Resolving Conflicting Priorities Concerning Food Safety Issues in Leafy Green Vegetables

Mary L. Bianchi
UC Cooperative Extension, San Luis Obispo, California
Kay L. Mercer
Southern San Luis Obispo – Santa Barbara Counties Agricultural Watershed Coalition, Paso Robles, California
David M. Crohn
Department of Environmental Sciences, UC Riverside, Riverside, California

Abstract: Efforts to exclude disease organisms from farms growing irrigated lettuce and leafy vegetables on California's central coast are conflicting with traditionally accepted strategies to protect surface water and environmental quality. The agricultural community, scientists *and* producers, are caught between the requirements to safeguard water quality and efforts to ensure a safe food supply. These programs evolved independently, albeit side-by-side, leading to separate habits of thought among environmental and food safety scientists in academia, business, and non-profit programs. The potential for coordinated management of water quality and food safety on-farm management practices was the focus of a conference held in San Luis Obispo, California in April 2007. Conference presentations, discussions, farm visits, and working groups used existing technical guidance to frame research and organizational objectives. These conference products were summarized for inclusion in iterative on-line questionnaires, with conference attendees participating as respondents. This process, called a Delphi process, produced general research priorities in coordinated management. Conference participants, who self identified as having either food safety or water quality as their primary area of focus, prioritized research objectives under theme areas. There were general research objectives, which approached consensus by the whole group, including:

1) persistence and fate of pathogen in the crop and in conservation practices;
2) pathways by which pathogens move through the crop production system; and
3) identification of environmental conditions that promote pathogen survival and proliferation.

Conference participants and Delphi respondents were not able to identify an existing forum for gathering and disseminating coordinated management information. Respondents placed their highest priority on the formation of a Coordinating Council, and identified those entities that ought to play specific roles within the Council. Two technical guidance documents, one emphasizing on-farm management of food safety and one stressing water quality practices, are already in use by a majority of leafy greens growers on California's Central Coast. Used together, these technical guidance documents can be used to develop an initial framework for the evaluation and development of coordinated management practices that protect both human health and the environment. The conference final report and accompanying materials are published online at http://groups.ucanr.org/wqfsconf/.

Key Words: food-borne pathogens, food safety, management practices, vegetables, water quality

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INTRODUCTION

Environmental and water quality protection is increasingly critical for scientists and agricultural producers in California, including cool-season vegetables. Presence of nitrates and pesticides are documented in surface and groundwater. At least 10% of public drinking water supply wells in California exceed drinking water standards, including some wells that are in agricultural areas (Moore et al. 2006). Nitrate present in surface water in Salinas, Santa Maria, and Oxnard in California's central Coast sometime exceeds the drinking water standard of 45 mg/L (10 mg/L as nitrate nitrogen) by as much as 4 times (see http://www.ccamp.org/ca0/3/Cwq/NO3_NO3_H2O.htm). For example, 32 of 68 wells sampled in 1995 in the East Side Sub-basin of the Salinas Valley Basin exceeded the drinking water standard (Department of Water Resources 2003). Persistent toxicity attributed to organophosphate and pyrethroid pesticides is also documented and is being further characterized (Anderson et al. 2003, Anderson et al. 2006). Sediments impact surface and ocean waters through California. Wildlife, both aquatic and avian species, are potentially threatened. Groundwater aquifers are impacted.

Since 1999, water quality regulations over and above the Clean Water Act have been adopted by Regional Water Quality Control Boards for agricultural operations in all 5 of California's cool-season vegetable growing areas: Salinas, Santa Maria, the Imperial Valley, Oxnard, and Huron (Anonymous 2004, 2005a,b,c). These regions together produce 80%, 93%, and 86% of the nation's lettuce, broccoli, and cauliflower, respectively (USDA 2008). Water quality regulations require growers to implement management practices such as irrigation and stormwater catch basins, grassed waterways, filter strips, and riparian buffers to trap nutrients, pesticides, and sediment discharges from their fields. These practices have been extensively researched and are recommended by federal and state scientists, educators, and regulators from the U.S. Environmental Protection Agency (EPA), the U.S. Department of Agriculture (USDA) National Resource Conservation Service (NRCS), University of California Cooperative Extension (UCCE), Resource Conservation Districts, and local agricultural industry organizations (Bianchi et al. 2004, 2008).

Since 1995, there have been 20 outbreaks of microbial food-borne illnesses in cool-season vegetables (Brackett 2005). Almonds, tomatoes, melons, and green onions have also had pathogenic outbreaks. Suspected sources are contaminated irrigation water, portable toilets, improperly handled manure fertilizer, poor field or facility hygiene, or fields flooded by fecal-contaminated stormwater (Beuchat 1996). The situation has been exacerbated by shifts in pathogenic populations and toxicity, resulting in critical issues for the produce industry.

The U.S. Food and Drug Administration (FDA) and Centers for Disease Control and Prevention (CDC) have stated they have "serious concerns with continuing outbreaks of food-borne illness" (Brackett 2005). In an effort to reduce microbial outbreaks, the produce industry and government authored the 1998 FDA/USDA "Guide to Minimize Microbial Hazards in Fresh Fruit and Vegetables" or "Good Agricultural Practices" (GAPs) (FDA 1998). GAPS establish a "standard of conduct" for growers and shippers during growing, harvesting, packing, storage, and shipping of fresh produce. Specific guidelines were developed for leafy greens and lettuce (Gorny 2006). Concurrently, third-party certifiers have emerged to audit and certify GAP compliance at all industry levels and growers must comply with audit guidelines in order to sell their produce. Significant efforts have been made to establish "science-based" GAPs, yet many are based on extrapolations from secondary sources. For example, there are concerns that in-field pollution prevention practices may attract wildlife, birds, rodents, and insects, and therefore increase the proliferation of animal-vectored microbial contamination. Consequently, some third-party auditors have mandated the elimination of certain water quality management practices (e.g., grassed waterways) which may attract animals and some concerned growers have voluntarily begun to remove these practices. While GAPs are vital to assure a safe food supply, prohibitions against water quality management practices could jeopardize fundamental efforts to protect the environment and drinking water supply in cool-season vegetable production areas.

Initial Steps in Conflict Resolution

Recognizing the need for collaboration in resolution of these issues, University of California Cooperative Extension and UC Riverside Environmental Sciences partnered with the San Luis Obispo and Santa Barbara Agricultural Watershed Coalition and the Agricultural Water Quality Alliance to form a working group. Participants included representatives from the California Department of Health Services (now Department of Public Health), California Lettuce Research Board, Davis Fresh Technologies, International Fresh-cut Produce Association, Produce Marketing Association, Raley's Family of Fine Stores, Scientific Certification Programs, United Fresh Fruit & Vegetable Association, Western Growers Association, Western Institute for Food Safety and Security, California Department of Food and Agriculture, Central Coast Regional Water Quality Control Board, UC Center for Water Resources, USDA Cooperative States Research Education and Extension Service Western Region, and U.S. EPA Region 9. Through meetings during the early months of 2005, the group identified mutual goals and challenges. A research conference was prioritized, and the collaborative effort in developing a conference format provided an effective format for beginning the process of identifying priorities for coordinating food safety and environmental quality initiatives.

The working group designed a conference program intended to create a common framework for private and public scientists and professionals from water quality, food safety, wildlife biology, and agriculture fields to identify ways to reduce barriers that inhibit coordinated management. The basis for the conference was the supposition that co-management of food safety and water quality is achievable when experts in both disciplines agree to focus on the same research objectives and organizational efforts.

The conference was designed in two parts; the first intended to create a common knowledge framework, and the second to begin the formation of collaborative efforts among diverse discipline. The two parts consisted of:

Presentations and Panel Discussions

- **Framing the Issue:** Participants gained perspective on the consequences of water quality protection and food safety conflicts through reviewing the habits of thought inherent in their separate scientific disciplines, and how those habits might inhibit technology transfer and innovations needed to promote coordinated management. The potential social, environmental, and economic consequences of current industry direction were addressed by an environmentalist advocating for water quality protection, a representative from a public health agency, and a lettuce grower trying to comply with regulations.
- **Review of the Current Situation:** In order to create a common framework for all attendees, presenters examined the multiple perspectives and driving forces behind the water quality and food safety protection efforts by discussing cool-season vegetable production practices, field discharge water quality and water catch basins, filter strips and grassed waterways, and different water quality regulatory initiatives, as well as the role of third-party auditors and the specific pathogens of concern for fresh produce. One session summarized research data regarding the efficacy of water quality management practices and the importance of on-farm microbial food safety mitigations, though a review of data on the benefits of water quality management practices in California, as well as data used to guide food safety programs that relate to water quality management practices, on-farm sources/vectors of food-borne pathogens, and pathogenic persistence in the field. A summary panel discussion centered on the role of wildlife as vectors of food-borne pathogens, and the degree to which water quality management practices might increase the presence of wildlife in the field.
- **Concerns and Limitations:** The second morning of the conference began with a session designed to address what we do not know and to explore interdisciplinary perspectives, assumptions, and scientific limitations, as well as current risk and liability

management approaches that inhibit the coordinated management of water quality protection and food safety initiatives. Presenters discussed the assumptions behind current food safety practices, identified information the food industry utilizes to assesses liability, and what data is needed to support or modify these assumptions. Also addressed were information needed about microbial pathogens to make coordinated management possible, microbial source tracking, and modes of transfer. Perspectives of on-farm risk factors were discussed through experience with recent pathogenic food-borne illness outbreak investigations, what data were used to resolve the investigations, and the identification of data that could have improved the investigation, and whether improved sampling, detection, and identification methods can be used to accurately identify sources of crop contamination.

Field Visits and Collaborative Workgroups provided, in a real-life situation, an understanding of the impacts of water quality management practices and food safety protection GAPs, followed by small collaborative workgroups sessions where scientists, regulators, and industry professionals devised innovative approaches to actual water quality management practices and food safety concerns.

- ***Field Visits*:** Field visits with conservation planners and agricultural producers were designed to provide realistic perspectives on practices and concerns. Participants selected one of 3 possible types of water quality management practice employed by a cool-season vegetable producer to allow them to become familiar with other group members as well as the specific management practices. Participants were asked to identify as to their area of work (food safety or water quality). Each of these two groups was tasked to identify field conflicts, data gaps that impede the decision-making process, and potential research to address those gaps, but from the perspective of the other group. Food safety participants identified water quality issues, and vice-versa. The groups were provided with trained recorders and facilitators to capture work of groups in field. Digital cameras were available to capture input for the final plenary session.
- ***Workgroups and Plenary Session*:** Collaborative workgroups identified barriers to and accomplishments during the problem solving exercise that summarized lessons learned. Working group reports focused on problem resolution and shared strategies to move forward. Finally, strategies for coordinated management were shared that included prioritized research objectives, research grant funding, and short-term actions for cool-season vegetable producers that address the current need for coexistence between water quality and food safety practices.

COORDINATED MANAGEMENT OF WATER QUALITY AND FOOD SAFETY CONFERENCE RESULTS

Leaders in water quality and food safety from throughout the nation gathered at the Coordinated Management of Water Quality and Food Safety Conference held in San Luis Obispo, CA, on April 23 through 25, 2007. The conference sought to answer the question **"*How can on-farm water quality management practices be co-managed with food safety initiatives in order to protect the environment and human health associated with the production and consumption of cool-season vegetables?*"**

Through the process outlined above, the conference yielded preliminary research objectives for informing the development of coordinated management practices, as well as action needed for creating an organizational structure to gather and disseminate coordinated management information. These objectives and actions were refined and prioritized through a post-conference, iterative evaluation process called the Delphi process (Adler and Ziglio 1996). The intent of this process was to identify those research objectives and organizational efforts that both disciplines jointly identified as high priorities and to solicit new ideas developed or identified as a result of participation in the conference.

