Impacts of the Food Safety Modernization Act on On-Farm Food Safety Practices for Small and Sustainable Produce Growers

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Abstract. We use data from a national survey of fruit and vegetable growers to examine the current prevalence and cost burden of food safety practices required in the proposed Produce Rule implementing the Food Safety Modernization Act. In particular, we analyze the influence of farm size and farming practices on the probability of adopting food safety measures that would be required by the Produce Rule; and we analyze how the costs of using those food safety practices vary by farm size and farm practices. Majorities of our respondents currently employ most of the food safety practices that would be required under the proposed Produce Rule, but a large number of growers will nonetheless face significant changes to meet the Rule's requirements. We do not find any effect of farm size on the probability of using food safety measures, but we find that food safety costs significant economies of scale. Sustainable farming practices are negatively correlated with the probability of testing and conducting field inspections, and they are associated with increased costs for testing and sampling, harvest container sanitation, and written records relative to conventional growers. While our estimates indicate that small and sustainable growers would face more significant changes and more burdensome costs to comply with the proposed Produce Rule, in our sample most of them would ultimately be exempt from the rule either based on farm size or the Tester-Hagan exemption.

Keywords. food safety, Food Safety Modernization Act, Produce Rule, compliance cost, regulatory burden.

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The enactment of the Food Safety Modernization Act [FSMA] gave the Food and Drug Administration [FDA] authority to regulate the growing, harvesting, packing, and holding of fresh fruits and vegetables and represents a major shift in the agency's approach from outbreak response to prevention-based controls across the food supply. Ninety-five percent of foodborne illnesses in the U.S. are caused by 14 major pathogens, which account for $14 billion in health costs annually (Hoffmann et al. 2012). As one of the implementing rules for FSMA, the FDA has proposed a rule (known popularly as the Produce Rule) intended to reduce health risks associated with foodborne illness from consumption of fresh produce. That rule, which is scheduled to be finalized in 2015, will require operational changes in many farms that could be costly. Specifically, the rule would set standards associated with agricultural water; biological soil amendments; domesticated and wild animals; employee training and health and hygiene; and equipment, tools, buildings, and sanitation. Small farms in particular worry that the costs of complying with the new rule may be disproportionately burdensome and could drive them out of business (Hassanein 2012, Paggi et al. 2013, Knutson et al. 2014). Farms employing sustainable agricultural practices are especially concerned that the Rule may make it impossible for them to use the biological soil amendments and livestock grazing practices in integrated agricultural systems they currently rely on. Both concerns suggest that the Rule may adversely affect important segments of the produce industry (Ribera and Knutson 2011).

There is very little publicly available information on the current prevalence and likely cost of the actions required under the proposed Rule. We use data from a national survey of fruit and vegetable growers to help fill that information gap. We address two major questions: (1) are small and/or sustainable growers more or less likely to use food safety practices that would be

required by the Produce Rule?; and (2) is the cost of compliance with the standards in the proposed Produce Rule disproportionately burdensome to small and/or sustainable farm operations? To investigate these questions, we identify systematic differences in the adoption of food safety measures and the cost burden based on these factors. In particular, we analyze the influence of farm size and use of sustainable farming practices on the probability of adopting food safety measures that would be required by the Produce Rule; and we analyze how the costs of those food safety practices vary by farm size and use of sustainable farming practices. For a more complete picture of the potential impact of the Rule on small and sustainable growers, we use our sample to estimate the fraction of small and sustainable growers that would be exempt from the Produce Rule either based on farm size or a direct marketing qualified exemption.

Background

Relevant Literature

In the last decade, a number of studies have investigated the prevalence of on-farm produce safety measures, each addressing a limited set of practices. Rangarajan et al. (2002) use data from a survey of 213 New York fruit and vegetable growers to study the prevalence of food safety practices related to testing and sanitation of agricultural water, manure management, composting processes, and recordkeeping. They find that small farms in particular required additional training related to recordkeeping, composting processes, and sanitation of wash water. Cohen et al. (2005) use data from a survey of 297 New England fruit and vegetable growers to analyze the prevalence of food safety practices related to water quality, soil amendments, employee health and hygiene, field sanitation, and recordkeeping, and find that the majority of farmers employed good agricultural practices across all practices. Hultberg, Schermann, and Tong (2012) use data from a survey of 246 Minnesota vegetable growers, 77% of whom farm 15

acres or less, and find that the majority of respondents believe they comply with many food safety best practices (e.g., worker hygiene practices, washing of harvest containers, tool sanitation, and water treatment, etc.), but are lagging in a number of key food safety areas.

Several recent studies analyze compliance costs for new on-farm produce safety standards. Hardesty and Kusunose (2009) use data from a survey of 49 California growers to estimate the compliance costs for food safety standards imposed by the California Leafy Greens Marketing Agreement [LGMA], which are similar to those required under the proposed Produce Rule. They find that growers' seasonal food safety costs more than doubled after implementation of the LGMA, and the largest growers benefit from significant economies of scale. Ribera et al. (2012) conduct three case studies of food safety outbreaks in muskmelon, spinach, and tomatoes and use a survey of producers participating in the California LGMA to estimate the compliance costs for new food safety standards. They find that the costs incurred by producers due to food safety outbreaks are much greater than LGMA compliance costs, and the most significant compliance cost increases are attributable to third party audits, staffing, and water testing. Paggi et al. (2013) use results from several studies to develop an example of the impact and compliance costs of LGMA-type standards for Florida cabbage producers and find that for a representative grower, the probability of operating at a net loss (in present value terms) over a 2-year period increased by 17%. Becot et al. (2012) use data from 17 survey responses and 10 in-depth interviews with small and medium size Vermont vegetable and apple growers to estimate the costs of adopting Good Agricultural Practice [GAP] requirements and find that GAP certification costs range from $37 to $54 per acre. Similarly, a University of Minnesota study uses data collected from in-person and telephone interviews with small and mid-sized vegetable farmers to estimate total costs incurred for Minnesota vegetable growers to adopt GAPs practices on their

farms (Driven to Discover 2012). The study also finds that compliance costs exhibit significant economies of scale—small farms in Minnesota would face food safety costs equal to 10% of gross revenue, while average-sized farm operations would incur costs around 2% of gross revenue.

A related literature on the effects of HACCP regulation in meat and poultry processing finds similar results (see Ribera and Knutson (2011) for a brief summary).

The Food Safety Modernization Act and the Proposed Produce Rule

FSMA was signed into law in January of 2011. While a growing number of supermarket chains, commodity group organizations and others had been instituting private food standards for food quality and safety over the preceding decade, a series of bacterial outbreaks during the mid-2000s indicated that such voluntary efforts would be insufficient to provide adequate levels of safety (Henson and Reardon 2005, Paggi et al. 2013). The FDA published the original proposed Produce Rule, officially known as *Standards for the Growing, Harvesting, Packing, and Holding of Produce for Human Consumption*, in January of 2013. The original proposed rule establishes standards across various aspects of agricultural production, most notably with regards to: (1) agricultural water; (2) biological soil amendments of animal origin; (3) health and hygiene; (4) intrusion of domesticated and wild animals; and (5) sanitation of equipment, tools, and buildings.

For agricultural water that contacts produce or food-contact surfaces, the Rule would establish quality standards, periodic inspection and testing provisions, and treatment requirements for water not meeting sanitary standards. For soil amendments of animal origin, the rule would establish treatment standards, application requirements for treated and untreated soil amendments, and required time intervals between application of soil amendments and crop harvest. For health and hygiene, the rule would establish hygienic practices and training

requirements for all farm personnel who handle produce covered by the Rule. For intrusion of domesticated and wild animals, the Rule would establish waiting periods between grazing and crop harvest for domesticated animals and monitoring requirements for wild animal intrusion. Lastly, the Rule would establish sanitary standards for equipment and tools that come in contact with produce, as well as requirements for pest control, hand washing and toilet facilities, and sewage and trash disposal. In addition to these measures, the proposed Rule would also require recordkeeping and documentation to show compliance with each the standard.

The proposed Produce Rule applies to farms that grow and sell produce usually consumed raw and not intended for commercial processing (e.g., canning, etc.). Farms with annual sales less than $25,000 (three-year average) are exempt from the Produce Rule. Additionally, farms that have annual total food sales of less than $500,000 based on a three year average, and sell a majority of food directly to a qualified end-user—a consumer, restaurant, or retail food establishment (e.g., a supermarket, etc.) located in-state or within 275 miles of the farm—are not subject to the food safety standards in the proposed Produce Rule[1]; they need only provide the name and full address of the farm where the produce is grown on a package label or a sign at the point of sale and meet the compliance and enforcement requirements of the rule.

Based on feedback from an initial public comment period, FDA published a Proposed Supplemental Rule for Produce Safety in September of 2014. The proposed changes make the Rule more flexible and less burdensome in key areas. Among the key revisions, the new rule makes the water quality standard and testing more flexible by allowing for additional means to meet the standard (such as microbial die-off) and by proposing a tiered approach to testing. The FDA also deferred establishment of a required minimum-time interval between the application of

[1] This provision is an amendment to FSMA introduced by Senators Jon Tester and Kay Hagan and is commonly referred to as the Tester-Hagan Exemption or, more formally, direct marketing modified requirements.

untreated soil amendments of animal origin and crop harvest until further research is conducted, and it eliminated the previously proposed 45-day minimum application interval for compost. The revised rule also defines covered farms based on *produce* sales rather than total *food* sales, establishes procedures for withdrawal of qualified exemptions for food safety reasons, and includes provisions on wild animal intrusion to protect endangered species[2]. Additionally, the compliance dates in the supplemental rule allow more time for smaller farms to adopt the proposed safety provisions. Farms with annual produce sales between $25,000 $250,000—classified as "very small" farms in the rule—would have four years after the rule's effective date to comply with most provisions. Farms with annual produce sales between $250,000 and $500,000—classified as "small" farms in the rule—would have three years. Farms with annual produce sales over $500,000[3] would have two years. Furthermore, the compliance dates for water quality standards (including testing and recordkeeping) would be an additional two years after the compliance dates for the rest of the rule.

Following publication of the Proposed Supplemental Rule for Produce Safety, FDA accepted comments during another 75-day period that closed in December of 2014. FDA intends to finalize the Produce Rule for an effective date in 2015.

