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Pollinator Protection – Article

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When faced with a pest problem, growers and pesticide applicators have a number of pest management options including cultural, chemical, biological, or physical methods. There are many situations where pest control is necessary and chemical controls must be used. Certain chemistries are known to have negative and long-term impacts on bees, other pollinators, and beneficial arthropods. Others have minimal impacts.

Pollinators are essential to the survival of the majority of flowering plants in our environment and to the production of more than 85 crops. Over $15 billion annually is attributed to the value of pollination of food crops, especially fruits, vegetables, and nuts. It is estimated that pollinators are responsible for 1 out of every 3 bites of food that we eat.

The areas treated for pests are often visited by pollinators; mainly insects such as bees, butterflies, wasps and flies, and birds and bats. Pollinators visit flowers in their search for nectar and pollen.

Insects are the most common and abundant pollinators. Among the pollinating insects, the honey bee is relied on to perform most of the commercial pollination services in the United States and around the world.

The EPA pollinator-protection language that is required to be on pesticide labels will outline how best to minimize these impacts.

Goals

- Understand how to legally, responsibly and effectively use of pesticides to protect bee health.
- Identify steps that you can take to reduce pesticide risks to pollinators without overly burdening pesticide users or beekeepers.
- Be able interpret legally enforceable label language including EPA mandated pollinator advisory hazard statements (pollinator protection language) on pesticide labels.
- Apply pollinator protection Best Management Practices when applying pesticides.
- Recognizing mortality due to pesticide exposure

As a pesticide applicator, you are critical to reducing pesticide risks to honey bees and other pollinators. Proper pesticide use starts with following the product label. Also, the use of Integrated Pest Management (IPM) and Best Management Practices (BMPs) wherever pollinators are present will help prevent harming honey bees, their food sources, water and habitat.

Beekeepers and producers of fruit, nut and vegetable crops are concerned that the availability of managed honey bees is not keeping pace with the growing demand for pollination services. In the U.S., a phenomenon called 'Colony Collapse Disorder or CCD' — first discovered in 2006 — has caused mysterious and catastrophic losses of managed bee colonies.

More recently these losses are now commonly referred to as elevated colony losses, or colony losses for short. Today, colony losses remain an important research topic and are under scrutiny as continuous scientific investigations have been unable to pinpoint any one factor that contributes most to these losses. Honey bee diet, lack of quality forage, poor queens, immunity, pests and parasites (especially the Varroa mite - *Varroa destructor*), as well as pesticide exposure, are among a multitude of stressors that may negatively impact bees.

Certain pesticide active ingredients are known to have negative and long-term impacts on bees, other pollinators, and beneficial arthropods. Others have minimal or no impacts at all.

Scientists across the country have been looking for the cause or causes of elevated colony losses, and have attributed the decline of bees in general, to four broad categories of factors:

- Pathogens (such as fungi, amoeba, bacteria, and viruses that infect honey bee brood and adults)
- Parasites (such as tracheal [internal] and Varroa [external] mites—Varroa mites injure adult bees and brood by direct feeding and transmission of pathogenic viruses)
- Environmental Stressors (such as miticides and antibiotics used inside the hive and pesticides used

outside the hive; or malnutrition through lack of nectar diversity); and

- Management Stressors (such as transportation stress by migratory beekeepers, overcrowding, feeding practices, and genetic fitness of the queen source)

What exactly is causing the increased colony losses remains unknown. It seems that rather than one single factor, there is a mixture, or accumulation, of potentially synergistic causes which contributes to colony losses. A better understanding of how the suspected causes interact and how bees respond to those causes is needed.

Pesticides play an important role in controlling insects, weeds, and diseases on farms and in urban landscapes. The areas treated for pests are often shared by pollinators; mainly insects such as bees, butterflies, wasps and flies, and birds and bats. Pollinators visit flowers in their search for nectar and pollen. During a flower visit a pollinator may accidentally brush against the flowers reproductive parts, depositing pollen from a different flower. The plant then uses the pollen to produce a fruit or seed.

Pollinators are essential to the survival of the majority of flowering plants in our environment and to the production of more than 85 crops. Over $15 billion annually is attributed to the value of pollination of food crops, especially fruits, vegetables, and nuts. The western honey bee (*Apis mellifera*) is conceivably the most important pollinator in Florida and American agricultural landscapes. The honey bee is credited with approximately 85% of the pollinating activity necessary to supply about one-quarter to one-third of the nation's food supply. Over 50 major crops in the United States and at least 13 in Florida either depend on honey bees for pollination or produce more abundantly when honey bees are plentiful.

Rental of honey bee colonies for pollination purposes is a highly sought after service and a viable component of commercial beekeeping and agriculture. Bee colonies are moved extensively across the country for use in multiple crops every year. There are also over 3,000 registered beekeepers in Florida, managing a total of more than 400,000 honey bee colonies and producing between 10–20 million pounds of honey annually.

Growers also use other managed bee species, such as the bumble bee (*Bombus* spp) to provide field and greenhouse crop pollination services. Additionally, there are more than 315 species of wild/unmanaged bees in Florida that play a role in the pollination of agricultural crops and natural and managed landscapes. These include mining bees, mason bees, sweat bees, leafcutter bees, feral honey bees, and carpenter bees, among others.

