USDA National Agroforestry Center

AGROFORESTRY NOTES

AF Note — 35

June 2007

Pesticide Considerations For Native Bees In Agroforestry

Introduction

Over 100 crop species in North America require insect pollinators in order to be most productive. In the past, native bees and feral honey bees could meet the pollination needs of smaller orchards, fields of sunflower and pumpkins, and berry patches. Those farms were typically smaller, more diverse, and adjacent to habitat that harbored important pollinators. Today, many farms are large, have less nearby habitat, and commonly rely on honey bees for crop pollination and pesticides to control weeds and pest insects. Native bees, however, can still be important crop pollinators when habitat is available (see *Agroforestry Notes* 33 and 34) and when they are protected from pesticides. The relative importance of native bees may increase if the number of honey bee colonies available for pollination continues to decline as it has over the past 50 years.

Pesticides are tools commonly used to control weeds and pest insects. However, pesticide use must be balanced against the importance of maintaining healthy populations of crop pollinators that can be damaged by pesticide applications. Agroforestry practices together with best management practices can help to reduce the unwanted side effects of pesticides and provide a refuge for native pollinators.

Overview

Herbicides. While herbicides don't directly target pollinators, they can destroy plants that provide flowers when crops are not in bloom. Herbicides are commonly applied around the edges of fields and elsewhere in the agricultural landscape for weed control or site preparation. Unless substitute flowers are available nearby, bees nesting on a farm are subsequently forced to forage more widely for nectar and pollen, which requires more energy and exposes them to more threats. As a result, they produce fewer offspring to emerge the following year.

Insecticides. Insecticides target insects and, depending upon the active ingredient and how it is formulated and applied, have a wide range of toxicities to bees. Foraging bees are poisoned by insecticides when they absorb the fast-acting toxins through their exoskeleton, drink toxin-tainted nectar, or gather polluted pollen or micro-encapsulated insecticides. Although an application of toxin can directly kill bees on contact, most poisonings occur when bees contact insecticide residue on plants in the hours or days after application.

This "no spray" sign, along the edge of an organic farm outside Salem, Oregon, is recognized by the Oregon State Department of Transportation. Well identified "no spray" areas provide a safe haven, free from pesticides, for wild bees to nest and forage. *Photo by Brian Baker, Ph.D., Organic Materials Review Institute, Eugene, Oregon. Used with permission.*

Poison risk is not restricted to contact with insecticides in the field. Slow-acting toxins may be carried back to the nest where they are stored with pollen and nectar and later eaten by larval bees. Contaminated pollen can remain toxic for a long time, killing the larvae or, in social species, the other adult bees in the nest. Also, many solitary bees gather nest-building materials, such as pieces of leaves, mud, plant hairs, or plant resins. If these materials are taken from a recently treated field, they too will contaminate bee nests.

Bee kills are not the only impact of insecticides. Sub-lethal doses of insecticides can affect the behavior of pollinators. Bees that are exposed in the field may have trouble navigating their way back to the nest after foraging, or they may simply be unable to fly. All of these changes in behavior make foraging and nest building difficult and, ultimately, lead to the premature death of bees and their offspring.

Agroforestry and pesticides

A properly designed agroforestry practice can reduce the impact of, or need for, pesticides in several ways.

Reduce drift. Windbreaks, hedgerows, riparian buffers, or alley cropping can help contain drifting pesticides, either those coming onto or leaving a farm. Tree and shrub layers provide a large surface area over which droplets or particles of pesticides may adhere, and the windspeed reduction at the application site reduces the movement of pesticides off their target. The ideal design of such agroforestry barriers remains elusive, as the vegetative porosity and wind flow turbulence through and around windbreaks is difficult to quantify and, therefore, hard to correlate with drift reduction. However, a growing body of literature demonstrates that windbreaks can reduce drift by up to 80 to 90 percent, and even single rows of trees or shrubs have a positive impact. Preliminary wind tunnel studies demonstrate that evergreen species have a capture efficiency of two to four times that of broadleaf species. Most drift originates from the boundary of sprayed areas. Therefore, properly designed agroforestry practices can greatly reduce the off-target movement of pesticides when combined with unsprayed buffer zones adjacent to non-target areas (see “Best management practices” below).

