Food safety and sustainable agricultural practices: Conflicts and their effects on policy and programs in California

A Resource for Policy-Makers and Program Managers

Authors: Emily Zakowski and Kevi Mace

Office of Pesticide Consultation and Analysis
California Department of Food and Agriculture

cdfa
CALIFORNIA DEPARTMENT OF FOOD AND AGRICULTURE

Abstract

California leads the country with $50 billion in annual agricultural sales while providing substantial investment in and support for sustainable practices across its 25.4 million agricultural acres (CDFA 2018). Consumers want healthy, safe food that is produced sustainably. However, some sustainable agricultural and food safety practices conflict. For example, sustainable practices that support wildlife or integrate livestock on farm are counterbalanced by costs to produce safety, such as lost production (from no-harvest buffer zones) and practices to reduce produce safety risk (e.g., removal of wildlife habitat around growing and packing areas, pest management practices, restrictiosn on the use of certain soil amendments); this balancing challenge can limit the adoption of alternative, sustainable practices, as well as the success of policies and programs that support them. We analyzed public documents and meetings, reviewed literature, and communicated with stakeholders to identify conflicts between food safety requirements and policies supporting sustainable farming practices in California. Given that food safety is an ever-evolving, demanding concern and California has significantly invested in encouraging the adoption of sustainable, climate-smart agricultural practices, the findings presented in this report will increase awareness of policy conflicts and serve as a resource for policy-makers and program managers to better promote co-management of food safety and environmental sustainability.

Table of Contents

Introduction

Foodborne illness outbreaks have serious consequences for public health—an estimated 48 million people experience illness related to contaminated food each year nationwide (CDC 2021)—and the agricultural industry by disrupting supply chains, shaking consumer confidence, and causing economic losses. Recent outbreaks and liability concerns have increased pressure on growers to address food safety risks. In 2019, the U.S. Food and Drug Administration (FDA) initiated the "new era of smarter food safety," while industry groups are working to strengthen their food safety standards, including water treatment, animal exclusion, and no-harvest buffer zones (U.S. FDA 2019; Ward 2020). Meanwhile, California has invested significantly in encouraging the adoption of sustainable, climate-smart agricultural practices through governmental policies and programs. Statewide initiatives include efforts to promote water quality and use-efficiency, soil health, wildlife conservation, and pest management with lower chemical inputs.

Among these system wide efforts to promote sustainability, are practices that interfere with on-farm government- or industry-set requirements for food safety. Where food safety and environmentally sustainable practices conflict, growers may be constrained by competing pressure in their attempt to balance and promote both objectives. In this report, we aim to better understand where food safety and sustainability pressures conflict and create challenges for co-management, with a key focus on governmental policies and programs. We document conflicts between food safety requirements and practices promoted by sustainable agricultural initiatives in the context of specific governmental policies and programs where the state's efforts to assist the transition to and widespread adoption of sustainable practices could fail owing to the more immediate need to comply with food safety requirements.

This report links both well established and less commonly documented conflicts to specific environmental policies. While there is a body of literature that documents conflicts between food safety and sustainable agricultural practices (Olimpi et al. 2019), it is primarily limited to California's Central Coast region; here, we build upon those studies by looking at conflicts experienced statewide and linking them to specific governmental policies and programs. The results have important implications for policy makers and program managers to evaluate how their policies and programs might contribute to, or be affected by, challenges growers experience in co-managing for food safety and environmental sustainability.

In this report we first provide context for California's agricultural industry, and then explore the policy landscape for food safety and sustainable agriculture for

California growers. Next, we present the results of our qualitative analysis documenting conflicts between food safety requirements and environmental policies. We conclude by discussing the policy implications of these conflicts.

Context: Food Safety and Sustainable Agricultural Policy Affecting California Growers

California leads the nation and world in agricultural production, delivering over $50 billion in total cash receipts, derived from 24.3 million acres, in 2018 (CDFA 2019b). The state's leading crops are fruits, nuts, and vegetables (CDFA 2019b). California is the country's largest agricultural producer and exporter, serving as the nation's sole exporter for many specialty crops, such as almonds, pistachios, walnuts and raisin grapes (CDFA 2019b). The European Union, Canada, and China were the top three agricultural export markets for California in 2018 (CDFA 2019b). California is also rich in biodiversity and natural resources. The state is home to over 400 state and federally protected wildlife species, with agricultural land serving as important habitat corridors. Supporting that wildlife, and supplying drinking and irrigation water, for the state are California's mountain ranges, wetlands, surface water, and groundwater reserves. As increasingly diversified agricultural landscapes coexist with and even support biodiversity, the introduction of foodborne pathogens is an accompanied risk. In recent years California has been linked to the source of foodborne illness outbreaks associated with spinach, romaine lettuce, and other leafy greens, with the most significant being the 2006 *Escherichia coli* O157:H7 outbreak originating on California's Central Coast (199 reported cases)(Turner et al. 2019; CDC 2006). Most recently a *Salmonella* outbreak in onions originating in Central California reported 1,127 infectioned individuals (CDC 2020b). An agricultural industry that is key to the state's economy and that feeds people around the world, paired with intermittent foodborne pathogen outbreaks, has led to the creation of a strong regulatory environment that requires growers to mitigate food safety risk on farms; this, combined with significant investment in environmental and sustainable agricultural efforts, means California growers must balance policy and program requirements for food safety and environmental protection to produce a safe, healthy, and sustainable food supply.

Key on-farm food safety requirements for California growers

Food safety in the United States primarily focuses on mitigating sources of foodborne pathogens through on the ground management of waterborne, soilborne and animal-borne potential routes of pathogen exposure (Baur 2020); major foodborne pathogens of concern in the U.S. include *Escherichia coli* (*E. coli)*, *Salmonella, Norovirus* and *Listeria* (CDC 2020a). Requirements vary in form,

governance and prescriptiveness across all stages of the supply chain (shippers, processors, buyers). The degree and variation of these requirements influence the conflicts growers face on the ground.

Federal and state government

The Food Safety Modernization Act (FSMA) directs the U.S. Food and Drug Administration (FDA) to set risk-based, prevention-oriented safety standards. FSMA's "Produce Safety Rule" (PSR) outlines guidelines for major sources of potential contamination of covered produce (raw agricultural commodities, with exceptions) including: water; soil amendments; and domesticated and wild animals (U.S. FDA 2015a). California Department of Food and Agriculture (CDFA)'s Produce Safety Program is the state's designated authority for inspection and enforcement of FSMA's PSR.