Protecting honey bees and other pollinators from pesticide impacts is important to the sustainability of agriculture. Consequently, pesticide applicators must determine if there is a clear hazard to managed or wild populations of bees. Potential exposure of bees to pesticides can vary greatly depending on the type of pesticide, formulation, application method, label restrictions, and other factors. The goal in using a pesticide is to achieve maximum benefit (success) with minimum negative impact, and these factors should always be considered in pesticide selection.

Agriculture in Florida is a multi-billion-dollar industry, occupying over nine million acres of the state's total land. Much of the United States depends on Florida for its winter supply of produce. However, Florida's favorable environment also supports a multitude of crop pests, and their management is a year-round component in agricultural production. The pests include various insects, mites, fungi, weeds, and other undesirable organisms. Collectively, these pests can cause severe damage, and some also spread diseases that can result in significant crop and financial losses. While integrated pest management (IPM)—a combination of chemical, physical, cultural, and biological pest control—has been systematically implemented in many of Florida's major cropping systems, Florida farmers must continue to rely heavily upon crop protection materials for high-yielding, cost-effective crop production.

Insects are the most common and abundant pollinators. Among the pollinating insects, the honey bee is relied on to perform most of the commercial pollination. As a pesticide applicator, you are critical to reducing pesticide risks to honey bees.

There are many situations where pest control is necessary and chemical controls must be used. Certain chemistries are known to have negative and long-term impacts on bees, other pollinators, and beneficial arthropods. Others have minimal impacts. The pollinator-protection language that is required to be on pesticide labels will outline how best to minimize these impacts. The United States Environmental Protection Agency (EPA) bases the labels they approve for pesticide products on a risk-benefit analysis. It is important to work within the system established so that pesticide applicators can have the appropriate tools to help manage pests while safeguarding pollinators, the environment, and humans. The bottom line is that the label is the law—it must be followed.

Honey Bee Life History

A review of honey bee colony life history is necessary to understand routes of bee exposure to pesticides. Honey bees are highly social, and a single colony may contain as many as 60,000 individuals, depending on the time of year and availability of nectar and pollen-bearing blossoms.

Each colony consists of three types of individuals: queens, drones, and workers. A single fertile queen lays all the eggs for her colony and is the sole reproductive bee in that colony. The male drones do little work around the hive, and their principle job is to provide sperm to virgin queens.

The vast majority of the bees in a colony are female workers. As the name suggests, they are responsible for doing all the work in the hive, including but not limited to foraging and processing food, caring for the brood or young bees, defending the colony, and maintaining the colony's temperature. While developing, all three types of honey bees pass through a larval (feeding) stage followed by a pupal (transformation) stage. A fully developed adult bee emerges after the pupal stage but does not leave the hive to forage until its hive duties are complete. Hive bees (the younger workers) build wax, care for the brood, cap cells, process pollen and nectar gathered in the field by older workers, and clean the nest. Eventually, they become field bees (the older workers). Field bees, or foragers, actively collect nectar, pollen, water, and propolis (sap or other resinous materials secreted by plants).

Routes of Exposure: Outside the Hive

Field bees are the bees most likely to be exposed to environmental toxins because they forage outside the hive later in life. They may encounter a variety of risks when leaving the hive: predators, accidents, weather, and exposure to toxins in the environment. While foraging, honey bees collect pollen from flower anthers and nectar from plant blossoms and extra-floral nectaries.

Foraging honey bees may fly 2–5 miles (3.2–8 km) from their colony in any direction. Thus, an actively foraging colony can cover an area up to 80 sq. miles or 201 km^2 (for a circle with a 5-mile [8-km] radius).

Despite this large possible foraging range, honey bees do tend to forage on the richest, most nutrient-dense and abundant food sources closest to the hive. Honey bees typically forage during daylight hours when temperatures are above 55°F, and they reduce their activity at dawn, dusk, and during inclement weather.

They forage for nectar and pollen and even collect water from sources close to their colonies. Different hives in the same location can forage on different food sources. As a result, hive exposure to environmental toxins can vary by hive, depending on the forage source and the pesticide residue it may contain. It is during these foraging hours and at these points of contact (foliage, pollen, nectar, water, and propolis) that bees are most likely to be exposed to pesticides and other environmental toxins present in their foraging area. Consequently, foliar surfaces, soils, and exposed pollen and/or nectar that have received direct spray, dusting, or other direct application or drift of pesticides provide an immediate route of exposure to field or foraging bees.

Systemic pesticides, which may be applied by soil treatment, seed treatment, direct injection, or foliar applications, are translocated within the treated plants and may be expressed in the nectar, pollen, or various plant tissues.

Bees can be affected by pesticides outside the hive acutely (they die of toxic exposure before returning to the nest) or chronically (they carry pesticide residues with them back to the nest where the residues may produce long-lasting, sublethal effects). Exposure to certain insecticides may have no detrimental impact at all on bees.

Honey bees can also be exposed to pesticides purposely administered to their colonies. The managed honey bee colony suffers from a number of invading insect pests, parasites, and pathogens. Two of the major honey bee pests that have historically required in-hive applications of synthetic pesticides are the nest-invading small hive beetle (*Aethina tumida*) and the parasitic Varroa mite (*Varroa destructor*). These two pests have posed immediate and lingering effects on honey bee colonies in America because the honey bee has had little time (since 1990s for small hive beetles and the 1980s for Varroa) to develop defenses against them.

