MASSACHUSETTS WILDLIFE

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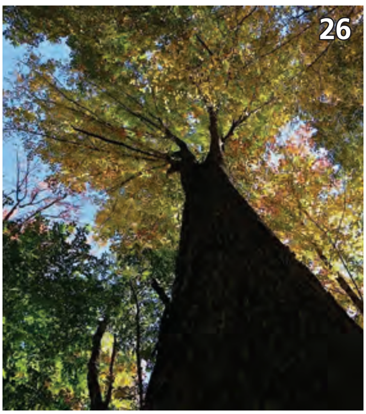
Bumblebees,
Wetlands Conservation,
Red Maple Bark

Photo © Robert J. Gegear/*Bombus fervidus*

Photo courtesy Ducks Unlimited Canada



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MASSACHUSETTS WILDLIFE

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FEATURES

On the Cover: A native bumblebee, the common *Bombus impatiens*, is approached by another pollinator, the non-native honeybee, *Apis mellifera*. Get the background story about bumblebees, their life history, and the disturbing decline of some of our native species, starting on page 6. Photographed with a Nikon 105mm macro lens. Photo © Bill Byrne

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Amplifying the Hum of the Bumblebee

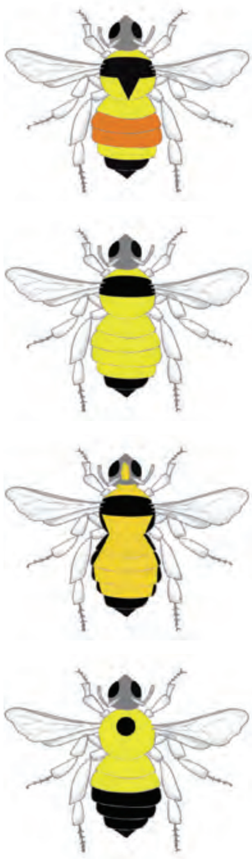
By Robert J. Gegear

Our story begins in a large outdoor dining tent that was purchased from the local hardware store. I was a young graduate student studying the remarkably sophisticated learning and memory capabilities of the bumblebee, 'the cute, black and yellow fuzzy ones' as my undergraduate research assistants have described them over the years. My project required that I place freshly collected flowers of several plant species in the tent and then observe how bees learn to exploit their rich nectar rewards. One of the plant species was butter-and-eggs (*Linaria vulgaris*), which ensures pollination by hiding its nectar reward from bee visitors at the base of a long spur. However, my efforts to find intact flowers in the area were thwarted by a perfectly placed circular hole at the base of every spur. I knew right away it was the handiwork of the highly abundant 'nectar robbing' bumblebee species *Bombus affinis*, the first, and unlikely not the last, North American bumblebee to be placed on the endangered species list. Fast-forward five years and I could not find a single *B. affinis* anywhere despite

Photo © Bill Byrne

an exhaustive search that extended miles from my project site. What you may be surprised to know is that I, and the handful of wildlife biologists studying bumblebees at the time, knew that *B. affinis* and other bumblebee species were in serious trouble; yet, public awareness and concern over an impending 'pollinator crisis' did not emerge until several years later with the unexplained loss of honeybee hives through 'Colony Collapse Disorder' (CCD). Why such a lag in the public outcry over the plight of the bumblebee? The answer boils down to a battle between dollars and diversity. And this is where our story gets interesting.

There is no question that the honeybee plays an important role in the pollination of crop plants and so it is easy to see why the public perception of bee decline is honeybee-centric—fewer honeybees mean lower crop yields and lower crop yields mean less (and more expensive) food items on our tables. Consequently, a significant amount of research effort and money has been dedicated to finding the cause of CCD and to developing management strategies to increase the abundance of either honeybees or an unidentified native bee species as a 'back-up' pollinator in agricultural areas. The problem is that the vast majority of our native bee species in North America, which includes *B. affinis* and thousands of others, do not visit crop plants to the extent of the honeybee and therefore have minimal economic value. So, while on the one hand CCD has greatly benefited native bee conservation by bringing the issue of bee decline into the public spotlight, on the other it has fueled the prevalent public misconception that by 'saving the honeybee', a single, managed non-native species, they are also helping to save diversity of native bees in the wild. In truth, the cause of *B. affinis* decline has nothing to do with CCD; thus, managing bee populations in agricultural areas, although important, is doing little, if anything, to help prevent our native bees from being placed on the endangered species list. To do so requires that we shift our views on the importance of bees from economics to ecology and our views of 'bee friendliness' from the number of bees we see buzzing around (abundance) to the number of species we see reflected in those numbers (diversity). Of course, loss of native bee diversity will eventually result in significant economic losses through the elimination of ecosystem services other than pollination, but I will save that story for another time. The next chapter of our story outlines how we make these conceptual shifts and then use them to conserve and restore bumblebee diversity.



