# Securing Pollinator Health and Crop Protection:

## Communication and Adoption of Farm Management Techniques in Four Crops

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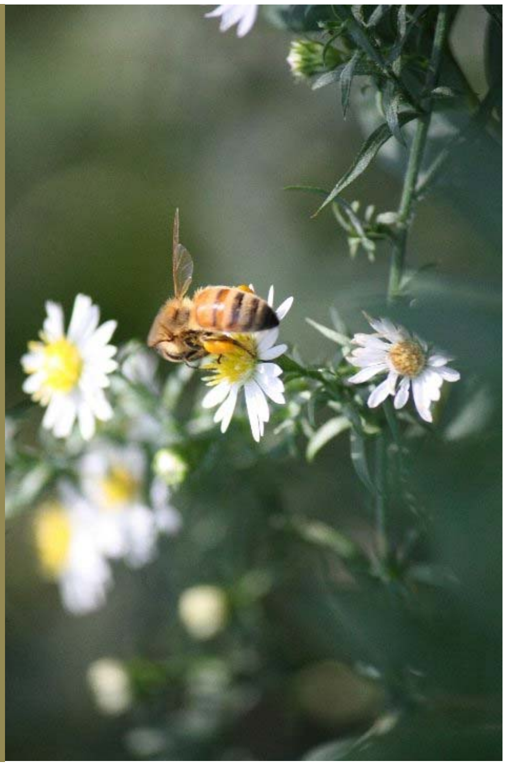


## Preface

Pesticides are tools available to farmers as they manage injury from pests; pesticides are powerful chemicals to be used with cause and extraordinary care under the guidance of well-established management protocols, and on a crop-by-crop basis. Pollinators are critical partners in agriculture and in the ecosystem services that keep the majority of flowering plants healthy. Best management practices (BMPs) in the use of crop protection tools can be designed to work to safeguard both pollinators and crop production. The development and implementation of multi-benefit BMPs combine careful analysis and balanced actions to accomplish both of those objectives. The best of these farm management techniques are based in science and guided by common sense. They demonstrate an appreciation for the needs of farmers and for pollinating animals, regardless of the pollinator's direct impact on the crop. Currently, as pollinator health has declined in several key areas, discussions and practices that consider both pollination and pesticide use and that are based on a scientific, practical, balanced approach have become extremely important.

This report does not examine effects or impacts of pesticides on pollinators, but provides a survey of existing training and practices available to mitigate exposure routes. The report also does not examine how effective these practices are in protecting pollinators. An evolving understanding of the impact of pesticides on pollinators is the source of considerable debate within the environmental and agricultural communities, often confounded by differences in evaluating exposure and in interpretation of laboratory vs. field testing and impacts to individual bees vs. impacts at the colony level. The sub-lethal effects of pesticides, and impacts on pollinator behavior, development, and reproduction, are also a part of this evolving knowledge. Further, from a beekeeper's perspective, any loss of colonies means an unacceptable reduction in current livelihood and the risk of unfulfilled obligations in the future. The welfare of unmanaged pollinators must also receive consideration. To address all needs, clear direction and balanced guidance are imperative.

Land-grant extension scientists have been working with farmers since the 1970's to establish Integrated Pest Management (IPM) practices that emphasize proper biological monitoring, use of predictive models and treatment thresholds to minimize uninformed and ill-timed pesticide use. It seems clear that the use of pesticides must be coupled with practices designed to mitigate exposure to non-target beneficial insects like pollinators. Pollinators have multiple routes of exposure to chemicals, and require the utmost consideration to mitigate exposures by those who accept the responsibility of pesticide use Yet, development of BMPs to mitigate harmful effects and the adoption and implementation of BMPs by farmers have not always been primary drivers in the decision-making process prior to engaging in management activities. As concerns for pollinator protection have become more pronounced in recent years, this dynamic is changing; and adoption and implementation of smart pollinator protections within pesticide use are being emphasized. It is in the farmer's and the beekeeper's best interest to seek and adopt these management techniques because their livelihoods are intertwined and co-dependent. In addition, for the farmer:

- Chemical tools at the farmer's disposal are formulated to be effective and safe only if label dosages, directions, and application rates are adhered to without fail. This has the potential to save time and money as well as protect pollinators.
- Overuse and misuse of any product can render it obsolete by encouraging resistance in the very pest or weed it seeks to eradicate. Keeping crop protection tools viable requires using them only when needed. Safe and effective use implies this sound judgment.
- Loss of crop protection tools is a reality when public opinion and confidence in chemical safety are compromised, even in a climate of scientific evidence on both sides of an issue.

It serves everyone's interest to create and instill a "pollinator ethic" in the application of crop protection tools; and that ethic is taking root, though unevenly and at inconsistent rates in different crops, as evidenced by the understanding gained by this report.

Though providing guidance for pesticide use has its historic basis in land grant universities and USDA extension agents, pesticide advice today is also offered by crop and pesticide consultants and pesticide manufacturers and dealers. The *main* issues in the consideration of pollinators in enacting management decisions (timing of application, choice of material, application technique, etc.) are consistent with a wise-use approach to chemical tools. This document is an effort to highlight the existing supports for best management practices in pollinator protection while seeking to expose gaps in understanding, learning, and action. Healthy and abundant pollinators contribute significantly to agriculture, and sound agriculture embraces the safety of pollinators in all cropping systems.

## Executive Summary

This report examines the presence and nature of actions and activities involving pesticide application that affect pollinator protection in three representative commercially-pollinated specialty crops (almonds, apples, and melons) and in one commodity crop (corn). The goal of this review is to understand the tools available to stakeholders in these cropping systems, understand the awareness of pollinator protection measures, and determine any barriers that might exist to adopting pollinator protection practices within a management framework. This report focuses on bees, both managed and wild, within or adjacent to each cropping system, and their interactions with applied pesticides and other pest management products.

The specialty crops reviewed here (almonds, apples, and melons) require pollination for fruit set, and routinely engage in pollination contracts with beekeepers. Within these systems we found frequent but inconsistent signs of a climate of understanding and concern for the protection of pollinators in pesticide application scenarios that might cause risk. Stated broadly, the best and most universal way to protect pollinators from harm in pesticide application scenarios is to avoid their contact with and exposure to pesticides. Each industry has a different approach to separating bees from pesticides. In some, like almonds, there is a need to manage the application of products that are used during bloom so that bees are not harmed. Hive placement, spray timing, and integrated pest management approaches are often employed to keep bees safe. Individual interpretations of how to reduce risk rely on the availability of technical information, alternative approaches, and the distribution networks that both promote ideas and work to support the development of new tools.

Consideration of pollinator protection in the commodity crop that is not pollinator dependent (corn) was less direct as producers do not integrate pollination contracts into their standard management strategies. As a result, their practices with respect to pollinators and pesticides are nascent and evolving.

Of the crops studied, almond systems have been the most rigorous in their regulated care for bee health; the intended use of pest management products must be registered at the county level with the agricultural commissioner. Product use is regulated throughout the year, with use during bloom and at such times when bees are in almond orchards generally prohibited by law and contracts. Fungicide is the main exception in this case due to the necessity of application during bloom in some almond regions. A narrow consensus on management activities is also employed in almond when pesticides are used, including the practice of night spraying and the application of products at temperatures below 55°F/13°C (when bees are usually not flying). Universally regulated management practices are possible in almonds because all production occurs in California and falls under the state regulation of chemical registration. Crops that are grown in multiple states, like apples, have a more varied set of regionally specific approaches to pollinator protection within pest management scenarios.

Apple production follows a similar set of pollinator protection guidelines to those employed in almonds, although registration of intended product use at the county level is not universal and not the norm. Apple production is also more varied by region and by cultivar. In this system, the product label is the predominant universal guide for pesticide application and pollination protection. Apple pollination contracts can involve a mix of honey bee and orchard bee services, which complicates applying pollinator protection actions derived from labels, as these are developed from honey bee standards.

Melon production relies less on formalized management protocol and instead uses long-standing industry knowledge handed down among growers who are keen to protect bee health and maintain good communication with beekeepers. Melon bloom occurs well after the occurrence of common pests that are managed with spray applications, which reduces the likelihood of direct interactions with bees. The adoption of pelletized seeds in melon production has also reduced the need for field applications of pesticides. Nevertheless, applications can occur during melon bloom and when bees are present in fields, in which case hive placement and drift avoidance are used.

Few pollinator protection provisions existed in corn planting prior to new research highlighting fugitive dust (drift of combinations of abraded seed coatings containing pesticides, seed planter lubricants and soil during planting) and subsequent off-site impacts to honey bees emerged. Bees do not play any role in the pollination of commodity crops such as corn and wheat, and only a limited role in commodity crops such as soy; but they are often found on nearby non-crop lands where these crops are grown. Field studies are underway to develop new products and targeted techniques in corn planting that would act to mitigate exposure of pollinators to pesticides from seed treatments.

In all of the crops examined, there are gaps in pollinator protection actions during pesticide application in non-bloom periods. While there is less concern for direct interactions between pollinators and pesticides outside of bloom, a lack of firm protocols during these periods increases the likelihood of pesticide-pollinator interactions. An example can be seen in treated seed planting in non-pollinated crops such as corn. Bee kill incidents were reported in 2008 in Germany that were associated with failed seed treatment sticking agents. In 2012 another set of bee kills was reported in Ontario, Canada associated with pesticide residues traveling in fugitive dust from corn planters. Actions relating to pollinator protection did not exist in corn seeding scenarios because both the practice (seeding) and the product (pesticide-treated seeds) are not managed in the same way that agricultural sprays are. Bee kill incidents from fugitive corn dust have resulted in the development of new products (lubricants and seed coatings) as well as draft recommendations in treated corn seed planting that include awareness of the non-target impacts on pollinators.

General information about the importance of pollinator protection in pesticide application and background information for on-farm pollinator management is available in a variety of formats including technical notes, general reviews, books on pollinator management, and regional guides for pest or crop management. The information contained in these resources, while accurate, is general. In the case of more comprehensive resources, pesticide management is found within chapters on pollinator biology, conservation of resources, or general farm management. These resources are more appropriate for educating and advising local agents or consultants and are not in a format that can be readily accessed and quickly understood in the field. A recommendation of this review is to produce a crop and region-specific set of guides that are compact, minimal in language, and convey the set of standard pollinator protection practices in the context of each crop and in each region if there are varied factors. Regionally-based crop-specific guidelines have a higher rate of use and adoption because they detail the specifics that each producer encounters in their crop production and are more effective in promoting the desired behavior.

In summary, the need to protect bees and to provide associated pollinator protection protocols exists in many crop systems. The dominant form of pollinator protection is the restriction of spray application to times of day when bees would not be likely to interact with blooms – non-bloom periods, late evening periods, and cool temperatures when bees are not active. These BMPs are strengthened when local product-use registration is required, as currently happens only in California and Arizona. Communication between growers, beekeepers, applicators, and others is also a key factor in protecting pollinators. Regional or county-level registration of both bees and product use can provide an information base that can help manage pollinator health and is especially useful in follow-ups and investigations when incidents to occur. There are identifiable gaps in BMP availably and awareness of formal protocols in crops that are less dependent on pollination contracts. Here again, county-level registration of pesticide plans would provide awareness and allow others managing pollinators or pollinator-dependent crops nearby to take precautions if needed.

Most formal practices and guidelines we encountered were written in English and presented in print or online formats. Presentation should be expanded to include both Spanish language and other languages common to growing regions (for example Russian and Chinese in the Central Valley of California), and should be developed in versions that address multiple learning modalities (video and audio) as this would increase accessibility to these guidelines and behaviors.

The majority of BMP sources emphasized protections for honey bees. Clearly this is not the only pollinator scenario in cropping systems; and protections for managed solitary bees, bumble bees, and wild pollinators need to be addressed.

As noted, across all crops there is room for technical improvement in guidelines for pollinator protection outside of bloom periods. It is our recommendation that activities promoting awareness of the need to promote pollinator health include season-long pollinator protection action development targeting specific crops, from seeding, into bloom, and through to harvest. The body of this report offers several more detailed recommendations and next steps to replicate successful programs and to fill gaps. These begin on page 63.

## Background

The health of honey bee (*Apis mellifera*) populations has received significant scientific attention due to their critical ecological and agricultural importance. Honey bees provide over $11 billion (Calderone 2009) in pollination services to the United States agricultural economy and are vital to keeping fruits, nuts, and vegetables in our diets. Recent threats to bee health and negative interactions with pesticide products have also brought pollinator health into the mainstream, solidifying the need to better manage agricultural systems with a focus on pollinators.

The United States Department of Agriculture (USDA), United States Environmental Protection Agency (EPA), and Pennsylvania State University conducted a National Stakeholders Conference on Honey Bee Health in October of 2012. Approximately 175 individuals participated, including beekeepers; scientists from industry, academia andgovernment; representatives from conservation groups, beekeeping, commodity groups and pesticide manufacturers; and government representatives from the U.S., Canada, and Europe.

Conference participants were assigned to one of four work groups to discuss areas associated with honey bee health, nutrition, pesticides, genetics, and arthropod and pathogen pests. A central theme throughout the pesticide working group session was the need for informed and coordinated communication, education, and extension to growers and beekeepers regarding the adoption of Best Management Practices (BMPs) to mitigate potential risk of pesticide use to bees and the need for effective collaboration between stakeholders.

Based upon this input, the USDA and the EPA have identified BMPs as an important component of the federal response to the declining health of insect pollinators and specifically the honey bee. BMPs, whether derived through consensus or supported through applied research, can be an important link between pollinator protection and crop production. With the identification and development of BMPs, the USDA and the EPA can engage in targeted efforts to broaden communication between beekeepers and farmers, and encourage the adoption of BMPs. Adoption of BMPs can yield tangible results in the protection of honey bee health and in ensuring their continuing contributions to food security in the U.S.

## Protecting Crops and Pollinators in Agricultural Systems

BMPs are often developed to achieve multiple goals in managed agricultural systems, including human and environmental health and safety; promoting marketable yield; minimizing off target movement of compounds; and protecting beneficial organisms while combating pests. The application of a pesticide product that can have a known negative impact on bees requires well-defined and communicable pollinator protection BMPs. The effectiveness of a pollinator protection BMP relies not only on the validity and accuracy of the recommended technique in mitigating exposure of bees to pesticide use, but on stakeholder knowledge of practices, proficiency with the technique, and commitment to BMP standards. A good BMP can fail when it is used incorrectly or when it is omitted due to a lack of stakeholder awareness, education, or buy-in. A BMP can also fail if its design is inconsistent with field-based application conditions, new techniques and products, or the ecological and economic conditions of particular agricultural systems.

This USDA-commissioned report aims to gather baseline information on pollinator protection and crop protection BMPs in order to identify the resources and actions needed to both protect pollinators and maintain viable and economic crop production. It is important to identify the currently available information on practices that protect pollinators. This knowledge will allow for:

1. understanding what practices have or have not been adopted and why;
2. organization and dissemination of this information; and
3. identification of new information or research that may be needed to promote crop protection and pollinator protection.