Beekeepers have relied mainly on the use of the organophosphate coumaphos to combat the hive beetle. Some IPM tactics such as traps and apiary care have become increasingly popular in hive beetle control tactics.

Traditionally, Varroa have been controlled chemically with tau-fluvalinate (a pyrethroid) and coumaphos. Both were efficacious against the mite initially; however, Varroa has developed resistance to these two pesticides. The formamidine pesticide amitraz is now a popular active ingredient used by beekeepers against the mite. Additional active ingredients used against Varroa include formic acid, hop beta acids, and thymol. Many of these in-hive applied pesticides and their residues have been detected inside various hive components, resulting in both acute and chronic bee exposure.

Pesticide Integration into the Hive

Honey bees collect nectar and pollen and consume honey derived from nectar and bee bread (a pollen/nectar mixture stored in combs and later fed to developing bees, as food. Digestion of contaminated bee bread and honey can lead to contaminated secretions, including both wax and royal jelly. Contaminated bee bread and honey are mixed into brood food, which is composed of glandular secretions of worker bees, and fed to developing larvae.

Wax is used to construct the hexagonal cells (the "comb") in which queens lay eggs, the brood develops, and honey and bee bread are stored. Beekeepers who repeatedly use contaminated comb will continue to expose bees to varying levels of pesticides and their metabolites (breakdown products). Many pesticides are lipophilic (wax-loving), a quality that makes them likely to remain in beeswax. Wax slows the degradation of these materials, thus possibly further increasing the exposure of bees to pesticides. Investigators surveying US honey bee colonies for pesticide residues have found residues from insecticides, herbicides, miticides, and fungicides in the various hive components. This and other studies highlight the reality of honey bee exposure to pesticides and emphasize the need for pollinator exposure mitigation programs.

Effects of Pesticides on Bees

Acute exposure to pesticides can kill individual honey bees and entire colonies immediately or within hours of exposure. Chronic pesticide exposure may include lethal and sublethal effects on the brood, workers, drones, and queen, who may be killed or rendered infertile. Within an individual bee, certain pesticides and their associated metabolites can attach to, alter, or destroy cells in the gut, brain, or other tissues, thus affecting the bee's physiology and behavior. Sublethal effects of pesticides include physiological effects that impact enzyme activity and brain activity, leading to impairment of olfaction, learning, and memory; and behavioral effects on motor activity leading to alterations in navigation, orientation, and feeding behavior. Reproductive effects may include reduced sperm viability in drones that causes poor mating for queens, and disruption of ovary activation in the developing queen. Compounded sublethal effects of individual bees may result in colony-level effects, such as poor brood build-up, poor nourishment, frequent queen replacement (supersedure), low overwintering success, and, potentially, colony demise. Sublethal effects of pesticides on bees and other pollinators is a growing research field.

In general, toxicity refers to the ability of a substance (a pesticide in this case) to produce adverse effects on an organism and its normal function. Acute toxicity refers to systemic damage as a result of a single or short-term exposure to the chemical. A pesticide with a high acute toxicity can be deadly in small amounts. The signal words found on the pesticide label are based on the acute toxicity of the pesticide to mammals (e.g., humans), not pollinators. For pollinators, acute toxicity from pesticides can result from either direct exposure (e.g., pesticide spray), exposure to residues on foliage and/or flowers, or from consumption of the pesticide in nectar or pollen (subacute or dietary exposure).

Toxicity to pollinators is typically determined using honey bees in oral or contact toxicity studies. Pesticide formulations are considered highly toxic to bees if the LD50 (the lethal dose that kills 50% of the test organisms) is < 2 μg/bee and moderately toxic if the LD50 is between 2 and 11 μg/bee. If the LD50 ≥ 11 μg/bee, then the pesticide is considered practically non-toxic to bees at an acute level.

Residual toxicity refers to pesticides that have residues that are expected to cause non-target organism mortality. Pesticide residues, often left on the foliage of plants, decrease in toxicity over time. The residual toxicity is determined with a bee residue study (honey bee or other bee species). For these studies, a crop (most likely alfalfa) is sprayed with the pesticide at the maximum label rate. Foliage is collected from the field (e.g., at 3, 8, and 24 hours after application) and is introduced to caged bees. Bee mortality is measured for each exposure of treated foliage to determine the toxicity of the residues over time. Those pesticide products that have residues that are toxic to bees for greater than 8 hours are considered to have "extended residual toxicity."

Pesticide labeling language to protect pollinators like honey bees is based on both direct acute toxicity (i.e., toxicity group) and on residual toxicity.

Proper pesticide use starts with following the product label. Also, the use of Integrated Pest Management (IPM) and Best Management Practices (BMPs) wherever pollinators are present will prevent harming honey bees, their food sources, water and habitat.

Although the information in this module is targeted to the protection of honey bees, the stewardship principles and practices described are applicable to all pollinators.

Pesticide Regulations

At the federal level, the EPA oversees the regulation of pesticides. The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) is the primary law establishing how the EPA is to register pesticides and oversee their regulation. The framework established in FIFRA for pesticide regulation gives primacy to states that have met certain criteria and provides for oversight by the EPA. The Florida Department of Agriculture and Consumer Services (FDACS) is the state lead agency for pesticide regulation in Florida. The EPA and FDACS work together to regulate pesticides.

