PROTECTING POLLINATORS FROM PESTICIDES

# Fungicide Impacts on Pollinators


Bees and other beneficial insects can be exposed to fungicides directly or through contaminated nectar and pollen in urban and agricultural settings. Fungicides can harm bees in a variety of ways, affecting bee development, behavior, immune health, and reproduction. (*Left to right:* Mining bee [*Andrena* sp.] on apple blossom, pesticide application in a crop field, small carpenter bee [*Ceratina* sp.] on wild bergamot [*Monarda fistulosa*].)

## Fungicide Effects Can Be Subtle but Significant

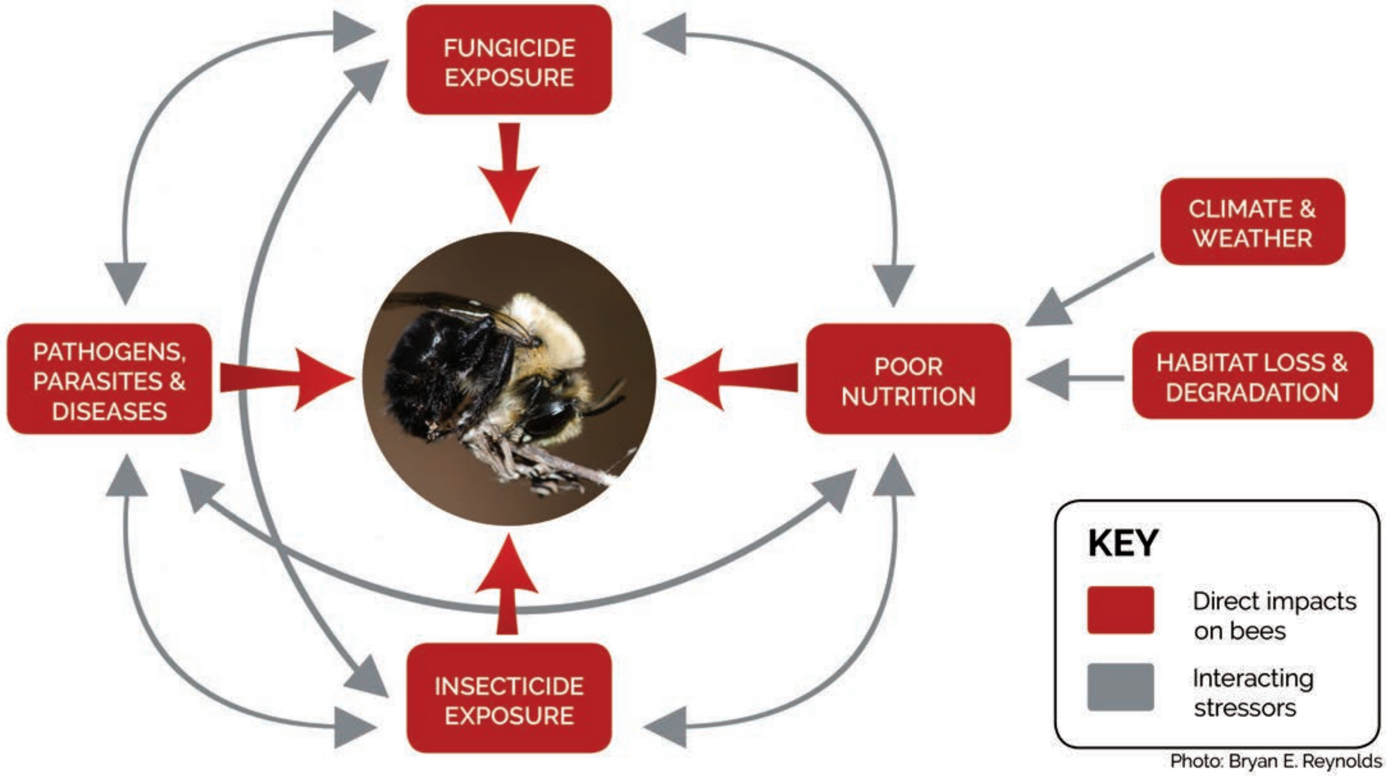
From large farms to small backyard gardens, many people use fungicides to control plant pathogens. While insecticides have long been recognized as a threat to bees and other beneficial insects, fungicides have generally been assumed to be relatively harmless. Though most fungicide exposures won't kill a bee immediately, a growing body of research suggests that some fungicides can cause subtle yet significant harm.