Commodity-specific agreements and programs

Voluntary programs, such as those under the Leafy Green Products Handler Marketing Agreement (LGMA) and California Cantaloupe Advisory Board, set commodity-specific food safety guidelines for crop production and harvest that typically require more rigorous, and additional, requirements compared to FSMA. Government (e.g. CDFA) audits—separate from inspections for FSMA—ensure compliance with program guidelines.

Processor and buyer requirements

Food safety requirements from large processors, retailers, and buyers (collectively called 'buyers') are cited as the most specific and taking the most precaution (Minor et al. 2019; Latack and Ozeran 2020; Astill et al. 2019). Owing to concern over food safety liability, requirements are often proprietary; bringing buyers into the conversation is difficult, with many hesitant to publicly share requirements, even anonymously (Taylor-Silva 2019). Because these large buyers hold a majority of the market, a significant portion of farms are subject to their strict requirements (Havinga 2006). Table 1 compares examples of varying requirements for no-harvest buffers between crops and potential contamination sources. Buyer standards can be run through third-party non-governmental (e.g. Primus GFS) or governmental (e.g. USDA GAP and GHP) audit programs both of which are separate and additional to FSMA compliance inspections.

Table 1. No-harvest buffer metrics by food safety standard.

Adjacent Land Use	Standard			
	FSMA PSR	**LGMA**	**Food Retailer**	**Shipper**
Concentrated Animal Feeding Operation (1,000 – 80,000 head)	"Must take all measures reasonably necessary to identify, and not harvest, covered produce that is reasonably likely to be contaminated with a known or reasonably foreseeable hazard" (U.S. FDA 2015a)	1200 ft.	1 – 2 miles	1200 ft. to 1-2 miles
Riparian/Vegetative Area		30 ft.	50 – 150 ft.	30 – 150 ft.
Irrigation reservoir/ pond/ catch basin		--	50 ft.	30 ft. with fencing
Large animal dropping		Minimum 5 ft. diameter	50 ft. – prohibit entire field	5 – 10 ft.
Visible amphibian activity		--	Prohibit	Buffer or prohibit
Composting operation		400 ft.	--	400 ft.

Table adapted from Gularte & Pereira (2019)'s presentation to the Central Coast Regional Water Quality Control Board

Key sustainable agricultural initiatives for California growers

California Governor Newsom's *proposed* 2020-2021 budget[1] allocated $200 million to the Environmental Farming Incentive Program, which funds soil health, water efficiency, and nutrient management practices on agricultural lands, including California Department of Food and Agriculture (CDFA)'s Healthy Soils (HSP) and State Water Efficiency and Enhancement (SWEEP) Programs. HSP, SWEEP and U.S. Department of Agriculture (USDA)'s Environmental Quality Incentives Program (EQIP) and Conservation Stewardship Program (CSP) promote practices such as cover crops, hedgerows, compost, buffer strips, grassed waterways, and constructed wetlands. These efforts are further supported by California Resource Conservation Districts, University of California's Division of Agriculture and Natural Resources (UC ANR), and nonprofit

[1] January 2020 budget proposal prior to COVID-19 budget changes

organizations. Although these programs are voluntary, environmental regulations can *require* growers to implement sustainable practices; for example, the Central Coast Regional Water Quality Control Board (RWQCB)'s *draft* Waste Discharge Requirements (WDR) would require Central Coast growers to manage riparian areas, including establishing vegetated setbacks (Central Coast RWQCB 2020). State efforts to support lower chemical inputs include the $5 million allocated to development of safer alternatives to the pesticide chlorpyrifos amid cancelation of most of its agricultural use in 2020 (CDFA 2019a).

Methods

This paper draws on government and other public documents, webinars, meetings, existing peer-reviewed literature, and stakeholder communications on topics related to food safety and environmental protection to identify conflicts between food safety policies and specific policies and programs supporting sustainable agriculture. To identify specific policy and programs that conflict with food safety, we collected information on the policy and regulatory landscape of food safety and sustainable agriculture for California growers by searching for regulations, laws, and policies on the websites of relevant government agencies, including: FDA, USDA, CDFA, California Department of Pesticide Regulation (DPR), and State Water Resources Control Board (SWRCB). We then analyzed these policies side-by-side to identify incompatibilities; this included documenting policies that mention practices referenced in peer-reviewed literature and stakeholder communications. We identified conflicts in the grey literature by watching and listening to live and recorded webinars and meetings that occurred from September 2019 to April 2020 based on subject matter relevance; webinars and meetings were found based on email listservs, personal communication, and personal invitation.

Conflicts were identified in the existing literature through a literature search to identify peer-reviewed articles relevant to food safety, agricultural sustainability, and related conflicts in California. The search was conducted from December 2019 to April 2020. We used Google Scholar and University of California, Davis library search engines; searches included one or multiple keywords and terms, including: 'food safety,' 'sustainable agriculture,' 'California,' 'policy,' environmental protection,' 'conflict.' We eliminated publications that were greater than 20 years old due to the recent adoption of national food safety policies (FSMA adopted in 2011) and consequential rise of conflicts with recent sustainability efforts. We narrowed down the list of search results to those that were relevant based on an assessment of whether article abstracts and keywords addressed our research question of identifying conflicts between food

safety requirements and sustainable agricultural practices, policies, or programs. We then identified additional relevant articles from those referenced within the papers from our initial search.

Further information on conflicts was identified through direct communication with stakeholders. We conducted in-person, phone, and email communication with 43 relevant stakeholders, which occurred from January to March 2020. Stakeholders were chosen to represent a variety of crop types, grower operations (including small farms), and geographic regions, as well as knowledge and experience in food safety and sustainable agriculture. These personal, semi-structured communications always included a summary introduction to the project context and objectives, and the following questions: (1) What is your experience/exposure to food safety and sustainable agricultural on-farm practices? (2) What specific practices have you experienced come into conflict? (3) If applicable, what issues cause concern during food safety audits? (4) Are there specific policies or programs that you have witnessed conflicts with? Information, including anecdotes, garnered from personal communications were integrated into the results. From each source, we identified material that was applicable to (1) on-farm food safety practices, (2) on-farm sustainable agricultural practices, and/or (3) California growers. Information obtained from stakeholder communication was not analyzed as qualitative data, but rather as supplementary information; stakeholders gave permission for their communications to be used anonymously. Table 2 lists the specific materials analyzed.

Table 2. Materials Analyzed.

