Towards Safer and More Sustainable Alternatives to Chlorpyrifos:

AN ACTION PLAN FOR CALIFORNIA

THE ALTERNATIVES TO CHLORPYRIFOS WORK GROUP, MAY 2020

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Summary of the five recommendations

THE WORK GROUP MAKES THE FOLLOWING RECOMMEN-DATIONS.

Short term:
immediately
(2020-2021)
Recommendations: 1.1, 1.2, 2.1.1, 2.2, 3.2, 4.1, 4.3, 4.4, 5.1, 5.3

Medium:
present - 5 years
Recommendations:
3.1, 3.3, 4.2, 5.2

Long term:
present - 20 years
Recommendations:
2.1.2, 4.3, 4.4, 5.4

1 OUTREACH TO GROWERS

- 1.1 Make sure all users of chlorpyrifos know about its ban and what that means for them.
- 1.2 Promote use of University of California's Pest Management Guidelines once they are updated to reflect the ban of chlorpyrifos.

2 BUILDING INSTITUTIONAL CAPACITIES

- 2.1 Reinvest in UC's Division of Agriculture and Natural Resources (UC ANR).
- 2.11 Rebuild UC Cooperative Extension system with an expanded, stable budget.
- 2.12 Revitalize the UC Statewide Integrated Pest Management Program.
- 2.2 Prevent new pests from coming into California and moving within the state.

3 REGULATORY IMPROVEMENTS

- 3.1 Adjust DPR staffing and priorities to reflect the high-priority need to identify alternatives to chlorpyrifos.
- 3.2 Expand the range of topics offered for pest control adviser certification and continuing education.
- 3.3 Report the changes in pesticide uses after the chlorpyrifos ban, and share this information with the public.

4 RESEARCH PRIORITIES

- 4.1 Invest in research to find immediate-term,crop-specific integrated pest management solutions.
- 4.2 Expand research on basic biology and ecology of pests and beneficial insects.
- 4.3 Invest long-term in research to support IPM.
- 4.4 Investigate the impact of changes in patterns of pesticide use and human and environmental exposure.

5 ROADMAP FOR FUTURE WORK

- 5.1 Deepen multi-sector collaboration on the future of pest management in California.
- 5.2 Find a shared language around agriculture, environmental protection, communityhealth, and consumers.
- 5.3 Explore monitoring and enforcement of existing regulations.
- 5.4 Invest in systems-based research to explore alternative approaches to agricultural production and effective pest management.

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Background

IN MAY 2019, THE CALIFORNIA ENVIRONMENTAL PROTECTION AGENCY (CALEPA) ANNOUNCED THAT THE DEPARTMENT OF PESTICIDE REGULATION (DPR) WAS TAKING ACTION TO BAN THE USE OF THE PESTICIDE CHLORPYRIFOS IN CALIFORNIA TO PROTECT PUBLIC HEALTH, WORKERS AND THE ENVIRONMENT.

DPR's action followed "mounting evidence that chlorpyrifos is associated with serious health effects in children and other sensitive populations at lower levels of exposure than previously understood, including impaired brain and neurological development."[1] On October 9, 2019, CalEPA announced[2] that virtually all uses of chlorpyrifos in California would be banned after December 31, 2020, following agreement between DPR and pesticide manufacturers to withdraw their products.[3]

As part of the announcement of the chlorpyrifos ban, DPR and the California Department of Food and Agriculture (CDFA) announced the establishment of a cross-sector work group "to identify, evaluate and recommend safer, more sustainable pest management alternatives to chlorpyrifos."

The recommendations of the Alternatives to Chlorpyrifos Work Group (referred to as the "Work Group" throughout this document) are presented here. They are the product of hundreds of hours of volunteer time by a diverse cross-section of stakeholders, including:

- Community and labor representatives
- Licensed pest control advisers
- Crop protection product registrants
- Farmer and crop interests
- County agricultural commissioners
- Researchers from a variety of disciplines including pest management and public health.[4]

[1] Findings of the Scientific Review Panel on the Proposed Identification of Chlorpyrifos as a Toxic Air Contaminant: https://www.cdpr.ca.gov/docs/whs/pdf/chlorpyrifos_srp_findings.pdf

[2] Press release: Agreement Reached to End Sale of Chlorpyrifos in California by February 2020 https://calepa.ca.gov/2019/10/09/press-release-agreement-reached-to-end-sale-of-chlorpyrifos-in-ca-by-feb-2020/

[3] Specific use and sale conditions for chlorpyrifos products are available at: https://www.cdpr.ca.gov/docs/chlorpyrifos/pdf/general_notice_append_o.pdf

[4] Appendix 10 lists members of the work group.

Leadership at CDFA, CalEPA, and DPR selected members for their expertise and perspective.

The group's charge was broad and ambitious: "The main goal of the work group[5] is to develop short- and long-term action plans to identify and develop safer, more sustainable alternatives to chlorpyrifos. The Work Group will leverage the work of experts from across the globe to identify and develop pest management tools. Ultimately the group is tasked to:

- Provide practical, short-term solutions (that can be implemented between 3 and 12 months) to begin the transition to safer, more sustainable pest management solutions.
- Provide direction for a five-year action plan on how to strategically manage pests using safer, less toxic alternatives. DPR and CDFA anticipate that this plan will include the estimated costs of, and opportunities and barriers to, implementing it, as well as information on possible resources to support continued research, production trials, and outreach to the grower community.
- Consider issues including farm worker safety, community health, efficacy, and climate-smart solutions as it seeks to develop alternatives to chlorpyrifos."

Over the course of five months, the Work Group met in three all-day sessions (with the final session being held virtually because of the COVID-19 crisis). Work Group members reviewed materials and reports provided by other members and the facilitation team and participated in 10 small- and full-group calls as well as multiple email exchanges in developing their recommendations.

In January of 2020, DPR hosted listening sessions in Sacramento, Fresno, and Oxnard to get public input on the draft recommendations and to surface issues and ideas around safer and more sustainable alternatives to chlorpyrifos. More than 300 individuals attended these meetings. For individuals unable to attend a public meeting, DPR also offered an online option for submitting comments. Many Work Group members participated in the listening sessions, and all members reviewed the summary of public input that DPR and the facilitation team prepared.[6]

The group took a collaborative, mutual learning approach to developing these recommendations. Its deliberations were guided by an agreement to focus on common interests, share all relevant information, and honor the differing professional and personal experiences of members. Decisions were made by consensus, using "good enough" or "I can live with this" as the threshold for agreement.

The task given to the Work Group was neither simple nor easy. It's dual mandate to identify safe short-term alternatives to chlorpyrifos, and to establish an action plan that would lead to safer and sustainable pest management solutions, required different problem-solving approaches and expertise. The Work Group worked diligently to prepare the information presented below on known alternatives to chlorpyrifos and made recommendations on how to accelerate development of safer and sustainable alternatives. *However, the scope of the mandate and the timeline of the Work Group meant much of the work given to the group was flagged as needing additional time and expertise to complete.* Such instances are noted throughout the report, and recommendation 5 identifies additional areas where the group agreed additional work is needed.

In crafting its recommendations, the group relied on currently available research and reports, particularly *Identifying and Managing Critical Uses of Chlorpyrifos Against Key Pests of Alfalfa, Almonds, Citrus and Cotton*,[7] the University of California's Integrated Pest Management Guidelines,[8] and data provided by members. The use of generally accepted public sources of data allowed the group a common language to work from. The results

[5] From DPR's chlorpyrifos cancellation FAQ: https://www.cdpr.ca.gov/docs/chlorpyrifos/faq.htm

[6] Appendix 9 summarizes public input.

[7] The 2014 DPR and UC ANR report *Identifying and Managing Critical Uses of Chlorpyrifos Against Key Pests of Alfalfa, Almonds, Citrus and Cotton* was the starting point for many of the discussions. http://ipm.ucanr.edu/IPMPROJECT/CDPR_Chlorpyrifos_critical_use_report.pdf

[8] https://www2.ipm.ucanr.edu/agriculture/

are the tables of alternatives presented below.

The five central recommendations in the report have equal priority, and vary in their timing, but the Work Group stressed that work towards all of these recommendations should begin immediately.

The recommendations span from improving outreach to the agricultural community about the ban of chlorpyrifos, to investments in research on alternatives, to continued dialogue on how to achieve an even safer pest management regime in California. Recommendations that can be achieved in the short term (within the next 12 months) are identified in **GREEN** text. Recommendations that the group suggests begin immediately and could be achieved in the medium term (within the next five years) are identified in **ORANGE** text. Long-term recommendations (more than five years to achieve implementation, but beginning immediately) are identified in **BLUE** text. Recommendations include a responsible party, an expected action date, and a budget where applicable. For many recommendations with budget implications, the Work Group provided as much detail as they were able to within the timeframe of the project, and acknowledged that more time to consider budget proposals would be beneficial. Additional work needed to refine the recommendations is noted.

All recommendations received consensus endorsement of the Work Group with the caveat that proposed funding levels, priorities, and timeframes are what most members feel are ideal but, due to time limitations, have not been fully vetted and agreed upon by the full group. All funding proposals included in the report are for new/increased support.

COVID-19 AND THIS REPORT

As the Work Group was completing its labors, the COVID-19 pandemic was looming in the background. The final meeting of the group, scheduled to be in-person on March 16, 2020, was converted to a virtual meeting. This meant that critical dialogues on the final language and funding recommendations of the report and capturing the nuance of varying perspectives of the path forward towards safe and sustainable chlorpyrifos alternatives were conducted under shelter-in-place recommendations or orders. *As a result, the Work Group strongly recommends that a successor effort be convened to complete this and other unfinished work.*

In developing its recommendations, the Work Group raised several concerns that it was not able to resolve:

- Despite the group's best efforts to identify safer and more sustainable alternatives to chlorpyrifos for all crops in California agriculture, it found none that are immediately available for a number of pest-crop combinations. These crops are at higher risk for pest damage and economic loss and include crops grown at scale as well as smaller-acreage specialty crops.
- Group members differed on their perspectives of the timeframe for the group's recommendations. This reflects the challenge of the group's dual mandate. Some members felt that priority should be given to the short-term need to identify pest management solutions that could be used in place of chlorpyrifos immediately. Others considered that discussions should focus on long-term, big-picture shifts in pest management practices and agricultural systems. While a significant portion of the Work Group's time was devoted to exploring these differences and seeking potential common ground, significant additional work is needed to create a common long-term vision for safe and sustainable pest management.
- Concern was expressed that the work of the group not be characterized as recommending a particular alternative practice or pesticide. The group presented data it was able to collect on alternatives that are currently available, but did not make specific recommendations to either the efficacy or safety of these alternatives. The Work Group provided what safety and efficacy data it could find without endorsing or evaluating that data.
- Many members expressed concern that there continues to be misunderstanding of the roles, activities, and concerns of stakeholders in the system. Addressing this lack of shared knowledge, experience, or trust in the system is a key recommendation of the group. The group highlighted two examples of key interests whose needs and perspectives need to be better understood and accounted for: 1) farmworkers and communities who experience impacts from pest management practices, and 2) licensed pest control advisers (PCAs) who ensure safe and sustainable pest management.
- The Work Group did not assess the cost-effectiveness of safe and sustainable alternatives. While the group recognized the importance of understanding and addressing potential economic impacts, it did not have the time or expertise to delve into the efficacy or cost trade-offs of alternatives.[9]
- The Work Group was unable to reconsider its funding recommendations in the context of the COVID-19 crisis and its impact on the state's finances and budget priorities. While the group felt strongly that investment in capacity and research around safe and sustainable alternatives is critical, it was not able to calibrate its recommendations to this newly-arising budget reality.

Managing agricultural pests in a state as populous and agriculturally diverse and productive as California is inherently complex.

In many places throughout the state, globally important agricultural production takes place immediately next to homes and communities. Work Group members called for a deeper exploration of how to move to safer alternatives that result in a secure food supply, healthy communities, and an improved environment. Recommendation 5 lays out a road map for this work; it calls for bringing together diverse voices to achieve systemwide pest management that is safe and effective, while maintaining the quality and diversity of agricultural production for which California is known.

[9] CDFA and UC produced a 2019 report that includes economic analysis for some of the affected crops: *Economic and pest management evaluation of the withdrawal of chlorpyrifos: six major California commodities* https://www.cdfa.ca.gov/files/pdf/ChlorpyrifosReport.pdf

Key Acronyms and Terms

AI: active ingredient. This is the ingredient in a pesticide product that controls pests. Active ingredients include biopesticides/biologicals (which are derived from natural materials) or synthesized ingredients.

CalEPA: California Environmental Protection Agency

CDFA: California Department of Food and Agriculture

DPR: California Department of Pesticide Regulation

IPM: Integrated pest management. Definition from the UC Statewide Integrated Pest Management Program: an ecosystem-based strategy that focuses on long-term prevention of pests or their damage through a combination of techniques such as biological control, habitat manipulation, modification of cultural practices, and use of resistant varieties. Pesticides are used only after monitoring indicates they are needed according to established guidelines, and treatments are made with the goal of removing only the target organism. Pest control materials are selected and applied in a manner that minimizes risks to human health, beneficial and nontarget organisms, and the environment.[10]

PCA: Pest control adviser. This is a licensed professional agricultural production consultant who makes written recommendations on pest management. California Department of Pesticide Regulation manages the licensing program.

PUR: Pesticide use reports.[11] In California, all agricultural pesticide use must be reported monthly to county agricultural commissioners, who in turn, report the data to DPR. DPR makes the pesticide use report publicly available through their PUR database.

Short-Medium-Long Term: The Work Group used these terms to identify when results of implementing the recommendation could be expected. The group suggested that all of the recommendations begin implementation within 12 months, but recognized that some would have longer time horizons for results. Short-term refers to recommendations that can be completed in the next 12 months. Medium-term refers to recommendations that will take up to 5 years to be completed. Long-term refers to recommendations that will take more than 5 years to complete.

UC: University of California

UC ANR: University of California Division of Agriculture and Natural Resources

UC Cooperative Extension: Within UC ANR, the UC Cooperative Extension network of researchers and educators cooperates with farmers, the ag industry, and state and government agencies to develop and provide science-based information to solve locally-relevant economic, agricultural, natural resource, youth development and nutrition issues.

UC IPM Program: Within UC Cooperative Extension, the UC Statewide Integrated Pest Management Program develops science-based, peer-reviewed integrated pest management guidelines, conducts field research, and provides pest management information to growers and pest control professionals throughout California.

USDA: U.S. Department of Agriculture

USDA-APHIS: U.S. Department of Agriculture, Animal and Plant Health Inspection Service

[10] https://www2.ipm.ucanr.edu/What-is-IPM/

[11] https://www.cdpr.ca.gov/docs/pur/purmain.htm

Currently Available Alternatives to Chlorpyrifos

One of the charges given the Work Group was the identification of safe and sustainable alternatives to chlorpyrifos that could be used immediately or brought into use in the short-to-intermediate term (one to three years). To accomplish this goal the group drew from publicly available data to assemble a comprehensive list of currently available alternatives. This work is presented in five tables described below and included in the appendices to this document.

The Work Group shares this information as a resource. It has not been vetted, evaluated or endorsed by the group for efficacy in addressing target pests, for impacts on community health and the environment, or for cost effectiveness.

The group discussed at length what alternatives to include. Some members emphasized that some alternatives exist as options, but do not offer a sufficient solution to replace chlorpyrifos because the alternative may not be as effective at controlling the target pest, or because it may be prohibitively costly. Others expressed concern that while these known alternatives are legal to use, they may present risks to other public interests, including public health and the environment, and would continue a practice of product substitution as opposed to a systematic approach to pest management.

Ultimately, the group agreed to compile the readily-available, legal alternatives that it could identify during the group's work together, to organize the content to make the information as accessible as possible, and to provide this as a resource without endorsement. As part of this work, the group also assembled information on relative health risk of alternatives. The Work Group gratefully acknowledges the support of the Department of Pesticide Regulation in the compilation of these tables.

Members acknowledged that a deeper exploration of longer-term alternatives would be beneficial, but recognized that this was not possible to address in this action plan because of the time limits of this project. As a result, the group called for continued development of cross-sector dialogue to identify long-term alternatives that could be suitable for California growers, workers, children, and consumers (see recommendation 5).

Table 1:

UC Integrated Pest Management's Pest Management Guidelines

The UC Statewide Integrated Pest Management Program develops guidelines that are written by crop scientists based on research, efficacy trials, and regulatory information. The guidelines are peer-reviewed before publication and revised regularly.

The information in this table comes from the published UC Pest Management Guidelines. The list consolidates that information for ease of reference, without any endorsement.

To create this list, the Work Group:

- Identified all crop-pest combinations for which chlorpyrifos was listed as a pest management tool in the UC Pest Management Guidelines prior to the announcement of the chlorpyrifos ban.
- Compiled the pest management options that are currently[12] included in the UC Pest Management Guidelines for each of these crop-pest combinations. These options include monitoring methods, information regarding cultural and biological controls, and alternative pesticides in the cases where alternative pesticides are approved for this crop-pest combination.

Appendix 1 Table 1: Alternatives to chlorpyrifos in UC Pest Management Guidelines

[12] As of April 2020.

Tables 2A/2B and 3A/3B:

Relative toxicities of insecticides that are listed as alternatives to chlorpyrifos in one or more of the UC Pest Management Guidelines published by the UC Statewide Integrated Pest Management Program

The group agreed that many alternatives to chlorpyrifos also present risks. Without the time and expertise to fully consider the relative toxicities of these alternatives during this specific project, the group agreed to create a compilation of the existing, publicly-available toxicity information about the active ingredients that are in Table 1 (Alternatives to chlorpyrifos listed in UC Pest Management Guidelines). The group identified the categories of information that it wanted to include, and requested DPR to compile the data. This information is presented in two ways:

- a quick-guide version that highlights AIs with higher risk profiles (Table 2A for agricultural crops, and Table 2B for floricultural crops)
- a version with links to source materials (Table 3A for agricultural crops, and 3B for floricultural crops)

Appendix 2 Table 2A: Agricultural crops

Relative toxicities of insecticide active ingredients that are listed in Table 1 as alternatives to chlorpyrifos according to the UC Pest Management Guidelines for agricultural crops

Appendix 3 Table 2B: Floriculture

Relative toxicities of insecticide active ingredients that are listed in Table 1 as alternatives to chlorpyrifos according to the UC Pest Management Guidelines for floriculture

Appendix 4 Table 3A: Agricultural crops, with links to source materials

Relative risks of chlorpyrifos alternatives identified in UC Pest Management Guidelines for agriculture, including links to product information reports, safety data sheets, and other documents used to generate Table 2A

Appendix 5 Table 3B: Floriculture crops, with links to source materials

Relative risks of chlorpyrifos alternatives identified in UC Pest Management Guidelines for floriculture, including links to product information reports, safety data sheets, and other documents used to generate Table 2B

Table 4:

Biopesticides currently registered in California that are approved for use on crops where chlorpyrifos has been used in the past

The Work Group requested the Department of Pesticide Regulation to prepare a comprehensive list of biopesticides that are registered for use in California and may be alternatives to chlorpyrifos. The group noted that most biopesticides are intended to be used as part of a comprehensive integrated approach that may involve the use of conventional pesticides and other biologicals. The Work Group acknowledged the need for more research into the efficacy of these products and how they could be better integrated into IPM systems.

Appendix 6 Table 4: Crops in which biopesticide active ingredients may be used in California

Table 5:

Crops with no alternatives identified

The Work Group identified from data in DPR's pesticide use reports (PUR) a number of crops, generally grown on a smaller scale in California, that have used chlorpyrifos in the most recent years for which data are available, but there are no UC pest management guidelines for these crops. Therefore, no existing alternatives or data were identified by the group. Table 5 lists the crops with the highest use rates but no UC pest management guidelines available.

Appendix 7 Table 5: Crops with significant use of chlorpyrifos, but no UC pest management guidelines

Recommendations

1 OUTREACH TO GROWERS

One of the first priorities the Work Group identified was to ensure that information about the end of chlorpyrifos use in California was clearly and widely communicated to producers and others who are involved in chlorpyrifos use. The group recommends these actions be taken immediately.

1.1 MAKE SURE ALL CURRENT USERS OF CHLORPYRIFOS KNOW ABOUT ITS BAN AND WHAT THAT MEANS FOR THEM.

Growers who include chlorpyrifos in their management approaches need to hear clear, consistent messaging about the practical details of the chlorpyrifos ban so they can meet the new regulatory requirements and put plans in place for future production cycles.

The Work Group recommends that in addition to the outreach that has already been conducted by DPR, CDFA, and the Ag Commissioners, regulatory agencies craft the communications about what is changing so that the messaging is consistent, and partners can communicate this information widely and accurately. The group requests that this outreach include easy-to-read, visually engaging materials in multiple languages that are easy to distribute digitally and in hard copy. The group notes that DPR would need to work with partners to make sure that the messages reach everyone who is affected. This may require making specific efforts to reach grower communities who may not have extensive contact with general agricultural communication channels, very small-scale producers, and producers and pesticide applicators whose primary language is not English.

Relevant details to share in the materials could include:

- technical details of the ban
- relevant dates for all components of implementation of the ban
- information about options to work with local dealerships to ensure that unused stocks of chlorpyrifos are collected prior to the deadline
- resources for identifying readily-available alternatives
- brief explanation that medium- and longer-term solutions are in development

Who: DPR to lead content development, outreach planning, and coordination. Partner with others (such as UC Cooperative Extension, commodity boards, pest control advisers, county agricultural commissioners, environmental justice groups, tribal rancheria environmental directors, and professional associations) to share the message and identify additional ways to target those affected by the ban.

When: Immediately (2020)

1.2
PROMOTE USE OF UC PEST MANAGEMENT GUIDELINES ONCE THEY ARE UPDATED TO REFLECT THE BAN OF CHLORPYRIFOS.

The group recognizes the Pest Management Guidelines[13] developed by the University of California Statewide Integrated Pest Management Program (UC IPM) as consistent, in-depth, peer-reviewed resources to support pest management. It recommends that these guidelines be promoted as a key set of resources.

As of this report's publication, chlorpyrifos is included in the UC Pest Management Guidelines only for uses that are legal in 2020 under DPR permit guidelines. After the cancellation goes into full effect in 2021, the guidelines will be updated to reflect that virtually all uses of chlorpyrifos, except granular formulations, will no longer be a legal management option in California.[14]

The group recommends an outreach campaign promoting the updated UC guidelines. This could include sharing the guidelines widely, holding face-to-face training sessions on the information the guidelines contain, conducting on-farm demonstrations of the range of tools, and providing ongoing technical assistance to support growers of these crops.

Who: UC IPM revises Pest Management Guidelines. Partners (such as UC Cooperative Extension, pest control advisers, commodity boards) amplify outreach and education based on the guidelines.

When: Initial revision and outreach: short term (2021)

[13] See https://www2.ipm.ucanr.edu/agriculture/

[14] Refer to DPR for full details of the cancellation: https://www.cdpr.ca.gov/docs/chlorpyrifos/index.htm

2 BUILDING INSTITUTIONAL CAPACITIES

The Work Group identified the long-term loss of capacity in the University of California's Cooperative Extension and Statewide Integrated Pest Management programs housed at the University of California as a limiting factor in research on and implementation of alternatives to chlorpyrifos. It strongly recommends a reinvestment in the University of California's research and extension infrastructure as a central strategy both to bring alternatives to chlorpyrifos forward as well as to move towards effective, ecologically sound, and even safer integrated pest management programs.

2.1 REINVEST IN UC'S DIVISION OF AGRICULTURE AND NATURAL RESOURCES (UC ANR).

Within UC ANR there are two main engines that drive institutional capacity around agricultural production and broader food systems in California. These are:

- UC Cooperative Extension, which takes a whole-systems approach that bridges science, industry and outreach to provide trusted third-party support for growers to manage their agricultural systems, and
- UC Statewide Integrated Pest Management Program, which develops peer-reviewed recommendations to manage pests with the most effective and least toxic combinations of practices (including active ingredients and many other practices).

The Work Group recommends reinvestment in these institutions to leverage the value of their existing expertise and rebuild their institutional resources so they can play a strong leadership role in developing critical public goods: strong agricultural economies, resilient food systems, and healthy communities.

The group suggests that, going forward, additional capacity for these UC entities should support development of a next-generation set of pest management approaches that over time move towards safer and more sustainable practices for all California crops. These approaches should include refinement of traditional crop and integrated pest management practices such as cultural, biological and chemical controls; and, they should include research into practices such as precision agriculture and holistic approaches such as regenerative agriculture, soil health, and agroecology-based practices. The group recommends that this increased capacity be built with an emphasis on serving agriculture of all scales in balance with the needs of their surrounding communities, human and environmental health, and the state's need for a sustainable and resilient economic and food system.

2.1.1
REBUILD UC COOPERATIVE EXTENSION SYSTEM WITH AN EXPANDED, STABLE BUDGET.

The UC Cooperative Extension system houses the statewide IPM program.

But it does much more. The Cooperative Extension network has a presence in every county of California. Its specialists and advisors support their districts on topics ranging from agricultural production, urban/peri-urban agriculture, nutrition, and Master Gardener programs. A stronger, better-funded Cooperative Extension system would amplify the integrated pest management advisers' work throughout the broader network of agricultural advice to California growers, gardeners, aspiring farmers, and communities.

Cooperative Extension operates with approximately half the staff positions it did in 1990, and continues to grapple with funding uncertainties. The Work Group identifies the need to increase the number of Cooperative Extension specialists, advisors, and outreach staff. They specifically noted that implementing this action plan would require additional new staff beyond staffing increases that are already planned.

The IPM technique of biological control bears special mention here. At its height of biocontrol capacity in the 1980s, UC had almost 40 entomologists working at least part-time in this field. Today, there are only two faculty actively working in this area. The Work Group recommends increasing UC staffing for biocontrol as the field is important in controlling pests generally, as well as invasive pests in particular.

The group understands that it may be necessary to approach restored funding for Cooperative Extension in an incremental way that would be consistent with state budget capacity and allow for a ramp-up in operations. Additionally, the Work Group notes that specialist roles require highly focused expertise, so these roles are challenging to hire for. This highlights the linkage between institutional strengthening and basic research, in that a new generation of trained researchers and advisors will be needed to staff up these institutions.

FUNDING PROGRESS IN THE COVID-19 ERA

The Work Group recognizes that the COVID-19 crisis will force the reevaluation of spending priorities in the State budget. Making the case for investing in reduced-risk pest management will require a robust and diverse coalition of agricultural and community interests who understand the shared need for public and private funding. Helping frame this case more fully and disseminating it widely is a high-priority task for a successor work group. It recognizes that with such an investment comes a responsibility for demonstrating results and impact, and recommends that mechanisms to do this be explored.

THE WORK GROUP SPECIFICALLY RECOMMENDS:

1 Short-term funding: Specific funding for new positions to develop alternatives to chlorpyrifos for the crops most at risk from its cancellation. A budget increase of $5 million would support at least 30 new positions and associated costs that the Work Group identified as necessary for this work. These roles could include approximately five specialists, 10 advisors, and a communications role to support multilingual outreach. To complete this work, these would need to be newly created positions, beyond the hiring already anticipated.

2 Planning for long-term funding: UC Cooperative Extension would need an estimated initial increase of $20 million in its annual budget to staff up and deliver the full role that has been recommended in this action plan. This level of funding would support approximately 100 new full-time positions to support California agriculture and valuable programs in IPM, biological control, and multilingual outreach. These positions could include approximately 20 specialists, 80 advisors in agronomy and specific disciplines, and multilingual outreach and support staff. The Work Group recommends that a $5 million increase continue yearly until full funding for these new roles is reached.

Who: UC Agriculture and Natural Resources recommends to UC President for inclusion in its budget request.

When: Short term, and sustained long term

Funding level: $5 million in additional general fund allocation to address the most critical immediate needs (for new positions beyond hiring that is planned for 2020/2021); increasing biennially by an additional $5 million from the general fund, until reaching approximately $20 million of additional annual funding by 2029.

2.1.2
REVITALIZE THE UC STATEWIDE INTEGRATED PEST MANAGEMENT PROGRAM.

The UC Statewide IPM Program encourages ecosystem-based approaches to pest management that minimize use of pesticides throughout California.

One aspect of the program is development of the UC Pest Management Guidelines, which are grounded in efficacy and toxicity research, and which have been field-tested and peer-reviewed by technical experts. It is from these guidelines that Table 1 (Appendix 1) was created to demonstrate a list of possible alternatives to chlorpyrifos.

The program's advisors also support growers through workshops, advice, and research to advance development and use of pest management practices that take ecological and community systems into account. This outreach is specific to pest management by crop or discipline, and nests into the broader UC Cooperative Extension network of research and outreach to support agricultural and food systems. Increased capacity would be needed to ensure that the diverse range of crops and cropping systems in California receive adequate attention.

Decades of erosion in funding for the Division of Agriculture and Natural Resources has reduced development and adoption of IPM practices in three ways:

The resulting budget reductions within UC ANR have reduced the capacity of the Statewide IPM Program to support and promote

collaborative research and extension projects focused on longer-term agricultural systems management.

Loss of specific Cooperative Extension IPM advisor positions has resulted in significant geographic and discipline gaps in integrated pest management in California.

The overall decline in Cooperative Extension county-based advisor positions has reduced the depth and breadth of subject-matter expertise available for developing and supporting on-farm adoption of crop-specific IPM tactics.

Increased, sustained investment will strengthen UC IPM's capacity to conduct research and extend information on integrated pest management so that lower-risk pest management practices can support a thriving agricultural economy throughout California.

The Work Group recommends $3.5 million of additional core funding per year for the UC Statewide IPM Program.

This would elevate staffing levels to support continued development of the UC Pest Management Guidelines, expand the number of crops and frequency of updates, manage statewide data, and support field staff's research and extension work with growers.

Who: UC IPM Director recommends to UC Agriculture and Natural Resources VP and UC President for inclusion in budget requests. Other vehicles for capacity-building funds may include USDA specialty crop block grants, USDA-NIFA, DPR alliance grants, and other research-based sources of funding.

When: Beginning in the short term (next 1-2 years), and sustained for long term (beyond five years).

Funding level: $3.5 million annually from the general fund.

2.2
PREVENT NEW PESTS FROM COMING INTO CALIFORNIA AND MOVING WITHIN THE STATE.

Stopping a pest before it spreads throughout the state is far less expensive than eradicating or managing the pest once it is established. Preventing a pest from coming into a new area requires strong institutions and strong coordination at county, state and federal levels.

THE WORK GROUP THEREFORE RECOMMENDS:

1. Increasing and sustaining funding to support staffing and institutional cooperation between federal, state, and county agencies that manage pest inspection, detection and exclusion at entry points into California. Specifically, this could include maintaining full funding and ensuring long-term oversight of the CDFA High Risk Pest Exclusion program.
2. Evaluating current staffing needs in order to provide adequate program coordination and oversight.
3. Strengthening public understanding of the importance of pest movement to the state's agricultural and wildland ecologies, economy and food supply. Outreach campaigns and community science opportunities could support this public understanding.