Illustrations courtesy of Robert J. Gegear/WPI

The study of bumblebees has a rich history in Massachusetts, with naturalists such as Otto Plath, Frederic Putnam, and Joseph Bequaert providing invaluable information on the abundance, diversity and habits of each species over 100 years ago. Armed with this information, and digitized (thankfully!) museum specimens dating back to the late 1800s, we can get an accurate picture of bumblebee health in the state. Things don't look good—the number of species has dropped from 11 to 7, with three of the seven (*B. fervidus, B. terricola and B. vagans*) in danger of being extirpated from the state in the next decade should current trends continue. From an ecological point of view, these losses have the potential to have catastrophic consequences for native biodiversity in Massachusetts due to the critical role that bumblebees and other native pollinators play as 'keystone species', meaning that the existence of each species has cascading positive effects on functioning of our natural ecosystems: diversity of

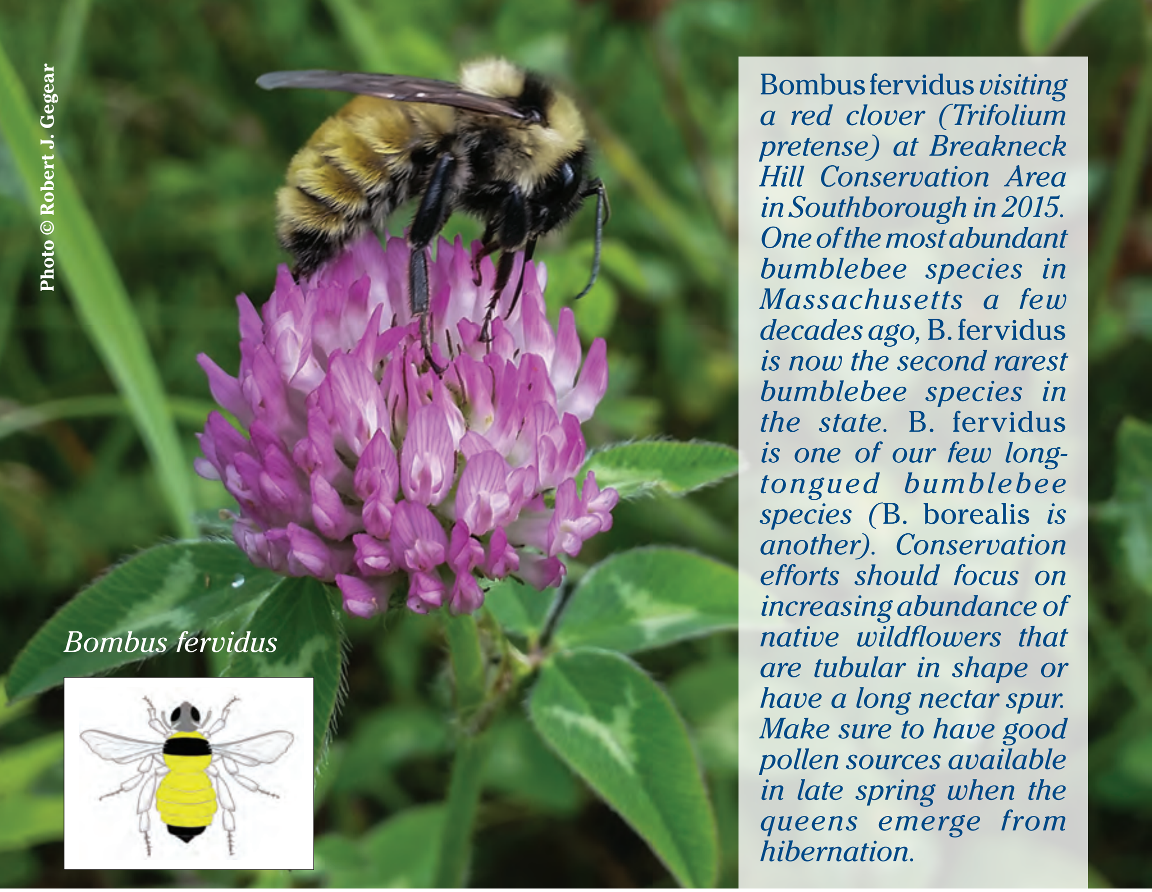


Photo © Robert J. Gegear

Bombus fervidus *visiting a red clover (Trifolium pretense) at Breakneck Hill Conservation Area in Southborough in 2015. One of the most abundant bumblebee species in Massachusetts a few decades ago,* B. fervidus *is now the second rarest bumblebee species in the state.* B. fervidus *is one of our few long-tongued bumblebee species (*B. borealis *is another). Conservation efforts should focus on increasing abundance of native wildflowers that are tubular in shape or have a long nectar spur. Make sure to have good pollen sources available in late spring when the queens emerge from hibernation.*

Bombus fervidus

bumblebees begets diversity of native plants begets diversity of animals utilizing bee-pollinator plants for food, shelter and nest sites begets diversity of predatory animals. Native bee decline is therefore akin to an ecological version of the classic children's game KerPlunk—eventually our actions will 'pull out' too many species and ecosystems will begin to collapse. I feel it is important to emphasize that the honeybee is not a native species and so its complete removal from the 'game' would have minimal ecological impact. Remember, dollars versus diversity.

