livestock is part of your operation, do you:

	Response Percent	Response Count
Rotate grazing/cropping areas	70.6%	12
Feed culls to the animals	35.3%	6
Use manure in operations	**82.4%**	**14**
	Other (please specify)	5
	answered question	**17**
	skipped question	**34**

10. Are there any natural and/or non-crop areas on your farm, and if so what kinds?

	Response Percent	Response Count
Native trees and shrubs	46.0%	23
Woodlots	**86.0%**	**43**
Hedgerows and tree lines	58.0%	29
Grassed areas	42.0%	21
Vegetated ditches	22.0%	11
Ponds	52.0%	26
Rivers/streams	46.0%	23
Springs/Wetlands/Bogs	30.0%	15
Other water bodies	2.0%	1
	Other (please specify)	7
	answered question	**50**
	skipped question	**1**

11. And if there are natural areas/vegetation on your farm, what percent of the farm do they compromise?

		Response Percent	Response Count
0		2.1%	1
<1%		6.4%	3
about 5%		4.3%	2
about 10%		27.7%	13
about 25%		14.9%	7
>25%		**44.7%**	**21**
		Other (please specify)	14
		answered question	**47**
		skipped question	**4**

12. What percent of your crops are surrounded by natural areas/vegetation?

	Response Percent	Response Count
0	7.7%	3
<1%	5.1%	2
about 5%	0.0%	0
about 10%	12.8%	5
about 25%	17.9%	7
>25%	**56.4%**	**22**
	Other (please specify)	18
	answered question	**39**
	skipped question	**12**

13. Do fields flood periodically?

	Response Percent	Response Count
Yes	45.1%	23
No. Skip to question 14.	**54.9%**	**28**
	Other (please specify)	3
	answered question	**51**
	skipped question	**0**

14. What is the source of the flooding?

	Response Percent	Response Count
Water collects in flat farmland because drainage is poor	**42.1%**	**8**
Overland flow from upland areas	26.3%	5
Waterways over-top their banks	**42.1%**	**8**
	Other (please specify)	9
	answered question	**19**
	skipped question	**32**

15. Have you ever received NRCS (Natural Resource Conservation Service) support for conservation practices, such as:

	Response Percent	Response Count
Erosion control	**69.2%**	**9**
Water quality protection	46.2%	6
Native plants and wildlife conservation	53.8%	7
Invasive species control (like feral pigs)	7.7%	1
Native insect support	15.4%	2
	Other (please specify)	25
	answered question	**13**
	skipped question	**38**

16. How do you harvest:

	Response Percent	Response Count
By hand	**82.0%**	**41**
By machine	48.0%	24
	Other (please specify)	5
	answered question	**50**
	skipped question	**1**

17. How do you market your product?

	Response Percent	Response Count
Direct	**56.0%**	**28**
Retail	46.0%	23
Wholesale (Regional)	50.0%	25
Wholesale (National)	18.0%	9
Wholesale (International)	0.0%	0
Sell to Processor	16.0%	8
Grow for Contract	4.0%	2
	Other (please specify)	6
	answered question	**50**
	skipped question	**1**

18. What is your source of water?

		Response Percent	Response Count
Rain water		44.4%	20
Surface water		48.9%	22
Ground water		**51.1%**	**23**
		Other (please specify)	7
		answered question	**45**
		skipped question	**6**

19. Do you use compost?

		Response Percent	Response Count
Yes		**52.0%**	**26**
No. Skip to question 7.		48.0%	24
		Other (please specify)	2
		answered question	**50**
		skipped question	**1**

20. Is the compost?

	Response Percent	Response Count
Made on the farm	**76.9%**	**20**
Purchased from other business	26.9%	7
Other (please specify)		3
answered question		**26**
skipped question		**25**

21. Is the compost manure based?

	Response Percent	Response Count
Yes	**80.8%**	**21**
No. Skip to question 7.	19.2%	5
Other (please specify)		3
answered question		**26**
skipped question		**25**

22. What is the source of manure?

	Response Percent	Response Count
Manure is from a large animal operation	47.4%	9
Manure is from a small animal operation	**57.9%**	**11**
Other (please specify)		1
answered question		**19**
skipped question		**32**

23. What type of animal manure is used?

	Response Percent	Response Count
Cattle	47.4%	9
Pig	15.8%	3
Poultry	**52.6%**	**10**
Horse	31.6%	6
Other (please specify)		7
answered question		**19**
skipped question		**32**

24. Do you use un-composted manure to improve fertility, water holding capacity, soil tilth/structure, and microbial communities? (note: NOP requires application to be 120 days before harvest)

	Response Percent	Response Count
Yes	45.7%	21
No. Skip to next page.	**54.3%**	**25**
Other (please specify)		4
answered question		**46**
skipped question		**5**

25. What type of un-composted manure is used on your fields?

	Response Percent	Response Count
Cattle	**85.0%**	**17**
Pig	10.0%	2
Poultry	15.0%	3
Horse	15.0%	3
Other (please specify)		5
answered question		**20**
skipped question		**31**

26. Are there livestock grazing or corralled on neighboring farms?

	Response Percent	Response Count
Grazing	42.0%	21
Confined spaces	30.0%	15
No. Skip to next page.	**44.0%**	**22**
Other (please specify)		9
answered question		**50**
skipped question		**1**

27. What kinds of animals are in those operations?

	Response Percent	Response Count
Cattle	**80.6%**	**25**
Pigs	6.5%	2
Sheep	0.0%	0
Goats	3.2%	1
Chickens	0.0%	0
Horses	32.3%	10
Other (please specify)		6
answered question		**31**
skipped question		**20**

28. If yes, would you describe those operations as large or small (take shorthand on size, hundreds vs thousands)?

	Large	Small	Response Count
Cattle	28.0% (7)	**84.0% (21)**	25
Pigs	0.0% (0)	0.0% (0)	0
Sheep	0.0% (0)	0.0% (0)	0
Goats	0.0% (0)	**100.0% (1)**	1
Chickens	**100.0% (1)**	0.0% (0)	1
		Other (please specify)	12
		answered question	**27**
		skipped question	**24**