Who: CDFA for state roles. USDA Agriculture and Plant Health Inspection Service for federal roles, including outreach to federal representatives to emphasize the importance of these investments.

When: Medium term

Funding Level: Current funding levels may be sufficient for the program itself, but overall administrative, scientific, and diagnostic lab support capacity at CDFA impacts the programs. The Work Group was not able to explore the scale and nature of this funding and recommends that the needs for full implementation of these programs be explored.

3 REGULATORY IMPROVEMENTS

The Work Group recognizes DPR's responsibility is, first and foremost, to protect human health and the environment in the registration and regula tion of pesticides. It also is the Agency most central to the approval of new, safe and sustainable alternatives to chlorpyrifos. In this set of recommen dations, the group identified several steps DPR could take to more quickly review and approve these alternatives to chlorpyrifos while continuing to maintain the State's rigorous standards. The key strategies recommended focus on prioritization and resource allocation at DPR that would allow it to meet statutory timelines, expansion of training options for PCAs to include more focus on non chemical alternatives, and for transparent information sharing around what alternatives to chlorpyrifos actually are used once the ban is complete.

3.1 ADJUST DPR STAFFING AND PRIORITIES TO REFLECT THE HIGH-PRIORITY NEED TO IDENTIFY ALTERNATIVES TO CHLORPYRIFOS.

The chlorpyrifos ban creates a gap in pest management options for some crop/pest combinations. This means some growers will have an urgent need for other ways to manage these pests. Several alternatives to chlorpyrifos have been submitted to DPR for review, and are still pending.

The Work Group recommends that DPR take the following actions to bring new alternatives to the market efficiently and safely under a consistent, transparent, and science-based regulatory framework:

1. Prioritize the review of alternative active ingredients if all required data have already been submitted.
2. For potential alternatives that are submitted in the future, adhere to the review timelines that are defined in regulations.
3. Identify options to address needs for immediate alternatives for some crop/pest combinations. Short-term alternatives may include exemptions such as emergency exemptions (Section 18), special local needs (Section 24(c)), and special use exemptions (Section 2(ee)).[15] One option may be that if there is no identified alternative for a crop/pest combination in California, and an active ingredient is approved at the federal level for that crop/pest combination, DPR could consider a temporary conditional approval for a defined period.
4. Complete and implement the Pesticide Registration Data Management System (PRDMS). This project would allow for online data submission and data management to facilitate the registration process. Currently, documents are submitted in hard copy. Registrants' fees were increased to fund the PRDMS project and other costs associated with registration, but the system has not been developed and the timeline for completion is not clear.[16] Getting this system up and running is essential for a more efficient registration process.

[15] Section 2(ee) "conflict with labeling" exemptions are reviewed federally, not by DPR.
[16] The original project was cancelled in 2019. DPR completed a new request for information in early 2020.

5. Update requirements, including statistical data, for product efficacy research trials.

Beyond this short-term need, the Work Group suggests additional options to prevent backlogs of registration reviews in the future. These suggestions include:

1. Ensure that DPR has sufficient staff, funding or other necessary resources to avoid bottlenecks in the process. Timelines for registration reviews that are described in regulations should be met in practice.
2. Conduct more registration reviews concurrently with the pesticide registration process at the federal level through the U.S. Environmental Protection Agency while maintaining California's often more stringent standards.[17]
3. Explore a modified registration process for lower-risk pesticide products[18] regulated by DPR that may be a potential alternative to chlorpyrifos.

Who: DPR

When: Short-to-medium term

Funding: A specific funding proposal was not developed for this recommendation.

[17] DPR accepts concurrent reviews for (1) new products containing new active ingredients, (2) new products and amendments to human health antimicrobials, and (3) new products and amendments to products that will be used in a public health program.

[18] Lower risk pesticides include a broad range of alternatives including biopesticides which the US EPA defines as pesticides derived from such natural materials as animals, plants, bacteria, and certain minerals. Biopesticides include biochemical pesticides, microbial pesticides, and plant-incorporated protectants (PIPs). The US EPA maintains a list of approved biopesticides.

3.2
EXPAND THE RANGE OF TOPICS OFFERED FOR PEST CONTROL ADVISER CERTIFICATION AND CONTINUING EDUCATION.

The Department of Pesticide Regulation oversees the Agricultural Pest Control Adviser (PCA) licensing program.[19] This license is for making recommendations for agricultural pest management; it requires college coursework and passing DPR-administered exams on pest management regulations and specific types of pests (such as insects, weeds and pathogens). Once licensed, pest control advisers need to earn continuing education units by taking DPR-approved classes or attending professional development events in order to renew their licenses every two years.

photo by James Nolan

The Work Group recommends that DPR expand the topics of coursework that can apply towards pest control advisers' initial certification and continuing education units.

Topics that the Work Group suggest that DPR consider for PCA licensing and recertification include integrated pest management focusing on non-chemical alternatives, plant health systems approaches, beneficial insects, water and nutrient management, crop system diversification, and soil health.

Who: DPR

When: Short term

Funding: No additional funding is required for this recommendation.

[19] https://www.cdpr.ca.gov/docs/license/adviser.htm

3.3
REPORT CHANGES IN PESTICIDE USES AFTER THE CHLORPYRIFOS BAN, AND SHARE THIS INFORMATION WITH THE PUBLIC.

DPR banned chlorpyrifos in California to protect public health. Growers will shift their pest management practices to respond to the ban. This may mean using different amounts or combinations of active ingredients, as well as new active ingredients that may enter the market.

It will be important to track how human and environmental toxicity exposures change as growers shift their practices, including cumulative exposure to multiple pesticides that may be combined to manage the multiple pests that chlorpyrifos controlled.

Changes in uses of active ingredients can be determined easily by comparing data from the existing pesticide use reports (PUR) database.[20] This information is needed to ensure that the ban on chlorpyrifos achieves its goal of protecting public health without resulting in unintended negative outcomes.

The Work Group recommends when the 2021 PUR data are published, DPR also release a summary of use of pesticides on crops where chlorpyrifos had been used in the years prior to the permit conditions being in place. This summary should identify significant changes in use, and include toxicity information about these exposure rates and combinations. This information should be presented in a format that is easily understood by the public, and available in multiple languages.

This report would be a first step of baseline information to inform research on long-term pesticide exposure.

Who: DPR

When: Medium term

Funding: No additional funding was recommended for this recommendation.

[20] Pesticide use reports are published on the DPR website, typically 2-3 years after the growing season.

4 RESEARCH PRIORITIES

The Work Group identified a critical lack of both applied and basic research into new pest management approaches and chlorpyrifos alternatives as a key gap in being able to manage pests, particularly in crops where chlorpyrifos use has been critical.

THE WORK GROUP IDENTIFIED FOUR HIGH-PRIORITY RESEARCH AREAS:

1 **AN IMMEDIATE AND CRITICAL NEED** for research into pest management tools for the crops where the most chlorpyrifos was applied in recent years. These crops were based on the group's review of recent PUR data.[21]

2 **LONGER-TERM RESEARCH** into lower-risk, ecosystem-based pest management tools and approaches that can be incorporated into robust integrated pest management protocols.

3 **BASIC SCIENTIFIC RESEARCH** into pest and natural-enemy biology and ecology that will enable new alternative management approaches to be developed.

4 **EVALUATION OF MONITORING AND OTHER DATA** to understand the impacts, on the environment and public and farmworker health, of alternatives being used at scale.

Members noted that lack of researchers with expertise on these topics exacerbates the acute need for additional research. The recommendations in this section are scaled to the current capacity of the research community, but the group recommends that the research areas increase over time as recommendation 3 is implemented and new research and extension capacity becomes available.

[21] Anyone can create customized reports on use of chlorpyrifos or other active ingredients through the DPR Pesticide Use Reports (PUR) database at https://www.cdpr.ca.gov/docs/pur/purmain.htm. The Work Group reviewed the five most recent years of data (2013-2017) of chlorpyrifos use on all crops in California.

4.1 INVEST IN RESEARCH TO FIND SHORT-TERM, CROP-SPECIFIC INTEGRATED PEST MANAGEMENT SOLUTIONS.

The Work Group reviewed the list of crops where chlorpyrifos has been used (see Appendix 1, List 1). Work Group members asked their networks for suggestions of immediate-term research needs to find tools for integrated pest management of these crops. Appendix 8 lists these immediate-term research priorities.

The group identified DPR's Pest Management Research Grants as a program that could be directed to address the immediate crop-specific research needs, and DPR's Pest Management Alliance Grant as a means to strengthen implementation and adoption of applicable and effective research. Funding levels of $5 million annually could fund approximately five crop-specific projects per year.

photo by: ames Nolan

Who: DPR grant programs

When: Requests for proposals out by third quarter 2020

Funding Level: $5 million annually for five years, from the general fund.

4.2 EXPAND RESEARCH ON BASIC BIOLOGY AND ECOLOGY OF PESTS AND BENEFICIAL INSECTS.

Integrated pest management approaches rely on understanding pest biology and ecology to identify how to prevent or reduce pest populations as effectively as possible while minimizing economic, environmental and human health risks. For example, monitoring for beneficial insects and reducing pest habitat requires an understanding of the pest life cycle. This basic life cycle information is not understood for many pests. Expanding the knowledge base of pest biology and ecology will create the foundation needed to identify an expanded range of pest management options. It will be relevant to research these issues in different cropping systems, including diverse agroecological approaches.

Areas of basic biology and ecology to strengthen through research include:

1. Pest life cycles: This information will inform options of how and when lower-risk management options can take place.
2. Pest natural enemies' life cycles: These beneficial insects reduce pest populations. Learning more about their habitats, life cycles, how to support their populations, and how to avoid unintentional reductions of their population will be an important component of safer approaches to reducing pest damage.
3. Plant/pest interactions, including relationships of plant vigor, soil health, crop system diversity, and plant vulnerability to pests and disease vectors.

Key areas for this research are identified in Appendix 8. The Work Group was not able to complete an estimate for the funding that these research priorities would require, and recommends that these research needs continue to be explored.

4.3 INVEST IN LONG-TERM RESEARCH TO SUPPORT IPM.

Long-term solutions for alternatives to chlorpyrifos require multi-year investments in the many different components of integrated pest management programs.

Managing pests on farms is complex. The severity of pest problems depends on a range of factors that often shift every year, such as the crops grown, soil and nutrient management practices, weather, and populations of natural enemies. Long-term alternatives to address the pest issues where chlorpyrifos was used requires understanding each of these factors, and how they interact.

The group recommends that grant programs such as CDFA's Biologically Integrated Farming Systems (BIFS) be funded to support long-term research into emerging approaches to pest management, in particular long-term research on integrating biological pesticides into ecological crop and pest management practices at all scales.

Who: CDFA grant programs

When: Requests for proposals out by third quarter 2020, continued long term.

Funding Level: $5 million per year for research from the general fund.

4.4 INVESTIGATE THE IMPACT OF CHANGES IN PATTERNS OF PESTICIDE USE AND HUMAN AND ENVIRONMENTAL EXPOSURE.

Chlorpyrifos was banned to address its public health impacts.

Changes in pest management practices to adapt to the ban may result in different quantities and combinations of uses of other active ingredients.

Research will be needed to assess the impact of the chlorpyrifos ban to make sure that the regulatory change is achieving its intended goal of protecting public health. Research will also be needed to identify whether the practices used in place of chlorpyrifos may be contributing to unintended consequences for human health or the environment. This research could draw from PUR data, pesticide air monitoring data, and the Biomonitoring California program.

The Work Group recommends that monitoring of exposure patterns begin immediately to gather appropriate data, before the ban is fully in effect, to adequately examine the consequences of the chlorpyrifos ban on human pesticide exposure and health.

This information will make it possible to understand whether the ban meets its intended goal of improving human health and safety.

The Work Group also recommends longer-term research as part of Recommendation 5.

Who: University of California

When: Immediately: Monitoring using existing systems. Medium term: Analysis of changes in pesticide use between 2019 and 2020 to be completed as data are available (early 2022). Long term: Analysis of changes in exposure patterns and health outcomes.

Funding level: $350,000 as a one-time, two-year grant. Long-term funding to follow.

photo by James Nolan

5 ROADMAP FOR FUTURE WORK

From its first meeting, the Work Group recognized it was tasked with interconnected responsibilities: to identify immediately-available alternatives to chlorpyrifos, and to explore longer-term alternatives to pest management that may require deeper changes in agronomic practices and consumer/market expectations.

This report has primarily focused on identifying immediately-available safer and sustainable alternatives to chlorpyrifos. But a number of the recommendations, particularly those for investments in capacity and research, can be seen as bridges toward discovering and implementing safer pest management practices.

That said, the group recognized that significant work remains to develop a shared vision and plan for pest management that is less dependent on individual active ingredients and takes advantage of the latest (and at times ancient) understanding of agronomic practices that are resilient to pest pressures by design. Work Group members were divided around the safety and sustainability of current pest management practices and what alternatives may be viable for California.

The group made some progress in bridging these views, and members expressed they gained a deeper appreciation of other viewpoints. But the group agreed that much good could come if additional work was taken by a successor group to finish the ambitious agenda it was given.

As a result, the group strongly recommends a series of follow-on activities that would build on their efforts towards lasting, meaningful impact at the intersection of agriculture, community health, and the environment.

5.1 DEEPEN MULTI-SECTOR COLLABORATION ON THE FUTURE OF PEST MANAGEMENT IN CALIFORNIA.

Throughout their time together, the Work Group members acknowledged that pest management's complexity means there are no quick and easy solutions. Managing pests requires balancing multiple pressures, including agricultural productivity and profitability, regional ecology, community health, local economies, global trade systems, supply chain systems, and regulatory frameworks.

The Work Group recommends that DPR establish a new project to continue these conversations for a longer period of time. All of the issues that the group discussed in the context of safer and sustainable alternatives to chlorpyrifos also apply to other active ingredients; a longer-term project could build on these discussions to explore thinking about the pest management system as a whole instead of individual active ingredients.

SPECIFIC SUGGESTIONS FOR A NEW GROUP INCLUDE:

- INCREASE BREADTH AND DEPTH OF EXPERTISE: The group valued the shared space across expertise in community health, medical research, agricultural production, research, pest control advisers, and growers. It is not often that this range of expertise comes together. The group suggests that this sharing and collaboration continue, and include additional perspectives such as expertise in policy, funding, export certification, agroecology, and medicine, along with consultation with specialists in the crops for which no alternatives were identified.

Who: DPR/CDFA/CalEPA

When: Beginning in the short term, extending several years.

Funding Level: $350,000 over the next two fiscal years.

- PROVIDE MORE CONTEXT FOR THE GROUP'S WORK: Setting group members up with a range of contextual information will support them to succeed. Background information on existing work on the range of topics will be essential so that participants with different backgrounds can participate actively and the group can learn together. It would be useful for the regulatory agencies to share the detailed context of what they do, how they are organized, where their scope begins and ends on each of these topics, and where their roles intersect with each other. Overviews of the expertise and perspective that the group members bring will enrich discussions and grow a shared culture that will support collaboration. Bringing in information from others outside of the group will also be useful, such as the work of the Pests, Pesticides, and IPM Project, and recently published research around pest management decision-making.[22]

- MORE TIME: Based on the Work Group's experience during its five months of collaboration, it could take years to build a strong group across many disciplines and make progress towards bold, long-term recommendations. A new group should have a 18-24-month timeline, capacity to define its scope, discussions to plan what could be achievable during its time together, and the resources to implement its plan.

[22] The group identified the Pests, Pesticides and IPM Project as another resource for a future project to draw from. Project website: https://www2.ipm.ucanr.edu/pests-pesticides-and-ipm-project/. Non-technical synopsis: https://www.cdpr.ca.gov/docs/pestmgt/ppi_non-technical_summary.pdf

5.2 FIND A SHARED LANGUAGE AROUND AGRICULTURE, ENVIRONMENTAL PROTECTION, COMMUNITY HEALTH, AND CONSUMERS.

The three public listening sessions held to discuss the draft of this document highlighted the ongoing lack of trust between many community members and both the pesticide regulatory system and agriculture more broadly. While there were many areas of common concern, particularly around maintaining agricultural jobs and ensuring worker safety, there were still marked differences in perception around risk of and exposure to agricultural pesticides.

One of the primary barriers to effective communication was the very different ways key terms and concepts in pest management were being used and understood by the various stakeholders. As a result, Work Group members and the public saw the need for affected communities and agriculture to develop a common language, a reservoir of trust and good will, and ongoing forums to resolve problems that could lead to both better pest management and reduced conflict.

To create this common language and interconnectivity, the Work Group recommends that DPR, in conjunction with county agricultural commissioners, develop an ongoing program for community engagement, education, and collaboration around pest management at the county level. The group recommends that this program use best practices for including diverse voices, fostering understanding between agricultural interests and their surrounding communities, as it works to address issues of concern at the local level.[23]

Who: DPR/CDFA/CalEPA

When: Medium term.

Funding: A specific funding proposal was not developed for this recommendation.

[23] This idea originally was made by members of the public. See Appendix 9 - Summary of Comments from Public Roundtable Sessions on the Chlorpyrifos Alternatives Work Group

5.3
EXPLORE IMPROVED ENFORCEMENT OF EXISTING REGULATIONS.

The Work Group recognized from the public listening sessions and the experiences of members that there are cases in California where current regulations and requirements for pest management, including use of personal protective equipment, are unevenly observed or enforced. These lapses are of critical concern and require further attention.

The group noted that more voluntary notification of spraying events could simultaneously reduce risks to community health and increase trust between communities, growers, and the regulatory community. This is just one example of a low-cost way to demonstrate effective regulation and a balanced awareness of community and grower needs that arose from both the listening sessions and the Work Group's dialogues.

The Work Group did not have time to explore next steps for this topic including who should lead it, or a suggested timeframe or budget. The Work Group recommends that a future group explore the topic of monitoring and enforcement of existing regulations.

5.4
INVEST IN SYSTEMS-BASED RESEARCH INTO ALTERNATIVE APPROACHES TO AGRICULTURAL PRODUCTION AND EFFECTIVE PEST MANAGEMENT.

THE GROUP EMPHASIZED THE NEED FOR LONG-TERM INTERDISCIPLINARY RESEARCH THAT EXTENDS BEYOND THE IMMEDIATE CRITICAL NEEDS.

Agriculture intersects with so many fields of academic study, from crop science to economics to public health. Interdisciplinary research will support ongoing discussions on how to continue to pursue a thriving agricultural system that supports resilient food systems and public, economic and environmental health.

Areas of research to consider include:

1. Leveraging behavior change research to explore ways to increase growers' uptake of cultural practices for pest management.
2. Incorporating human health and environmental evaluation into pest management options early in the research process, and including monitoring long-term exposure as a continual part of ongoing research.[24]
3. Assessing new economic thresholds of crops under changing conditions, including new management approaches, and how this may affect growers, workers and communities who rely on these crops.
4. Conducting economic analysis of pest management approaches, including economic thresholds of crops under changing conditions, and return on investment of different forms of agricultural production and pest management.
5. Taking systems approaches to manage pests, in particular pests that are relevant for international trade. This could include expanding proactive biocontrol efforts and other collaborations to prepare for new invasive species that may be expected to establish and do damage if they are introduced in California.

[24] Currently, California tracks acute illnesses due to pesticide poisoning, but does not track the health effects of chronic, low-dose exposure, including to vulnerable populations such as pregnant women and children.

6. Exploring the interactions of soil health, crop system diversity, role of neighboring ornamental plants as pest hosts, climate stresses, and efficacy of production approaches that do not rely on synthetic pesticides.
7. Creating incentives for adoption of novel approaches for critical pest issues.
8. Developing area-wide and landscape-scale approaches to addressing challenges and opportunities for pest management.

The group did not have sufficient time or expertise to recommend specific funding levels for this work. It noted that individual research projects can make a contribution, but with over 400 crops grown in California, making transformative changes to the way pests are managed would require a different order of magnitude of investment than is currently in place.

Who: CDFA, DPR, UC ANR

When: Beginning 2021, continuing long term.

Funding: A specific funding proposal was not developed for this recommendation.

This action plan is the final product of the Alternatives to Chlorpyrifos Work Group.

The Work Group was established and sponsored by the California Environmental Protection Agency, California Department of Pesticide Regulation, and California Department of Food and Agriculture.

Ag Innovations facilitated the Work Group's collaboration, drafted the report based on the Work Group's discussions, and coordinated revisions based on Work Group input. The Ag Innovations team for this project included Joseph McIntyre (project lead), Sonya Hammons, and Suzannah Sosman.

About Ag Innovations:

Ag Innovations is a 501c3 nonprofit dedicated to improving the quality of public engagement and problem solving in the areas of agriculture and food systems, fire and forest resiliency, water stewardship, and climate resiliency. As neutral, non-partisan experts in processes for making sound decisions around issues of great complexity, we help design, facilitate, and convey the results of efforts ranging from public input, to stakeholder work groups, to long-term coalitions. Ag Innovations focuses on California issues and works statewide. The organization was founded in 1999 and is based in Sebastopol, CA.

The Alternatives Chlorpyrifos Work Group was convened by the California Environmental Protection Agency, California Department of Pesticide Regulation, and California Department of Food and Agriculture. It was facilitated and coordinated by Ag Innovations, a nonprofit organization dedicated to helping stakeholders solve systemic issues through effective collaboration.

www.aginnovations.org info@aginnovations.org

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Appendix 1

Table 1. Alternatives to chlorpyrifos found in Pest Management Guidelines (http://ipm.ucanr.edu/)

Published by the University of California Statewide Integrated Pest Management Program for crop-pest combinations that previously included chlorpyrifos as a chemical control option prior to cancellation. Pests listed in bold face indicate critical uses according to DPR's Chlorpyrifos Interim Recommended Permit Conditions for 2019 (https://www.cdpr.ca.gov/docs/enforce/compend/vol_3/append_o.pdf). For critical uses, implementation of alternatives may not provide adequate levels of pest control, or may have their own unintended consequences, such as disruption of biological control.

COMMODITY	PEST	MONITORING AND DECISION MAKING TOOLS	NON-CHEMICAL ALTERNATIVES	CHEMICAL ALTERNATIVES
ALFALFA http://ipm.ucanr.edu/PMG/selectnewpest.alfalfa-hay.html	**Blue alfalfa aphid**	Evaluate stems weekly for aphids and natural enemies. Use treatment thresholds for stand establishment and established stands.	Plant resistant varieties. Use border-strop cutting to maintain natural enemies. Conserve lady beetles, other generalist predators, and *Aphidius* spp. parasites.	Flupyradifurone Flonicamid Dimethoate Methomyl Lambda-cyhalothrin Zeta-cypermethrin
	Cowpea aphid	Evaluate stems weekly for aphids and natural enemies. Use treatment thresholds for stand establishment and established stands.	Use border-strop cutting to maintain natural enemies. Conserve lady beetles, other generalist predators, and *Lysiphlebus* spp. and *Diaeretiella* spp. parasites.	Flupyradifurone Flonicamid Dimethoate Malathion Lambda-cyhalothrin Zeta-cypermethrin Beta-cyfluthrin
	Cutworm	Monitor crop rotations and residue degradation before planting. Once stands are established, monitor crowns for feeding damage and worms.	Tillage, flood irrigation and weed control prior to planting.	Indoxacarb

COMMODITY	PEST	MONITORING AND DECI SION MAKING TOOLS	NON-CHEMICAL ALTERNATIVES	CHEMICAL ALTERNATIVES
ALFALFA	Leafhopper	Sweep net sampling in July and August. Check stubble for damage from toxins injected by leafhoppers.	Early cutting.	Flupyradifurone Permethrin Dimethoate Zeta-cypermethrin Methomyl Lambda-cyhalothrin Beta-cyfluthrin
	Palestriped flea beetle	Monitor crop rotations to assess risk before planting. Frequent monitoring of seedlings during stand establishment.	Rotate from non-host plants before planting. Deep disk previous crop if beetles were present. Maintain fields and borders free of weeds. Maintain good plant health (no water stress).	Beta-cyfluthrin Lambda-cyhalothrin
	Pea aphid	Evaluate stems weekly for aphids and natural enemies. Use treatment thresholds for stand establishment and established stands.	Plant resistant varieties. Use border-strop cutting to maintain natural enemies. Conserve lady beetles, other generalist predators, and *Aphidius* spp. parasites.	Flupyradifurone Flonicamid Dimethoate Malathion
	Weevils	Monitor for feeding damage on short alfalfa. With adequate plant height, sweep sampling every 2-4 days prior to first cutting. Use treatment thresholds.	Early harvest of first cutting.	Indoxacarb Lambda-cyhalothrin Beta-cyfluthrin Malathion Spinosad
ALMOND https://www2.ipm.ucanr.edu/agriculture/almond/	**Leaffooted bug**	In spring monitor for dropped nuts, gummosis, and bugs in trees. Cross-section damaged nuts to confirm stylet penetration	Remove overwintering locations. Avoid close proximity to pomegranates and other key hosts.	Bifenthrin Lambda-cyhalothrin Abamectin Esfenvalerate Clothianidin

COMMODITY	PEST	MONITORING AND DECI SION MAKING TOOLS	NON-CHEMICAL ALTERNATIVES	CHEMICAL ALTERNATIVES
ALMOND	**Stink bugs**	Monitor for bugs and gummo-sis from May to July, watch for egg masses		Bifenthrin Lambda-cyhalothrin Clothianidin
	Ants (southern fire and pyramid)	Mound counts	Prompt removal of nuts after shaking.	Granular baits containing Pyriproxifen, Abamectin, Methoprene, or Metaflumizone
	European fruit lecanium	Use dormant spur sampling for scale and parasitoids, use treatment thresholds	Predators including lady beetles, sap beetles and seed bugs. Parasitism by *Coccoph-agus* spp., *Encarsia* spp. and *Metaphycus* spp	Dormant oils Narrow range oils
	Navel orangeworm	Use pheromone traps, egg traps, and degree-day models to assist in treatment decisions	Winter sanitation Early/timely harvest Hard-shelled varieties	Mating disruption (various) Methoxyfenozide Chlorantraniliprole Spinetoram Bifenthrin Lambda-cyhalothrin Fenpropathrin Bacillus thuringiensis Emamectin benzoate Esfenvalerate Phosmet
	Oriental fruit moth	Use pheromone traps and degree-day models. Do shoot strike monitoring in the spring.	Conserve natural enemies	Chlorantraniliprole Methoxyfenozide Spinetoram Phosmet Spinosad

COMMODITY	PEST	MONITORING AND DECISION MAKING TOOLS	NON-CHEMICAL ALTERNATIVES	CHEMICAL ALTERNATIVES
ALMOND	Peach twig borer	Use pheromone traps and degree-day models. Do shoot strike monitoring in the spring.	Conserve parasitoids such as *Copidosoma* spp., *Euderus* spp. and *Macrocentrus* spp. Predation of larvae in the hibernacula by *Formica* spp. ants.	Spinosad Spinetoram Diflubenzuron Chlorantraniliprole Acetamiprid Methoxyfenozide Emamectin benzoate Bacillus thuringiensis Various pyrethroids
	San Jose scale	Use of dormant spur sampling and established treatment thresholds. In-season use of pheromone traps to monitor males and parasitoids.	Preservation of natural enemies (esp. *Aphytis* and *Encarcia* spp.)	Narrow range oil Pyriproxyfen Buprofezin Carbaryl
	Tree borers	Monitor for frass and gum pockets, treat in spring	Painting trunk following sprays to increase residual effects	Carbaryl
APPLE http://ipm.ucanr.edu/PMG/selectnewpest.apples.html	Rosy apple aphid	Use dormant fruit spur sampling for eggs, especially on young trees that tolerate less damage	Removal of buckhorn plantain and other *Plantago* spp. alternate weed hosts. Conserve natural enemies such as lady beetles, lace-wings and syrphids	Narrow range oil Spirotetramat Imidacloprid Acetamiprid Diazinon Stylet oil and azadirachtin
	San Jose scale	At harvest, monitor for scale on fruit. During dormancy check prunings for scale in tops of trees. Do in-season monitoring with pheromone traps and degree-day models.	Conserve highly effective natural enemies, including ladybeetles and chalcid and aphelinid wasps.	Narrow range oil Pyriproxyfen Buprofezin Esfenvalerate Diazinon

COMMODITY	PEST	MONITORING AND DECISION MAKING TOOLS	NON-CHEMICAL ALTERNATIVES	CHEMICAL ALTERNATIVES
ASPARAGUS http://ipm.ucanr.edu/PMG/selectnewpest.asparagus.html	Beet and yellowstriped armyworms	Monitor twice weekly for egg masses and larvae on weeds near ferns. Use pheromone traps (beet).	Use good weed management practices to help prevent infestation of ferns.	Chlorantraniliprole Bacillus thuringiensis Methomyl Spinosad Carbaryl Permethrin
	Asparagus beetles	Monitor for severe beetle feeding on spears early in the season. Treatments are rarely needed.	In spring, allow some plants to fern at field edges to attract beetles away from spears.	Spinetoram Methomyl Carbaryl Permethrin Pyrethrin/rotenone
	European asparagus aphid	Monitor field edges regularly for both aphids and natural enemies. Treat if numbers of aphids increase faster than beneficials.	Clean fields of crop debris in winter, including mowing, chopping and incorporating ferns to reduce eggs. Burn ferns where permitted. Conserve natural enemies, including lady beetles and parasitoid *Diaeretiella rapae*.	Pyromezine Pyrethrin Narrow range oil
	Garden symphylan	Monitor using potato bait traps in warm moist soil prior to planting.	Spring/summer flooding prior to planting. Cultivation to dry out soil surface and drive symphylans deeper. Avoid mounding soil on spears to produce white asparagus	Preplant fumigation
CHERRY http://ipm.ucanr.edu/PMG/selectnewpest.cherries.html	American plum borer	Monitor young orchards in spring for frass and gum pockets	Maintain healthy trees to overcome damage	Diazinon Carbaryl