A few fungicides, such as captan and mancozeb (e.g., Captan, Manzate), have insecticidal properties and can kill bees on contact. Other fungicides harm bees in more subtle ways. These sublethal effects—including changes in development, behavior, immune health, or reproduction—can negatively impact bee populations by reducing long-term survival and population size.

Bees exposed to fungicides directly or through their food (contaminated pollen and nectar) can experience a variety of sublethal effects, which may reduce their ability to forage and reproduce. For example, dietary exposure to chlorothalonil (e.g., Bravo, Echo) can reduce honey bee (*Apis mellifera*) larval survival and decrease the number of offspring produced by bumble bee (*Bombus* spp.) colonies (Zhu et al. 2014, Bernauer et al. 2015). A mix of pyraclostrobin and boscalid (e.g., Pristine) commonly applied during bloom in some crops has been found to reduce honey bee forager survival and queen production, increase virus loads in honey bee colonies, and impair nest recognition by managed solitary bees (Fisher et al. 2017; DeGrandi-Hoffman et al. 2013, 2015; Artz & Pitts-Singer, 2015).

### Exposure to Fungicides Can Increase Toxicity of Certain Insecticides

Certain fungicides can interact with other pesticides, in some cases synergistically increasing toxicity to bees. Demethylation inhibitor (DMI) fungicides, which include the azole fungicides (e.g., fenbuconazole [Enable, Indar]; propiconazole [Banner, Tilt]), appear to increase the toxicity of pyrethroids and some neonicotinoids to bees by blocking the enzyme pathway bees use to detoxify these insecticides. Some multi-site contact activity fungicides also exhibit synergism with insecticides. For example, field-realistic levels of boscalid (e.g., Endura, Pristine) doubled the toxicity of clothianidin (e.g., Belay, Clutch, Poncho) and thiamethoxam (e.g., Cruiser, Platinum) fed to adult honey bees (Tsvetkov et al. 2017).




Fungicides can interact with many other stressors to negatively impact wild and managed bees. For instance, fungicide exposure can increase the toxicity to bees of certain insecticides; make bees more vulnerable to pathogens, parasites, and diseases; and alter bee gut microbiomes and foraging behavior, contributing to poor nutrition of individual bees and social colonies.

### Fungicides Linked with Increased Pathogen Infection and Poor Nutrition

Exposure to fungicides may make bees more susceptible to harmful pathogens and diseases. Lab tests have found that honey bees fed fungicide-contaminated pollen are more susceptible to damaging *Nosema* parasitic fungal infections (Wu et al. 2012, Pettis et al. 2013). Fungicide residues in collected pollen may also harm the beneficial fungi honey bees rely on for fermenting pollen and nectar into bee bread, a critical food source for both larvae and adults in honey bee colonies (Yoder et al. 2013).

## How are Bees Exposed?

Current fungicide use is leading to widespread exposure of wild and managed bees in both agricultural and urban landscapes. A wide array of pesticides, including fungicides, have been found both in and on foraging wild bees and in pollen, wax, and honey samples collected from managed honey bee colonies in agricultural landscapes (Hladik et al. 2016; Botias et al. 2017; Mullin et al. 2010, David et al. 2016). Understanding how field exposures occur is an important step in protecting managed and wild bees.

### Bloom Time Applications: High Chance of Exposure

In many crops, fungicides are applied just before or during bloom, which can be a critical time for infection or development of plant pathogens. Bloom is also when bees are most active in crop fields and most likely to be exposed to pesticides. This overlap is one of the key challenges growers face when trying to manage crop diseases while protecting pollinators.

### Seed Treatments: Extensive Use Means Widespread Potential for Exposure

In row crops such as corn, soybean, and wheat, fungicides are commonly applied as seed coatings. This widespread use represents a near-ubiquitous exposure route for bees in agricultural landscapes—particularly when crops are planted—as pesticide-laden dust from treated seeds can contaminate non-crop areas (Nuyttens et al. 2013, David et al. 2016). Some seeds are coated with both insecticides and fungicides that may have synergistic toxicity to bees. The risk of these potential exposures is not well studied, but fungicide and insecticide mixtures have been found at harmful levels in the pollen and foliage of wildflowers growing near crops planted with treated seed (Botias et al. 2016).

## Solutions

### Use Preventive Pest Management to Reduce Fungicide Use

Reducing reliance on fungicides for disease control starts with preventive pest management, or breaking disease cycles using a variety of cultural and mechanical techniques. Preventive strategies are similar across agricultural and home landscapes: choosing the right plants for your conditions and ensuring those plants have proper nutrition, water, and airflow will maximize their resilience to fungal pathogens. Practices such as rotating crops, selecting resistant cultivars, ensuring appropriate soil fertility and irrigation, and removing infested vegetation can reduce the likelihood of disease development.

