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Factors Contributing to Bee Decline

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Quick Facts

- Native and managed bees provide important pollination services, but many of these species are experiencing significant population declines worldwide.
- The western bumble bee (*Bombus occidentalis*) (Fig. 1) was once the most common bumble bee species in western North America, but its population has decreased by 93% over the last two decades.
- Factors that contribute to bee decline include habitat loss, improper apiary management, pesticides, climate change, pests and pathogens, competition among introduced and native bee species, and poor nutrition.
- Landscapes can be optimized for bees by providing shelter and nesting sites, an abundance of spring-through-fall pollinator-friendly flowers, and protection from pesticides.

INTRODUCTION

Bees provide an important ecosystem service by contributing to the pollination of crop and wild plant species. The non-native honey bee (*Apis mellifera*) is often recognized as the most important of the bee pollinators; however, the roughly 4,000 native North American bee species (including approximately 1,100 species in Utah) are important pollinators and propagators of about 75% of flowering plant species in diverse systems (Ollerton et al., 2011; Project Eleven Hundred, 2021). Indeed, some native bee species are more efficient pollinators of some native and crop plants than are honey bees; consequently, some of these species (e.g., the eastern bumble bee [*B. impatiens*] and the blue orchard bee [*Osmia lignaria*]) are now also intensively managed.

Bee diversity (i.e., the number and abundance of species) is important for maintaining pollination services through time (Winfree et al., 2018), but unfortunately, some species and populations have been on the decline. Of the native bee species in North America and Mexico, 27% of mason bees and 50% of leafcutter bees are at risk (i.e., proposed for threatened status under the Endangered Species Act [ESA]) (Xerces Society, n.d.-a). In North America, 26% of bumble bee species (*Bombus* spp.) are

Fig. 1. *Western Bumble Bee* (Bombus occidentalis) *on Aster.*

considered threatened (i.e., likely to be listed as endangered under the ESA), with widespread declines occurring throughout the genus (Cameron et al., 2011). In 2021, the Franklin's bumble bee (*B. franklini*) became the first bee in the western continental U.S. to receive protection under the ESA following its last sighting in 2006 (U.S. Federal Register, 2021). Further, the western bumble bee (*B. occidentalis*) (Fig. 1) has gone from being the most common bumble bee in western North America to being petitioned for listing under the ESA after experiencing population declines of 93% over two decades (Graves et al., 2020).

Many factors have been attributed to bee declines, including habitat loss, improper apiary management, pesticide usage, climate change, pests and pathogens, competition among native and introduced bee species, poor nutrition, and other factors (Koh et al., 2016; Goulson et al., 2015; Graves et al., 2020; Soroye et al., 2020). Acting together, these factors intensify the pressure for survival beyond the adaptability of many species.

HABITAT LOSS

Bees and other pollinators can be negatively affected by urban development and other human activities that degrade or remove naturalized areas, and these habitat losses can impact both social and solitary bee species as well as the species' composition of communities (Bommarco et al., 2010). Urban and suburban areas

can provide refuges for bees, but bumble bees (*Bombus* spp.) and sweat bees (*Dialictus* spp.) have been shown to be negatively affected by urbanization (Wilson, 2019; Gruver & CaraDonna, 2021). Loss of nesting habitat from landscape weed fabrics can affect ground-nesting bees, including some bumble bee species. Roads and tidy landscapes can pose significant barriers to bee movement, especially for small bees, and can lead to reduced floral diversity in the landscape (Fitch & Vaidya, 2021), which can affect bee health as well as bee diversity. Research has shown that conventional crop fields isolated from natural habitats reduces native bee abundance, diversity, and pollination services. For example, in a conventional crop of watermelons (a highly pollinator-dependent crop) isolated from natural habitats, honey bees were required for pollination. However, in organic fields near suitable habitat, native bees alone provided sufficient pollination services for this crop (Kremen et al., 2002). Further, honey bee performance and health are enhanced when colonies are located near lands in conservation easements (Ricigliano et al., 2019).