Provide refugia. Windbreaks, hedgerows, and riparian buffers serve as safe havens for pollinators if they are well protected from insecticides. These agroforestry refugia may hold pollinators by providing supplemental forage (see *Agroforestry Note* 33: Improving forage for native bee crop pollinators) at times when nearby crop fields are sprayed with insecticides, so long as these crops are not in flower. At the same time, refugia can provide unpolluted nesting habitat (see *Agroforestry Note* 34: Enhancing nest sites for native bee crop pollinators).

Supply habitat for pest-controlling insects and pollinators. The diverse vegetation structure and floral resources that can be incorporated into agroforestry practices can provide the permanent microclimate and food (pollen and nectar) necessary to encourage beneficial insects, such as predators or parasites of pest insects. Ideally, these beneficial insects can be part of an integrated pest management program that helps to reduce the need for pesticide applications, and thus their impact on pollinators.

Best management practices

If the pest level has reached an economic threshold and pesticides must be used, the following steps can be taken to minimize their risk to pollinators and other beneficial insects.

Reduce the impact of herbicides

- **Look twice at weeds.** While some weeds are truly noxious, pose a direct threat to adjacent crop production, or harbor pest insects, others pose little risk and may in fact provide abundant pollen and nectar for pollinators and other beneficial insects. If weeds are indeed noxious and herbicides are the best management tool, application should be limited and targeted. For example, spot treat invasive weeds, rather than apply a broadcast spray. Targeted treatments allow other plants to flower, providing nectar and pollen for foraging bees.

- **Consider planting non-weedy substitutes** that feed bees, such as fodder legumes, or native forbs. These plants may suppress weeds while shrubs and trees are being established, and also provide forage for bees. Mulching around the base of new plantings will also help control weeds and will conserve water at the same time.

Reduce the impact of insecticides

- **Active ingredients and specificity**. Choose active ingredients that will have the least impact on bees. Some insecticides, such as Bacillus thuringiensis (Btk) for caterpillars, are targeted to particular pests and have little or no impact on native bees. Other active ingredients, however, are very deadly to bees. These are known as "broad-spectrum" insecticides because of their general toxicity to insects and often times vertebrates too. *Broad-spectrum insecticides should only be used when field scouting indicates a significant pest problem, not on a calendar spray schedule, and then in ways that are safe for bees (see below).* [Note: Specific lists of the toxicity of various active ingredients for bees can be found in Riedl et al. (2006)].

- **Application method.** To have the least impact on bees and to minimize drift, apply insecticides from the ground. Fine sprays pose less of a hazard to bees than coarse sprays. Apply when weather conditions are optimal for reducing drift, such as when the wind is calm. To minimize drift from a target area, ideally leave a 25 foot pesticide-free buffer around the edge of the target spray area.

- **Formulation.** Use formulations that are safest for bees. The insecticide formulations at the top of this table are significantly more hazardous to bees than those toward the bottom. Micro-encapsulated products (not included in the table), if formulated using a traditional broad-spectrum insecticide, offer a unique threat to developing larvae in the nest because foraging bees will gather them like pollen and bring them back to the nest where they slowly release their active ingredients.

Formulation	Hazard level
Dust	Worst
Wettable powder	
Flowable	
Emulsifiable concentrate	
Soluble powder	
Solution	
Granular	Least

- **Timing.** Insecticides that are toxic to bees never should be applied to a crop in bloom, or to adjacent blooming plants. Insecticides that are less toxic to bees or degrade quickly may be applied over flowers when pollinators are not active, such as in the late evening, after bees stop foraging for the day. However, even if insecticides don't outright kill the bees visiting the crop, insecticide residue left on the plants still may have some negative impact, especially on smaller bees.

- **Temperature and dew.** Temperature and dew have a significant effect on the duration of toxicity of most insecticides. In general, cooler temperatures result in much longer periods of toxicity, and dewy nights cause the insecticide to remain wet on the foliage and thus more toxic to bees the following morning. In general, it is better to apply insecticides when the weather is warmest. Keep in mind, when it's hot, bees are active both earlier in the morning and later in the evening.

- **Label guidelines.** Never apply more than the label recommends. Also, guidelines for protecting honey bees require that beekeepers move hives away from spray areas or shut the bees in and cover their hives during spraying operations, and that pesticide applicators avoid spraying over apiaries, alkali bee beds, and so forth. Such protective measures are not possible with wild bees.

