

Landscape solutions for managing disease in bumble bees

Heather M. Hines, Pennsylvania State University



Possible photos to use: Upper left - *Bombus impatiens* queen hanging on to a bleeding heart (*Dicentra*) flower. Upper right - *Bombus impatiens* worker, unsuccessfully trying to push her way into a Gentian flower. Lowerleft - *Bombus occidentalis*, a declining bumble bee species from the western United States, hanging on to a coneflower. This species and sister species eastern bumble bee *Bombus terricola* are particularly susceptible to *Vairimorpha* infection. Lower right: *Bombus terricola*, a species in decline in the eastern United States largely due to susceptibility to *Vairimorpha* infection, struggling under the weight of milkweed pollinia. Photos: Heather Hines

Bumble bees are dominant native pollinators of temperate regions and thus many flowering plants native to these regions rely heavily on pollination by these bees. This includes crop plants such as buzz-pollinated plants in the nightshade family (tomatoes and peppers) and boreally distributed berries (blueberries and cranberries). Unfortunately, in the last three decades these important bee pollinators have been in decline. Data supports climate being a problem for these bees, but for species declining most precipitously, pathogens are most likely involved.

There are multiple diseases that impact bumble bees that vary in their dynamics. Two abundant viruses in bumble bees are shared with honey bees: Black Queen Cell Virus (BQCV) and Deformed Wing Virus (DWV), both of which have mild-moderate effects on these bees. There are several other viruses shared between these bees that are rare but can be more deadly. Bumble bees are also impacted by two mostly bumble bee specific protozoans: common *Crithidia bombi* manifests in disease in less healthy bees, while the sporadic fungal *Vairimorpha bombi* is very harmful and thought to be most responsible for heavy losses in some bumble bee species.

To find solutions to reduce bee disease, our research team investigated how landscape management impacts disease loads in bumble bees. Landscapes suited to these bees will result in healthier bees that are less likely to be diseased even when exposed to pathogens. Climate and habitat may also modify disease loads by impacting pathogen transmission. In two recent research studies, the research team investigated impacts of diverse landscape factors,

including habitat type and management, nesting and seasonal floral resource quality, honey bee abundance, and weather on loads of bumble bee pathogens BQCV, DWV, *Nosema*, and *Crithidia* in two states spanning the eastern United States - Pennsylvania and North Carolina. Altogether, we sampled bumble bee (*Bombus impatiens*) disease loads across ~80 sites. We sought to determine which landscape factors best predicted pathogen loads. As part of this, we also summarized the literature on landscape effects on North American bumble bees.

This research revealed five main lessons in how land management impacts bumble bee disease:

- 1) *Viral loads in honey bees have considerable impact on disease in bumble bees.* Sites with more honey bees harbor more viruses. Other research in our group showed honey bees are more likely to hold onto viruses across the winter and thus act as a virus reservoir for native bees. Honey bees are great for improving pollination services and for their hive products, but they can negatively impact local bee communities. Management practices that ensure healthy honey bees can reduce viral loads in bumble bees and other wild bees.
- 2) *Impacts of habitat on disease depends on the pathogen* - Virus loads are lower in forests, perhaps because these forests harbor less honey bees or improve spring nutrition. *Crithidia* levels, in contrast, were found to be higher in forests. While the cause is unclear, this may be because forests have different bumble bee communities that vary in their susceptibility, transmission may be enhanced in the shade, plant forage may impact disease persistence (*Crithidia* is reduced when bees feed on asters), or forests may offer less food resources later in the season.
- 3) *More nutrition most likely helps, but effects vary* - The best thing we can do for bees in general is to provide more forage. Typically we find less pathogen loads in places with better floral resources, especially in the vulnerable growth period for colonies in the spring, but the impact of more floral resources on pathogens is inconsistent across studies. This relationship is complex because flowers are hubs for pathogen transmission while also providing better nutrition to resist disease. Effects of flowers on disease depend on bee population size and density on flowers and landscape context. For example, a floral oasis in a resource-depauperate landscape can draw a high density of bees, including stressed and diseased bees from neighboring landscapes.
- 4) *Climate effects exist but need more research* - The deadly fungal pathogen *Vairimorpha* appears to be more prevalent in wetter years and environments. Hotter places tended to have more viruses. Heat can impact bee resistance to stress but also pathogen survival. Effects of climate on pathogens is in need of more research.
- 5) *Developed areas have more pathogens* – Places with more development, in other words, those that are less natural and have more people, tend to harbor more disease,

especially bee viruses. This may be because of more human-induced stressors overall and may be influenced by more honey bees in developed areas.

This research was managed by Dr. Heather Hines and Dr. Christina Grozinger and was performed by former Penn State Entomology graduate student Elena Gratton, former postdoctoral researcher and now faculty member at University of Kentucky, Dr. D.J. McNeil, and several undergraduate researchers.

[1] Gratton, E.M., D.J. McNeil, C.M. Grozinger, H.M. Hines. 2023. Local habitat type influences bumble bee pathogen loads and bee species distribution. *Environmental Entomology*, nvad027, <https://doi.org/10.1093/ee/nvad027>

[2] Gratton, E.M., D.J. McNeil, D.J., R. Sawyer, A. Martinello, C.M. Grozinger, H.M.Hines. 2024. The role of landscape factors in shaping bumble bee pathogen loads in regions of the eastern Nearctic. *Insect Conservation and Diversity*. 1-15. <https://doi.org/10.1111/icad.12773>

Some landscape and people photos:



