POLLINATION AND PROTECTING BEES AND OTHER POLLINATORS

Home Garden Series

FS174E

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Pollination and Protecting Bees and Other Pollinators

Introduction

Pollination is a critical process that most plants need to set seeds and produce fruit. Understanding pollination ecology is important for both commercial growers and home gardeners; however, this publication focuses on the home gardener. The following information will help gardeners optimize pollination conditions to ensure maximum seed and fruit quantity and quality. If more information is needed, see the References and Further Reading sections at the end of the publication.

What is pollination? Pollination is the transfer of pollen from the male part of the plant to the female part of the plant of the same species. Figure 1 shows a honey bee pollinating an apple blossom. The anthers, the male part of the flower, produce pollen. The pollen must be transferred to the upper female part of the flower, the stigma. Here the pollen germinates and grows down the style (the elongated portion of a pistil that connects the ovary with the stigma of a plant) (see Figure 2) to where fertilization occurs and the seeds develop in the ovaries. A fruit is a ripened ovary. Usually transfer of pollen occurs with the help of animals (insects, birds, and bats), but gravity, wind, and water can also transport pollen (Willmer 2011).

Figure 1. Honey bee collecting nectar from an apple blossom. (Photo courtesy Kathy Keatley Garvey, University of California, Davis)

Pollination is needed to produce seeds and to ensure uniformly shaped fruits and vegetables. The diversity of insect pollinators is quite extensive and includes flies, butterflies and moths, and beetles, but bees are, by far, the primary pollinator of many fruits and vegetable plants.

Without bees providing pollination, the number of fruits and vegetables will be reduced significantly. Bees are not necessary for the growth of vegetable plants themselves, but they are necessary for producing the seeds to grow them.

How important are bees? Directly or indirectly responsible for a third of our food, bees pollinate the majority of the types of food we eat. So protecting bees and understanding how human actions can enhance or hinder their well-being is critical.

Flowers

There are many types of flowers, from very simple to very complex, and each has evolved ways to ensure successful plant reproduction. Some plants are self-fertile and require no external assistance for pollen transfer. Wheat, for example, is self-fertile, and pollination occurs within the flower before it opens.

Other flowers are self-fertile but still dependent upon wind, water, or animals to help the transfer of pollen to the stigma. Depending on the plant species, the pollen may need to come from another plant or another variety of the same species to set seed. The transfer of pollen from one plant to another plant is called cross-pollination. Cross-pollination helps to increase the fitness and survival of plants by increasing genetic diversity.

Evergreen trees, called conifers, are wind pollinated; these trees include pine, fir, and hemlock. In the Pacific Northwest large amounts of "yellow-green dust" fill the air in the spring. This is pollen from the conifers or evergreen trees, and it is an "expensive" way to pollinate, from the plant's point of view. Plants that rely on wind must produce massive amounts of pollen to ensure an adequate amount is available for successful pollination.

Pollinators

A far more efficient means of pollination is to attract an animal that will travel from flower to flower and transfer the pollen between plants. Of the more than 250,000 flowering plant species in the world, most (over 75%) rely on animals for pollination. Most of these animals are insects, although birds, and even some bats are important pollinators (National Research Council 2007).

Between 130,000 and 300,000 species of animals regularly visit flowers and pollinate while in the process of feeding. These animals visit flowers for food; the pollen itself provides protein and the nectar provides sugar (carbohydrates).