### Reduce Bee Exposure to Fungicides

Even when growers have shifted their practices to limit pathogen pressure, some challenging pathogens can prompt the use of fungicides to prevent diseases that can negatively affect marketable yields. If you do decide to use fungicides, take steps to limit the potential for bees to be exposed.

- Avoid applying fungicides during bloom and as possible during pre-bloom.
- Avoid applying combinations of insecticides and fungicides that together may increase risk to pollinators. The UC–IPM Bee Precaution Pesticide Rating Tool (https://www2.ipm.ucanr.edu/beeprecaution) can help determine which pesticides may have synergistic toxicity when applied together.
- Take measures to limit off-site movement into flowering habitat.

### Provide Flowering Habitat for Bees that is Protected from Pesticide Contamination.

Natural areas may buffer the impacts of pesticides on bee communities in agricultural settings (Park et al. 2015). Identifying existing pollinator habitat areas and protecting these areas from pesticide contamination is a good first step. If natural habitat is sparse, consider creating new habitat that provides pollinators with flowering resources, undisturbed nesting areas, and protection from pesticides. A spatial buffer or vegetative drift barrier between crop fields and natural areas can help minimize off-site movement of pesticides into nearby habitat. Refer to this Xerces guidance document for more information on protecting habitat from pesticides.

## Conclusions

A growing body of research clearly links fungicide use with harm to bees. Still, there are many uncertainties around the risks fungicides pose to bees, especially given the complexity of stressors that bees experience. There will always be ambiguity, imprecise information, and gaps in knowledge around the risks of pesticides to bees. However, there is enough evidence of harm to bees from fungicide exposure to seek alternative management methods and take precautions with their use to reduce bee exposure.

For many crops, bloom is a critical time when bees are most likely to be exposed to fungicides. (Photo: Honey bee on blueberry [*Vaccinium* sp.].)

### Real-World Impacts

Several new field studies have highlighted concerns with fungicide exposures for bees in real-world settings.

- **Pre-Bloom Fungicides Negatively Impact Wild Bees in Apple Orchards.** A field study in New York apple orchards found that wild bee abundance decreased significantly with increasing use of insecticides and fungicides in the previous year (Park et al. 2015). Pre-bloom fungicide sprays had the strongest negative relationship with bee abundance of all the pesticides applied.
- **Honey Bee Colony Losses Associated with High Levels of Certain Fungicides.** Researchers found that honey bee colonies that died over the summer were significantly associated with elevated levels of a few groups of fungicides (Traynor et al. 2015).
- **Fungicide Use Linked with Declining Bumble Bees.** A landscape-scale study that sampled bumble bees across the United States found that total fungicide use was the strongest predictor of range contraction for four declining bumble bee species (McArt et al. 2017). The use of chlorothalonil (e.g., Bravo, Echo) was the best predictor of the prevalence of a common pathogen (*N. bombi*) that can impact the health of declining bumble bee species.

# Notes

Any trade names contained in this document are for identification and reference only, and no product endorsement or discrimination against similar materials is intended. A helpful resource for determining currently registered products and trade names for pesticide active ingredients is the U.S. Environmental Protection Agency Pesticide Product and Label System.

# References


Artz, D., and T. Pitts-Singer. 2015. Effects of fungicide and adjuvant sprays on nesting behavior in two managed solitary bees, *Osmia lignaria* and *Megachile rotundata*. *PLoS ONE* 10(8):e0135688.

Bernauer, O. M., H. R. Gaines-Day, and S. A. Steffan. 2015. Colonies of bumble bees (*Bombus impatiens*) produce fewer workers, less bee biomass, and have smaller mother queens following fungicide exposure. *Insects* 6(2):478–488.

Botias, C., A. David, E. M. Hill, and D. Goulson. 2016. Contamination of wild plants near neonicotinoid seed-treated crops, and implications for non-target insects. *Science of the Total Environment* 566-567:269–278.

Botias, C., A. David, E. M. Hill, and D. Goulson. 2017. Quantifying exposure of wild bumblebees to mixtures of agrochemicals in agricultural and urban landscapes. *Environmental Pollution* 222:73–82.