Government or other, public texts and documents related to these policies and programs: • Food Safety Modernization Act (FSMA) • Environmental Impact Statement (EIS) for "Standards for Growing, Harvesting, Packing, and Holding of Produce for Human Consumption" • Leafy Green Products Handler Marketing Agreement (LGMA) • Commodity Specific Food Safety Guidelines for the Production, Harvest, Cooling, Packing, Storage, and Transporting of Cantaloupes and Other Netted Melons • *All policies and programs listed in Table 3*
Webinars and other public meetings • 19 September 2019. Central Coast Regional Water Quality Control Board: "Board Meeting" • 19 November 2019. CCOF: "Small Farm Food Safety Questions De-mystified"

• 7 January 2020. CA State Board of Food and Agriculture: "Board Meeting" • 15 January 2020. Center for Produce Safety: "The Risk of Wildlife to Produce Safety: What do we know?" • 4 March 2020. University of California Division of Agriculture and Natural Resources: "Diversified Farming and Food Systems Program Team Meeting" • 16 April 2020. Central Valley Regional Water Quality Control Board: "Board Meeting"
Personal, semi-structured communications • 6 growers • 7 grower/industry representatives • 13 University of California Cooperative Extension (UCCE) employees • 11 government employees • 6 university scientists *Occurred January – March 2020*
Peer-reviewed published literature • *See references*

Findings: Conflicts

In this section we present the findings of our analysis; we note conflicts that exist between on-farm food safety requirements and sustainable agricultural practices funded, or otherwise supported by, key governmental policies and programs.

Growers—particularly those selling to large shippers and packers—are often constrained by food processing and retail firms who can reject crops if safety standards are not met (Beretti and Stuart 2008; Stuart 2009; Beretti 2009). This pressure can constrain a grower's ability to implement sustainable practices, as documented by examples in the sections that follow; each section is organized by topic to include (1) description of key environmental policies, (2) overview of key food safety objectives, and (3) conflicts between the two. Table 3 summarizes these conflicts.

Table 3. Governmental policies and programs that may conflict with food safety requirements.

Environmental policy or program (Federal*, State[s])	Food safety practice in conflict with environmental policy or program	Conflict description or consequence
Water quality and quantity		
Federal Water Pollution Control Act ("Clean Water Act")*	Lack of water quality practices (e.g. natural filtration of runoff by non-crop vegetation)	May impair waters of the United States
Porter-Cologne Water Quality Control Act[s]; and Antidegradation Policy[s]	Lack of water quality practices	May impair waters of the State
Sustainable Groundwater Management Act (SGMA)[s]	Preference for groundwater usage (vs. surface water); lack of non-crop vegetation; risk from flood/pooled water	Conflicts for groundwater use restrictions and barriers to recharge efforts
Irrigated Lands Regulatory Program[s]: Waste Discharge Requirements	Lack of non-crop vegetation; discing fields of crops when food safety risk is present	May impede ability to comply with riparian buffer and nitrogen removal requirements
The Water Conservation Act of 2009 (SB X7-7)[s]	Preference for groundwater usage; lack of non-crop vegetation; risk from flood/pooled water	Can conflict with SB X7-7 water use efficiency objectives
State Water Efficiency and Enhancement Program (SWEEP)[s]	Risk from flood/pooled water	SWEEP promoted practices include tailwater recovery, use of recycled water, and stormwater capture, which causes food safety concern over

Environmental policy or program (Federal*, States)	Food safety practice in conflict with environmental policy or program	Conflict description or consequence
		pooled water and water reuse
Wildlife protection		
California Endangered Species Acts Endangered Species Act* Migratory Bird Treaty Act*	Lack of non-crop vegetation; other wildlife deterrents (e.g. rodenticide use)	Can be directly (deterrents) or indirectly (habitat) harming threatened, endangered, and other protected species (as well as non-target species)
Regional Conservation Investment Strategy (RCIS) Programs	Lack of non-crop vegetation and other wildlife habitat	Can interfere with RCIS objectives for regional-scale conservation efforts
Habitat Conservation Plans (HCPs) *; and Natural Community Conservation Plans (NCCPs)s		Can interfere with HCP and NCCP objectives for landscape-scale conservation efforts
Ecosystem Restoration on Agricultural Lands (ERAL) Programs		Can interfere with ERAL wildlife conservation objectives
California Biodiversity Initiative: Biodiversity Executive Order (EO) B-54-18s		Can interfere with the EO's efforts to promote native vegetation and wildlife habitat
Air Quality and Climate		
CA Air Resources Board Resolution 17-46s: California's 2017 Climate Change Scoping Plan; and California 2030 Natural and Working	Lack of non-crop vegetation and other soil health practices (cover crops, compost use, silvopasture)	May conflict with climate goals to support carbon sequestration on working lands

Environmental policy or program (Federal*, States)	Food safety practice in conflict with environmental policy or program	Conflict description or consequence
Lands Climate Change Implementation Plan 2006 Global Warming Solutions Act (AB 32)s Senate Bill 1386: Resource conservation, natural and working lands (2016)s Healthy Soils Program (HSP)s Sustainable Agricultural Lands Conservation (SALC) Programs		May conflict with HSP-promoted practices May conflict with SALC funding aims to conserve agricultural lands and reduce GHG emissions, including maintaining natural habitat
Other		
National Organic Program (NOP)* California Organic Food and Farming Act	Risk associated with biological soil amendments and non-crop vegetation	Conflicts may interfere with common organic practices
Canella Environmental Farming Acts	[See SWEEP and HSP above]	Conflicts with CDFA's Environmental Farming programs (HSP, SWEEP)
Environmental Quality Incentives Program (EQIP)* Conservation Stewardship Program (CSP)*	Risk associated with use of cover crops, silvopasture, and filter strips	Conflicts with EQIP, CSP, and CRP promoted practices

Environmental policy or program (Federal*, States)	Food safety practice in conflict with environmental policy or program	Conflict description or consequence
Conservation Reserve Program (CRP)*		
Biologically Integrated Farming Systems Program (BIFS)s Proactive Integrated Pest Management Solutions Programs DPR's Pest Management Grant Programs UC Statewide Integrated Pest Management Programs	Lack of non-crop vegetation; demands for pesticide use (e.g. rodenticide, herbicide); use of synthetic products (e.g. fertilizer)	Conflicts with these programs, which promote lower chemical inputs and sustainable pest management practices that rely on natural predators supported by non-crop vegetation

Water (quality, source)

Maintaining water quality is important to human and environmental health. Vegetative buffers, grassed waterways, and constructed wetlands help maintain water quality through natural filtration of harmful microbes, fertilizers, and pesticides (Grismer et al. 2006). Growers are encouraged – sometimes mandated – to limit nitrogen runoff. Regional Water Quality Control Boards (RWQCB) are starting to require growers to monitor and report, as well as limit, the amount of nitrogen that is applied and removed from fields (Central Coast RWQCB 2020). Water conservation and efficiency practices, such as groundwater recharge, are increasingly prevalent amid frequent drought conditions statewide: The Sustainable Groundwater Management Act (SGMA) recently reached its first submission deadline for groundwater sustainability plans, and SWEEP has invested $81.2 million in 836 projects to date (CDFA 2020d).