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CHERRY	Black cherry aphid	Assess populations at bloom. If natural enemies are insufficient, treat during dormancy or after petal fall. High populations are mainly a problem on young trees.	Conserve natural enemies, including lady beetles, lace-wings and several parasitoids.	Narrow range oil Imidacloprid Thiamethoxam Acetamiprid Diazinon
	Cherry leafhopper	When X-disease (cherry buckskin) is present, consider leafhopper treatments during dormancy and in June when new nymphs hatch.	Remove trees infected with cherry buckskin disease. Treat or remove ornamental leafhopper hosts near the orchard	Narrow range oil Diazinon Esfenvalerate Lambda-cyhalothrin Thiamethoxam
	European fruit lecanium	Use dormant spur sampling for scale and natural enemies, including parasitoids. Use double-sided sticky tape to monitor for crawler emer-gence in spring.	Predators including lady beetles, sap beetles and seed bugs. Parasitism by *Coccoph-agus* spp., *Encarsia* spp. and *Metaphycus* spp	Narrow range oil Diazinon Pyriproxyfen
	Peachtree borer	Look for frass and gum at tree bases in the spring on young trees.	Kill larvae with knife or wire Mating disruption is available but not used due to scarcity of this pest. Keep vegetation away from tree bases.	Esfenvalerate
	San Jose scale	Monitor for scale, sooty mold, and parasitoids. Pheromone traps attract male scale and parasitoids. Degree-day model is available.	Conserve highly effective natural enemies, including ladybeetles and *Encarsia* and *Aphytis* parasitoids	Narrow range oil Pyriproxyfen Diazinon
CITRUS http://ipm.ucanr.edu/PMG/selectnewpest.citrus.html	**Sugar-feeding ants** (Argentine and Native gray)	Inspect trees for ant activity, especially in association with insects that produce honey-dew	No biological control. Skirt pruning and trunk banding with sticky material to keep ants out of trees	None

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CITRUS	Protein-feeding ants (Southern fire and red imported fire)	Monitor young trees for fire ants and damage to bark, especially under trunk wraps	Plant trees with bud union 6-8 in. above soil line, avoid pooling of water near trunk, control Phytopthora to avoid trunk gumming, cultivation	Baits containing abamectin, pyriproxyfen or metaflumizone
	Amorbia	Check buttons for small larvae at the base of small fruit at petal fall. Monitor for larger larvae and leaf rolling later in spring and summer	Prune trees so they do not touch. Thin or selectively harvest fruit in clusters. Control weeds that are alternate hosts. Reduce dust to help biocontrol	Bacillus thuringiensis Cryolite Spinosad Carbaryl Naled Methomyl
	Asian citrus psyllid	Monitor using yellow sticky cards, visual monitoring and sweep net or tap sampling every two weeks	*Tamarixia radiata* parasitoids	Fenpropathrin Beta-cyfluthrin Cyfluthrin Zeta-cypermethrin Thiamethoxam Dimethoate Carbaryl
	Broad mite	Inspect leaves and fruit for mites	Conserve predatory mites. Control sugar-feeding ants that disrupt biological control	Narrow range oil Abamectin Spirodiclofen Fenpyroximate Wettable sulfur
	Brown soft scale	Visually monitor for scale and parasitoids from June to October	Conserve highly effective parasitoids in the genus *Metaphycus*, and lady beetles. Control sugar-feeding ants to maintain biological control.	Narrow range oil Carbaryl Malathion

COMMODITY	PEST	MONITORING AND DECI SION MAKING TOOLS	NON-CHEMICAL ALTERNATIVES	CHEMICAL ALTERNATIVES
CITRUS	California red and yellow scale	Use pheromone trap and degree-day models to under-stand phenology. Monitor fruit from August to October, plus bins, for scale and levels of parasitism	Conserve parasitoids and lady beetles. Augmentative releases of *Aphytis melinus*. Control sugar-feeding ants, minimize dust, and prune to open up trees.	Narrow range oil Pyriproxyfen Buprofezin Spirotetramat Carbaryl
	Citricola scale	Twig sampling in spring, leaf monitoring from July to September. Use twig and leaf count thresholds.	*Cetaphycus* and *Coccophagus* parasitoids in Southern CA (not effective in the Central Valley).	Buprofezin Acetamiprid Thiamethoxam Flupyradifurone Malathion Carbaryl Narrow range oil
	Citrus bud mite	In lemons, monitoring and dissection of buds from mid-spring to autumn. Remove and inspect button of small green fruit for mites.	None reported	Fenbutatin-oxide Abamectin Narrow range oil Spirotetramat Fenpyroximate
	Citrus cutworm	Use pheromone traps for adults with degree-day models. Use thresholds based on timed searches before, during, and after petal fall when small fruit are present	Conserve *Ophion* spp. and *Banchus* spp. parasitoids	Bacillus thirun giensis Cryolite Methoxyfenozide Carbaryl Naled Methomyl
	Citrus peelminer	Inspect leaves and fruit for mines. Use degree-day model to assist in spray timing	Avoid susceptible varieties of citrus, or plant them away from alternate hosts such as cotton or grapes. In the Coachella Valley, conserve *Cirrospilus coachellae*	Diflubenzuron + oil Fenpropathrin Beta-cyfluthrin

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CITRUS	Citrus rust mite	Monitor foliage in early spring, or fruit in summer (oranges) or all year (lemon). Look for scarring to fruit surface and presence of mites	Conserve generalist mite predators	Spirodiclofen Diflubenzuron Abamectin Spirotetramat Sulfur Fenpyroximate Narrow range oil
	Earwig	In young trees, lift and shake trunk wraps to expose earwigs. In mature trees, use beat samples in foliage and inspect small fruit for damage after petal fall	Prompt removal of trunk wraps on young trees. No biocontrol	Beta-cyfluthrin Carbaryl
	Fruittree leafroller	Monitor for egg masses in early March, and larvae in leaf nests through harvest. Use 20% thresholds for infested terminals when mature fruit is present	Conserver generalist predators and *Trichogramma* egg parasitoids	Bacillus thuringiensis Cryolite Carbaryl Naled Methomyl
	Fuller rose beetle	For fruit going to Korea, monitor for leaf notching and beetles from June to Septem-ber.	Skirt pruning (all orchards) with sticky trunk barriers (organic). Suppression from the parasitoid *Fidiobia citri*.	Bifenthrin Cryolite Thiamethoxam Carbaryl Imidacloprid/beta-cyfluthrin Thiamethoxam/chlorantraniliprole
	Greenhouse thrips	In coastal Valencias (especially near avocados), monitor for fruit damage from March to May	Conserve natural enemies. Harvest early in areas with historic damage	Pyrethrins/piperonyl butoxide

COMMODITY	PEST	MONITORING AND DECI SION MAKING TOOLS	NON-CHEMICAL ALTERNATIVES	CHEMICAL ALTERNATIVES
CITRUS	Katydid	Search for feeding on new-ly-expanding leaves before petal fall. Inspect small fruit for damage	Egg parasitoids exist but are generally not effective	Cryolite Diflubenzuron Naled Dimethoate Beta-cyfluthrin Fenpropathrin Zeta-cypermethrin
	Leaffooted bug	Monitor for winter aggrega-tions. Look for excrement on leaves and fruit. If found, cross-section fruit to inspect for internal damage	No cultural controls. Egg parasitoid (*Gryon* sp.) exists but is generally not effective	Fenpropathrin Beta-cyfluthrin
	Mealybugs	Monitor for mealybugs on leaves, twigs and fruit. Monitor for sugar-feeding ants that disrupt biocontrol.	Conserve parasitoids and generalist predators, includ-ing *Cryptolaemus*. Augmenta-tive releases of *Cryptolaemus*. Control sugar-feeding ants and prevent dust	Spirotetramat Narrow range oil
	Omnivorous leafrollers	In spring, look for small larvae under sepals. In summer, conduct larvae searches and use threshold	Conserve parasitism of larvae by a tachinid fly and wasps. Trichogramma attacks eggs	Bacillus thuringiensis Cryolite Carbaryl Naled Methomyl
	Orange tortrix	Monitor for larvae and levels of parasitism from spring through summer. Use thresholds in conjunction with parasitism levels	None reported	Bacillus thuringiensis Cryolite Carbaryl Naled Methomyl
	Purple scale	In coastal areas monitor for scale on twigs and fruit	Conservation of the parasitoid *Aphytis* lepidosaphes and lady beetles.	Narrow range oil Carbaryl

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CITRUS	Western tussock moth	In Southern California or SJV near foothills, look for egg masses and larvae in spring. Use thresholds.	Conservation of natural enemies, including a dermestid egg predator and a wasp.	Bacillus thuringiensis Cryolite Carbaryl Naled Methomyl
COLE CROPS http://ipm.ucanr.edu/PMG/selectnewpest.cole-crops.html	Cutworms	Check for cutworms in weeds around field edges before planting. Monitor for cutworms near wilted or severed stems during stand establishment.	Eliminate weeds 10 days before planting. Avoid planting in fields with history of damage.	Carbaryl bait Diazinon Esfenvalerate Indoxacarb Methomyl
	Flea beetles	Monitor newly emerged seedlings twice weekly for damage until well established. Monitor again just prior to thinning	Remove weeds along field margins. Deep disc plant residues after harvest	Carbaryl Diazinon Esfenvalerate Insecticidal soap Cryolite
	Garden symphylan	Potato wedge sampling on moist soil prior to planting	Avoid soil types favored by symphylans. Packing the soil surface or pre-plant flooding can provide suppression. Biocontrol is poorly understood	Diazinon Ethoprop
	Other aphids	Note other aphids while monitoring for cabbage aphid. If needed, treatments for cabbage aphid also control other aphids	Remove infested culls and alternate host weeds. Crop rotation for turnip aphid. Conservation of generalist aphid predators and the parasites *L. testaceipes*, *A. matricariae*, *A. semiflavus*, and *D. rapae*.	Acephate Acetamiprid Flonicamid Spirotetramat Diazinon Insecticidal soap Pymetrozine

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COLE CROPS	Cabbage aphid	Sample twice weekly. A presence-absence sequential sampling program exists for Brussels sprouts. For other brassicas check young inner-most leaves. After heading check heads, including under wrapper leaves of cabbage	Control alternate hosts, including mustards, around field borders. Use pest-free seedlings. Promptly destroy crop remnants after harvest. Rogue infested plants early in the season. Protect natural enemy habitat around field to encourage immigration after planting.	Acetamiprid Flonicamid Spirotetramat Chlorpyrifos Diazinon Imidacloprid Insecticidal soap Pymetrozine
	Cabbage maggot	Monitor crop rotations and residue breakdown from pre-vious crops. Monitor weather conditions for planting. Watch for wilting or damaged plants during stand establishment.	Rotate crops or ensure complete decomposition of previous residues. Disk crops immediately after harvest. Use transplants. Avoid planting in cool, wet conditions.	Diazinon
CORN http://ipm.ucanr.edu/PMG/selectnewpest.corn.html	Aphids	Monitor for aphids, honeydew and sooty mold on foliage and in the whirl. Monitor for biocontrol.	Conserve the parasite *Lysiphlebus testaceipes* and generalist predators. Remove Johnsongrass and other hosts of maize dwarf mosaic virus	Dimethoate Esfenvalerate Narrow range oil
	Corn earworm	Monitor crop development and watch for eggs on fresh silks of sweet corn. Manage-ment rarely needed in field or silage corn.	Plant as early as possible. Parasitism of eggs by Tricho-gramma. Predation of eggs and small larvae by lacewings, minute pirate bugs and damsel bugs	Spinosad Spinetoram Methomyl Esfenvalerate Permethrin Bacillus thuringiensis
	Cutworms	Monitor stand establishment during seedling stage, especially near field edges or area with weeds	Eliminate weeds 2 weeks before planting.	Permethrin Carbaryl
	Wireworms	Monitor field history to determine the need for a preventative seed treatment	Avoidance through crop rotation	Thiamethoxam Clothianidin

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COTTON http://ipm.ucanr.edu/PMG/selectnewpest.cotton.html	Beet armyworm	Weekly monitoring for egg masses and larvae with webbing on foliage. Watch for larvae in sweep samples for lygus, or using drop sheets under the canopy	Use transgenic cotton. Minimize alternate hosts, including weeds. Conserve generalist predators and the parasotoid *Hyposoter exiguae*. Other parasitoids and viruses help.	Bacillus thuringiensis Methoxyfenozide Chlorantraniliprole Spinosad Indoxacarb Diflubenzuron Novaluron Bifenthrin Esfenvalerate Methomyl
	Cutworm	Monitor stand establishment during seedling stage, especially near field edges or area with weeds	Allow adequate time for decomposition of plant residues before planting	Indoxacarb
	Pink bollworm	Boll sampling in Southern California. Trapping in the San Joaquin Valley is conducted by the Areawide Pink Bollworm Program	Promptly observe plow-down requirements and host-free periods. Plant transgenic cotton. Early crop termination. Support CDFA monitoring and eradication programs using sterile insect technique.	Esfenvalerate Indoxacarb Spinosad Mating disruption
	Seedcorn maggot	Monitor weather conditions to avoid planting when soil is cool and excessively moist	Avoid planting cotton after corn. Plant later in spring for quick seedling emergence. Destroy previous crop/ residues at least one month before planting	None
	Stink bugs	Note stink bug presence while sampling for lygus. In early September, monitor for brown stains and fecal spot under bracts of bolls. Use thresholds.	None noted	Acephate Zeta-cypermethrin Bifenthrin

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COTTON	Wireworms	Monitor for wireworms near damaged or missing plants	Avoid planting cotton after alfalfa or pasture. Cultivation, flooding and dry fallowing before planting can help	None
	Cotton aphid	Monitor foliage for aphids while sampling for mites, thrips and whitefly.	Plant early. Avoid over-watering and over-fertilization that stimulate vegetative growth late in the season. Conserve biocontrol, including parasitoids and many generalist predators.	Acetamiprid Flonicamid Flupyradifurone Imidacloprid Thiamethoxam Pymetrozine Naled Soaps and oils (for organic) Seed treatments
	Sweetpotato whitefly	'Ring' sampling for adults and nymphs on the undersides of leaves. Use of treatment thresholds	Prompt plow-down of neighboring host crops. Maintain good sanitation from alternate host weeds. Early termination of crop and prompt destruction of stalks. Conserve predators and parasitoids	Buprofezin Pyriproxyfen Spiromesifen Acetamiprid Flupyradifurone Dinotefuran Clothianidin Bifenthrin Fenpropathrin
FIG http://ipm.ucanr.edu/PMG/selectnewpest.figs.html	Driedfruit beetle	Use bait traps prior to fruit ripening. Spray (if needed) when ripening fruit becomes more attractive than the traps	Plant resistant varieties with small eyes. Removal of cull fruit and mummies from the orchard. Harvest early and rapidly before larvae pupate in soil.	Malathion

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FLORICULTURE http://ipm.ucanr.edu/PMG/selectnewpest.floriculture.html	Aphids	Yellow sticky cards and visual inspections	Conservation of predators and parasites. Multiple species of parasitoids available for augmentative releases	Multiple http://ipm.ucanr.edu/PMG/r280300111.html
	Armored scale	Visual plant inspections	Conserve biocontrol. Releases of *Aphytis melinus* for California red scale	Multiple http://ipm.ucanr.edu/PMG/r280300211.html
	Armyworms and cutworms	Visual inspections. Pheromone traps to monitor phenology and assist in timing of Bt products	Maintain environment free of alternate host weeds. Exclusion of adults from greenhouses with screens (especially for crops using lights). Row covers outdoors. Conserve parasitoids.	Multiple http://ipm.ucanr.edu/PMG/r280300311.html
	Cabbage looper	Visual inspections. Pheromone traps to monitor phenology and assist in timing of Bt products	Maintain environment free of alternate host weeds. Exclusion of adults from greenhouses with screens (especially for crops using lights). Row covers outdoors. Conserve parasitic wasps and flies.	Multiple http://ipm.ucanr.edu/PMG/r280300511.html
	Diamondback moth	Visual inspections. Pheromone traps to monitor phenology and assist in timing of Bt products	Maintain environment free of alternate host weeds. Exclusion of adults from greenhouses with screens (especially for crops using lights). Row covers outdoors. Conserve parasitic wasps and flies.	Multiple http://ipm.ucanr.edu/PMG/r280300611.html
	Foliar-feeding mealybugs	Plant inspections for mealybugs, honeydew, and ant activity.	Conservation and augmentative releases of *Cryptolaemus*. Releases of *Leptomastix dactylopii* for citrus mealybug. Control sugar-feeding ants	Multiple http://ipm.ucanr.edu/PMG/r280300711.html

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FLORICULTURE	Fungus gnats	Monitor adults using yellow sticky traps and larvae using potato slices	Avoid overwatering and algal scum. Avoid incompletely composted organic matter or manure in potting media. Steaming of potting media (esp. peat) prior to use. Biocontrol using nematodes, predaceous mites and bacteria	Multiple http://ipm.ucanr.edu/PMG/r280300811.html
	Leafhoppers/ sharpshooter	Use visual inspections or beat samples on plants. Monitor adults using yellow sticky traps within the crop and outdoors on property edges to watch for immigration	Exclusion using screening or row covers. Removal of alternate hosts, including weeds. Reflective mulches for some outdoor crops	Multiple http://ipm.ucanr.edu/PMG/r280301711.html
	Leafminers	Yellow sticky cards for adults in greenhouses	Maintain weed-free environment. Exclusion using screens with pores <600 microns. Inspection/roguing of incoming plants. Remove pupae from beds through steaming before planting	Multiple http://ipm.ucanr.edu/PMG/r280300911.html
	Leafrollers	Varies by species. Includes plant inspections for egg masses and larvae. Pheromone traps available for light-brown apple moth	Removal of alternate hosts, including weeds. Exclusion of adults from greenhouses with screens	Multiple http://ipm.ucanr.edu/PMG/r280300411.html
	Shore fly	Yellow sticky card monitoring for adults	Avoid overwatering and control algae	Multiple http://ipm.ucanr.edu/PMG/r280301111.html
	Soft scales	Visual inspection of plants for scale and ant activity. For woody plants, monitor crawlers using double-sided sticky tape	Control sugar-feeding ants. Prune out and discard heavily infested plants. Conservation and augmentation of parasitoids and *Cryptolaemus*	Multiple http://ipm.ucanr.edu/PMG/r280301211.html

COMMODITY	PEST	MONITORING AND DECISION MAKING TOOLS	NON-CHEMICAL ALTERNATIVES	CHEMICAL ALTERNATIVES
FLORICULTURE	Thrips	Monitor adults using blue or yellow sticky cards	Removal of alternate weed hosts. Use of screens with pore sizes <145 microns if allowed by venting systems. Augmentative releases of minute pirate bug and predatory mites	Multiple http://ipm.ucanr.edu/PMG/r280301411.html
GRAPE http://ipm.ucanr.edu/PMG/selectnewpest.grapes.html	**Sugar-feeding ants (Argentine and native gray)**	Monitor for ant activity while conducting mealybug evaluations.	Tilling to disrupt nesting sites. Cover crops with nectaries (such as common vetch) can lure gray field ants off the vines.	Disodium tetraborate or S-methoprene liquid baits in EPA-approved bait stations
	Mealybugs (Grape and obscure)	Monitor spurs for crawlers in late February to early March. Pheromone traps exist for grape mealybug. Monitor throughout the season for mealybugs, honeydew and sooty mold. Check mealybugs for evidence of parasitism. Use thresholds.	Lure field ants away from vines using vetch cover crops where water availability allows. Train vines so that clusters hang freely and do not touch wood. Control ants that disrupt biological control. Many parasitic wasps, specialized lady beetles, and generalist predators attack grape and obscure mealybug.	Buprofezin Spirotetramat Imidacloprid Clothianidin Dinotefuran Thiamethoxam
	Mealybugs (Vine)	Monitor for mealybugs, honeydew and sooty mold on the roots, trunk, cordon, leaves or clusters depending on the time of year. During the main growing season, use sugar-feeding ants as indicators of infestations. Use pheromone traps to monitor for incipient mealybug populations in vineyards thought to be uninfested.	Avoid transporting mealybugs to new vineyards on contaminated equipment or through winery waste. Train vines so that clusters hang freely and do not touch the cordon. Tanglefoot bands on the trunk (with bark removed) may slow movement up the vine. Use mating disruption (sprayable or by hanging dispensers).	Spirotetramat Buprofezin Imidacloprid Clothianidin Thiamethoxam Dinotefuran Acetamiprid

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NECTARINE http://ipm.ucanr.edu/PMG/selectnewpest.nectarine.html	Peachtree borer	Monitor for gumming at the tree base. Adults can be monitored with pheromone traps.	None reported.	Esfenvalerate
ONION/GARLIC https://www2.ipm.ucanr.edu/agriculture/onion-and-garlic/	**Maggots**	Monitor adults using yellow sticky traps. Use degree-day models to assist with planting timing after the first spring flight is over. Monitor weather conditions to avoid planting when soil is cool and excessively moist. Monitor organic matter decomposition before planting.	Use a press wheel or chain drag to cover seeds. Plant later in spring for quick seedling emergence. Use crop rotation away from alliums. Avoid planting in fields with high amounts of undecomposed organic matter. For onions, use a higher seeding rate. Consider no-till seeding. For onion maggot, do not plant until first generation of adults are gone. For seed-corn maggot delay planting 2-3 weeks after cultivation, tillage or bed-shaping.	Seed treated with spinosad, thiamethoxam Clothianidin Imidacloprid
PEACH http://ipm.ucanr.edu/PMG/selectnewpest.peach.html	Peachtree borer	Monitor for gumming at the tree base. Adults can be monitored with pheromone traps.	None reported.	Esfenvalerate

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PEAR http://ipm.ucanr.edu/PMG/selectnewpest.pears.html	Codling moth	Monitor using pheromone traps and degree-day models. Supercharged, regular, and DA lures are available depending on the situation. Sample dropped fruit (early July) and fruit damage towards the end of each CM generation.	Destroy reservoirs of codling moth (including nearby abandoned pear, apple and walnut orchards). For small, organic orchards, hand thinning to remove infested fruit in each generation. Trunk banding to collect and remove larvae/pupae before adult emergence.	Mating disruption (various) Spinetoram Chlorantraniliprole Lambda-cyhalothrin Acetamiprid Phosmet Methoxyfenozide Spinosad Cydia pomonella granulovirus Narrow range oil Kaolin Clay
	Mealybugs (grape and obscure)	During dormancy, look for mealybugs and egg masses under the bark. Monitor weekly for mealybugs on fruit spurs (spring) or the fruit calyx (through harvest).	Conserve predatory *Chyptolaemus* beetles and multiple parasitoid species. Control sugar-feeding ants that disrupt biological control.	Spirotetramat Buprofezin Thiamethoxam Clothianidin Diazinon
	Oblique-banded leafroller	At cluster bud look for larvae and feeding damage on flowers. Use pheromone traps and degree-days to monitor phenology. Conduct fruit evaluations during the summer.	Conserve biocontrol by the parasitic wasp *Macrocentrus irridescens*.	Bacillus thuringiensis Methoxyfenozide Spinosad Chlorantrilinprole Spinetoram
	San Jose scale	Use of dormant spur sampling and established treatment thresholds. In-season use of pheromone traps to monitor males and parasitoids. Monitor crawler emergence using double-sided sticky tape.	Conservation of predaceous beetles and parasitoids (esp. *Aphytis* and *Encarcia* spp.)	Oils (various Buprofezin Pyriproxyfen Spirotetramat

COMMODITY	PEST	MONITORING AND DECI SION MAKING TOOLS	NON-CHEMICAL ALTERNATIVES	CHEMICAL ALTERNATIVES
PECAN https://www2.ipm.ucanr.edu/agriculture/pecan/	Black pecan aphid	Scout for aphids and damage in late summer through harvest	Conservation of natural enemies	Flupyradifurone Flonicamid Spirotetramat Pymetrozine Imidacloprid Dimethoate potassium salts of fatty acids Azadirachtin Narrow range oil
	Yellow aphid complex	Scout for aphids, honeydew and sooty mold from May through nut development.	Conservation of natural enemies	Flupyradifurone Flonicamid Imidacloprid Spirotetramat Pymetrozine Dimethoate Potassium salts of fatty acids Azadirachtin Narrow range oil
PEPPERMINT http://ipm.ucanr.edu/PMG/selectnewpest.peppermint.html	**Mint root borer**	Examine soil, roots and rhizomes for larvae from September through October. Use thresholds to determine the need for post-harvest treatments.	Inoculative releases of parasitic nematodes. Plant in field rotated from non-host crop. Tillage in late fall or spring	Chlorantraniliprole Ethoprop
PLUM http://ipm.ucanr.edu/PMG/selectnewpest.plum.html	European fruit lecanium	Dormant spur sampling for scale and level of parasitism. If scale are present, reassess parasitism levels in the summer.	Control typically achieved by conserving parasitoids (*Aphytis* spp., *Coccophagus* spp., *Encarsia* spp., and *Metaphycus* spp.) and generalist predators	Oil (various) Diazinon

COMMODITY	PEST	MONITORING AND DECI SION MAKING TOOLS	NON-CHEMICAL ALTERNATIVES	CHEMICAL ALTERNATIVES
PLUM	Oblique-banded leafroller	March-April monitoring for larvae and feeding damage.	Conserve *Macrocentrus irri-descens* and *Glypta variegata* parasitoids.	Oil (various) Oil + insecticide combinations Bacillus thuringiensis Spinosad Methoxyfenozide Diflubenzuron
	Peach twig borer	Search for feeding damage on buds and larvae during bloom and shoot emergence. Dissect hibernacula from February to bloom to assist with bloom treatment timings. Monitor adults using pheromone traps and degree-day models.	Conserve the more than 30 natural enemy species that attack PTB. Mating disruption can supplement other control measures, especially in organic plums.	Narrow range oil Oil + insecticide combinations Bacillus thuringiensis Spinosad Methoxyfenozide Diflubenzuron Phosmet Esfenvalerate Diazinon
	San Jose scale	Dormant spur sampling for live scale and levels of parasitism. Use thresholds. In-season monitoring for adult males and parasitoids using pheromone traps. Track phenololgy using degree-day model. Evaluate fruit at harvest to assess program effectiveness.	Conserve natural enemies, including lady beetles and the parasitoids *Aphytis* and *Encarsia.*	Oil (various) Pyriproxyfen Diazinon
PRUNE http://ipm.ucanr.edu/PMG/selectnewpest.prune.html	Oblique-banded leafroller	Monitor spring emergence of larvae when using bloom sprays. Monitor adults and phenology starting post-bloom using pheromone traps and degree-day models. Monitor larvae in leaf rolls and where fruit touch. Use thresholds. Assess damage at harvest.	Conserve natural enemies, including generalist predators (lacewings, assassin bugs and minute pirate bugs) and the parasitoids *Macrocentrus, Cotesia* and *Exochus.*	Spinosad Oil (various) Oil + insecticide combinations Bacillus thuringiensis Methoxyfenozide Diflubenzuron

COMMODITY	PEST	MONITORING AND DECI SION MAKING TOOLS	NON-CHEMICAL ALTERNATIVES	CHEMICAL ALTERNATIVES
PRUNE	Peach twig borer	Search for feeding damage on buds and larvae during bloom and shoot emergence. Dissect hibernacula from February to bloom to assist with bloom treatment timings. Monitor adults using pheromone traps and degree-day models.	Conserve the more than 30 natural enemy species that attack PTB. Mating disruption can supplement other control measures, especially in organic plums.	Narrow range oil Oil + insecticide combinations Bacillus thuringiensis Spinosad Methoxyfenozide Diflubenzuron Phosmet Esfenvalerate Lambda cyhalothrin Diazinon
	San Jose scale	Dormant spur sampling for live scale and levels of parasit-ism. Use thresholds. In-season monitoring for adult males and parasitoids using phero-mone traps. Track phenololgy using degree-day model. Monitor crawler activity with double-sided sticky tape.	Conserve natural enemies, including lady beetles and the parasitoids Aphytis and Encarsia.	Oil (various) Oil + insecticide combinations Pyriproxyfen
SMALL GRAINS http://ipm.ucanr.edu/PMG/selectnewpest.small-grains.html	Bird cherry-oat aphid	Monitor for aphids and natural enemies. Do not consider treatment until aphids exceed 50-60 per tiller.	Destroy volunteer cereals prior to planting. Conserve predators and parasites that usually provide adequate control.	Dimethoate Malathion
	Corn leaf aphid	Monitor for corn leaf aphid while looking for other aphids.	Predators and parasites provide excellent control.	Dimethoate Malathion
	English grain aphid	Monitor for aphids in the wheat head.	Predators and parasites provide excellent control.	Dimethoate Malathion
	Greenbug	Monitor weekly from seedling emergence to tillering. Also look for natural enemies.	Conserve natural enemies, including parasitoids, lady beetles, green lacewings and syrphid flies.	Dimethoate Malathion

COMMODITY	PEST	MONITORING AND DECISION MAKING TOOLS	NON-CHEMICAL ALTERNATIVES	CHEMICAL ALTERNATIVES
SMALL GRAINS	Rosy-grain aphid	Monitor for corn leaf aphid while looking for other aphids.	Predators and parasites provide excellent control.	Dimethoate Malathion
	Russia wheat aphid	Check fields regularly for aphid presence. Use thresholds according to plant growth stage.	Conserve natural enemies that feed on many aphid species. Destroy volunteer cereals before planting. Maintain adequate soil moisture and fertilization to avoid plant stress. Grow wheat in areas isolated from pastures. Select oats and wheat over barley (highly susceptible) in areas with high aphid pressure.	Dimethoate Malathion
STRAWBERRY https://www2.ipm.ucanr.edu/agriculture/strawberry/	Beet armyworm	Monitor adults using pheromone traps. If trap catches are high, monitor plants for eggs and larvae. Check larvae for parasitism. If needed, time treatments to egg hatch.	Remove alternate host weeds in and around fields. Conserve the parasitoid *Hyposoter exiguae* and generalist predators. Armytworms often become infected with a virus.	Methoxyfenozide Spinetoram Spinosad Bacillus thuringiensis Diazinon
	Garden symphylan	Use potato or carrot wedge sampling to determine the need for control prior to planting.	Avoid symphylans by fumigating prior to planting. In non-fumigated fields, ensure full breakdown of crop residues before planting. Summer flooding may help.	Pre-plant fumigation Diazinon
	Root beetles	Monitor field history to determine risks of beetle damage in fields not using fumigation.	Use annual strawberry plantings. Rotate to non-hosts between plantings. Parasitic nematode releases are available but not documented to be effective.	Pre-plant fumigation

COMMODITY	PEST	MONITORING AND DECISION MAKING TOOLS	NON-CHEMICAL ALTERNATIVES	CHEMICAL ALTERNATIVES
SUGARBEET http://ipm.ucanr.edu/PMG/selectnewpest.sugarbeet.html	Bean aphids	For April and May plantings, monitor plants during the first 6-8 weeks after emergence. Use thresholds based on plant age and damage level assessments.	Adhere to beet-free restrictions and good field sanitation to reduce virus inoculum. Conserve the parasitic wasp, *Lysiphlebus testaceipes*. Watch for aphid infection by a fungus after rains and general aphid predators.	Phorate Methomyl
	Armyworms	Use weekly sweep samples for larvae and generalist predators, and pheromone traps to determine flights.	Recognize great compensation ability of sugarbeets in mid to late season. Conserve the parasitic wasp Hyposoter exiguae and generalist predators. Viral and bacterial diseases also attack armyworms.	Methoxyfenozide Spinetoram Chlorantraniliprole Spinosad Methomyl Bacillus thuringiensis
	Cutworms	Dig around missing or damaged plants during stand establishment to find cutworms.	Manage crop rotation to avoid planting to fields with cutworms. Spring plowing and disking. Maintain fields free of alternate weed hosts.	Methoxyfenozide Bacillus thuringiensis Methomyl Carbaryl
	Seedcorn maggot	Monitor field history to assess risk of seedcorn maggot	Ensure full decomposition of crop residues prior to planting. Avoid planting during cold, wet periods.	Phorate
	Wireworms	Monitor field history to assess risk of wireworms	Reduce populations using summer fallow with frequent tillage prior to planting. Rotate from nonhost crops.	None
WALNUT https://www2.ipm.ucanr.edu/agriculture/walnut/	Aphids	Leaf sampling from May through periods of nut growth for aphids and natural enemies	Conserve the parasitic wasp *Trioxys pallidus* and generalist predators.	Imidacloprid Acetamiprid Phosmet Narrow range oil

COMMODITY	PEST	MONITORING AND DECI SION MAKING TOOLS	NON-CHEMICAL ALTERNATIVES	CHEMICAL ALTERNATIVES
WALNUT	Codling moth	Monitor using pheromone traps and degree-day models. Supercharged, regular, and DA lures are available depending on the situation. Weekly nut sampling. Use treatment thresholds for each flight.	Suppression by the parasitic wasp *Trichogramma platneri*.	Mating disruption (various) Spinetoram Chlorantraniliprole Cyantraniliprole Lambda-cyhalothrin Cyfluthrin Bifenthrin Acetamiprid Emamectin Benzoate Phosmet Methoxyfenozide Esfenvalerate Permethrin Carbaryl Diflubenzuron Cydia pomonella granulovirus Spinosad
	San Jose scale	Use dormant spur sampling and treatment thresholds.	Conserve parasites and predators, including many that control walnut scale.	Pyriproxyfen Buprofezin Narrow range oil

COMMODITY	PEST	MONITORING AND DECI SION MAKING TOOLS	NON-CHEMICAL ALTERNATIVES	CHEMICAL ALTERNATIVES
WALNUT	Walnut husk fly	Monitor adults twice weekly with unbaited yellow sticky traps super-charged with ammonium carbonate. Examine female flies for eggs. Monitor fruit for stings. Use treatment thresholds.	Hasten maturity and husk split suing ethephon. Avoid planting more susceptible varieties like Tulare, Hartley, Serr and Franquette.	Bait (molasses + corn gluten meal + corn steep liquor) plus… Acetamiprid Bifenthrin Beta-cyfluthrin Lambda-cyhalothrin Fenpropathrin Esfenvalerate Spinetoram Spinosad Phosmet Malathion Imidacloprid Clothianidin

Appendix 2

Table 2A – Relative toxicities of insecticide active ingredients that are listed in Table 1 as alternatives to chlorpyrifos according to the UC IPM Pest Management Guidelines for agricultural crops.