The steps of the Delphi process included:

1) **First Delphi Questionnaire:** Sixty-nine individuals received the first iteration Delphi questionnaire. They responded to questions regarding research objectives needed for development of coordinated management practices, and actions for the creation of an organizational structure to gather and disseminate information about coordinated management.
2) **Second Delphi Questionnaire:** Thirty-five respondents followed through to complete the second iteration Delphi questionnaire, representing a 51% response rate. Nine of these respondents (26%) identified food safety and 26 (74%) identified water quality as the best description of their primary area of expertise. To establish priorities in the second round, Delphi participants were asked to rank their preferences among 18 available choices carried forward from the first round. These choices were partitioned into 3 major themes of pathogen vector or pathways, management practices and mitigation, and risk management. Participants ranked objectives within themes. Participants were then asked, more broadly, to select their top 5 research priorities. Results presented here reflect the second Delphi questionnaire responses and a subsequent analysis of those second-round responses.
3) **Delphi Process Results Analysis:** Two methods of analysis were used to rank research objectives for those that most strongly exhibited consensus among both food safety and water quality participants. The more traditional method of ranking survey results is by a "Top Preference" method, in which one simply identifies that rank most often selected by respondents. The second method used to evaluate the results was the **D**istance-based ideal-seeking **C**onsensus ranking **M**odel (DCM), a new approach recently reported in the management sciences literature (Tavana et al. 2007). This is a mathematical approach for locating consen-

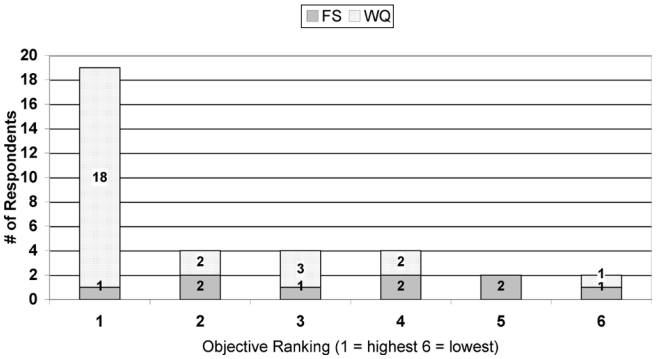

Figure 1. Preference results for objective #10: Identify the fate of pathogens captured through various conservation practices (e.g., grassed waterways, sediment basins, etc.).

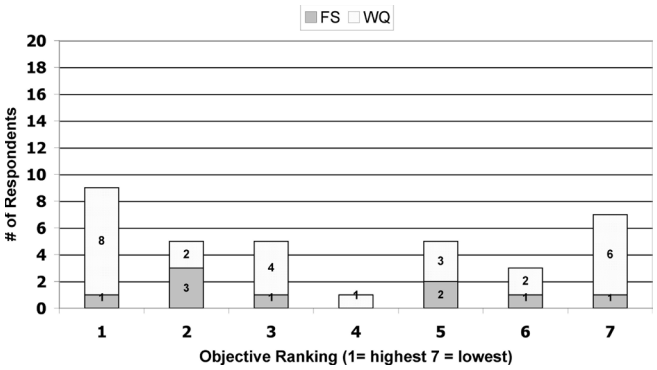

Figure 2. Preference results for objective #5: Identify animals, including smaller mammals and/or birds, which are significant pathogen vectors.

sus when respondents are asked to order their priorities. DCM rankings represent a simultaneous consideration of responses from all included respondents to all included options. Options were given the same priority number when DCM preference differences were not evident.

The DCM method was used to rank the responses of all respondents together, and then to separately consider rankings from respondents self-identified as Water Quality (WQ) or as Food Safety (FS) participants. Because there were 26 WQ respondents and 9 FS respondents, combined results are weighted in favor of the concerns of WQ respondents. The WQ responses tended to be consistent within the group. The responses of FS participants shows that their preferences were generally widely distributed among available options, but also did not show any clear or consistent disagreements. Figures 1 and 2 are included to demonstrate the effects of these patterns of response on the analysis of Delphi results.

Figure 1 illustrates results for Objective #10, which seeks to identify the fate of pathogens captured through various conservation practices (e.g., grassed waterways, sediment basins, etc.). This objective was ranked as the highest priority within the mitigation and management practice theme when measured by top preference or by combined DCM analysis, and selected as the top research priority overall. Results demonstrate the wide range in preferences expressed by FS participants with respect to this objective with nearly equal responses at all levels of ranking. Water Quality participants were more clearly in agreement that this was a preferred objective. Even with the lack of consensus among FS respondents, this objective achieves a very high priority.