- **Consider non-pesticide solutions.** Other alternatives to pesticides should also be considered. For example, planting crop varieties that are resistant to pests will lessen the need for insecticides. Also look for lures, baits, and pheromones for mating disruption, tools that are solving more and more pest problems.

Conclusion

Windbreaks, hedgerows, riparian buffers, and other agroforestry plantings offer a strong line of defense against drifting pesticide sprays, alternative resources for beneficial insects, and a refuge in a landscape commonly treated with chemicals. When agroforestry practices go hand in hand with best management practices for the use of pesticides, the impact of these chemicals on pollinators can be significantly reduced, or even eliminated.

Additional information

AF Note – 32: Agroforestry: Sustaining Native Bee Habitat For Crop Pollination. M. Vaughan and S. Black. 2006. USDA National Agroforestry Center.

AF Note – 33: Improving Forage For Native Bee Crop Pollinators. M. Vaughan and S. Black. 2006. USDA National Agroforestry Center.

AF Note – 34: Enhancing Nest Sites For Native Bee Crop Pollinators. M. Vaughan and S. Black. 2006. USDA National Agroforestry Center.

Pollinator Protection: A Bee and Pesticide Handbook. C. Johansen and D. Mayer. 1990. Wicwas Press, Cheshire, CT. 212 pp.

Forest application of the insecticide Fenitrothion and its effect on wild bee pollinators (Hymenoptera: Apoidea) of lowbush blueberries (Vaccinium spp.) in southern New Brunswick, Canada. P. Kevan. 1975. Biol. Conserv. 7:301-309.

How to Reduce Bee Poisoning From Pesticides. H. Riedl, E. Johansen, L. Brewer and J. Barbour. 2006. Oregon State University, Corvallis, OR. PNW 591. *http://extension.oregonstate.edu/catalog/pdf/pnw/pnw591.pdf*

Pollinator Conservation Handbook. M. Shepherd, S. Buchmann, M. Vaughan and S. Black. 2003. The Xerces Society. Portland, OR. 145 pp.

Windbreaks as a pesticide drift mitigation strategy: a review. T. Ucar and F. Hall. 2001. Pest Management Science. 57:663-675.

Farming for Bees: Guidelines for Providing Native Bee Habitat on Farms. M. Vaughan, M. Shepherd, C. Kremen, and S. Black. 2004. Xerces Society. 34 pp. *www.xerces.org/Pollinator_Insect_Conservation/Farm_Pollinator_Guidelines.pdf*

Xerces Society Pollinator Program, *http://www.xerces.org/Pollinator_Insect_Conservation/*

Authors

Mace Vaughan and Scott Hoffman Black, Xerces Society For Invertebrate Conservation, 4828 SE Hawthorne Boulevard, Portland, Oregon 97215. Phone: 503-232-6639, email: *info@xerces.org*.

Acknowledgements

We wish to thank the following scientists who generously reviewed this Agroforestry Note: James Cane, USDA ARS; Gretchen LeBuhn, San Francisco State University, T'ai Roulston, University of Virginia; Matthew Shepherd, Xerces Society; Connie Stubbs, University of Maine; Robbin Thorp, University of California, Davis; and Neal Williams, Bryn Mawr College.

USDA National Agroforestry Center

A partnership of

Contact: USDA National Agroforestry Center (NAC), UNL–East Campus, Lincoln, Nebraska 68583-0822. Phone: 402-437-5178; fax: 402-437-5712; Web site: *www.unl.edu/nac*.

The USDA National Agroforestry Center (NAC) is a partnership of the Forest Service (Research and Development and State and Private Forestry) and the Natural Resources Conservation Service. It is administered by the Forest Service, Southern Research Station; its program manager and headquarters are located in Huntsville, AL, on the campus of Alabama A&M University, while its research, clearinghouse, and technology transfer staff are concentrated in Lincoln, NE, at the University of Nebraska. NAC's purpose is to accelerate the development and application of agroforestry technologies to attain more economically, environmentally, and socially sustainable land use systems. To accomplish its mission, NAC interacts with a national network of partners and cooperators to conduct research, develop technologies and tools, establish demonstrations, and provide useful information to natural resource professionals.