This program review examined BMPs in cropping systems where crop protection practices can interact with pollination services both directly and indirectly. The goals of this review included:

1. developing an annotated list of resources and BMPs relating to honey bee health and crop protection in pesticide usage scenarios;
2. examining the awareness of and availability of these BMPs within each stakeholder group;
3. determining the most commonly used BMPs by each stakeholder and in each system;
4. determining any gaps in BMP awareness, adoption, or use, as well as missing BMPs within each sector; and
5. recommending any needed BMPs, tools, or outreach programs.

## Pollination and Agricultural Economies

Animal pollination is required for nearly 80% of crop varieties (fruits, vegetables, and seeds) grown in the United States (McGregor 1976; Buchmann and Nabhan 1996). While acreages of crops that are not dependent on pollinators generally exceed those planted in dependent crops, the economic and nutritional value of pollinator-dependent crops is significant and translates to $15.2B in agricultural income using most recent estimates (Calderone 2009). Honey bees alone are estimated to contribute $11.68B (Calderone 2009), while native bees account for approximately $3.44B, although this number is more difficult to calculate directly (Calderone 2009; Losey and Vaughan 2003). Global economic support derived from insect pollination has been proposed to be as high as $217B (Gallai et al. 2008). Acreages of pollinator-dependent crops are increasing, meaning more demand for pollination services (Aizen et al. 2008). If pollinator populations, both managed and wild, were to decline, a similar decline could be expected in pollinator-dependent crops (Garibaldi et al. 2009); and this could significantly compromise yields, food security, and human health and nutrition. The ecosystem service benefits that pollination provides outside of agricultural economies are difficult to monetize, but essential nevertheless; and these would be threatened as well.

## Pollinators and Pesticides

The production of marketable crops involves crop enhancement and protection practices such as preventing damage from arthropods, pathogens, and weeds and can also include providing pollination services. Crops can be impacted by factors such as pathogens that include bacteria, fungi, mold, rot, rust, and other disease agents; competition for resources and nutrients with weeds; and attack from herbivorous insects and vertebrates throughout any part of the growing and fruit ripening period. Crop protection products have been developed to combat many, if not all, of these factors in order to protect marketable crops in an economically viable production system.

Beneficial insects, such as those that provide pest management or pollination services, have similar physiologies to many common insect pests, meaning that products intended to stop development or kill these pests may have the same actions on beneficial arthropods if they are exposed to them in harmful doses. BMPs are therefore developed to provide the best possible pest management solution with the least possible impact on pollinators or other non-target beneficial species. Proper application methods, doses, and climatic conditions are a fundamental aspect of these management-based protections.

The adverse effect that pesticide application can have on honey bee colony numbers has been recorded as far back as the early 1900s when the common practice of spraying fruit trees with arsenic was noted as one reason why honey bee colony numbers in California were declining (Voorhies et al., 1933). Agricultural sprays used widely in the 1960s and 1970s were particularly hard on honey bees. Records indicate a 48% drop in colony numbers in Arizona between 1963 and 1977 that was attributed to pesticide-mediated bee kills (vanEngelessdorp and Meixner 2010). California records between 1962 and 1972 show an average loss of 62,500 colonies a year (~11.5%) from pesticide poisoning (vanEngelessdorp and Meixner 2010).

Product registration, toxicity testing, and product regulation are in place to protect honey bees and other pollinators from the negative effects of pesticides and chemicals used in the agricultural sector. In the US the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) requires the testing and registration of products. Currently, EPA determines a pesticide’s toxicity to bees by the dose that causes death of bees and the length of time the pesticide can affect bees after it has been applied.

Toxicity is determined through a combination of lab and field tests that use established EPA protocols. The Honey Bee Acute Contact $LD_{50}$ determines the amount of pesticide that kills 50% of a test group of bees (EPA OCSPP 850.3020 2012). Extended Residual Toxicity determines the amount of time that pesticide residues on leaves remain toxic to honey bees using a lab test (EPA OCSPP 850.3030 2012). Field-testing of products on pollinators may also be required if the first two tests indicate adverse effects on bees (EPA OCSPP 850.3040 2012). Currently pesticides are tested for their toxicity to honey bees and not on other managed and wild pollinators (bumble bees, orchard bees, mason bees, sweat bees, alkali bees, etc.).

Categories of toxicity are determined for all registered products and carry associated warnings if they are harmful to honey bees. If the $LD_{50}$ of the pesticide is greater than 11 micrograms per honey bee (Toxicity Group III), it is relatively nontoxic; and no bee caution statement is required on the label. If the $LD_{50}$ is less than 11 but greater than 2 micrograms per honey bee, it is classified as Toxicity Category II, “toxic to bees.” If the $LD_{50}$ is less than or equal to 2 micrograms per honey bee, it is classified as Toxicity Category I, “highly toxic to bees.” (EPA OCSPP 850.3020 2012).

Because of guidelines and regulation on product use, large-scale honey bee deaths are uncommon in developed countries, especially in recent years. Nevertheless incidents where large quantities of bees are killed by pesticides do occur and suggest a misuse of a product, system, or management protocol.

### Sub Lethal and Non-Adult Effects

When pollinators are exposed to a pesticide with a bee hazard warning mortality is possible and is associated with the dosage encountered. Sub lethal and non-adult (varying instar) effects are also possible, including delayed or reduced egg laying; delayed, arrested, or irregular larval development; colony or brood size reductions; and behavioral or cognitive impacts. Reductions in the size of pollinator populations or their pollination function can significantly impact the productivity and viability of cropping systems.

Pollinators, and bees in particular, have intimate relationships with flowers that make them particularly susceptible to unintended and non-target impacts of pesticide products that are applied to or drift onto blooms. *Insecticides* are potentially the most toxic to pollinators because most pollinators are insects. *Herbicides* do not normally harm pollinators directly, but pollinators may be indirectly harmed when herbicides destroy flowers that serve as a food source. There may be some other adverse effects to normal function and development. *Fungicides* are thought to be non-toxic to pollinators, but could potentially impact pollinators by contaminating their food sources. The impacts of chemical contamination in honey bee hives from herbicides and fungicides have also been shown to correlate with high susceptibility to disease, and in some cases modified behaviors (Pettis et al. 2013). Fungicide contamination of bee bread has been shown reduce nutritional value, compromising the development of brood (Yoder et al. 2013). *Nematicides* and *miticides* are toxic to insect pollinators in varying degrees. Miticides are applied to crops in the field to prevent damage from mites, but are also used in the hive by beekeepers to combat *Varroa* mite (*Varroa destructor*) even though they can impact bee health (Boncristiani et al. 2011). *Rodenticides* may be toxic to vertebrate pollinators such as bats and birds; the interactions of these pollinators with this class of pesticide can occur when they are distributed in pelletized form on the ground or dispensed in the field.

Pollinators come in contact with pesticide products that can impact their health through direct and indirect exposure routes. Understanding how each pathway might interact with pollinator biology is important in regulating products, determining label requirements, and developing BMP techniques. Among the pollinators, bees have a high likelihood of being impacted by pesticides because of their pollen and nectar collection and storage biology.

Solitary and social bees have different responses and interactions with contaminants in the environment; and understanding their individual biologies is also important in developing, implementing, and reviewing BMPs. Solitary bees and social bees may have similar physiological responses to interactions with chemical contamination; however, social, mass foraging species can bring greater quantities of contaminated product back into colonies. Wild pollinators and managed pollinators will also have some differences in their scope of interactions with pesticides due to several factors, including timing and range of foraging flights; body size and physiology; feeding preferences and strategies; nesting and hive locations; and reproduction and brood rearing differences. Managed honey bees have a high likelihood of interacting with pesticides as they are placed in conventional agricultural settings where multiple exposure pathways are possible.

## Pesticide Exposure Pathways

Bees and other pollinators can be exposed to a pesticide product through direct contact, ingestion, or a combination of both. Multiple pathways and circumstances can cause bees to come in contact with a pesticide.

Direct exposure pathways include:

- Direct spray of foraging bees or colonies.
- Application of pesticides onto bloom and subsequent direct contact with bees foraging on bloom.

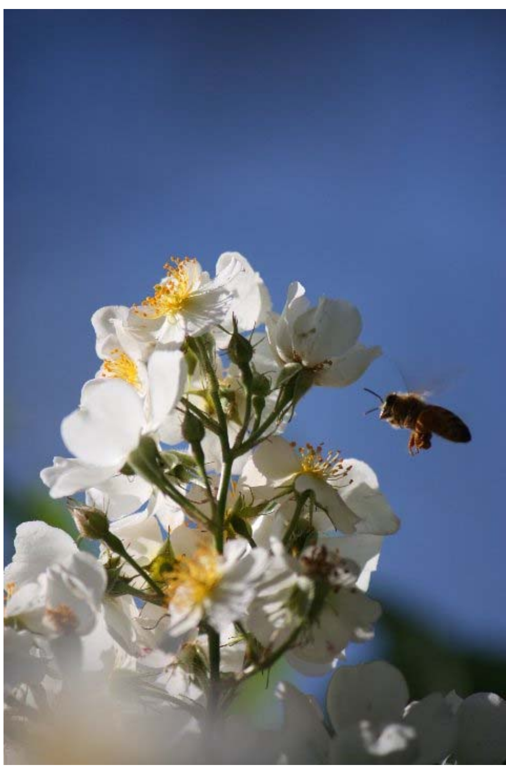
Indirect exposure pathways include:

- Drift of pesticides onto adjoining crops or plants that are in bloom.
- Contamination of flowering ground cover plants when sprayed with pesticides.
- Movement of systemic pesticides into pollen, nectar, and guttation fluid.
- Contamination of water sources used by pollinators.

## Industry Acceptance of Best Management Practices

Certain ideas and topics can be rejected by their target audience based on preconceptions. Use of the term Best Management Practices (BMPs) can create adoption problems in the agricultural community as many producers find the term to carry restrictive and regulatory requirements. All too often receptive audiences shut down when they are presented with a BMP. While we refer to this term throughout this report we recommend a renaming of pollinator and crop protection BMPs to increase acceptance and suggest "integrated crop management", "good agricultural practices", or "sustainable use guidelines" as possible substitutions.

Behavior change and the adoption of new practices take time. Innovations and novelties, no matter how logical or correct, gain momentum from adoption by innovators and other early adopters before the general public engages these ideas. In all cases there are laggards that will be the last to change their practice (Rogers 2003). Rogers' *Diffusion of Innovation* theory shows that there is logistic growth in the market share of any new innovation into existing practice or program (Rogers 2003); the adoption of BMPs that support pollinator health within pesticide application scenarios will logically follow this trend.  Studies of Integrated Pest Management (IPM) adoption throughout California verify this pattern and indicated lag times of 5 years or more before majority acceptance of new, less environmentally toxic, practices for the management of San Jose Scale, even with a broad outreach and education program offered by UC IPM (Brodt et al. 2004a).  This was also the case in the popularization of the threshold damage approach to pesticide application.  Today, pest population models, degree day calculations, and damage thresholds are used almost universally.  Increasing the speed of innovation adoption will involve seeking out innovators and early adopters of pollinator protection practice and using these individuals as ambassadors of programs and protocols.



## Research Methods

*Database and Web-based resource searches*

We aggregated resources available to growers, university cooperative extension, county extension agents, crop advisors, industry groups, beekeepers, and other relevant stakeholders using a combination of methods that we would expect these stakeholders to employ in resource searches. We conducted a search of available online resources through a general world wide web search using keywords *pollinator, bee, bees* + *pesticide*, *protection, best management, guidelines* and either *almond, apple, corn,* or *melon*. A literature search for peer-reviewed books, guidelines, and publications was also conducted using the Web of Science and BIOSIS with the same key words.

The available web resources presented by each regional IPM Center (North Central, Northeastern, Southern, and Western) reflecting common crops grown in each region were reviewed and accessed. A subsequent web search of resources available at land grant universities in states that commonly grow large quantities of each crop was conducted. Resources provided by individual specialty crop and commodity crop organizations were also reviewed as were those produced by beekeeping organizations and other NGOs.

As resources were collected they were reviewed and examined for their level of detail, scientific and technical accuracy, and validity. We categorized resources as *general pollinator protection or biology* pieces, or as more *specific guidelines* and *management protocols* for pesticide use scenarios in each crop.

*Stakeholder Surveys and Interviews*

P2 held an initial working session engaging members of the North American Pollinator Protection Campaign (NAPPC) Pesticide Task Force to guide survey question development and determine the areas of BMPs development, distribution, and implementation that required initial investigation. P2 staff attended five specialty crop and commodity crop meetings, including the American Seed Trade Association (ASTA) Corn and Soybean Expo (December 2013, Chicago, IL); the ASTA Vegetable Seed and Flower meeting (January 2014, Monterey, CA); Western Orchard Pest and Disease Management annual meeting (January 2014, Portland, OR); Colusa Almond Day (February 2014, Colusa, CA); and the annual meeting of the Almond Board of California (January 2014, Modesto, CA – via teleconference).

Specific stakeholder surveys were designed for two separate stakeholder groups identified by early project work. Questions were developed for individuals advising on crop protection and separate questions were developed for producers. Detailed notes were also taken on general information provided by the interviewee relevant to understanding pollinator protection and pest management in each crop. Sixteen different stakeholders were interviewed either individually or in group settings. All responses were kept anonymous for the purposes of this report. Individuals who were willing to continue conversations on BMPs are listed as project contacts and resources in the back of this report.

*Surveys Questions:*

For Agents/Advisors

1. Do you ever have producers requesting pollinator protection information?  If so, what is their main question?
2. Do you consider pollinator protection when advising crop protection?
3. What pests are you commonly targeting during the bloom?
4. What flowers and/or weeds are present when you target pests?
5. What products, guidelines, and resources are you familiar with that speak to how to protect pollinators in pest management systems?  What is the strongest resource you've seen and why?
6. What additional resource information would you find useful?

For Producers

1. What relationship do bees have with your crop?
2. Are you doing anything in your production practices to protect bees?  If so, what are you doing?  If nothing, why?
3. Where do you get your crop and bee protection information?  What resource do you use?
4. Have you contacted local USDA or Extension Offices regarding pest management and pollinator protection?
5. What additional resource information would you find useful?

We conducted a series of stakeholder surveys and interviews with producers and advisers at the events listed previously to gauge understanding and awareness of issues, resources, resource availability, and attitudes toward BMPs and pollinator protection.  Follow-up phone calls were also used to access additional information and to further investigate answers provided by some of the interviewed stakeholders.

*BMPs Assessment and Gap Analysis*

We reviewed the content and delivery method of each BMP available.  From this review we have highlighted key resources and proficient distribution networks.  We provide an assessment of missing BMPs and suggested next steps in research and outreach.  We have also examined potential barriers that might prevent the development or implementation of BMPs in each cropping system reviewed.

## Current Status of Crop Protection and Pollinators

- Almonds
- Apples
- Melons
- Corn

## Almonds

### Production and Economics

California accounts for one third of the world's almond production, with Australia and a few Mediterranean countries providing the rest. The California almond industry has been on a steady rise since 2000 when the state produced about 1B shelled pounds of almonds. Production has doubled in the last decade and was around 2B pounds of shelled almonds in 2013. Presently, more than 6000 growers produce almonds on 800,000 acres in the Central Valley across 16 counties.