Chapter 487, Florida Statutes is the primary state law overseeing pesticide registration and regulation. Chapter 487 serves to regulate the distribution, sale, and use of pesticides and to protect people and the environment from the adverse effects of pesticides. In some instances, Florida law and rules are more stringent than federal regulations and set forth Florida-specific requirements for licensing and enforcement of pesticide use. It is this chapter that outlines Florida's state-specific laws regarding pesticides and that, together with pesticide product label instructions, determines how pesticides are to be used in Florida. Florida's pesticide laws and rules do not specifically address the protection of honey bees or pollinators, but interpretations of sections can and should be used in good judgment for that purpose.

Pollinator Language on Pesticide Labels

Those who use pesticides, who are affected by pesticides, and who make decisions regarding their applications should not only read the pesticide label but also interpret the meaning of label wording.

See UF/IFAS publication Interpreting Pesticide Label Wording - **http://edis.ifas.ufl.edu/pi071** for more detail on interpreting pesticide label wording and the FDACS website **www.FloridaBeeProtection.org** for compliance interpretations of pollinator protection label statements.

Remember, when using pesticides: the label is the law.

All pesticide products (except exempt products that meet specific low-risk criteria) are registered by the EPA. Each pesticide requires an extensive suite of testing to yield information concerning the hazards to people and to non-target organisms in the environment. Each pesticide is required to list precautionary and advisory statements on the label. The environmental hazards statement provides precautionary language informing users of the potential hazards to the environment from transport, use, storage, or spill of the product. These hazards may be to water, soil, air, beneficial insects, plants, and/or wildlife as identified in EPA risk assessments or when there is other information such as accident history indicating significant risks to non-target wildlife. Statements other than those listed may be required if more appropriate to the formulation or use.

In addition, non-target organism statements are required for each chemical. The Code of Federal Regulations title 40 (40 CFR) section 156.85 gives example statements that EPA typically requires when data indicate certain acute toxicity levels for mammals, birds, fish, etc.,

The section also states:

"If a product is intended for or involves foliar application to agricultural crops, forests or shade trees, or mosquito abatement treatments, and contains a pesticide toxic to pollinating insects, the label must bear appropriate label cautions."

For an outdoor-use pesticide, a "bee hazard" warning may be required in the environmental hazard section of the label if the pesticide active ingredient or formulation is acutely toxic to honey bees (LC50 < 11 μg/bee; see Table 1). Examples of pollinating insect hazard statements taken from the environmental hazards section of product labels include, but are not limited to:

1. This product is toxic to bees exposed to treatment and for more than five days following treatment.
2. Do not apply this product to blooming, pollen-shedding, or nectar-producing parts of plants if bees may forage on plants during this time period, unless the application is made in response to a public health emergency declared by appropriate state or federal authorities.
3. This product is highly toxic to bees exposed to direct treatment or residues on blooming crops or weeds. Do not apply this product or allow it to drift to blooming crops or weeds if bees are visiting the treatment area.
4. This product is potentially toxic to honey bee larvae through residues in pollen and nectar, but not to adult honey bees. Exposure of adult bees to direct treatment or residues on blooming crops can lead to effects on honey bee larvae. See the "Directions for Use" section of this label for specific crop application instructions that minimize risk to honey bee larvae.
5. This product is toxic to bees exposed during the 3 hours following treatment. Do not apply this pesticide to blooming, pollen-shedding, or nectar-producing parts of plants if bees may forage on the plants during this time.
6. Applications to all crops may be made at any time. Fenpyroximate is practically nontoxic to bees and wasps when used according to this label.