Food safety requirements relating to water quality and source focus on minimizing the risk of contact with pathogen-contaminated water. PSR sets agricultural water quality standards, where treatment can include the use of antimicrobials and chlorine (U.S. FDA 2015b). Buyer food safety requirements

can mandate specific no-harvest buffers between harvestable crops and pooled water, as well as raise concern over the use of exposed water sources.

Food safety water quality requirements can conflict with environmental and water conservation goals by restricting or eliminating the use of on-farm practices that protect water quality and quantity. Chemically treated water that is open to the environment (e.g. in ditches, irrigation ponds) may expose wildlife to toxins. Growers can lose points on audits if they irrigate with surface water—which can be at risk of contamination from uncontrollable sources (e.g. wildlife)—rather than groundwater, despite depleted groundwater reservoirs in some regions (grower personal communication). PSR requires measures to reduce potential "hazards as a result of contact of covered produce with pooled water" (U.S. FDA 2015a). Industry standards are stricter: LGMA requires a no-harvest buffer of at least 30 feet from flood water, while buyer and shippers may require 30-50 feet from irrigation reservoirs, ponds, and catch basins (Table 1). These requirements may conflict with groundwater recharge and flood management efforts (Dahlke et al. 2018).

Several studies report that, owing to conflicts with food safety requirements, growers have discontinued some water quality best management practices (Crohn and Bianchi 2008; Lowell, Langholz, and Stuart 2010; Baur et al. 2016). Following the 2006 Central Coast *E. coli* spinach outbreak, 13.3% of riparian habitat—in place to help maintain water quality—in the Salinas River Valley was eliminated or degraded (Gennet et al. 2013). Despite these efforts to reduce food safety risk, *E. coli* in fresh produce increased after non-crop vegetation clearing at farm field borders (Karp, Gennet, et al. 2015) . Growers have reported creating no-harvest buffers and even discing under entire fields of crops when a perceived risk (e.g. animal feces) is present; discing, however, leaves excess nitrogen in the field, which conflicts with enforceable water quality regulations that require applied and removed nitrogen reporting (e.g. Waste Discharge Requirements). One almond grower reported that guidance provided to them by food safety auditors would have resulted in violation of the Clean Water Act (gov. employee personal communication).

Reusing water, saving water, or using water for habitat improvements can conflict with food safety. Pooled and flood water, waterbodies (ponds, reservoirs, wetlands), and irrigation reuse systems (tailwater recovery ponds), may attract animals; 10.8% of surveyed growers lost points on food safety audits due to the presence of ponds or waterbodies (Beretti and Stuart 2008). Tailwater recovery is an important water efficiency practice but can have higher microbial activity than groundwater; the occurrence of *Salmonella* and concentration of *E. coli* was found to be positively associated with the use of surface water compared to groundwater (Partyka et al. 2016). Biological material from utilizing dairy effluent for irrigation presents a food safety concern

for crops harvested from the ground (gov. employee personal communication). Land fallowed under SGMA and other water use restrictions – projected at up to 1 million acres in the San Joaquin Valley – may be managed with non-crop vegetation to support groundwater recharge (Sunding and Roland-Holst 2020). Non-crop vegetation is one of the most cited food safety concerns (discussed in section 4.2).

Soil (amendments, cover crops, crop rotation)

Practices that support soil health are heavily incentivized; $50.5 million of state funding was allocated to HSP from 2016-2020 (CDFA 2020b). HSP, EQIP, CSP, and many other programs promote practices including compost, crop rotation, and cover crops, which can enhance soil microbial abundance, activity, and diversity (Kim et al. 2020). The state continues to create incentives for these practices, including a recently proposed bill (AB 2106) to fund cover crops, as well as other non-crop vegetation, through game bird hunting revenue (Aguiar-Curry 2020).

Food safety requirements raise concern over the use of soil amendments containing animal materials that may introduce pathogenic *E. coli,* or other pathogens, into the crop. Non-crop vegetation, including cover crops, can create issues for food safety when they serve as attractants to wildlife that may harbor pathogens.

PSR sets application and microbial treatment standards for the use of biological soil amendments of animal origin; however, they tend to be broadly described, which can leave growers subject to varying interpretations for enforcement. LGMA does not allow soil amendments that contain raw manure, untreated animal products, or un-composted green waste; if they have been applied, there is a required one year wait period prior to producing leafy greens (LGMA 2021). The National Organic Program (NOP) requires a 90-120 day wait-time following manure application (Rittenhouse 2015). Buyers may require longer waiting periods. As a result of food safety requirements, growers in orchard systems are moving toward composted manure; however, current requirements can make on-farm composting difficult (grower/industry rep. personal communication). Shelling factories would not accept one grower's almonds if compost had been applied to the ground (gov. employee personal communication). Soil amendment requirements may result in greater reliance on synthetic fertilizers (Baur 2020).

Wildlife (e.g. deer) are sometimes attracted to non-crop vegetation (e.g. cover crops) in ground-harvested nut orchards (gov. employee personal communication), which conflicts with some buyer food safety requirements to

restrict wildlife. Furthermore, growers will use animals to graze cover crops prior to harvest, whose droppings can create food safety concern. Buyers can dictate which fields are safe for crop production; some growers may only be able to grow one crop type in certain fields, preventing crop rotation (grower/industry rep. personal communication).

Animals (domesticated and wildlife)

Diversified, mixed crop-livestock farming systems are a sustainable practice (HSP promotes silvopasture), where grazing can help enhance soil fertility and recycle nutrients (Patterson et al. 2018). Many programs promote on-farm wildlife habitat through practices that support non-crop vegetation such as hedgerows (Table 1). Hedgerows provide habitat for natural pest enemies, potentially reducing the need for insecticide, as well as support pollinators and other native wildlife (Morandin et al. 2011). Increasing habitat on farms is a key component of developing an agricultural landscape that can co-exist with wildlife (Karp, Baur, et al. 2015), a goal that is in line with California's desire to conserve vulnerable species.