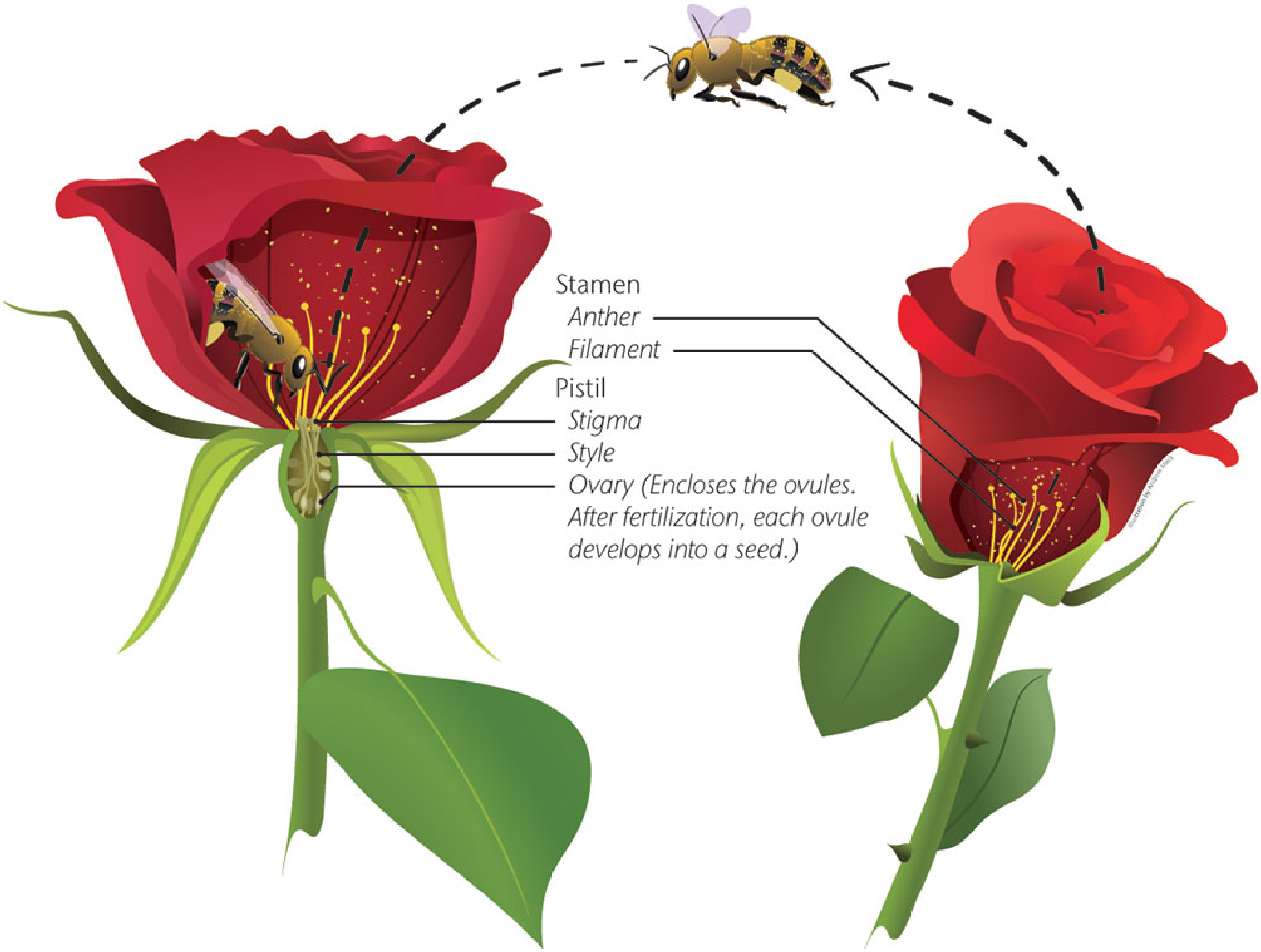

Figure 2. Parts of the flower where bees need to collect and deposit pollen for successful pollination. (Illustration by Andrew Mack, Washington State University.)

Besides protein, pollen contains other nutrients such as starch, sugars, fat or oil, minerals, antioxidants, and vitamins like thiamin (Abrol 2011). The most common type of animals that regularly visit flowers include ants, bats, bees, beetles, birds, butterflies, flies, moths, and wasps. Insects are by far the most common flower visitors. Of the insects, bees are the most important pollinator.

The hairy body of the bee and its ability to fly quickly from flower to flower make it perfectly adapted for this job. There are more than 4,000 species of bees in North America and more than 20,000 worldwide. Almost all bees rely on pollen as their only source of protein and an important dietary resource for essential vitamins and minerals. The ability of European honey bees to adapt to artificial nest sites (beehives) makes them easy to move when and where pollination services are needed. Honey bees have become the most important managed pollinator throughout most of the world.

Attracting pollinators

Plants use many ways to attract pollinators to visit their flowers, including color, shape, scent, and food reward. The number of flowers in a location and on each plant, and their accessibility, are all factors attracting animals to seek the rewards plants offer in exchange for transferring the pollen.