Figure 2 represents a different response pattern for the objective of identifying animals, including smaller mammals and/or birds, which are significant pathogen vectors. In ranking by top preferences, this objective was ranked as the second highest priority. When evaluated by the DCM method, which compares all responses to the potential for unanimity to measure consensus, this objective falls to 4th-highest priority for water quality and food safety respondents combined. There were both food safety and water quality respondents who felt strongly that this was an important objective, and those who felt equally strongly that it was a lower priority.

Delphi responses for the research objectives shown in Figures 1 and 2 indicate that barriers would appear to exist for engaging both FS and WQ researchers in collaborative work to address these specific objectives. As previously noted, the intent of the Delphi process was to identify those research objectives and organizational efforts that *both* disciplines jointly identified as high priorities for immediate response. Additionally, although the following results report rankings for second-round Delphi objectives, it is important to remember that all of the objectives reported should be considered important since the Delphi process culls minor priorities.

RESULTS OF THE DELPHI PROCESS

What research should be conducted to better inform development of coordinated management practices?

Research Priorities

Results reported below reflect the outcomes of the second round of the Delphi questionnaire. In the second round, objectives chosen from a broader first-round list were carried forward for further consideration. The complete list of research objectives contained in the first Delphi, retained in the second-round Delphi, the distributions of individual responses for each second-round research objective, and both the top preference and DCM rankings for each objective, are included in the final report available on-line at http://groups.ucanr.org/wqfsconf/.

Consensus of both FS and WQ respondents attributed the highest priorities to research objectives related to the fate and persistence of pathogens. Research objectives were grouped into themes related to Pathogen Vectors or Pathways, Mitigation and Management Practices, and Risk Management.

Within themes of pathogen vectors or pathways and mitigation and management practices, the most highly prioritized research objectives for both food safety and water quality participants concerned:

- persistence and fate of pathogen in the crop and in conservation practices,
- pathways by which pathogens move through the crop production system, and
- the identification of environmental conditions that promote pathogen survival and proliferation.

Within risk management, the highest priorities identified by WQ respondents were:

Table 1. Research objectives identified during the San Luis Obispo conference selected by Delphi participants as their top 5 research priorities (*n* = number out of 35 participants who identified objective as one of their top 5).

	Top 5 Research Priorities	
	Water quality	Food safety
Objective #10 (Mgt Practice): 66% of respondents Identify the fate of pathogens captured through various conservation practices (e.g., grassed waterways, sediment basins, etc).	1 n=19	3 n=4
Objective #3 (Vector/Pathway): 51% of respondents Characterize pathogen pathways during crop production, harvesting, and packing.	2 n=12	1 n=6
Objective #4 (Vector/Pathway): 49% of respondents Characterize the persistence of pathogens in the growing and harvested crop.	3 n=11	1 n=6
Objective #5 (Vector/Pathway): 48% of respondents Identify animals, including smaller mammals and/or birds, which are significant pathogen vectors.	3 n=11	2 n=5
Objective #14 (Risk Mgt): 40% of respondents Specify proven practices that preserve food safety while improving water quality.	3 n=11	2† n=5

†Food safety participants also identified objectives seeking a way to categorize and rank specific sources of risk (n=5) as one of their top 5 priorities.

- specifying proven practices that preserve food safety while improving water quality, and
- development of risk assessment protocols that consider both food safety and water quality concerns.

While FS respondents agreed with the objective of risk assessment protocols, they identified a way to categorize and rank specific sources of risk as their highest priority.

Participants were asked to specify the "top 5" research priorities from a list of all 18 objectives presented in the major theme areas. Table 1 represents responses by WQ and FS, with major theme area noted.

New Research Priorities Identified

Participants in the first-round Delphi questionnaire were also asked to identify "new research priorities" they had identified after participation in the San Luis Obispo conference. Since not formally vetted in the first-round questionnaire by all participants, these ideas were considered separately in the second round of the Delphi. Participants were asked again to identify their "top 5 newly identified" short- and long-term research priorities from the following list, and the results are presented in Table 2.

Short-Term Actions

Respondents were asked to rank 4 "short-term actions that could be undertaken to further the goal of coordinated food safety and water quality practices" and to identify *specific* individuals to participate in these action items. The highest priority was assigned to the training of auditors to recognize and understand common production and conservation practices. Individuals from the University of California Cooperative Extension, the Western Institute for Food Safety and Security, the USDA Natural Resources Conservation Service, and certification providers were specified as potential participants in this action item.