The presence of animal activity, wild or domestic, can cause food safety concerns. Livestock are known to harbor pathogens in feces, where risk of crop contamination can come from both on-farm livestock (e.g. grazing) and runoff from nearby animal operations; thus, the integration of livestock into farm operations is often prohibited (Patterson et al. 2018; grower personal communication). Even wildlife habitat can cause food safety concern. The role of wildlife in vectoring pathogens is still relatively unclear (Langholz and Jay-Russell 2013), and some research supports the safety of ecologic diversity (D. Karp 2019; Sellers et al. 2018). Nonetheless, perceived risk can create pressure for growers to mitigate animal intrusion.

Small and medium farms have shown increased interest in diversifying operations by integrating livestock, such as poultry, sheep, and pigs, that can help support soil health but are discouraged by food safety inspectors (grower/industry rep. personal communication). Animals that support natural rodent control (e.g. cats) can cause concern over carrying pathogens (e.g. toxoplasmosis) into packing houses (UCCE employee personal communication).

While FSMA does not require farms "to exclude animals…destroy animal habitat…or otherwise clear farm borders," growers may employ these practices, especially under pressure from stricter requirements (U.S. FDA 2015a). PSR does require growers to check for potential contamination from animals and "take all measures reasonably necessary" to determine whether the crop can be harvested (U.S. FDA 2015a). LGMA and buyer no-harvest buffer requirements

range from five feet to an entire field (Table 1). To minimize the risk of animal intrusion, growers report discouraging and even directly eliminating wildlife and habitat. The removal of non-crop vegetation (e.g. filter strips, trees) and bare-ground buffers adjacent to riparian corridors are common practices (Stuart et al. 2006; Lowell et al. 2010; Baur et al. 2016; Olimpi et al. 2019); 88.9% of surveyed growers took at least one measure to "actively discourage or eliminate wildlife" from production areas (Beretti and Stuart 2008). However, fencing to exclude wildlife from production areas has been associated with greater bird fecal density (Karp 2019), while species that may vector pathogens (e.g. deer mice) have been found to prefer less-vegetated sites (Sellers et al. 2018). Auditors have required buffers due to the mere presence of trees (Gularte and Pereira 2019). A farm adjacent to wildlife refuges that also manages on-farm habitat reported that wildlife observed by auditors at harvest resulted in crop destruction (grower personal communication). Hedgerows, a highly incentivized field structure, can result in lost points on food safety audits (grower personal communication). Though not a *pathogenic* food safety concern, birds dropping nuts onto production fields pose allergy concerns; if a nut makes its way into a (e.g. leafy green) processing facility, operations can halt and lead to crop destruction (Gularte and Pereira 2019). Fencing, trapping, and poisoned bait traps to prevent wildlife intrusion are also common, which can impact wildlife movement and non-target species (Olimpi et al. 2019).

Pest control (pesticide usage, disease management)

California has demonstrated substantial interest in integrated pest management (IPM), alternatives to synthetic pesticides, and lower chemical inputs; CDFA's Biologically Integrated Farming Systems and Proactive IPM, and DPR's Pest Management grants aim to refine IPM programs designed to reduce chemical insecticide inputs (CDFA 2020a; 2020c; CDPR 2020). UC ANR Statewide IPM program efforts have helped reduce pesticide usage for over 40 years (Goodell et al. 2014).

Food safety concerns related to pest control are driven by potential for pests to directly introduce or spread pathogens, cause damage that makes crops prone to pathogens, or remain in a crop sold to consumers. Processors can impose strict standards on the percent of damaged crop that they will accept owing to threat of contamination. Non-crop vegetation can serve as habitat for rodents, and other wildlife, that may harbor pathogens; as a result, food safety requirements can involve the removal of this vegetation and maintenance of bare-ground buffers. Food safety requirements can include eliminating areas for pests to live and breed (i.e. non-crop vegetation removal) to reduce the risk of pathogen introduction.

Concern about aflatoxin—a carcinogenic toxin correlated with navel orangeworm damage in almonds—has caused some processors to require very low damage, which is hard to achieve using an IPM approach (Palumbo et al. 2014) and generally requires an increased use of insecticides. Black widow spiders—which naturally feed on crop pests and are venemous to humans—have been found in San Joaquin and Coachella Valleys' table grape vineyards; export and consumer concerns may increase insecticide usage (Bentley 2009). Removal of non-crop vegetation and maintenance of bare-ground buffers frequently involves herbicides. Perceived threats from rodent pests, namely pathogenic *E. coli*, have increased rodenticide use, often required by buyers (grower personal communication). LGMA calls for pest control methods including avian deterrents (LGMA 2021), and PSR requires pest removal around buildings and equipment (U.S. FDA 2015a). Utilizing natural predators instead of rodenticides, a key IPM strategy, can create conflicts. One grower withdrew their USDA funding application after concern from neighbors that owl boxes—to support non-chemical rodent control—would attract birds (gov. employee personal communication).

Natural insect pest management efforts, such as support for beneficial insects and using vegetation as wind barriers to decrease pesticide drift, are supported through incentivizing practices like hedgerows. Non-crop vegetation conflicts with food safety requirements; yet, research has shown pest control can be enhanced by non-crop habitat (Karp et al. 2016; Tooker, O'Neal, and Rodriguez-Saona 2020). Eliminating beneficial insect habitat to comply with food safety requirements can increase insecticide use.

Policy Implications

Our findings demonstrate that the difficulty a growers faces in both protecting food safety and implementing and maintaining sustainable agricultural practices may inhibit the success of governmental policies and programs meant to support those sustainable practices. Consequently, growers may have trouble achieving regulatory compliance in the face of policies with competing objectives. These results further reinforce the role of regulatory, legal, and market forces that drive decision making and practice adoption at the farm level (Baur 2020).

If growers face barriers to implementation of practices that enhance biodiversity and ecosystem services, then they will have to rely more on practices that can be a detriment to the natural environment. Impacts to biodiversity and ecosystem services from practices adopted to comply with food safety requirements are well-documented (Karp, Baur, et al. 2015; Olimpi et al. 2019).

Pollination and natural pest control can decrease in the absence of natural vegetation on field margins (Letourneau et al. 2015; Olimpi et al. 2019); semi-natural vegetation in lettuce fields supported greater natural predation of herbivores than farms with simplified landscapes (Karp et al. 2016). Fences along river corridors can impede wildlife movement (Lowell, Langholz, and Stuart 2010). Minimizing non-crop vegetation, maintaining bare ground, and synthetic pesticide use can impact water (nutrient loading, aquatic habitat, sedimentation), soil (erosion, fertility), air quality (Karp, Baur, et al. 2015), and carbon storage and sequestration (Smukler et al. 2010).