ACTIVE INGREDIENT	IRAC #[1]	IRAC MODE OF ACTION GROUPING[1]	COMMON LABEL NAME[2]	SIGNAL WORD	RESTRICTED USE	ACUTE ORAL TOXICITY[3] (mg/kg)	ACUTE DERMAL TOXICITY[3] (mg/kg)	PROP 65[4] (cancer)	PROP 65[4] (repro)	EPA CARCINOGEN[5]	BEE TOXICITY RATING[6]
1, 3-DICHLOROPROPENE	-	-	Telone II	Warning	Federally	> 110	333	Yes	No	Probable	3
	-	-	InLine	Danger/ Poison	Federally	100 - 200	> 600	Yes	No	Probable	3
ABAMECTIN	6	Avermectins, Milbemycins	Agri-Mek SC	Warning	Federally	310	> 2,000	No	Yes	No	1
	6	Avermectins, Milbemycins	Clinch Ant Bait	Caution	No	> 5,000	> 2,000	No	Yes	No	1
ABAMECTIN/ THIAMETHOXAM	6/ 4A	Avermectins, Milbemycins/ Neonicotinoids	Agri-Flex	Warning	Federally	550	> 5,000	No/ No	Yes/ No	No/ No	1
ACEPHATE	1B	Organophosphates	Orthene 97	Caution	No	1,030	> 1,000	No	No	Possible	1
ACETAMIPRID	4A	Neonicotinoids	Assail 70WP	Caution	No	1,064	> 2,000	No	No	No	2
	4A	Neonicotinoids	Assail 30SG	Caution	No	805	> 2,000	No	No	No	2
AZADIRACHTIN	UN	Azadirachtin	Neemix 4.5	Caution	No	> 5,000	> 2,000	No	No	Not listed	3

ACTIVE INGREDIENT	IRAC #[1]	IRAC MODE OF ACTION GROUPING[1]	COMMON LABEL NAME[2]	SIGNAL WORD	RESTRICTED USE	ACUTE ORAL TOXICITY[3] (mg/kg)	ACUTE DERMAL TOXICITY[3] (mg/kg)	PROP 65[4] (cancer)	PROP 65[4] (repro)	EPA CARCINOGEN[5]	BEE TOXICITY RATING[6]
BACILLUS THURINGIENSIS	11A	Bacillus Thuringiensis and the Insecticidal Proteins they Produce	DiPel	Caution	No	> 5,050	> 2,020	No	No	Not listed	3
	11A	Bacillus Thuringiensis and the Insecticidal Proteins they Produce	Dipel ES	Caution	No	> 5,050	> 5,050	No	No	Not listed	3
	11A	Bacillus Thuringiensis and the Insecticidal Proteins they Produce	Deliver	Caution	No	> 5,000	> 5,050	No	No	Not listed	3
	11A	Bacillus Thuringiensis and the Insecticidal Proteins they Produce	Agree WG	Caution	No	> 5,050	> 2,020	No	No	Not listed	3
	11A	Bacillus Thuringiensis and the Insecticidal Proteins they Produce	Xentari	Caution	No	> 5,000	> 2,000	No	No	Not listed	3
BETA-CYFLUTHRIN	3A	Pyrethroids, Pyrethrins	Baythroid XL	Warning	Federally	647	> 2,000	No	No	No	1
BIFENTHRIN	3A	Pyrethroids, Pyrethrins	Brigade WSB	Warning	Federally	335	> 2,000	No	No	Possible	1
BUPROFEZIN	16	Inhibitors of Chitin Biosynthesis, Type 1	Courier SC	Warning	No	> 5,000	> 2,000	No	No	Suggestive	3

ACTIVE INGREDIENT	IRAC #[1]	IRAC MODE OF ACTION GROUPING[1]	COMMON LABEL NAME[2]	SIGNAL WORD	RESTRICTED USE	ACUTE ORAL TOXICITY[3] (mg/kg)	ACUTE DERMAL TOXICITY[3] (mg/kg)	PROP 65[4] (cancer)	PROP 65[4] (repro)	EPA CARCINOGEN[5]	BEE TOXICITY RATING[6]
BUPROFEZIN	16	Inhibitors of Chitin Biosynthesis, Type 1	Applaud	Caution	No	> 5,000	> 2,000	No	No	Suggestive	3
	16	Inhibitors of Chitin Biosynthesis, Type 1	Centaur WDG	Caution	No	> 5,000	> 2,000	No	No	Suggestive	3
CARBARYL	1A	Carbamates	Sevin XLR Plus	Caution	Yes	699	> 4,000	Yes	Yes	Likely	1
	1A	Carbamates	Sevin Bait 5%	Caution	No	2,330	> 2,000	Yes	Yes	Likely	1
CHLORANTRANILIPROLE	28	Diamides	Coragen	None	No	> 5,000	> 5,000	No	No	No	3
	28	Diamides	Altacor	None	No	> 5,000	> 5,000	No	No	No	3
CHLOROPICRIN	8	Miscellaneous Non-Specific (Multi-Site) Inhibitors	Tri-Clor EC	Danger/ Poison	Federally	37.5	Not listed	No	No	No	3
CLOTHIANIDIN	4A	Neonicotinoids	Belay	Caution	No	3,900	> 5,000	No	No	No	2
	4A	Neonicotinoids	Belay	Caution	No	3,044	> 5,000	No	No	No	2
	4A	Neonicotinoids	Poncho	Caution	No	2,000	> 4,000	No	No	No	1
	4A	Neonicotinoids	Clutch 50WDG	Caution	No	3,900	> 5,000	No	No	No	2

ACTIVE INGREDIENT	IRAC #[1]	IRAC MODE OF ACTION GROUPING[1]	COMMON LABEL NAME[2]	SIGNAL WORD	RESTRICTED USE	ACUTE ORAL TOXICITY[3] (mg/kg)	ACUTE DERMAL TOXICITY[3] (mg/kg)	PROP 65[4] (cancer)	PROP 65[4] (repro)	EPA CARCINOGEN[5]	BEE TOXICITY RATING[6]
CLOTHIANIDIN/ IMIDACLOPRID	4A/ 4A	Neonicotinoids/Neonicotinoids	Sepresto 75WS	Caution	No/No	1,000	> 2,000	No/ No	No/ No	No/ No	3
CRYOLITE	8C	Fluorides	Prokil Cryolite 96	Caution	No	> 1,960	> 2,020	No	No	No	3
CYANTRANILIPROLE	28	Diamides	Exirel	Caution	No	> 5,000	> 5,000	No	No	No	1
CYANTRANILIPROLE/ ABAMECTIN	28/6	Diamides/ Avermectins, Milbemycins	Minecto Pro	Warning	Federally	451.1	> 2,000	No/ No	No/ Yes	No/ No	1
CYDIA POMONELLA GRANULOVIRUS	31	Granuloviruses (Gvs), Nucleopolyhedroviruses (Npvs)	Cyd-X	Caution	No	Not listed	Not listed	No	No	Not listed	3
	31	GGranuloviruses (Gvs), Nucleopolyhedroviruses (Npvs)	Cyd-X	Caution	No	Not listed	Not listed	No	No	Not listed	3
CYFLUTHRIN	3A	Pyrethroids, Pyrethrins	Tombstone	Danger	Federally	1,030	> 5,000	No	No	No	1
	3A	Pyrethroids, Pyrethrins	Tombstone	Warning	Federally	1,030	> 2,000	No	No	No	1
	3A	Pyrethroids, Pyrethrins	Baythroid XL	Warning	Federally	647	> 2,000	No	No	No	1
DIAZINON	1B	Organophosphates	Diazinon 50WP	Caution	Federally	> 1,960	> 2,020	No	No	No	1
	1B	Organophosphates	Diazinon AG600 WBC	Caution	Federally	1,600	> 2,020	No	No	No	1
	1B	Organophosphates	Diazinon AG500	Caution	Federally	66	2,150	No	No	No	1

ACTIVE INGREDIENT	IRAC #[1]	IRAC MODE OF ACTION GROUPING[1]	COMMON LABEL NAME[2]	SIGNAL WORD	RESTRICTED USE	ACUTE ORAL TOXICITY[3] (mg/kg)	ACUTE DERMAL TOXICITY[3] (mg/kg)	PROP 65[4] (cancer)	PROP 65[4] (repro)	EPA CARCINOGEN[5]	BEE TOXICITY RATING[6]
DIFLUBENZURON	15	Benzoylureas	Dimilin 2L	Caution	Federally	> 5,000	> 5,000	No	No	No	2
	15	Benzoylureas	Dimilin 25W	Caution	Federally	> 10,000	> 20,000	No	No	No	2
DIMETHOATE	1B	Organophosphates	Dimethoate 2.67EC	Warning	No	425	2,020	No	No	Possible	1
	1B	Organophosphates	Dimethoate 2.67EC	Warning	No	345	> 2,020	No	No	Possible	1
	1B	Organophosphates	Dimethoate 400	Warning	No	425	2,020	No	No	Possible	1
	1B	Organophosphates	Dimethoate 4EC	Warning	No	450	> 2,000	No	No	Possible	1
DINOTEFURAN	4A	Neonicotinoids	Venom	Caution	No	> 5,000	> 5,000	No	No	No	1
DISODIUM TETRABORATE	8D	Borates	Gourmet Liquid Ant Bait	Caution	No	Not listed	Not listed	No	No	No	3
EMAMECTIN BENZOATE	6	Avermectins, Milbemycins	Proclaim	Caution	Federally	1,516	> 2,000	No	No	No	1
ESFENVALERATE	3A	Pyrethroids, Pyrethrins	Asana XL	Warning	Federally	458	> 2,000	No	No	No	1
ETHOPROP	1B	Organophosphates	Mocap 15G	Danger/ Poison	Federally	300	41.4	Yes	No	Likely	2
	1B	Organophosphates	Mocap EC	Danger/ Poison	Federally	15.9	166	Yes	No	Likely	2
FENBUTATIN-OXIDE	12B	Organotin Miticides	Vendex 50WP	Danger/ Poison	Federally	> 5,000	> 2,000	No	No	No	3
FENPROPATHRIN	3A	Pyrethroids, Pyrethrins	Danitol 2.4EC	Warning	Federally	66	> 2,000	No	No	No	1

ACTIVE INGREDIENT	IRAC #[1]	IRAC MODE OF ACTION GROUPING[1]	COMMON LABEL NAME[2]	SIGNAL WORD	RESTRICTED USE	ACUTE ORAL TOXICITY[3] (mg/kg)	ACUTE DERMAL TOXICITY[3] (mg/kg)	PROP 65[4] (cancer)	PROP 65[4] (repro)	EPA CARCINOGEN[5]	BEE TOXICITY RATING[6]
FENPYROXIMATE	21A	Meti Acaricides and Insecticides	Fujimite SC	Warning	No	6,789	> 2,000	No	No	No	3
FLONICAMID	29	Chordotonal Organ Modulators - Undefined Target Site	Beleaf 50SG	Caution	No	> 2,000	> 2,000	No	No	Not listed	3
	29	Chordotonal Organ Modulators - Undefined Target Site	Carbine 50WG	Warning	No	> 2,000	> 2,000	No	No	Not listed	3
FLUPYRADIFURONE	4D	Butenolides	Sivanto 200SL	Caution	No	> 2,000	> 2,000	No	No	No	2
IMIDACLOPRID	4A	Neonicotinoids	Admire Pro	Caution	No	> 500	> 2,000	No	No	No	1
IMIDACLOPRID (SEED TREATMENT)	4A	Neonicotinoids	Gaucho 60F	Caution	No	> 300	> 2,000	No	No	No	1
IMIDACLOPRID/ BETA-CYFLUTHRIN	4A/ 3A	Neonicotinoids/ Pyrethroids, Pyrethrins	Leverage 360	Caution	Federally	> 1,044	> 2,000	No/ No	No/ No	No/ No	1
INDOXACARB	22A	Oxadiazines	Steward EC	Caution	No	977	> 5,000	No	No	No	1
	22A	Oxadiazines	Avaunt	Caution	No	687	> 5,000	No	No	No	1
INSECTICIDAL SOAP	-	-	M-Pede	Warning	No	> 5,050	> 2,020	No	No	No	3
KAOLIN CLAY	-	-	Surround	Caution	No	> 5,000	Not listed	No	No	Not listed	3

ACTIVE INGREDIENT	IRAC #[1]	IRAC MODE OF ACTION GROUPING[1]	COMMON LABEL NAME[2]	SIGNAL WORD	RESTRICTED USE	ACUTE ORAL TOXICITY[3] (mg/kg)	ACUTE DERMAL TOXICITY[3] (mg/kg)	PROP 65[4] (cancer)	PROP 65[4] (repro)	EPA CARCINOGEN[5]	BEE TOXICITY RATING[6]
LAMBDA-CYHALOTHRIN	3A	Pyrethroids, Pyrethrins	Warrior II with Zeon	Warning	Federally	310	> 2,000	No	No	No	1
MALATHION	1B	Organophosphates	Malathion 8-E	Caution	No	> 5,000	> 5,000	Yes	No	Suggestive	1
METAFLUMIZONE	22B	Semicarbazones	Altrevin 0.063%	Caution	No	> 2,000	> 2,000	No	No	No	3
METHOMYL	1A	Carbamates	Lannate SP	Danger/ Poison	Federally	23	> 2,000	No	No	No	1
	1A	Carbamates	Lannate LV	Danger/ Poison	Federally	49	> 2,000	No	No	No	1
METHOPRENE	7A	Juvenile Hormone Analogues	Extinguish	Caution	No	> 5,010	> 5,010	No	No	Not listed	3
METHOXYFENOZIDE	18	Diacylhydrazines	Intrepid 2F	Caution	No	> 5,000	> 2,000	No	No	No	3
METHOXYFENOZIDE /SPINETORAM	18/5	Diacylhydrazines/ Spinosyns	Intrepid Edge	Caution	No/No	> 5,000	> 5,000	No/ No	No/ No	No/ No	2
NALED	1B	Organophosphates	Dibrom 8E	Danger	Federally	235	5,050	No	No	No	1

ACTIVE INGREDIENT	IRAC #[1]	IRAC MODE OF ACTION GROUPING[1]	COMMON LABEL NAME[2]	SIGNAL WORD	RESTRICTED USE	ACUTE ORAL TOXICITY[3] (mg/kg)	ACUTE DERMAL TOXICITY[3] (mg/kg)	PROP 65[4] (cancer)	PROP 65[4] (repro)	EPA CARCINOGEN[5]	BEE TOXICITY RATING[6]
NARROW RANGE OIL	-	-	JMS Stylet Oil	Caution	No	> 5,000	> 5,000	Yes	No	No	3
	-	-	TriTek	Caution	No	> 5,000	> 2,000	Yes	No	No	3
	-	-	Omni Supreme	Caution	No	> 5,000	> 2,000	Yes	No	No	3
	-	-	415	Caution	No	> 5,000	> 2,000	Yes	No	No	3
	-	-	440	Caution	No	Not listed	Not listed	Yes	No	No	3
NOVALURON	15	Benzoylureas	Diamond 0.83EC	Warning	No	> 5,000	> 2,000	No	No	No	2
PERMETHRIN	3A	Pyrethroids, Pyrethrins	Pounce 25WP	Caution	Federally	1,100	> 2,000	No	No	Not listed	1
	3A	Pyrethroids, Pyrethrins	Ambush 25W	Caution	No	> 5,000	> 2,000	No	No	Not listed	1
PHORATE	1B	Organophosphates	Thimet 20SG	Danger/ Poison	Federally	5.1	86	No	No	No	3
PHOSMET	1B	Organophosphates	Imidan 70W	Warning	No	258	> 2,000	No	No	Suggestive	1
POTASSIUM SALTS OF FATTY ACIDS	-	-	DES-X	Warning	No	> 5,000	> 5,000	No	No	Not listed	3
	-	-	M-Pede	Warning	No	> 5,050	> 2,020	No	No	Not listed	3
PYMETROZINE	9B	Pyridine Azomethine Derivatives	Fulfill	Caution	No	> 5,000	> 2,000	Yes	No	Likely	3

ACTIVE INGREDIENT	IRAC #[1]	IRAC MODE OF ACTION GROUPING[1]	COMMON LABEL NAME[2]	SIGNAL WORD	RESTRICTED USE	ACUTE ORAL TOXICITY[3] (mg/kg)	ACUTE DERMAL TOXICITY[3] (mg/kg)	PROP 65[4] (cancer)	PROP 65[4] (repro)	EPA CARCINOGEN[5]	BEE TOXICITY RATING[6]
PYRETHRIN	3A	Pyrethroids, Pyrethrins	PyGanic EC 1.4	Caution	No	> 2,000	> 2,000	No	No	No	1
PYRIPROXYFEN	7C	Juvenile Hormone Mimics	Knack	Caution	No	4,733	> 2,000	No	No	No	3
	7C	Juvenile Hormone Mimics	Esteem Ant Bait 0.5%	Caution	No	> 5,000	> 2,000	No	No	No	3
	7C	Juvenile Hormone Mimics	Esteem 0.86EC	Caution	No	4,733	> 2,000	No	No	No	3
	7C	Juvenile Hormone Mimics	Seize 35WP	Caution	No	> 5,000	> 5,000	No	No	No	2
S-METHOPRENE LIQUID BAITS IN EPA-APPROVED BAIT STATIONS	7A	Juvenile Hormone Analogues	Tango	Caution	No	> 34,000	> 2,000	No	No	Not listed	3
SPINETORAM	5	Spinosyns	Delegate WG	Caution	No	> 5,000	> 5,000	No	No	No	1
	5	Spinosyns	Radiant SC	Caution	No	> 5,000	> 5,000	No	No	No	1
SPINOSAD	5	Spinosyns	Entrust SC	None	No	> 5,000	> 5,000	No	No	No	1
	5	Spinosyns	Regard SC	None	No	> 5,000	> 5,000	No	No	No	2
	5	Spinosyns	Success	None	No	> 5,000	> 5,000	No	No	No	2
	5	Spinosyns	GF-120 NF Naturalyte Fruit Fly Bait	Caution	No	> 5,000	> 5,000	No	No	No	3

ACTIVE INGREDIENT	IRAC #[1]	IRAC MODE OF ACTION GROUPING[1]	COMMON LABEL NAME[2]	SIGNAL WORD	RESTRICTED USE	ACUTE ORAL TOXICITY[3] (mg/kg)	ACUTE DERMAL TOXICITY[3] (mg/kg)	PROP 65[4] (cancer)	PROP 65[4] (repro)	EPA CARCINOGEN[5]	BEE TOXICITY RATING[6]
SPIRODICLOFEN	23	Tetronic And Tetramic Acid Derivatives	Envidor 2SC	Caution	No	> 2,000	> 4,000	Yes	No	Likely	2
SPIROMESIFEN	23	Tetronic And Tetramic Acid Derivatives	Oberon 2SC	Caution	No	> 2,000	> 4,000	No	No	No	3
SPIROTETRAMAT	23	Tetronic And Tetramic Acid Derivatives	Movento	Caution	No	> 2,000	> 4,000	No	No	No	2
THIAMETHOXAM	4A	Neonicotinoids	Centric 40WG	Caution	No	> 5,000	> 2,000	No	No	No	1
	4A	Neonicotinoids	Cruiser 5FS	Caution	No	> 5,000	> 5,050	No	No	No	1
	4A	Neonicotinoids	Platinum	Caution	No	> 5,000	> 2,000	No	No	No	1
	4A	Neonicotinoids	Actara	Caution	No	> 5,000	> 2,000	No	No	No	1
THIAMETHOXAM/ CHLORANTRANILIPROLE	4A/ 28	Neonicotinoids/ Diamides	Voliam Flexi	Caution	No/No	> 5,000	> 5,000	No/ No	No/ No	No/ No	1
ZETA-CYPERMETHRIN	3A	Pyrethroids, Pyrethrins	Mustang	Warning	Federally	310	> 5,000	No	No	Possible	1

[1]IRAC- The Insecticide Resistance Action Committee. See https://www.irac-online.org/modes-of-action

[2] Representative label name is the trade name of one commercial insecticide pesticide that typifies this active ingredient, as listed in the UC IPM Guidelines. In many cases, other trade names exist to segregate markets (such as for field crop vs. tree crop use), or in cases where the active ingredients are off-patent and produced by multiple manufacturers.

[3] Acute oral and dermal toxicities are reported as the LC_{50}, in mg of active ingredient per kg of body weight, for rats. LC_{50} values were referenced from SDS sheets of commercial products that are labeled for use in California Agriculture. Color coding was designated as >2,000 (green), 500-2,000 (beige), <500 (red).

[4] Chemicals Known to the State to Cause Cancer or Reproductive Toxicity, Jan 3, 2020. Chemicals listed through Proposition 65 identify a hazard, not a risk. (https://oehha.ca.gov/media/downloads/proposition-65/p65list010320.pdf)

[5] Chemicals Evaluated for Carcinogenic Potential Annual Cancer Report 2018 (http://npic.orst.edu/chemicals_evaluated.pdf). Highlighted cells include "likely to be carcinogenic to humans", Group B (Probable), Group C (Possible), and Group D (Suggestive) classifications.

[6] Ratings are as follows: I—Do not apply or allow to drift to plants that are flowering; II—Do not apply or allow to drift to plants that are flowering, except when the application is made between sunset and midnight if allowed by the pesticide label and regulations; III—No bee precaution, except when required by the pesticide label or regulations.

[7] FarMore F1500 does not have a California label, but does have a federal label allowing treatment to onion seed, which can then be imported into California. The insecticide components of FarMore F1500 are the California equivalent of Regard (spinosad) and Cruiser (thiamethoxam).

Appendix 3

Table 2B – Relative toxicities of insecticide active ingredients that are listed in Table 1 as alternatives to chlorpyrifos according to the UC IPM Pest Management Guidelines for Floriculture (http://ipm.ucanr.edu/PMG/selectnewpest.floriculture.html).

ACTIVE INGREDIENT	IRAC #[1]	IRAC MODE OF ACTION GROUPING[1]	COMMON LABEL NAME[2]	SIGNAL WORD	RESTRICTED USE	ACUTE ORAL TOXICITY[3] (mg/kg	ACUTE DERMAL TOXICITY[3] (mg/kg)	PROP 65[4] (cancer)	PROP 65[4] (repro)	EPA CARCIN OGEN[5]	BEE TOXICITY RATING[6]
ABAMECTIN	6	Avermectins, Milbemycins	Avid 0.15EC	Warning	No	300	> 1,800	No	Yes	No	1
ACEPHATE	1B	Organophos-phates	Acephate 97UP	Caution	No	688	> 2,000	No	No	Possible	1
	1B	Organophos-phates	Orthene T	Caution	No	688	> 2,000	No	No	Possible	1
ACETAMIPRID	4A	Neonicotinoids	TriStar 70WSP	Caution	No	1,064	> 2,000	No	No	No	2
AZADIRACHTIN	UN	Azadirachtin	Azatin XL	Caution	No	> 5,000	> 2,000	No	No	Not Listed	3
	UN	Azadirachtin	Ornazin 3%EC	Warning	No	> 5,050	> 5,050	No	No	Not Listed	3
BACILLUS THURINGIENSIS SSP. KURSTAKI	11A	Bacillus Thuring-iensis and the Insecticidal Proteins they Produce	Dipel Pro	Caution	No	> 5,050	> 2,020	No	No	Not listed	3
BACILLUS THURINGIENSIS SSP. ISRAELENSIS	11A	Bacillus Thuring-iensis and the Insecticidal Proteins they Produce	Gnatrol	Caution	No	> 5,000	> 5,000	No	No	Not Listed	3

ACTIVE INGREDIENT	IRAC #[1]	IRAC MODE OF ACTION GROUPING[1]	COMMON LABEL NAME[2]	SIGNAL WORD	RESTRICTED USE	ACUTE ORAL TOXICITY[3] (mg/kg	ACUTE DERMAL TOXICITY[3] (mg/kg)	PROP 65[4] (cancer)	PROP 65[4] (repro)	EPA CARCIN OGEN[5]	BEE TOXICITY RATING[6]
BEAUVERIA BASSIANA	UNF	Fungal Agents of Unknown or Uncertain MOA	BotaniGard 22WP	Caution	No	> 5,000	> 2,000	No	No	Not Listed	2
	UNF	Fungal Agents of Unknown or Uncertain MOA	BotaniGard ES	Caution	No	Not listed	Not listed	No	No	Not Listed	2
BIFENTHRIN	3A	Pyrethroids, Pyrethrins	Attain TR	Warning	No	1,030	> 5,000	No	No	Possible	3
	3A	Pyrethroids, Pyrethrins	Talstar Professional	Caution	No	632	> 2,000	No	No	Possible	1
CARBARYL	1A	Carbamates	Sevin	Caution	Yes	699	> 4,000	Yes	Yes	Likely	1
CHLORFENAPYR	13	Pyrroles, Dinitrophenols, Sulfluramid	Pylon	Caution	No	45	> 2,000	No	No	Sugges-tive	2
CINNAMALDE-HYDE	-	-	Cinnacure	Caution	No	2,200	1,260	No	No	Not Listed	3
CRYOLITE	8C	Fluorides	ProKil Cryolite 96	Caution	No	Not listed	Not listed	No	No	No	3
CYFLUTHRIN	3A	Pyrethroids, Pyrethrins	Decathlon 20 WP	Caution	No	1,733	> 2,000	No	No	No	1
CYROMAZINE	17	Moulting Dis-ruptor, Dipteran	Citation 75WP	Caution	No	4,460	> 2,010	No	No	No	3
DELTAMETHRIN	3A	Pyrethroids, Pyrethrins	DeltaGard	Caution	No	2,613	> 5,000	No	No	No	3
DIFLUBENZURON	15	Benzoylureas	Adept	Caution	No	> 10,000	> 20,000	No	No	No	3
DINOTEFURAN	4A	Neonicotinoids	Safari 20G	Caution	No	> 2,000	> 2,000	No	No	No	1

ACTIVE INGREDIENT	IRAC #[1]	IRAC MODE OF ACTION GROUPING[1]	COMMON LABEL NAME[2]	SIGNAL WORD	RESTRICTED USE	ACUTE ORAL TOXICITY[3] (mg/kg	ACUTE DERMAL TOXICITY[3] (mg/kg)	PROP 65[4] (cancer)	PROP 65[4] (repro)	EPA CARCIN OGEN[5]	BEE TOXICITY RATING[6]
FENPROPATHRIN	3A	Pyrethroids, Pyrethrins	Tame 2.4 EC	Warning	Federally	66	> 2,000	No	No	No	1
TAU-FLUVALINATE	3A	Pyrethroids, Pyrethrins	Mavrik Aquaflow	Caution	No	5,150	> 2,100	No	Yes	No	2
HORTICULTURAL OIL (MINERAL OIL)	-	-	Ultra-Fine Oil	Caution	No	> 5,000	> 2,000	No	No	Not Listed	3
	-	-	JMS Stylet Oil	Caution	No	> 5,000	> 5,000	No	No	Not Listed	3
IMIDACLOPRID	4A	Neonicotinoids	Marathon 1G	Caution	No	> 4,820	> 2,000	No	No	No	1
	4A	Neonicotinoids	Marathon II	Caution	No	> 4,143	> 2,000	No	No	No	1
	4A	Neonicotinoids	Marathon 60 WP	Caution	No	1,858	> 2,000	No	No	No	1
LAMBDA-CYHALOTHRIN	3A	Pyrethroids, Pyrethrins	Scimitar GC	Caution	Federally	> 5,000	> 2,000	No	No	No	1
METHIOCARB	1A	Carbamates	Mesurol 75W	Danger/ Poison	Federally	60	> 2,000	No	No	No	1
NEEM OIL	UNE	Botanical Essence Including Synthetic, Extracts and Unrefined Oils With Unknown or Uncertain MOA	Triact 70	Caution	No	> 5,000	> 2,000	No	No	Not Listed	3
NOVALURON	15	Benzoylureas	Pedestal	Caution	No	> 2,000	> 5,000	No	No	No	3
PERMETHRIN	3A	Pyrethroids, Pyrethrins	Astro	Caution	No	998	> 2,000	No	No	Not Listed	1

ACTIVE INGREDIENT	IRAC #[1]	IRAC MODE OF ACTION GROUPING[1]	COMMON LABEL NAME[2]	SIGNAL WORD	RESTRICTED USE	ACUTE ORAL TOXICITY[3] (mg/kg	ACUTE DERMAL TOXICITY[3] (mg/kg)	PROP 65[4] (cancer)	PROP 65[4] (repro)	EPA CARCIN OGEN[5]	BEE TOXICITY RATING[6]
POTASH SOAP	-	-	M-Pede	Warning	No	> 5,050	> 2,020	No	No	Not Listed	3
PYMETROZINE	9B	Pyridine Azome-thine Derivatives	Endeavor	Caution	No	> 5,000	> 2,000	Yes	No	Likely	3
PYRETHRIN/PBO	3A/-	Pyrethroids, Pyrethrins/-	PT Pyre-thrum TR	Caution	No/No	4,900	> 2,000	No/No	No/No	No/ Possible	3
PYRIPROXYFEN	7C	Juvenile Hor-mone Mimics	Distance	Caution	No	4,733	> 2,000	No	No	No	3
S-KINOPRENE	7A	Juvenile Hor-mone Analogues	Enstar II	Caution	No	3,129	> 5,000	No	No	Not Listed	3
SPINOSAD	5	Spinosyns	Conserve SC	None	No	> 5,000	> 5,000	No	No	No	2
THIAMETHOXAM	4A	Neonicotinoids	Flagship 25WG	Caution	No	> 5,000	> 2,000	No	No	No	1

[1] IRAC- The Insecticide Resistance Action Committee. See https://www.irac-online.org/modes-of-action

[2] Representative label name is the trade name of one commercial insecticide that typifies this active ingredient, as listed in the UC IPM Guidelines. In many cases, other trade names exist to segregate markets (such as for field crop vs. tree crop use), or in cases where the active ingredients are off-patent and produced by multiple manufacturers.