Many common almond varieties are grown in California including Nonpareli, Carmel, Butte, Padre, Mission, Monterey, Sonora, Fritz, Peerless, and Price. The average U.S. market value for almonds was $2.20 a pound in 2012 and $2.50 a pound in 2013, with small differences in price seen between varietal. The current average production cost to almond growers is around $1.79 a pound (USDA – NASS 2013).

### Key Pollinators

Almond trees require extensive pollination for seed and fruit development. Honey bees (*Apis mellifera*) are the main pollinator, and most producers depend on renting hives from beekeepers to achieve full crop yield. Pollination occurs in late February through to early March. The Nonpareli varietal is one of the first to bloom, and the Mission varietal is one of the last to bloom. A typical orchard will have three almond varieties to provide maximum cross-pollination, a requirement for fertilization. Native bee species can also be good pollinators of almond, but the large acreages planted in California and early bloom make providing pollination services with non-*Apis* bees a challenge.

Almonds are a fully pollinator-dependent crop. Their vast acreage and narrow bloom period require large numbers of bee colonies within a narrow pollination window to ensure adequate yields and to keep the industry viable. Nearly 70% of the bee colonies in the United States migrate to California for almond pollination contracts each year. Pollination contracts in almond are commonly arranged through bee brokerages. A sophisticated supply and demand network determines hive rental prices, minimum colony size, and stocking rates in orchards.

Honey bees commonly arrive in California in advance of bloom and are placed in orchards waiting the maturation of blooms.

Seed and fruit development occurs from March to June, hull splitting occurring from July to early August. Almond harvest occurs from mid-August to October and is conducted by mechanically shaking trees to release dry fruits into a harvester or onto the orchard floor where they are then mechanically picked up with another specialized harvester.

## Pests and Pesticides

Almond orchards are targeted by a handful of insect and animal pests and by many more fungal diseases. Pest and disease treatments vary seasonally with bloom and post bloom period being the most active. Some of the most aggressive and abundant pests during this period are navel orangeworm (*Amyelois transitella*), oriental fruit moth (*Grapholitha molesta*), peach twig borer (*Anarsia lineatella*), and San Jose scale (*Quadraspidiotus perniciosus*). Fungal diseases during bloom include brown rot (*Monilinia fructicola*), almond scab (*Cladosporium carpophilum*), shothole (Wilsonomyces carpophilus), rust (*Tranzchelia discolor*), alternaria (*Alternaria* spp.), and hull rot (*Rhizopus stolonifer* and *Monilinia* spp.). Navel orangeworm is the key almond pest. Because bees are most active at the time of year when pest management is critical, careful consideration is needed when planning control tactics, especially considering bloom occurs at different times for different varietals. Almonds grown in the southern portion of the growing range in California are also under heavy drought stress due to low precipitation and irrigation restrictions. Drought conditions can complicate pest management by increasing stress on crops. Bees pollinating in drought conditions can also be under stress, further complicating and perhaps elevating the potential for negative interactions with pesticides.

## Available Information and Management Guidelines

*Key Developers of Actions and Guidelines*

In almond production, the usage guidelines provided by pesticide product labels provide a minimum standard; industry-driven guidelines are extensively used and often go beyond those set forth by the EPA. BMPs for pollinator protection in almonds are developed in large part through research programs funded either through government or through industry support. For example, the Almond Board of California (http://www.almonds.com) provides support to test product efficacy and application timing, develops guidelines and promotes of cultural practices, and investigates enhancements to almond production that can be gained with IPM and other coordinated management. Land grant universities (in particular the University of California system) and the Almond Board conduct a significant amount of product testing and technical development and have focused heavily on developing products and standards that improve honey bee health and subsequent pollination services.

Government support for the testing and development of BMPs has come in the form of Specialty Crop Block Grants that have been awarded to academic institutions, trade organizations, and non-profits within California to study almond pest management and bee health. Beekeepers working in almond pollination often have their entire stock invested, and as such are very active in developing and promoting guidelines that protect the health of bee and their industry. Locally, the California State Beekeepers Association (CBSA - http://www.californiastatebeekeepers.com/) is involved in supporting the development of pollinator protection BMPs and guidelines for beekeepers to follow. The CBSA serves as a distributor of relevant material to beekeepers as well as almond growers.

The development of BMPs in almond also includes supporting distribution networks and programs that connect growers, industry representatives, regulators, and beekeepers. The Almond Pest Management Alliance, a cooperative group that includes the Almond Board of California and their Environmental Committee, University of California Farm Advisors, Area IPM Advisors, the California Department of Pesticide Regulation, and United States EPA Region 9, works to cooperatively develop guidelines on responsible pest management in almonds (http://cesanjoaquin.ucanr.edu/Almonds_/Almond_Pest_Management_Alliance_PMA).

*Key Distributors of Material*

The management and cultivation of almonds in California is a sophisticated and insular system. Crop protection and pollinator protection are synonymous in this industry. The almond industry and relevant trade organizations provide the majority of information relating to protecting pollinators from harm when performing standard cultivation practices. Trade organizations, and in particular the Almond Board working with NGO Project Apis m., are key providers of BMPs for pollinator protection in almond. The California State Beekeepers Association, and other locally specific beekeeping associations, repost and redistribute this information for their members, keeping both growers and beekeepers informed.

There is a long history of research and innovation in California almond growing as this crop is unique to California. UC IPM has played a significant role in general pest management outreach and education. Outreach to the almond industry has been well-received and resulted in high rates of practice adoption over time. For example, UC IPM initiatives such as the implementation of monitoring and damage thresholds resulted in a reduction in organophosphate between 1989 and 1999 (Brodt et al. 2004b).

Certified Pest Control Advisers (CPCAs or PCAs) practice in California, and the majority of almond growers (97%) make use of their services when determining treatment options, with nearly 80% implementing the proposed practices for insect pest control (Brodt et al. 2004a). This trend was seen commonly throughout the northern and southern growing regions. A critique of PCAs is that many are affiliated with manufactures and promote specific product use. Growers that worked with independent PCAs (20%) were found to be more likely to use cultural control such as field sanitation and mowing in lieu of chemical products for pests control, and were also more likely to monitor using thresholds (Brodt et al. 2004a). PCAs are more common in almond operations than in other orchard and specialty crops in California. Because PCAs provide a direct link to easy and universal behavior change and new innovations adoptions, they are good partners in education and can be a vector for enhancing BMP adoption and pest management innovations in this and other systems.

Available BMP resources include current bulletins, newsletters, technical notes, original peer-reviewed research papers, synthesis publications, and listings of other comprehensive sources. The Almond Board maintains an updated website for growers and has a page dedicated to pollinators and pesticides that contains current practice, guidelines, and issues (http://almondboard.com/Growers/orchardmanagement/Pollination/Pages/Default.aspx). A recent addition to the outreach spectrum includes the Bee-Active resource page (http://www.almonds.com/consumers/about-almonds/bees) that targets the general public and provides information on almond pollination and what almond growers are doing to protect honey bee health.

In addition to providing clear guidelines for products known to be pollinator-toxic and labeled as such, the Almond Board provides information on managing the use of products that do not carry bee hazard labels but that research and field experience have shown can be toxic to bees. The Almond Board's monthly newsletter *Almond Outlook* commonly includes specific information on bee management and issues. Frequent radio and agricultural news updates provide current information to growers and the community around almonds.

*Key Resources Examined*

Almond Outlook - The Almond Board of California. 2014. Available at: http://almondboard.com/Growers/Pages/Default.aspx. - **Newsletter**

> This 12-issue newsletter is produced by The Almond Board of California monthly and provides information to growers and handlers in the almond industry. The January issue of Almond Outlook commonly includes information on "bloom caution" as this corresponds to the time when growers begin to have honey bees present in or near their fields. In November and December reminders and primers on pollination contracts are included and spring issues (following almond pollination) include updates on contracts or issues that arose in the current pollination year. This form of recurring information provides continuous issue awareness. Specific pest and crop protection articles and event information can be accessed and are archived online.

Best Management Practices Using Insecticides During Bloom and Honey Bee Brood - Curtis B and G Ludwig. 2013.Available at: http://www.almondboard.com/Growers/Documents/Pollination%20Website%202013%20Review-BMPractices%20Using%20Insecticides%20During%20Bloom%20and%20Honey%20Bee%20Brood.Curtis-Ludwig.2-1-13.pdf– **Technical Note**

> This Almond Board of California resource outlines new information and provides an overview of BMPs for insecticide applications during bloom to minimize possible impact on honey bee brood. New findings

suggest certain insecticides can affect developing honey bee larvae. Cautions to avoid tank mixes and other pre-mixed products that are approved for use during bloom, but provide potential hazards to bees, are included.

Best Management Practices for Beekeepers Pollinating California's Agricultural Crops - Heintz et al. 2011. Available at: http://projectapism.org/wp-content/uploads/2013/10/CAPArticleMarch20112.pdf. – **Technical Note**

Project Apis m. and Coordinated Agricultural Project collaborated to create this BMP for that outlines the best ways to promote bee nutrition including bee pests like the *Varroa* mite. This resource details hive maintenance and grower-beekeeper interactions with an emphasis on communication when seeking to protect bees from harm in pest management applications. Pollination contracts and application timing are stressed. Avoiding tank mixes is also recommended. Draft contracts for growers are also available.

BMPs for Almond Growers - Project Apis m. BMPs for Almond Growers: eLearning module. Available at: http://projectapism.org/?page_id=231. – **Technical Note/Educational Module**

This resource is in the form of a power point presentation that outlines how almond growers should approach pollination contracts and communication with beekeepers in order to preserve bee health. Background information on pollinator biology and pesticide interactions is provided. Strict BMPs are not outlined in detail but avoiding spraying when bees are active is mentioned.

How to Reduce Bee Poisoning from Pesticides - Hooven et al. 2013. Available at: http://wasba.org/how-to-reduce-bee-poisoning-from-pesticides-pnw-591/ – **Booklet/Guide**

This document provides a brief background on the biology of pollinators and cautions those applying pesticides in orchard systems to read the product label as the primary BMP. Background information and general information on how to protect bees in pesticide application scenarios is provided as it relates to all orchard crops and includes ways to prevent harm to managed honey bees, managed orchard bees, managed and wild bumble bees, and other wild bees. The booklet also provides contact information on state-specific pesticide application guidelines and bee registries. This robust resource is extensive in coverage but does not provide many crop-specific guidelines.

Honey Bees and Agricultural Sprays - Mussen E. 2014. Available at: http://www.almondboard.com/Growers/Documents/Bee-Protection.pdf – **Technical Note**

This article explores the potential risks and possible poisoning of honey bees by a range of common agricultural sprays (insecticides, herbicides, and fungicides). Products are mentioned by name and formulation. Examining bee forage (in nearby locations) is important in evaluating the full set of risks associated with pesticide use and pollinator protection.

Pest Management - Almond Board of California. 2014. Available at: http://www.almondboard.com/Growers/OrchardManagement/PestManagement/Pages/Default.aspx – **Technical Note**

This pest management resource helps growers to manage pests for healthy orchards. There are additional links to management details for 1) insects and mites, 2) soil-borne pests, 3) soil fumigation, and 4) diseases. The detailed of each pest management system are outlined and a general statement on protecting and promoting the health of bees is included. Key points promoted include:

- Monitor both pest and beneficial insects and mites and spray only when treatments are necessary
- Do not treat for pests as long as populations remain below economic thresholds
- Use effective, environmentally friendly and less toxic materials whenever possible
- Use cultural and biological controls rather than pesticides whenever possible
- Avoid broad-spectrum insecticides unless pests exceed treatment thresholds and effective environmentally friendly insecticides are not available

Pollination Pages - The Almond Board of California. 2014. Available at: http://almondboard.com/Growers/orchardmanagement/Pollination/Pages/Default.aspx. – **Web Resource**

The Almond Board of California has developed this general overview of pollination showing the importance of bloom and full pollination in a successful almond harvest. The resource highlights the importance of beekeepers from not only California but the rest of the United States in pollination contracts for almonds. A series of links to other relevant resources and BMPs is also presented on this site that is maintained and updated annually.

Seasonal Guide to Environmentally Responsible Pest Management Practices in Almonds - Pickel et al. 2014. University of California Agriculture and Natural Resources Leaflet 21619: Pp 1-8 http://anrcatalog.ucdavis.edu/pdf/21619.pdf. – **Booklet/Guide**

This publication is a general resource to help almond growers make environmentally conscious decisions when considering pest management. Its contents are outlined by dormant, bloom/post-bloom, in-season, harvest and post-harvest stages of development. It describes the differences in pest concerns throughout the year.

The Bee Box - Heintz, C., Ribotto, M. 2013. Available at: http://projectapism.org/wp-content/uploads/2013/12/The-Bee-Box-2013-12-scan.pdf. – **Technical Note**

The Bee Box is a bi-monthly honey bee newsletter that informs about current bee issues produced by Project Apis m. A recent volume from November/December, 2013 highlighted the “largest pollination event in the world” – Almond Pollination in California. This issue gives tips on hive placement, spraying, and pollination contracts, all of which are to ensure bee nutrition and safety. Writers of this piece stress the overall risk reduction to honey bees whenever possible.

## Stakeholder Knowledge of Resources

Our conversations with members of the almond-growing community, beekeepers, and Crop Certified Advisors (CCA) or Certified Pest Advisors (CPA) showed a strong awareness of the role that pollinators play almond systems and that there are broad set of the BMPs used to protect pollinators. With approximately 70% of the honey bee colonies in the United States coming into California for almond pollination in February, the industry is aware of the need to preserve pollinator health and has developed many BMPs that target complete management of honey bee services (from arrival at California agricultural inspection stations, to feeding prior to and post pollination). All individuals and representatives from the almond industry who were interviewed in this report were highly aware of the importance of honey bees in pollination, their potential interactions with pesticides, and the need to take precautions to ensure pollinator protection when applying products.

Beekeepers and bee brokers have developed contractual guidelines to ensure pollinator health when honey bees are placed in almonds for pollination services. A no-spray clause is enforced when hives are present in orchards, with the exception of fungicides that are applied during bloom. In California, the County Agriculture Commissioner must sign off on the use of all chemical treatments. Once approved this list is made available to beekeepers for review. In this manner a product that is not pre-registered cannot be used unless special permission is granted, and there is transparency in the pest management actions in the field. A beekeeper has the opportunity to contest the use of any product he or she feels will negatively impact bees. In addition to these strict guidelines, there are fines if these processes are violated.

Attention is also given to non-toxic agricultural sprays that might interact with honey bees during pollination. Products that do not carry a bee hazard warning may still have negative non-target effects on bees. For example, an insect growth regulator (IGR) that is applied during bloom has no toxicity to adult bees, but if brought back to the hive can impact larval and queen development. IGRs can be mixed in with fungicides that are applied using pre-formulated mixes. These products would not carry a bee hazard warning, but precautions against their use have been promoted in the almond industry because of the significant downstream effect this can have on bee health and subsequent pollination contracts.

There is ample knowledge and desire to go above and beyond current EPA label instructions with BMPs to ensure that no harm is done to honey bees in almonds. This promotes a precautionary approach to the use of any product that might impact or interact with bees. Almond pollination and pest management strategies are the most developed of any industry examined in this report. Multiple players have taken lead roles in managing for pollinator health in almonds as this is a major component of a successful and viable industry. The overarching awareness and acceptance of pollinator conservation techniques also relates to the bottom-up, internal development of many practices, rather than a top-down regulatory approach. Regulations do exist, but the industry has been involved in their development.