Data

Survey Design

We use data from a national survey of fruit and vegetable growers to analyze the current prevalence and likely cost of produce safety measures required under the proposed Product Rule. The survey includes background questions on farm economics, demographics and use of

[2] There were concerns raised that growers would interpret the originally proposed provisions on wild animals in ways that would harm wildlife and destroy animal habitats, so this clarification addresses those concerns.
[3] The proposed Produce Rule does not designate a name for farms that fall into this category, so we refer to them as "medium/large" farms throughout the text and tables.

marketing channels in addition to questions regarding use and treatment of soil amendments, microbial testing, field monitoring, remedial food safety actions, preventive food safety actions, and recordkeeping. Soil amendment questions covered whether animal-based soil amendments were used; whether they were treated, and if so, at what cost; and the time interval between application of soil amendments and crop harvest. Microbial testing questions covered whether the farm collected water, soil amendment, and/or crop samples for testing, and if so, at what cost (including employee wages, materials, etc.). Field monitoring questions covered whether the fields were monitored for animal intrusion, flooding, and/or other contamination; how often these events were observed; and the costs associated with monitoring the fields. Remedial action food safety questions covered whether any remedial actions (e.g., sanitation, product disposal, water treatment, etc.) were taken following test results, flooding, and/or animal intrusion, and if so, at what cost. Preventive food safety questions covered whether harvest containers were sanitized prior to harvest or if new containers were used, whether crops were washed prior to sale, whether the farm used third party food safety audits, and whether precautions were taken with regards to employee sanitation and hygiene (e.g., training, tool sanitation, toilet and hand washing facilities, etc.). Lastly, recordkeeping questions covered whether the farm kept written records for food safety practices, and if so, how many hours each week were spent doing so. A full copy of the survey is included in Appendix A.

Survey Administration

The survey was designed and administered electronically using Qualtrics survey software. It included skip logic so respondents only answered questions relevant to their farm operation. Data was collected in person at eight major fruit and vegetable grower conferences across the U.S. and through online grower Listservs of several state fruit and vegetable growers'

associations, university extension services, and other grower organizations via a password-protected Internet survey. To specifically address concerns related to the Rule's impact on sustainable growers, we also surveyed members of Listservs for several sustainable grower organizations and attendees at a major sustainable grower conference. Tables 1 and 2 include detailed lists of grower conferences and online Listservs, respectively, from which responses were collected.

At the conferences, a booth was set up alongside other exhibitors in the trade show or a similar high traffic area, and attendees passing by the booth were asked to participate in the survey, after which they could enter a drawing for a chance to win an Apple iPad. After consenting to participate, respondents completed the fifteen-minute survey on tablet computers, providing information about the 2014 growing season. Upon completing the survey, the software automatically redirected each respondent to a separate form in which she could choose to enter the iPad drawing.

The survey sent to grower Listservs was identical to the version administered at the grower conferences, except that respondents completed the survey independently on their own web-enabled device, typically either a personal computer or tablet. Members of each Listserv were sent an email soliciting their participation in the survey. Each email included a description of the survey and research goal, our contact information, and a web link and password to take the survey. We used the password to identify the Listserv through which the respondent was contacted. As an incentive to participate, online respondents were given the same offer to enter a drawing for an iPad after completing the survey. All the survey collectors for the grower Listservs remained open until May 2, 2015.

Summary Statistics

In total, 394 growers completed the survey: 311 grow vegetables, 193 grow berries, and 194 grow fruit and tree nuts (many growers raise produce from more than one category). Table 3 presents the breakdown of respondents according to the FDA Produce Rule farm size classes. Table 4 presents the regional distribution of respondents according to ERS Farm Resource Regions.[4] Both tables also include corresponding distributions of vegetable, berry, and fruit and tree nut growers from the 2012 USDA Agricultural Census.

In terms of farm size, our sample is weighted towards larger farms, particularly in the case of berry and fruit and tree nut growers, with fewer exempt operations and more very small, small, and medium/large farms. In terms of regional distribution, our sample consists of relatively more farms in the Northern Crescent and Southeast and fewer farms in the Fruitful Rim and Great Plains than the U.S. as a whole. The Fruitful Rim consists of states that represent a significant portion of large fruit and vegetable agribusiness growers in the U.S. (e.g., Florida, Texas, California, Arizona, etc.) who account for a majority of the produce consumed nationwide. The geographic distribution of respondents suggests that, while our sample is less representative of total U.S. fruit and vegetable *production* but more representative of the population of U.S. produce *growers,* which is ultimately of greater relevance to the issues we wish to address.

Overall, one-third of our sample comes from members of sustainable grower organizations[5], with the balance comprised of members of conventional grower organizations. This distribution is fairly consistent across crop type, but in terms of farm size, sustainable

[4] The ERS Farm Resource Regions are defined at that county-level, and, as such, a single state may occupy several regions. In our summary statistics, we simplified this mapping by assigning each state to one region only. We also consolidated several regions for ease of exposition. The modified mappings are included in Appendix B.

[F] To be conciseness, we refer to members of sustainable grower organizations as "sustainable growers" and members of conventional grower organizations as "conventional growers" throughout the text.

growers in our sample tend to operate smaller farms than conventional growers, with almost all of sustainable growers falling into the exempt or very small farm classification compared to just over half of conventional growers (Table 5). On average, growers in our sample sell more than half their produce directly to consumers, with direct sales comprising about three-fourths of sales for exempt and very small growers (Table 6). Medium/large growers, who are more representative of large fruit and vegetable agribusiness, are the only class that does not sell a majority of produce directly to consumers, with nearly half their sales going to wholesalers. Across crop types, fruit and tree nut growers tend to sell a larger share to wholesalers than vegetable and berry growers. Unsurprisingly, sustainable growers, who are largely comprised of exempt and very small operations, also sell over three-fourths of their produce directly to consumers.

Based on current sales and practices, over three-fourths of our sample would be exempt from the Produce Rule, which is almost evenly split based on the farm size and the Tester-Hagan exemptions (Table 7). Almost all very small growers and three-fourths of small growers in our sample qualify for the Tester-Hagan exemption. In terms of farming practices, nearly all sustainable growers in our sample qualify for an exemption, with over half exempt based on size, and about two-thirds of conventional growers are exempt. By crop type, both types of exemption are less common among fruit and tree nut growers compared to vegetable and berry growers.

Prevalence of Food Safety Practices

This section uses cross tabulation to examine the raw prevalence of sampling and testing, field inspections, harvest container sanitation, product washing, employee sanitation and hygiene, recordkeeping, soil amendment usage, and third-party auditing by farm size, farming practices,

and crop type. The next section uses a multivariate econometric approach to isolate systematic differences in the prevalence of these food safety measures among growers.

Sampling and Testing

In the survey, we asked whether growers collected water samples, animal-based soil amendment samples[6], and/or crop samples for microbial testing (e.g., pathogens, generic E. coli, coliforms, etc.). Half of growers already collect agricultural water samples for testing, which will be required under the currently proposed Produce Rule (Table 8). Less than half of exempt and very small farms test water samples, whereas most small and medium/large farms do so. Additionally, while over half of conventional growers collect water samples, only about a third of sustainable growers do so, suggesting that this measure may require a greater change among sustainable growers. While testing soil amendment samples and product samples is not required in the currently proposed Produce Rule, we find that some growers still choose to collect these samples. Product testing is more prevalent among medium/large and conventional growers in our sample.

Field Inspections

Respondents were asked whether they conducted field inspections for flooding, animal intrusion, or other contamination prior to harvest during the 2014 growing season. About half of surveyed growers overall and the majority of exempt and very small growers did not conduct any inspections (Table 9); however, almost half of growers monitored for animal intrusions and just under a third inspected for flooding. Small and medium/large growers were more likely to conduct field inspections on the whole, with majorities of these groups inspecting for animal intrusion. Similar to testing and sampling, while a majority of conventional growers perform

[6] Only respondents that indicated that they used soil amendments containing animal manures or animal products were asked whether they tested soil amendments.

some type of field inspection, less than half of sustainable growers do so on average. As such, smaller growers and sustainable farm operations subject to these provisions would be more greatly affected on average.

Harvest Container Sanitation

In addition to sampling, testing, and field inspections, the proposed Produce Rule includes requirements for several types of preventive safety measures including sanitation of harvest containers, washing of certain produce, and numerous provisions for employee sanitation and hygiene. Eighty-six percent of the growers in our sample reported washing containers prior to harvest (Table 10). The prevalence of washing harvest containers is quite consistent across farm size, grower organization, and crop type, although medium/large growers appear somewhat less likely to wash containers compared to smaller growers on average. Just over half of growers also reported using new harvest containers, which also remains consistent across these categories.

Washing Product

While not as prevalent as harvest container sanitation, nearly three-fourths of growers reported washing produce prior to sale (Table 11). Exempt and very small growers were more likely to wash produce than small and medium/large growers, possibly due to the fact that more of these growers sell directly to consumers. We also observe that vegetable and berry producers wash produce more often that fruit and tree nut growers on average. Washing of produce is more prevalent among sustainable growers, with 91% of respondents doing so, but two-thirds of conventional growers do so as well. Again, this may reflect the fact that more sustainable growers market their produce directly to consumers on average.

Employee Sanitation and Hygiene

As detailed in the Produce Rule, employee sanitation and hygiene entails several specific practices: education and training of farm workers; equipment, tool, and building sanitation; providing toilets and handwashing facilities; and proper disposal of trash and sewage. Nearly all growers engaged in at least one of these safety practices (Table 12), and majorities of growers used each specific practice. Toilet and handwashing facilities were the most prevalent practice, followed by trash and sewage disposal, education and training, equipment sanitation, and building sanitation. Prevalence of each employee sanitation practice is very consistent across grower organization and crop type, although small and medium/large growers are somewhat more likely to employ these practices than exempt and very small growers.

Written Records

Requiring growers to maintain written records and documentation for food safety practices is a key aspect of the proposed Produce Rule intended to facilitate auditing and enforcement of required food safety measures. The proposed rule calls for written documentation for food safety policies and procedures, water treatment methods, water treatment monitoring results, water testing results, soil amendment application dates, crop harvest dates, soil amendment testing results, crop testing results, flooding, animal intrusion, and other contamination sources. Three-fourths of growers kept records for crop harvest dates, about half of growers each maintained documentation for food safety policies and procedures and water testing results, a third of growers kept records for soil amendment application dates, and a fifth recorded animal intrusion incidents (Table 13). Less than 15% of growers maintained records for each of the remaining practices, and almost a fifth of growers kept no written records for food safety whatsoever.