29. What large to medium-sized wildlife is present near the growing area?

	Deer	Moose	Feral pigs	Coyotes	Bobcats	Fox	Raccoon	Possum	Res Co
Large - Medium Sized Mammals	**98.0% (49)**	6.0% (3)	10.0% (5)	48.0% (24)	12.0% (6)	50.0% (25)	58.0% (29)	40.0% (20)	
								Other (please specify)	
								answered question	
								skipped question	

30. What small-sized wildlife is present near the growing area? (Small mammals in field, not rats near buildings)

	Gophers	Mice	Voles	Ground squirrels	Groundhogs	Nutria	Response Count
Small Mammals	40.6% (13)	**71.9% (23)**	34.4% (11)	56.3% (18)	56.3% (18)	3.1% (1)	32
					Other (please specify)		29
					answered question		**32**
					skipped question		**19**

31. What birds are present near the growing area?

	Crows and ravens	Geese and ducks	Hawks and owls	Shorebirds	Songbirds	Response Count
Birds	62.8% (27)	**72.1% (31)**	62.8% (27)	30.2% (13)	67.4% (29)	43
					Other (please specify)	21
					answered question	**43**
					skipped question	**8**

32. What amphibians and reptiles are present near the growing area?

	Frogs	Salamanders	Lizards	Snakes	Alligators (in FL)	Response Count
Amphibians and Reptiles	73.1% (19)	46.2% (12)	30.8% (8)	**88.5% (23)**	0.0% (0)	26
					Other (please specify)	11
					answered question	**26**
					skipped question	**25**

33. Where do you most often see wildlife or their signs?

	Animal	Fecal matter	Digging	Tracks	Response Count
In crop fields	**92.3% (36)**	17.9% (7)	12.8% (5)	38.5% (15)	39
In non-crop vegetation, tree and shrub lines, natural areas	**95.2% (40)**	31.0% (13)	33.3% (14)	38.1% (16)	42
In barns/buildings	**100.0% (14)**	28.6% (4)	14.3% (2)	35.7% (5)	14
Around water bodies	**92.3% (24)**	11.5% (3)	11.5% (3)	26.9% (7)	26
Around brush piles	**84.6% (11)**	23.1% (3)	30.8% (4)	38.5% (5)	13
Around cull piles and compost	**71.4% (5)**	14.3% (1)	28.6% (2)	28.6% (2)	7
In wildlife corridors	**100.0% (9)**	22.2% (2)	33.3% (3)	44.4% (4)	9
				Other (please specify)	15
				answered question	**47**
				skipped question	**4**

34. Based on your own awareness of food safety risk factors, and/or information/guidance from buyers and/or food safety auditors, what is your understanding of the degree of food safety risk posed by each of the following:

	High	Medium	Low	Response Count
Water	25.5% (12)	14.9% (7)	**59.6% (28)**	47
Wildlife	10.9% (5)	17.4% (8)	**71.7% (33)**	46
Natural areas/vegetation	0.0% (0)	6.5% (3)	**93.5% (43)**	46
Compost	11.6% (5)	23.3% (10)	**65.1% (28)**	43
Workers	21.3% (10)	27.7% (13)	**51.1% (24)**	47
			Other (please specify)	18
			answered question	**47**
			skipped question	**4**

35. If you have identified food safety issues on your farm, what have you done? If you haven't, skip the next question.

	Response Percent	Response Count
Thought out a food safety plan	50.0%	13
Wrote a food safety plan	**57.7%**	**15**
Removed wildlife (by trapping, hunting or using poison to kill wildlife)	46.2%	12
Fenced out wildlife	23.1%	6
Removed habitat to discourage wildlife presence near crops	11.5%	3
Planted windbreak/hedgerow barrier to reduce movement of airborne pathogens	0.0%	0
Redirected water to discourage wildlife movement near crops	0.0%	0
Stopped growing crops where wildlife are commonly seen	3.8%	1
	Other (please specify)	39
	answered question	**26**
	skipped question	**25**

36. In your opinion, did these steps to discourage wildlife presence on a farm reduce food safety risk?

	Response Percent	Response Count
Yes	**78.9%**	**15**
No	10.5%	2
They were done to satisfy a buyer or food safety professional and didn't really change food safety risk.	10.5%	2
	Other (please specify)	13
	answered question	**19**
	skipped question	**32**

37. If food safety audits have been done on your farm, who conducted them?

	Response Count
	28
answered question	**28**
skipped question	**23**

38. Would you be interested in a food safety training for growing and harvesting fresh produce?

		Response Percent	Response Count
Yes		**56.5%**	**26**
No		43.5%	20
		Other (please specify)	20
		answered question	**46**
		skipped question	**5**

39. For Florida: If interested, who would be the right organization to do that training?

Florida Organizations

	FOG (Florida Organic Growers)	FFVA (Florida Fruit and Vegetable Association)	University of Florida's Food Safety and Quality Program	Florid He Hyg
Organization	0.0% (0)	0.0% (0)	0.0% (0)	

Private Industry

	Food safety auditors	Buyers
Organization	0.0% (0)	0.0% (0)

Federal Government

	FDA	USDA Natural Resources Conservation Service	USDA Ag Marl GAPs l
Organization	0.0% (0)	0.0% (0)	0.0'

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40. For New York: If interested, who would be the right organization to do that training?