## Catalogue of Pollinator Protection Mechanisms

| Practices<br><br>Items highlighted in **green** indicate the practice is commonly promoted across the industry.<br><br>Items highlighted in **grey** indicate the practice is not mentioned or missing. | Almond Board of California, 2014 Pest Management Guidelines | Almond Outlook: January 2014 | Best Management Practices Using Insecticides During Bloom and Honey Bee Brood | CDFA - California policies for bee protection and hive management | Honey Bees and Agricultural Sprays | How to Reduce Bee Poisoning from Pesticides: Pacific Northwest Extension publication PNW591 | Project Apis M. Bee Box, Nov/Dec 2013 | Project Apis m. BMPs for Almond Growers: eLearning module | Project Apis m. Managed Pollinator Coordinated Agricultural Project | Relationships of Honey Bees and Pesticides: Eric Mussen and Gene Brandi | Seasonal Guide to Environmentally Responsible Pest Management Practices in Almonds | The Almond Board of California, Pollination Pages - orchard management | UC Apiaries: Pesticides and Honey bees. | UC IPM Almond | UC IPM Fungicides, bactericides, and biologicals for deciduous tree fruit, nut, strawberry, and vine crops |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Background** | | | | | | | | | | | | | | | |
| guidelines to protect *Apis mellifera* | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x |
| guidelines to protect other native bees | | | | | | x | | | | | | | | | |
| crop specific pollinator protection guidelines present (almond) | x | x | x | | x | | x | x | x | | x | x | | x | |
| outreach materials for growers | x | x | x | | x | x | x | x | x | | x | x | | | |
| outreach materials for applicators | | | | | | x | | | | | | | | | |
| background on product use, effectiveness, and hazards | | | x | | x | | | | | | | | | | x |
| understanding pollinator biology and habitat | | | x | | x | x | | | x | x | x | | x | | |
| regional/statewide integrated plans present | | | | x | | | | | | | | | | | |



POLLINATOR PARTNERSHIP

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Pre-Application** | | | | | | | | | | | | | | | |
| bee hive registration | | | | x | | | | x | | | | | | | |
| pest/damage threshold used for spray decision-making | x | | | | | x | x | | | | x | | | | |
| choose a product with the lowest toxicity possible | | | | | | | | | | | | | | | x |
| product use registration with county ag commissioner | | | | x | | | | | | | | | | | |
| formal pollination contract with bee protection clause | | x | | | x | x | x | x | x | | | x | | | |
| provide notice of application and list of intended products to beekeeper | | x | | x | | x | x | x | x | | | | | | |
| avoid tank mixing | | x | x | | | x | x | | x | | | | | | |
| control bloom on non-target areas | | x | | | | x | | | | | | | | | |
| **Application** | | | | | | | | | | | | | | | |
| drift prevention - avoiding wind | | | | | x | x | x | x | x | | | | | | |
| drift prevention - low drift equipment | | | | | | | | | | | | | | | |
| avoid damp/dewy conditions | | | | | x | x | | | | | | | | | |
| apply when bees are not active | | x | | | x | | x | x | x | | | | | | x |



POLLINATOR PARTNERSHIP

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Application - continued** | | | | | | | | | | | | | | | |
| apply at night | | x | | | x | | x | x | x | | | | x | | |
| spraying below 55°F/13°C | | | | | x | | | | | | | | | | x |
| avoid spraying during pollen production | | | x | | | | x | x | x | | | | x | | |
| avoid spraying during bloom on crop | x | x | | | | | | x | | | | | x | | x |
| guidelines for bloom in adjacent fields | | | | | | | | | | | | | | | |
| know properties of pesticide - effectiveness | | | | | | | | | | | x | | | x | x |
| know properties of pesticide - bee toxicity ratings | | | | | | | | | | x | | | | x | x |
| non-bloom guidelines | | | | | | | | | | | | | | | |
| following label instructions | | | | | | | | | | | | | | | |
| pictorial label instructions | | | | | | | | | | | | | | | |
| label instructions in Spanish or other language | | | | | | | | | | | | | | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Post-Application** | | | | | | | | | | | | | | | |
| clean and dispose of product safely | | | | | | | | | | | | | | | |
| monitoring bee health after product application | | | | x | | | | | | | | | | | |
| network for reporting incidents | | | | x | | | | | | | | | | | |



POLLINATOR PARTNERSHIP

## Practices Commonly Employed

- Almond growers employ a consensus-based set of BMPs when using or intending to use pesticides in this crop.
- Some actions are driven by regulations; for example, all products that are considered for use in any given growing year must be registered with the County Agricultural Commissioner. The list of registered products is available to any beekeeper that will be providing bees for pollination in that county. The beekeeper has the right to request that products not be used or substituted, and can refuse to provide bees if there is any concern that products might impact colony health.
- The registration of both beehives and intended crop protection product use is regulated in California by the California Food and Agriculture Code as follows:

DIVISION 13. BEE MANAGEMENT AND HONEY PRODUCTION
Article 7. Use of Pesticides
SECTION 29100-29103

29100. (a) The Legislature hereby finds and declares that bees perform a valuable service to agriculture in this state.
(b) The Legislature further finds and declares that the necessary application of certain pesticides to blossoming plants poses a potential hazard to bees.
(c) The Legislature further finds and declares that the use of pesticides is necessary for the protection of agricultural crops.
(d) The Legislature further finds and declares that certain factors, including, but not limited to, the time of application, the type of pesticides used, the type of blossoming plant involved, the proximity of the apiaries, and the ability to locate and notify the owners of the apiaries involved, directly affect the extent of the harm to bees resulting from pesticides.

29101. (a) Each beekeeper shall report to the commissioner of the county in which his or her apiary is located on a form approved by the director, each location of apiaries for which notification of pesticide usage is sought. This report for notification may be filed with and be part of the form used for registration pursuant to Article 4 (commencing with Section 29040), or shall be thereafter submitted in writing if telephonic notice of relocation is made as set forth in Section 29070. Except for reports filed as part of an initial registration pursuant to Section 29040, each request shall be mailed within 72 hours before locating an apiary, where feasible, but in no event later than 72 hours after locating an apiary.
(b) The beekeeper shall not be entitled to notification until receipt and processing of the report is made by the commissioner. However, the commissioner may provide notice earlier if practicable.
(c) Notice to pesticide applicators shall not be required until the written report by the beekeeper has been received and processed by the commissioner, except that the commissioner may provide notice earlier if practicable.
(d) The commissioner shall process the written report as expeditiously as reasonable, but shall not exceed 16 working hours. The 16-hour period shall commence upon receipt of the written report.

29102. (a) The director shall adopt regulations necessary to minimize the hazard to bees, while still providing for the reasonable and necessary application of pesticides toxic to bees to blossoming plants. The regulations may be limited to specific blossoming plants.
(b) Regulations adopted pursuant to this section may be applicable to either the entire state or specified areas of the state. Regulations that are applicable to only specified areas of the state shall include provisions for the mandatory notice of movement of apiaries, including any relocation thereof within the area to which the regulations are applicable.
(c) The regulations may also include provisions for timely notification of apiary owners of proposed pesticide applications, and limitations on the time and method of application of pesticides and the pesticides used.

29103. Failure of a beekeeper to remove hives from a specific location, except during specific periods of time, as provided in subdivision (c) of Section 29102 after notification, shall not prevent the application of pesticides to blossoming plants if consistent with the pesticide's labeling and regulations. When the pesticide applicator has complied with the notification pursuant to subdivision (c) of Section 29102 the applicator shall not be liable for injury to bees that enter the area treated during or after the application.

- Bloom is a large factor in determining what product can or cannot be used; however, any product, even a pollinator non-toxic product, can be restricted at the request of a beekeeper if there is a concern for bee health. Fungicides are commonly applied during bloom as this is the time at which various fungi attack almond. Bees are present in fields at this time; and applications are done using guidelines for night spray, cool weather spray, and dry weather spray as bloom cannot be avoided.

- The consensus BMP list for product use in almonds when bees are present includes:
  - Use only approved pesticides, following any bee-specific restrictions.
  - Avoiding spray during bloom, with the exception of fungicides.
  - Avoiding spraying when honey bee hives are present in the orchard or in nearby orchards.
  - Spraying is done at night.
  - Spraying is done when humidity is low.
  - Spraying is only done when air temperature is below 55°F/13°C when bees are not active.
  - Providing beekeepers with notice of product use and at least 48 hours to move bees if this is desired by the beekeeper.

*Gaps in Information and Practice*

While the list of precautions is greatest in the almond industry, and while most of the landscapes adjacent to almond fields are almonds, there is still risk of non-target impacts on pollinators when bloom might be present near to orchards that are out of bloom. Almonds bloom earlier than the natural phenology of wildflowers in the area; however, when fruit is in development on almond trees, other floral resources may be present within or near to an area that is treated with a pesticide. Most industry BMPs regarding pollinator management are focused on honey bees, with less attention on the native bee community. County product and bee hive registration provides a protection network for honey bees with easier follow-up when issues do arise, but this does not address impacts to wild native bees.

The floral landscape in and around almonds, particularly in the southern part of their region, is a water stressed landscape that does not support many cover crops, weeds, ditch vegetation, or adjacent planted wildflower areas. The impact of drought on application practices and on bee health in almond orchards may need consideration as stresses to both crops and bees can change the dynamics of pesticide use and pollinator-pesticide interactions.

Pre-mixed product application is common in almonds, and has benefits of reducing applicator error. Many of these products, however, are tank mixes of multiple pesticide products, some of which can and have had negative impacts on bees when applied during bloom as they contain insect growth regulators. A deeper understanding of potential downstream effects is needed in almond production. Major groups that provide guidance and BPMs for pesticide use in almonds recommend against the use of pre-mixed products of tank mixes.

## Crop Summary

Standard practice in almonds reflects best practices. As such the almond industry can serve as a model for developing a cohesive BMPs protocol that is universally known and accepted. The almond industry is highly pollinator-dependent and that puts a significant demand on the pollination industry and therefore uses BMPs as a matter of course. The almond industry follows a strict information-sharing policy that is mandated through product use registration at the county level, and this undoubtedly benefits both producers and beekeepers. If pollination in almonds were to become undesirable for beekeepers, both industries would suffer; and the almond industry would become unviable. Thus, there is an industry-driven goal to make bee health a priority.

Although the almond industry is a leader in the protection of honey bees using thoughtful and regulated crop protection programs, certain non-target impacts, such as low hive productivity due to interactions with insect growth regulators (IGR) and the interaction of native bees with pesticide residues on nearby vegetation outside of bloom periods, remain potential hazards.

## Apples


### Production and Economics

The United States grows nearly 400,000 acres of apples across the country with production concentrated in the northwest and northeast regions. In the northwest Washington State grows over 44% of the total national production and California provides another 5.3%. In the northeast, New York, Michigan, and Pennsylvania grow 12.8%, 10.4% and 6.4%, respectively. There are over 7,500 varieties of apples grown across the world; nine varieties dominate western US production: Red Delicious, Golden Delicious, Gala, Fuji, Granny Smith, Braeburn, Honey Crisp, Cripps Pink and Cameo. A larger diversity is grown in the east.

As a crop, apple has a high yield success rate with nearly 90% of orchard acres bearing fruit. The current market price as of September 2013 was $1.41 per pound. Considering this, apple growers are able to make a large profit with production costs at only $0.24 per pound depending on varietal (USDA – AMS 2014).

### Key Pollinators

Fruit production in apples is dependent on pollination during the bloom period. Pollination usually occurs between mid to late April in the northwest and from April through May in the northeast (MI, NY, PA), each corresponding to the opening of the king blossom. The king blossom is the largest, centermost of clusters that contain five blossoms and indicates pollination receptivity in the flower. It is around this time that pollinators facilitate the fertilization of the seeds. Common apple pollinators include bees in the genera *Apis*, *Bombus*, *Osmia*, and *Halictus*.

Apple growers rent commercial honey bee hives to maximize crop yield. Commercial pollination contracts suggest that 1.5 hives per acre are used to achieve desired results. In large orchards, hives are clustered in groups of 8 to 16 at 200 to 300-yard intervals; in smaller orchards this is between 4 and 6 hives at 150-yard intervals (Delaplane and Mayer 2000). Commercial hives are placed in fields at 5% bloom and stay until bloom is complete. The consequence of insufficient pollination is misshapen, or small fruit, early fruit drop, lower concentrations of calcium leading to a shorter storage life, and overall lower yield. Commercial pollination with managed orchard bees (*Osmia lignaria*) is also employed by some growers, as these bees are considered to be more effective apple pollinators compared to honey bees.

## Pests and Pesticides

Apple orchards are host to many insect, animal, fungal, and bacterial pests. Codling moth (*Cydia (Laspeyresia) pomonella)* and its larvae have the highest damage potential of any insect pest. Fireblight bacteria (*Erwinia amylovora*) can kill an entire orchard. Integrated Pest Management (IPM) plans usually call for a combination of pheromones to disrupt pest mating and insecticides if populations reach damage threshold levels. These programs monitor pest populations before pesticide application decisions are made. The timing of pesticide spraying is very important considering the bloom period and flux of bee activity that is common in apple orchards.

## Available Information and Management Guidelines

*Key Developers of Actions and Guidelines*

Universities, and in particular extension offices within apple-growing regions, have taken the dominant role in developing practices for pollinator protection through the development and field testing of products and protocols. The majority of tests have involved determining product efficacy in managing targeted pests, residual toxicity, and determining the amount of time needed for safe bee foraging after spray has occurred. Good general overviews of the pollinators and pollination requirements for apple systems have been produced through partnerships of universities and NGOs (Park et al. 2012). General lists of product toxicity to bees were also provided by many groups and resources (Park et al. 2012, Hoven et al. 2012, UC Pest Management Guides Apple 2011).

Unlike almonds, apples are grown in multiple states and in varied climatic regions, which results in a more diverse set of pest concerns as well as recommendations for pollinator protection. In the west, Washington State has a well-developed tree-fruit pesticide management program for pollinator protection in orchards and has produced *Pesticide Timing Recommendations for Pollinator Protection*, which is available online at: http://www.tfrec.wsu.edu/pages/cpg/Pollinator_Protection and as part of Pacific Northwest Publication 591, *How to Reduce Bee Poisoning from Pesticides.*

For eastern growing regions Michigan State University is in the process of developing a Pest Management Strategic Plan (PMSP) called “Best Management Practices to Protect Bees in Michigan Orchards” due to be drafted July of 2014. This document will help bridge gaps in knowledge to help protect pollinators in orchard management and is being developed using collaboratively using discussions with growers, consultants, industry representatives, extension educators, and specialists. A key component of this plan is outlining the use, effectiveness, and potential negative impacts to pollinators of all pesticides applied throughout the season.

Annual trade organization meetings are primary venues for information exchange in the apple industry. Each year the Michigan State Horticulture Society, a cross-commodity group, hosts the Great Lakes Fruit, Vegetable, &

Farm Market Expo in Grand Rapids where growers can attend educational sessions organized by extension educators and specialists from Michigan State University. There are outreach and education opportunities at this event to gain more understanding of pollinator protection. In the west the annual Western Orchard Crop Pest Management meeting provides a similar venue for growers, crop consultants, researchers, and regulators.