Food safety conflicts can be costly for growers. No-harvest buffers can lead to unharvestable crops (Crohn & Bianchi 2008; Calvin et al. 2017); 8% of surveyed growers experienced crop rejection due to practices utilized to improve water quality or wildlife habitat (Beretti and Stuart 2008). Growers forced to alter practices may experience yield loss or increased production costs (especially for small and medium growers), with cascading effects for farm consolidation and reduced socioeconomic diversity (Hardesty and Kusunose 2009; D. S. Karp, Baur, et al. 2015). Conflicts may result in growers facing ethical dilemmas; food safety pressure, particularly from large industry firms, can cause a grower who values environmental protection to compromise and act against that value (e.g. deterring wildlife) (Stuart 2009). These conflicts can also prevent information sharing between growers – a key strategy for sustainable practice adoption. In the face of regulatory uncertainty with regard to competing objectives and conflicting practice requirements, growers may be hesitant to discuss their farm management practices in fear of regulatory enforcement (grower/industry rep. personal communication); this prevents the spread of best practices through farmer-to-farmer knowledge networks.

Given the challenges discussed in this report, policy-makers and program managers can evaluate their policies and programs to (1) help growers balance both important food safety and sustainable practices and (2) increase the effectiveness and success of policies and programs that aim to promote/increase adoption of sustainable, environmentally friendly, and climate-smart practices. This may include considering the following: list of eligible practices for incentive funding; metrics for policy/program and practice adoption success; environmental mandatory/regulatory requirements should not compromise food safety. Environmental program and policy managers should participate in conversations between regulators, growers, distrubutors on how to best support on-farm co-management for food safety and environmental sustainability.

Next steps

In the face of market pressure toward increasingly stringent food safety requirements, the adoption of sustainable practices—led by investments in governmental policies and programs—may be minimal. This analysis highlights that a broader, more inclusive conversation is needed to address conflicts growers face in on-farm management practices. There is a need for more research around how to achieve food safety objectives while also using sustainable practices. Greater awareness of the conflicts and impacts, and communication between sustainable agricultural program managers and policymakers, along with industry firms crafting food safety requirements, is key in order to better achieve a system that supports safe and sustainable food production.

Acknowledgements

We acknowledge the support of our colleagues John Steggall, Steve Blecker, Brian Gress, Rachael Goodhue, Don Stoeckel, and Shelley Phillips who helped proofread this report.

References

Aguiar-Curry, Assembly Member. 2020. *Wildlife Habitat: Nesting Bird Habitat Incentive Program: Upland Game Bird Hunting Validation: State Duck Hunting Validation.* https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201920200AB2106.

Ampt, Eline A., Daniel S. Bush, Joel P. Siegel, and May R. Berenbaum. 2016. "Larval Preference and Performance of *Amyelois Transitella* (Navel Orangeworm, Lepidoptera: Pyralidae) in Relation to the Fungues Aspergillus Flavus." *Environmental Entomology* 45 (1): 155–62. https://doi.org/10.1093/ee/nvv160.

Astill, Gregory, Travis Minor, Suzanne Thornsbury, and Linda Calvin. 2019. "U.S. Produce Growers' Decisionmaking Under Evolving Food Safety Standards." USDA Economic Research Service.

Baur, Patrick. 2020. "When Farmers Are Pulled in Too Many Directions: Comparing Institutional Drivers of Food Safety and Environmental Sustainability in California Agriculture."

Baur, Patrick, Laura Driscoll, Sasha Gennet, and Daniel Karp. 2016. "Inconsistent Food Safety Pressures Complicate Environmental Conservation for California Produce Growers." *California Agriculture* 70 (3): 142–151. https://doi.org/10.3733/ca.2016a0006.

Bentley, Walter J. 2009. "The Integrated Control Concept and Its Relevance to Current Integrated Pest Management in California Fresh Market Grapes." *Pest Management Science* 65 (12): 1298–1304. https://doi.org/10.1002/ps.1840.

Beretti, Melanie. 2009. "Challenges to Co-Management of Food Safety and Environmental Protection: A Grower Survey." Resource Conservation District of Monterey County.
Beretti, Melanie, and Diana Stuart. 2008. "Food Safety and Environmental Quality Impose Conflicting Demands on Central Coast Growers." *California Agriculture* 62 (2): 68–73. https://doi.org/10.3733/ca.v062n02p68.
Calvin, Linda, Helen Jensen, Karen Klonsky, and Roberta Cook. 2017. "Food Safety Practices and Costs under the California Leafy Greens Marketing Agreement." No. 1476-2017-2065. USDA Economic Research Service.
CDC. 2006. "Multistate Outbreak of E. Coli O157:H7 Infections Linked to Fresh Spinach." Centers for Disease Control and Prevention. 2006. https://www.cdc.gov/ecoli/2006/spinach-10-2006.html.
———. 2020a. "Foodborne Germs and Illnesses." Centers for Disease Control and Prevention. 2020. https://www.cdc.gov/foodsafety/foodborne-germs.html.
———. 2020b. "Outbreak of Salmonella Newport Infections Linked to Onions." Centers for Disease Control and Prevention. 2020. https://www.cdc.gov/salmonella/newport-07-20/index.html.
———. 2021. "Estimates of Foodborne Illness in the United States." Centers for Disease Control and Prevention. 2021. https://www.cdc.gov/foodborneburden/2011-foodborne-estimates.html.
CDFA. 2018. "California Agricultural Statistics Review 2017-2018." California Department of Food and Agriculture. https://www.cdfa.ca.gov/statistics/PDFs/2017-18AgReport.pdf.
———. 2019a. "ALTERNATIVES TO CHLORPYRIFOS WORK GROUP ANNOUNCED." 2019. https://www.cdfa.ca.gov/egov/Press_Releases/Press_Release.asp?PRnum=19-061.
———. 2019b. "California Agricultural Statistics Review 2018-2019." https://www.cdfa.ca.gov/statistics/PDFs/2018-2019AgReportnass.pdf.
———. 2020a. "Biologically Integrated Farming Systems Program." 2020. https://www.cdfa.ca.gov/oefi/opca/bifs.html.
———. 2020b. "Healthy Soils Program." 2020. https://www.cdfa.ca.gov/oefi/healthysoils/.
———. 2020c. "Proactive IPM Solutions Program." 2020. https://www.cdfa.ca.gov/oefi/opca/proactive-ipm.html.
———. 2020d. "State Water Efficiency & Enhancement Program." CDFA. 2020. https://www.cdfa.ca.gov/oefi/sweep/.
CDPR. 2020. "Pest Management Grants." 2020. https://www.cdpr.ca.gov/dprgrants.htm.
Central Coast RWQCB. 2020. "Draft General Waste Discharge Requirements for Discharges from Irrigated Lands." CA Regional Water Quality Control Board Central Coast Region. https://www.waterboards.ca.gov/centralcoast/water_issues/programs/ag_waivers/docs/ag_order4_renewal/2020feb/dao.pdf.
Crohn, David M., and Mary L. Bianchi. 2008. "Research Priorities for Coordinating Management of Food Safety and Water Quality." *Journal of Environmental Quality* 37 (4): 1411–1418. https://doi.org/10.2134/jeq2007.0627.
Dahlke, Helen E., Gabriel T. LaHue, Marina R. L. Mautner, Nicholas P. Murphy, Noelle K. Patterson, Hannah Waterhouse, Feifan Yang, and Laura Foglia. 2018. "Chapter