New York Organizations

	NOFA (either presenting or co-sponsoring)	NYSVGA (either presenting or co-sponsoring)	New York Dept of Health	Cornell Unive
Organization	40.9% (9)	4.5% (1)	0.0% (0)	**45.5% (10**

Private Industry

	Food safety auditors	Bu
Organization	**50.0% (2)**	**50.**

Federal Government

	FDA	USDA Natural Resources Conservation Service	USDA
Organization	0.0% (0)	0.0% (0)	

41. For California: If interested, who would be the right organization to do that training?

CA Organizations

	CAFF (Community Alliance with Family Farmers)	ALBA (Ag Land-Based Association)	Monterey Resource Conservation District	California Public I
Organization	0.0% (0)	0.0% (0)	0.0% (0)	0.0%

Private Industry

	Food safety auditors	
Organization	0.0% (0)	

Federal Government

	FDA	USDA Natural Resources Conservation Service	U
Organization	0.0% (0)	0.0% (0)	

42. Who else should we talk to that knows a lot about food safety and agriculture in your area? (take names and contact information, if they have it)

	Response Count
	23
answered question	23
skipped question	28

43. From what list did the farmer contact information come from?

	Response Percent	Response Count
NOFA- Northeast Organic Farming Association	33.3%	7
NYSVGA - New York State Vegetable Growers Association	**66.7%**	**14**
FOG - Florida Organic Growers	0.0%	0
FFVA - Florida Fruit and Vegetable Association	0.0%	0
CAFF - Community Alliance with Family Farmers	0.0%	0
Other California databases	0.0%	0
	Other (please specify)	0
	answered question	**21**
	skipped question	**30**

44. Demographic Information:

	Response Percent	Response Count
Name:	95.5%	21
Company or Farm:	**100.0%**	**22**
Organic or Conventional	90.9%	20
State:	**100.0%**	**22**
Email Address:	45.5%	10
Phone Number:	95.5%	21
	answered question	**22**
	skipped question	**29**

Appendix 9

21 CA growers surveyed with Survey Monkey, see first 26 pages

16 CA growers surveyed at conference, see pages 27-33

10 CA growers surveyed at meeting, see pages 34-37

Food Safety and Farm Conservation

SurveyMonkey

1. Your name (person filling out survey):

		Response Count
		21
	answered question	**21**
	skipped question	**0**

2. From what list did the farmer contact come from:

	Response Percent	Response Count
Florida Organic Growers (FOG)	0.0%	0
Florida Fruit & Vegetable Association (FFVA)	0.0%	0
Northeast Organic Farming Association of New York (NOFA-NY)	0.0%	0
New York State Vegetable Growers Association (NYSVGA)	0.0%	0
Community Alliance with Family Farmers (CAFF)	**100.0%**	**21**
other CA list	0.0%	0
	Other (please specify)	0
	answered question	**21**
	skipped question	**0**

3. Demographic Information

	Response Percent	Response Count
Name:	**100.0%**	**21**
Company or Farm:	**100.0%**	**21**
Organic or Conventional?	**100.0%**	**21**
State:	**100.0%**	**21**
Email Address:	52.4%	11
Phone Number:	95.2%	20
	answered question	**21**
	skipped question	**0**

4. How many acres do you farm?

	Response Percent	Response Count
10 acres or less	**33.3%**	**7**
100 acres or less	**33.3%**	**7**
1,000 acres or less	28.6%	6
> 1,000 acres	4.8%	1
	Other (please specify)	6
	answered question	**21**
	skipped question	**0**

5. What type of specialty crops do you grow? (Vegetable Row Crops)

	Response Percent	Response Count
Alliums (garlic, onions, leeks, green onions)	52.9%	9
Artichokes	17.6%	3
Asparagus	23.5%	4
Beans, peas, legumes	58.8%	10
Beets	52.9%	9
Brassicas (cabbage, broccoli, cauliflower, Brussel sprouts, turnip, radish)	58.8%	10
Carrots	47.1%	8
Celery	29.4%	5
Corn	52.9%	9
Cooked greens (kale, collards, chard)	58.8%	10
Cucurbits (summer and winter squash, cucumbers)	76.5%	13
Eggplant	47.1%	8
Lettuces	64.7%	11
Peanuts	0.0%	0
Peppers (green, hot)	64.7%	11
Potatoes, Sweet Potatoes	47.1%	8
Salad greens (arugula, endive, parsley, radicchio, spinach)	58.8%	10
Spinach	35.3%	6
Tomatoes	**82.4%**	**14**

	Other (please specify)	6
	answered question	**17**
	skipped question	**4**

6. What types of specialty crops do you grow? (Fruit Row Crops)

	Response Percent	Response Count
Blueberries	10.0%	1
Cranberries	0.0%	0
Grapes	30.0%	3
Kiwis	10.0%	1
Raspberries	20.0%	2
Strawberries	**80.0%**	**8**
	Other (please specify)	3
	answered question	**10**
	skipped question	**11**

7. What types of specialty crops do you grow? (Orchard Crops)

	Response Percent	Response Count
Avocado	7.1%	1
Citrus (orange, grapefruit, tangerine, lime, lemon)	42.9%	6
Nuts (almonds, walnuts, pecans, pistachios)	50.0%	7
Pome fruit (apples, pears)	**71.4%**	**10**
Stone fruit (cherries, plums, peaches)	50.0%	7
	Other (please specify)	6
	answered question	**14**
	skipped question	**7**

8. Do you also raise livestock?

	Response Percent	Response Count
No. Skip to question 10.	**61.9%**	**13**
Cattle	4.8%	1
Pigs	4.8%	1
Sheep	14.3%	3
Goats	9.5%	2
Chickens	28.6%	6
	Other (please specify)	0
	answered question	**21**
	skipped question	**0**

9. If livestock is part of your operation, do you:

	Response Percent	Response Count
Rotate grazing/cropping areas	71.4%	5
Feed culls to the animals	71.4%	5
Use manure in operations	**100.0%**	**7**
	Other (please specify)	1
	answered question	**7**
	skipped question	**14**

10. Are there any natural and/or non-crop areas on your farm, and if so what kinds?

	Response Percent	Response Count
Native trees and shrubs	29.4%	5
Woodlots	41.2%	7
Hedgerows and tree lines	**52.9%**	**9**
Grassed areas	35.3%	6
Vegetated ditches	29.4%	5
Ponds	29.4%	5
Rivers/streams	**52.9%**	**9**
Springs/Wetlands/Bogs	23.5%	4
Other water bodies	0.0%	0
	Other (please specify)	5
	answered question	**17**
	skipped question	**4**