*Key Distributors of Material*

Advice on pesticide and crop protection practices is most commonly provided by extension offices, chemical sales and distribution staff, and third-party crop management consultants. These individuals rely heavily on the interpretation of the product labels for pollinator protection information and guidelines. Documents prepared in conjunction by UC IPM and the Western IPM Center, that are available online outline the sensitivity of honey bees to commonly used crop protection chemicals (UC IPM: http://www.ipm.ucdavis.edu/PMG/r4900211.html) and these were also noted as resources that were used in pest management decision making. Extension offices also issue technical bulletins that address relevant issues, including pollinator protection during times of pesticide application. Extension offices in Michigan, New York, Washington, and Oregon were noted as places where stakeholders would look for technical and management advice.

*Key Resources Examined*

Bee Protection - Crop Protection Guide for Tree Fruits in Washington. 2014. Available at: http://www.tfrec.wsu.edu/pages/cpg/Bee_Protection – **Technical Note**

A current list of precautions, specific product alerts and contact information is provided for local growers. This resource is updated annually and serves as a web-based technical note:

1. Do not place honey bees in an orchard until blossoms are open. This will help minimize the number of bees foraging on blooming weeds in the cover crop.
2. Application of insecticides to blossoming orchards can kill foraging honey bees. Insecticide residues on blooming broadleaf weeds in orchard cover crops can also cause bee kills. Never apply insecticides that are hazardous to bees (see following table) when any blossoms are open in the orchard, or allow insecticide drift onto blooming weeds in cover crops, or onto adjoining orchards that are blossoming.
3. Controlling blooming broadleaf weeds (e.g. clover, dandelion, mustard) in orchards is an essential part of preventing honey bee kills. Mow or beat down orchard cover crops before applying sprays hazardous to bees - especially chlorpyrifos (Lorsban), and carbaryl (Sevin). Blossom removal is especially important in relation to the first cover spray on apples. Treatment is applied during a critical foraging period, when bees will fly several miles when temperatures are higher than 50°F to obtain pollen and nectar from even a few blooms of dandelion. Using a labeled herbicide to eliminate broadleaf weeds from cover crops will help to prevent bee kills.

4. Many insecticides commonly used in orchards are highly toxic to honey bees and are hazardous to bees for several days. This includes insecticides like thiamethoxam (Actara) and chlorpyrifos (Lorsban). Some formulations of carbaryl (Sevin) are also hazardous to bees for several days.
5. Proper timing can help to minimize the potential for honey bee kills if the insecticide has an intermediate or short residual hazard to bees. Cool temperatures and higher insecticide use rates can greatly lengthen the residual hazard. Spraying at night will not prevent a bee kill if the insecticide has a long residual hazard to bees.
6. In general, herbicides and bioregulators are relatively low in toxicity to bees (except carbaryl).
7. Certain fungicides, including captan, iprodione (Rovral) and ziram, are harmful to honey bee larvae when applied to bloom.
8. The orchardist must know who owns the honey bees in the orchard and where the beekeeper can be contacted. Beekeepers should place their name and phone number on hives to identify them.
9. Beekeepers must register their honey bees with the Washington State Department of Agriculture, Plant Protection Division. To request an apiary registration form, call 360-902-2070. For technical questions, call 360-902-2071.

This above guide includes a reproduction of the four category spray guidelines provided by the Pacific Northwest Tree Fruit Research and Extension Center that outlines commonly used products and their spray restrictions in both an online (http://www.tfrec.wsu.edu/pages/cpg/Pollinator_Protection) and book format:

- Category I - Do not apply to blooming plants (including fruit trees and broadleaf weeds)
- Category II - May be applied to blooming plants in late evening (do not begin spraying until 6 p.m., and stop spraying at midnight)
- Category III - May be applied to blooming plants in late evening or early morning (do not begin spraying until 6 p.m., and stop spraying at 7 a.m.)
- Category IV - May be applied to blooming plants at any time

How to Reduce Bee Poisoning from Pesticides - Hooven, L. et al. 2013. A Pacific Northwest Extension Publication, PNW 591. Available at: http://wasba.org/how-to-reduce-bee-poisoning-from-pesticides-pnw-591/ – **Booklet/Guide**

This document provides a brief background on the biology of pollinators and cautions those applying pesticides in orchard systems to read the product label as the primary BMP. Background information and general information on how to protect bees in pesticide application scenarios are provided as they relate to all orchard crops and include ways to prevent harm to managed honey bees, managed orchard bees, managed and wild bumble bees, and other wild bees. The booklet also provides contact information on state-specific pesticide application guidelines and bee registries. This robust resource is extensive in coverage but does not provide many crop-specific guidelines.

*New York Integrated Fruit Production Protocol for Apples* - Cornell Tree Fruit Work Group. 2006. Available at: http://nysipm.cornell.edu/publications/nyifp_agrochem/files/fls158.pdf

> This resource gives an overview of apple production systems. It provides a section on safe and efficient spray application methods that outlines BMPs focusing on drift and maintenance of equipment. It also provides an operator checklist for airblast sprayers, which are common in orchard applications.

Pest Management Guidelines for Commercial Tree Fruit Production - Cornell Cooperative Extension Publication. 2014. Available at: http://ipmguidelines.org/treefruits/ – **Booklet/Guide**

> This guide provides an extensive review of pest issues in fruit trees with attention given to pollinator protection. Originally online and in booklet format this guide is currently only available for purchase due to budget restrictions. The re-release of this information in a free web-based format is expected in 2015.

*Wild Pollinators of Eastern Apple Orchards and How to Conserve Them* (Park et al. 2012) – **Booklet/Guide**

> Penn State supported the production of this guide that focuses on apple growing regions in the northeast. This booklet outlines the biology and phenology of bee pollinators important to apples and other tree fruit in the northeast and provides information on their promotion through landscape conservation efforts. The protection of pollinators within pesticide application is given a very general treatment including:

- If you have a choice, use the least hazardous formulation.
- Avoid dusts and microencapsulated sprays; bees easily pick them up on their hairs or mistake them for pollen.
- Follow label guidelines.
- Minimize drift and direct exposure of chemicals to foraging bees. Apply sprays at night or very early when winds are usually calm and bees are not active. Application of the product according to label instruction, including night spraying is a primary BMP.

## Stakeholder Knowledge of Resources

Apple growers who were interviewed expressed an understanding of the need for strict bee protection practices driven by beekeeper contract agreements that often explicitly prohibit the use of any foliar application when bloom is present in the orchard. Many growers have recurring contracts with beekeepers and develop strong personal relationships that they strive to maintain. Apple growers may put forth more effort to protect bees in order to maintain these relationships. The need for honey bee and native bee pollinators for viable fruit production was also clear in the apple industry. The main incentive for growers to prioritize bee protection is higher yield from pollination services. Stakeholders involved in our survey were not aware of specific BMPs available at government or NGOs sites; local Cooperative Extension and the product label were the key sources of information used. The majority of those involved in product application receive their understanding of pollinator protection during product continuing education credit sessions that focus on understanding product labels.

## Catalogue of Pollinator Protection Mechanisms

| **Practices**<br><br>Items highlighted in **green** indicate the practice is commonly promoted across the industry.<br><br>Items highlighted in **grey** indicate the practice is not mentioned or missing. | Crop Protection Guide for Tree Fruits in Washington | Wild Pollinators of Eastern Apple Orchards and How to Conserve Them | How to Reduce Bee Poisoning from Pesticides | Cornell Pest Management Guidelines for Commercial Tree Fruit Production | NY Integrated Fruit Production Protocol for Apples |
|---|---|---|---|---|---|
| **Background** | | | | | |
| guidelines to protect *Apis mellifera* | x | x | x | | |
| guidelines to protect other native bees | | x | x | | |
| crop specific pollinator protection guidelines present | | x | | x | |
| outreach materials for growers | | x | x | x | |
| outreach materials for applicators | | x | x | x | x |
| toxicity level ratings | | x | x | x | |
| background on product use, effectiveness, and hazards | x | x | x | x | |
| understanding pollinator biology and habitat | | x | | | |
| regional/statewide integrated plans present | | | x | x | x |
| **Pre-Application** | | | | | |
| bee hive registration | x | | x | | |
| product use registration with county ag commissioner | | | | | |
| general communication with beekeeper | x | | x | | |
| formal pollination contract with bee protection clause | | | x | | |
| 48 hour notice of application given to beekeeper | | | | | |
| present bees only after blossoms are open | x | | x | | |
| safe hive placement with appropriate buffers | | | x | | |
| use labeled herbicide to eliminate broadleaf weeds | x | | x | | |
| use of pheromone traps/beneficial insects to eliminate pests | | | x | | |
| cover hives with wet burlap | | | x | | |



POLLINATOR PARTNERSHIP

| **Practices**<br><br>Items highlighted in **green** indicate the practice is commonly promoted across the industry.<br><br>Items highlighted in **grey** indicate the practice is not mentioned or missing. | Crop Protection Guide for Tree Fruits in Washington | Wild Pollinators of Eastern Apple Orchards and How to Conserve Them | How to Reduce Bee Poisoning from Pesticides | Cornell Pest Management Guidelines for Commercial Tree Fruit Production | NY Integrated Fruit Production Protocol for Apples |
|---|---|---|---|---|---|
| **Application** | | | | | |
| applicators must be certified in their state | | | | x | x |
| drift prevention - avoiding wind | x | x | x | x | x |
| drift prevention - low drift equipment | x | | x | x | x |
| runoff prevention- avoid water sources | | | x | x | x |
| avoid aerial application | | | x | | x |
| night spraying | x | x | x | | x |
| spraying below 55°F/13°C | x | | | | |
| no spraying when unusually low temps or dew are forecast | | | x | | |
| avoid spraying when high temperatures and low humidity exist | | | | | x |
| no spraying during bloom on crop | x | | x | | |
| no spraying during bloom on weeds | x | | x | | |
| guidelines for bloom in adjacent fields | x | | x | | |
| non-bloom guidelines | | | x | | |
| avoid dust and mircoencapsulated sprays | | x | x | | |
| avoid highly toxic insecticides (thiamethoxam, chlorpyrifos, carbaryl) | x | x | x | | |
| avoid tank mixing of insecticides and fungicides | | | x | x | |
| insecticide use with short residual hazards | x | | x | | |
| following label instructions | | x | x | | |
| pictorial label instructions | | | | | |
| label instructions in Spanish | | | | | |
| visible warning signs should be posted on sprayed orchard blocks | | | | | x |

| **Practices**<br><br>Items highlighted in **green** indicate the practice is commonly promoted across the industry.<br><br>Items highlighted in **grey** indicate the practice is not mentioned or missing. | Crop Protection Guide for Tree Fruits in Washington | Wild Pollinators of Eastern Apple Orchards and How to Conserve Them | How to Reduce Bee Poisoning from Pesticides | Cornell Pest Management Guidelines for Commercial Tree Fruit Production | NY Integrated Fruit Production Protocol for Apples |
|---|---|---|---|---|---|
| **Post-Application** | | | | | |
| clean and dispose of product safely | | | | x | x |
| monitoring bee health after product application | | | x | | |
| network for reporting incidents | | | x | | |
| keep application records | | | | | x |
| **Year Round** | | | | | |
| increase other floral resources | | x | | | |
| provide safe nesting sites - maximize undisturbed areas | | x | x | | |
| investigate and document a suspected bee poisoning | | x | | | |
| keep hives away from plants treated with systemic pesticides | | | x | | |
| regularly service sprayers/annual inspection | | | | x | x |

## Practices Commonly Employed

- In apple production, as in other pollinator dependent orchard crops, there is an understanding that pollinators are necessary for fruit production and that some of the crop protection products used can negative impact or kill bees in the field.
- Following the label guidelines was stated as the most commonly used BMP for pollinator protection, taking note of 'bee hazard' warnings.
- Apple growers and crop management consultants to this industry often employ a no-spray policy outlined in the contract required by beekeepers when bees are present in the orchard and when there is any bloom on the apple trees.
- Precautions to avoid bee harm are not as obvious when there is no bloom in the orchard and when there are no rented honey bees present. BMPs during non-bloom periods were not present.

*Gaps in Information and Practice*

Apples are grown in a variety of regions across multiple states, meaning that multiple state commodity groups provide information on pesticide application scenarios. BMPs relating to apple protection and pollinator protection are generally scattered between a diversity of sources including pesticide labels, extension offices, and local apple community groups. New resources are in production and are expected to fill many of the gaps outlined in this piece.

In the Northwest, where a large portion of apples are grown, there is no requirement for beekeepers to register hive locations (either in adjacent fields or in nearby natural areas), although this practice is recommended by extension staff. Not knowing where hives are located increases the potential for drift and other non-target interactions with pesticides if pest management is employed in an adjacent field that is not in bloom as the applicator is not expecting any bees within the area. Beekeepers are reluctant to register hives that are not in contract because they fear that the location of hives might encourage vandalism, theft, or competition with another beekeeper for the forage sites. For this reason, many hives are placed outside of visual detection on these properties.

Growers struggle with guidelines that restrict product use during bloom as apples can have a protracted bloom period throughout the season. Different cultivars of apple bloom at different times. The agricultural matrix in many apple-growing regions includes cherries, pears, peaches, nut trees, plums, and other tree fruit, many of which flower asynchronously throughout the year. Avoiding bloom in the grower's own property can be achieved, but bloom might be present in an adjacent property when a grower needs to make a pest management decision. Bloom in adjacent properties is generally not taken into consideration when making on-orchard decisions unless the same crop advisor or consultant is contracted to work on nearby properties or there exist good lines of communication between adjacent farms. Local Cooperative Extension agents in some regions (Washington) have developed bloom density metrics to help in decision-making; however, it is still considered difficult to fully avoid product application during bloom in apple prodcution.

Many recent changes in state and county personnel and staffing have created a gap in local communication and understanding of practices. A solution is more follow-up and updates for new growers, applicators, and beekeepers. Local extension agents have historically played a larger role in BMP development and distribution, but their numbers are currently reduced. This was cited by many stakeholders as a key area for improvement.

Many of the individuals directly responsible for pest application and management are Spanish speakers and there is a lack of resources available in Spanish.

### Crop Summary

Best management practices in apple production are delivered primarily by the individuals responsible for applying the chemical product or the crop consultants and focus on an interpretation of the product label combined with overall industry knowledge that pollinators are important.  There is a push from beekeepers to include no-spray clauses in pollination contracts. One of the greatest consequences to farmers of not prioritizing honey bee protection is the potential of degrading working relationships with beekeepers. The implementation of pollinator protection BMPs is complicated by the landscape matrix and the phenology of the target tree species in apple production, both of which make avoiding bloom impossible. Thresholds have been established to minimize risk, but applications do occur in orchards when some bloom is present. The reduction of drift onto non-target areas is critical. Conversations with stakeholders indicated the desire to use pollinator protection techniques, even outside of bloom, after learning of the various exposure pathways that could impact pollinators. There is a gap in BMPs when bloom is not present.