Eight - Managed Aquifer Recharge as a Tool to Enhance Sustainable Groundwater Management in California: Examples From Field and Modeling Studies." In *Advances in Chemical Pollution, Environmental Management and Protection*, edited by Jan Friesen and Leonor Rodríguez-Sinobas, 3:215–75. Advanced Tools for Integrated Water Resources Management. Elsevier. https://doi.org/10.1016/bs.apmp.2018.07.003.

Diaz, Francisco J., Anthony T. O'geen, and Randy A. Dahlgren. 2012. "Agricultural Pollutant Removal by Constructed Wetlands: Implications for Water Managment and Design." *Agricultural Water Management* 104 (February): 171–83. https://doi.org/10.1016/j.agwat.2011.12.012.

Food Safety Leadership Council. 2007. "Food Safety Leadership Council On-Farm Produce Standards." Version 1.0. http://www.perishablepundit.com/docs/FSLC-On-FarmStandards-11-2007.pdf.

Gennet, Sasha, Jeanette Howard, Jeff Langholz, Kathryn Andrews, Mark D. Reynolds, and Scott A. Morrison. 2013. "Farm Practices for Food Safety: An Emerging Threat to Floodplain and Riparian Ecosystems." *Frontiers in Ecology and the Environment* 11 (5): 236–242. https://doi.org/10.1890/120243.

Goodell, Peter B., Frank G. Zalom, Joyce F. Strand, Cheryl A. Wilen, and Karey Windbiel-Rojas. 2014. "Over 35 Years, Integrated Pest Management Has Reduced Pest Risks and Pesticide Use." *California Agriculture* 68 (4): 153–57. https://doi.org/10.3733/ca.v068n04p153.

Grismer, Mark E., Anthony Toby O'Geen, and David Lewis. 2006. "Vegetative Filter Strips for Nonpoint Source Pollution Control in Agriculture." Publication 8195. UC ANR.

Gularte, Jynel, and Colby Pereira. 2019. "Food Safety, A Farmer's Perspective: Understanding How Proposed Riparian Mandates Will Change Food Safety Management on the Central Coast." Presented at the Central Coast Regional Water Quality Control Board Meeting, Watsonville, CA, September 19.

Hardesty, Shermain D., and Yoko Kusunose. 2009. "Growers' Compliance Costs for the Leafy Greens Marketing Agreement and Other Food Safety Programs."

Havinga, Tetty. 2006. "Private Regulation of Food Safety by Supermarkets." *Law & Policy* 28 (4): 515–33. https://doi.org/10.1111/j.1467-9930.2006.00237.x.

Karp, Daniel. 2019. "Presentation to the Central Coast Regional Water Quality Control Board Meeting." Presented at the Central Coast Regional Water Quality Control Board Meeting, Watsonville, CA, September 19.

Karp, Daniel S., Patrick Baur, Edward R. Atwill, Kathryn De Master, Sasha Gennet, Alastair Iles, Joanna L. Nelson, Amber R. Sciligo, and Claire Kremen. 2015. "The Unintended Ecological and Social Impacts of Food Safety Regulations in California's Central Coast Region." *BioScience* 65 (12): 1173–1183. https://doi.org/doi.org/10.1093/biosci/biv152.

Karp, Daniel S., Sasha Gennet, Christopher Kilonzo, Melissa Partyka, Nicolas Chaumont, Edward R. Atwill, and Claire Kremen. 2015. "Comanaging Fresh Produce for Nature Conservation and Food Safety." *Proceedings of the National Academy of Sciences* 112 (35): 11126–11131. https://doi.org/10.1073/pnas.1508435112.

Karp, Daniel S., Rebekah Moses, Sasha Gennet, Matthew S. Jones, Shimat Joseph, Leithen K. M'Gonigle, Lauren C. Ponisio, William E. Snyder, and Claire Kremen. 2016. "Agricultural Practices for Food Safety Threaten Pest Control Services for Fresh Produce." *Journal of Applied Ecology* 53 (5): 1402–1412. https://doi.org/10.1111/1365-2664.12707.

Kim, Nakian, María C. Zabaloy, Kaiyu Guan, and María B. Villamil. 2020. "Do Cover Crops Benefit Soil Microbiome? A Meta-Analysis of Current Research." *Soil Biology and Biochemistry* 142 (March): 107701. https://doi.org/10.1016/j.soilbio.2019.107701.

Langholz, Jeff, and Michele Jay-Russell. 2013. "Potential Role of Wildlife in Pathogenic Contamination of Fresh Produce." *Human–Wildlife Interactions* 7 (1). https://doi.org/10.26077/e5gg-r037.

Latack, B., and R. Ozeran. 2020. "Hasty Responses to Foodborne Illness Outbreaks Impact California Growers." *California Agriculture* 74 (1): 4–10.

Letourneau, Deborah K., Sara G. Bothwell Allen, Robert R. Kula, Michael J. Sharkey, and John O. Stireman III. 2015. "Habitat Eradication and Cropland Intensification May Reduce Parasitoid Diversity and Natural Pest Control Services in Annual Crop Fields." *Elementa: Science of the Anthropocene*. https://doi.org/10.12952/journal.elementa.000069.

LGMA, California. 2021. "Commodity Specific Food Safety Guidelines for the Production and Harvest of Lettuce and Leafy Greens." https://lgmatech.com/wp-content/uploads/2020/08/August-2021-CA-LGMA-Metrics_FINAL-v20210818.pdf.

Lowell, Karen, Jeffrey Langholz, and Diana Stuart. 2010. "Safe and Sustainable: Co-Managing for Food Safety and Ecological Health in California's Central Coast Region."