11. And if there are natural areas/vegetation on your farm, what percent of the farm do they compromise?

	Response Percent	Response Count
0	10.0%	2
<1%	10.0%	2
about 5%	**25.0%**	**5**
about 10%	15.0%	3
about 25%	15.0%	3
>25%	**25.0%**	**5**
	Other (please specify)	1
	answered question	**20**
	skipped question	**1**

12. What percent of your crops are surrounded by natural areas/vegetation?

	Response Percent	Response Count
0	11.1%	2
<1%	5.6%	1
about 5%	5.6%	1
about 10%	16.7%	3
about 25%	11.1%	2
>25%	**50.0%**	**9**
	Other (please specify)	2
	answered question	**18**
	skipped question	**3**

13. Do fields flood periodically?

	Response Percent	Response Count
Yes	38.1%	8
No. Skip to question 14.	**61.9%**	**13**
	Other (please specify)	1
	answered question	**21**
	skipped question	**0**

14. What is the source of the flooding?

	Response Percent	Response Count
Water collects in flat farmland because drainage is poor	14.3%	1
Overland flow from upland areas	14.3%	1
Waterways over-top their banks	**71.4%**	**5**
Other (please specify)		3
answered question		**7**
skipped question		**14**

15. Have you ever received NRCS (Natural Resource Conservation Service) support for conservation practices, such as:

	Response Percent	Response Count
Erosion control	37.5%	3
Water quality protection	**50.0%**	**4**
Native plants and wildlife conservation	25.0%	2
Invasive species control (like feral pigs)	0.0%	0
Native insect support	37.5%	3
Other (please specify)		4
answered question		**8**
skipped question		**13**

16. How do you harvest:

	Response Percent	Response Count
By hand	**90.5%**	**19**
By machine	38.1%	8
Other (please specify)		1
answered question		**21**
skipped question		**0**

17. How do you market your product?

	Response Percent	Response Count
Direct	**76.2%**	**16**
Retail	42.9%	9
Wholesale (Regional)	52.4%	11
Wholesale (National)	28.6%	6
Wholesale (International)	0.0%	0
Sell to Processor	14.3%	3
Grow for Contract	19.0%	4
Other (please specify)		1
answered question		**21**
skipped question		**0**

18. What is your source of water?

	Response Percent	Response Count
Rain water	15.0%	3
Surface water	50.0%	10
Ground water	**75.0%**	**15**
Other (please specify)		3
answered question		**20**
skipped question		**1**

19. Do you use compost?

	Response Percent	Response Count
Yes	**76.2%**	**16**
No. Skip to question 7.	23.8%	5
Other (please specify)		1
answered question		**21**
skipped question		**0**

20. Is the compost?

		Response Percent	Response Count
Made on the farm		56.3%	9
Purchased from other business		**68.8%**	**11**
		Other (please specify)	0
		answered question	**16**
		skipped question	**5**

21. Is the compost manure based?

		Response Percent	Response Count
Yes		**50.0%**	**8**
No. Skip to question 7.		**50.0%**	**8**
		Other (please specify)	3
		answered question	**16**
		skipped question	**5**

22. What is the source of manure?

	Response Percent	Response Count
Manure is from a large animal operation	50.0%	4
Manure is from a small animal operation	**75.0%**	**6**
Other (please specify)		0
answered question		**8**
skipped question		**13**

23. What type of animal manure is used?

	Response Percent	Response Count
Cattle	25.0%	2
Pig	0.0%	0
Poultry	**62.5%**	**5**
Horse	50.0%	4
Other (please specify)		0
answered question		**8**
skipped question		**13**

24. Do you use un-composted manure to improve fertility, water holding capacity, soil tilth/structure, and microbial communities? (note: NOP requires application to be 120 days before harvest)

	Response Percent	Response Count
Yes	35.3%	6
No. Skip to next page.	**64.7%**	**11**
Other (please specify)		2
answered question		**17**
skipped question		**4**

25. What type of un-composted manure is used on your fields?

	Response Percent	Response Count
Cattle	33.3%	2
Pig	0.0%	0
Poultry	**50.0%**	**3**
Horse	33.3%	2
Other (please specify)		0
answered question		**6**
skipped question		**15**

26. Are there livestock grazing or corralled on neighboring farms?

	Response Percent	Response Count
Grazing	33.3%	7
Confined spaces	14.3%	3
No. Skip to next page.	**57.1%**	**12**
	Other (please specify)	1
	answered question	**21**
	skipped question	**0**

27. What kinds of animals are in those operations?

	Response Percent	Response Count
Cattle	**66.7%**	**6**
Pigs	11.1%	1
Sheep	11.1%	1
Goats	0.0%	0
Chickens	11.1%	1
Horses	33.3%	3
	Other (please specify)	0
	answered question	**9**
	skipped question	**12**

28. If yes, would you describe those operations as large or small (take shorthand on size, hundreds vs thousands)?

	Large	Small	Rating Count
Cattle	**66.7% (4)**	50.0% (3)	6
Pigs	0.0% (0)	**100.0% (1)**	1
Sheep	**100.0% (1)**	0.0% (0)	1
Goats	0.0% (0)	0.0% (0)	0
Chickens	0.0% (0)	**100.0% (1)**	1
		Other (please specify)	4
		answered question	**8**
		skipped question	**13**

29. What large to medium-sized wildlife is present near the growing area?

	Deer	Moose	Feral pigs	Coyotes	Bobcats	Fox	Raccoon	Possum	Ra Co
Large - Medium Sized Mammals	**70.0% (14)**	0.0% (0)	20.0% (4)	65.0% (13)	35.0% (7)	40.0% (8)	**70.0% (14)**	60.0% (12)	
								Other (please specify)	
								answered question	
								skipped question	