IMPROPER APIARY MANAGEMENT

Over the past decade, interest in backyard beekeeping has increased exponentially. As such, many novice beekeepers have struggled to properly maintain their hives. Poor management of honey bee hives can negatively affect not only colony health and longevity, but it can also negatively affect native bees when pathogen spillovers occur. For example, the Varroa mite (*Varroa destructor*), which is a specialist honey bee parasite, has been shown to vector deformed wing virus (DWV) to wild bumble bees (Manley et al., 2019). Apiaries can benefit from positive management practices that include prompt diagnosis and control of pests and diseases, providing proper nutrition, obtaining local queens that are better acclimated to local conditions and stressors, purchasing queens from reputable breeders, separating healthy colonies from those showing signs of collapsing, regularly cleaning and replacing older frames, and minimizing risk from pesticides. In addition, beekeepers should avoid placing bees in areas with inadequate floral resources and using equipment from hives where the cause of bee death is suspicious (Honey Bee Health Coalition, 2019). Utah beekeepers can contact the Utah Apiary Program administered by the Utah Department of Agriculture and Food (UDAF) for help diagnosing pests and diseases in their hives. For more information regarding proper beekeeping practices, refer to https://beekeeping.usu.edu/.

PESTICIDES

Although pesticides (i.e., insecticides, fungicides, and herbicides) vary in their toxicity to bees depending on their mode of action, concentration, formulation, and residual action, many of them are harmful to bees and other beneficial insects when not used as directed. Note that it is a violation of federal law to use a pesticide in a way that differs from the product labeling. In an effort to protect bees and other pollinators, the U.S. Environmental Protection Agency (EPA) now requires pesticides that are toxic to bees, such as the products containing the neonicotinoids imidacloprid, thiamethoxam, clothianidin, and dinotefuran, have labels with a bee advisory box (Fig. 2) or other warning label. They include instructions to alert applicators to specific use restrictions to limit bee exposure and minimize drift of the product. Using these products is prohibited where bees and flower petals are present. If chemical control of pests is warranted, preference should be given to less toxic options, such as insecticidal soap, and applications should not be made during times of the day when bees are actively foraging or when plants are flowering, shedding pollen, or producing nectar (May et al., 2015). Applying pesticides early in the spring prior to bee emergence may especially affect the success of solitary bees as well as bumble bee colonies, which depend entirely on their overwintering solitary queen.

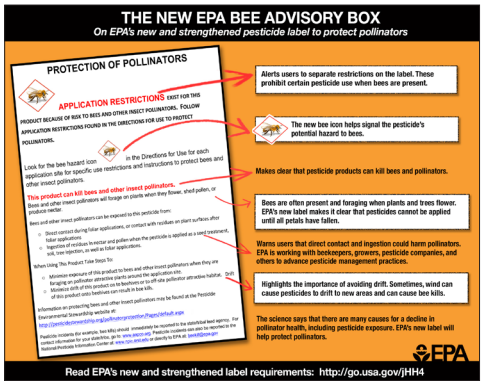

Fig. 2. *Current EPA Bee Advisory Box.*

CLIMATE CHANGE

Changes in climate can greatly affect bee abundance, distribution, phenology (timing of life history events), and pollination, and lead to an increased risk from bee diseases and pests (Kammerer et al., 2021). Some bee species are emerging from overwintering habitats earlier than normal, likely due to increased temperatures, and this shift in spring emergence can disrupt plant-pollinator interactions. For example, in a subalpine area of western Colorado, the yellow avalanche lily (*Erythronium grandiflorum*), which also occurs in Utah, has experienced poor pollination rates and diminished fruit set. This is thought to be caused by a mismatch between the timing of flowers and pollinator emergence (Thomson, 2010). Research has also shown that warm winters can result in decreased abundances of some bees species, such as mason bees (*Osmia* spp.) and mining bees (*Andrena* spp.), which are important native pollinators of tree-fruit crops (Kammerer et al., 2021). Further, the severe decline of some bumble bee (*Bombus* spp.) species and populations across North America and Europe has been linked to the increased number of unusually hot days (Soroye et al., 2020). A warming climate also facilitates invasions of bee pests. The small hive beetle (SHB) (*Aethina tumida*), a bee pest that can have a significant impact on apiculture and wild bee populations, is expected to expand its range as climate change continues, especially in the temperate regions of the Northern Hemisphere (Cornelissen et al., 2019). A native to sub-Saharan Africa, SHB was first detected in Utah in 2016 (Spears & Mull, 2018).