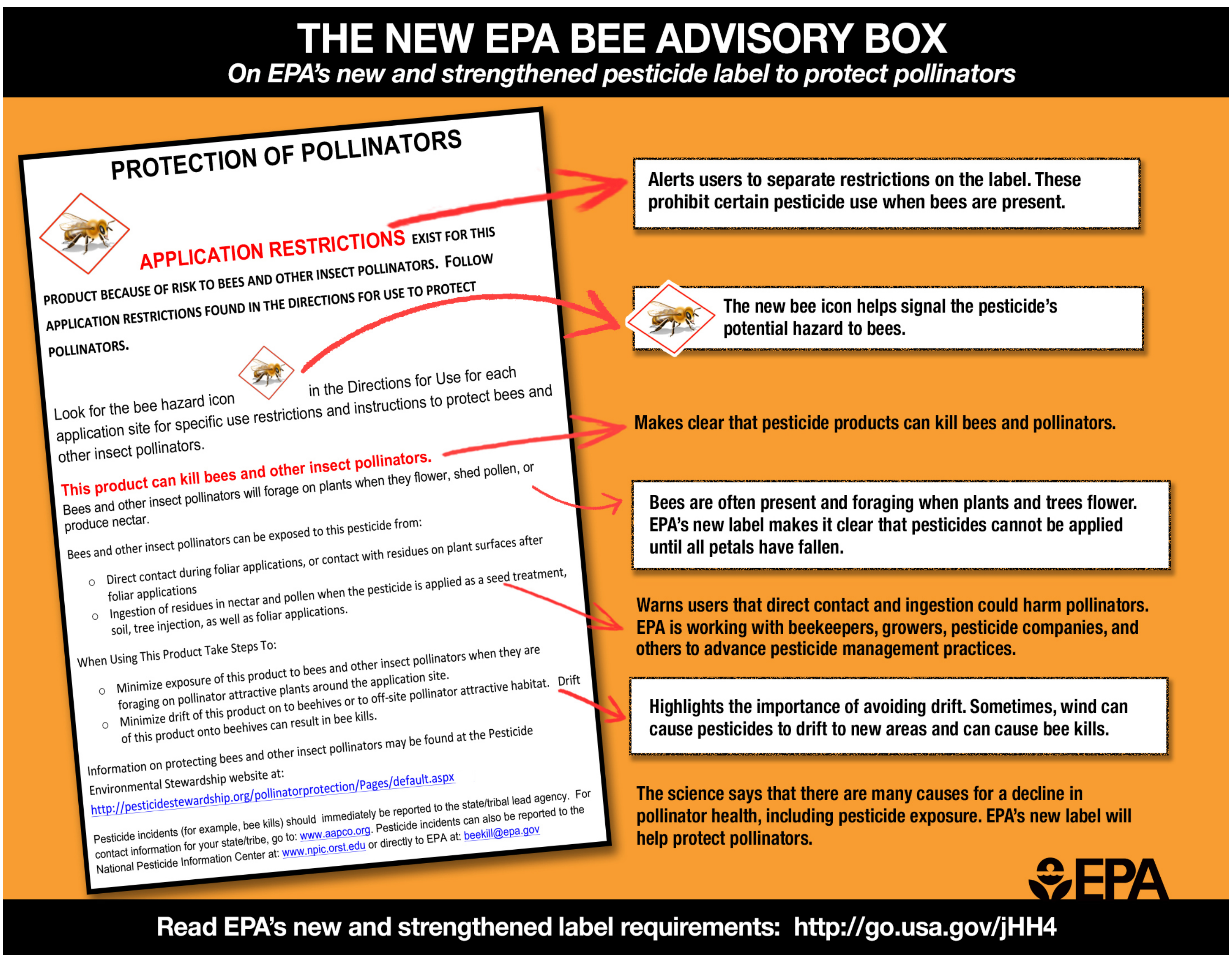
Table 1 provides a *general* template for the relationship between pesticide toxicity groupings and the corresponding pollinator protection label statements found on pesticide products. It is important to note that the EPA is in the process of reviewing pollinator protection label statements and, in some cases, requiring that revised label language be adopted by pesticide manufacturers.

The EPA is in the process of requiring additional "Pollinator Protection Labeling" for all neonicotinoid products registered for foliar use outdoors. Beginning in 2014, these product labels bear a pollinator protection portion of the label that includes a "bee advisory box" with general information concerning routes of exposure and spray drift precautions, and a "Directions for Use" portion that provides mitigation options for protecting pollinators from pesticide exposure. The EPA has also indicated that such new language may be required for pesticides other than neonicotinoids.

Table 1. Honey bee toxicity groups and precautionary statement.*

Toxicity group	Precautionary statement if extended residual toxicity is not displayed	Precautionary statement if extended residual toxicity is displayed
I – Product contains any active ingredient with acute LD_{50} of ≤ 2 micrograms/bee.	This product is highly toxic to bees exposed to direct treatment on blooming crops or weeds. Do not apply this product or allow it to drift to blooming crops or weeds while bees are actively visiting the treatment area.	This product is highly toxic to bees exposed to direct treatment or residues on blooming crops or weeds. Do not apply this product or allow it to drift to blooming crops or weeds if bees are visiting the treatment area.
II – Product contains any active ingredient(s) with acute LD50 of > 2 micrograms/bee but < 11 micrograms/bee.	This product is toxic to bees exposed to direct treatment. Do not apply this product while bees are actively visiting the treatment area.	This product is toxic to bees exposed to direct treatment or residues on blooming crops or weeds. Do not apply this product if bees are visiting the treatment area.
III – All others.	No bee caution required.	No bee caution required.

*New label requirements may cause the actual precautionary statement used to deviate from those presented here.



Neonicotinoids in pest control

Controlling pests in agriculture, urban environments, and forests is a vital function we have as stewards for our environments. The use of pesticides is just one tool we use to accomplish pest control. It is important to remember the purpose of insecticides—they kill insects. Neonicotinoid chemistry, first developed in the 1990s, represents an advancement in insecticides.

The chemical is based on the nicotine molecule that has been altered so as not to impact human nerve endings but to retain its ability to impact insects. The chemical's ability to act systemically in the plant means that applicators do not need to spray broadly but instead can target pesticide applications. With systemic insecticides, the application method can improve pest management while minimizing direct contact with non-targets (e.g. via soil applications or injections).

Additionally, the residual control nature of neonicotinoids means fewer applications are required, thus minimizing risk to the environment relative to frequent high volume applications required for other pesticides (a common alternative). Thus far, the scientific data suggest that when neonicotinoids are used as described on the EPA-approved label, they are safer for humans, safer for the environment, and safer for non-target insects than many other pesticides available.

Recognizing Mortality Due to Pesticide Exposure

Many times, acute exposure to pesticides by bees in the field (often when pesticides are sprayed during a daytime bloom) will cause an immediate lack of foraging bees, forager disorientation, and/or reduced foraging efficiency. Large numbers of dead, crawling, and walking bees at the hive entrance or intense fighting at the hive entrance can be an indication of acute poisoning. Poisoned bees will often appear confused with rapid movements, may be spinning on their backs, may appear to be "chilled," can become irritable (likely to sting) or paralyzed, or exhibit other abnormal behavior. Queens may be superseded (replaced by the workers) when a colony has been exposed to chronic pesticide doses. Lethargic, immobile bees may be unable to leave flowers or may exhibit abnormal hive dances (impaired communication).