Good communication is considered the primary source of honey bee protection as there is no formal honey bee registry and many beekeepers are hesitant to register hives due to fears of vandalism. Beekeeping contracts are not universal in apple pollination.  In California, County Agriculture Commissioners must sign off on the use of all chemical treatment and the growers must sign the contract in agreement. In addition to these strict guidelines, there are fines if these processes are violated. A similar set of county-level product registration is recommended for apple-growing regions as this provides an additional safety net for beekeepers and makes pollinator-pesticide incidents easier to investigate if they do occur.

Well-organized community groups can play a significant role in pollinator protection within pesticide application scenarios. Commodity group leadership is well established in Michigan. Apple groups, like the Michigan Apple Committee, meet regularly and are funded by yearly assessments based on annual production. Additionally, there are many other trade organizations and regional commodity groups that could take on an outreach role.

## Melons

### Production and Economics

Melon production has been on a steady rise with worldwide growth of 42% since the year 2000. China accounts for nearly 52% of total global production, growing over 16 million tons of melons in 2009 alone. The United States is the fourth largest grower producing over 1.1 million tons in 2009. Within the U.S., California is the leading state in melon production with a handful of southern states from Arizona to Florida following equally behind. Iowa State University, the UC Cooperative Extension, and Purdue University are among the top land grant universities researching melons.

On average the U.S. market price for melons in November of 2013 was 36 cents a pound or $2.69 per fruit. The national average production cost per unit pound is about 29 cents (USDA – AMS 2014). Melon is a labor-intensive row crop that needs much care from producers and is susceptible many pest and diseases pre bloom. For this reason many melon crops are started in greenhouses and subsequently transplanted into fields when they are more mature. Greenhouse starting also allows the producer to cultivate multiple harvests in regions where temperatures allow more than one maturation period.

Melon seeds are commonly pelletized, meaning that they are encased in coatings to increase the ease of planting and to provide improvements to germination and growth. Pellets contain proprietary commercial blends of growth enhancers, fertilizers, and some pesticide products. Growers using pelletized seeds cite a reduction in spray application of pesticides. Faster growth and the development of more vigorous seedlings also provide the plant with more resistance to minor pest interactions. Chemigation (the application of fertilizers, pesticides, or other chemicals through irrigation systems) is also implemented in melon growing, often through drip irrigation systems.

### Key Pollinators

Melons are either started in a greenhouse; and then the plugs are transplanted in the field, or the untreated melon seeds are planted directly in well-drained soil in the field. Seeds are usually planted in January for harvest in late May to June. At least one colony of bees per acre is recommended for proper pollination. The fruit producing flowers open for a limited time period, narrowing the window for effective pollination, meaning that yields increase with heavy bee saturation. Honey bees are the most common commercial pollinator with *Peponapis* spp., *Halictus* spp., *Agaposteon splendens*, *Lepeletier* spp., and *Augochloropsis caerulea* also visiting flowers.

## Pests and Pesticides

Melon fields are host to many insect pests and fungal diseases that can greatly affect production. Some common insect pests include crickets (Gryllid family), various beetles, silverleaf whiteflies *(Bemisia tabaci)*, cutworms (Noctuid family), aphids (*Aphis gossypii)*, mites (*Tetranychus spp.)*, loopers (*Trichoplusia ni)*, leafhoppers (*Empoasca* spp.*)*, and leafminers (*Liriomyza* spp.*)*. Harmful diseases such as sudden wilt (*Phythium* spp.), mosaic viruses, mildews, and fruit rot (*Fusarium roseum*) can cause severe crop loss. Weeds are less of a problem for melon growers, generally being controlled with mechanical cultivation or hand hoeing.

## Available Information and Best Management Practices

*Key Developers of Actions and Guidelines*

Cooperative Extension and various local specialty crop groups produce guidelines for melon production, inclusive of pollination requirements and pest management issues. We did not uncover or see mention of Best Management Practices aimed specifically at the protection and promotion of pollinators in melon systems during crop protection activities. While formal guidelines are scarce, melon cultivation practice is cautious of pollinators as they are required for yield.

*Key Distributors of Material*

Our review of the understanding of BMPs in melon does not show a formal distribution network in this community and crop sector. Instead, long-standing institutional knowledge dictates awareness of and protection for bees as they are essential to the development of fruit. Formalized pollination contracts are also less common; instead more casual arrangements of paid pollination services are made. These melon grower-beekeeper relationships are also historical and include good communication based on local community connections rather than contractual obligation. When questioned further growers indicated that they would seek information on pollinator protection from online resources associated with seed companies, at chemical training and recertification sessions, and at growers meetings and conventions. USDA and extension offices in melon-growing regions were not considered to be sources of pollinator protection and pesticide use guidelines.

*Key Resources Examined*

Pest Management Strategic Plan Cantaloupe, Honeydew, and Mixed Melon Production in California. 2003. California Melon Research Advisory Board and the California Minor Crops Council. Available at: http://www.ipmcenters.org/pmsp/pdf/CAMelon.pdf - **Booklet/Guide**

> This detailed resource, prepared for USDA and EPA, was created as a result of the Food Quality Protection Act which sets out to reduce risk in pest management. This paper explores potential solutions

to a wide range of melon producer concerns. It establishes priorities in research, regulation and education.

Melon Insect Pest Management in Arizona. - Palumbo, JC and DL Kerns. 1998. University of Arizona, College of Agriculture and Life Sciences, Cooperative Extension, Tucson, Arizona. 7 pp. Available at: http://cals.arizona.edu/crop/vegetables/insects/general/melon.html - **Booklet/Guide**

This resource gives an overview of melon production in AZ outlining the ground dwelling, foliar feeding, sucking, and fruit feeding insect pests. The last section briefly talks about pollination and the importance of bee protection. General BMPs are given with the most important being to notify the beekeeper before aerial applications.

## Stakeholder Knowledge of BMPs

Limited specific information exists for BMPs in melon production; however, the recognition of the importance of pollinators to this crop is clear. Melon growers interviewed in this review stated that spraying crops in the field is not a common practice, as many of the pests that are combatted do not occur during bloom periods. Bloom is also very restricted in time, especially with new varieties of melons that are bred for a narrow phenology that improves harvest efficiency. To the best knowledge of the interviewed producers there have been no bee kill incidents reported in melon pollination contracts.

Melon growers surveyed produced conventional products but focused on sustainable production. Most employed field entomologists and used integrated pest management approaches to pest problems. Spraying of insecticides was uncommon and in response to pest breaks in these systems. Prophylactic methods of pest management that included timed spraying would include two to three applications a year; but these applications would be done well in advance of any bud development; and therefore no residuals would be present.

## Catalogue of Pollinator Protection Mechanisms

| **Practices**<br><br>Items highlighted in **green** indicate the practice is commonly promoted across the industry.<br><br>Items highlighted in **grey** indicate the practice is not mentioned or missing. | Pest Management Strategic Plan Cantaloupe, Honeydew, and Mixed Melon Production in California | Melon Insect Pest Management in Arizona |
|---|---|---|
| **Background** | | |
| guidelines to protect *Apis mellifera* | x | x |
| guidelines to protect other native bees | x | |
| crop specific pollinator protection guidelines present | x | |
| outreach materials for growers | x | x |
| outreach materials for applicators | x | |
| toxicity level ratings | x | |
| background on product use, effectiveness, and hazards | x | |
| understanding pollinator biology and habitat | | |
| regional/statewide integrated plans present | x | |
| **Pre-Application** | | |
| bee hive registration | | |
| product use registration with county ag commissioner | | |
| general communication with beekeeper | x | |
| formal pollination contract with bee protection clause | x | |
| 48 hour notice of application given to beekeeper | x | x |
| present bees only after blossoms are open | | |
| safe hive placement with appropriate buffers | x | |
| use labeled herbicide to eliminate broadleaf weeds | x | |
| use of pheromone traps/beneficial insects to eliminate pests | x | |
| cover hives with wet burlap/plastic | x | |

| **Practices**<br><br>Items highlighted in **green** indicate the practice is commonly promoted across the industry.<br><br>Items highlighted in **grey** indicate the practice is not mentioned or missing. | Pest Management Strategic Plan Cantaloupe, Honeydew, and Mixed Melon Production in California | Melon Insect Pest Management in Arizona |
|---|---|---|
| **Application** | | |
| choose a product that is not toxic to bees | | x |
| applicators must be certified in their state | | |
| drift prevention - avoiding wind | | |
| drift prevention - low drift equipment | | |
| runoff prevention- avoid water sources | | |
| avoid aerial application | | |
| night spraying | | x |
| spraying below 55°F/13°C | | |
| no spraying when unusually low temps or dew are forecast | | |
| avoid spraying when high temperatures and low humidity exist | | |
| no spraying during bloom on crop | | x |
| no spraying during bloom on weeds | | |
| guidelines for bloom in adjacent fields | | |
| non-bloom guidelines | | |
| avoid dust and mircoencapsulated sprays | | |
| avoid tank mixing of insecticides and fungicides | | |
| insecticide use with short residual hazards | | |
| following label instructions | | |
| pictorial label instructions | | |
| label instructions in Spanish | | |
| visible warning signs should be posted on sprayed orchard blocks | | |

| **Practices**<br><br>Items highlighted in **green** indicate the practice is commonly promoted across the industry.<br><br>Items highlighted in **grey** indicate the practice is not mentioned or missing. | Pest Management Strategic Plan Cantaloupe, Honeydew, and Mixed Melon Production in California | Melon Insect Pest Management in Arizona |
|---|---|---|
| **Post-Application** | | |
| clean and dispose of product safely | | |
| monitoring bee health after product application | | |
| network for reporting incidents | | |
| keep application records | | |
| **Year Round** | | |
| increase other floral resources | | |
| provide safe nesting sites - maximize undisturbed areas | | |
| investigate and document a suspected bee poisoning | | |
| keep hives away from plants treated with systemic pesticides | | |
| regularly service sprayers/annual inspection | | |

## Practices Commonly Employed

Melon producers take precautions to protect bees, but there are no formal BMPs for melon production. They communicate with beekeepers and understand the need to keep bees safe from pesticide interactions. As a first step melon growers would aim to select a product that does not have any known bee hazard. If such a product were not available, steps to minimize exposure would then be taken. Following label guidelines is the practice employed in melon production.

Pollinator protection mechanisms mentioned by melon growers included the avoidance of spraying during bloom and spraying at night, when there is low wind, low humidity, and when temperatures are cool to cold. Many melon- growing regions experience temperatures higher than 55°F/13°C when an application might be required, and in this case it is not feasible to use a temperature-based application rule. Growers restrict application to evening periods when they do not see foraging bees. The placement of hives upwind of the prevailing wind direction is also used as a general drift-avoidance precaution.

Chemigation is regulated in melon production and the pooling of water is not permitted as this could provide local wildlife, including bees, with a contaminated water source. Drip chemigation is employed to prevent the pooling of water. Honey bees have been noted to collect water from driplines which potentially exposes them to contamination. Beekeepers often note declines in colony health after melon pollination and attribute this to interactions with chemigation water.

*Gaps in Information and Practice*

One gap in pollinator protection within the melon industry is a lack of formal guidelines or BMPs. The components of pelletized seed coatings are proprietary and not always listed. There is a possibility that the products used in pelletized melon seed coatings and applied in greenhouses could have interactions with pollinators; this was not investigated and was outside of the scope of this report.

One prominent grower suggested that guidelines and BMPs in the form of a checklist would be a helpful resource and could possibly be delivered through a mobile application. Another area for consideration is to color coat only treated seeds – there have been some instances where seeds have been colored as a branding mechanism rather than a warning.

It should be clearly stated that melon growers function within a heavily regulated industry focusing on public health and safety. Growers can be penalized with fines for not maintaining these standards. Additional regulations, such as those that related to pollinator protection, would be prioritized below current rules that carry heavy fines. While a lack of formal BMPs is a gap in this sector, the solution to this gap will more reliably come from highlighting the work of innovators or early adopters that have voluntarily implemented bee protection measures rather than from top-down regulation.

## Crop Summary

Melon production includes greenhouse growing phases and subsequent field maturation phases. Spray applications of products that might have negative impacts on pollinators would occur in field situations, and could possibly occur during times of pollination; but most chemical treatments of field melons occur well before bud development. There was no formal set of BMPs for pollinator protection present in this industry, but there was an overall climate of concern for bees. Producers are committed to protecting bees because they are essential to crop production. The melon industry would benefit from documentation or a technical note to provide a clear list of BMPs to be used. BMPs for chemigation scenarios can also be examined further as current guidelines prevent larger wildlife from accessing contaminated water, but do not prevent access from bees. Pollinator protection is institutionalized but not high on growers' priority lists as a result of the more challenging food safety concerns that can lead to more pressing problems such as disease outbreak and sanitation. Producers state that they do not feel the need to develop specific regulation for melon growing and pollinator protection as this would represent more red tape in an already heavily inspected industry.

## Corn

### Production and Economics

The United States is the number one corn grower in the world. China follows closely behind in total production, and Brazil follows in third at a significant distance. Corn production in the U.S. is concentrated in the Midwest and the Great Plains. In 2012, Iowa was the largest corn producing state, and Minnesota was the second largest. Iowa State University is the top land grant university studying corn.

Corn production and consumer prices fluctuate frequently due to demand, environmental conditions, and the biofuel market. The current market price of corn in the United States is $4.49 per bushel. The national average cost of corn production is about $4.25 a bushel (Duffy 2014).

Preparation for planting in corn can be quite extensive with a combination of spring plowing, pre-plant tillage for weed control, and often employs seed treatment. No-till planting has grown in acceptance in the U.S. and makes use of seeding drills that minimize soil disturbance, conserve soil, preserve carbon sequestration, and reduce the likelihood of weeds. Planting occurs in the spring between mid-April and mid-May. Sprouting occurs 5-10 days after planting, and developed plants are present 65-72 days after sprouting. Corn is a self-pollinated/wind pollinated crop with bloom and pollination occurring 69-76 days after sprouting. Fruit becomes mature 128-135 days after planting. Crop harvest occurs in the fall between mid-September and mid-October.

### Key Pollinators

Corn is self-pollinated/wind pollinated and does not require animal pollination for fruit set. While corn does not require animal pollination, it does produce an ample amount of pollen that can in some landscapes become appealing to honey bees and other pollinators looking for forage. Corn is often planted in mosaic landscapes adjacent to Conservation Reserve Program (CRP) lands or other areas where beekeepers can place bees to feed. Roadside ditches can also harbor floral resources that can provide forage for bees. Some pollinators can therefore be expected to be present in or around corn cropping areas.

## Pests and Pesticides

Corn growers are challenged by a long list of insect, fungal, and weed pests. The most injurious insects include wireworms (*Limonius* spp.), black cutworms (*Agrotis ipsilon)*, corn borers (*Ostrinia spp.)*, corn rootworms (*Diabrotica spp.)*, grasshoppers (*Melanoplus* spp.), fall armyworm (*Mythimna spp.)*, and corn earworm (*Helicoverpa zea)*. These insect pests occur at various times throughout corn production, which requires ongoing crop protection.

Seed treatments, including coating with antimicrobial and antifungal agents, have been a common practice in the industry. Insecticide treated seeds became available in 2006 for corn varieties planted throughout North America. Common seed treatments in corn include the systemic neonicotinoid insecticides, which can impact bee and other pollinator health. Farmers consider the sowing of treated seeds to be planting and therefore not pesticide application. As such, BMPs did not exist for the planting of neonicotinoid treated seeds.