[3] Acute oral and dermal toxicities are reported as the LC_{50}, in mg of active ingredient per kg of body weight, for rats. LC_{50} values were referenced from SDS sheets of commercial products that are labeled for use in California Agriculture. Color coding was designated as >2,000 (green), 500-2,000 (beige), <500 (red).

[4] Chemicals Known to the State to Cause Cancer or Reproductive Toxicity, Jan 3, 2020. Chemicals listed through Proposition 65 identify a hazard, not a risk. (https://oehha.ca.gov/media/downloads/proposition-65/p65list010320.pdf)

[5] Chemicals Evaluated for Carcinogenic Potential Annual Cancer Report 2018 (http://npic.orst.edu/chemicals_evaluated.pdf). Highlighted cells include "likely to be carcinogenic to humans", Group B (Probable), Group C (Possible), and Group D (Suggestive) classifications.

[6] Ratings are as follows: I—Do not apply or allow to drift to plants that are flowering; II—Do not apply or allow to drift to plants that are flowering, except when the application is made between sunset and midnight if allowed by the pesticide label and regulations; III—No bee precaution, except when required by the pesticide label or regulations.

Appendix 4

Table 3A- Detailed version of the relative risks of chlorpyrifos alternatives identified in UC Pest Management Guidelines for Agriculture including on Links to Product Information Reports, Safety Data Sheets, and other documents used to generate Table 2A

ACTIVE INGREDIENT	REGISTERED BRAND NAME	EPA REG. NO.	FIRM NAME	SIGNAL WORD	ACUTE ORAL TOXICITY (mg/kg)	ACUTE DER MAL TOXICITY (mg/kg)
1, 3-DICHLOROPRO-PENE	Telone II	62719- 32-ZA	Dow Agrosciences LLC	Warning	> 110	333
	Inline	62719- 348-AA	Dow Agrosciences LLC	Danger/Poison	100 - 200	> 600
ABAMECTIN	Agri-Mek Sc Miticide/Insecticide	100- 1351-ZA	Syngenta Crop Protection, LLC	Warning	310	> 2,000
	Clinch Ant Bait	100- 894-ZB	Syngenta Crop Protection, LLC	Caution	> 5,000	> 2,000
ABAMECTIN/ THIAMETHOXAM	Agri-Flex Miticide/ Insecticide	100- 1350-ZA	Syngenta Crop Protection, LLC	Warning	550	> 5,000
ACEPHATE	Orthene 97	59639-26-AA	Valent USA Corporation	Caution	1,030	> 1,000
ACETAMIPRID	Assail 70wp Insec-ticide	8033- 23-AA-70506	United Phosphorus, LLC/UPL	Caution	1,064	> 2,000
	Assail 30sg Insec-ticide	8033- 36-AA-70506	United Phosphorus, LLC/UPL	Caution	805	> 2,000
AZADIRACHTIN	Neemix 4.5	70051- 9-ZA	Certis USA, LLC	Caution	> 5,000	> 2,000
BACILLUS THURINGIENSIS	Dipel Df Biological Insecticide Dry Flowable	73049- 39-AA	Valent Biosciences LLC	Caution	> 5,050	> 2,020

ACTIVE INGREDIENT	REGISTERED BRAND NAME	EPA REG. NO.	FIRM NAME	SIGNAL WORD	ACUTE ORAL TOXICITY (mg/kg)	ACUTE DER MAL TOXICITY (mg/kg)
BACILLUS THURING-IENSIS	Dipel ES Biological Insecticide Emulsifi-able Suspension	73049- 17-AA	Valent Biosciences LLC	Caution	> 5,050	> 5,050
BACILLUS THURING-IENSIS	Deliver Biological Insecticide	70051- 69-ZB	Certis USA, LLC	Caution	> 5,000	> 5,050
BACILLUS THURING-IENSIS	Agree WG Biologi-cal Insecticide	70051- 47-ZC	Certis USA, LLC	Caution	> 5,050	> 2,020
BACILLUS THURING-IENSIS	Xentari Biological Insecticide Dry Flowable	73049- 40-AA	Valent Biosciences LLC	Caution	> 5,000	> 2,000
BETA-CYFLUTHRIN	Baythroid XL	264- 840-AA	Bayer Cropscience LP	Warning	647	> 2,000
BIFENTHRIN	Brigade Wsb Insecticide/Miticide	279- 3108-AA	FMC Corporation Agricultural Products Group	Warning	335	> 2,000
BUPROFEZIN	Courier SC Insect Growth Regulator	71711- 20-ZB	Nichino America, Inc.	Warning	> 5,000	> 2,000
BUPROFEZIN	Applaud Insect Growth Regulator	71711- 21-ZB	Nichino America, Inc.	Caution	> 5,000	> 2,000
BUPROFEZIN	Centaur WDG Insect Growth Regulator	71711- 21-ZA	Nichino America, Inc.	Caution	> 5,000	> 2,000
CARBARYL	Sevin Brand XLR Plus Carbaryl Insecticide	61842- 37-AA	Tessenderlo Kerley, Inc.	Caution	699	> 4,000
CARBARYL	Gardentech Sevin-5 Ready-To-Use 5% Dust	432- 1209-ZA-71004	Techpac, LLC	Caution	2,330	> 2,000
CHLORANTRANILIP-ROLE	Coragen Insect Control	279- 9606-AA	FMC Corporation Agricultural Products Group	None	> 5,000	> 5,000

ACTIVE INGREDIENT	REGISTERED BRAND NAME	EPA REG. NO.	FIRM NAME	SIGNAL WORD	ACUTE ORAL TOXICITY (mg/kg)	ACUTE DER MAL TOXICITY (mg/kg)
CHLORANTRANILIP-ROLE	Altacor Insect Control	279- 9607-AA	Fmc Corporation Agricultural Products Group	None	> 5,000	> 5,000
CHLOROPICRIN	Tri-Clor EC Fumigant	58266- 5-AA-11220	Trical, Inc.	Danger/Poison	37.5	Not listed
CLOTHIANIDIN	Belay 50 WDG Insecticide	59639- 152-ZA	Valent U.S.A. Corporation	Caution	3,900	> 5,000
CLOTHIANIDIN	Belay Insecticide	59639- 150-AA	Valent U.S.A. Corporation	Caution	3,044	> 5,000
CLOTHIANIDIN	Poncho 600	264- 789-AA	Bayer Cropscience LP	Caution	2,000	> 4,000
CLOTHIANIDIN	Clutch 50 WDG Insecticide 1	59639- 152-AA	Valent U.S.A. Corporation	Caution	3,900	> 5,000
CLOTHIANIDIN/ IMIDACLOPRID	Sepresto 75 WS	264- 1081-AA	Bayer Cropscience LP	Caution	1,000	> 2,000
CRYOLITE	Prokil Cryolite 96	10163- 41-AA	Gowan Company	Caution	> 1,960	> 2,020
CYANTRANILIPROLE	Exirel Insect Control	279- 9615-AA	Fmc Corporation Agricultural Products Group	Caution	> 5,000	> 5,000
CYANTRANILIPROLE/ ABAMECTIN	Minecto Pro	100- 1592-AA	Syngenta Crop Protection, LLC	Warning	451.1	> 2,000
CYDIA POMONELLA GRANULOVIRUS	CYD-X	70051- 44-AA	Certis USA, LLC	Caution	Not listed	Not listed
CYDIA POMONELLA GRANULOVIRUS	CYD-X HP	70051- 112-AA	Certis USA, LLC	Caution	Not listed	Not listed
CYFLUTHRIN	Tombstone	34704- 912-AA	Loveland Products, Inc.	Danger	1,030	> 5,000

ACTIVE INGREDIENT	REGISTERED BRAND NAME	EPA REG. NO.	FIRM NAME	SIGNAL WORD	ACUTE ORAL TOXICITY (mg/kg)	ACUTE DER MAL TOXICITY (mg/kg)
CYFLUTHRIN	Tombstone Helios Insecticide	34704- 978-AA	Loveland Products, Inc.	Warning	1,030	> 2,000
CYFLUTHRIN	Baythroid Xl	264- 840-AA	Bayer Cropscience LP	Warning	647	> 2,000
DIAZINON	Diazinon 50W	66222- 10-ZA	Makhteshim Agan of North America, Inc., D/B/A Adama	Caution	> 1,960	> 2,020
DIAZINON	Diazinon AG 600 WBC	66222- 103-AA	Makhteshim Agan of North America, Inc., D/B/A Adama	Caution	1,600	> 2,020
DIAZINON	Diazinon AG 500	66222- 9-ZA	Makhteshim Agan of North America, Inc., D/B/A Adama	Caution	66	2,150
DIFLUBENZURON	Dimilin 2L	400- 461-ZA	Macdermid Agricul-tural Solutions, Inc.	Caution	> 5,000	> 5,000
DIFLUBENZURON	Dimilin 25W	400- 465-ZB	Macdermid Agricul-tural Solutions, Inc.	Caution	> 10,000	> 20,000
DIMETHOATE	Dimethoate 2.67 EC	34704- 489-ZA	Loveland Products, Inc.	Warning	425	2,020
DIMETHOATE	Drexel Dimethoate 2.67	19713- 232-AA	Drexel Chemical Company	Warning	345	> 2,020
DIMETHOATE	Dimethoate 400	34704- 207-ZA	Loveland Products, Inc.	Warning	425	2,020
DIMETHOATE	Dimethoate 400 EC	34704- 207-AA-279	FMC Corporation Agricultural Products Group	Warning	450	> 2,000
DINOTEFURAN	Venom Insecticide	59639- 135-AA	Valent U.S.A. Corpo-ration	Caution	> 5,000	> 5,000
DISODIUM TETRABO-RATE	Gourmet Liquid Ant Bait	73766- 2-ZA	Innovative Pest Control Products	Caution	Not listed	Not listed

ACTIVE INGREDIENT	REGISTERED BRAND NAME	EPA REG. NO.	FIRM NAME	SIGNAL WORD	ACUTE ORAL TOXICITY (mg/kg)	ACUTE DER MAL TOXICITY (mg/kg)
EMAMECTIN BENZOATE	Proclaim Insecticide	100- 904-ZB	Syngenta Crop Protection, LLC	Caution	1,516	> 2,000
ESFENVALERATE	Asana XL Insecticide	59639- 209-AA	Valent U.S.A. Corporation	Warning	458	> 2,000
ETHOPROP	Mocap 15% Granular Lock 'N Load Closed Loading System	5481- 9040-AA	Amvac Chemical Corporation	Danger/Poison	300	41.4
ETHOPROP	Mocap EC Nematicide-Insecticide	5481- 9041-AA	Amvac Chemical Corporation	Danger/Poison	15.9	166
FENBUTATIN-OXIDE	Vendex 50WP Miticide	70506- 211-AA	United Phosphorus, Inc.	Danger/Poison	> 5,000	> 2,000
FENPROPATHRIN	Danitol 2.4 EC Spray	59639- 35-AA	Valent U.S.A. Corporation	Warning	66	> 2,000
FENPYROXIMATE	Fujimite Sc Miticide/ Insecticide	71711- 4-ZB	Nichino America, Inc.	Warning	6,789	> 2,000
FLONICAMID	Beleaf 50 SG Insecticide	71512- 10-AA- 279	Fmc Corporation Agricultural Products Group	Caution	> 2,000	> 2,000
FLONICAMID	Carbine 50WG Insecticide	71512- 9-AA- 279	Fmc Corporation Agricultural Products Group	Warning	> 2,000	> 2,000
FLUPYRADIFURONE	Sivanto 200 SL	264- 1141-AA	Bayer Cropscience LP	Caution	> 2,000	> 2,000
IMIDACLOPRID	Admire Pro Systemic Protectant	264- 827-ZA	Bayer Cropscience LP	Caution	> 500	> 2,000
IMIDACLOPRID (SEED TREATMENT)	Gaucho 600 Flowable	264- 968-ZA	Bayer Cropscience LP	Caution	> 300	> 2,000
IMIDACLOPRID/ BETA-CYFLUTHRIN	Leverage 360 Insecticide	264- 1104-AA	Bayer Cropscience LP	Caution	> 1,044	> 2,000

ACTIVE INGREDIENT	REGISTERED BRAND NAME	EPA REG. NO.	FIRM NAME	SIGNAL WORD	ACUTE ORAL TOXICITY (mg/kg)	ACUTE DER MAL TOXICITY (mg/kg)
INDOXACARB	Steward EC Insecticide	279- 9596-AA	FMC Corporation Agricultural Products Group	Caution	977	> 5,000
INDOXACARB	Avaunt Insecticide	279- 9587-AA	FMC Corporation Agricultural Products Group	Caution	687	> 5,000
INSECTICIDAL SOAP	M-Pede Insecticide-Miticide-Fungicide	10163- 324-AA	Gowan Company	Warning	> 5,050	> 2,020
KAOLIN CLAY	Surround WP Crop Protectant	61842- 18-AA	Tessenderlo Kerley, Inc.	Caution	> 5,000	Not listed
LAMBDA-CYHALOTHRIN	Warrior Ii With Zeon Technology	100- 1295-ZA	Syngenta Crop Protection, LLC	Warning	310	> 2,000
MALATHION	Malathion 8-E Insecticide	34704- 452-ZA	Loveland Products, Inc.	Caution	> 5,000	> 5,000
METAFLUMIZONE	Altrevin Fire Ant Bait Insecticide	7969- 270-AA	BASF Corporation	Caution	> 2,000	> 2,000
METHOMYL	Du Pont Lannate SP Insecticide	352- 342-ZB	E.I. Du Pont De Nemours and Company	Danger/Poison	23	> 2,000
METHOMYL	Du Pont Lannate LV Insecticide	352- 384-AA	E.I. Du Pont De Nemours and Company	Danger/Poison	49	> 2,000
METHOPRENE	Extinguish Professional Fire Ant Bait	2724- 475-ZA	Wellmark International	Caution	> 5,010	> 5,010
METHOXYFENOZIDE	Intrepid 2F	62719- 442-AA	Dow Agrosciences LLC	Caution	> 5,000	> 2,000
METHOXYFENOZIDE/ SPINETORAM	Intrepid Edge	62719- 666-AA	Dow Agrosciences LLC	Caution	> 5,000	> 5,000

ACTIVE INGREDIENT	REGISTERED BRAND NAME	EPA REG. NO.	FIRM NAME	SIGNAL WORD	ACUTE ORAL TOXICITY (mg/kg)	ACUTE DER MAL TOXICITY (mg/kg)
NALED	Dibrom 8 Emulsive	5481- 479-AA	Amvac Chemical Corporation	Danger	235	5,050
NARROW RANGE OIL	JMS Stylet-Oil	65564- 1-AA	JMS Flower Farms, Inc.	Caution	> 5,000	> 5,000
NARROW RANGE OIL	Tri-Tek	48813- 1-ZF	Brandt Consolidated, Inc.	Caution	> 5,000	> 2,000
NARROW RANGE OIL	Omni Supreme Spray	5905- 368-AA	Helena Agri-Enter-prises, LLC D/B/A Helena Chemical Company	Caution	> 5,000	> 2,000
NARROW RANGE OIL	Narrow Range 415 Spray Oil	34704- 1025-ZA	Loveland Products, Inc.	Caution	> 5,000	> 2,000
NARROW RANGE OIL	440 Superior Spray Oil	2935- 546-ZB	Wilbur-Ellis Company LLC	Caution	Not listed	Not listed
NOVALURON	Diamond	66222- 35-ZF	Makhteshim Agan of North America, Inc., D/B/A Adama	Warning	> 5,000	> 2,000
PERMETHRIN	Pounce 25 WP	279- 3051-AA	Fmc Corporation Agricultural Products Group	Caution	1,100	> 2,000
PERMETHRIN	Ambush Insecticide & Repellent	270- 294-ZC	Farnam Companies, Inc.	Caution	> 5,000	> 2,000
PHORATE	Thimet 20-G Smartbox	5481- 530-AA	Amvac Chemical Corporation	Danger/Poison	5.1	86
PHOSMET	Imidan 70-W	10163- 169-ZA	Gowan Company	Warning	258	> 2,000
POTASSIUM SALTS OF FATTY ACIDS	Des-X Insecticidal Soap Concentrate	67702- 22-AA-70051	Certis USA, LLC	Warning	> 5,000	> 5,000
POTASSIUM SALTS OF FATTY ACIDS	M-Pede Insecti-cide-Miticide-Fungicide	10163- 324-AA	Gowan Company	Warning	> 5,050	> 2,020

ACTIVE INGREDIENT	REGISTERED BRAND NAME	EPA REG. NO.	FIRM NAME	SIGNAL WORD	ACUTE ORAL TOXICITY (mg/kg)	ACUTE DER MAL TOXICITY (mg/kg)
PYMETROZINE	Fulfill	66222- 274-AA	Makhteshim Agan of North America, Inc., D/B/A Adama	Caution	> 5,000	> 2,000
PYRETHRIN	Pyganic Crop Protection Ec 1.4 II	1021- 1771-AA	Mclaughlin Gormley King Company D/B/A MGK	Caution	> 2,000	> 2,000
PYRIPROXYFEN	Knack Insect Growth Regulator	59639- 95-AA	Valent U.S.A. Corporation	Caution	4,733	> 2,000
PYRIPROXYFEN	Esteem Ant Bait	59639- 114-AA	Valent U.S.A. Corporation	Caution	> 5,000	> 2,000
PYRIPROXYFEN	Esteem 0.86 EC Insect Growth Regulator	59639- 95-ZA	Valent U.S.A. Corporation	Caution	4,733	> 2,000
PYRIPROXYFEN	Seize 35 Wp Insect Growth Regulator	59639- 115-ZA	Valent U.S.A. Corporation	Caution	> 5,000	> 5,000
S-METHOPRENE LIQUID BAITS IN EPA-APPROVED BAIT STATIONS	Tango	2724- 420-ZD	Wellmark International	Caution	> 34,000	> 2,000
SPINETORAM	Delegate WG	62719- 541-AA	Dow Agrosciences LLC	Caution	> 5,000	> 5,000
SPINETORAM	Radiant SC	62719- 545-AA	Dow Agrosciences LLC	Caution	> 5,000	> 5,000
SPINOSAD	Entrust SC	62719- 621-AA	Dow Agrosciences LLC	None	> 5,000	> 5,000
SPINOSAD	Regard SC	100- 1621-AA	Syngenta Crop Protection, LLC	None	> 5,000	> 5,000
SPINOSAD	Success	62719- 292-AA	Dow Agrosciences LLC	None	> 5,000	> 5,000
SPINOSAD	Gf-120 Nf Natur-alyte Fruit Fly Bait	62719- 498-AA	Dow Agrosciences LLC	Caution	> 5,000	> 5,000

ACTIVE INGREDIENT	REGISTERED BRAND NAME	EPA REG. NO.	FIRM NAME	SIGNAL WORD	ACUTE ORAL TOXICITY (mg/kg)	ACUTE DER MAL TOXICITY (mg/kg)
SPIRODICLOFEN	Envidor 2 SC Miticide	264- 831-AA	Bayer Cropscience LP	Caution	> 2,000	> 4,000
SPIROMESIFEN	Oberon 2SC Insecti-cide/Miticide	264- 719-AA	Bayer Cropscience LP	Caution	> 2,000	> 4,000
SPIROTETRAMAT	Movento	264- 1050-AA	Bayer Cropscience LP	Caution	> 2,000	> 4,000
THIAMETHOXAM	Centric 40WG	100- 1147-ZA	Syngenta Crop Protection, LLC	Caution	> 5,000	> 2,000
THIAMETHOXAM	Cruiser 5FS	100- 941-ZA	Syngenta Crop Protection, LLC	Caution	> 5,000	> 5,050
THIAMETHOXAM	Platinum	100- 939-ZA	Syngenta Crop Protection, LLC	Caution	> 5,000	> 2,000
THIAMETHOXAM	Actara	100- 938-ZA	Syngenta Crop Protection, LLC	Caution	> 5,000	> 2,000
THIAMETHOXAM/ CHLORANTRANILIP-ROLE	Voliam Flexi	100- 1319-ZA	Syngenta Crop Protection, LLC	Caution	> 5,000	> 5,000
ZETA-CYPERMETHRIN	Mustang Insecticide	279- 3126-ZB	FMC Corporation Agricultural Products Group	Warning	310	> 5,000

Appendix 5

Table 3B – Detailed version of the relative risks of chlorpyrifos alternatives identified in UC Pest Management Guidelines for floriculture with links to product information reports, safety data sheets, and other documents used to generate Table 2B

ENERGETIC INGREDIENT	REGISTERED BRAND NAME	EPA REG. NO.	FIRM NAME	SIGNAL WORD	ACUTE ORAL TOXICITY (mg/kg)	ACUTE DERMAL TOXICITY (mg/ kg)
ABAMECTIN	Avid 0.15 EC Miticide/Insecticide	100-896-ZD	Syngenta Crop Protection, LLC	Warning	300	> 1,800
ACEPHATE	Acephate 97UP Insecticide	70506-8-AA	United Phosphorus, LLC/UPL	Caution	688	> 2,000
ACEPHATE	Orthene Turf, Tree & Ornamental 97 Spray	5481- 8978-ZB	Amvac Chemical Corporation	Caution	688	> 2,000
ACEPHATE	1300 Orthene TR Total Release Insecticide	499-421-ZA	BASF Corporation	Caution	> 2,000	> 2,000
ACETAMIPRID	Master Label - Tristar 70 WSP Insecticide	8033- 22-ML	Nippon Soda Company, Ltd.	Caution	1,064	> 2,000
AZADIRACHTIN	Azatin O Biological Insecticide	70051- 9-AA-59807	OHP, Inc.	Caution	> 5,000	> 2,000
AZADIRACHTIN	Ornazin 3% EC	5481- 476-ZC	Amvac Chemical Corporation	Warning	> 5,050	> 5,050
BACILLUS THURINGIENSIS SPP. KURSTAKI	Dipel Pro	73049- 39-ZA	Valent Biosciences LLC	Caution	> 5,050	> 2,020

ENERGETIC INGREDIENT	REGISTERED BRAND NAME	EPA REG. NO.	FIRM NAME	SIGNAL WORD	ACUTE ORAL TOXICITY (mg/kg)	ACUTE DERMAL TOXICITY (mg/ kg)
BACILLUS THURINGIENSIS SSP. ISRAELENSIS	Gnatrol WDG Biological Larvicide	73049- 56-ZB	Valent Biosciences LLC	Caution	> 5,000	> 5,000
BEAUVERIA BASSIANA	Botanigard 22WP	82074- 2-AA	Laverlam International Corporation	Caution	> 5,000	> 2,000
BEAUVERIA BASSIANA	Botanigard ES	82074- 1-AA	Laverlam International Corporation	Caution	Not listed	Not listed
BIFENTHRIN	Attain TR Total Release Insecticide	499- 472-ZA	BASF Corporation	Warning	1,030	> 5,000
BIFENTHRIN	Talstar P Professional Insecticide	279- 3206-ZC	FMC Corporation	Caution	632	> 2,000
CARBARYL	Sevin Brand XLR Plus Carbaryl Insecticide	61842- 37-AA	Tessenderlo Kerley, Inc.	Caution	699	> 4,000
CHLORFENAPYR	Pylon Miticide-Insecticide	241- 374-AA	BASF Corporation	Caution	45	> 2,000
CINNAMALDEHYDE	Cinnacure Ready To Use	58866- 13-AA	Proguard, Inc.	Caution	2,200	1,260
CRYOLITE	Prokil Cryolite 96	10163- 41-AA	Gowan Company	Caution	Not listed	Not listed
CYFLUTHRIN	Decathlon 20 WP	59807- 17-AA	OHP, Inc.	Caution	1,733	> 2,000
CYROMAZINE	Citation Insecticide	100- 667-ZB	Syngenta Crop Protection, LLC	Caution	4,460	> 2,010
DELTAMETHRIN	Deltagard G Insecticide Granule	432- 836-ZB	Bayer Environmental Science	Caution	2,613	> 5,000
DIFLUBENZURON	Adept	400- 477-ZC	Macdermid Agricultural Solutions, Inc.	Caution	> 10,000	> 20,000

ENERGETIC INGREDIENT	REGISTERED BRAND NAME	EPA REG. NO.	FIRM NAME	SIGNAL WORD	ACUTE ORAL TOXICITY (mg/kg)	ACUTE DERMAL TOXICITY (mg/ kg)
DINOTEFURAN	Safari 20 SG Insecticide	86203- 11-AA-59639	Valent USA Corporation	Caution	> 2,000	> 2,000
FENPROPATHRIN	Tame 2.4 EC Spray	59639- 77-AA	Valent USA Corporation	Warning	66	> 2,000
TAU-FLUVALINATE	Mavrik Aquaflow Insecticide/Miticide	2724- 478-AA	Wellmark International	Caution	5,150	> 2,100
HORTICULTURAL OIL (MINERAL OIL)	Sunspray Ultra-Fine Spray Oil	86330- 11-AA	Hollyfrontier Refining & Marketing LLC	Caution	> 5,000	> 2,000
HORTICULTURAL OIL (MINERAL OIL)	JMS Stylet-Oil	65564- 1-AA	JMS Flower Farms, Inc.	Caution	> 5,000	> 5,000
IMIDACLOPRID	Marathon 1% Granular	59807- 15-AA	OHP, Inc.	Caution	> 4,820	> 2,000
IMIDACLOPRID	Marathon Ii Green-house And Nursery Insecticide	432- 1369-AA-59807	OHP, Inc.	Caution	> 4,143	> 2,000
IMIDACLOPRID	Marathon 60 WP Greenhouse and Nursery Insecticide in Water Soluble Packaging	432- 1361-AA-59807	OHP, Inc.	Caution	1,858	> 2,000
LAMBDA-CYHALOTHRIN	Scimitar GC Insecticide	100- 1088-ZB	Syngenta Crop Protection, LLC	Caution	> 5,000	> 2,000
METHIOCARB	Mesurol 75-W	10163- 231-AA	Gowan Company	Danger/ Poison	60	> 2,000
NEEM OIL	Triact 70EC	70051- 2-ZC	Certis USA, LLC	Caution	> 5,000	> 2,000
NOVALURON	Pedestal	66222- 40-ZA- 400	Macdermid Agricultural Solutions, Inc.	Caution	> 2,000	> 5,000
PERMETHRIN	Astro Insecticide	279- 3141-AA	FMC Corporation	Caution	998	> 2,000

ENERGETIC INGREDIENT	REGISTERED BRAND NAME	EPA REG. NO.	FIRM NAME	SIGNAL WORD	ACUTE ORAL TOXICITY (mg/kg)	ACUTE DERMAL TOXICITY (mg/ kg)
POTASH SOAP	M-Pede Insecticide-Miticide-Fungicide	10163- 324-AA	Gowan Company	Warning	> 5,050	> 2,020
PYMETROZINE	Endeavor	100- 913-ZB	Syngenta Crop Protection, LLC	Caution	> 5,000	> 2,000
PYRETHRIN/PBO	Pyrethrum TR Total Release Insecticide	499- 479-ZA	BASF Corporation	Caution	4,900	> 2,000
PYRIPROXYFEN	Distance Insect Growth Regulator	59639- 96-AA	Valent USA Corporation	Caution	4,733	> 2,000
S-KINOPRENE	Enstar Aq Insect Growth Regulator	2724- 793-AA	Wellmark International	Caution	3,129	> 5,000
SPINOSAD	Conserve SC Turf And Ornamental	62719- 291-AA	Dow Agrosciences LLC	None	> 5,000	> 5,000
THIAMETHOXAM	Flagship 25wg	100- 955-ZA	Syngenta Crop Protection, LLC	Caution	> 5,000	> 2,000

Appendix 6

Product/Brand names included in the tables are presented as representative examples of an active ingredient and is not an endorsement by the Work Group of the products and/or their efficacy.

Table 1A – Crops in which biopesticide active ingredients may be used.