David, A., C. Botias, A. Abdul-Sada, E. Nicholls, E. L. Rotheray, E. M. Hill, and D. Goulson. 2016. Widespread contamination of wildflower and bee-collected pollen with complex mixtures of neonicotinoids and fungicides commonly applied to crops. *Environment International* 88:169–178.

DeGrandi-Hoffman, G., Y. Chen, and R. Simonds. 2013. The effects of pesticides on queen rearing and virus titers in honey bees (*Apis mellifera*). *Insects* 4(1):71–89.

DeGrandi-Hoffman, G., Y. Chen, E. Watkins Dejong, M.L. Chambers, and G. Hidalgo. 2015. Effects of oral exposure to fungicides on honey bee nutrition and virus levels. *Journal of Economic Entomology* 108(6):2518–2528.

Fisher, A., C. Coleman, C. Hoffman, B. Fritz, and J. Rangel. 2017. The synergistic effects of almond protection fungicides on honey bee (Hymenoptera: Apidae) forager survival. *Journal of Economic Entomology* 110(3):802–808.

Hladik, M. L., M. Vandever, and K.L. Smalling. 2016. Exposure of native bees foraging in an agricultural landscape to common-use pesticides. *Science of the Total Environment* 542:469–477.

McArt, S.H., C. Urbanowicz, S. McCoshum, R.E. Irwin, and L.S. Adler. 2017. Landscape predictors of pathogen prevalence and range contractions in US bumblebees. *Proceedings of the Royal Society B: Biological Sciences* 284:20172181.

Mullin, C. A., M. Frazier, J. L. Frazier, S. Ashcraft, R. Simonds, D. vanEngelsdorp, and J. S. Pettis. 2010. High levels of miticides and agrochemicals in North American apiaries: Implications for bee health. *PLoS ONE* 5(3):e9754.

Nuyttens, D. W. Devarrewaere, P. Verboven, and D. Foqué. 2013. Pesticide-laden dust emission and drift from treated seeds during seed drilling: a review. *Pest Management Science* 69:564-575.

Park, M. G., E. J. Blitzer, J. Gibbs, J. E. Losey, and B. N. Danforth. 2015. Negative effects of pesticides on wild bee communities can be buffered by landscape context. *Proceedings of the Royal Society B: Biological Sciences* 282:20150299.

Pettis, J. S., E. M. Lichtenberg, M. Andree, J. Stitzinger, R. Rose, and D. vanEngelsdorp. 2013. Crop pollination exposes honey bees to pesticides which alters their susceptibility to the gut pathogen *Nosema ceranae*. *PLoS ONE* 8(7):e70182.

Traynor, K. S., J. S. Pettis, D. R. Tarpy, C. A. Mullin, J. L. Frazier, M. Frazier, and D. vanEngelsdorp. 2016. In-hive pesticide exposome: Assessing risks to migratory honey bees from in-hive pesticide contamination in the Eastern United States. *Nature Scientific Reports* 6:33207.

Wu, J. Y., M. D. Smart, C. M. Anelli, and W. S. Sheppard. 2012. Honey bees (*Apis mellifera*) reared in brood combs containing high levels of pesticide residues exhibit increased susceptibility to *Nosema* (Microsporidia) infection. *Journal of Invertebrate Pathology* 109(3):326-329.

Yoder, J. A., A. J. Jajack, A. E. Rosselot, T. J. Smith, M. C. Yerke, and D. Sammataro. 2013. Fungicide contamination reduces beneficial fungi in bee bread based on an area-wide field study in honey bee, *Apis mellifera*, colonies. *Journal of Toxicology and Environmental Health, Part A* 76(10):587-600.

Zhu, W., D. R. Schmehl, C. A. Mullin, and J. L. Frazier. 2014. Four common pesticides, their mixtures and a formulation solvent in the hive environment have high oral toxicity to honey bee larvae. *PLoS ONE* 9(1):e77547.


# Acknowledgements


**AUTHORS:** Emily May, Aimée Code, and Sarah Hoyle of the Xerces Society. **PHOTO CREDITS:** Wisconsin Department of Natural Resources / Flickr Creative Commons 2.0 (pesticide application in crop field); Xerces Society / Emily May (small carpenter bee on wild bergamot, honey bee on blueberry); Xerces Society / Matthew Shepherd (mining bee on apple blossom). **ARTWORK CREDITS:** Interacting stressors graphic by Jenni Denekas and Emily May of the Xerces Society. **LAYOUT:** Emily May and Jenni Denekas of the Xerces Society. **EDITING:** Sara Morris and Jenni Denekas of the Xerces Society.