In 2008, a large number of honey bee colonies in Germany were affected by the drift of pesticide-contaminated dust generated through the abrasion of treated seeds during planting. Since that time, there has been concern regarding the extent to which one class of pesticides, the neonicotinoids, can move off-site and represent a route of exposure for bees foraging in the vicinity of fields where neonicotinoid-treated seeds have been planted. Although the incident in Germany was attributed to a combination of factors (i.e., lack of a suitable sticking agent for the pesticide on the seed, seeding equipment that vents upward, dry windy conditions, and an abundance of oilseed rape (canola) in full bloom immediately adjacent to the fields being planted), subsequent research (Krupke et al. 2012; Tapparo et al. 2012) has indicated that fugitive dust (pesticide abraded from the seed during planting combined with lubricant agents such as talc or graphics and/or soil) may still represent a route of exposure.

## Available Information and Best Management Practices

*Key Developers of Actions and Guidelines*

Guidance for proper use of pesticide treated seed products and the lubricants used in pneumatic seeding equipment to ensure that seeds flow freely through the seeder is provided by product manufacturers. The Corn Dust Research Consortium (CDRC) was formed in early 2013 to explore potential exposure routes of honey bees to fugitive dust as well as potential options to mitigate exposure.  An alternative lubricant product (Bayer fluency agent) designed to minimize pesticide abrasion and reduce dust movement was developed and then tested by the manufacturer and also by members of the CDRC. The results of these field tests informed preliminary BMPs. A second year of research will be conducted and should further inform the recommendations.

*Key Distributors of Material*

Guidance for product use and bee protection in corn planting systems has been taken on by product and machine manufacturers and includes the distribution of precautionary guidelines for product use, as well as webinars and videos that outline planting techniques to reduce pesticide-contaminated dust during planting. In addition, various government and NGO websites have distributed the draft findings of the CDRC, a copy of which is downloadable at http://www.pollinator.org/PDFs/CDRCfinalreport2013.pdf.

*Key Resources Examined*

Best Management Practices for Planting Insecticide-Treated Corn Seed - Bayer BeeCare. 2013. Best Management Practices for Planting Insecticide-Treated Corn Seed Available at: http://beecare.bayer.com/service-center/videos/video-galleries-detail/canada-best-management-practices-for-planting-insecticide-treated-corn-seed

Growers rave about new plant lubricant - Bayer CropScience. 2014. Available at: http://www.bayercropscience.us/news/press-releases/2013/growers-rave-about-new-planter-lubricant

Seed Treatment Matters: Guide to seed treatment stewardship - American Seed Trade Association. 2013. Available at: http://seed-treatment-guide.com/wp-content/uploads/2013/03/Guide-to-Seed-Treatment-Stewardship.pdf - **Brochure**

Protecting Bees in Iowa: What is your role? - Iowa State University Extension. July 2009 Available at: http://pesticidestewardship.org/PollinatorProtection/Documents/IowaProtectingBees.pdf - **Brochure**

Corn Dust Research Consortium (CDRC) Preliminary Report - Corn Dust Research Consortium (CDRC). 2014. January 30, 2014 pp. 1-26: Available at: http://www.pollinator.org/PDFs/CDRCfinalreport2013.pdf - **Research Report**

## Stakeholder Knowledge of Resources

From the perspective of the grower and crop adviser, the sowing of pesticide treated seeds is considered to be planting, not a pesticide application. No precautions or bee hazards were listed on these products, and no particular precautions were taken.

Following reported incidents of bee kills near corn planting areas, producers, crop advisers, regulators and manufactures became aware of a pressing need for product evaluation. During this time no specific pollinator protection BMPs existed for this situation in the corn cropping system. Stakeholders in the corn industry, in particular product manufacturers and various seed trade organizations, made efforts to develop information packets and precautionary guidelines as proactive measures until research produces vetted guidelines.

## Catalogue of Pollinator Protection Mechanisms

| **Practices**<br><br>Items highlighted in **green** indicate the practice is commonly promoted across the industry.<br><br>Items highlighted in **grey** indicate the practice is not mentioned or missing. | Best Management Practices for Planting Insecticide-Treated Corn Seed | Growers rave about new plant lubricant | American Seed Trade Association. 2013. Seed Treatment Matters: Guide to seed treatment stewardship. | Corn Dust Research Consortium (CDRC) Preliminary Report January 2014 | Protecting Bees in Iowa: What is your role? |
|---|---|---|---|---|---|
| **Background** | | | | | |
| guidelines to protect *Apis mellifera* | x | x | | x | x |
| guidelines to protect other native bees | | | | x | |
| crop specific pollinator protection guidelines present | x | x | x | x | |
| outreach materials for growers | x | x | x | x | x |
| outreach materials for applicators | x | x | x | x | x |
| toxicity level ratings | | | | | |
| background on product use, effectiveness, and hazards | | | x | x | |
| understanding pollinator biology and habitat | | | | x | |
| regional/statewide integrated plans present | | x | | x | |
| **Pre-Application** | | | | | |
| bee hive registration | | | | | x |
| ensure applicators are adequately trained | | | x | | |
| product use registration | | | | | x |
| general communication with beekeeper | x | x | | | x |
| safe hive placement with appropriate buffers | x | | x | x | x |
| use labeled herbicide to eliminate broadleaf weeds | x | | | | |
| use of pheromone traps/beneficial insects to eliminate pests | | | | | |

| **Practices**<br><br>Items highlighted in **green** indicate the practice is commonly promoted across the industry.<br><br>Items highlighted in **grey** indicate the practice is not mentioned or missing. | Best Management Practices for Planting Insecticide-Treated Corn Seed | Growers rave about new plant lubricant | American Seed Trade Association. 2013. Seed Treatment Matters: Guide to seed treatment stewardship. | Corn Dust Research Consortium (CDRC) Preliminary Report January 2014 | Protecting Bees in Iowa: What is your role? |
|---|---|---|---|---|---|
| **Application** | | | | | |
| applicators must be certified in their state | | | | | |
| commercial applicators shall not spray within 1 mile of hives | | | | | x |
| drift prevention - avoiding wind | x | x | x | x | x |
| drift prevention - low drift equipment | x | x | x | x | x |
| runoff prevention- avoid water sources | | | x | x | |
| avoid aerial application | | | | x | |
| night spraying | | | | x | x |
| spraying below 55°F/13°C | | | | | |
| no spraying when unusually low temps or dew are forecast | | | | | |
| avoid spraying when high temperatures and low humidity exist | x | | | | |
| no spraying during bloom on crop | | | | x | |
| no spraying during bloom on weeds | | | | x | |
| guidelines for bloom in adjacent fields | x | | x | x | |
| non-bloom guidelines | | | | x | |
| avoid dust and mircoencapsulated sprays | | | | x | x |
| avoid highly toxic insecticides (thiamethoxam, chlorpyrifos, carbaryl) | | | | x | x |
| avoid tank mixing of insecticides and fungicides | | | | | |
| insecticide use with short residual hazards | | | | x | |
| following label instructions | x | | x | x | |
| pictorial label instructions | | | | | x |
| label instructions in Spanish | | | | | |
| visible warning signs should be posted | | | | | |

| **Practices**<br><br>Items highlighted in **green** indicate the practice is commonly promoted across the industry.<br><br>Items highlighted in **grey** indicate the practice is not mentioned or missing. | Best Management Practices for Planting Insecticide-Treated Corn Seed | Growers rave about new plant lubricant | American Seed Trade Association. 2013. Seed Treatment Matters: Guide to seed treatment stewardship. | Corn Dust Research Consortium (CDRC) Preliminary Report January 2014 | Protecting Bees in Iowa: What is your role? |
|---|---|---|---|---|---|
| **Application - continued** | | | | | |
| Use of lubricants such as talc and graphite on seeds | | | x | | |
| Use of Bayer fluency agent – made of a polyethylene wax substrate | | x | | | |
| **Post-Application** | | | | | |
| clean and dispose of product safely | x | | x | | |
| monitoring bee health after product application | | | | x | |
| network for reporting incidents | | | | x | |
| keep application records | | | x | x | |
| **Year Round** | | | | | |
| maintain, clean, and calibrate application equipment | x | | x | | |
| handle, store, and dispose of treated seeds/seed bags with care | x | | x | | |
| increase other floral resources | x | | | x | |
| provide safe nesting sites - maximize undisturbed areas | x | | | x | |
| investigate and document a suspected bee poisoning | | | | x | |
| keep hives away from plants treated with systemic pesticides | | | | | |
| regularly service sprayers/annual inspection | | | | | |

## Practices Developed and Recommended

Research concluded in the fall of 2013 has developed a set of provisional recommendation for the 2014 planting season for all the stakeholders associated with corn planting and pollinators. These include:

Farmers

- Use drift-reducing lubricants during planting to reduce dust. This recommendation comes with a caveat; though the CDRC tests showed that when the Bayer Fluency Agent (BFA) lubricant was used, total dust and net pesticide load in exhaust emissions were reduced when compared to the use of conventional lubricants, the concentration of pesticide in the exhausted dust appeared to be higher in these tests. This result may be inconsistent with other tests of BFA elsewhere. Further research is needed to determine the extent to which Bayer's new lubricant consistently reduces net emission of dust-borne pesticide during planting of treated seed.
- Follow all precautions to reduce dust and drift, especially with respect to wind and weather conditions during corn planting. Bee-attractive woody pollen sources are particularly vulnerable to drift of pesticides in exhausted dust when corn is planted within 50 meters of such forage.
- Control herbaceous flowers blooming in fields to be planted with corn. This action provides modest benefits to honey bees. Although pesticide residues were detected on cover plants (predominantly dandelions) within seeded fields, the study demonstrated that honey bees did not forage heavily on these plants, but tended to forage on trees and shrubs.
- Minimize unnecessary use of insecticide-treated seed. Use them only when needed, such as where historic pest infestations are above threshold or high risk factors for pest pressure have been anticipated or determined.
- Follow the principles of Integrated Pest Management.
- Communicate with beekeepers to ensure that they are aware of planting timing and can take appropriate precautions to protect colonies.

Beekeepers

- Protect supplemental food and water from drift dust.
- Position hives away from areas where drift of corn dust can settle on herbaceous or woody plants during planting. Prevailing wind direction and wind speed may be helpful indicators for placement.
- Supplement the hive with food to suppress the need for foraging during corn planting, and provide clean water to reduce the need for bees to seek water from sources in and adjacent to corn fields. However, this recommendation is made with the awareness that bees will often seek out any natural pollen before artificial sources.
- Communicate with producers when you have hives in the area.
- Label hives with your contact information.
- Check hives regularly and report incidents.

Pesticide and Lubricant Manufacturers

- Work to reduce movement of corn dust (i.e., improved sticking agents, improved fluency agency).
- Work to keep all the insecticide on the seed until the seeds are in the ground (i.e., polymer seed coatings).
- Work to reduce abrasion potential of treated seed coatings.
- Ensure the lowest effective labeled rate of neonicotinoid treatment is applied to the seed.
- Offer untreated (fungicide only) seed options.
- Reach out to farmers, and help make them aware of the situation and of the importance of farmers implementing recommended actions to reduce bee exposure.

Equipment Manufacturers

- Ensure that equipment users understand the importance of bee protections and the value of using lower-drift lubricants.
- Provide mechanical means to reduce the movement of dust from fan exhaust during planting using equipment design principles and verification methods established in internationally recognized standards (ref. ISO 17962 under development).

Seed Dealers

- Support bee health by providing outreach to producers to make wise seed choices and to follow best seed planting practices.
- Offer untreated seeds as an option for farmers.

Provincial, State, and Federal Government Agencies and Regulators

- Provide financial and instructional support for maintaining trees and shrubs outside drift areas for bee forage available during planting season.
- Provide guidance for the reduction of attractive herbaceous forage in corn fields.
- Fully fund governmental programs to increase and maintain pollinator forage plantings.
- Encourage application of the lowest effective labeled rate of neonicotinoid treatment on the seed.
- Ensure that both insecticide only and fungicide-only treated seeds are available.
- Ensure that IPM practice information is available to the producer.
- Provide a responsive process for bee-incident reporting.  Ensure that incident report procedures are adequately funded and operate in a timely fashion commensurate with the urgency of this situation for honey bees and beekeepers.
- Ensure that seed bag labeling is clear and that growers are aware of the potential risk posed by planter dust.
- Dedicate public and private rights-of-way plantings to the establishment of pollinator habitat.

- Conduct outreach/education targeting farmers to raise awareness and practice of recommended actions to reduce bee exposure.

Extension Agents, Agricultural and Commodity Organizations, and Agricultural Media

- Ensure that IPM practice information is available to the producer.
- Educate the beekeeper in practices that will safeguard bees.
- Educate beekeepers on bee-incident reporting.
- Educate so that label directions are clearly understood.
- Help producers become aware of the situation, and encourage them to adopt recommendations from this report on a timely basis to reduce bee exposure.
- Help agricultural producers, seed dealers, and other stakeholders become aware of the situation and encourage them to adopt recommendations from this report to reduce bee exposure.

*Gaps in Information and Practice*

A gap in information existed and is being filled with field research that will inform BMP development; however, current recommendations are considered preliminary BMPs and ONLY cover recommendations during planting.

## Crop Summary

As a non-pollinated crop, pest management in corn has not historically included precautions for pollinator protection. Pesticide-treated seeds are currently used and regulated as seeds, not as pesticide applications. BMPs and new technologies are rapidly being developing in this crop to protect bees. Pollinator protection BMPs in the corn industry could serve as a model for much needed BMPs in other crops that do not directly interact with pollinators but have shown non-target and indirect impacts due to exposure from pesticides from fugitive dust created during planting or from pesticide residue in pollen or nectar.

## New EPA Labeling Guidelines

In late 2013, the EPA issued new label guidelines that altered the language, placement, and visual components of the "Bee Hazard" label. The "Protection of Pollinators" label spells out the new guidelines. Syntax issues relating to "visiting" and "actively visiting" have been resolved with the substitution of "bloom" as the trigger word. A new bee symbol has been placed on products that previously had wordy bee caution warnings nested within the environmental hazard statement. The visual bee symbol is meant to immediately attract attention to the product as having a potential negative impact on bees and requiring caution.

*Benefits of New EPA Labels*

The new labeling guidelines provide practical information on use restriction and actions in three distinct scenarios: 1) the presence of contracted honeybees; 2) a pollinator attractive food crop or commercial ornamental; and 3) any potentially pollinator attractive non-agricultural product. In cropping systems that lacked BMPs or guidelines for bee protection developed by trade organizations, universities, and others, the primary source of information on how to protect pollinators was taken from the product label. The new label should fill an information gap in many cropping systems by providing the best management practice on the product. Awareness of the need to protect bees is still a key factor in maintaining pollinator health and involves the cooperation of regulators, manufacturers, trade organizations, beekeepers, and others.

*Gaps in New EPA Labels*

The general nature of the label, however, will still leave room for interpretation and does not actively tell producers or applicators how to implement pollinator protection practices specific to their target crop. There is no mention of minimizing drift or applying the product in low wind conditions, however, these practices are recommended to reduce exposure to pollinators. There is no clear mention of assessing bloom within the application area, not just the target crop. This presents a challenge for applicators or farmers that are attempting to manage for pollinator health using the currently available information.