	ALFALFA	ASPARAGUS	CITRUS	COLE CROPS	CORN	COTTON	GRAPE	LETTUCE	ONIONS	ORNAMENTALS	PECAN	POME FRUIT	SMALL GRAINS	STONE FRUITS	STRAWBERRY	SUGARBEET	TREE NUTS	TURF	WALNUT
***CHROMOBACTERIUM SUBTSUGAE*, STRAIN PRAA4-1T AND SPENT FERMENTATION MEDIA**	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
HEAT-KILLED *BURKHOLDERIA RINOJENSIS*, STRAIN A396 CELLS AND SPENT FERMENTATION MEDIA	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X
AZADIRACHTIN (4.5 %)	X	X				X							X						X
CLARIFIED HYDROPHOBIC EXTRACT OF NEEM OIL (70%)	X					X							X						X
POTASSIUM SALTS OF FATTY ACIDS (47% POTASH SOAP) (E.G. DES-X)	X	X				X							X						X
POTASSIUM SALTS OF FATTY ACIDS (49% POTASH SOAP) (E.G. M-PEDE)						X	X	X		X					X				
***BEAUVERIA BASSIANA* STRAIN GHA (11.3%)**	X		X			X							X	X					X
***ISARIA FUMOSOROSEA* APOPKA STRAIN 97 (FORMERLY *PAECILOMYCES FUMOSOROSEUS*) (20.0%)**	X		X			X							X	X	X				X
COLD PRESSED NEEM OIL (70.0%)	X		X	X		X			X			X	X	X	X		X		X

	ALFALFA	ASPARAGUS	CITRUS	COLE CROPS	CORN	COTTON	GRAPE	LETTUCE	ONIONS	ORNAMENTALS	PECAN	POME FRUIT	SMALL GRAINS	STONE FRUITS	STRAWBERRY	SUGARBEET	TREE NUTS	TURF	WALNUT
AZADIRACHTIN (1.2%)	X	X										X		X			X		
KAOLIN (95%)	X	X	X	X			X					X		X			X		X
PYRETHRINS (0.75%), *BEAUVERIA BASSIANA* STRAIN GHA (0.06%)		X																	
MINERAL OIL (80%)		X	X	X		X	X			X		X		X					
CAPSICUM OLEORESIN EXTRACT 7.6%, GARLIC OIL 23.4%, CANOLA OIL 55%		X	X	X		X				X		X	X	X			X		
POTASSIUM SILICATE (29%)			X											X					
SPINOSAD (A MIXTURE OF SPINOSYN A AND SPINOSYN D)			X				X									X			
SODIUM TETRABOROHYDRATE DECAHYDRATE (0.99%)						X	X						X	X					
***BACILLUS THURINGIENSIS*,(BERLINER), SUBSPECIES KURSTAKI, STRAIN SA-11**																X			
***BACILLUS THURINGIENSIS* SUBSPECIES KURSTAKI STRAIN SA-11 SOLIDS, SPORES, AND LEPIDOPTERAN ACTIVE TOXINS**																X			
***BACILLUS THURINGIENSIS* (BERLINER), SUBSPECIES AIZAWAI, GC-91 PROTEIN**																X			
***BACILLUS THURINGIENSIS* SUBSPECIES KURSTAKI, GENETICALLY ENGINEERED STRAIN EG7841 LEPIDOPTERAN ACTIVE TOXIN**																X			

	ALFALFA	ASPARAGUS	CITRUS	COLE CROPS	CORN	COTTON	GRAPE	LETTUCE	ONIONS	ORNAMENTALS	PECAN	POME FRUIT	SMALL GRAINS	STONE FRUITS	STRAWBERRY	SUGARBEET	TREE NUTS	TURF	WALNUT
PYRETHRINS (0.75%) + *BEAUVERIA BASSIANA* STRAIN GHA (0.06%)																X	X		
TERPENE CONSTITUENTS OF THE EXTRACT OF CHENOPODIUM AMBROSIOIDES NEAR AMBROSIOIDES AS SYNTHETICALLY MANUFACTURED 16.75%																	X		

Table 1B – Crops and target pests of biopesticide that can be potential alternatives to Chlorpyrifos.

CROP	PESTS	BIOPESTICIDE ACTIVE INGREDIENT	REPRESENTATIVE PRODUCT/ CA REG. NO.
ALFALFA	Alfalfa caterpillar, alfalfa webworm, armyworms, cutworms, european skipper, sod webworm. aphids, billbugs, chinch bug, leafhoppers, lygus, plant bugs, spittle bugs, mites (such as clover, bermuda grass stunt, two-spotted, winter grain)	*Chromobacterium subtsugae*, Strain PRAA4-1T and spent fermentation media	Grandevo WDG, Reg. No.84059-27-AA
	Alfalfa caterpillar, armyworms, aphids, loopers, lygus, mites, spittle bug, thrips, whiteflies (2ee)[1]	Heat-killed *Burkholderia rinojensis*, Strain A396 cells and spent fermentation media	Venerate XC, Reg. No. 84059-14-ZA
	Aphids	Azadirachtin, 4.5 %	Neemix 4.5, Reg. No. 70051-9-ZA
		Clarified hydrophobic extract of neem oil 70%	Trilogy, Reg. No. 70051-2-ZB
		Potassium salts of fatty acids 47%	Des-X Insecticidal Soap Concentrate, Reg. No. 67702-22-AA-70051
		Beauveria bassiana Strain GHA 11.3%	BoteGHA ES, Reg. No. 82074-1-ZB, BotaniGard ES, Reg. No. 82074-1-AA
		Isaria fumosorosea apopka Strain 97 (ATCC 20874)	PFR-97 20% WDG, Reg. No. 70051-19
	Aphids and weevils	*Isaria fumosorosea* apopka Strain 97 (formerly *Paecilomyces fumosoroseus*), 20.0%	PFR-97 20% WDG, Reg. No. 70051-19-ZA
	Aphids and cutworms	Cold pressed neem oil 70.0%	Rango[2], Reg. No. 88760-10-AA 2

CROP	PESTS	BIOPESTICIDE ACTIVE INGREDIENT	REPRESENTATIVE PRODUCT/ CA REG. NO.
ALFALFA	Aphids (such as pea aphid, rosy apple aphid), beetles (such as japanese beetle), borers, (such as peachtree borers, peach twig borers), true bugs, (such as lygus bugs, stink bugs), caterpillars, (such as leafrollers, cutworms, loopers, armyworms), flies (such as walnut husk fly, leafminers and fungus gnats), leafhoppers, leafminers, whiteflies, mealy bugs, mites, psyllids (such as pear psylla), weevils, scales (such as san jose scale), thrips, (such as western flower thrips); 2(ee)[1] asian citrus psyllid mirids	Azadirachtin (1.2%)	Aza-Direct, Reg. No. 71908-1-AA-10163
	Thrips, leafhoppers, flea beetles	Kaolin (95%)	Surround WP Crop Protectant, Reg. No. 61842-18-AA
ASPARAGUS	Aphids	Azadirachtin (4.5%)	Neemix 4.5, Reg. No. 70051-9-ZA
		Potassium salts of fatty acids (47%)	Des-X Insecticidal Soap Concentrate, Reg. No. 67702-22-AA-70051
		Pyrethrins (0.75%) + *Beauveria bassiana* Strain GHA (0.06%)	BotaniGard Maxx (Reg. No. 82074-5-ZA) as a knockdown, BotaniGard ES (Reg. No. 82074-1-AA) tank-mixed or in rotation with Molt-X (Reg. No.68539-11-AA) Note: The sole AI of BotaniGard ES is *Beauveria bassiana* Strain GHA; The AI of Molt-X is Azadirachtin (3%)
		Mineral oil (80.0%)	Suffoil X, Reg. No.48813-1-AA-68539
	Aphids, armyworms, cutworms	*Chromobacterium subtsugae*, Strain PRAA4-1T and spent fermentation media	Grandevo WDG, Reg. No. 84059-27-AA
	Aphids, armyworms, stinkbugs	Heat-killed *Burkholderia rinojensis*, Strain A396 cells and spent fermentation media	Venerate XC, Reg. No. 84059-14-ZA

CROP	PESTS	BIOPESTICIDE ACTIVE INGREDIENT	REPRESENTATIVE PRODUCT/ CA REG. NO.
ASPARAGUS	Common and spotted asparagus beetle, grass-hoppers	Kaolin (95%)	Surround WP Crop Protectant, Reg. No. 61842-18-AA
CITRUS	Ants	Spinosad (a mixture of spinosyn A and spinosyn D)	Seduce Insect Bait, Reg. No. 67702-25-AA-70051
	Citrus cutworm, citrus leafminer, fruittree leaf-roller, orangedog, asian citrus psyllid, aphids, citrus blackfly, citrus red mite, citrus rust mite, citrus thrips, citrus whitefly, cloudy-winged whitefly, glassy-winged sharpshooter, mealy-bugs, six-spotted spider mite, texas citrus mite, two-spotted spider mite	*Chromobacterium subtsugae*, Strain PRAA4-1T and spent fermentation media	Grandevo WDG, Reg. No. 84059-27-AA
	Asian citrus psyllid, citrus cutworm, citrus leafminer, citrus rust mite, fruittree leafroller, orangedog. aphids, citrus red mite, citrus thrips, florida red scale, mealybugs, texas citrus mite, twospotted spider mite, six-spotted mite, stink bugs	Heat-killed *Burkholderia rinojensis*, Strain A396 cells and spent fermentation media	Venerate XC, Reg. No. 84059-14-ZA
	Scales	Potassium silicate (29%)	Sil-Matrix, Reg. No. 82100-1-AA
		Beauveria bassiana Strain GHA (11.3%)	BoteGHA ES, Reg. No. 82074-1-ZB
		Mineral oil (80.0%)	Suffoil X, Reg. No.48813-1-AA-68539
	Scales, asian citrus psyllid, whiteflies, thrips	*Isaria fumosorosea* Apopka Strain 97 (formerly *Paecilomyces fumosoroseus*) (20.0%)	PFR-97 20% WDG, Reg. No. 70051-19-ZA
	Scales, mealybug, asian citrus psyllid	Cold pressed neem oil (70.0%)	Rango[2], Reg. No. 88760-10-AA
	Leafhoppers, thrips, asian citrus psyllid, root weevils, grasshoppers	Kaolin (95%)	Surround WP Crop Protectant, Reg. No. 61842-18-AA
	Mites, thrips, psyllids, leafhoppers, lepidotera larvae, white flies; other pests such as borers, mealybugs and plant bugs	Capsicum oleoresin extract (7.6%), garlic oil (23.4%), canola oil (55%)	Captiva Prime, Reg. No. 10163-336-AA

CROP	PESTS	BIOPESTICIDE ACTIVE INGREDIENT	REPRESENTATIVE PRODUCT/ CA REG. NO.
COLE CROPS	Armyworms, beet armyworm, cabbage looper, cabbage webworm, cross-striped cabbageworm, cutworms, diamondback moth, imported cabbageworm, light brown apple moth, aphids, billbugs, leafhoppers, mites, plant bugs, thrips, whiteflies, yellow margined leaf beetle larvae yel-low margined leaf beetle larvae (newly hatched). If adult beetles are also present, tank mix with a knockdown insecticide.	*Chromobacterium subtsugae*, Strain PRAA4-1T and spent fermentation media	Grandevo WDG, Reg. No. 84059-27-AA
CORN	Armyworms, cabbage looper, cabbage webworm, diamondback moth, imported cabbageworm. aphids, billbugs, leafhoppers, mites, plant bugs, stink bugs, swede midge, thrips, whiteflies	Heat-killed *Burkholderia rinojensis*, Strain A396 cells and spent fermentation media	Venerate XC, Reg. No. 84059-14-ZA
	Aphids	Mineral oil (80.0%)	Suffoil X, Reg. No.48813-1-AA-68539
	Aphids, stink bugs, loopers, cutworms	Cold Ppessed neem oil (70.0%)	Rango[2], Reg. No. 88760-10-AA
	Flea beetles	Kaolin (95%)	Surround WP Crop Protectant, Reg. No. 61842-18-AA
	Mites, thrips, psyllids, leafhoppers, lepidotera larvae, white flies; other pests such as borers, mealybugs and plant bugs	Capsicum oleoresin extract (7.6%), garlic oil (23.4%), canola oil (55%)	Captiva Prime, Reg. No. 10163-336-AA
	Cabbage maggot	*Isaria fumosorosea* apopka Strain 97 (ATCC 20874)	PFR-97 20% WDG, Reg. No. 70051-19
		Spinosad	Seduce Insect Bait, Reg. No. 67702-25-AA- 70051
	Armyworms, common stalk borer, corn earworm, european corn borer, lesser cornstalk borer, southwestern corn borer, webworms, western bean cutworm, chinch bugs, corn leaf aphid, mites, thrips	*Chromobacterium subtsugae*, Strain PRAA4-1T and spent fermentation media	Grandevo WDG, Reg. No. 84059-27-AA

CROP	PESTS	BIOPESTICIDE ACTIVE INGREDIENT	REPRESENTATIVE PRODUCT/ CA REG. NO.
CORN	Armyworm, corn earworm, european corn borer, southwestern corn borer, western bean cutworm. corn leaf aphid, leafhoppers, mites, stink bugs. wireworms, maggots (through bio st sub label for seed treatment); rootworm 2(ee)[1]	Heat-killed *Burkholderia rinojensis*, Strain A396 cells and spent fermentation media	Venerate XC, Reg. No. 84059-14-ZA
	2(ee)[1] for seed treatment of soil pests including maggot, corn rootworm and nematodes; in-furrow treatment of rootworm	*Chromobacterium subtsugae*, Strain PRAA4-1T and spent fermentation media	Grandevo WDG, Reg. No. 84059-27-AA
COTTON	Aphids	Azadirachtin (4.5 %)	Neemix 4.5, Reg. No. 70051-9-ZA
		Clarified hydrophobic extract of neem oil (70%)	Trilogy, Reg. No. 70051-2-ZB
		Potassium salts of fatty acids (47%)	Des-X Insecticidal Soap Concentrate, Reg. No. 67702-22-AA-70051
		Isaria fumosorosea apopka Strain 97 (formerly *Paecilomyces fumosoroseus*) (20.0%)	PFR-97 20% WDG, Reg. No. 70051-19-ZA
		Beauveria bassiana Strain GHA (11.3%)	BoteGHA ES, Reg. No. 82074-1-ZB
		Sodium tetraborohydrate decahydrate (0.99%)	Prev-Am, Reg. No. 72662-3-ZB
	Cotton aphid and other aphids, whiteflies	Cold pressed neem oil (70.0%)	Rango[2], Reg. No. 88760-10-AA
	Aphids, whiteflies, thrips	Mineral oil (80.0%)	Suffoil X, Reg. No.48813-1-AA-68539
	Aphids, mites and whiteflies; also adelgids, caterpillars, earwigs, lace bugs, leafhoppers, leafminers, mealybugs, mole crickets, plant bugs, psyllids, sawfly larvae, scales, spider mites, tent caterpillars, thrips, gypsy moth, and chinch bugs	Potassium salts of fatty acids	M-Pede Insecticide-Miticide-Fungicide, Reg. No. 10163-324-AA
	Armyworms, cotton bollworm, european corn borer, loopers (soybean and cabbage), saltmarsh caterpillar, tobacco budworm, cotton aphid, leafhoppers, mites, thrips, stink bugs	Heat-killed *Burkholderia rinojensis*, Strain A396 cells and spent fermentation media	Venerate XC, Reg. No. 84059-14-ZA

CROP	PESTS	BIOPESTICIDE ACTIVE INGREDIENT	REPRESENTATIVE PRODUCT/ CA REG. NO.
COTTON	European corn borer, fall armyworm, loopers (soybean and cabbage), saltmarsh caterpillar, tobacco budworm, yellow-striped armyworm, cotton aphid, cotton leafhopper, leafhoppers, lygus mites, silverleaf whitefly, thrips	*Chromobacterium subtsugae*, Strain PRAA4-1T and spent fermentation media	Grandevo WDG, Reg. No. 84059-27-AA
	Mites, thrips, psyllids, leafhoppers, lepidotera larvae, white flies; other pests such as borers, mealybugs and plant bugs	Capsicum oleoresin extract (7.6%), garlic oil (23.4%), canola oil (55%)	Captiva Prime, Reg. No. 10163-336-AA
	Whitefly	*Isaria fumosorosea* apopka Strain 97 (atcc 20874)	PFR-97 20% WDG, Reg. No. 70051-19
		Beauveria bassiana Strain GHA 11.3%	BotaniGard ES, Reg. No. 82074-1-AA
GRAPE	Ants	Spinosad (a mixture of spinosyn A and spinosyn D)	Seduce Insect Bait, Reg. No. 67702-25-AA-70051, Firefighter Fire Ant Bait, Reg. No. 67702-56-70051
	Mealybugs	Mineral oil (80.0%)	Suffoil X, Reg. No.48813-1-AA-68539
	Mealybugs (+ many others not relevant to Chlorpyrifos)	*Chromobacterium subtsugae*, Strain PRAA4-1T and spent fermentation media	Grandevo WDG, Reg. No. 84059-27-AA
	Mealybugs (+ many others not relevant to Chlorpyrifos)	Heat-killed *Burkholderia rinojensis*, Strain A396 cells and spent fermentation media	Venerate XC, Reg. No. 84059-14-ZA
	Mealybugs (not for table grapes)	Sodium tetraborohydrate decahydrate (0.99%)	Prev-Am, Reg. No. 72662-3-ZB
	Rose chafer, omnivorous leafroller, grape leaf-roller, grape leaf folder, grasshoppers, grape leaf skeletonizer, japanese beetle, june beetle	Kaolin (95%)	Surround WP Crop Protectant, Reg. No. 61842-18-AA

CROP	PESTS	BIOPESTICIDE ACTIVE INGREDIENT	REPRESENTATIVE PRODUCT/ CA REG. NO.
GRAPE	Soft bodied pests including adelgids, aphids, caterpillars, earwigs, lace bugs, leafhoppers, leafminers, mealybugs, mole crickets, plant bugs, psyllids, sawfly larvae, scales, spider mites, tent caterpillars, thrips, whiteflies, gypsy moth, and chinch bugs; most effective on mites, aphids and whiteflies; curative control of powdery mildew.	Potassium salts of fatty acids	M-Pede Insecticide-Miticide-Fungicide, Reg. No. 10163-324-AA
LETTUCE	Armyworm, cabbage looper, cutworm species, diamondback moth, green cloverworm, loopers, tobacco budworm, aphids, mites, pysllids, thrips and whiteflies.	*Chromobacterium subtsugae*, Strain PRAA4-1T and spent fermentation media	Grandevo WDG, Reg. No. 84059-27-AA
	Leafhoppers including sharpshooter	Heat-killed *Burkholderia rinojensis*, Strain A396 cells and spent fermentation media	Venerate XC, Reg. No. 84059-14-ZA
	Soft bodied pests including adelgids, aphids, caterpillars, earwigs, lace bugs, leafhoppers, leafminers, mealybugs, mole crickets, plant bugs, psyllids, sawfly larvae, scales, spider mites, tent caterpillars, thrips, whiteflies, gypsy moth, and chinch bugs; most effective on mites, aphids and whiteflies; curative control of powdery mildew.	Potassium salts of fatty acids	M-Pede Insecticide-Miticide-Fungicide, Reg. No. 10163-324-AA
ONIONS	Armyworm, cross-striped cabbageworm, cut-worm, diamondback moth, green cloverworm, heliothis, hornworm, imported cabbageworm, loopers, omnivorous leafrollers, saltmarsh caterpil-lar, webworm, aphids and thrips.	Heat-killed *Burkholderia rinojensis*, Strain A396 cells and spent fermentation media	Venerate XC, Reg. No. 84059-14-ZA

CROP	PESTS	BIOPESTICIDE ACTIVE INGREDIENT	REPRESENTATIVE PRODUCT/ CA REG. NO.
ONIONS	Armyworm, cross-striped cabbageworm, cut-worm, diamondback moth, european corn borer, green cloverworm, heliothis, hornworm, imported cabbageworm, leek moths, loopers, omnivorous leafrollers, saltmarsh caterpillar, webworm, aphids and thrips	*Chromobacterium subtsugae*, Strain PRAA4-1T and spent fermentation media	Grandevo WDG, Reg. No. 84059-27-AA
	Maggots, thrips	Cold pressed neem oil (70.0%)	Rango[2], Reg. No. 88760-10-AA
ORNAMENTALS	Whiteflies, aphids, thrips, azalea lace bug, lygus, and mites, loopers, tobacco budworm, omnivo-rous looper, omnivorous leafroller, diamondback moth, armyworms, ello moth, io moth, oleander moth, and azalea caterpillar	*Chromobacterium subtsugae*, Strain PRAA4-1T and spent fermentation media	Grandevo WDG, Reg. No. 84059-27-AA
	Armyworms, azalea caterpillar, diamondback moth, ello moth, lo moth, loopers, oleander moth, omnivorous leafroller, omnivorous looper, tobacco budworm, aphids, azalea lace bug, lygus, mites, thrips, whiteflies	Heat-killed *Burkholderia rinojensis*, Strain A396 cells and spent fermentation media	Venerate XC, Reg. No. 84059-14-ZA
	Aphids, black spot, leaf miners, mites, plant bugs, powdery mildew, psyllids, rust, sawfly, scales, whiteflies	Mineral oil (80.0%)	Suffoil X, Reg. No.48813-1-AA-68539
	Mites, thrips, psyllids, leafhoppers, lepidotera larvae, white flies; other pests such as borers, mealybugs and plant bugs	Capsicum oleoresin extract (7.6%), garlic oil (23.4%), canola oil (55%)	Captiva Prime, Reg. No. 10163-336-AA
	Soft bodied pests including adelgids, aphids, caterpillars, earwigs, lace bugs, leafhoppers, leafminers, mealybugs,mole crickets, plant bugs, psyllids, sawfly larvae, scales, spider mites, tent catepillars, thrips, whiteflies, gypsy moth, and chinch bugs; most effective on mites, aphids and whiteflies; curative control of powdery mildew.	Potassium salts of fatty acids	M-Pede Insecticide-Miticide-Fungicide, Reg. No. 10163-324-AA

CROP	PESTS	BIOPESTICIDE ACTIVE INGREDIENT	REPRESENTATIVE PRODUCT/ CA REG. NO.
PECAN	Aphids, mealybugs, mites, pecan weevil, whiteflies (+ various caterpillars)	*Chromobacterium subtsugae*, Strain PRAA4-1T and spent fermentation media	Grandevo WDG, Reg. No. 84059-27-AA
	Aphids, mealybugs, whiteflies	Heat-killed *Burkholderia rinojensis*, Strain A396 cells and spent fermentation media	Venerate XC, Reg. No. 84059-14-ZA
POME FRUIT	Codling moth, leafrollers (including fruittree, oblique-banded, redbanded, variegated), light brown apple moth, oriental fruit moth, tufted apple budmoth, leafrollers, and oriental fruit moth, aphids, mealybugs, mites, pear psylla, thrips, whiteflies; 2(ee)[1] for san jose scale	*Chromobacterium subtsugae*, Strain PRAA4-1T and spent fermentation media	Grandevo WDG, Reg. No. 84059-27-AA
	Pear psylla, san jose scale, stink bugs, mites, green apple aphid, rosy apple aphid and wooly apple aphid. 2(ee)[1] for san jose scale	Heat-killed *Burkholderia rinojensis*, Strain A396 cells and spent fermentation media	Venerate XC, Reg. No. 84059-14-ZA
	Aphids, scales, leafrollers	Cold pressed neem oil (70.0%)	Rango[2], Reg. No. 88760-10-AA
	Acales	Mineral oil (80.0%)	Suffoil X, Reg. No.48813-1-AA-68539
	Stinkbugs, thrips, lygus, various lepidopterans, psylla	Kaolin (95%)	Surround WP Crop Protectant, Reg. No. 61842-18-AA
	Aphids (such as pea aphid, rosy apple aphid), beetles (such as japanese beetle), borers, (such as peachtree borers, peach twig borers), true bugs, (such as lygus bugs, stink bugs), caterpillars, (such as leafrollers, cutworms, loopers, armyworms), flies (such as walnut husk fly, leafminers and fungus gnats), leafhoppers, leafminers, whiteflies, mealy bugs, mites, psyllids (such as pear psylla), weevils, scales (such as san jose scale), thrips, (such as western flower thrips).	Azadirachtin (1.2%)	Aza-Direct, Reg. No. 71908-1-AA-10163
	Mites, thrips, psyllids, leafhoppers, lepidotera larvae, white flies; other pests such as borers, mealybugs and plant bugs	Capsicum oleoresin extract (7.6%), garlic oil (23.4%), canola oil (55%)	Captiva Prime, Reg. No. 10163-336-AA

CROP	PESTS	BIOPESTICIDE ACTIVE INGREDIENT	REPRESENTATIVE PRODUCT/ CA REG. NO.
SMALL GRAINS	Aphids	Azadirachtin (4.5%)	Neemix 4.5, Reg. No. 70051-9-ZA
		Clarified hydrophobic extract of neem oil 70%	Trilogy, Reg. No. 70051-2-ZB
		Potassium salts of fatty acids 47%	Des-X Insecticidal Soap Concentrate, Reg. No. 67702-22-AA-70051
		Isaria fumosorosea apopka Strain 97 (formerly *Paecilomyces fumosoroseus*), 20.0%	PFR-97 20% WDG, Reg. No. 70051-19-ZA
		Beauveria bassiana Strain GHA 11.3%	BoteGHA ES, Reg. No. 82074-1-ZB
	Aphids, wireworms	Cold pressed neem oil (70.0%)	Rango[2], Reg. No. 88760-10-AA
	Armyworm (rye) – requires a supplemental label.	Sodium tetraborohydrate decahydrate (0.99%)	Prev-Am, Reg. No. 72662-3-ZB
	Aphids (including greenbug), armyworms, corn earworm (headworm), southwestern corn borer, web worms, chinch bugs, mites, thrips	*Chromobacterium subtsugae*, Strain PRAA4-1T and spent fermentation media	Grandevo WDG, Reg. No. 84059-27-AA
	Aphids (including greenbug), armyworms, corn earworm (headworm), southwestern corn borer, web worms, chinch bugs, mites, thrips, wireworm	Heat-killed *burkholderia rinojensis*, Strain A396 cells and spent fermentation media	Venerate XC, Reg. No. 84059-14-ZA
	Mites, thrips, psyllids, leafhoppers, lepidotera larvae, white flies; other pests such as borers, mealybugs and plant bugs	Capsicum oleoresin extract (7.6%), garlic oil (23.4%), canola oil (55%)	Captiva Prime, Reg. No. 10163-336-AA
STONE FRUIT	Green fruitworm, leafrollers (including fruittree, oblique-banded, pandemic, redbanded, and variegated), oriental fruit moth, peach twig borer, redhumped caterpillar, tent caterpillar, leafrollers and peach twig borer, aphids, mealybugs, mites, thrips, whiteflies	*Chromobacterium subtsugae*, Strain PRAA4-1T and spent fermentation media	Grandevo WDG, Reg. No. 84059-27-AA

CROP	PESTS	BIOPESTICIDE ACTIVE INGREDIENT	REPRESENTATIVE PRODUCT/ CA REG. NO.
STONE FRUIT	Green fruitworm, leafrollers (including oblique-banded, fruit tree, pandemic, redbanded, varie-gated), oriental fruit moth, peach twig borer, plum curculio, redhumped caterpillar, tent caterpillar, aphids incl rosy apple aphid and green apple aphid, mealybugs, mites, thrips, whiteflies, san jose scale.	Heat-killed *Burkholderia rinojensis*, Strain A396 cells and spent fermentation media	Venerate XC, Reg. No. 84059-14-ZA
	Scale	*Isaria fumosorosea* spopka Strain 97 (formerly *Paecilomyces fumosoroseus*), 20.0%	PFR-97 20% WDG, Reg. No. 70051-19-ZA
		Beauveria bassiana Strain GHA 11.3%	BoteGHA ES, Reg. No. 82074-1-ZB
		Mineral oil (80.0%)	Suffoil X, Reg. No.48813-1-AA-68539
		Potassium silicate (29%)	Sil-Matrix, Reg. No. 82100-1-AA
	Scale, peach twig borer	Heat-killed *Burkholderia rinojensis*, Strain A396 cells and spent fermentation media	Venerate XC, Reg. No. 84059-14-ZA
	San jose scale (2ee)[1], peach twig borer	*Chromobacterium subtsugae*, Strain PRAA4-1T and spent fermentation media	Grandevo WDG, Reg. No. 84059-27-AA
	Insects and mites including aphids, beetles, caterpillars/moths/worms, flies/gnats, grasshop-pers, leafhoppers, leafminer, maggots/grubs, mealy bugs, mites, pysllids, scales, thrips, true pant bugs, weevils, wioreworms and whiteflies; diseases such as foliar and soil fungal diseases; nematodes.	Cold pressed neem oil (70.0%)	Rango[2], Reg. No. 88760-10-AA
	Mealybugs	Sodium tetraborohydrate decahydrate (0.99%)	Prev-Am, Reg. No. 72662-3-ZB
	Cherry fruit flies, grasshoppers, june beetle, leafhoppers, navel orange worm, oriental fruit moth, oblr, leafhoppers including sharpshooters	Kaolin (95%)	Surround WP Crop Protectant, Reg. No. 61842-18-AA

CROP	PESTS	BIOPESTICIDE ACTIVE INGREDIENT	REPRESENTATIVE PRODUCT/ CA REG. NO.
STONE 'FRUIT	Leafhoppers, navel orange worm, oriental fruit moth	Kaolin (95%)	Surround WP Crop Protectant, Reg. No. 61842-18-AA
	Mites, thrips, psyllids, leafhoppers, lepidotera larvae, white flies; other pests such as borers, mealybugs and plant bugs	Capsicum oleoresin extract (7.6%), garlic oil (23.4%), canola oil (55%)	Captiva Prime, Reg. No. 10163-336-AA
STRAWBERRY	Beetle, cinch bug, lygus bug, mites, sawfly, sugarcane aphids, thrips, whitefly	*Chromobacterium subtsugae*, Strain PRAA4-1T and spent fermentation media	Grandevo WDG, Reg. No. 84059-27-AA
	Armyworms, leafminers, (and various sucking insects)	Heat-killed *Burkholderia rinojensis*, Strain A396 cells and spent fermentation media	Venerate XC, Reg. No. 84059-14-ZA
	Thrips, whiteflies, plant bugs, lygus, lepidopter-ans, aphids, others	Cold pressed neem oil (70.0%)	Rango[2], Reg. No. 88760-10-AA
	Aphids, thrips, whiteflies	*Isaria fumosorosea apopka* Strain 97 (formerly *Paecilomyces fumosoroseus*), 20.0%	PFR-97 20% WDG, Reg. No. 70051-19-ZA
	Soft bodied pests including adelgids, aphids, caterpillars, earwigs, lace bugs, leafhoppers, leafminers, mealybugs, mole crickets, plant bugs, psyllids, sawfly larvae, scales, spider mites, tent catepillars, thrips, whiteflies, gypsy moth, and chinch bugs; most effective on mites, aphids and whiteflies; curative control of powdery mildew.	Potassium salts of fatty acids	M-Pede Insecticide-Miticide-Fungicide, Reg. No. 10163-324-AA
SUGARBEET	Aphids, armyworms, loopers, potato aphid, psyllids, whiteflies	Heat-killed *Burkholderia rinojensis*, Strain A396 cells and spent fermentation media	Venerate XC, Reg. No. 84059-14-ZA
	Seed corn maggots, wireworms, grubs	Heat-killed *Burkholderia* spp. Strain A396 cells and spent fermentation media	Venerate XC, Reg. No. 84059-14-ZA