30. What small-sized wildlife is present near the growing area? (Small mammals in field, not rats near buildings)

	Gophers	Mice	Voles	Ground squirrels	Groundhogs	Nutria	Rating Count
Small Mammals	**90.0% (18)**	80.0% (16)	40.0% (8)	65.0% (13)	5.0% (1)	0.0% (0)	20
						Other (please specify)	8
						answered question	**20**
						skipped question	**1**

31. What birds are present near the growing area?

	Crows and ravens	Geese and ducks	Hawks and owls	Shorebirds	Songbirds	Rating Count
Birds	77.8% (14)	50.0% (9)	**100.0% (18)**	27.8% (5)	**100.0% (18)**	18
					Other (please specify)	6
					answered question	**18**
					skipped question	**3**

32. What amphibians and reptiles are present near the growing area?

	Frogs	Salamanders	Lizards	Snakes	Alligators (in FL)	Rating Count
Amphibians and Reptiles	76.5% (13)	29.4% (5)	70.6% (12)	**94.1% (16)**	0.0% (0)	17
					Other (please specify)	2
					answered question	**17**
					skipped question	**4**

33. Where do you most often see wildlife or their signs?

	Animal	Fecal matter	Digging	Tracks	Rating Count
In crop fields	**83.3% (15)**	27.8% (5)	38.9% (7)	55.6% (10)	18
In non-crop vegetation, tree and shrub lines, natural areas	**100.0% (18)**	44.4% (8)	50.0% (9)	55.6% (10)	18
In barns/buildings	**83.3% (5)**	33.3% (2)	0.0% (0)	33.3% (2)	6
Around water bodies	**100.0% (9)**	33.3% (3)	33.3% (3)	55.6% (5)	9
Around brush piles	66.7% (2)	33.3% (1)	66.7% (2)	**100.0% (3)**	3
Around cull piles and compost	66.7% (2)	33.3% (1)	**100.0% (3)**	**100.0% (3)**	3
In wildlife corridors	**100.0% (11)**	90.9% (10)	81.8% (9)	81.8% (9)	11
				Other (please specify)	4
				answered question	**20**
				skipped question	**1**

34. Based on your own awareness of food safety risk factors, and/or information/guidance from buyers and/or food safety auditors, what is your understanding of the degree of food safety risk posed by each of the following:

	High	Medium	Low	Rating Count
Water	28.6% (6)	14.3% (3)	**57.1% (12)**	21
Wildlife	14.3% (3)	23.8% (5)	**61.9% (13)**	21
Natural areas/vegetation	0.0% (0)	0.0% (0)	**100.0% (21)**	21
Compost	10.0% (2)	10.0% (2)	**80.0% (16)**	20
Workers	33.3% (7)	23.8% (5)	**42.9% (9)**	21
			Other (please specify)	6
			answered question	**21**
			skipped question	**0**

35. If you have identified food safety issues on your farm, what have you done? If you haven't, skip the next question.

	Response Percent	Response Count
Thought out a food safety plan	**50.0%**	**8**
Wrote a food safety plan	43.8%	7
Removed wildlife (by trapping, hunting or using poison to kill wildlife)	31.3%	5
Fenced out wildlife	43.8%	7
Removed habitat to discourage wildlife presence near crops	6.3%	1
Planted windbreak/hedgerow barrier to reduce movement of airborne pathogens	31.3%	5
Redirected water to discourage wildlife movement near crops	0.0%	0
Stopped growing crops where wildlife are commonly seen	18.8%	3
	Other (please specify)	9
	answered question	**16**
	skipped question	**5**

36. In your opinion, did these steps to discourage wildlife presence on a farm reduce food safety risk?

	Response Percent	Response Count
Yes	33.3%	4
No	**66.7%**	**8**
They were done to satisfy a buyer or food safety professional and didn't really change food safety risk.	0.0%	0
	Other (please specify)	6
	answered question	**12**
	skipped question	**9**

37. If food safety audits have been done on your farm, who conducted them?

	Response Count
	17
answered question	**17**
skipped question	**4**

38. Would you be interested in a food safety training for growing and harvesting fresh produce?

		Response Percent	Response Count
Yes		**52.4%**	**11**
No		47.6%	10
		Other (please specify)	5
		answered question	**21**
		skipped question	**0**

39. For Florida: If interested, who would be the right organization to do that training?

Florida Organizations

	FOG (Florida Organic Growers)	FFVA (Florida Fruit and Vegetable Association)	University of Florida's Food Safety and Quality Program	Florid He Hyg
Organization	0.0% (0)	0.0% (0)	0.0% (0)	

Private Industry

	Food safety auditors	Buyers
Organization	0.0% (0)	0.0% (0)

Federal Government

	FDA	USDA Natural Resources Conservation Service	USDA Ag Marl GAPs I
Organization	0.0% (0)	0.0% (0)	0.0

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40. For New York: If interested, who would be the right organization to do that training?

New York Organizations

	NOFA (either presenting or co-sponsoring)	NYSVGA (either presenting or co-sponsoring)	New York Dept of Health	Cornell Unive
Organization	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)

Private Industry

	Food safety auditors	Bu
Organization	0.0% (0)	0.(

Federal Government

	FDA	USDA Natural Resources Conservation Service	USDA
Organization	0.0% (0)	0.0% (0)	

41. For California: If interested, who would be the right organization to do that training?

CA Organizations

	CAFF (Community Alliance with Family Farmers)	ALBA (Ag Land-Based Association)	Monterey Resource Conservation District	California Public I
Organization	**71.4% (5)**	0.0% (0)	0.0% (0)	28.6%

Private Industry

	Food safety auditors	
Organization	0.0% (0)	

Federal Government

	FDA	USDA Natural Resources Conservation Service	U
Organization	0.0% (0)	**100.0% (1)**	

42. Who else should we talk to that knows a lot about food safety and agriculture in your area? (take names and contact information, if they have it)