Many insects are attracted to ultraviolet light, and birds are able see into the infrared spectrum, both of which are invisible to the human eye (Kevan, Chittka, and Dyer 2001). Flowers may display ultraviolet or infrared patterns that help guide an animal to the food reward, and, most importantly from the plant's perspective, the transfer of pollen (Thorp et al. 1975). Some plants also provide electrostatic cues to the pollinator to help them identify flowers that have not yet been visited sufficiently for effective pollen transfer (Clarke et al. 2013) .

Pollination effectiveness

Not all animal visitors to flowers are effective pollinators. Just because an animal is visiting a plant for its many rewards does not mean the visitor is a good pollinator. Some animals can gain access to pollen or nectar rewards without transferring pollen. For example, a hummingbird, with its long beak, can take up the nectar reward in some plants without touching or transferring the male pollen to the female parts of the flower. Some bees learn to bypass the process by cutting holes in the side of the flower and gaining quick access to nectar.

Some pollinators visit many different types of flowers during the day, which is good for the insect but not the best strategy for the plants it visits. A pollinator that visits many different kinds of flowers will transfer pollen, but it may not transfer enough of the right type of pollen for the plant to set seed and produce fruit. Transfer of the wrong type of pollen could actually reduce the chances of seed set, by clogging the stigma. A plant that must be cross-pollinated needs pollen from a compatible plant of the same species to land on its female receptor (the stigma) to succeed in setting seeds and producing fruit. Honey bees are generalists as a colony. Forager bees from one hive can visit many different species of plants, but each bee is a specialist, visiting only one type of flower on each flight. Other types of bees are true specialists. For example, the squash bee (Figure 3), a very common bee throughout North America, visits only plants that are in the cucurbit family (that is, cucumbers, pumpkins, zucchini, melons, etc.).

Figure 3. Close-up of the tiny squash bee, genus ***Peponapis***. (Photo courtesy Kathy Keatley Garvey, University of California, Davis)

Collectively bees are by far the best adapted animals for transferring large amounts of compatible pollen to flowers. The key factors that make them good pollinators are that:

- Bees have hairy bodies, the hairs are very feathery in appearance (Figure 4) and are capable of trapping and holding large numbers of pollen grains.

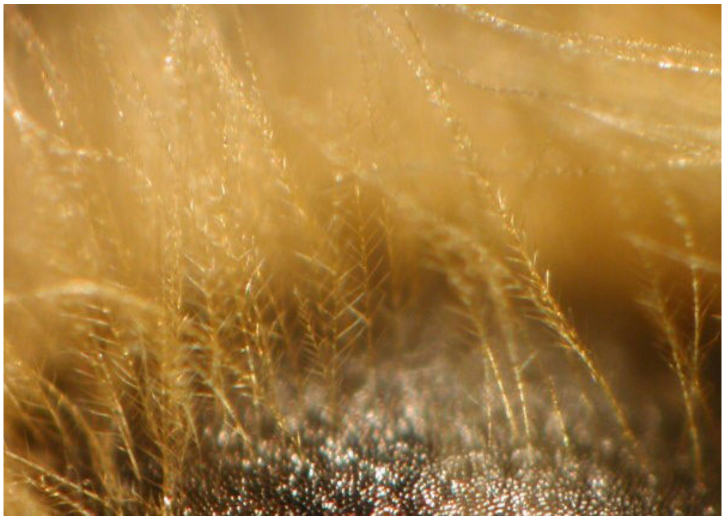

Figure 4. Close-up of feathery hairs on a honey bee, which are well adapted to collect pollen. (Photo courtesy Zachary Huang, Michigan State University)

- Bees generate static electricity as they fly through the air and this helps hold pollen on their bodies. The very small pollen grains stick to the body of the bee and are then transferred to the next flower visited.
- Most bees have a specialized body structure for carrying pollen. Some bees, including honey bees, have pollen baskets on their hind legs. These baskets are called corbicula. The pollen on the hind legs of bees is carried back to the hive to feed the bee larvae (baby bees). Other bees, such as leaf-cutter bees, collect pollen on a dense mat of hairs on the underside of their abdomen. These specialized structures for carrying pollen give the bees the ability to visit many flowers on a single collection trip, thus improving the distribution of pollen. When the bees groom the pollen grains off their body hairs and transfer them to the pollen-holding area, some of them will fall off and land on the waiting stigma. This process completes pollination and begins the flower's fertilization process.
- Bees have vision that allows them to pick up on visual cues provided by the plant. Bees can see the ultraviolet light range and can detect electric fields provided by the flower.