CROP	PESTS	BIOPESTICIDE ACTIVE INGREDIENT	REPRESENTATIVE PRODUCT/ CA REG. NO.
SUGARBEET	Wireworms and cutworms	Spinosad (a mixture of spinosyn A and spinosyn D)	Seduce Insect Bait, Reg. No. 67702-25-AA-70051
	Lepidoptera	*Bacillus thuringiensis*,(Berliner), subspecies kurstaki, Strain SA-11	Javelin WG Biological Insecticide, Reg. No.70051-66-ZA
		Bacillus thuringiensis subspecies kurstaki Strain SA-11 solids, spores, and Lepidopteran active toxins	Deliver Biological Insecticide, Reg. No. 70051-69-ZB
		Bacillus thuringiensis (Berliner), subspecies aizawai, GC-91 Proetin	Agree WG Biological Insecticide, Reg. No. 70051-47-ZC
		Bacillus thuringiensis subspecies Kurstaki, genetically engineered Strain EG7841 Lepidopteran active toxin	Crymax Bioinsecticide, Reg. No.70051-86-AA
	Hoppers, flea beetles and worms	Pyrethrins (0.75%) + *Beauveria bassiana* Strain GHA (0.06%) (Botanigard Maxx)	Botanigard ES (Reg. No. 82074-1-AA), and Botanigard Maxx (Reg. No. 82074-5-ZA) Note: Botanigard ES is solely *Beauveria bassiana* Strain GHA (11.3 %)
TREE NUTS	Fall webworm, filbert worm, hickory shuckworm, navel orange worm, oblique-banded leafroller, peach twig borer, pecan nut casebearer, red-humped caterpillar, aphids, mealybugs, mites, pecan weevil, whiteflies, codling moth; san jose scale 2(ee)[1].	*Chromobacterium subtsugae*, Strain PRAA4-1T and spent fermentation media	Grandevo WDG, Reg. No. 84059-27-AA
	Fall webworm, filbert worm, hickory shuckworm, naval orange worm, oblique banded leafroller, peach twig borer, pecan nut casebearer, red-humped caterpillar, aphids, mealybugs, whiteflies; 2(ee)[1] san jose scale	Heat-killed *Burkholderia rinojensis*, Strain A396 cells and spent fermentation media	Venerate XC, Reg. No. 84059-14-ZA
	Walnut husk fly and mites (brown mite, peach silver mite, citrus flat mite, pacific spider mite, european red mite, two-spotted spider mite, strawberry spider mite).	Terpene constituents of the extract of *Chenopodium ambrosioides* near ambrosioides as synthetically manufactured (16.75%)	Requiem Prime[3], Reg. No. 264-1185-AA

CROP	PESTS	BIOPESTICIDE ACTIVE INGREDIENT	REPRESENTATIVE PRODUCT/ CA REG. NO.
TREE NUTS	Leaffooted bug and stinkbug	Pyrethrins (0.75%) + *Beauveria bassiana* Strain GHA (0.06%)	BotaniGard Maxx, Reg. No. 82074-5-AA
	Scales, aphids, navel orange worm, peach tree borer	Cold pressed neem oil (70.0%)	Rango[2], Reg. No. 88760-10-AA
	Mites, thrips, psyllids, leafhoppers, spodoptera, helicoverpa, whiteflies, mealybugs (planococcus/ pseudomcoccus), plant bugs (leptoglossus and nezara)	Capsicum oleoresin extract (7.6%), garlic oil (23.4%), canola oil (55%)	Captiva Prime, Reg. No. 10163-336-AA
	Stinkbugs, navel orange worm, codling moth, aphids such as black and yellow aphids	Kaolin (95%)	Surround WP Crop Protectant, Reg. No. 61842-18-AA
	Aphids (such as pea aphid, rosy apple aphid), beetles (such as japanese beetle), borers, (such as peachtree borers, peach twig borers), true bugs, (such as lygus bugs, stink bugs), caterpillars, (such as leafrollers, cutworms, loopers, armyworms), flies (such as walnut husk fly, leafminers and fungus gnats), leafhoppers, leafminers, whiteflies, mealy bugs, mites, psyllids (such as pear psylla), weevils, scales (such as san jose scale), thrips, (such as western flower thrips)	Azadirachtin (1.2%)	Aza-Direct, Reg. No. 71908-1-AA-10163
TURF	Armyworms, cutworms, and sod webworms. chinch bug and leafhoppers, white grubs (such as larvae of black turfgrass ataenius, european chafer, green june beetle, aphodius spp., may or june beetles (phyllophaga spp.), northern and southern masked chafers (cyclocephala spp.), and sugarcane grub (tomarus spp.)). for control of white grubs and annual bluegrass weevils	*Chromobacterium subtsugae*, Strain PRAA4-1T and spent fermentation media	Grandevo WDG, Reg. No. 84059-27-AA

CROP	PESTS	BIOPESTICIDE ACTIVE INGREDIENT	REPRESENTATIVE PRODUCT/ CA REG. NO.
WALNUT	Aphids	Azadirachtin (4.5%)	Neemix 4.5, Reg. No. 70051-9-ZA
		Clarified hydrophobic extract of neem oil (70%)	Trilogy, Reg. No. 70051-2-ZB
		Potassium salts of fatty acids (47%)	Des-X Insecticidal Soap Concentrate, Reg. No. 67702-22-AA-70051
		Isaria fumosorosea apopka Strain 97 (formerly *Paecilomyces fumosoroseus*) (20.0%)	PFR-97 20% WDG, Reg. No. 70051-19-ZA
		Beauveria bassiana Strain GHA (11.3%)	BoteGHA ES, Reg. No. 82074-1-ZB
	Aphids, walnut husk fly, scale	Cold pressed neem oil (70.0%)	Rango[2], Reg. No. 88760-10-AA
	Aphids, walnut husk fly, navel orange worm, stinkbugs	Kaolin (95%)	Surround WP Crop Protectant, Reg. No. 61842-18-AA
	Aphids, walnut husk fly (2ee)[1], san jose scale	Heat-killed *Burkholderia rinojensis*, Strain A396 cells and spent fermentation media	Venerate XC, Reg. No. 84059-14-ZA
	Codling moth (2ee)[1]	*Chromobacterium subtsugae*, Strain PRAA4-1T and spent fermentation media	Grandevo WDG, Reg. No. 84059-27-AA

1 FIFRA section 2(ee) are exemptions "to use any registered pesticide in a manner inconsistent with its labeling" and may include the following: a decrease in dosage rate per unit treated, decrease in concentration of the mixture applied, less frequent applications than specified, use to control a target pest not listed in labeling (provided the application is to a commodity or site listed in labeling and the use of the product against an unnamed pest is not expressly prohibited), the application method is not prohibited, mixing with another pesticide or with a fertilizer (tank mixing), mixing with other substances, increase in the concentration of the mixture, PPE exceptions and substitutions allowed by 3 CCR 6738, simultaneous use of two products with conflicting labeling statements, illegal mixing of two pesticides with the same AI to increase dosage, and the use of vegetable oils in pesticide mix.

2 Rango is an Additional Brand Name (ABN) of TNO70 Broad Spectrum, EPA Reg. No 88760-10

3 Requiem Prime is an Additional Brand Name (ABN) for Terpenoid Blend QRC 460 EC, EPA Reg. No. 264-1185

Table 2 – Diatomaceous Earth Products

REPRESENTATIVE PRODUCTS	CA REG. NO.	% AI	SITE INFORMATION FROM DPR PRODUCT LABEL DATABASE 1	INDICATED PEST ON SPECIMEN LABEL
AG DE-CIDE	7655-1-AA-71074	85%	Agricultural crops, barley, buckwheat, cocoa, commercial storages or warehouses, corn, feed/food storage, flax, flour mills, fruit trees (orchards), gardens (ornamental, flowers), grain crops, grain/cereal/flour bins, oats, ornamental herbaceous, peanuts, peas, popcorn, railroad cars, rice, rye, shipholds, silos, sorghum, soybeans, wheat	Specimen label source: (Note: specimen label obtained from US EPA PPLS using Reg. No. 7655-1 resulted in a label for Crop Guard™): https://www3.epa.gov/pesticides/chem_search/ppls/007655-00001-20180206.pdf Roaches, slugs, ants, earwigs, grasshoppers, crickets, silverfish, millipedes, centipedes, sow bugs, pill bugs, lice, mites, box elder bugs, carpet beetles; fleas, ticks, aphids, snails and japanese beetles; stored grain insects (rice weevils, granary weevils, angoumois grain moths, mediterranean flour moths, indian meal moths, red flour beetles and tribolium)[4]
DESECT AG[2]	7655-1-ZA	85% + Diatomaceous Earth, other related (10%)	Agricultural crops, cole crops, flavoring and spice crops, fruit trees (orchards), grain crops, orchards (fruit/nut), ornamental and/or shade. root crops	Same as Ag-Decide
DESECT DIATOMACEOUS EARTH INSECTICIDE[3]	7655-1-AA	85% + Diatomaceous Earth, other related (10%)	Animal husbandry premises, cracks and crevices, farm or ag structures, household or domestic dwelling	Same as Ag-Decide

CELITE 610®[4]	Reg No. 73729-1-AA	85% (diatomaceous earth, chemical composition consisting of silicon dioxide)	Animal husbandry premises, barley (grain crop), buckwheat (cereal) (grain crop), carpets (hospital, commercial, household), corn, field, dent (grain crop), eating establish. (food handling/serving area), feed mills, feed stores, feed processing plants, feed/food commodities - temporary storage, feed/food storage areas (unspecified), food marketing, storage & distribution facilities, food processing/handling plant/area (food area), food stores, food markets, supermarkets, etc., garbage disposal units, food disposals, grain/cereal/flour - temporary storage, household or domestic dwellings (all or unspec), human bedding, oats (grain crop), private roads, walkways, lanes, patios, etc., rice (grain crop), rye (grain crop), sorghum (grain crop) (milo, sudan hybrids, etc.), wheat (grain crop)	Specimen label source: (Note: specimen label obtained from US EPA PPLS using Reg. No. 73729-1 resulted in a label for Diafil 610): https://www3.epa.gov/pesticides/chem_search/ppls/073729-00001-20180404.pdf Beetles; moths; weevils; flies, gnats & maggots; "worms" slugs & caterpillars; "bugs" scale and mites; aphids, borers, leafhoppers, leaf miners, loopers and other insects (listed)

1 CDPR Product Label Database (https://apps.cdpr.ca.gov/docs/label/labelque.cfm)

2 Desect AG is an Alternative Brand Name (ABN) for Crop Guard™ (US EPA PPLS)

3 Desect Diatomaceous Earth Insecticide is an Alternate Brand name (ABN) for Crop Guard™(US EPA PPLS)

4 Celite 610® is an Alternate Brand name (ABN) for Diafil® 610 (US EPA PPLS)

Table 3 – Additional NEEM Azadirachtin Products

REPRESENTATIVE PRODUCTS	CA REG. NO.[1]	% AI	SITE INFORMATION FROM SPECIMEN LABEL	INDICATED PEST ON SPECIMEN LABEL
AZATIN O BIOLOGICAL INSECTICIDE	70051-9-AA-59807	4.5%	Specimen label source: https://www.greenbook.net/ohp-inc/azatin-o From Greenbook specimen label[3]: bedding plants, foliage plants, flowers, potted plants and other ornamental plants; cole crops; bulb vegetables; citrus fruits; cucurbit vegetables; fruiting vegetables; herbs and spices; leafy vegetables; ornamental trees and shrubs; pome fruits; root and tuber crops; small fruits and berries; stone fruits; tree nuts; tropical and subtropical fruits; turfgrass; miscellaneous crops	Aphids and adelgids; beetle larvae, weevil larvae, grubs; borers; bugs; cankerworms; armyworms, bollworms, caterpillars, fruit-worms, loopers, webworms and other worms' chafers, crickets; cutworms, grasshoppers and locusts; leaffolders and leaftiers; leafhoppers, leafminers, leafrollers, maggots, marsh flies, mealybugs, midges, millipedes, moth larvae, nematodes, phylloxera, psyllids, sawflies, scale insects, sowbugs, spittlebugs, thrips, webworms, whiteflies
AZERA INSECTICIDE	1021-1872-AA	1.2% + Pyre-thrins (1.4%)	Specimen label source: https://www.greenbook.net/valent-usa-llc-agricultural-products/azera-insecticide From Greenbook specimen label[3]: Root and tuber vegetables; leaves of root and tuber vegetables; bulb vegetables; leafy vegetbles; cole leafy vegetables; legume vegetables; foliage of legume vegetables ; fruiting vegetables; cucurbit vegetables; citrus fruits; pome fruits; stone fruits; small fruits and berries; tree nuts; tropical fruits; cereal grains; forage, fodder and straw of cereal grains; grasses for seed, forage, fodder and hay; non-grass animal feeds; herbs and spices; oil seed group and additional crops	Aphids; armyworms, caterpillars and loopers; beetles and weevils; leafrollers; borers; flies; leafhoppers and sharpshooters; leafminers; midges; moths; whiteflies; psyllids; thrips; others (some ants, maggots, mites, cutworms, etc.)

REPRESENTATIVE PRODUCTS	CA REG. NO. 1	% AI	SITE INFORMATION FROM SPECIMEN LABEL	INDICATED PEST ON SPECIMEN LABEL
DEBUG TRES	70310-8-AA	3.0 %	Specimen label source: https://www.greenbook.net/agro-logistics-systems-inc/debug-tres From Greenbook specimen label[3] : Top fruits including but not limited to citrus, lemons, oranges, grapefruits, pummalo, apples, plums, peaches, apricots, avocados, figs, prunes, nectarines, pears. mangoes, cherries, kiwifruit, kumquats, loquats, quinces, persimmons, and palm. cucurbits, watermelons, gherkins, squashes, pumpkins, gourds, bitter melons, chayote, okra, asparagus, and melons. bulb, cole and leafy vegetables including but not limited to broccoli, brussels sprouts, cabbage, cauliflower, celery, lettuce, endives, kale, parsley, onions, garlic, shallots, leeks, kohlrabi, chard, collard, amaranth, radicchio, chicory, mustard greens, rapeseed, mizuna, arugula, and spinach. root and tuber vegetables including but not limited to beets, carrots, ginger, radish, horseradish, potatoes, turnips, yams, sweet potatoes, ginseng, rutabagas, watercress, artichokes and turmeric. legumes including but not limited to beans, lentils, peas, peanuts, soybeans and garbanzo beans. cereals including but not limited to barley, corn, millet, rice, rye, sorghum, triticale, oats, and wheat. alfalfa and other feed & forage crops. grasses fruiting vegetables including but not limited to tomatoes, tomatillos, bell peppers, chili peppers, and eggplant. berries including but not limited to blackberries, blueberries, currants, strawberries, cane berries, gooseberries, raspberries, cranberries, loganberries, huckleberries, and boysenberries grapes tropical fruits including but not limited to banana, cherimoyas, mangoes, guavas, papayas and pineapple. cotton and oilseeds including but not limited to canola, sesame, rapeseed, sunflower, safflower, olive, peanut and jojoba herbs & spices including but not limited to mints, anise, basil, chives, coriander, dill, fennel, marigold, sage, and thyme. mushrooms, including but not limited to agaricus, bella, enoki, maitake, oyster, shitake, and other specialty mushrooms nuts including but not limited to almonds, pecans, pistachios, cashews, chestnuts, macadamia, hazelnuts, brazil nut, water chestnuts, and walnuts. coffee, tea, tobacco and sugarcane. greenhouse crops and ornamentals including but not limited to chrysanthemums, poinsettias, roses, lilies, geraniums, daisies, carnations, salvias and dahlias. all starter crops	Aphids, armyworms, fall armyworms, beetles, beanleaf beetles, cucumber beetles, japanese beetles, mexican beetles, colorado potato beetles, potato flea beetles, corn beetles, flea beetles borers, budworms. casebearers, caterpillars, codling moth fruit flies gnats, fungus gnats, grasshoppers, grubs leaf hoppers, leaf perforators, leafminers, leafrollers, loopers, cabbage loopers, lygus bug maggots, onion maggots, mealy bugs, mealybugs, mildew, rust and powdery mildew, mites, two spotted spidermites, pacific spider mites, moths, diamondback moths, gypsy moths, grape berry moths, nematodes, orange totrix, phylloxera, phythium, psylla, psyllids, rhizoctonia solani, scales, san jose scale, sclerotinia sclerotiorum, sclerotium rolfsii, sharpshooters, sucker ants, thrips, weevils, pepper weevils, boll weevils, whiteflies, worms, wireworms, webworms, budworms, alfalfa worms, boll worms, pickle worms ,fagot worms, root worms, ear worms, cut worms

REPRESENTATIVE PRODUCTS	CA REG. NO. 1	% AI	SITE INFORMATION FROM SPECIMEN LABEL	INDICATED PEST ON SPECIMEN LABEL
MOLT-X	68539-11	3.0%	Specimen label source: https://www.greenbook.net/bioworks-inc/molt-x From Greenbook specimen label[3]: Root and tuber vegetables; leafy vegetables (including brassica leafy vegetables); legume vegetables; fruiting vegetables; cucurbit vegetables; citrus fruits; pome fruits; stone fruits; cereal grains; herbs and spices; bulb vegetables; nuts; oilseed crops; tropical fruits; ornamental plants, trees and shrubs	Whiteflies; leafmniners; scales; mealy bugs; thrips; aphids; psyllids; leafhoppers; bugs; flies; sawflies; caterpillars; beetles, weevils; borers, mole crickets; nematodes
ORNAZIN 3% EC	5481-476-ZC	3.0%	Specimen label source: https://www.greenbook.net/amvac/amazin-3-ec From Greenbook specimen label[3]: "ORNAZIN 3% EC is intended for use on outdoor plants and plants grown indoors or in greenhouses, shadecloths, interiorscapes and nurseries. It can be used to control any of the following insects and nematodes. ORNAZIN 3% EC can be used on: Greenhouse food crops, ornamental plants, ornamental trees and shrubs, turf and turfgrass."	Aphids, beetles, caterpillars, flies, lacewings, leafhoppers, leafminers, mealybugs, nematodes, psyllids, sawflies, scales, soft scales, thrips, weevils, whiteflies

Table 4 – *Bacillus thuringiensis* Products

REPRESENTATIVE PRODUCT	CA REG. NO.	*BACILLUS THURINGIENSIS* SUBSPECIES/ STRAIN	INFORMATION FROM SPECIMEN LABEL
DIPEL DF	73049-39-AA	*Bt*, subsp. kurstaki, strain ABTS-351, fermentation solids and solubles (54%)	**Specimen label source:** https://www.greenbook.net/valent-usa-llc-agricultural-products/dipel-df **Crops:** Vegetables (root and tuber, bulb, leafy, brassica, legume, fruiting, cucurbit), citrus fruit, pome fruit, stone fruit, berry and small fruit group, tree nut, cereal grain, grass forage/fodder/ hay, herbs, alfalfa, artichokes, asparagus, avocado, banana, coffee, cotton, tropical fruit, hop, kiwi, malanga, mint and peppermint, peanut, pineapple, pomegranate, rape (canola), safflower, sugarcane, sunflower, tobacco, watercress **Pests:** Achema sphinx moth (hornworm), alfalfa caterpillar, almond moth, amorbia moth, armyworm, artichoke plume moth, azalea caterpillar, bagworm , banana moth , banana skipper, blackheaded budworm, california oakworm , cankerworm, cherry fruitworm, china mark moth, citrus cutworm, codling moth, cotton bollworm, cranberry fruitworm, cross-striped cabbageworm, cutworm, diamondback moth, douglas fir tussock moth, ello moth (hornworm), elm spanworm , european corn borer , european grapevine moth , european skipper, fall webworm, filbert leafroller, fruittree leafroller, grape berry moth, grape leafroller, grapeleaf skeletonizer (ground only), green cloverworm, greenstriped mapleworm, gummosos-batrachedra comosae (hodges), gypsy moth, headworm, head moth, hemlock looper, hornworm, imported cabbageworm, indian meal moth, io moth, jack pine budworm, light brown apple moth, looper, melonworm, mimosa webworm, oblique banded leafroller, oleander moth, omnivorous leafroller, omnivorous looper, orange dog, orange tortrix, oriental fruit moth, peach twig borer, pine butterfly, podworm, redbanded leafroller, redhumped caterpillar, rindworm complex, saddleback caterpillar, saddle prominent caterpillar, saltmarsh caterpillar, sod webworm, soybean looper, spanworm, spring and fall cankerworm, spruce budworm, tent caterpillar, tobacco budworm, tobacco hornworm, tobacco moth, tomato fruitworm, tufted apple budmoth, twig borer, variegated cutworm, variegated leafroller, velvetbean caterpillar, walnut caterpillar, webworm, western tussock moth, southern cornstalk borer, sugarcane borer, corn earworm, cotton bollworm, tomato fruitworm, tobacco budworm [3]

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REPRESENTATIVE PRODUCT	CA REG. NO.	*BACILLUS THURINGIENSIS* SUBSPECIES/ STRAIN	INFORMATION FROM SPECIMEN LABEL
JAVELIN-WG BIOLOGICAL INSECTICIDE	70051-66-ZA	*Bt* (Berliner), subp. Kurstaki, strain SA-11 (85%)	**Specimen label source:** http://www.cdms.net/Label-Database/Advanced-Search#Result-product/3556/state/5 **Crops:** Vegetable crops; field crops; fruit, nut and vine crops; shade trees and ornamentals, turf and grass seed production, stored soybeans/grains, flowers and ornamentals **Pests** (Note: Label specifies county specific limitations): Alfalfa caterpillar, almond moth, amorbia, armyworm, artichoke plume moth, bagworm, banana moth, banana skipper, bertha armyworm, blueberry leafroller, blueberry spanworm, bollworm, california oak moth, cherry fruitworm, citrus cutworm, codling moth, cotton leafperforator, cotton leafworm, cutworm, diamondback moth, douglas fir tussock moth, elm spanworm, european corn borer, european grapevine moth, fall cankerworm, fall webworm, filbert webworm, fruittree leafroller, grape leaffolder, grapeleaf skeletonizer, green cloverworm, green fruitworm, gypsy moth, helicoverpa species, heliothi, hornworm, imported cabbageworm, indian meal moth, jack pine budworm, light brown apple moth, looper, mexican leafroller, mimosa webworm, navel orangeworm, obliquebanded leafroller, omnivorous leafroller, omnivorous leaftier, orange tortrix, orangedog, oriental fruit moth, pandemis leafroller, peach twig borer, pecan nut casebearer, redbanded leafroller, redhumped caterpillar, rindworm (complex), roughskinned cutworm, saltmarsh caterpillar, sod webworm, southwestern corn borer, spotted cutworm, spring cankerworm, spruce budworm, tent caterpillar, tobacco budworm, tobacco hornworm, tomato pinworm, tropical sod webworm, tufted apple budmoth, variegated leafroller, velvetbean caterpillar, western tussock moth

REPRESENTATIVE PRODUCT	CA REG. NO.	*BACILLUS THURINGIENSIS* SUBSPECIES/ STRAIN	INFORMATION FROM SPECIMEN LABEL
THURICIDE BACILLUS THURING-IENCES (BT)	4-226-AA	*Bt* (Berliner), subsp. Kurstaki strain SA-12 (15%)	**Specimen label source:** https://www.greenbook.net/bonide-products-inc/bacillus-thuringiensis-bt-thuricide-concentrate **Crops and corresponding pests:**

CROP	PEST
Almonds	Redhumped caterpillar, tent caterpillar
Apples, pears	Redbanded leafroller, tufted apple budmoth, variegated leafroller, tent caterpillar, fruit tree leafroller, gypsy moth
Broccoli, brussels sprouts, cabbage, cauliflower, collards, kale, mustard greens, turnip greens	Cabbage looper, imported cabbage worm, green cloverworm, diamondback moth
Beans, beets, carrots, celery, chard, chinese cabbage, endive, escarole, garlic, kohlrabi, lentils, lettuce, onions, parsley, radishes, spinach, squash	Cabbage looper
Cherries	Tent caterpillar
Cucumbers, melons, potatoes	Cabbage looper
Currants, blueberries, caneberries, (blackberries, dewberries, raspberries)	Omnivorous leafroller
Eggplant, peppers, tomatoes	Tomato hornworm, tomato fruitworm (supression only), cabbage looper
Filberts	Tent caterpillar, filbert leafroller
Watermelons (Florida)	Rindworm complex

REPRESENTATIVE PRODUCT	CA REG. NO.	*BACILLUS THURINGIENSIS* SUBSPECIES/ STRAIN	INFORMATION FROM SPECIMEN LABEL CONTINUED
THURICIDE BACILLUS THURINGIENCES (BT)	4-226-AA	*Bt* (Berliner), Subsp. Kurstaki Strain SA-12 (15%)	**Specimen Label Source:** https://www.greenbook.net/bonide-products-inc/bacillus-thuringiensis-bt-thuricide-concentrate **Crops and corresponding pests:**

CROP	PEST
Watermelons (Florida)	Rindworm Complex
Grapes	Grape Leaf Roller, Omnivorous Leaf Roller
Mint	Cabbage Looper
Strawberries	Cabbage Looper, R oughskinned Cutworm
Oranges	Fruit Tree Leaf Roller, Citrus Cutworm, Orange Dog
Peaches, Nectarines	Redhumped Caterpillar, Tent Caterpillar, Omnivorous Leafroller

REPRESENTATIVE PRODUCT	CA REG. NO.	*BACILLUS THURINGIENSIS* SUBSPECIES/ STRAIN	INFORMATION FROM SPECIMEN LABEL	
MONTEREY B.T.	70051-106-AA-54705	*Bt* (Berliner), subsp. Kurstaki strain SA-12 (98.35%)	**Specimen label source:** https://assets.greenbook.net/20-58-52-25-01-2018-MontereyBt-2-column-030514_03_.pdf **Crops and corresponding pests:**	
			CROP	PEST
			Broccoli, cauliflower, collards, kale, mustard, greens, turnip greens, cabbage, celery, lettuce, melons and tomatoes	Cabbage looper
			Broccoli, cabbage, cauliflower, collards, kale, mustard greens, and turnip greens	Imported cabbage worm
			Tomatoes	Tomato hornworm
			Shade trees & ornamentals	Bagworm, spring cankerworm, fall cankerworm, gypsy moth, tent caterpillar, elm spanworm, fall webworm

REPRESENTATIVE PRODUCT	CA REG. NO.	*BACILLUS THURINGIENSIS* SUBSPECIES/ STRAIN	INFORMATION FROM SPECIMEN LABEL
XEN TARI BIOLOGICAL INSECTICIDE DRY FLOWABLE	73049-40	*Bt*, subsp. Aizawai, strain Abts-1857 (54%)	**Specimen label source:** https://assets.greenbook.net/L52948.pdf **Crops and corresponding pests:** (Note: The specimen label lists substantially more pests by crop than shown below but use of the product on these crops is allowed "for all states except California"; The product label indicates that it can be used against various pests on trees and forests (Forest, shade, sugar maple trees, ornamentals) "for all states except California"):

CROP	PEST
Vegetable, root and tuber/ leaves of root and tuber vegetables/ vegetable, bulb/ vegetable, leafy except brassica/ vegetables, brassica	Loopers, imported cabbageworm, diamondback moth, webworm, armyworm, cross-striped cabbageworm, heliothis
Legume vegetables/ foliage of legume vegetables	Loopers, soybean looper, armyworms
Vegetable, fruiting except cucurbits	Loopers, hornworms, tomato fruitworm, armyworm
Vegetable, cucurbits	Loopers, armyworms, cutworms
Fruit, citrus/ fruit, pome/ fruit, stone	Armyworms
Berry and small fruit	Grapeleaf skeletonizer, loopers, armyworms, tobacco budworm, grape berry moth, spanworm
Nut trees	Codling moth, armyworm
Grain, cereal	Heliothis, armyworms, european corn bearer
Grass forage, fodder, and hay/ nongrass animal feeds (forage, fodder, straw and hay)	Loopers, armyworms
Herbs and spices	Loopers, armyworms

REPRESENTATIVE PRODUCT	CA REG. NO.	*BACILLUS THURINGIENSIS* SUBSPECIES/ STRAIN	INFORMATION FROM SPECIMEN LABEL (CONTINUED)
XEN TARI BIOLOGICAL INSECTICIDE DRY FLOWABLE	73049-40	*Bt*, subsp. Aizawai, strain Abts-1857 (54%)	**Specimen label lource:**: https://assets.greenbook.net/L52948.pdf **Crops and corresponding pests:** (Note: The specimen label lists substantially more pests by crop than shown below but use of the product on these crops is allowed "for all states except California"; The product label indicates that it can be used against various pests on trees and forests (Forest, shade, sugar maple trees, ornamentals) "for all states except California"):

CROP	PEST
Oilseed	Loopers, armyworms
Asparagus, avocado	Armyworms
Flowers, bedding plants and ornamentals	Loopers, tobacco budworm, diamondback moth, armyworms
Fruit, tropical (grow in USA)	Armyworms, loopers, batrachedra comosae (hodges), thecla moth,
Globe artichoke	Artichoke plume moth, thistle butterfly
Hops	Loopers, armyworms
Malanga	Armyworms
Peanut	Armyworms, loopers, podworms
Tobacco	Armyworms, tobacco budworm, loopers
Turf	Armyworms
Watercress	Loopers, armyworms, diamondback moth
Greenhouse/shadehouse and outdoor nursery	Loopers, heliotis, armyworms

REPRESENTATIVE PRODUCT	CA REG. NO.	*BACILLUS THURINGIENSIS* SUBSPECIES/ STRAIN	INFORMATION FROM SPECIMEN LABEL
AGREE WG BIOLOGICAL INSECTICIDE	70051-47-ZC	*Bt* (Berliner), subsp. Aizawai, GC-91 protein (50%)	**Specimen label source:** https://assets.greenbook.net/L108750.pdf **Crops and corresponding pests:**

CROP	PEST
Cole crops, terrestrial chinese vegetables, terrestrial green leafy vegetables, celery	Loopers, imported cabbageworm, cross-striped cabbageworm, diamondback moth, armyworms, beet armyworms, saltmarsh caterpillar, light brown apple moth
Beans, peas	Loopers, armyworms, green cloverworm, velvetbean caterpillar, light brown apple moth
Tomatoes, peppers	Loopers, tomato fruitworm, hornworm, armyworms, light brown apple moth
Tobacco	Loopers, tobacco budworm, hornworm, light brown apple moth
Cotton	Tobacco budworm, cotton bollworm, armyworms, loopers, light brown apple moth
Terrestrial ornamental and flowers	Loopers, budworms, diamondback moth, european grapevine moth, armyworms, light brown apple moth
Stone fruit	Twig borer, navel orangeworm, european grapevine moth, light brown apple moth
Tree nuts/ pistachios	Twig borer, codling moth, gypsy moth, navel orangeworm, european grapevine moth, light brown apple moth
Greenhouse vegetables (tomatoes, cole crops, peppers)	Armyworms, loopers, diamondback mnoths, fruitworms, hornworms, budworms, light brown apple moth
Grapes	Grapeleaf skeletonizer, european grapevine moth, light brown apple moth