	Response Count
	12
answered question	**12**
skipped question	**9**

43. From what list did the farmer contact information come from?

	Response Percent	Response Count
NOFA- Northeast Organic Farming Association	0.0%	0
NYSVGA - New York State Vegetable Growers Association	0.0%	0
FOG - Florida Organic Growers	0.0%	0
FFVA - Florida Fruit and Vegetable Association	0.0%	0
CAFF - Community Alliance with Family Farmers	**100.0%**	**12**
Other California databases	0.0%	0
	Other (please specify)	0
	answered question	**12**
	skipped question	**9**

44. Demographic Information:

	Response Percent	Response Count
Name:	**100.0%**	**14**
Company or Farm:	**100.0%**	**14**
Organic or Conventional	**100.0%**	**14**
State:	**100.0%**	**14**
Email Address:	42.9%	6
Phone Number:	**100.0%**	**14**
	answered question	**14**
	skipped question	**7**

4. In what county and state is your farm or ranch located?

	Response Count
	16
answered question	**16**
skipped question	**0**

5. What specialty crops (vegetables, fruits, herbs, tree nuts, etc.) do you produce? (check all that apply)

	Response Percent	Response Count
a. leafy greens	75.0%	12
b. vegetables other than leafy greens	**81.3%**	**13**
c. herbs	68.8%	11
d. tree nuts	37.5%	6
e. wine grapes	6.3%	1
f. berries / small fruits (including table grapes)	56.3%	9
g. tree fruits	**81.3%**	**13**
Other (please specify)	0.0%	0
answered question		**16**
skipped question		**0**

Note 1 - The individual 'fill in' answers to the open ended questions are included after the summary. They start on pg 9 (or page 6 if you are counting sheets of paper and not looking at the page numbers.

Note 2 - The survey results start on page 2 because, questions were added at the beginning of the survey for purposes of tracking who entered the data into Survey Monkey. These questions were not included in the summary of survey results.

6. How many acres of specialty crops do you have in production?

	Response Percent	Response Count
a. 10 acres or less	**43.8%**	**7**
b. 11 - 100 acres	**43.8%**	**7**
c. 101 - 1000 acres	12.5%	2
d. more than 1000 acres	0.0%	0
Other (please specify)	6.3%	1
	answered question	**16**
	skipped question	**0**

7. How do you market your specialty crops? (check all that apply)

	Response Percent	Response Count
a. directly to the consumer (CSA, farmers' market, farm stand, etc.)	**81.3%**	**13**
b. retail (grocery stores, restaurants, etc.)	75.0%	12
c. wholesale, regional	43.8%	7
d. wholesale, national	25.0%	4
e. wholesale, international	12.5%	2
f. sell to processor	31.3%	5
g. grow on contract	6.3%	1
Other (please specify)	18.8%	3
	answered question	**16**
	skipped question	**0**

8. How do you currently address food safety on your farm or ranch? (check all that apply)

	Response Percent	Response Count
a. Use common sense to avoid contaminating specialty crops with food-borne pathogens.	**87.5%**	**14**
b. Follow GAPS (Good Agricultural Practices) related to food safety.	50.0%	8
c. Implement a food safety plan that describes all the steps you take to protect your specialty crops.	18.8%	3
d. Utilize on-farm conservation practices that also reduce the risk of contaminating specialty crops with food-borne pathogens.	50.0%	8
e. Provide proper sanitation facilities for all employees.	81.3%	13
f. Food safety is not a major concern.	0.0%	0
Other (please specify)	37.5%	6
	answered question	**16**
	skipped question	**0**

9. Share your "Co-Management" Stories In this workshop you heard about various food safety and conservation "co-management" strategies such as: - using compost to promote soil biodiversity - planting grassed waterways to reduce the movement of water-borne pathogens - using monitoring practices to assess food safety risks in crops growing near wildlife habitat - working with a food safety auditor to allow conservation practices on your land while still addressing food safety concerns. Are there any additional practices you use on your farm/ranch to effectively "co-manage" food safety and conservation not included in this workshop? If so, please share your innovative ideas with us:

		Response Count
		7
	answered question	7
	skipped question	9

10. Is there any additional information you would like to know about "co-managing" food safety and conservation?

		Response Count
		8
	answered question	8
	skipped question	8

11. If you have any additional comments, please share them here.

		Response Count
		3
	answered question	3
	skipped question	13

Page 2, Q4. In what county and state is your farm or ranch located?

1	Santa Barbara, CA	Feb 8, 2013 3:35 PM
2	Santa Barbara, CA	Feb 8, 2013 3:18 PM
3	Loudoun, Virginia	Feb 8, 2013 3:17 PM
4	CA	Feb 8, 2013 3:15 PM
5	Maui, HI	Feb 8, 2013 3:13 PM
6	Santa Barbara & Kern, CA	Feb 8, 2013 3:10 PM
7	Santa Cruz, CA	Feb 8, 2013 3:05 PM
8	Mendocino	Feb 8, 2013 3:03 PM
9	Leelanan, MI	Feb 8, 2013 2:58 PM
10	Monterey, CA	Feb 8, 2013 2:56 PM
11	Franklin & Hampshire Counties, MA	Feb 8, 2013 2:50 PM
12	CA	Feb 8, 2013 2:47 PM
13	Mendocino County, CA	Feb 8, 2013 2:46 PM
14	Marin	Feb 8, 2013 2:44 PM
15	Yolo, CA	Feb 8, 2013 2:42 PM
16	Merced, CA	Feb 8, 2013 2:08 PM

Page 2, Q6. How many acres of specialty crops do you have in production?