Similar to other practices, written documentation is more prevalent among larger growers, conventional growers, and fruit and tree nut growers on average. The one major

exception is recordkeeping for animal-based soil amendment application dates. For this practice, recordkeeping is more prevalent among smaller and sustainable growers. This may be attributable to the fact that these types of growers are simply more likely to use animal-based soil amendments, given that a greater portion of smaller and sustainable growers did not keep any written records. These results suggest that non-exempt small and sustainable growers would face greater changes to meet the recordkeeping provision of the proposed rule.

Soil Amendments

In the originally proposed Produce Rule, animal-based soil amendments must be treated using a scientifically-valid physical, chemical or composting process prior to application; or, if untreated, soil amendments may only be applied outside certain time intervals prior to harvest. In the currently proposed rule, the FDA has deferred establishing time intervals for application of untreated soil amendments. Just over half of surveyed growers used at least one animal-based soil amendments during the 2014 growing season (Table 14). Exempt and very small farms were three times as likely as small farms and more than twice as likely as medium/large farms to use soil amendments. Over 80% of sustainable growers used animal-based soil amendments, while just over a third of conventional growers used them. Overall, of the growers that used soil amendments, three-fourths used multiple soil amendments, and two-thirds treated the soil amendments using a scientifically-valid process. Almost three-fourths of sustainable growers that currently use soil amendments also treat them, suggesting that, contrary to popular belief, any future FDA ruling regarding the application of untreated soil amendments may actually have a less significant impact on most of these growers.

Third-Party Audits

While not required under the proposed Produce Rule, growers may be contractually obligated to maintain a third-party food safety audit program by downstream buyers. Over a third of growers that sold to downstream buyers had some type of contractual safety obligation. Overall, about a quarter of growers in the sample maintained a third-party food safety audit program (Table 15). Fruit and tree nut growers were twice as likely as vegetable and berry growers to engage in third-party audits. Audit programs are much more prevalent among growers in the small and medium/large FDA size classes, about half of whom had audits conducted. Not surprisingly, a third of conventional growers used third-party audits compared to only 6% of sustainable growers. Because third-party audits are costly, it is unlikely that growers selling directly to consumers would voluntarily choose to conduct them.

Summary

The proposed Produce Rule would necessitate changes in all food safety practices for some produce growers. The greatest degree of change affect only a handful of food safety practices. About half our sample currently do not test water samples, which would be required under the proposed Rule. In terms of required field inspections, two-thirds of our sample do not inspect for flooding and half do not inspect for animal intrusion. For employee sanitation and hygiene, currently about half our sample do not perform building sanitation, and a third do not sanitize equipment and tools. Lastly, the most significant change required under the proposed Rule would likely be to meet the recordkeeping requirements. Written records would be required for almost a dozen different practices. Currently, three-fourths of our sample keep records for crop harvest dates, but less than half keep records for each of the other practices.

Econometric Model

The foregoing estimates of the current prevalence of food safety practices that would be required by the proposed Produce Rule point to some interesting differences across farm size and sustainable versus conventional growers. To isolate systematic differences in the probability of adoption and cost burden of food safety measures across farm size and use of sustainable growing practices, we employ a multivariate econometric model that controls for confounding factors, such as marketing channel and crop type.

Since it is likely that unobserved factors affect both the probability of a grower using a specific food safety practice and the cost of implementing that practice, we use a Heckman selection model to correct for potential selection bias. Our econometric model consists of the following two equations:

(1) $$s_{ij}^{*} = \beta_{0,i} + \beta_{1,i}\text{Acreage}_j + \beta_{2,i}\text{Direct} + \beta_{3,i}\text{Wholeother}_j + \beta_{4,i}\text{Sustainable} + \mathbf{CropType_j'}\,\boldsymbol{\beta_{5,i}} + \epsilon_{ij}$$

(2) $$\ln(c_{ij}) = \gamma_{0,i} + \gamma_{1,i}\ln(\text{Acreage}_j) + \gamma_{2,i}\text{Sustainable} + \mathbf{CropType_j'}\boldsymbol{\gamma_{3,i}} + \mathbf{TypeofAction_i'}\boldsymbol{\gamma_{4,i}} + \nu_{ij}$$

where ϵ_{ij} and ν_{ij} are jointly normally distributed, mean-zero random variables.

In Equation 1, we model the adoption of each food safety practice using a latent variable model. We assume that grower *j* obtains an unobserved net benefit from adopting food safety practice *i*, which is a function of fruit and vegetable acreage, share of direct sales, share of wholesale/other sales, a sustainable practices indicator, and indicators for crop types grown. We observe the grower's choice, and we assume he chooses to use safety practice *i* if the net benefits of doing so are positive:

$$s_{ij} = \begin{cases} 1 \text{ if } s_{ij}^{*} > 0 \\ 0 \text{ if } s_{ij}^{*} \leq 0 \end{cases}$$

We can express the probability that grower *j* uses safety practice *i* as

$$\text{Prob}(s_{ij} = 1) = \Phi(s_{ij}^*),$$

where $\Phi(\cdot)$ is a standard normal cumulative distribution, which provides the basis for probit estimation in Equation 1.

In Equation 2, we use a log-log specification to regress the cost of food safety practice *i* for grower *j*, c_{ij}, on fruit and vegetable acreage, a sustainable practices indicator, and indicators for crop types grown. Since we only observe cost c_{ij} for growers that choose to adopt safety practice *j*, using standard regression techniques would yield biased estimates for the cost equation because the adoption and cost decisions are unlikely to be independent.

To help streamline the survey, respondents were asked to provide total cost estimates for all forms of testing, all field inspections, all harvest container sanitation measures, all employee sanitation and hygiene measures, all recordkeeping and documentation, and treatment of all soil amendments. For these food safety practices, we control for each specific action by including indicator variables for each type of action used by the grower. We interpret the coefficient on log of acreage, $\gamma_{1,i}$, as the elasticity of food safety costs for practice *i* with respect to acreage, which provides an economically meaningful estimate of the potential economies of scale for each food safety practice.

A substantial theoretical literature suggests that marketing channels may be important in creating incentives for growers to adopt food safety practices (Henson and Caswell 1999, Segerson 1999, Fares and Rouviere 2010, Hennessy, Roosen, and Miranowski 2001, Henson and Reardon 2005, Fulponi 2006, Carriquiry and Babcock 2007, Rouviere and Caswell 2012). Therefore, we include regressors for share of direct sales and share of wholesale/other sales in the selection model. At the same time, we have no reason to believe that marketing channel

affects the actual costs of food safety practices, so we do not include these regressors in the cost model.

Similarly, based on differences we observed in the prevalence of each food safety practice across crop types, we also include regressors for each crop type in the selection model. It is also plausible that the cost of implementing a specific food safety practice may differ by crop type, so we include crop type indicators in the cost model as well.

In Equation 2, the coefficient of interest, $\gamma_{1,i}$, effectively represents a measure of the elasticity of cost with respect to acreage (farm size) for each food safety practice. To better understand the potential burden of food safety costs, we need a measure of how food safety costs as a share of total expenditures vary with farm size. To derive that measure, we estimate a model of how total expenditures of fruit and vegetable production on each farm j vary with acreage using a log-log specification:

(3) $$\ln(\text{FruitVegExp}_j) = \theta_0 + \theta_1 \ln(\text{Acreage}_j) + \eta_j$$

where η_j is a normally distributed random error term. We can then use the estimate of θ_1 to calculate the elasticity of the food safety cost share with respect to acreage for each food safety practice i, E_i, as:

(4) $$E_i = \gamma_{1,i} - \theta_1$$

Results

The estimated coefficients for the probit selection equations and the safety cost regression equations for each food safety practice are presented in Tables 16 and 17, respectively. The models were estimated using maximum likelihood, and each model converged in no more than six iterations (Table 16). The estimated correlation coefficients are significantly different from zero for several food safety practices, validating our use of the sample selection model (Table

17). Because the probit model is nonlinear, we calculate average marginal effects for each of the regressors in the probit selection models to help quantify the effect farm size, farming practices, and marketing channel have on the probability that growers use each safety measure (Table 18). We focus on interpreting these results rather than the raw probit coefficients in the following discussion on use of food safety practices.

Effect of Farm Size on Use and Costs of Food Safety Practices

There is concern that the proposed Rule may adversely affect small produce growers and that compliance costs may be unduly burdensome and force them out of business, negatively impacting the industry market structure as well. To better gauge this concern, we investigate how the use and costs of food safety practices vary with farm size. The cross tabulation results suggest that differences exist by farm size for the use of most food safety practices. However, after controlling for farming practices, marketing channel, and crop type, we find no statistically or economically significant differences by farm size. The estimated marginal effects for fruit and vegetable acreage are not significantly different from zero for any food safety practice and are in fact precisely measured at zero in the case of sampling and testing, washing product, and third-party audits. This implies that larger farms are no more or less likely than smaller operations to use any of the food safety practices examined here.

We use the estimated coefficient on the log of acreage from each safety cost regression in Equation 2 (the elasticity of food safety cost for practice *i* with respect to acreage) to analyze how the cost for each food safety practice varies with farm size (Table 17). A coefficient equal to one indicates that costs rise proportionally with acreage and is consistent with constant returns to scale. A coefficient equal to zero means that cost are fixed with respect to acreage, which in turn implies increasing returns to scale. A coefficient between zero and one indicates that costs

increase with acreage, but not proportionally, which is also consistent with increasing returns to scale. Lastly, a coefficient greater than one means that costs increase more than proportionally with acreage and is consistent with decreasing returns to scale.

While we find no evidence that farm size influences the use of food safety practices, our results indicate that farm size does affect food safety costs. The estimated coefficients of log of acreage are all between zero and one and significantly different from both zero and one for each of the food safety cost regressions, except in the case soil amendments. These estimates indicated that compliance costs increase with operation size but less than proportionally, thus exhibiting significant economies of scale. The coefficients for sampling and testing, field inspection, harvest container sanitation, employee sanitation and hygiene, and third-party audits all suggest that costs increase at roughly the square root of acreage. For written records, the coefficient indicates that costs rise even less rapidly with acreage, roughly proportional to the sixth root of acreage. Lastly, for soil amendment treatment costs, the estimated coefficient of log of acreage is significantly different from zero but not one, indicating that these costs rise proportionally with acreage and do not exhibit economies of scale.

Overall, these results support the hypothesis that the cost of compliance with the proposed Produce Rule requirements will be more burdensome to small farms than large ones. However, to provide a better understanding of the magnitudes of the economies of scale for these food safety practices, we estimate the total expenditure model in Equation 4 (Table 19) and use the estimated coefficient on the log of acreage, θ_1, to calculate an estimated elasticity of food safety cost share with respect to acreage for each food safety practice *i* using Equation 3 (Table 20). We find that the estimated coefficient on log of acreage is positive and significantly different from zero, but not significantly different from one, indicating that total fruit and

vegetable expenditures increase proportionally with acreage. We thus assume $\theta_1 = 1$ to calculate the elasticity of food safety cost share with respect to acreage.

For each food safety practice, the estimated elasticity of the safety cost share with respect to acreage is less than zero, indicating that safety cost shares decrease with farm size. In other words, as farm size increases, food safety costs make up a smaller fraction of total expenditures. For sampling and testing, field inspection, harvest container sanitation, employee sanitation and hygiene, and third-party audits, the safety cost share falls at roughly the square root of acreage. For written records, the safety cost share falls even more rapidly with acreage, almost proportionally to acreage. Once again, for soil amendment treatment costs, the safety cost share falls at a much slower rate, roughly proportional to the twelfth root of acreage. This result further supports the premise that the costs of complying with the new Rule will more burdensome to smaller farm operations, since these costs effectively represent a larger share of total expenditures relative to larger farms.

To illustrate the effect of farm size on the cost burden of the Rule, consider a comparison of a mid-sized commercial vegetable farm with $500,000 in annual produce sales (Farm M) and a much larger vegetable operation with $5 million in annual produce sales (Farm L). For the food safety practices in which the safety cost share falls at roughly the square root of acreage (E_i = -0.5)—a group that includes sampling and testing, field inspection, harvest container sanitation, employee sanitation and hygiene, and third-party audits—Farm L's safety cost share for each practice is about 68% less ($10^{-0.5} - 1$) than that of Farm M. In other words, for these practices, a farm ten times as large faces a safety cost burden only a third as large. Similar calculations indicate that written records are about a seventh as burdensome and soil amendments about five-sixths as burdensome for Farm L. Our estimated coefficients thus indicate that that mid-sized

farm operations will face a much larger food safety cost burden than large, multimillion-dollar produce farms.

Effect of Sustainable Farming on Use and Costs of Food Safety Practices

Sustainable growers are concerned that some provisions in the proposed Rule may make it impossible to maintain the farming practices on which they currently rely, such as the use of untreated biological soil amendments and integrated livestock grazing practices. Similar to the analysis of farm size, we examine the effect of sustainable farming practices on the likelihood and the cost of using food safety measures that would be required in the proposed Rule. For several food safety practices, the estimated marginal effects of sustainable farming status are negative and significantly different from zero, indicating a decreased probability of using that practice. In particular, sustainable farming is associated with a 10 percentage point decrease in the probability of sampling and testing and an 18 point decrease in the probability of conducting field inspections, suggesting that sustainable growers could face more significant changes for these food safety practices under the proposed rule. While measured imprecisely, the average marginal effect of sustainable on the use of third-party audits is relatively large and negative; and its estimated effect on washing product is large and positive, but also insignificant. Use of sustainable farming practices does not significantly affect the probability of using any other food safety practices, suggesting that, as a group, sustainable growers face changes of similar magnitude to conventional growers for these practices.

Sustainable grower organizations have expressed concern that some provisions of the Produce Rule may be unduly burdensome to sustainable growers, particularly for the treatment of animal-based soil amendments. The estimated coefficient of the sustainable indicator is positive and significantly different from zero in the cost regressions for testing and sampling,

harvest container sanitation, and written records, which suggests that sustainable growers in the sample face higher costs implementing these food safety practices relative to conventional growers. The estimates are large in magnitude as well, indicating that sustainable growers incur costs that are about 250%, 80%, and 40% more for each practice, respectively.

While the estimated coefficient of sustainable is positive in the soil amendment treatment cost regression, it is not statistically significant, so we cannot draw firm conclusions regarding any disparate impact of soil amendment treatment costs on sustainable growers. Similarly, the estimated coefficients for sustainable are positive but not statistically significant for field inspection, washing product, and employee sanitation and hygiene cost regressions. If we interpret these result together with the cost share results in Table 20, we expect food safety costs for smaller, sustainable farm operations to be disproportionately burdensome across all practices relative to larger growers; additionally, sustainable growers face higher implementation costs per acre, regardless of farm size, compared to conventional growers for testing and sampling, harvest container sanitation, and recordkeeping.

Effects of Marketing Channel on Use of Food Safety Practices

Marketing channels may be important in incentivizing growers to use food safety practices. A foodborne illness outbreak can damage the reputation of a downstream agent that sells directly to consumers (such as a grocery store or restaurant), and, if a seller is found liable, it can result in direct financial losses as well. Therefore, in some marketing channels downstream buyers may require produce growers to use certain food safety practices, so we examine its effect on the likelihood that growers use each food safety practice.

Interestingly, we observe small negative effects associated with the share of products sold through direct and wholesale/other channels on the probability of adopting all food safety

practices except for employee hygiene and sanitation measures and treatment of soil amendments (Table 18). Since shares of sales to grocery retailers and food service providers are omitted from the probit specifications, we can also interpret these results as equal and opposite positive effects associated with grocery retailer and foodservice marketing channel shares. For sampling and testing, a one-percentage point increase in the share of direct sales is associated with a 0.6 point decrease in the probability of testing. Similarly, a one-percentage point increase in wholesale/other sales corresponds to a 0.4 percentage point decreases in the probability of testing. For the remaining food safety measures, a one-percentage point increase in the share of direct sales or wholesale/other sales is associated with decreases of a similar order of magnitude (to that of testing) in the probabilities of using each safety measure.

These results are consistent with the notion that greater traceability among grocery retailers and foodservice providers enhances incentives for taking greater safety precautions. In these local marketing channels, any foodborne illness outbreaks from produce consumption could be traced back to the originating grower since grocery stores typically have a separate section for locally grown produce, and restaurants often buy from a limited number of local growers and keep purchase records.

Conclusion

The passing of the Food Safety Modernization Act in 2011 authorized the FDA to regulate growing, harvesting, packing, and holding of fresh fruits and vegetables. The proposed rule for produce safety is scheduled to be finalized in 2015, and it sets standards for agricultural water, soil amendments of animal origin, domesticated and wild animals, employee health and hygiene, and equipment and building sanitation that could be costly for growers to implement. In particular, small farms worry that the costs of implementing the required food safety practices

could put them out of business, and sustainable growers are afraid that the new standards could make it prohibitively expensive for them to maintain their current farming practices.

Data on the current prevalence and likely cost of the actions required under the proposed Rule is limited. We use data from a national survey of 394 fruit and vegetable growers to examine the current prevalence and cost burden of food safety practices by FDA size classes and by farming practices. Majorities of our respondents currently employ most of the food safety practices that would be required under the proposed Produce Rule, but a large number of growers will nonetheless face significant changes to meet the Rule's requirements.

We estimate a sample selection model for each food safety practice to isolate systematic differences in the probability of adoption and cost burden of food safety measures across farm size and use of sustainable growing practices. We do not find any effect of farm size on the probability of using food safety measures. With the exception of soil amendment treatment costs, all other food safety costs rise less than proportionally with farm size and exhibit increasing returns to scale. Furthermore, we find that food safety cost shares decrease with farm size, which means that as farm size increases, food safety costs make up a smaller portion of farm expenditures.

Sustainable farming practices are negatively correlated with the probability of testing and conducting field inspections, suggesting that sustainable growers may face more significant changes in adopting these food safety practices. We also find that sustainable practices are associated with increased implementation costs for testing and sampling, harvest container sanitation, and written records relative to conventional growers. Therefore, we expect food safety cost for smaller farms to be more burdensome across all practices compared to larger growers,

and even more so for sustainable growers, regardless of farm size, for testing and sampling, harvest container sanitation, and recordkeeping.

We also find some evidence of marketing channel effects in the probability of using testing and sampling, field inspections, harvest container sanitation, washing product, recordkeeping, and third-party audits. These results are consistent with theoretical literature suggesting that traceability enhances incentives for taking greater safety precautions, since it is quite plausible that produce could be traced back to the originating grower in local marketing channels. However, these effects are relatively small and may not be sufficient to fully incentivize voluntary adoption of the food safety practices required by the proposed Rule for all growers.

The aforementioned results regarding farm size and sustainable farming practices provide some justification for the exemptions and extended phase-in times included in the proposed Produce Rule. However, while the proposed Produce Rule will require more significant changes in food safety practices for small and sustainable growers affected by the rule, and while these changes will be more financially burdensome for those growers; our results suggest that *most* small and sustainable growers will ultimately be exempt from the rule either based on farm size or the Tester-Hagan exemption. Therefore, the farms required to comply with the proposed Rule consist primarily of larger, conventional operations, where food safety cost burdens are relatively lower on average. However, also in this non-exempt group are farm operations that one might describe as mid-sized (e.g., commercial farms with produce sales of $500,000); and these growers will face a much more significant cost burden than farms with multimillion-dollar sales that one would typically classify as large operations.