There is expressed concern and confusion regarding the label recommendation to communicate the intent to apply a product with beekeepers 48 hours prior to application.  Though this communication is helpful, it does not shift the responsibility of protecting the health of honey bees from the applicator to the beekeeper, especially since movement of hives is not always an option.  Further, this provides no protection to non-managed pollinators.

Barriers to understanding how to implement pollinator protection due to non-proficiency in English or lack of literacy are not addressed in the new label.

## Conclusions

In commercially-pollinated crops there is general industry awareness across stakeholder groups for the importance of protecting pollinators from possible negative interactions with pesticide products applied during bloom periods. Less awareness and information exists regarding pollinator protection during non-bloom periods and the non-target impacts on pollinators that might be present in adjacent landscapes. Our review of the technical guidance developed and provided by government agencies, cooperative extension, NGOs, trade organizations, and others reveals a similar trend: generally good protocols exist for the use of products that are toxic to bees when bloom is present, but guidelines are limited and often missing for non-bloom periods.

Pollinator protection precautions and protocols can be fit into any cropping system; however, some systems are more easily adaptive to current techniques. Crops that are both highly pollinator dependent and have significant market values linked to successful pollination (almonds, and apples in this review, but likely most orchard crops) have very good networks in place for BMP development, information distribution, and successful implementation. Row crops, like melon, are less inclined to prioritize pollinator protection due to more demanding industry stressors, especially food safety, that take priority. In these instances pollinator protection will be best adopted within the context of field maintenance and food safety.

Ample information and distribution networks for pollinator protection exist in the almond and apple industry, but this is not the case for melon (which represented commercially-pollinated row crops in this review). While there is producer, crop adviser, and beekeeper awareness in melon production, a concise document or technical note on pollinator protection is not available. In cropping systems without specific technical advice on BMPs for pollinator protection in pesticide application scenarios the product label becomes the only source of BMPs. With recent upgrades in product labeling, we expect there to be an overall improvement in the understanding of pollinator management; but nevertheless gaps do exist.

## Gaps in Practice

*We have identified the following gaps:*

- Lack of BMPs for non-bloom periods, inclusive of planting/seeding, growth, and post-harvest practices.
- Lack of simple, universal crop-specific resources for each individual crop and growing region that address pollination protection BMPs and highlight key commonly used products that have potential harmful impacts on bees.
- Lack of regionally specific modification to general BMPs (i.e., applying products below 55°F/13°C is not a possibility in some regions of the country during growing season).
- Lack of BMPs that protect off-farm pollinators (both native bees and honey bee colonies that might be foraging nearby).
- Lack of demonstration-based information that shares technical knowledge.
- Lack of general information for pollinator protection for each stakeholder – farmer, grower, beekeeper, pesticide manufacturer, etc.
- Narrow presentation of BMPs with respect to language and literacy. (Many of the individuals directly responsible for product application are Spanish speakers, and many also have limited literacy skills.)

## Recommendations

The following set of recommendations is made based upon a review of the current status of pollinator protection BMP availability, quality, awareness, and distribution. Our recommendations include increased awareness and promotion of existing techniques; technical enhancement and the development of new outreach materials; and the initiation of research that will fill technical data gaps. We recommend the enhancement and expansion of current BMPs and the diversification of distribution networks. The repackaging of good BMPs into formats that are more accessible and available will increase the likelihood of adoption. We also recommend new research in some areas to better understand how all pollinators interact with commonly used pesticides.

1. **Technical Enhancement:** *Provide crop-specific BMP guidelines that take into account regional factors.* Each cropping systems is unique, and we recommend that BMPs specific to each crop be developed and distributed in the form of a technical note, cooperative extension, or industry publication. There is a higher likelihood of use and adoption within each crop system if the producer and all stakeholders involved receive information on "How to protect pollinators during melon production," etc. In the absence of crop-specific guidelines, repackaging the standard set of pollinator protection BMPs found on the new EPA label guidelines for each specific crop would be beneficial.

2. **Technical Enhancement + Increased Outreach:** *Develop and maintain regional and crop-specific lists of products commonly used to combat pests, their effectiveness, and their impacts on pollinators or other impacts they may have.*
   Some information exists on the full scope of products commonly used to combat pests in a variety of crops. This is not universal; nor is this information commonly available at the source that a grower or pesticide applicator would approach first. We recommend that key information distributors within each crop have such a resource that is maintained and easily accessible. The forthcoming *Michigan State Pest Management Strategic Plan* will include such a list.

3. **Increased Outreach:** *Identify early adopters of pollinator protection BMPs, and engage them in the demonstration of practices.*
   Behavior-based research has indicated a spectrum in the adoption of new practices. There are innovators and early adopters that precede the majority in taking on new practices. These individuals can play significant roles in speeding up the rate of pollinator protection practice adoption and complement efforts by local extension offices and outreach groups. Filming the practice as demonstrated by the early adopter provides a powerful learning technique.

4. **New Research:** *Develop BMPs that address pollinator protection when bloom is not present in the crop.* Pollinators may be present near or adjacent to crops that are no longer in bloom. These pollinators might be feeding on hedgerows, weeds in ditches, or nearby wild areas. There is currently no stated guideline or awareness statement about nearby bees. The creation of local bloom calendars that could serve as a reference for growers and applicators would assist in understanding potential offsite risks.

5. **New Research:** *Develop a set of toxicity guidelines for other common managed pollinators (bumble bees, alfalfa leaf-cutter bees, mason bees, and alkali bees).*
   Current pesticide toxicity is established through a series of tests using honey bees. These tests are conducted on individual bees to determine $LD_{50}$; however, honey bees vary in size and feeding pattern when compared to other managed pollinators. Understanding the interactions and toxicity ranges for these common managed pollinators would improve BMP development. We recommend testing and research protocols be developed to understand the full scope of managed pollinator interactions with products they are likely to encounter. We also recommend expanding toxicity testing to include common representatives of native bee groups as a research need.

6. **Increased Outreach:** *Encourage the registration of bee hives.*
   Knowing where honey bees might be located is a promising step in protecting them from unintended pesticide contamination. If incidents of bee poisoning occur, a registration system can facilitate investigation and forensic reconstruction. In many cases beekeepers fear that registration might lead to vandalism, competition for available forage, or to a shift in responsibility from pesticide application to the beekeeper. Facilitating a system that would be endorsed and used by beekeepers would be key.

7. **Increased Outreach:** *Increase outreach to stakeholders at commodity group and agricultural meetings.* Issue salience is key to driving the adoption of pollinator protection actions. We recommend that information sessions, webinars, and technical notes are delivered to stakeholders on a consistent basis to keep the issue of protecting pollinators as central as possible. We also recommend that certified pesticide applicators have the opportunity to achieve continuing education credits for learning about pollinator-protecting BMPs. Since not all states require certification to apply a product, this would provide additional awareness on the need to protect pollinators. This education should be extended to and made available to all producers and crop advisors

8. **Increased Outreach:** *Make technical notes, handouts and web resources available.*
   Increasingly all stakeholders are seeking information in web-based formats. Feedback from interviewed farmers indicated a desire to have resources accessible in an online format.

9. **Increased Outreach:** *Provide BMPs to all stakeholders – growers, beekeepers, crop consultants, product manufacturers, professional associations, ag media, etc.*
The responsibility to protect pollinators in agricultural systems does not fall solely onto one group or individual. Each player, farmer, beekeeper, pesticide applicator, etc., can demonstrate actions and behaviors that protect and promote pollinators. We recommend providing BMPs to each stakeholder and promoting associated activities that will encourage adoption. For beekeepers this might mean hive registration, as mentioned above. For pesticide applicators this could include bloom checklists and enhanced product labels. A system with multiple checks that aim to prevent pollinator harm in pesticide application scenarios would create a safer environment for pollinators.

10. **Technical Enhancement + Increased Outreach:** *Provide label information in multi-lingual and pictorial formats, and clarify inconsistencies and contradictions.*
The individuals responsible for direct pesticide application may not be proficient in English. Providing information in Spanish as a first multi-lingual step would be ideal. The development of pictorial instructions is also advised. The label needs clarification with respect to communication with beekeepers about notice of application and also with respect to exceptions that may be open to misinterpretation and abuse.

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## Conference and Meeting Details:

**Meeting Name:** American Seed Trade Association (ASTA) Corn and Sorghum Research Conference
**Location:** Chicago, IL
**Date:** December 10-13, 2013
**Scope and Schedule:** Annual, National
**Attendees:** 1000
**Relevant Crops and Systems:** Corn

**Meeting Name:** Western Orchard Pest and Disease Management
**Location:** Portland OR
**Date:** January 7-9, 2014
**Scope and Schedule:** Annual, Regional
**Attendees:** 250
**Relevant Crops and Systems:** Almonds and apples, other orchard crops as well

**Meeting Name:** Almond Board of California Environmental Committee Meeting
**Location:** Modesto, CA
**Date:** January 23, 2014
**Scope and Schedule:** Annual, National, Advisory Committee
**Attendees:** 40
**Relevant Crops and Systems:** Almonds

**Meeting Name:** American Seed Trade Association (ASTA) Vegetable and Flower Seed Conference
**Location:** Monterey, CA
**Date:** January 25-28, 2014
**Scope and Schedule:** Annual, National
**Attendees:** 800
**Relevant Crops and Systems:** Melons

**Meeting Name:** Colusa County Almond Day
**Location:** Colusa, CA
**Date:** February 4, 2014
**Scope and Schedule:** Annual, Regional
**Attendees:** 40
**Relevant Crops and Systems:** Almonds

## Project Contacts List:

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| Environmental Committee | Almond Board of California | | http://www.almondboard.com/Growers/Sustainability/EnvironmentalStewardship/EnvironmentalCommittee/Pages/Default.aspx |
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## Appendix 1: Annotated List of General Pollinator Protection Resources

Bayer CropScience.2014.BeeCare Tour. http://beecaretour.bayer.com/

> Summary of an outreach tour that provides local stakeholders with current information on honey bee health relevant to Bayer CropScience products. Location and events included.
>
> - 02.06.14 Washington State University (Pullman, WA)
> - 02.12.14 University of California, Davis (Davis, CA)
> - 02.18.14 Oregon State University (Corvallis, OR)
> - 02.27.14 to 03.01.14 Commodity Classic Convention and Tradeshow (San Antonio, TX)
> - 03.12.14 South Dakota State University (Brookings, SD)
> - 03.20.14 Purdue University (West Lafayette, IN)
> - 06.16.14 to 06.23.14 National Pollinator Week (Washington, DC)

Beyond Pesticides. Pollinators and Pesticides: Protecting honeybees and wild pollinators. http://beyondpesticides.org/pollinators/pollinators.pdf

> Briefly covers the threat and affects pesticides have on pollinators with a focus on bees. Explores potential causes of Colony Collapse Disorder (CCD) and how going organic can protect pollinators.

Cures Works. Pollinators and Pesticide Stewardship: Protecting Pollinators on Farms and Urban Landscapes. http://www.curesworks.org/publications/pollinators.asp

> Provides tips on safe application when using Pollinator Toxic Pesticides (PTPs) with an emphasis on awareness and communication. Includes a pollinator protection checklist for applicators.

Hunt, G., Ewards, R., Foster, R. 2003. Purdue University Cooperative Extension. Beekeeping: Protecting honey bees form pesticides. http://extension.entm.purdue.edu/publications/E-53.pdf

> Brief explanation of bee poisoning and how growers and beekeepers can reduce the hazards. Includes lists of highly toxic, moderately toxic, and relatively non-toxic pesticides.

Johansen, Erik. 10 Ways to Protect Bees from Pesticides. Washington State Department of Agriculture. Pesticide Management Division. http://agr.wa.gov/fp/pubs/docs/388-TenWaysToProtectBeesFromPesticides.pdf

> States a general need for bees and how applicators can help protect bees. Includes a brief overview of neonicotinoids and seven additional resources for further education.

Mayer, D.F., Johansen, C.A., Baird, C.R. 1999. Pacific Northwest Extension. How to Reduce Bee Poisoning From Pesticides. PNW518. http://cemerced.ucanr.edu/files/40411.pdf

> Review of the causes behind bee poisoning pesticides. Overview of beekeeper-grower cooperation and regulations. Lists precautions to reduce bee poisoning, including information on levels of pesticide toxicity.

North Dakota Department of Agriculture. 2014. North Dakota Pollinator Plan. http://www.nd.gov/ndda/files/resource/NorthDakotaPollinatorPlan2014.pdf

> 90% of North Dakota's acreage is sued for agriculture and beekeepers bring approximately half a million hives into the state each year. The goal of this pollinator plan is to bring awareness to the issues faces by all stakeholders involved in crop and pollinator protection. There is an emphasis on positive relationships and communication between beekeepers, landowners, and pesticide applicators, and BMPs are outlined for each.

Pesticide Taskforce. North American Pollinator Protection Campaign. Solving your pest problems without harming pollinators. http://www.pollinator.org/PDFs/NAPPC.pesticide.broch.Consumer%20FINAL%2005%2027%2010.pdf

This brochure is targeted for home gardeners and growers who are using pesticides on a smaller scale on their private land. The resource explains what constitutes a pesticide and provides application tips. It also gives pollinator-friendly pest control strategies.

Pesticide Task Force. North American Pollinator Protection Campaign. Protecting Pollinators: Why and how pesticide applicators can help them. http://www.pollinator.org/PDFs/NAPPC.pesticide.broch.Applicators17.pdf

This brochure gives an overview of why pesticide applicators should care about pollinators and lists pollinator facts to better inform them. It touches on safe pesticide application, paying attention to labeling such as “Bee Hazard” warnings. Sections include how to identify pesticide toxicity and pollinator poisoning.

Pesticide Task Force. North American Pollinator Protection Campaign. 2014. Protecting Pollinators: NAPPC Pesticide Applicator Training Workbook. *Under Development*

A training module for certified pesticide applicators, pesticide and crop advisors, and agricultural producers. This training manual will help the reader understand:

- The importance and current status of pollinators
- How professional pesticide applicators can help protect pollinators
- How to select pesticides, and application strategies that control the target pest with minimal risk to pollinators
- How to assess the potential effects of treating crops during flowering period, and adjacent blooming crops and plants
- The importance of the label and label language

Pesticide Task Force. North American Pollinator Protection Campaign. 2014. Protecting Pollinators: A training module for certified pesticide applicators, pesticide and crop advisors, and agricultural producers. *Video*. *Under Development*

This video resource accompanies the NAPPC Pesticide Applicator Training Workbook. It outlines similar teachings of protecting crops in conjunction with protecting pollinators. The video features images of crop production, pesticide application, and commercial beekeeping. It also includes insight from beekeepers, applicators, and producers.

Stanford, Malcolm. 2003. University of Florida IFAS Extension. Protecting Honey Bees From Pesticides. http://orange.ifas.ufl.edu/mg/mg_compendium/pdffiles/aa/aa14500.pdf

In depth report on the importance of honey bees and how they can be protected from pesticides. It includes a honey bee mortality predictor and a list of the relative toxicity of specific pesticides to honey bees.