1	planned for production in 2013	Feb 8, 2013 3:13 PM

Page 2, Q7. How do you market your specialty crops? (check all that apply)

1	planning to sell to farmers' markets and grocery stores in 2013	Feb 8, 2013 3:13 PM
2	grow directly for hospital kitchen on site farm	Feb 8, 2013 3:03 PM
3	schools, hospitals	Feb 8, 2013 2:58 PM

Page 2, Q8. How do you currently address food safety on your farm or ranch? (check all that apply)		
1	planning the checked food-safety practices for 2013	Feb 8, 2013 3:13 PM
2	currently working on developing 'b.' &'c.'	Feb 8, 2013 3:03 PM
3	use aggressive rodent control program to keep a healthy balance ecosystem through mechanical trapping	Feb 8, 2013 2:56 PM
4	took a CDFA sponsored food safety workshop in Nov.2012 & in process of developing a food safety program & policies	Feb 8, 2013 2:46 PM
5	note: 'internal' written next to option 'b.'	Feb 8, 2013 2:42 PM
6	note in the margin on this question: 'ready to start'	Feb 8, 2013 2:08 PM

Page 2, Q9. Share your "Co-Management" Stories

In this workshop you heard about various food safety and conservation "co-management" strategies such as:
- using compost to promote soil biodiversity
- planting grassed waterways to reduce the movement of water-borne pathogens
- using monitoring practices...

1	utilizing windrows to prevent wind drift from adjacent grazing animals	Feb 8, 2013 3:17 PM
2	You covered many practices, and I hope to learn more myself for the farm I am starting in 2013.	Feb 8, 2013 3:13 PM
3	Nothing comes to mind.	Feb 8, 2013 3:05 PM
4	wash all produce with city water in covered area in stainless sinks. Use plastic bins to transport produce. Bins washed & sterilized on receiving end.	Feb 8, 2013 3:03 PM
5	no	Feb 8, 2013 2:58 PM
6	?? Farming with no chemicals ?? Field flowers	Feb 8, 2013 2:56 PM
7	Hedgerows Windbreaks Soil Biodiversity Plant nutibor biofungicides	Feb 8, 2013 2:42 PM

Page 2, Q10. Is there any additional information you would like to know about "co-managing" food safety and conservation?		
1	I want to understand how to allow my domestic farm animals to coexist with GAP certified produce. Also how to incorporate their manure.	Feb 8, 2013 3:35 PM
2	Any farm examples.	Feb 8, 2013 3:13 PM
3	no.	Feb 8, 2013 3:05 PM
4	All produce grown in garden goes directly to hospital kitchen or to hospital employees as CSA based on giving & donation to the garden project. Will we need to show good internal documentation & food safety procedures and be exempt from some of these regulations?	Feb 8, 2013 3:03 PM
5	less than 45 days to harvest crops with compost - side dressing compost in season	Feb 8, 2013 2:58 PM
6	I have coytes that eat the berries off the vines and defecate in the rows. Do coytes present a food safety problem for berry growers.	Feb 8, 2013 2:56 PM
7	Don't give up on the argument that safety achieved with combo of GAP (simple) & biodiversity. And for GOOD verifiable science and not assumptions.	Feb 8, 2013 2:42 PM
8	bat house, bird house, owl box, buffers & placement	Feb 8, 2013 2:08 PM

Page 2, Q11. If you have any additional comments, please share them here.		
1	trying to help the farm I work for write a food safety plan	Feb 8, 2013 3:15 PM
2	no.	Feb 8, 2013 3:05 PM
3	I appreciate the role of WFA in help for small operators.	Feb 8, 2013 2:56 PM

Surveys conducted at Food Safety Modernization Act meeting, Sept 2013

Timestamp	1. What specialty crops do you produce? (check all that apply)	2. How many acres of specialty crops do you have in production?	3. How do you market your specialty crops? (check all that apply)	4. How do you currently address food safety on your farm or ranch (check all that apply)?	5. Using Non-Crop Vegetation and Ditches to Reduce Food Safety Risk	6. Using Soil Conservation Practices to Reduce Food Safety Risk	7. Other "Co-Management" Practices	8.Using Monitoring Strategies to Reduce Food Safety Risk	9. Do You Have to Discourage Wildlife From Contaminating Your Crop?	10. Working With Food Safety Auditors to Allow "Co-Management" Practices	10. Food Safety Plan	11. Keeping Up to Date
9/14/2013 8:00:47	tree fruits	11 - 100 acres	directly to consumer (CSA, farmer's market, farm stand, etc), retail (grocery stores, restaurants, etc.)	Use common sense to avoid contaminating specialty crops with food-borne pathogens., Provide proper sanitation facilities for all employees., Utilize on-farm conservation practices that also reduce the risk of contaminating specialty crops with food-borne pathogens., Follow GAPS (Good Agricultural Practices) related to food safety., Have a food safety plan., Have a food safety plan and have been audited by third party auditor.	No raw or composted manure is used.	No raw or composted manure is used.	Leave land fallow for 2-3 years to reduce nematode and other diseases.	Walk the fields during irrigation just prior to picking an area.	Wildlife do not present a significant risk to our crop.	We don't have the results of our audit, yet.	Yes, I would like help	Mike & Nori Naylor naylor. organics@gmail. com
9/15/2013 10:22:05	vegetables other than leafy greens, berries/small fruits, herbs	10 acres or less	directly to consumer (CSA, farmer's market, farm stand, etc), retail (grocery stores, restaurants, etc.)	Use common sense to avoid contaminating specialty crops with food-borne pathogens.					fencing, use of floating row cover, use of scare crows		No, I don't have a food safety plan, and I don't need one at this time.	
9/24/2013 18:44:47	vegetables other than leafy greens		wholesale, regional	Use common sense to avoid contaminating specialty crops with food-borne pathogens., Provide proper sanitation facilities for all employees., Utilize on-farm conservation practices that also reduce the risk of contaminating specialty crops with food-borne pathogens., Follow GAPS (Good Agricultural Practices) related to food safety., Have a food safety plan.							Yes, I would like help	Silvia Lucassians lucassy2004@yaho