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Table 1. Grower Conferences Surveyed

Conference	Location	Dates
Pacific Northwest Vegetable Conference & Trade Show	Kennewick, WA	November 12-13, 2014
29th Annual Southeast Vegetable & Fruit Expo	Myrtle Beach, SC	December 2-3, 2014
Great Lakes Fruit and Vegetable Expo	Grand Rapids, MI	December 9-11, 2014
Southeast Regional Fruit & Vegetable Conference	Savannah, GA	January 8-11, 2015
Future Harvest Chesapeake Alliance for Sustainable Agriculture Conference	College Park, MD	January 15-17, 2015
Ohio Produce Growers & Marketers Association Congress	Sandusky, OH	January 19-21, 2015
Mid-Atlantic Fruit and Vegetable Convention	Hershey, PA	January 27-29, 2015
New Jersey Agricultural Convention and Trade Show	Atlantic City, NJ	February 2-5, 2015

Table 2. Online Grower Listservs Surveyed

Organization	Start Date[a]
Georgia Fruit & Vegetable Growers Association	January 9, 2014
Michigan State University Extension	December 11, 2014
Future Harvest Chesapeake Alliance for Sustainable Agriculture	January 16, 2015
Center for Produce Safety	February 10, 2015
North Carolina Farm Bureau	January 23, 2015
Ohio State University Extension	January 18, 2015
Oregon State University Extension	January 30, 2015
Pennsylvania Association for Sustainable Agriculture	January 27, 2015
Pennsylvania Vegetable Growers Association	January 26, 2015
University of Florida Extension	January 22, 2015
Virginia Association for Biological Farming	February 8, 2015
Vegetable Growers Association of New Jersey	February 2, 2015
Carolina Farm Stewardship Association	December 8, 2014
Cornell Produce Safety Alliance	December 9, 2014
Michigan Food & Farming Systems	December 9, 2014

[a] The survey closed on May 2, 2015, for all online grower Listservs

Table 3. Revenue Distributions of Farm Operations

Crop Type and Economic Class	U.S. Census of Agriculture (%)[a]	Sample (%)[b]
Vegetables		
Exempt ($25,000 or less)	57.0	44.4
Very Small ($25,001 to $250,000)	26.0	33.8
Small ($250,001 to $500,000)	4.7	9.2
Medium/Large (More than $500,000)	12.4	12.6
Berries		
Exempt ($25,000 or less)	59.0	40.8
Very Small ($25,001 to $250,000)	29.9	32.3
Small ($250,001 to $500,000)	4.1	11.5
Medium/Large (More than $500,000)	7.0	15.4
Fruit and Tree Nuts		
Exempt ($25,000 or less)	50.6	32.3
Very Small ($25,001 to $250,000)	33.5	28.5
Small ($250,001 to $500,000)	5.5	19.2
Medium/Large (More than $500,000)	10.4	20.0

[a] Source: 2012 USDA Census of Agriculture

[b] Note: 140 respondents (36%) chose not to report revenue

Table 4. Regional Distributions of Farm Operations

ERS Production Region[a]	U.S. Census of Agriculture (%)[b]	Sample (%)[c]
Vegetables		
Fruitful Rim	25.3	9.8
Great Plains[d]	8.5	1.4
Heartland	14.1	11.5
Northern Crescent	28.1	40.8
Southeast[e]	24.0	36.6
Berries		
Fruitful Rim	25.7	10.5
Great Plains[d]	3.7	0.6
Heartland	12.4	8.8
Northern Crescent	33.9	38.7
Southeast[e]	24.3	41.4
Fruit and Tree Nuts		
Fruitful Rim	62.3	26.0
Great Plains[d]	14.6	0.6
Heartland	2.2	8.8
Northern Crescent	1.3	37.6
Southeast[e]	19.6	27.1

[a] Note: Regions reflect modified state-level mappings as detailed in Appendix B
[b] Source: 2012 USDA Census of Agriculture – Vegetable Operations
[c] Note: 5 respondents (1%) chose not to report state
[d] Great Plains is a consolidation of Northern Great Plains, Prairie Gateway, and Basin and Range
[e] Southeast is a consolidation of Eastern Uplands, Southern Seaboard, and Mississippi Portal

Table 5. Survey Distribution of Type of Grower Organization by Farm Size and Crop Type

Classification	Conventional	Sustainable
Economic Class[a]		
Exempt ($25,000 or less)	42 (46%)	49 (54%)
Very Small ($25,001 to $250,000)	46 (53%)	40 (47%)
Small ($250,001 to $500,000)	28 (88%)	4 (12%)
Medium/Large (More than $500,000)	41 (91%)	4 (9%)
Crop Type		
Vegetables	193 (62%)	118 (38%)
Berries	119 (62%)	74 (38%)
Fruit and Tree Nuts	127 (65%)	67 (35%)
TOTAL	265 (67%)	129 (33%)

[a] Note: 140 respondents (36%) chose not to report revenue

Table 6. Average Share of Sales to Various Marketing Channels by Farm Size, Crop Type, and Grower Organization

Classification	Direct Sales (%)	Grocery Retailers (%)	Foodservice Providers (%)	Produce Wholesalers (%)	Other (%)
Economic Class[a]					
Exempt ($25,000 or less)	77.4	4.5	5.0	6.4	7.6
Very Small ($25,001 to $250,000)	72.0	6.9	3.3	12.0	5.8
Small ($250,001 to $500,000)	50.7	12.6	3.8	25.3	7.8
Medium/Large (More than $500,000)	26.8	11.7	3.0	44.1	15.2
Crop Type					
Vegetables	68.7	9.0	4.0	8.8	9.8
Berries	68.5	7.2	4.0	10.4	10.0
Fruit and Tree Nuts	53.9	8.1	2.7	25.7	10.4
Grower Organization					
Conventional	50.8	10.8	2.2	24.8	12.0
Sustainable	77.5	5.1	4.1	4.3	7.7
TOTAL	59.3	9.0	3.4	18.3	10.6

[a] Note: 87 respondents (26%) chose not to report revenue

Table 7. Exemption Status by Farm Size, Crop Type, and Grower Organization

Classification	Size Exempt	Tester-Hagan Exempt	Grand Total Exempt
Economic Class			
Exempt ($25,000 or less)	91 (100%)	-	91
Very Small ($25,001 to $250,000)	-	80 (93%)	80
Small ($250,001 to $500,000)	-	24 (75%)	24
Medium/Large (More than $500,000)	-	-	-
Crop Type			
Vegetables	85 (42%)	88 (44%)	173 (86%)
Berries	49 (39%)	57 (45%)	106 (84%)
Fruit and Tree Nuts	37 (29%)	50 (40%)	87 (69%)
Grower Organization			
Conventional	42 (27%)	60 (38%)	102 (65%)
Sustainable	49 (51%)	44 (45%)	93 (96%)
TOTAL	91 (36%)	104 (41%)	195 (77%)

Note: 140 respondents (36%) chose not to report revenue, so exemption status cannot be determined.

Table 8. Testing and Sampling by Farm Size, Crop Type, and Grower Organization

Classification	Water Samples	Soil Amendment Samples[a]	Crop Samples	No Samples
Economic Class[b]				
Exempt ($25,000 or less)	27 (31%)	5 (9%)	4 (5%)	58 (66%)
Very Small ($25,001 to $250,000)	34 (41%)	6 (10%)	5 (6%)	45 (54%)
Small ($250,001 to $500,000)	22 (69%)	1 (14%)	3 (9%)	10 (31%)
Medium/Large (More than $500,000)	33 (79%)	2 (15%)	10 (24%)	8 (19%)
Crop Type				
Vegetables	114 (44%)	21 (13%)	29 (11%)	132 (51%)
Berries	70 (45%)	7 (8%)	17 (11%)	81 (52%)
Fruit and Tree Nuts	97 (60%)	7 (10%)	19 (12%)	60 (37%)
Grower Organization				
Conventional	129 (58%)	15 (18%)	40 (18%)	82 (37%)
Sustainable	38 (36%)	7 (8%)	3 (3%)	65 (61%)
TOTAL	167 (51%)	22 (13%)	43 (13%)	147 (45%)

[a] Only respondents that indicated that they used soil amendments containing animal manures or animal products were asked whether they tested soil amendments (N=169).
[b] Note: 83 respondents (25.3%) chose not to report revenue

Table 9. Field Inspections by Farm Size, Crop Type, and Grower Organization

Classification	Flooding	Animal Intrusion	Other Contamination Sources	No Inspections
Economic Class[a]				
Exempt ($25,000 or less)	22 (25%)	31 (36%)	7 (8%)	51 (59%)
Very Small ($25,001 to $250,000)	17 (20%)	38 (46%)	7 (8%)	44 (53%)
Small ($250,001 to $500,000)	11 (34%)	23 (72%)	3 (9%)	7 (22%)
Medium/Large (More than $500,000)	13 (32%)	22 (54%)	8 (20%)	17 (41%)
Crop Type				
Vegetables	72 (29%)	114 (46%)	22 (9%)	125 (50%)
Berries	42 (27%)	66 (43%)	15 (10%)	83 (54%)
Fruit and Tree Nuts	39 (25%)	79 (51%)	22 (14%)	74 (47%)
Grower Organization				
Conventional	73 (34%)	114 (54%)	27 (13%)	89 (42%)
Sustainable	18 (17%)	37 (35%)	9 (9%)	66 (63%)
TOTAL	91 (29%)	151 (47%)	36 (11%)	155 (49%)

[a] Note: 75 respondents (24%) chose not to report revenue

Table 10. Harvest Container Sanitation by Farm Size, Crop Type, and Grower Organization

Classification	Washed Containers	Used New Containers	No Action
Economic Class[a]			
Exempt ($25,000 or less)	76 (87%)	49 (57%)	5 (6%)
Very Small ($25,001 to $250,000)	71 (86%)	41 (51%)	8 (10%)
Small ($250,001 to $500,000)	30 (94%)	19 (59%)	1 (3%)
Medium/Large (More than $500,000)	27 (68%)	20 (51%)	7 (17%)
Crop Type			
Vegetables	222 (88%)	139 (56%)	18 (7%)
Berries	143 (91%)	99 (63%)	6 (4%)
Fruit and Tree Nuts	133 (84%)	90 (57%)	13 (8%)
Grower Organization			
Conventional	182 (85%)	122 (58%)	18 (8%)
Sustainable	93 (88%)	53 (50%)	7 (7%)
TOTAL	275 (86%)	175 (55%)	25 (8%)

[a] Note: 79 respondents (25%) chose not to report revenue

Table 11. Produce Washed by Farm Size, Crop Type, and Grower Organization

Classification	Produce Washed	No Action
Economic Class[a]		
Exempt ($25,000 or less)	67 (79%)	18 (21%)
Very Small ($25,001 to $250,000)	66 (80%)	16 (20%)
Small ($250,001 to $500,000)	20 (63%)	12 (37%)
Medium/Large (More than $500,000)	27 (69%)	12 (31%)
Crop Type		
Vegetables	207 (84%)	40 (16%)
Berries	120 (79%)	32 (21%)
Fruit and Tree Nuts	112 (72%)	44 (18%)
Grower Organization		
Conventional	142 (66%)	72 (34%)
Sustainable	94 (91%)	9 (9%)
TOTAL	236 (74%)	81 (26%)

[a] Note: 79 respondents (25%) chose not to report revenue

Table 12. Employee Sanitation and Hygiene by Farm Size, Crop Type, and Grower Organization