- Some bees "buzz pollinate" by shaking the pollen grains from the anthers (the male part of the plant) onto their bodies or directly onto the stigma (female part) of the flower. These plants have co-evolved with the buzz-pollinating species of bees. Some bees buzz more effectively than others. Bumble bees, for example, are very good "buzz pollinators." Plants like tomatoes and blueberries can release more pollen when they are "buzz pollinated."

Both honey bees and the many native bee species are critically important for pollination of our many fruit and vegetable plants. It is our responsibility to improve bee habitat and to protect bees from toxins and pests in the environment.

The Decline in Honey Bee Populations

There are many factors involved in the decline of honey bees—one of the most notable is a parasitic mite (*Varroa destructor*) that vectors (transfers) pathogens. This mite is a major threat to the U.S. honey bee industry. It is directly and indirectly responsible for the loss of tens of thousands of honey bee colonies every year. Varroa first appeared in the United States in 1987. This mite weakens honey bees (Figure 5), making them more susceptible to toxins and pathogens such as viruses, bacteria, and fungi. The Varroa mite is by far the largest single cause of honey bee decline. However, the decline in bees is complex and researchers have identified multiple variables contributing to their decline.

Figure 5. Varroa mite, Varroa destructor, on a honey bee. Photo courtesy of the Electron and Confocal Microscopy Laboratory, Agricultural Research Service, U. S. Department of Agriculture (USDA-ARS).

Reducing Pesticide Hazards for Bees

Bees are insects that are often exposed to pesticides that can have both lethal (dead bees) and sub-lethal (harmful) effects. Recent research has shown that even chemicals that do not kill bees outright can cause them to become disoriented, less efficient at what they do, and/or reduce their life span. Thus, it is critical to be cautious when using pesticides, and only use them when absolutely necessary to control an outbreak of pests.

There are some important precautions that are good to follow when applying chemicals on plants:

- Avoid spraying whenever bees are or might be flying. It can be difficult to see some bees on some types of flowers. Additional precautions should be used when using pesticides where flowers are present.
- Try to spray before bloom or after the flowers are done blooming.
- Look for other flowers that may be blooming nearby or on the ground below the tree or bush to be sprayed. Look around for other flowering bushes or trees where the pesticide may drift.
- Try not to spray just before or during bloom, but if it is necessary, try to spray at night or very early in the morning, before the bees are flying. Once the spray has dried on the plant, it may be less toxic to bees.
- Avoid spraying if there is heavy fog or dew, as this will keep the pesticide wet and will increase the chance of the bees receiving a toxic dose.

If a pesticide must be used on fruit trees, and/or vegetable or landscape plants just before or during bloom, use a product with low toxicity to bees. Look for the "Protection of Pollinators" section on the label for information on the toxicity of the product to bees (Figure 6). Always follow label recommendations when applying any product.

Bees are sensitive to many pesticides approved for use around the home, including neonicotinoid (pronounced neo-nih-CAH-tin-oid) and pyrethroid (pronounced pie-ree-throid) insecticides. Recently, there has been a great deal of concern that neonicotinoid insecticides (also known as "neonics") are *the* cause for the decline of honey bees (see sidebar). To date, there is insufficient scientific evidence that pesticide exposure from contaminated pollen or nectar is the cause of bee decline. However, these insecticides can be harmful to bees if not used properly. Be careful whenever applying any pesticides. Again, always read and follow the label instructions.