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9/25/2013 15:06:51	leafy greens, vegetables other than leafy greens, berries/small fruits , tree fruits, herbs	101 - 1,000 acres	directly to consumer (CSA, farmer's market, farm stand, etc), retail (grocery stores, restaurants, etc.), wholesale, regional, wholesale, national, grow on contract	Use common sense to avoid contaminating specialty crops with food-borne pathogens., Provide proper sanitation facilities for all employees., Utilize on-farm conservation practices that also reduce the risk of contaminating specialty crops with food-borne pathogens., Follow GAPS (Good Agricultural Practices) related to food safety., Have a food safety plan., Have a food safety plan and have been audited by third party auditor.	windbreaks, ditches, riparian habitat	yes, we use compost from reliable sources	buffer zones	all of the above, plus trapping, buffer zones	fencing, trapping, bait stations (will discontinue due to evidence that it is not effective in preventing possible contamination)	N/A		Yes, thank you. We just passed out audit with NFS yesterday, yeah!!
9/25/2013 15:11:54	leafy greens, vegetables other than leafy greens, herbs, flowers	10 acres or less	directly to consumer (CSA, farmer's market, farm stand, etc), retail (grocery stores, restaurants, etc.), wholesale, regional, grow on contract	Use common sense to avoid contaminating specialty crops with food-borne pathogens.	Swails/burms to catch water from wash basin - let it soak in, instead of oozing back into the field. Also utilize a beneficial Hedgerow between a neighbor and our property, it is a vineayard that sprays many fungicides.	We purchase manure since we need more than we can simply create on our property.	We have many pollinator attracting plants in our landscapes that surround the fields. This supports bees and other crop pollinators, and supplies us with delicious 'estate' honey from the hive. Our dog loves apples and other fruit, so when when we find worm-infested or partially rotten fruit we feed it to the dog. Great nutrition for our dog and eliminates that pest from overwintering in neglected crop debris.	do not monitor. if we see a kale leaf, for example, with bird poop on it, I pick the leaf and drop it on the ground, so that poop does not enter our wash water and contaminate everything else.	Yes, quail are a major problem in our fields. Thanks to our handy habitat-creating borders - we have created an inadvertent habitat for this pest too. The quail feast on young seedling sprouts. We must cover all seeded crops with white floating row cover. Even our cover crops, until the young plants become about 6" tall and can withstand some damage. This has created an increased cost and hassle, to cover such large expanses.		No, I don't have a food safety plan, and I don't need one at this time.	

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9/25/2013 18:44:31	leafy greens, vegetables other than leafy greens, berries/small fruits, tree nuts, tree fruits	101 - 1,000 acres	directly to consumer (CSA, farmer's market, farm stand, etc), retail (grocery stores, restaurants, etc.), wholesale, regional, sell to processor	Use common sense to avoid contaminating specialty crops with food-borne pathogens., Provide proper sanitation facilities for all employees., Utilize on-farm conservation practices that also reduce the risk of contaminating specialty crops with food-borne pathogens., Follow GAPS (Good Agricultural Practices) related to food safety., Have a food safety plan.	hedgerow between compost yard and cropped field	make and apply thermophilic, aerobic produced compost using manure as a feedstock, compost is important part of soil building and fertility	yes	yes	yes, row cover over crops next to hedgerows, game fence		Yes, I would like help	Phil Foster, pfoster@pinnacleorg
9/25/2013 19:53:11	leafy greens, vegetables other than leafy greens, berries/small fruits, tree nuts, tree fruits, herbs, wine grapes	10 acres or less	directly to consumer (CSA, farmer's market, farm stand, etc)	Use common sense to avoid contaminating specialty crops with food-borne pathogens., Provide proper sanitation facilities for all employees., Utilize on-farm conservation practices that also reduce the risk of contaminating specialty crops with food-borne pathogens., Follow GAPS (Good Agricultural Practices) related to food safety., Have a food safety plan.								
9/26/2013 10:26:26	leafy greens, vegetables other than leafy greens, berries/small fruits, tree fruits, herbs, wine grapes	101 - 1,000 acres	directly to consumer (CSA, farmer's market, farm stand, etc), retail (grocery stores, restaurants, etc.)	Use common sense to avoid contaminating specialty crops with food-borne pathogens., Provide proper sanitation facilities for all employees., Utilize on-farm conservation practices that also reduce the risk of contaminating specialty crops with food-borne pathogens., Follow GAPS (Good Agricultural Practices) related to food safety., Have a food safety plan.	We maintain ample setbacks from streams. We also have created wildlife migration corridors on our main ranch. This dramatically reduces pressure from wildlife - especially deer.	We use properly composted manure. We manage and monitor composting temperature.	We have a self-certified GAP program with a detailed manual and associated documentation.	We do not have major wildlife issues.	No.		Yes, I would like help	Ted Hall tedhall@longmeado Tony Fernandez tony@longmeadowr Kipp Ramsey kipp@longmeadowr

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9/26/2013 19:10:44	leafy greens, vegetables other than leafy greens	11 - 100 acres	directly to consumer (CSA, farmer's market, farm stand, etc), retail (grocery stores, restaurants, etc.), wholesale, regional	Use common sense to avoid contaminating specialty crops with food-borne pathogens., Provide proper sanitation facilities for all employees., Utilize on-farm conservation practices that also reduce the risk of contaminating specialty crops with food-borne pathogens., Follow GAPS (Good Agricultural Practices) related to food safety.		We use CCOF-compliant composted materials in our field, or, follow 90/120 day rule for fields with manure applications.	Pollinator habitat via hedgerows and windbreaks	Visual presence or feces	Bird tape		Yes, I would like help	chris hay sayhayfarms@gmai
9/26/2013 19:53:39	berries/small fruits	11 - 100 acres	wholesale, national	Provide proper sanitation facilities for all employees., Utilize on-farm conservation practices that also reduce the risk of contaminating specialty crops with food-borne pathogens., Follow GAPS (Good Agricultural Practices) related to food safety., Have a food safety plan., Have a food safety plan and have been audited by third party auditor.		Do not any manures of any kind. I do use soil conservation practices, across the hill grading at 1% fall between rows, seeding furrows at the ends, during the winter seed all areas to reduced soil loss. cover crop in fallow area.	planting of plants on the banks around the ranch to reduce errosion. planted Ceanothis low growing again to reduce soil loss.	yes I do monitor the fields for wild life activity. birds and squirrels are an issue.			No, I don't have a food safety plan, and I don't need one at this time.	