Classification	Education & Training	Equipment & Tool Sanitation	Building Sanitation	Toilets & Handwashing Facilities	Proper Disposal of Trash/Sewage	Other Actions	No Action
Economic Class[a]							
Exempt ($25,000 or less)	50 (61%)	50 (61%)	34 (41%)	69 (84%)	66 (80%)	11 (13%)	5 (6%)
Very Small ($25,001 to $250,000)	71 (87%)	54 (66%)	42 (51%)	75 (91%)	69 (84%)	5 (6%)	1 (1%)
Small ($250,001 to $500,000)	32 (100%)	27 (84%)	20 (63%)	32 (100%)	30 (94%)	0 (0%)	0 (0%)
Medium/Large (More than $500,000)	31 (82%)	25 (66%)	17 (45%)	36 (95%)	34 (89%)	4 (11%)	1 (3%)
Crop Type							
Vegetables	186 (76%)	159 (65%)	120 (49%)	217 (89%)	205 (84%)	20 (8%)	8 (3%)
Berries	120 (79%)	104 (69%)	75 (50%)	142 (94%)	129 (85%)	13 (9%)	3 (2%)
Fruit and Tree Nuts	127 (84%)	115 (76%)	86 (57%)	145 (95%)	135 (89%)	13 (9%)	4 (3%)
Grower Organization							
Conventional	172 (81%)	145 (68%)	110 (52%)	192 (91%)	190 (90%)	12 (6%)	5 (2%)
Sustainable	77 (76%)	67 (66%)	50 (50%)	93 (92%)	81 (80%)	11 (11%)	3 (3%)
TOTAL	249 (80%)	212 (68%)	160 (51%)	285 (91%)	271 (87%)	23 (7%)	8 (3%)

[a] Note: 79 respondents (25%) chose not to report revenue

Table 13. Written Records and Documentation by Farm Size, Crop Type, and Grower Organization

Classification	Policies & Procedures	Water Treatment Methods	Water Treatment Monitoring Results	Water Testing Results	Soil Amendment Appl. Dates	Crop Harvest Dates	Soil Amendment Testing Results	Crop Testing Results	Flooding	Animal Intrusion	Other Contamin-ation	No Records
Economic Class[a]												
Exempt ($25,000 or less)	21 (26%)	2 (3%)	1 (1%)	19 (24%)	34 (43%)	59 (74%)	4 (5%)	2 (3%)	6 (8%)	8 (10%)	3 (4%)	18 (23%)
Very Small ($25,001 to $250,000)	27 (33%)	0 (0%)	0 (0%)	27 (33%)	35 (43%)	59 (72%)	4 (5%)	2 (2%)	4 (5%)	7 (9%)	0 (0%)	17 (21%)
Small ($250,001 to $500,000)	21 (66%)	2 (6%)	2 (6%)	21 (66%)	5 (16%)	28 (88%)	1 (3%)	2 (6%)	4 (13%)	10 (31%)	2 (6%)	3 (9%)
Medium/Large (More than $500,000)	25 (66%)	2 (5%)	2 (5%)	29 (76%)	9 (24%)	33 (87%)	1 (3%)	9 (24%)	10 (26%)	16 (42%)	5 (13%)	3 (8%)
Crop Type												
Vegetables	90 (38%)	7 (3%)	5 (2%)	89 (37%)	96 (40%)	176 (73%)	16 (7%)	23 (10%)	30 (13%)	39 (16%)	8 (3%)	45 (19%)
Berries	62 (41%)	6 (4%)	5 (3%)	58 (39%)	54 (36%)	106 (71%)	5 (3%)	13 (9%)	17 (11%)	24 (16%)	7 (5%)	29 (19%)
Fruit and Tree Nuts	85 (56%)	8 (5%)	7 (5%)	83 (55%)	41 (27%)	121 (80%)	6 (4%)	17 (11%)	21 (14%)	42 (28%)	14 (9%)	17 (11%)
Grower Org.												
Conventional	114 (55%)	10 (5%)	8 (4%)	112 (54%)	49 (23%)	162 (78%)	11 (5%)	33 (16%)	36 (17%)	54 (26%)	15 (7%)	33 (16%)
Sustainable	26 (26%)	1 (1%)	1 (1%)	27 (27%)	52 (52%)	72 (72%)	6 (6%)	1 (1%)	6 (6%)	11 (11%)	3 (3%)	20 (20%)
TOTAL	140 (45%)	11 (4%)	9 (3%)	139 (45%)	101 (33%)	234 (76%)	17 (6%)	34 (11%)	42 (14%)	65 (21%)	18 (6%)	53 (17%)

[a] Note: 77 respondents (25%) chose not to report revenue

Table 14. Animal-Based Soil Amendment Use by Farm Size, Crop Type, and Grower Organization

Classification	Soil Amendment Use	Multiple Soil Amendment Use[b]	Treatment of Soil Amendments[c]
Economic Class[a]			
Exempt ($25,000 or less)	58 (66%)	44 (76%)	43 (74%)
Very Small ($25,001 to $250,000)	58 (67%)	51 (88%)	40 (69%)
Small ($250,001 to $500,000)	7 (22%)	7 (100%)	5 (71%)
Medium/Large (More than $500,000)	13 (30%)	8 (62%)	6 (46%)
Crop Type			
Vegetables	161 (62%)	123 (76%)	110 (69%)
Berries	89 (56%)	71 (80%)	61 (69%)
Fruit and Tree Nuts	71 (44%)	55 (77%)	49 (70%)
Grower Organization			
Conventional	82 (36%)	54 (66%)	52 (63%)
Sustainable	87 (81%)	72 (83%)	63 (73%)
TOTAL	169 (51%)	126 (75%)	115 (68%)

[a] Note: 84 respondents (25%) chose not to report revenue

[b] Only respondents that indicated that they used soil amendments containing animal manures or animal products were asked whether they used multiple soil amendments.

[c] Only respondents that indicated that they used soil amendments containing animal manures or animal products were asked whether they treated soil amendments.

Table 15. Third-Party Audits by Farm Size, Crop Type, and Grower Organization

Classification	Contractual Safety Obligation[a]	Audit Program
Economic Class[b]		
Exempt ($25,000 or less)	10 (23%)	3 (4%)
Very Small ($25,001 to $250,000)	11 (17%)	11 (14%)
Small ($250,001 to $500,000)	14 (52%)	14 (44%)
Medium/Large (More than $500,000)	21 (51%)	21 (57%)
Crop Type		
Vegetables	48 (28%)	36 (15%)
Berries	31 (29%)	24 (16%)
Fruit and Tree Nuts	58 (48%)	49 (32%)
Grower Organization		
Conventional	81 (49%)	68 (33%)
Sustainable	9 (13%)	6 (6%)
TOTAL	90 (38%)	74 (24%)

[a] Only respondents that reported a positive share of sales to grocery retailers, foodservice providers, produce wholesalers, or other marketing channel were asked about contractual safety obligations

[b] Note: 72 respondents (24%) chose not to report revenue

Table 16. Estimated Coefficients for Probit Selection Equations of Heckman Selection Models

Variables	*Sampling & Testing*	*Field Inspections*	*Harvest Container Sanitation*	*Washing Product*	*Employee Sanitation & Hygiene*	*Written Records*	*Soil Amendment Treatment*	*Third-Party Audits*
Fruit and Vegetable Acreage	0.000**	0.000	0.000	0.000*	0.000	0.003	-0.006	0.002**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.002)	(0.004)	(0.001)
Direct Sale Share	-0.017***	-0.012***	-0.013**	-0.008*	-0.009	-0.013***	-0.003	-0.016***
	(0.005)	(0.004)	(0.006)	(0.004)	(0.010)	(0.005)	(0.007)	(0.006)
Wholesale / Other Sale Share	-0.012**	-0.007*	-0.014**	-0.006	-0.011	-0.009*	-0.009	-0.006
	(0.005)	(0.004)	(0.007)	(0.005)	(0.009)	(0.005)	(0.008)	(0.005)
Sustainable	-0.294*	-0.518***	0.027	0.590	0.158	0.071	-0.018	-0.411
	(0.176)	(0.191)	(0.302)	(0.417)	(0.275)	(0.208)	(0.260)	(0.283)
Berries	-0.098	-0.160	0.659**	0.239	0.560**	-0.128	0.019	-0.250
	(0.16)	(0.172)	(0.266)	(0.214)	(0.242)	(0.193)	(0.264)	(0.227)
Fruit and Tree Nut	0.298*	0.19	-0.016	0.129	-0.178	0.53***	-0.069	0.112
	(0.166)	(0.18)	(0.254)	(0.211)	(0.359)	(0.204)	(0.267)	(0.228)
Vegetables	-0.450**	0.335	0.031	1.359***	-0.961*	0.134	-0.96	-0.674***
	(0.210)	(0.242)	(0.315)	(0.287)	(0.564)	(0.303)	(0.780)	(0.231)
No. of Observations	267	247	224	245	250	282	111	283
Log Likelihood	-363.402	-312.376	-425.316	-421.665	-469.355	-451.173	-175.854	-180.496

Note: Robust standard errors are reported in parentheses. Asterisk (*), double asterisk (**), and triple asterisk (***) indicate significance at the 10, 5 and 1 percent level, respectively.

Table 17. Estimated Coefficients for Safety Cost Regression Equations of Heckman Selection Models

Variables	*Sampling & Testing*	*Field Inspection*	*Harvest Container Sanitation*	*Washing Product*	*Employee Sanitation & Hygiene*	*Written Records*	*Soil Amendment Treatment*	*Third-Party Audits*
ln(Fruit and Vegetable Acreage)	0.409***	0.451***	0.579***	0.720***	0.547***	0.159***	0.922***	0.408*
	(0.070)	(0.091)	(0.060)	(0.079)	(0.061)	(0.045)	(0.192)	(0.240)
Sustainable	1.276***	0.131	0.598**	0.112	0.134	0.320*	0.177	-0.151
	(0.431)	(0.414)	(0.273)	(0.464)	(0.255)	(0.172)	(0.494)	(0.708)
Berries	0.108	-0.196	-0.261	-0.248	-0.278	0.139	-0.054	0.935**
	(0.275)	(0.315)	(0.237)	(0.297)	(0.258)	(0.172)	(0.374)	(0.377)
Fruit and Tree Nut	-0.784***	0.457	0.065	0.280	-0.044	-0.482***	0.234	-0.225
	(0.291)	(0.313)	(0.246)	(0.312)	(0.255)	(0.170)	(0.312)	(0.434)
Vegetables	0.244	0.654*	0.353	-1.174	0.206	-0.417*	0.619	0.017
	(0.335)	(0.335)	(0.334)	(0.876)	(0.359)	(0.234)	(0.410)	(0.552)
Water Samples	0.665							
	(0.591)							
Soil Amendment Samples	0.697**							
	(0.309)							
Product Samples	1.503***							
	(0.305)							
Flooding Inspections		0.605						
		(1.044)						
Animal Intrusion Inspections		1.439*						
		(0.774)						
Other Inspections		0.430						
		(0.318)						
Flooding & Animal Intrusion Simultaneous Inspections		-0.249						
		(1.096)						
Wash Harvest Containers[a]			---					
New Harvest Containers			0.279					
			(0.204)					