PATHOGENS AND PESTS

Diseases can be transmitted within and between pollinator species by shared floral resources (Manley et al., 2015). Declines in bee populations can be caused by diseases such as parasitic mite syndrome, *Nosema bombi*, and American foulbrood*; viruses such as deformed wing virus, black queen cell virus, Lake Sinai virus 2, and Israeli acute paralysis virus; interactions with pests such as small hive beetle and the introduced Africanized honey bee (*Apis mellifera scutellata*); and parasites such as the Varroa mite (*V. destructor*) (Mallinger et al., 2017), an invasive external parasite that is thought to play a large role in colony collapse disorder (see below for more information). Varroa mites became established throughout the U.S. within 10 years of their first detection in the country in 1987; they act by sucking the "blood" of bees, weakening the bees' immune system, and making them more susceptible to pathogens.

COMPETITION

In Utah, roughly 37,000 honey bee colonies (UDAF, 2021) compete with the state's native bees (Fig. 3). Although the honey bee is a critical part of agriculture, its presence alongside native bees has many negative effects that include increased competition for essential resources (i.e., pollen, nectar, and nesting habitat), the spread of pathogens, and the altering of plant communities by pollinating exotic weeds and facilitating their spread (Mallinger et al., 2017). Competition between honey bees and native bees has been observed on public wildlands, including Utah's national forests (Cane & Tepedino, 2016) (Fig. 4).

To a lesser extent, competition also occurs among bee species native to North America, which includes parasitic bee specialists as well as bees used commercially (e.g., *B. insularis*) in greenhouses outside their native range that have since escaped. These feral bees can also spread disease (Sachman-Ruiz et al., 2015).

Africanized honey bees (*A. mellifera scutellata*) (AHB), sometimes called "killer bees," are a competitive hybrid between the African honey bee and the European honey bee. In Utah, AHBs are established in Emery, Garfield, Grand, Iron, Kane, San Juan, Washington, and Wayne counties (UDAF, 2021), where they compete with both the honey bee and native bees. In south-western Utah, the invasion of AHB is believed to have caused the recent and rapid local extinction of *Perdita meconis*, a specialized pollinator of an endangered Utah poppy (Portman et al., 2018).

Fig. 3. *A Honey Bee Sharing Floral Resources With a Native Blue Orchard Bee* (Osmia sp.) (*left*) *and Bumble Bee* (Bombus sp.) (*right*).

Fig. 4. *Honey Bee Hives in Utah's Wasatch-Cache National Forest.*

POOR NUTRITION

Pollen is the most important food source for bees, as it provides them with nutrients (proteins, amino acids, lipids, vitamins, and minerals) necessary for growth and development. Honey bees and other generalist bees require a variety of plants (pollen sources) to obtain the nutrients they need, and in honey bees, a mixed pollen diet has been shown to improve their health, reproduction, and resilience to stress (Branchiccela et al., 2019). For example, naturally foraging honey bees exhibited lower virus levels and queen losses than those fed only pollen supplements, while a poor diet resulted in a 30% loss of colonies (DeGrandi-Hoffman et al., 2016). Further, honey bees parasitized by *Nosema ceranae* and fed pollen from diverse floral sources lived longer than parasitized bees fed from only a few floral sources (Di Pasquale et al., 2013). Poor nutrition may be the consequence of other factors such as habitat loss, agricultural intensification, and reduced pollen and nectar production from increased drought and heat events (see above). Many agricultural crops in the U.S. are grown in monoculture, thus reducing a bee's choice in plant selection. For generalist bees, feeding on limited pollen resources has been likened to a human eating only sardines for one month and only chocolate the next (Goulson et al., 2015).