REPRESENTATIVE PRODUCT	CA REG. NO.	*BACILLUS THURINGIENSIS* SUBSPECIES/ STRAIN	INFORMATION FROM SPECIMEN LABEL (CONTINUED)
AGREE WG BIOLOGICAL INSECTICIDE	70051-47-ZC	*Bt* (Berliner), subsp. Aizawai, GC-91 protein (50%)	**Specimen label ource:** https://assets.greenbook.net/L108750.pdf **Crops and corresponding pests:**

CROP	PEST
Corn	European corn borer, light brown apple moth
Terrestrial small fruits and berries	Armyworms, european grapevine moth, light brown apple moth
Pomegranate/ tropical and subtropical fruit (papaya, avocado, guava, lychee, sugar apple)	European grapevine moth, light brown apple moth
Cranberries	Gypsy moth, spanworm, false armyworm, cutworm, blossom worm, european
Cucurbits	Rindworm complex (loopers, armyworms, diamond-back moth), melonworms, light brown apple moth
Potatoes	Loopers, armyworms, diamondback moth, light brown apple moth
Soybeans	Soybean looper, armyworms, velvetbean caterpillar, podworms, loopers, loopers, light brown apple moth
Pome fruit (apples, pears)	Codling moth, pandemic leaf roller, tufted apple bud moth, red banded leafroller, oblique banded leafroller, european grapevine moth, light brown apple moth
Alfalfa and other forage crops	Armyworms, alfalfa caterpillar, loopers, light brown apple moth
Citrus (oranges, grapefruit, tangerine)	Orange dog, citrus cutworm, light brown apple moth

REPRESENTATIVE PRODUCT	CA REG. NO.	*BACILLUS THURINGIENSIS* SUBSPECIES/ STRAIN	INFORMATION FROM SPECIMEN LABEL (CONTINUED)
AGREE WG BIOLOGICAL INSECTICIDE	70051-47-ZC	*Bt* (Berliner), subsp. Aizawai, GC-91 protein (50%)	**Specimen label source:** https://assets.greenbook.net/L108750.pdf **Crops and corresponding pests:**

CROP	PEST
Sugarbeets/ radish and other root crops/leaves of root and tuber vegetables	Armyworms, cross-striped cabbageworm, diamondback moth, hornworms, imported cabbageworm, loopers, light brown apple moth
Herbs and spices	Armyworms, diamondback moth, imported cabbageworm, loopers, light brown apple moth
Peanuts	Armyworms, velvetbean caterpillar, podworms, loopers, light brown apple moth
Peppermint, spearmint	Armyworms, cutworms, loopers, light brown apple moth
Artichokes	Artichoke plume moth, light brown apple moth
Bulb vegetables (onion, garlic)	Armyworms, diamondback moth, hornworms, imported cabbageworm, loopers, light brown apple moth
Coffee	Banana moth, light brown apple moth
Olives	European grapevine moth, light brown apple moth

Table 5 – US EPA Exempt Products (25B)[1]

ACTIVE INGREDIENTS AND %	REPRESENTATIVE PRODUCT	PRODUCT INFORMATION
CORN OIL (90%)+ THYME OIL (5%)+ LECITHINS (5%)	Mammoth Biocontrol	Specimen label source: http://legacy.picol.cahnrs.wsu.edu/~picol/pdf/wa/69314.pdf Pests indicated on label: Mites and thrips
ROSEMARY OIL (50%)	TetraCURB	Specimen label source: https://www.kemin.com/content/dam/pdf/tetracurb%20concentrate_specimen%20label%20-%20watermark.pdf Pests indicated on label: Spider mites and small, soft bodied insects, including but not limited to aphids and whiteflies
ROSEMARY OIL (10%) + GERANIOL (5%) + PEPPERMINT OIL (5%)	Essentria IC	Specimen label source: https://www.doyourownpestcontrol.com/spec/labels/essentria%20ic-3%20insect%20concentrate%20specimen%20label.pdf Pests indicated on label: Ants, aphids, armyworms, bagworms, beetles, billbugs, chinch bugs, chiggers, crickets, cutworms, earwigs, fleas, grasshoppers, hyperodes weevils (adults), japanese beetles (adults), lace bugs, mealybugs, mites, mole crickets, scale insects, sod webworms, tent caterpillars, ticks, whiteflies livestock pests; bedbugs, darkling beetles, (lesser meal worms), flies (deer, face, house), gnats, lice, litter beetles, maggots (fly larvae), mites, mosquitoes, poultry lice, spiders, stable lice, ticks, wasps
ROSEMARY EXTRACT (10%) + ROSEMARY EXTRACT (0.23%)	SNS 209™	Specimen label source: https://sierranaturalscience.com/wp-content/uploads/2019/10/209-gallon-label-r14-sample.pdf Pests indicated on label: Spider mites, whiteflies, fungus gnats, thrips, root aphids, larvae "and more"
SOYBEAN OIL (10%) + CORN OIL (5%)	PureCrop1	Specimen label source: https://s3.amazonaws.com/cdn.arbico-organics.com/downloads/1274200-1274201-1244202-1274203_purecrop1_label2019.pdf Pests indicated on label: Spider mites, broad mites, russet mites, aphids, thrips, white flies, leaf hoppers (including their larva), as well as botrytis, fusarium wilt, downy and powdery mildew.

1 The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) Section 25(b) and California Code of Regulations Sections 6147-6148 exempt minimum risk pesticide products from registration, provided the product meet certain criteria. Refer to https://www.cdpr.ca.gov/docs/legbills/calcode/25.htm for more information on 25(b) products, including a list of active ingredients.

Table 6 – Pheromone Products

ACTIVE INGREDIENT	PRODUCTS	CA REG. NO.	% AI	SITE INFORMATION FROM DPR PRODUCT LABEL DATABASE 1	INDICATED PEST ON SPECIMEN LABEL
LAVANDULYL SENECIOATE	Checkmate VMB Dispenser	56336-56-AA	5.91 %	Grapes (all or unspecified), grapes (wine), raisin (dried grape)	Vine mealybug[3]
	Checkmate VMB-F	56336-67-AA	19.35 %	Grapes (all or unspecified), grapes (wine), raisin (dried grape)	Vine mealybug[2]
	Checkmate VMB-XL	56336-57-AA	8.6 %	Grapes (all or unspecified), grapes (wine), raisin (dried grape)	Vine mealybug[2]
(E)-11-TETRADECENYL ACETATE + (E,E)-9,11-TETRADECADIENYL ACETATE	Checkmate LBAM Dispenser	56336-58-AA	8.36 % / 0.44 %	Apple, apricot, citrus fruits, grapes, kiwi, peach, pear, raisin, strawaberry, walnut, etc.	Oriental fruit moth and peach twig borer[3]
	Checkmate LBAM-F	56336-59-AA	16.33 % / 0.860 %	Agricultural crops, forest trees, nursery block	Light brown apple moth[4]
	Isomate LBAM Plus	53575-33-AA	67.15% / 2.74 %	Agricultural crops. forest trees. commercial/ institutional, ornamental nurseries, recreational areas, uncultivated non-ag area, etc.	Light brown apple moth[2]
(Z,E)-9,12-TETRADE CADIEN-1-YL ACETATE	Allure MD	73813-3-ZA-499	93%	Aircraft, automobiles, bakeries, commercial storages, commercial transport facilities, eating establishments, feed/food storage, schools, etc.	Almond moth, indian meal moth, mediterranean flour moth, tropical warehouse moth, tobacco moth, raisin moth[3]

ACTIVE INGREDIENT	PRODUCTS	CA REG. NO.	% AI	SITE INFORMATION FROM DPR PRODUCT LABEL DATABASE 1	INDICATED PEST ON SPECIMEN LABEL
(Z,E)-9,12-TETRADE CADIEN-1-YL ACETATE	Checkmate BAW-F	56336-43-AA	15.43% + (Z)-11-Hexade-cen-1-YL Acetate (1.71 %)	Alfalfa (forage-fodder), bok choy, broccoli, brussel sprouts, cab-bage, cauliflower, celery, chinese cabbage, cole crops, cotton, fruiting vegetables, leady vege-tables, lettuce, parsley, parsnip, peppers, root crop vegetables, spin-ach, sugarbeet, toma-tillo, tomato, tomatoes for processing, etc.	Beet armyworm moth[3]
	Checkmate Puffer IMM	73479-16-AA	3.65 %	Apple, commercial stor-ages/warehouses, food processing/handling, pear, silos, walnut	India meal moth, mediter-ranean flour moth, raisin moth, almond moth and tobacco moth[4]
	Cidetrak IMM	51934-9-AA	3.20 %	Storage areas (contain-ing raw grains and bean seeds and products including wheat, barley, rye, oats, corn, popcorn, rice, all edible bean varieties, soybeans, cocoa beans; tobacco; birdseed; all spices; nuts including but not limited to peanuts, walnuts, almonds, pecans, hazelnuts, brazil nuts and pistachios)	India meal moth, tobacco moth, raisin moth, almond moth, and mediterranean flour moth[4]
(Z,Z)-11,13-HEXADECADIENAL	Checkmate NOW-F	56336-38-ZA	1.16 %	Almond, fig, pistachio, walnut	Navel orangeworm[2]
	Checkmate Puffer NOW Ace	73479-19-AA	2.00 %	Almond, fig, pistachio, walnut, orchards (fruit/ nut etc.)	Navel orangeworm[2]

ACTIVE INGREDIENT	PRODUCTS	CA REG. NO.	% AI	SITE INFORMATION FROM DPR PRODUCT LABEL DATABASE 1	INDICATED PEST ON SPECIMEN LABEL
(Z,Z)-11,13-HEXADECADIENAL	Checkmate Puffer NOW Pro	73479-15-AA	0.49 %	Almond, fig, pistachio, walnut	Navel orangeworm[4]
	Cidetrak CMDA + NOW MESO	51934-17-AA	3.50 % + E,E-8,10-Dodeca-dien-1-OL (1.7 %) + 2,4-Decadienoic Acid, Ethyl Ester, (2E,4Z) (1.0 %)	Almond, fig, pistachio, walnut	Codling moth, hickory shuckworm and navel orangeworm[2]
	Cidetrak NOW Meso	51934-19-AA	3.50 %	Almond, fig, pistachio, walnut	Navel orangeworm[2]
	Isomate Mist NOW	53575-52-AA	2.16 %	Almond, apple, apricot, carob, date, fig, **filbert or hazelnut**, grapefruit, lemon, loquat, orange, peach, pear, pecan, pistachio, plum, pluot, pomegranate, prune, walnut	Navel orangeworm[2]
	Isomate NOW Mist	53575-47-AA	2.16 %	Almond, apple, apricot, carob, date, fig, grape-fruit, lemon, loquat, orange, peach, pear, pecan, pistachio, plum, pluot, pomegranate, prune, walnut	Navel orangeworm[2]
	Paramount Aerosol NOW/CM	73479-5-AA	0.66 % + E,E-8,10-Dodecadi-en-1-OL (23.075 %)	Almond, fig, walnut	Coddling moth, navel orangeworm[4]
	Puffer NOW	73479-3-ZA	0.98 %	Almond, fig, pistachio, walnut	Navel orangeworm[3]

ACTIVE INGREDIENT	PRODUCTS	CA REG. NO.	% AI	SITE INFORMATION FROM DPR PRODUCT LABEL DATABASE 1	INDICATED PEST ON SPECIMEN LABEL
(Z,Z)-11,13-HEXADECADIENAL	Semios NOW DS	89850-17-AA	3.92 %	Almond, apple, apricot, cherry, citrus fruits, date, figs, grapefruit, kumquat, lemon, lime, nectarine, orange, peach, pear, pistachio, plums, pluot, pome fruits, prune, quince, tangerine, walnut	Navel orangeworm[4]
	Semios NOW ECO	89850-18-AA	1.96 %	Agricultural crops, almond, apple, apricot, cherry, citrus fruits, date, fig, grapefruit, kumquat, lemon, lime, nectarine, orange, peach, pear, pistachio, plums, pluot, pome fruits, prune, quince, tangerine, walnut	Navel orangeworm[3]
	Semios NOW Extra	89850-11-AA	1.96 %	Agricultural crops, almond, apple, apricot, cherry, citrus fruits, crabapple, date, fig, grapefruit, lemon, nectarine, orange, peach, pear, pistachio, plums, pluot, pome fruits, prune, stone fruits, tangelo, tangerine, walnut	Navel orangeworm[3]

1 CDPR Product Label Database (https://apps.cdpr.ca.gov/docs/label/labelque.cfm)

2 From a specimen label obtained from CDMS (http://www.cdms.net/)

3 From a specimen label obtained from Greenbook (https://www.greenbook.net/)

4 From a specimen label obtained from the US EPA Pesticide Product Label System, PPLS (https://iaspub.epa.gov/apex/pesticides/f?p=PPLS:1)

Appendix 7

Table 5 - Crops for which chlorpyrifos has been an important management tool according to Pesticide Use Report data, but no UC pest management guideline is available.

This table was developed through the Work Group's review of 2012-2017 Pesticide Use Report (PUR) data for the crops where UC pest management guidelines are published. Based on this PUR data, the Work Group identified which crops used the most chlorpyrifos (in volume and/or concentration). The group did not identify alternatives for these uses of chlorpyrifos because the alternatives that the Work Group identified are sourced from UC pest management guidelines, and no UC pest management guidelines are available for these crops.

TABLE 5. CROPS FOR WHICH CHLORPYRIFOS HAS BEEN AN IMPORTANT MANAGEMENT TOOL ACCORDING TO PESTICIDE USE REPORT DATA, BUT NO UC PEST MANAGEMENT GUIDELINE IS AVAILABLE
Sweet potato
Sorghum
Sunflower, general
Peas, general
Guava (subtropical and tropical fruit)

Appendix 8: Immediate-term Research Priorities for Identifying Alternatives to Chlorpyrifos

CROP	PEST	IMMEDIATE RESEARCH NEEDS
ALFALFA	Blue alfalfa aphid	1. Need additional resistant varieties/higher levels of resistance (may not be immediate) 2. Need for additional selective insecticide options 3. Better understanding of interaction between insecticide options (including new) and biological control 4. Development of better sampling methods and thresholds
ALFALFA	Cowpea aphid	1. Need additional resistant varieties/higher levels of resistance (may not be immediate) 2. Need for additional selective insecticide options 3. Better understanding of interaction between insecticide options (including new) and biological control 4. Development of better sampling methods and thresholds
ALFALFA	Weevils	1. Better understanding of current insecticide resistance levels 2. Strategies for improving integrated resistance management 3. Need for additional insecticide options
ALMONDS	Leaffooted bug	1. Develop seasonal phenology of leaffooted bug statewide to assess where to monitor, potential habitat modification opportunities, and life stage vulnerabilities 2. Complete development of monitoring traps to detect arrival into almond in early spring 3. Evaluation of new and experimental insecticides including biologicals and organic options in almonds (for example clothianidin and azadirachtin) especially in integrated programs 4. Determine the action or economic thresholds 5. Evaluate the options for border sprays, and attract-and-kill tactics

CROP	PEST	IMMEDIATE RESEARCH NEEDS
ALMONDS	Stink bugs	1. Develop seasonal phenology of stinkbugs and stinkbug parasite statewide to assess where to monitor, potential habitat modification opportunities, and life stage vulnerabilities 2. Monitoring traps to detect arrival of native stinkbugs and brown marmorated stink bug into almond 3. Evaluation of new and experimental insecticides including biological and organic options in almonds (for example, clothianidin and azadirachtin) including border spray and attract-and-kill tactics and in integrated programs 4. Determine the action or economic thresholds for brown marmorated stink bug and native stinkbugs 5. Determine if native and introduced beneficial insects significantly reduce stinkbug populations and damage
ASPARAGUS	European asparagus aphid	1. Efficacy trials for newer insecticides (flupyradifurone and sulfoxaflor label expansions in review at EPA/CalEPA) 2. Integration of softer insecticides with botanicals and microbials, especially considering application method, coverage and droplet size 3. Use of insectary plants; releasing beneficial insects with drones
ASPARAGUS	Garden symphylan	1. Better monitoring techniques; insecticide application delivery methods (chemigation, banded, etc) 2. Evaluate efficacy of biological products (Beauveria, Isaria) 3. Determine influence of tillage and irrigation frequency on populations 4. Determine efficacy of biofumigants and fumigant alternatives such as anaerobic soil disinfestation, solarization, and biosolarization
CITRUS	Sugar-feeding ants (Argentine and Native gray)	1. Develop effective ant bait and earwig system for commercial citrus 2. Evaluate the efficacy of conventional, biological, and organic insecticides against ants 3. Develop methods (hydrogel or otherwise) to make insecticides effective and economically feasible in citrus orchards 4. Nonchemical methods of Asian Citrus Psyllid control 5. Mating disruption for California red scale 4. Post harvest treatments to replace methyl bromide and eliminate in-field treatments for Asian citrus psyllid and fuller rose beetle
COLE CROPS	Cabbage maggot	1. Efficacy trials for newer insecticides; insecticide application delivery methods (chemigation, banded, etc) 2. Attractant lures for attract-and-kill of adults 3. Tillage impacts on crop residue and soil organic matter and influence populations

CROP	PEST	IMMEDIATE RESEARCH NEEDS
COTTON	Cotton aphid	1. Need for additional selective insecticide options 2. Better understanding of interaction between insecticides (including new) and biological control 3. Better understanding of interaction between coverage and efficacy to account for sub-optimal applications in the late season 4. Any research that mitigates the sticky cotton issue, even without altering pest populations
COTTON	Sweetpotato whitefly	1. Need for additional selective insecticide options 2. Better understanding of interaction between insecticides (including new) and biological control 3. Better understanding of interaction between coverage and efficacy to account for sub-optimal applications in the late season 4. Any research that mitigates the sticky cotton issue, even without altering pest populations
GRAPE	Mealybugs (Vine)	1. Need for additional selective insecticides, especially with international tolerances 2. Improved understanding of the role of generalist predators in regulating mealybug populations 3. Improved management of sugar-feeding ants that disruption biocontrol of mealybugs 4. Expedition of the registration review process for sulfoxaflor
GRAPE	Sugar-feeding ants (Argentine and native gray)	1. Development of effective, affordable ant baiting systems 2. Evaluate new methods of bait delivery, such as hydrogels, that allow the delivers of liquid baits through granular bait spreaders
ONIONS/GARLIC	Maggots	1. Evaluate in-furrow at-planting options in addition to seed treatment with spinosad, clothianidin, and microbial products 2. New product in IR-4 pipeline now
PEPPERMINT	Garden symphylans	Not an economic pest on California peppermint
PEPPERMINT	Mint root borer	1. Additional tools besides chlorantraniliprole in order to prevent insecticide resistance 2. Monitoring/thresholds for rhizome infestation levels
WALNUT	DPR permit conditions allows use for "Borers"	1. Determine the monitoring tools and ways to assess infestation 2. Develop seasonal phenology of the pest statewide to identify life stage vulnerabilities 3. Testing new and existing insecticides against flatheaded borer to look at time of application, efficacy, application rate, etc

Appendix 9: Summary of Comments from Public Roundtable Sessions on the Chlorpyrifos Alternatives Work Group

OVERVIEW

The Chlorpyrifos Alternatives Work Group shared an outline of its draft action plan with the public at three public roundtable sessions (in Fresno, Oxnard and Sacramento) in January of 2020. The goal of these meetings was to get input on the draft recommendations that the Work Group could incorporate into its final recommendations.

The meetings were open to all interested members of the public. Notification for the meetings was both through the Department of Pesticide Regulation's (DPR) communication channels (listservs, web) as well as through the networks of Workgroup members. Interpretation was available in Hmong, Mixteco and Spanish in Fresno, Mixteco and Spanish in Oxnard, and Spanish in Sacramento. Space was provided for children to work and play during the Fresno and Oxnard meetings. Light refreshments were offered.

The format of the meetings included an introductory presentation of the Workgroup recommendations followed by breakout group roundtable sessions. Each breakout group had both a host and a scribe whose role was to ensure each participant had an opportunity to speak if they wished.

Participants were asked to respond to three questions during the breakout session:

1. What suggestions or comments would you like to share about the draft recommendations?
2. Where do you see opportunities for farmers, workers, and communities to work together to increase the use of safer pest management practices?
3. Where would you like to see more research done or funding providing to create a more sustainable and healthy agricultural system?

The answers to these questions were captured on flipcharts (primarily in the speaker's original language, other times the simultaneous interpretation was summarized) and were transcribed (and if necessary translated) by DPR staff. This information was then synthesized into 12 general themes that arose from across the meetings.

CAVEATS TO THE INPUT AND THE THEMES

The participation in the public meetings was robust. Over the three meetings approximately 300 individuals attended and provided input. Because of the scale and format of the meetings, the data presented must be interpreted with these caveats:

- The transcription of input from the public necessarily abbreviated what was spoken. Only the essence of the speaker's comment was captured. While scribes were asked to check to ensure what was captured was accurate, the length of some of the comments received, the skill of the hosts and scribes, and the clarity of the speakers may have impacted the accuracy of some of the information captured.
- Significant input was collected in languages other than English. This also adds the potential for error in capture and in translation.
- The input captured reflects differing understandings about the intended scope of the Work Group's draft action plan. For example some participants expressed that the plan was too broad and others

that it was not broad enough. Because of this, the conversations during the sessions at times ranged beyond the scope of the draft plan.

- What is reflected below are 12 broad general themes. Themes are overarching messages that reflect common sentiments shared broadly by participants. For simplicity in reading, the themes are clustered in 5 general buckets.
- For each theme, representative quotes from participants were selected. These quotes represent comments expressed by at least two participants. Quotes have been edited for clarity.
- This summary does not include comments about the process of developing the plan. There were additional comments about the composition of the Work Group, and requests for further public input on future stages of the plan.

Themes

ON-FARM NEEDS

The plan for alternatives to chlorpyrifos needs to be robust and specific

- The plan is broad but has no near-term solutions. We need specifics – what alternatives are there, how much money will there be for research and adaptation.
- The plan needs a timetable and sequence for the recommendations, milestones, and deliverables to be able to adjust course.
- There are short-term needs that cannot wait 5 years – pest explosion risk – what impact (pests, crops) will be most affected. Need short list of priorities.
- Good recommendations, but out of sync. We need specific solutions, now.
- Provide a systematic plan to assist the growers with their pest control and cultural practices.
- What about chlorpyrifos disposal? What about the future? Need information now.

Growers need answers immediately for crops that are at risk

- Farmers are worried what they will do next – alternatives are a long process – hard to fast track pesticide regulation.
- Is the Work Group looking at emergency situations? i.e. invasive pests – need a regulatory mechanism – not seen in the draft plan – there are mechanisms but will they be available?
- A safety valve is needed where there is no alternative for a crop/ pest combination.
- The ban on chlorpyrifos will create a void of pest management options for some minor crops; this should be a big concern.

Some of the listed alternatives are not proven effective or sufficient

- There needs to be efficacy data tied to the alternatives to make the list worthwhile.
- What are the criteria for alternatives? Agriculture isn't simple – it is rare to have 1 to 1 effective replacements. Cost effectiveness is a concern.
- We need appropriate alternatives to address gaps. Chlorpyrifos was good for cross protection and longer lasting impact (14-day residual).
- Newer products have more narrow focus (1 pest vs 3) plus shorter impact (7-day residual). This could mean more spraying of chemicals. Some of the alternatives are worse for beneficial insects which could mean more pests (example: thrips kill spider mites) which again means more spraying.
- Most of the alternatives listed are not effective for certain pests.

PUBLIC AND WORKER HEALTH

The listed alternatives need to be screened for public and environmental health

- Will the alternatives also be dangerous to workers and the public?
- Near-term lists of alternatives need public health guard rails (e.g. developmental risk or carcinogens).
- Concern about hazards associated with alternatives – combine table of alternative practices with information on health effects to allow tiering.
- Define what we mean by "safe alternative" – define goal posts for an acceptable alternative (for example, neonicotinoids and bees).
- Consider other actions versus other active ingredients (i.e. 1,3-dichloropropene, Pyrethroids). Consider the cumulative impact. Process versus comparisons – look into future, and not just by active ingredient.
- Might face same issues with an alternative – Don't want to look at short term – focus on better practices/long-term - why are bio pesticides not on the readily available alternative list.

The health and safety needs of farmworkers needs to be part of the plan

- Need industrial hygienists involved in this process for worker protection. To be involved in every step of the way as we transition. Use array of comparative genomic hybridization (aCGH) biological monitoring methods to connect data from exposed farmers/workers.
- Need a health person to help the County Agricultural Commissioners.
- Provide education to the farmworkers. Education provided while workers on the clock and are being paid. Once they are educated, create a whistleblower protection.
- Accessibility to pesticide application safety information is not enough, have to include language access.
- Find a way to examine the health of those who have been exposed.

THE REGULATORY SYSTEM

The regulatory system needs to improve its review of emerging alternatives

- There are new registration processes in DPR that are extremely burdensome and prevent products from being available to growers. DPR says it should take 2 years to register a new product but it is longer and has gotten worse.
- Need a process for ensuring that alternatives are reviewed in a timely manner.
- The registration process is broken and there are many hurdles for registrants in California.
- It is expensive to register a product for a single crop and pest (for example small industries like persimmon-growers cannot afford this).
- The switch for safer alternatives needs to come from the top down (government regulators) rather than farmworkers and communities.

Enforcement of existing regulations needs to be strengthened

- Increase inspection and enforcement to ensure farmworkers are protected and aware.
- There is a disconnect in the rules versus the practices. It would be useful to have an established group that can do outreach to workers and peer to peer workgroups on personal protective equipment.
- Need to have a posting of the highest toxicity of all pesticides used, and enforcement of personal protective equipment regulations.

We need to strengthen notification and reporting systems

- Growers and local communities can work together. When growers let the community know when there will be a spray, there is more transparency and mutual benefit.

- The power of reporting: we should keep reporting and work together, report the information and learn about the consequences of exposure.
- There is a very short time for communication about pesticide drift.
- There should be comprehensive, accurate real-time reports on how much/what is being sprayed and when. The return entry interval needs to be communicated to workers.
- There needs to be a conversation on how to properly report misuse. Provide more access to reports for all workers and regular people.
- We are neighbors. Pesticide application should not take place in school hours.

INVESTMENTS NEEDED

We need long-term investment in research on topics ranging from pest management to human health and behavior change

- Consistent funding is needed for a long-term plan, on the scale of 50 years rather than 5 years.
- Research funding needs to focus more on the effect on the human body.
- More research is needed on costs and benefits of sustainable agriculture.
- More research is needed on effects of pesticides to environment.
- More funding for prevention/education/data collection from farm workers.
- Research is needed to support more effective outreach to farmworkers, growers and consumers.
- Long term research is needed to see if alternatives work. Need to research how things play out in the field, not just in laboratory settings.

We need to invest in improved agriculture systems and the infrastructure to support them

- Want to see bigger, broader change – need investment and technical support to work towards common ground.
- Funding is needed to grow the next generation of researchers, growers and pest control advisors.
- County crop advisors have not been replaced - funding is needed to sustain that model.
- Continued funding to support pest exclusion (border stations) and detection.
- More incentives and support to small farmers-they can be an example/leaders to the industry.
- Support farmers (to produce) and the community (for organic production consumption). This investment will benefit the public by reducing costs of health impacts from pesticides.

BUILD MORE UNDERSTANDING

We need to build more understanding between rural communities, growers, and consumers

- We need to create trust and bridge gaps between DPR and the environmental justice community. DPR should get people together.
- Pesticide use does not just affect the fieldworkers, it affects everyone. We all need to learn more about this.
- We need to understand each other's (researchers, farmers, health workers) perspective.
- County Agricultural Commissioners should bring groups together to interface with the growers, workers and community. Commissioners should have a representative that workers can call directly.
- Invest in community education. There is no understanding until someone in the family suffers.
- People need to understand the declining usage rates and why and where chlorpyrifos was being used.

- We need to communicate the robust regulatory system that we have, support understanding of enforcement practices, and share case study examples of how different pest management tools have worked.

CA needs a broader conversation around farming and pesticide use

- This is a lot of investment for a single pesticide, but it is not that different from other pesticides. Long-term investments should be broader than one active ingredient.
- Alternatives are not the solution – real goal to understand pesticides – concern to force an alternative – understand bigger picture.
- Changing systems is more than just chemical substitution. Big, broad change is needed. State can assist with procurement and markets.
- Need to build foundational health of farms rather than identify a replacement chemical. Take a systems approach and build up beneficial insect communities; it takes time for science to catch up.
- We need more long-term thinking. This seems "rushed". Chlorpyrifos is used a lot in CA – hear the need for a replacement but need to look at long term issues such as mono-cropping, etc.
- Dissolution of BIFS plus less money for UCANR was disappointing. Good to hear this may improve. Larger framework is needed in the pest management discussion. We need broader discussion, not just about chlorpyrifos (use was already declining).
- We should move towards a non-chemical approach long term – discussion of equality in food consumption is needed.

This document was prepared by Ag Innovations, a non-profit collaboration and facilitation organization hired to facilitate the Chlorpyrifos Alternatives Workgroup. 3/3/20.

Workgroup Members

CLIFF OHMART
Ohmart Consulting Services

DAVE LAWSON
Western Plant Health Association

DAVID HAVILAND
University of CA,
Ag and Natural Resources

DOUG DEVANEY
JG Boswell Company

GABRIELE LUDWIG
Almond Board of California

GREG SIMMONS
US Department of Agriculture

JIM CRANNEY
California Citrus Quality Council

JIM FARRAR
University of CA,
Integrated Pest Management

KENT DAANE
University of CA, Ag and Natural Resources

KIM HARLEY
University of CA,
Berkeley School of Public Health

LISA HERBERT
Sutter County Agricultural Commissioner

MARGARET REEVES
Pesticide Action Network North America

MICHAEL RETHWISCH
University of CA,
Ag and Natural Resources

NAYAMIN MARTINEZ
Central CA Environmental Justice Network

NICK FREY
Retired, Sonoma Winegrape Commission

PAM MARRONE
Marrone Bio Innovations

PAUL SQUIRES
Squires Ag Consulting, Inc.,
Pest Control Advisor

ROBERT HARRISON
University of CA San Francisco, Health

SARA SAVARY
Crop Care Associates, Inc,
Pest Control Advisor

SUGUET LOPEZ
Lideres Campesinas

Workgroup Advisors

Workgroup Advisors

KAREN MORRISON
CA Department of
Pesticide Regulation

JESSE CUEVAS
CA Department of
Pesticide Regulation

JOHN STEGGALL
CA Department
of Food and Agriculture

JULIE HENDERSON
CalEPA