One readily recognized symptom and good evidence of pesticide damage is the presence of many dead or dying bees near a colony's entrance. Dead and dying brood and newly emerged but dead workers are removed from the colonies and accumulate at the hive entrance. Acute pesticide exposure incidents will most often present a mass of dead bees and/or dying bees, shaking and disoriented in front of the hive, and will tend to affect most or all of the hives in an apiary, not just one. In a short period of time, however, these dead bees may dry up and the remains be blown away and eaten by ants or other scavengers. A beekeeper who visits his or her yards only occasionally may not see these dead bees and thus may not be aware that his/her colonies have been acutely exposed. Chronic pesticide exposure may present itself as poor brood development or weakened colonies that die over winter. Again, regular colony maintenance and accurate logs will keep the beekeeper informed of potential incidences.

Some of these symptoms are not always distinct and they cannot be taken as definite signs of pesticide poisoning. Many chronic management problems such as starvation, winter kill, chilled brood, or disease may present the same symptoms. These problems may be caused by pesticides in an indirect manner. It is difficult in many instances to state categorically that bees have been poisoned.

Pesticide Applicator BMPs for Pollinators

Proper pesticide use avoids harm to honey bees, their food sources, water and habitat.

Best Management Practices (BMPs) are not considered regulatory requirements (such as label directions and local ordinances), but they can be shown to provide direct benefits to pesticide users, growers, and consumers who enjoy the "fruits" of pollination. The following BMPs apply to virtually all pest management decisions and actions. Realize that there may be other BMPs, not listed below, that are specific to certain crops and locations.

- Apply pesticides only when needed. Foraging honey bees, other pollinators, and beneficial arthropods are a natural resource, and their intrinsic value should be taken into consideration. Vegetable, fruit, and seed crop yields in nearby fields can be adversely affected by reducing the population of pollinating insects and beneficial arthropods.
- Monitor and assess pest populations to determine if levels warrant control. It is always a good idea to check the field to be treated for populations of both harmful and beneficial arthropods. Pesticides play an important role in IPM but should be used only when needed.
- Pesticide applicators are required to follow the label. The label is the law and it was written in such a way to minimize product impact on pollinators. Consult with UF-IFAS extension specialists if there are questions as to the interpretation of pollinator protection provisions on labels.
- Select the best combination of pest control options that minimizes risks to pollinators.

When a Pesticide is needed

Be Alert to Bloom. The presence of bloom is the key factor influencing pollinator exposure to pesticides. Honey bees and other pollinators are most at risk of poisoning when bee-toxic pesticides are applied to crops, weeds or other vegetation that is blooming. Develop a pest management plan that considers the likelihood of bees foraging during bloom.

When feasible, it may be possible to remove blossoms of flowering weeds such as Spanish needles (*Bidens pilosa*) in the alleys of a grove by mowing before applying bee-toxic pesticides.

Avoid bee-toxic pesticide use during bloom

Consider less toxic compounds. Some pest control situations allow the grower-applicator a choice of compounds to use. Products that are hazardous to honey bees must state so on the label. Where possible, choose products with low acute and residual toxicity. Caution should always be used with “broad spectrum” insecticides, because of their general toxicity to all or most insects, including pollinators. There are special cases such as insect growth regulators, which generally have low adult bee toxicity but can be highly toxic to bee larvae. When in doubt, consult your county Extension specialist for details, recommendations, and further information about the toxicity of specific compounds to honey bees.

Labels for products that are toxic to bees may state that the applicator should not apply pesticides while crops are in bloom or may provide more specific instructions. Always carefully read and follow the instructions for pollinator safety. Such instructions may be found on the label’s environmental hazards statement, the general use directions, and/or in crop-specific use instructions. Some labels may not contain bee protection statements and others may even allow applications during bloom under some circumstances. Still others may prohibit application during the bloom season.

Be aware that pollinator statements on pesticide labels vary widely by product and crop and restrictions may also vary on whether or not the grower is paying for pollination services.

One example of such a statement follows - FOR FOLIAR APPLICATIONS OF THIS PRODUCT TO SITES WITH BEES ON-SITE FOR COMMERICAL POLLINATION SERVICES: Foliar application of this product is prohibited from onset of flowering until flowering is complete when bees are on-site under contract.

Consult IFAS or FDACS if you have questions about the meaning of label language

Use the Least Hazardous Formulation

In pesticides, the active ingredient typically is mixed with inactive ingredients to improve application and handling properties of the chemical. These are listed in percentage by weight on the label, although the specific inert ingredients are not disclosed. The mixture of active (pesticide) and inactive ingredients (solvents, stabilizers, adjuvants) is called the formulation.

Consider less toxic formulations. Not all insecticides have the same effects when prepared in different formulations. Do not assume a pesticide is 100% safe for bees if it fails to state on the label that it is not toxic to bees. Remember that some pesticides may affect brood or produce unknown, long-term effects from low-dose, chronic exposure. Whenever possible, use formulations of pesticides that are less hazardous to bees. Also, if the pesticide label and pest management programs allow, avoid tank mixing different classes of pesticides or applying premixes of more than one active ingredient. The synergistic effects of pesticides on bees and other pollinators are not well known and should be considered with caution. Theoretically, the impact of some tank mixes on pollinators may be more detrimental than the impact of these materials when applied alone. Finally, consider lures, baits, and pheromones as alternatives to insecticides for pest management. Many have been developed to target the mating of some insect pests and thus may be safer to bees than toxicants.