Minor, Travis, Gerard Hawkes, Edward W. McLaughlin, Kristen S. Park, and Linda Calvin. 2019. "Food Safety Requirements for Produce Growers: Retailer Demands and the Food Safety Modernization Act." Economic Information Bulletin Number 206. USDA Economic Research Service. https://www.ers.usda.gov/webdocs/publications/92761/eib-206.pdf?v=2376.5.

Morandin, L., R. Long, C. Pease, and C. Kremen. 2011. "Hedgerows Enhance Beneficial Insects on Farms in California's Central Valley." *California Agriculture* 65 (4): 197–201.

Olimpi, Elissa M., Patrick Baur, Alexandra Echeverri, David Gonthier, Daniel Sol Karp, Claire Kremen, Amber Sciligo, and Kathryn T. De Master. 2019. "Evolving Food Safety Pressures in California's Central Coast Region." *Frontiers in Sustainable Food Systems* 3: 102. https://doi.org/10.3389/fsufs.2019.00102.

Palumbo, Jeffrey D., Noreen E. Mahoney, Douglas M. Light, Joel Siegel, Ryan D. Puckett, and Themis J. Michailides. 2014. "Spread of <i>Aspergillus Flavus<i/> by Navel Orangeworm (Amyelois Transitella) on Almond." *Plant Disease* 98 (No. 9). https://doi.org/10.1094/PDIS-09-13-1015-RE.

Partyka, Melissa L., Ronald F. Bond, Jennifer A. Chase, Luana Kiger, and Edward R. Atwill. 2016. "Multistate Evaluation of Microbial Water and Sediment Quality from Agricultural Recovery Basins." *Journal of Environmental Quality* 45 (2): 657–65. https://doi.org/10.2134/jeq2015.06.0323.

Patterson, Laura, Nora Navarro-Gonzalez, Michele T. Jay-Russell, Peiman Aminabadi, Elizabeth Antaki-Zukoski, and Alda FA Pires. 2018. "Persistence of Escherichia Coli in the Soil of an Organic Mixed Crop-Livestock Farm That Integrates Sheep Grazing within Vegetable Fields." *Zoonoses and Public Health* 65 (7): 887–896. https://doi.org/10.1111/zph.12503.

Rittenhouse, Thea. 2015. "Manure in Organic Production Systems." NCAT. https://www.ams.usda.gov/sites/default/files/media/Manure%20in%20Organic%20Production%20Systems_FINAL.pdf.

Sellers, Laurel A., Rachael F. Long, Michele T. Jay-Russell, Xunde Li, Edward R. Atwill, Richard M. Engeman, and Roger A. Baldwin. 2018. "Impact of Field-Edge Habitat on Mammalian Wildlife Abundance, Distribution, and Vectored Foodborne Pathogens in Adjacent Crops." *Crop Protection* 108 (June): 1–11. https://doi.org/10.1016/j.cropro.2018.02.005.

Smukler, S. M., S. Sánchez-Moreno, S. J. Fonte, H. Ferris, K. Klonsky, A. T. O'Geen, K. M. Scow, K. L. Steenwerth, and L. E. Jackson. 2010. "Biodiversity and Multiple Ecosystem Functions in an Organic Farmscape." *Agriculture, Ecosystems & Environment* 139 (1): 80–97. https://doi.org/10.1016/j.agee.2010.07.004.

Stuart, Diana. 2009. "Constrained Choice and Ethical Dilemmas in Land Management: Environmental Quality and Food Safety in California Agriculture." *Journal of Agricultural and Environmental Ethics* 22 (1): 53. https://doi.org/10.1007/s10806-008-9129-2.

Stuart, Diana, Carol Shennan, and Martha Brown. 2006. "Food Safety versus Environmental Protection on the Central California Coast: Exploring the Science behind an Apparent Conflict."

Sunding, David, and David Roland-Holst. 2020. "Blueprint Economic Impact Analysis: Phase One Results." UC Berkeley. https://waterblueprintca.com/wp-content/uploads/2020/03/Blueprint.EIA_.PhaseOne.2.28.pdf.

Taylor-Silva, Abby. 2019. "Public Comment at the Central Coast Regional Water Quality Control Board Meeting." Presented at the Central Coast Regional Water Quality Control Board Meeting, Watsonville, CA, September 19.

Tooker, John F., Matthew E. O'Neal, and Cesar Rodriguez-Saona. 2020. "Balancing Disturbance and Conservation in Agroecosystems to Improve Biological Control." *Annual Review of Entomology* 65: 81–100. https://doi.org/10.1146/annurev-ento-011019-025143.

Turner, Kali, Chee Nou Moua, Maha Hajmeer, Amber Barnes, and Michael Needham. 2019. "Overview of Leafy Greens–Related Food Safety Incidents with a California Link: 1996 to 2016." *Journal of Food Protection* 82 (3): 405–14. https://doi.org/10.4315/0362-028X.JFP-18-316.

U.S. FDA. 2015a. *Standards for the Growing, Harvesting, Packing, and Holding of Produce for Human Consumption*. *CFR*. Vol. 21. https://www.fda.gov/food/food-safety-modernization-act-fsma/fsma-final-rule-produce-safety.

———. 2015b. "Final Environmental Impact Statement (EIS) for the Proposed Rule: Standards for Growing, Harvesting, Packing, and Holding of Produce for Human Consumption." FDA. https://www.fda.gov/food/food-safety-modernization-act-fsma/environmental-impact-statement-eis-fsma-final-rule-produce-safety.

———. 2019. "New Era of Smarter Food Safety." *U.S. Food & Drug Administration* (blog). November 2019. https://www.fda.gov/food/food-industry/new-era-smarter-food-safety?utm_campaign=National%20Broadcast%20Message%20-%20FDA%20Statement%20on%20Romaine%20Lettuce%20Outbreak&utm_medium=email&utm_source=Eloqua.

———. 2020. "2020 Leafy Greens STEC Action Plan."

Ward, April. 2020. "All Hands on Deck: Efforts Underway to Prevent Future Outbreaks." *California LGMA News* (blog). January 23, 2020. https://lgma.ca.gov/news/romaine-lettuce-safer.

Wild Farm Alliance, Wild Farm. 2016. "Co-Managing Farm Stewardship with Food Safety GAPs and Conservation Practices: A Grower's and Conservationist's Handbook."

https://d3n8a8pro7vhmx.cloudfront.net/wildfarmalliance/pages/131/attachments/original/1455409115/WFA_Co-Managing_Farm_Stewardship.pdf?1455409115.