Long-Term Actions

Respondents were asked to rank 5 "long-term actions that could be undertaken to further the goal of coordinated food safety and water quality practices" as well as to identify *specific* individuals to participate in these action items. The DCM evaluation assigned the highest priority to developing education and outreach materials explaining coordinated management for major produce buyers and consumer advocates. Individuals from produce trade associations and major retailers were identified as potential participants in this action item.

These action items are not specifically related to research, but rather seek to inform influential private industries outside the sphere of influence of the water quality and food safety research and regulatory communities.

What actions are needed to create an organizational structure for gathering and disseminating coordinated management information?

Organization Needs

The need for a Coordinating Council to help disseminate coordinated management information garnered the greatest consensus among all respondents. Eighty-three percent of respondents (85% of water quality and 78% of food safety professionals) indicated that a Coordinating Council is necessary. Throughout the Delphi process, no respondents were able to identify an existing forum for gathering and disseminating coordinated management information. Table 3 summarizes those organizations that approximately 70% of respondents selected from an offered list as ones that "should be included in the Coordinating Council". The respondents were asked to identify the role they felt this organization would play in the Coordinating Council. The role categories represent broad topics identified from participant comments during the first-round Delphi.

Table 2. Research objectives introduced as new research priorities selected by Delphi participants as their top 5 research priorities (n= number out of 35 participants who identified objective as one of their top 5).

Top 5 New Short-term Research Priorities		
	Water quality	Food safety
Objective #3: identified by 60% of respondents Develop course materials on food safety and water quality co-management	1 n=18	6† n=3
Objective #10: identified by 51% of respondents Develop a systems approach to water quality and food safety co-management .	2 n=13	1 n=5
Objective #8: identified by 43% of respondents Investigate the extent that beneficial microbial populations control pathogens in water, soils, on plants, and in manures.	3 n=11	3 n=4
Objective #1: identified by 40% of respondents Examine how pathogens respond to climate (solar radiation, temperature, humidity, wind, etc.)	4 n=9	1 n=5
Objective #7: identified by 34% of respondents Determine whether the probability that E. coli will move into food has been increased by regional developments (e.g., changes in riparian ecosystems, cultural practices, and processing).	5 n=8	3 n=4
Top 5 New Long-term Research Priorities		
	Water quality	Food safety
Objective #2: identified by 60% of respondents Determine whether farm practices significantly affect other pathogens, beyond E. coli O157:H7 (Salmonella, Campylobacter, Listeria, Cryptosporidium, etc).	2 n=14	1 n=7
Objective #1: identified by 54% of respondents Examine who pathogens respond to climate (solar radiation, temperature, humidity, wind, etc.)	2 n=14	2§ n=5
Objective #7: identified by 54% of respondents Determine whether the probability that E. coli will move into food has been increased by regional developments (e.g., changes in riparian ecosystems, cultural practices, and processing).	1 n=15	5 n=4
Objective #10: identified by 37% of respondents Develop a systems approach to water quality and food safety co-management.	4 n=10	6 n=3
Objective #17: identified by 34% of respondents Describe how the water management options are affected by different degrees of acceptable food safety risk (small, very small, extremely small, zero).	8‡ n=7	2 n=4

†Food safety participants identified objectives seeking to find ways to reduce pathogen loading into irrigation water (n=4) and to develop a water quality monitoring and reporting program (n=4) as one of their top 5 priorities.
‡WQ participants identified objectives #9 to develop a water quality monitoring and reporting program (n=9), #4 seeking to find ways to reduce pathogen loading into irrigation water (n=8), #3 Develop course materials on food safety and water quality co-management (n=8), and #14 to evaluate factors contributing to wildlife movement (n=7) as one of their top 5 research priorities.
§ FS participants identified objective #11 to derive a procedure to match food crops to specific fields upon which they can be grown securely (n=5) as one of their top 5 research priorities.