Not all pesticides have the same effects or toxicities when prepared in different formulations. The following list includes the formulations that may pose hazards to bees and other pollinators. The formulations are listed in the general order of toxicity to bees from most toxic (microencapsulated pesticides) to least toxic (granular pesticides), though exceptions exist for each formulation.

- Microencapsulated insecticides tend to be more toxic to honey bees than other formulations developed. The active ingredient is encased in a polymer sphere similar to the size of a pollen grain that either abrades to release its contents or it oozes out over time. Because of their size, these capsules are carried back to the colony and can remain toxic for long periods. The risk of drift with microencapsulated insecticides generally is low due to low application pressure.
- Dusts, similar to the size of pollen, stick to the bees and are generally more hazardous than liquid formulations. They carry a drift risk due to their fine particle size.
- Wettable powders have particles that form a suspension but do not dissolve in water. They can be applied as a liquid spray and are generally more hazardous than

liquid formulations. There is a low risk of drift if the liquid is applied at low pressure.
- Ultra-low-volume (ULV) formulations are usually more toxic than other liquid formulations because of the high concentration of active ingredient and high drift risk. High concentration solutions are diluted by a powerful air flow into a large volume of air to produce a very fine droplet size prone to long distance drift.
- Emulsifiable concentrates and solutions or soluble powders are hazardous in that they are directly sprayed and can leave residues on foliage. The drift risk depends on application pressure and spray tip height. Emulsifiable concentrates formulations usually are less hazardous to bees than wettable powders because the powders remain toxic in the field longer.
- Seed coatings are applied directly to seeds. Bee exposure should be minimal, though the active ingredient can transfer to the talc carrier during planting. The resulting dust can drift onto blooming crops, weeds, adjacent habitat, etc.
- Generally, granular formulations are the least hazardous to bees because of their large size and low drift risk. Granular formulations are dissolved and activated during rain or irrigation, when bees are less active, and are distributed directly into the soil or thatch.

Systemic insecticides can be delivered in any formulation, and they warrant additional consideration. They are usually applied to soils or foliage, or are injected into the plant. The plant absorbs the active ingredient, which may translocate to nectar, pollen, guttation droplets, and the honeydew of sucking insects, thus being available to foraging bees

Employ Residual Toxicity Safeguards

Many bee-toxic pesticides can be used on blooming crops in an appropriate “window” of time. Evening applications are generally the least harmful to honey bees, but stricter application restrictions may be necessary when a pesticide has extended residual toxicity (ERT). Pesticides that have an ERT to bees of more than 8 hours are hazardous when that toxicity will extend into the period of bloom. Pesticides that do not have ERT, or an ERT of 8 hours or less, have a more flexible application “window.”

Check the Weather

Environmental conditions affect pesticide persistence. Daytime applications at low temperatures may cause some classes of pesticides to remain toxic much longer than during warm weather. Cloud cover also may prolong toxicity due to lower levels of ultraviolet light which breaks down many pesticides. Do not apply bee-toxic pesticides with extended residual toxicity on nights when dew is forecast. Dew may re-wet pesticides and increase bee exposure.

Environmental conditions also affect bee activity. When high daytime temperatures encourage bees to begin foraging earlier or continue later than usual, adjust application times of bee-toxic pesticides accordingly. Experience shows that when bee-toxic pesticides are applied before or during cold nights, followed by warm summer days, the incidence of bee kills greatly increases.

Honey bees fly when the air temperature is above 55°F – 60°F and are most active from 8 a.m. to 5 p.m. Always check a field for bee activity immediately before an application, when the pesticide label bee protection statements apply. Evening applications, if allowed, may provide time for some pesticides to degrade or dry during the night. Be conscious of early days and longer hours in the peak of the summer, when bees will typically forage earlier and longer. Also, consider avoiding application during unusually low temperatures or when dew is forecast because under these conditions sprays remain wet longer and their residues can persist.

Minimize Drift

Honey bees visiting the blooms of crops and/or weeds near target crops and may be unintentionally impacted by drift and pesticide residues. Keep the product on the intended area/crop and apply pesticides with equipment that has been calibrated for the particular application.

In general, ground applications are less hazardous to bees than are aerial applications. It is very important to reduce pesticide drift to non-target crops and vegetation. Drift-reducing application techniques include spray technologies such as drift-reduction nozzles and the use of drift-retardant adjuvants, determining whether to use ground or aerial applications, avoiding applications during windy conditions, and using windbreaks, hedgerows, and vegetative buffers around crops. These activities will reduce the incidence or severity of honey bees’ exposure to pesticides and aid in protecting non-managed pollinators. Although the above rules of thumb can be helpful, remember, ultimately you are responsible for complying with the specific label instructions of the pesticide product you are using.

Consider non-cropped areas.