Variables	*Sampling & Testing*	*Field Inspection*	*Harvest Container Sanitation*	*Washing Product*	*Employee Sanitation & Hygiene*	*Written Records*	*Soil Amendment Treatment*	*Third-Party Audits*
Employee Education/Training					0.798***			
					(0.301)			
Equipment & Tool Sanitation					0.165			
					(0.247)			
Building Sanitation					0.257			
					(0.200)			
Toilet & Handwashing Facilities					1.184***			
					(0.459)			
Proper Disposal of Sewage/Trash					0.515			
					(0.325)			
Other Employee Actions					-0.034			
					(0.368)			
Total Number of Employees					0.001**			
					(0.000)			
Policies & Procedures Records						0.063		
						(0.167)		
Water Treatment Method Records						0.205		
						(0.323)		
Water Treatment Monitoring Results Records						-0.064		
						(0.438)		
Water Testing Results Records						0.118		
						(0.172)		
Soil Amendment Application Date Records						0.515***		
						(0.178)		
Crop Harvest Dates Records						0.670**		
						(0.283)		
Soil Amendment Test Records						0.129		
						(0.320)		
Crop Testing Results Records						0.208		
						(0.231)		

Variables	*Sampling & Testing*	*Field Inspection*	*Harvest Container Sanitation*	*Washing Product*	*Employee Sanitation & Hygiene*	*Written Records*	*Soil Amendment Treatment*	*Third-Party Audits*
Flooding Records						0.501**		
						(0.225)		
Animal Intrusion Records						0.182		
						(0.223)		
Other Contamination Records						0.132		
						(0.265)		
Multiple Soil Amendments							0.147	
							(0.718)	
No. of Observations	267	247	224	245	250	282	111	283
Inverse Mill's Ratio (λ)	-1.624***	0.792	-1.226**	-1.604	-0.816	-0.025	(0.169)	-0.012
	(0.250)	(0.565)	(0.388)	(0.851)	(1.129)	(0.193)	(0.488)	(0.926)

Note: Robust standard errors are reported in parentheses. Asterisk (*), double asterisk (**), and triple asterisk (***) indicate significance at the 10, 5 and 1 percent level, respectively.

[a] The variable indicating the washing of harvest containers was omitted due to collinearity.

Table 18. Marginal Effects of Size, Marketing Channel, Sustainable, and Crop Type on the Probability of Safety Measure Use

Variables	*Sampling & Testing*	*Field Inspections*	*Harvest Container Sanitation*	*Washing Product*	*Employee Sanitation & Hygiene*	*Written Records*	*Soil Amendment Treatment*	*Third-Party Audits*
Fruit and Vegetable Acreage	0.000**	0.000	0.000	0.000*	0.000	0.001	-0.002	0.000**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)
Direct Sale Share	-0.006***	-0.004***	-0.002**	-0.002*	-0.002	-0.003***	-0.001	-0.003***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)	(0.003)	(0.001)
Wholesale / Other Sale Share	-0.004**	-0.003*	-0.002**	-0.002	-0.002	-0.002*	-0.003	-0.001
	(0.002)	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)	(0.003)	(0.001)
Sustainable	-0.100*	-0.182***	0.005	0.160	0.029	0.017	-0.006	-0.072
	(0.059)	(0.065)	(0.051)	(0.108)	(0.05)	(0.049)	(0.096)	(0.048)
Berries	-0.033	-0.056	0.112**	0.065	0.102**	-0.030	0.007	-0.044
	(0.054)	(0.060)	(0.044)	(0.059)	(0.043)	(0.045)	(0.098)	(0.039)
Fruit and Tree Nut	0.102*	0.067	-0.003	0.035	-0.032	0.124***	-0.026	0.019
	(0.056)	(0.063)	(0.043)	(0.057)	(0.065)	(0.047)	(0.099)	(0.039)
Vegetables	-0.153**	0.118	0.005	0.368***	-0.175*	0.031	-0.355	-0.118***
	(0.070)	(0.084)	(0.053)	(0.069)	(0.100)	(0.071)	(0.282)	(0.039)

Note: Standard errors (reported in parentheses) were estimated using the delta method. Asterisk (*), double asterisk (**), and triple asterisk (***) indicate significance at the 10, 5 and 1 percent level, respectively.

Table 19. Estimated Coefficients for Expenditure Regression Models

Variables	*ln(Fruit and Veg. Expenditure)*
ln(Fruit and Vegetable Acreage)	1.005***
	(0.046)
Constant	8.320***
	(0.145)
No. of Observations	244
R-Squared	0.664

Note: Standard errors are reported in parentheses. Asterisk (*), double asterisk (**), and triple asterisk (***) indicate significance at the 10, 5 and 1 percent level, respectively

Table 20. Estimated Elasticity of Food Safety Cost Share with Respect to Acreage

	Sampling & Testing	*Field Inspections*	*Harvest Container Sanitation*	*Washing Product*	*Employee Sanitation & Hygiene*	*Written Records*	*Soil Amendment Treatment*	*Third-Party Audits*
E_i	-0.591	-0.549	-0.421	-0.280	-0.453	-0.841	-0.078	-0.592

Appendix A. Survey Instrument

Q1.1 Do you own or manage a farm?
- ❍ Own (1)
- ❍ Manage (2)
- ❍ Own and Manage (3)
- ❍ Neither (5)

Q1.1a Is ALL the produce you grow intended for canning or a similar type of commercial processing that kills pathogens?
- ❍ No (4)
- ❍ Yes (5)

Q1.2 What vegetables and/or fruit were produced in 2014?
- ❑ Artichokes (1)
- ❑ Asparagus (2)
- ❑ Beans (any type) (3)
- ❑ Beets (4)
- ❑ Berries (any type) (28)
- ❑ Broccoli and/or Cauliflower (5)
- ❑ Brussel Sprouts (6)
- ❑ Carrots (8)
- ❑ Celery and/or Rhubarb (9)
- ❑ Cucumbers (11)
- ❑ Eggplant (12)
- ❑ Fresh Herbs (14)
- ❑ Grains, Oilseeds, and/or Hay (30)
- ❑ Leafy Greens (16)
- ❑ Melons (any type) (7)
- ❑ Okra (17)
- ❑ Onions (any type) (18)
- ❑ Peas (any type) (19)
- ❑ Peppers (any type) (20)
- ❑ Potatoes and/or Sweet Potatoes (21)
- ❑ Radishes and/or Turnips (22)
- ❑ Squash (any type) and/or Pumpkins (23)
- ❑ Sweet Corn (24)
- ❑ Tomatoes (25)
- ❑ Tree Fruits (45)
- ❑ Tree Nuts (13)
- ❑ Other Vegetables (26)
- ❑ Other Fruit (29)

Q1.3 Were livestock or other domesticated animals raised on the farm, as well?
- ❍ Yes (1)
- ❍ No (2)

Q1.4 In what county and state are your farm fields located?

Q1.5 How many full-time and seasonal employees were employed?
Full-time employees (1)
Seasonal employees (2)

Q1.6 In total, how many acres of land were in production?
Vegetables and Fruit (3)
All Farm Production (4)

Q1.7 What was the total annual revenue and total annual expenditures for all farm production?Estimates are acceptable.
Total Annual Revenue (3)
Total Annual Expenditures (2)

Q1.8 What share of total annual revenue and total annual expenditures were attributable to vegetable and fruit production?
Share of Revenue (4)
Share of Expenditures (5)

Q1.9 Please identify the percentage share of all vegetables and fruit sold directly to the listed entities. The column must sum to 100.

	Direct Sales (1)	Grocery Retailers (2)	Foodservice Operations (3)	Produce Wholesalers/Repackers (4)	Mass Merchandisers (5)	Exporters (6)	Brokers (7)	Other (8)
All Vegetables and Fruit (1)								

Q1.10 Did you have any contractual obligation to adhere to any specific safety standards and testing procedures?
❍ Yes (1)
❍ No (2)

Q1.11 Please identify the entities with which you had contractual obligations regarding food safety and any corresponding safety standards (e.g., guidance documents, certification programs, USDA GAP, Harmonized GAP, etc.).

	Vegetables and Fruit	Vegetables and Fruit
	Safety Standard (e.g., GAPs, Certification, etc.) (1)	Contractual Safety Obligation? (1)
Grocery Retailers (1)		❑
Foodservice Operations (2)		❑
Produce Wholesalers/Repackers (3)		❑
Mass Merchandisers (4)		❑
Exporters (5)		❑
Brokers (6)		❑
Shippers (7)		❑
Other: (8)		❑

Q1.12 For vegetable and fruit production, did operations include the use of a soil amendment or soil treatment that contained animal manures or animal products (e.g., raw manure, compost, fish emulsions, fish meal, blood meal, etc.)?

- ❍ Yes (1)
- ❍ No (2)

Q1.13 Was more than one soil amendment and/or soil treatment of animal origin used for vegetable and fruit production?

- ❍ Yes (1)
- ❍ No (2)

Q1.14 Were any biological soil amendments of animal origin treated using scientifically-valid physical, chemical or composting processes before application?

- ❍ Yes: All soil amendments were treated. (1)
- ❍ Yes: Some soil amendments were treated, while some were left untreated. (4)
- ❍ No: All soil amendments were untreated. (2)

Q1.15 Was the biological soil amendment of animal origin treated using a scientifically-valid physical, chemical or composting process before application?

- ❍ Yes (1)
- ❍ No (2)

Q1.16 What was the approximate total annual cost of treating biological soil amendments of animal origin before application?Estimates are acceptable.

Q1.17 What was the shortest time interval in days between the application of soil amendments of animal origin and harvesting of crops for any growing area on which they were applied?

Treated Soil Amendments (1)
Untreated Soil Amendments (2)

Q2.1 Was more than one water source used for growing, harvesting, packing, or holding vegetables and fruit?

- ❍ Yes (1)
- ❍ No (2)

Q2.2 What water source(s) was used for growing, harvesting, packing, or holding vegetables and fruit?Please check all that apply.

- ❑ Pond or Lake (1)
- ❑ River (7)
- ❑ Stream or Spring (2)
- ❑ Shallow Well (less than 30 feet) (3)
- ❑ Deep Well (greater than 30 feet) (4)
- ❑ Municipal / City Water (5)
- ❑ Other (6) _____

Q2.3 Please indicate whether the following samples were collected for microbial testing (e.g., pathogens, generic E. coli, coliforms, etc.).If no samples were taken, please check the last box.