Responsibilities and Tasks Related to a Coordinating Council's Mission

Delphi participants were asked to select their "top 5" most important responsibilities related to a Coordinating Council's mission from a list of 10 items identified during the first-round Delphi survey. Food safety respondents assigned top priority for a Coordinating Council to provide a forum for discussion and resolution of food safety and environmental issues. Water Quality respondents prioritized leadership and direction in developing coordinated management strategies. Both agreed that promoting fundamental information transfer regarding water quality and food safety accountability, goals and objectives, mitigation and enforcement procedures, standards development, and monitoring and reporting program development as the second priority responsibility for a Coordinating Council.

Tasks Associated with a Coordinating Council

Respondents were not able to achieve consensus on the specific tasks of a Coordinating Council. The WQ respondents assigned the highest priority to the development of research priorities and coordination of research activi-

Table 3. Organizations selected by Delphi participants as ones that should be included in a Coordinating Council, and their role in a proposed council (*n* = 35).

Organization	Include in Council	Coordination	Research	Extension	Standards Setting	Monitoring
UC Cooperative Extension	29	12	18	23	2	5
California Department of Food and Agriculture	28	15	16	7	19	12
California Department of Health Services	27	13	16	2	17	13
Western Institute for Food Safety and Security	27	15	18	10	10	9
County Agricultural Commissioners	26	14	0	11	10	10
Regional Water Quality Control Boards	26	8	5	2	14	18
Grower/shipper Associations	25	12	3	14	6	7
USDA Agricultural Research Service	25	6	22	5	6	3
Western Growers Association	25	17	1	15	9	5
California Cattlemen's Association	24	13	7	14	5	8
California Department of Fish and Game	24	10	8	4	6	15
Environmental Protection Agency	24	12	15	1	12	11

ties and demonstration. No FS respondents selected this as a top 5 priority. Conversely, FS respondents identified the need to develop an information base and identify information gaps as their highest priority items, which were ranked 6th and 12th by WQ respondents, respectively.

Additional Action Items for a Coordinating Council

The greatest number of respondents (86%) identified engaging buyers, their insurance companies, attorneys, auditors, marketing firms, and representatives from their customer base to better understand food safety liability and litigation concerns. Respondents clearly indicated they felt a Coordinating Council was necessary and could identify those groups who ought to play specific roles within the council. The specific mission and tasks associated with a Coordinating Council did not achieve the same level of consensus.

DISCUSSION

The Coordinated Management of Water Quality and Food Safety Conference (April 2007 San Luis Obispo CA) and the ensuing Delphi process consolidated and prioritized the perspectives of participants regarding coordinated management of food safety and water quality practices initiated at the conference. Conference presentations, discussions, farm visits, and working groups used existing technical guidance to frame research and organizational objectives for inclusion in the iterative Delphi process. Delphi results showed broadly stated objectives generally received more support than narrower ones.

The initial premise of the San Luis Obispo Conference remains: "How can on-farm water quality management practices be co- managed with food safety initiatives in order to protect the environment and human health associated with the production and consumption of cool-season vegetables?" The Delphi results indicate two specific next steps:

1. applying specific research goals to general research priorities in coordinated management, and
2. creating an organizational structure to support co-management of food safety and water quality.

Conflicts for Central Coast co-management of food safety and water quality continue to evolve. There are two recognized sources of regulatory guidance for growers to identify strategies to protect food safety and water quality. The 'Introduction' to the "Commodity Specific Food Safety Guidelines for the Production and Harvest of Lettuce and Leafy Greens" (LGMA 2007) notes: "Growers should implement strategies that not only protect food safety but also support conservation practices, water quality, and habitat protection". The "Conditional Waiver of Waste Discharge Requirements for Discharges from Irrigated Lands" (Anonymous 2004), a regulatory program of the Central Coast Regional Water Quality Control Board, notes: "The intent of this Conditional Waiver is to regulate discharges from irrigated lands to ensure that such discharges are not causing or contributing to exceedances of any Regional, State, or Federal numeric or narrative water quality standard".

There are two recognized sources of technical guidance for growers to identify strategies to protect food safety and water quality. These are the Metrics (LGMA 2007) and the UC ANR Farm Water Quality Plan (Bianchi et al.