Before treating a field with pesticides, determine the presence of other blooming plants and weeds (such as clover, Spanish needle, etc.) that might attract bees. In some instances, bees have been killed even though the crop being sprayed was not in bloom. Some label statements restrict applications when weeds are in bloom. Attractive blooms in areas to be treated often can be mowed or otherwise removed, although mowing may not always be the best option because it can destroy other beneficial insect habitat or force destructive insects into the crop being cultivated. Applicators should also be aware of pesticide drift to non-target vegetation, because the vegetation can serve as a refuge for pollinators and a supply of nesting materials for native bees.

Provide Clean Water

Beekeepers and growers should discuss and address the need for clean drinking water for bees, particularly when the weather is warm. This should include multiple stations. Water does not have to be limited to human-made stations (for example, a river, lake or pond, if it provides clean water, would do).

Do not contaminate water. Bees require water to cool the hive and feed the brood. Avoid contaminating standing water with pesticides or draining spray tank contents onto the ground, creating puddles to which bees may be attracted. Be mindful that contaminated water can also come from drip irrigation being used for chemigation (application of pesticides through the use of irrigation), runoff, improper storage or spills, irrigation ditches, and leaking pipes. Vinegar may be added to these puddles as a bee deterrent.

Know your farm and your crop. Understanding your crop and its pollination requirements might be the best tactic in deciding how to use pesticides and minimize the exposure to pesticides of non-target pollinators likely to be visiting your crop site and nearby areas. Understanding bloom times, pollination needs, and the environmental variables that affect them is crucial to developing a plan that protects honey bees and other pollinators while keeping pests at bay. Consider hiring an IPM professional or consult with your county Extension specialist for help identifying species of crop pests, their abundance, and life cycle. A crop- and season-specific approach to pest management may reduce the overall need for chemical pesticide application.

Conduct a native bee survey. Your crop may already be pollinated by unaccounted-for species of native bees. Your knowledge of the species and nesting preferences will aid in preventing unintended exposure. Crop-edges and vegetation patches within and surrounding planted areas on a farm provide habitat and additional forage for pollinators. Consider reducing herbicide applications in these areas because “weeds” can act as refuge and habitat for other pest-controlling beneficial insects. Consider planting vegetative buffers of non-noxious weeds and other nectar- or pollen-producing plants around crops and on-site apiaries to provide additional refuge and forage for bees and other pollinators. Protect the pollinators visiting these buffers by designating the buffers as no-spray zones. It is important to note that not all weeds are beneficial; some are sources of crop pests and pathogens, so it is best to conduct a farmscape analysis in collaboration with UF/IFAS Extension specialists when managing weeds for pollinators.

Communicate with Beekeepers

Cooperation and communication among growers, applicators, beekeepers, crop advisors and local officials greatly increase sthe likelihood of success in protecting pollinators and their habitats. Take the initiative to establish good relations and communication with commercial and local beekeepers.

Notify beekeepers. If beekeepers are notified in advance of application, colonies can be moved away from the treatment area. Florida law requires every apiary or bee yard to be plainly marked with the owner’s name, address, and telephone number.

Cooperation between applicators, growers, beekeepers, Extension workers, and government officials is necessary to control problem crop pests and protect pollinators from pesticide exposure. The key to this cooperation is constant communication fostered by trust on the part of all involved. Protecting honey bees and other pollinators from pesticides can be difficult despite the fact that many of these chemicals are not considered hazardous to bees. There are many variables in the decision-making process leading to pesticide use, and the protection of pollinators is likewise a complicated undertaking. In general, pollinators die when pesticide applications are made based on insufficient information and/or made without regard to the safety of pollinators.

It is recommended that growers and beekeepers develop a contract of agreement before placing honey bee colonies onto managed agricultural land. Some points to consider within this agreement include the number and placement of hives, the duration of the colony presence, identification of temporary holding zones for when bees need to be moved, signage for no-spray or buffer zones, liability limitations for each party, and methods of contact (see next section for more information on agreements). Land managers and beekeepers must maintain an open line of communication throughout the season.

If crop-specific or season-specific spray-schedules are known, this information could be released to a beekeeper who may be interested in moving their hives onto the property. For resident honey bee colonies, this and additional advanced notification of intermittent pesticide application would allow honey bee colonies to be moved.

Learn about Local Regulations/ Programs

In Florida, the Florida Department of Agriculture and Consumer Services (FDACS) maintains a website which provides information about pollinator protection. **http://www.freshfromflorida.com/Business-Services/Bees-Apiary/Florida-Bee-Protection**. Florida requires that commercial beehive operations register the location where hives are being kept.

The future sustainability of bees and agriculture depends on defining and respecting the complex relationship between bees and pesticides. Agricultural pest management schemes and the use of chemical pesticides to combat crop pests must be done cautiously and in balance with the intrinsic value of the native and honey bee pollinators. In many cases, the success of one is tied to that of the other. Implementation of the outlined risk-reducing strategies in this document and use of the explanations of the laws, labels, and associated definitions will help maintain the delicate balance between pollinators and crop production. There is no doubt that communication between beekeepers and growers and other pesticide applicators is the best line of defense in protecting honey bees and other pollinators from harmful exposure to pesticides.

Those who use pesticides, who are affected by pesticides, and who make decisions regarding their applications should not only read the pesticide label but also understand the meaning of label wording.

Remember, when using pesticides: the label is the law.

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Florida Department of Agriculture and Consumer Services – Florida Bee Protection Website - **http://www.freshfromflorida.com/Business-Services/Bees-Apiary/Florida-Bee-Protection**