COLONY COLLAPSE DISORDER

Colony collapse disorder (CCD) was first reported in honey bee hives over the winter of 2006-2007. CCD results in the disappearance of worker bees, while the queen, brood (young), and food remain. The collapsing colonies have an insufficient number of bees to maintain brood, and the remaining bees are reluctant to eat food provided by the beekeeper. Colony losses specifically attributed to CCD were first observed in 2006 and still occur, but unusual colony losses have occurred in Utah in the past. The USDA ARS (2021) states that in 1903, 2,000 honey bee colonies in Cache Valley perished from a mysterious "disappearing disease" following a "hard winter and a cold spring." The cause of CCD is unknown, but it is thought to be due to multiple factors working in combination or synergistically, including pests and diseases, secondary pesticide poisoning, and poor nutrition (ARS, 2021). Whether CCD affects North America's native bees is not well established.

PROMOTING POLLINATORS

Given the importance of bees to the environment and human food security, and considering the significant declines in bee species across much of the world, it is critical that we act to protect these species. Below we highlight a few ways you can encourage both native bees and managed pollinators to your gardens and landscapes. For more Utah-centered information on promoting native bees, see *Gardening for Native Bees in Utah and Beyond* (Cane & Kervin, 2013), *Gardening and Landscaping Practices for Nesting Native Bees* (Cane, 2015), and *Pollinator Conservation Resources: Mountain Region* (Xerces Society, n.d.-b).

* If American or European foulbrood is suspected, UDAF bee inspectors must be notified: (801)982-2313 or UDAF-insects@utah.gov.

- If you are a beekeeper, ensure your hives are healthy and hydrated. Properly feed and maintain all hives, and paint supers with light colors to help keep hives cooler in summer. Healthy honey bee colonies can consume up to a gallon of water daily, so check water sources often and refill as needed.
- Commit to prioritizing pollinator health when creating your pest management plan.
- Incorporate native plants that provide blooms throughout the entire growing season into your landscape. In urban areas, focus on creating diverse floral habitats. For a list of water-wise native plants, visit www.extension.usu.edu/cwel/native-other.
- Some modern plants are highly hybridized and produce limited amounts of pollen, so ensure the plants you select are pollinator friendly. Mints, herbs, and disc-type flowers with a single row of petals, such as coneflower and sunflower, are good choices, as their pollen stores are easier for bees to access. Highly hybridized, double blooms are beautiful but difficult for bees to access nectar and pollen.
- Plant early blooming flowers, and plant in groups of three to five of the same plant. The early blooms provide an important food source for overwintering bees, and the plant groupings provide a more effective food source than a single plant alone.
- Minimize or avoid using pesticides and chemical fertilizers in your landscape, especially in early spring, to give all bees a healthy start to their year.
- Dandelions are an important early-blooming resource for bees. If you remove them from your landscape, kindly replace them with another early-blooming floral resource.
- Consider joining the "No Mow May" movement to help pollinators and other wildlife get a nurtured start to their busy year. Visit https://beecityusa.org/no-mow-may/ for details.
- Grow a garden to provide nectar and pollen for bees. If you lack yard space for a garden, consider adding pollinator-friendly planters to your doorstep or patio.
- Avoid using overhead sprinklers during daytime hours when bees are active, and use caution when flood irrigating near nests of native ground-nesting bees.
- Provide cool, shaded areas for bees to rest, and a clean water source with floating objects on the surface to provide escape routes for drowning bees.
- Increase nesting and overwintering habitat for ground-nesting bees by not tilling or disturbing the ground where nests occur, and by limiting the use of landscape weed fabric.
- Incorporate plants with hollow or pithy stems into your landscape throughout the year, and consider providing (and properly maintaining) nesting blocks to encourage native cavity-nesting bees.
- Join the "Leave the Leaves" campaign. Fallen leaves provide safe and insulated hibernating spots for queen bumble bees, so consider leaving areas of unraked leaves in your landscape.
- Consider joining a citizen science project such as Bumble Bee Watch to contribute what you see in your landscape, as this information can help researchers better assess population trends on a broader scale (https://www.bumblebeewatch.org/).

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1 Rich Hatfield, Xerces Society

2 https://www.epa.gov/pollinator-protection/new-labeling-neonicotinoid-pesticides

3 Derek Artz, USDA-ARS (left); Kathy Keatley Garvey, University of California at Davis (right)

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