2008). Excerpts from these guidance documents were used in exercises during the conference farm visits to promote better understanding of on-farm food safety and water quality management strategies. Both the Metrics and the Farm Water Quality Plan (Farm Plan) have characteristics in common. Both technical guidance documents:

- employ an assessment format to identify appropriate strategies and actions,
- evaluate past land uses and adjacent land uses for their potential impact,
- assess the potential for pollutants to move onto and off of production fields,
- review crop production practices for their potential impact, and
- rely on the best available science and/or technical expertise, recognizing that not all practices have a complete research profile.

Growers are using these technical guidance documents. Through their involvement with handlers enrolled in the Leafy Green Marketing Agreement, leafy greens producers evaluate production systems with the Metrics. Estimates are that 99% of all California leafy greens handlers participate in this program (pers. commun., Dr. Hadi Tabbara, Western Growers Association, Nov. 2007). According to a February 2007 survey of Monterey County vegetable producers, more than 80% of the 181 survey respondents had completed Farm Water Quality Plans (Anonymous 2007).

As was demonstrated during the San Luis Obispo conference farm visits, a comparison of the guidance contained in the Metrics and the Farm Plan should help researchers to identify points of divergence in food safety and water quality practices. In combination with the general objectives identified in the Delphi process, those points of divergence could be used to identify specific research goals. Research goals that address the specific points of divergence stand to yield the greatest impact for coordinated management.

There are examples of conservation management practices, like Riparian Buffers, recommended in the Farm Plan that are practices of concern in the Metrics. The Farm Plan encourages growers to protect water quality in waterways by providing setbacks between cultural operations and waterways through the use of a Riparian Forest Buffer (NRCS 2006). Tall woody vegetation and low growing grasses are combined to provide a minimum of a 35-foot buffer between cropland and the adjacent water body. Riparian buffers are noted in the Farm Plan as filtering pollutants, reducing erosion, and providing wildlife habitat and shade. The Metrics, in the Environmental Assessments Section, ask producers to determine whether there is sufficient buffer distance maintained between the crop edge and riparian areas, asks if the distance is based on a risk assessment or authoritative citation, and requires documentation of the distances. No specific distances are included in the Metrics, in recognition of the many factors that might be found in a particular environment, and due to the lack of suitable science for defining "safe" distances.

Can research guided by the priorities identified in the Delphi process shed light on the use of riparian buffers in co-managing water quality and food safety? The identified research priorities, relative to the use of riparian buffers in proximity to leafy green production fields, are:

- identify the fate of pathogens captured in riparian buffers;
- characterize pathogen pathways from riparian buffers to crops during crop production, harvesting, and packing;
- characterize the persistence of pathogens and the role of adjacent riparian buffers in the growing and harvested crop;
- identify animals, including smaller mammals and/or birds, which are significant pathogen vectors that have the potential to be harbored by riparian buffers;
- specify under what conditions riparian buffers can be included as a proven practice to preserve food safety while improving water quality.

Conference participants considered similar questions during farm visits, and subsequently crafted their response about where those evaluations should occur, and who should lead the efforts. Conference participants and the respondents to the Delphi process assigned a high priority to the need for a Coordinating Council, and identified those entities to whom the initiation of that Council should fall:

- California Department of Food and Agriculture
- University of California's Cooperative Extension and Western Institute for Food Safety and Security
- California Department of Health Services
- Regional Water Quality Control Boards
- County Agricultural Commissioners
- Western Growers Association

Food safety *and* water quality respondents to the Delphi assigned a Coordinating Council the responsibilities of creating a forum for discussion and resolution of food safety and environmental issues, and providing leadership and direction in developing coordinated management strategies.

The Metrics and Farm Plan are available to a Council to begin a lively discussion of specific research goals for coordinated management. There are few points of direct conflict in recommended practices between these carefully worded documents. Newly proposed agricultural practices guidance, such as the Food Safety Leadership Council's On-Farm Produce Standards (2007), may provide increased areas of divergence. Yet, conflict is already evident in the actual removal of water quality management practices in response to food safety concerns. The Delphi process identified key Council participants, including those whose requirements for leafy greens production affect food safety and water quality management practices. A Coordinating Council's first challenge may be engaging full participation in the discussion of co-managing food safety and water quality. A far more complex challenge will be addressing the co-management of social, political, economic, legal, and regulatory concerns so that both human health and the environment are protected.

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