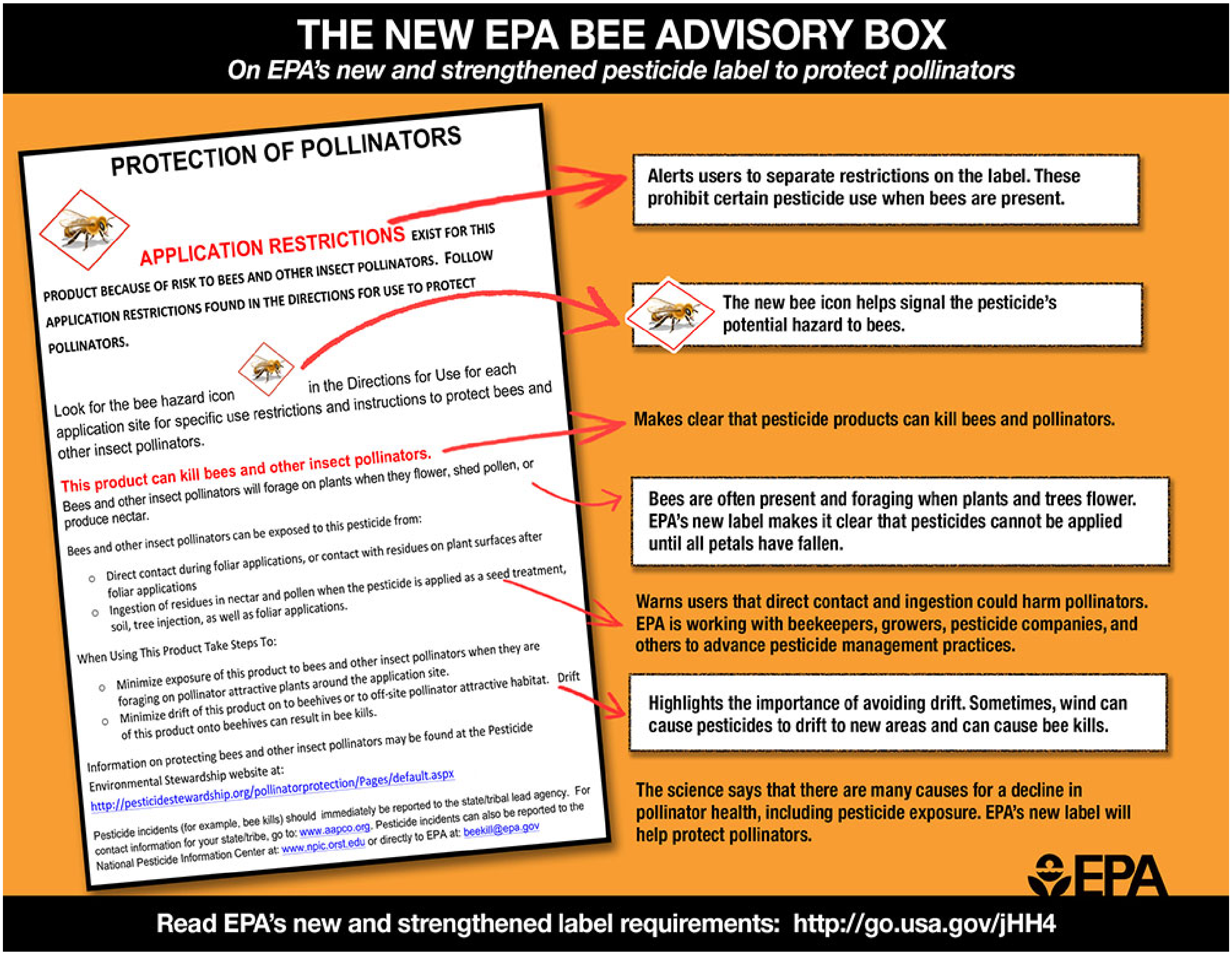

Figure 6. A portion of the new EPA Protection of Pollinators label.

The most important thing you can do to help bees is to PLANT FLOWERS!

Aside from limiting pesticide exposure, one of the most important things that can help bees is to grow flowering plants. Bees are healthier when they forage upon a diversity of pollen and nectar sources. One recent study has demonstrated that bees that receive a natural diet are better able to detoxify chemicals including pesticides (Mao, Schuler, and Berenbaum 2013). An abundance of nectar and pollen can reduce the impact of pesticide exposure on bees.

Many plants that are native or eco-appropriate (non-invasive) are good sources of nectar and pollen for bees and do well without the need for pesticides. Plants such as lavender, chives, borage, sage, oregano, sunflowers, phacelia, clover, mint, and dandelion are all excellent sources of pollen and nectar, and they grow well without pesticides.

The WSU Extension office, local nurseries, or the Ecoregional Planting Guides on the Pollinator Partnership website at http://pollinator.org/guides.htm are good resources for ideas on pollinator-friendly plants.

Summary

Many plants need pollinators to set fruit or to ensure adequate seed set and uniformly shaped fruit. The diversity of pollinators is quite extensive, but bees are the primary pollinator of fruit trees and vegetables. Without bees, the amount of fruit produced will be significantly reduced. Thus, it is very important to limit the exposure of bees to pesticides, most notably insecticides and fungicides.

A good general rule is to avoid spraying whenever bees are present or when flowers are blooming. This includes not only the blossoms on the trees themselves, but also flowers on the ground or nearby bushes and shrubs.

Neonicotinoids have been in the news recently because of concerns about the impact they have on bees and other pollinators. These insecticides (that are a class of pesticide) can be taken up by a plant through its roots or seed coat and move through the plant just like water and nutrients. Foliar applications penetrate through the leaves and remain in the leaf cells, but can also move to other parts of the plant.

These insecticides provide very effective control of piercing and sucking insects. They are also very effective treatment for certain beetles, fleas, flies, and cockroaches (Elbert et al. 2008). The big advantage of neonicotinoids is that they are very safe for use around people and pets. Because of their effectiveness and relative safety, neonicotinoids have become one of the fastest growing classes of pesticides used in agriculture and in home and garden products.

Over the last few years, the neonicotinoid class of insecticides has become important for use in agriculture and home landscapes (Jeschke and Nauen 2008). According to the Washington Department of Agriculture (Erik Johansen personal communication), there are approximately 480 products containing neonicotinoids ("neonics") approved for use in the state of Washington. Approximately 200 neonics are approved for use in the home and garden.

Because neonicotinoid products move systemically throughout the plant, there is far less direct pesticide exposure to both the person applying the pesticide and the environment. Ironically, it is this systemic action that can make the neonicotinoids a problem for honey bees and other pollinators after the application is completed. Neonicotinoids spread within the entire plant and can sometimes be found in the nectar and pollen of the flowers long after they have been applied to the plant. There is little evidence to support the idea that exposure to neonicotinoids contained in pollen and nectar is a cause for the decline in bee populations. On the other hand, foliar application (spraying) of neonicotinoids when bees are present often kills them. To keep bees safe, caution should be used when using neonicotinoids or any other pesticide.

Some of the more common "active ingredients" in neonicotinoids include: Acetamiprid; Clothianidin; Dinotefuran; Imidacloprid; Thiacloprid; and Thiamethoxam. Again, take precautions with these or any pesticide and avoid using them when bees are present or during and just before flower bloom. For more information, please see *Neonicotinoid Pesticides and Honey Bees* (Lawrence and Sheppard 2013) at http://cru.cahe.wsu.edu/CEPublications/FS122E/FS122E.pdf.

If the use of a pesticide is necessary, use a product with low toxicity to bees, and do not apply until late in the day, just before dark, or early in the morning, when bees are not present.

Always follow label recommendations when applying any chemical product. Finally, consider using flowering plants that do not need to be sprayed to control pests. Plant a variety of flowers throughout the garden, including some that will bloom in the early spring and others that continue to bloom right up to the first frost in the fall. Planting a diversity of flowers improves bee habitat and is perhaps the single most important thing that can be done to help bees.

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Further Reading

Washington State Department of Agriculture. 2013. *10 Ways to Protect Bees from Pesticides.* Washington State Department of Agriculture Pest Management Division. http://agr.wa.gov/fp/pubs/docs/388-TenWaysToProtectBeesFromPesticides.pdf.

Use pesticides with care. Apply them only to plants, animals, or sites as listed on the label. When mixing and applying pesticides, follow all label precautions to protect yourself and others around you. It is a violation of the law to disregard label directions. If pesticides are spilled on skin or clothing, remove clothing and wash skin thoroughly. Store pesticides in their original containers and keep them out of the reach of children, pets, and livestock.

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