- ❑ Water Samples (1)
- ❑ Soil Amendment and/or Soil Treatment Samples (2)
- ❑ Crop/Product Samples (3)
- ❑ No samples were taken (4)

Q2.4 How frequently were samples collected?

	Weekly (1)	Monthly (2)	Once a Season (3)	Never (4)	Other (5)
Water (1)	❍	❍	❍	❍	❍
Soil Amendments and/or Soil Treatments (2)	❍	❍	❍	❍	❍
Crop/Product (3)	❍	❍	❍	❍	❍

Q2.5 How frequently were the following samples collected?
Water Samples (1)
Soil Amendments and/or Soil Treatment Samples (2)
Crop/Product Samples (3)

Q2.6 What were the total annual expenditures associated with sampling and testing (including employee wages, materials, etc.)?Estimates are acceptable.

Q2.7 Were animals allowed to graze and/or used as working animals in fields where vegetables and fruit is grown?
- ❍ Grazing only (1)
- ❍ Working Animals only (2)
- ❍ Grazing and Working Animals (3)
- ❍ Neither (4)

Q2.8 What was the shortest time interval in days between grazing and harvesting of crops for any growing area that was grazed?

Q2.9 Were any measures taken to prevent the introduction of hazards onto covered produce from working animals (e.g., segregated horse paths, etc.)?
- ❍ Yes (1)
- ❍ No (2)

Q2.10 Were field inspections for flooding, animal intrusion, and/or other contamination sources conducted prior to harvest?If no field inspections were conducted, please check the last box.
- ❑ Flooding (1)
- ❑ Animal Intrusion (2)
- ❑ Other Contamination Sources (3) _____
- ❑ No field inspections were conducted (4)

Q2.11 What was the total annual cost of conducting field inspections (including employee wages, etc.)?Estimates are acceptable.

Q2.12 For each of the following, did test results, flooding, animal intrusion, and/or other contamination sources lead to remedial actions (e.g., sanitation, product disposal, water treatment, etc.)?

	Yes (1)	No (2)
Test Results (3)	❍	❍
Flooding (4)	❍	❍
Animal Intrusion (5)	❍	❍
Other Contamination Sources (6)	❍	❍

Q2.13 Please identify all remedial actions taken following testing, flooding, and/or animal intrusion.

- ❑ Sanitary Surveys/Sanitation (1)
- ❑ Additional Testing (2)
- ❑ Water Treatments (3)
- ❑ Leave enough time between last irrigation and harvest or between harvest and end of storage for microbes to die off (17)
- ❑ Processing/Treatment of Soil Amendments (10)
- ❑ Use of Substitutes for Contaminated Materials (4)
- ❑ Material Disposal (5)
- ❑ Product Disposal (6)
- ❑ Delayed Future Production on Site (7)
- ❑ Other: (8) _____
- ❑ Other: (9) _____

Q2.14 What was the approximate total annual cost associated with these remedial actions (including the value of any disposed materials/products, value of lost future production on site, etc.)?Estimates are acceptable.

Q3.1 Were harvest containers washed and/or sanitized prior to harvest for any vegetable or fruit crops?

- ❍ Yes (1)
- ❍ No (2)

Q3.2 Were new harvest containers used for any vegetable or fruit crops?

- ❍ Yes (1)
- ❍ No (2)

Q3.3 For which vegetables and fruit crops were harvest containers washed and/or sanitized prior to harvest?

- ❑ Artichokes (1)
- ❑ Asparagus (2)
- ❑ Beans (any type) (3)
- ❑ Beets (4)
- ❑ Berries (any type) (28)
- ❑ Broccoli and/or Cauliflower (5)
- ❑ Brussel Sprouts (6)
- ❑ Carrots (8)
- ❑ Celery and/or Rhubarb (9)
- ❑ Cucumbers (11)
- ❑ Eggplant (12)
- ❑ Fresh Herbs (14)
- ❑ Grains, Oilseeds, and/or Hay (30)
- ❑ Leafy Greens (16)
- ❑ Melons (any type) (7)
- ❑ Okra (17)
- ❑ Onions (any type) (18)
- ❑ Peas (any type) (19)
- ❑ Peppers (any type) (20)
- ❑ Potatoes and/or Sweet Potatoes (21)
- ❑ Radishes and/or Turnips (22)
- ❑ Squash (any type) and/or Pumpkins (23)
- ❑ Sweet Corn (24)
- ❑ Tomatoes (25)
- ❑ Tree Fruits (45)
- ❑ Tree Nuts (13)
- ❑ Other Vegetables (26)
- ❑ Other Fruit (29)

Q3.4 For which vegetables and fruit crops were new harvest containers used?

- ❑ Artichokes (1)
- ❑ Asparagus (2)
- ❑ Beans (any type) (3)
- ❑ Beets (4)
- ❑ Berries (any type) (28)
- ❑ Broccoli and/or Cauliflower (5)
- ❑ Brussel Sprouts (6)
- ❑ Carrots (8)
- ❑ Celery and/or Rhubarb (9)
- ❑ Cucumbers (11)
- ❑ Eggplant (12)
- ❑ Fresh Herbs (14)
- ❑ Grains, Oilseeds, and/or Hay (30)
- ❑ Leafy Greens (16)
- ❑ Melons (any type) (7)
- ❑ Okra (17)
- ❑ Onions (any type) (18)
- ❑ Peas (any type) (19)
- ❑ Peppers (any type) (20)
- ❑ Potatoes and/or Sweet Potatoes (21)
- ❑ Radishes and/or Turnips (22)
- ❑ Squash (any type) and/or Pumpkins (23)
- ❑ Sweet Corn (24)
- ❑ Tomatoes (25)
- ❑ Tree Fruits (45)
- ❑ Tree Nuts (13)
- ❑ Other Vegetables (26)
- ❑ Other Fruit (29)

Q3.5 What was the total approximate annual cost of washing and/or sanitizing harvest containers (including the cost of disinfectants, employee wages, etc.)?Estimates are acceptable.

Q3.6 What was the total approximate annual cost for the new harvest containers?Estimates are acceptable.

Q3.7 Were any harvested crops/products washed prior to storage or sale?

- ❍ Yes (1)
- ❍ No (2)

Q3.8 Which vegetable and fruit crops were washed prior to storage or sale?

- ❑ Artichokes (1)
- ❑ Asparagus (2)
- ❑ Beans (any type) (3)
- ❑ Beets (4)
- ❑ Berries (any type) (28)
- ❑ Broccoli and/or Cauliflower (5)
- ❑ Brussel Sprouts (6)
- ❑ Carrots (8)
- ❑ Celery and/or Rhubarb (9)
- ❑ Cucumbers (11)
- ❑ Eggplant (12)
- ❑ Fresh Herbs (14)
- ❑ Grains, Oilseeds, and/or Hay (30)
- ❑ Leafy Greens (16)
- ❑ Melons (any type) (7)
- ❑ Okra (17)
- ❑ Onions (any type) (18)
- ❑ Peas (any type) (19)
- ❑ Peppers (any type) (20)
- ❑ Potatoes and/or Sweet Potatoes (21)
- ❑ Radishes and/or Turnips (22)
- ❑ Squash (any type) and/or Pumpkins (23)
- ❑ Sweet Corn (24)
- ❑ Tomatoes (25)
- ❑ Tree Fruits (45)
- ❑ Tree Nuts (13)
- ❑ Other Vegetables (26)
- ❑ Other Fruit (29)

Q3.9 What was the approximate total annual cost of washing the crops/products (including employee wages, etc.)?Estimates are acceptable.

Q3.10 With regards to employee hygiene and general sanitation, please identify all preventive actions taken.If no action was taken, please check the last box.

- ❑ Employee Education/Training (1)
- ❑ Clean and Accessible Toilet and Handwashing Facilities (3)
- ❑ Equipment and Tool Sanitation (2)
- ❑ Building Sanitation (8)
- ❑ Proper Disposal of Sewage and Trash (7)
- ❑ Other: (4) _____
- ❑ Other: (5) _____
- ❑ No preventive action was taken. (6)

Q3.11 What was the approximate total annual cost associated with these preventive actions?Estimates are acceptable.

Q3.12 Besides field inspections, employee hygiene precautions, general sanitation, washing, sampling, and/or testing, were any other preventive actions taken to directly reduce the risk of pathogen contamination?

- ❍ Yes (1)
- ❍ No (2)

Q3.13 What other preventive actions were taken to directly reduce the risk of pathogen contamination?

Q3.14 What was the total annual cost of implementing these additional preventive actions (including employee wages, cost of materials and equipment, etc.)?Estimates are acceptable.

Q91 Do you have a third-party food safety audit program in place?

- ❍ Yes (9)
- ❍ No (10)

Q92 What is the total annual cost of these food safety audits?Estimates are acceptable.

Q3.15 Do you keep written records or documentation for any of the following? If not, please check the last box.

- ❑ Food Hygiene and Food Safety Policies and Procedures (7)
- ❑ Water Treatment Methods (1)
- ❑ Water Treatment Monitoring Results (5)
- ❑ Water Testing Results (6)
- ❑ Soil Amendment and/or Soil Treatement Application Dates (2)
- ❑ Produce/Crop Harvest Dates (8)
- ❑ Soil Amendment and/or Soil Treatement Testing Results (9)
- ❑ Produce/Crop Testing Results (3)
- ❑ Flooding (4)
- ❑ Animal Intrusion (10)
- ❑ Other Contamination (11)
- ❑ No written records or documentation were kept (12)

Q3.16 On a weekly basis, how much time do you spend on record keeping (in hours)?

Appendix B. Modified ERS Farm Resource Region Mappings

Region	States
Fruitful Rim	Arizona, California, Florida, Idaho, Oregon, Texas, Washington
Great Plains	Colorado, Kansas, Montana, Nebraska, Nevada, New Mexico, North Dakota, Oklahoma, South Dakota, Utah, Wyoming
Heartland	Illinois, Indiana, Iowa, Minnesota, Missouri, Ohio
Northern Crescent	Connecticut, Maine, Massachusetts, Michigan, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, Wisconsin
Southeast	Alabama, Arkansas, Delaware, Georgia, Kentucky, Louisiana, Maryland, Mississippi, North Carolina, South Carolina, Tennessee, Virginia, West Virginia