So, what do we need to do to save our bumblebees and other native pollinators? First and foremost, we need to recognize that the persistence of each species depends on its ability to meet a unique set of ecological demands throughout its life cycle (page 14). For bumblebees, these demands include: suitable microhabitats for queen bees to hibernate in the winter and establish nests in early to mid-spring; enough flowering plants for worker production (in the late spring to summer) and for the colony to produce sufficient queens and males in mid-summer to fall. Unfortunately, we know little about how and why bumblebee species differ in such demands and therefore lack the tools needed to build effective conservation and restoration strategies for threatened bees. Fortunately, we are rapidly filling that knowledge gap through our 'Bee-cology' project (page 16), a scientific research program that 'crowd sources' the collection of ecological data on Massachusetts bumblebees. We also need to recognize that bees vary tremendously in how they respond to environmental changes or stressors introduced through human activity. For example, our research on *B. vagans*, a declining species in the state, has shown that it is highly sensitive to doses of neonicotinoid pesticides that have no effect on managed bumblebee (*B. impatiens*) and honeybee populations. This begs the question: should we be using the economic or ecological value of pollinators to make decisions on the potential hazards of pesticide use?

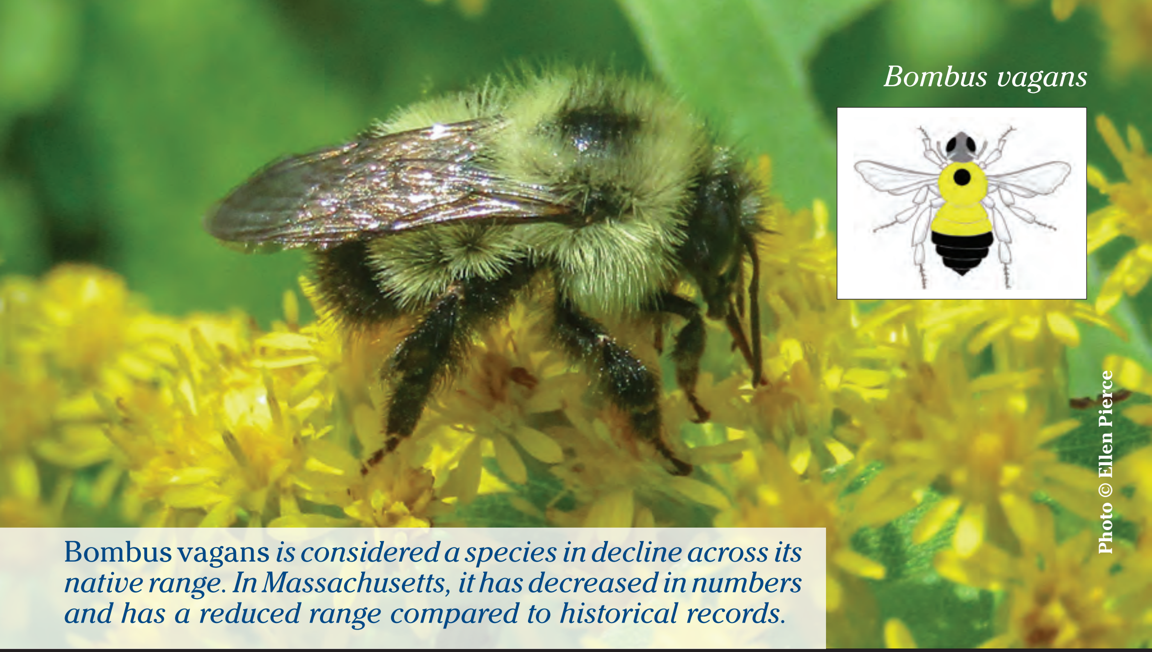
We also must abandon any notion that 'one size fits all' when it comes to creating habitat for bumblebees and other native pollinators in our gardens, parks, and conservation lands. Each bumblebee species has evolved special features that dictate its co-dependent relationship with flowering plants—that is why we have so much native bee and plant diversity in the first place. Consequently, it is important to ensure that habitats have floral diversity sufficient to service or 'match' a wide variety of bumblebee species from start to finish of their colony cycle. A short list of questions related to floral resources to consider include: is it being used as source of pollen (needed to produce new bees) or nectar (needed to survive)?; which species can and cannot access the nectar rewards (e.g. long-tongued bees match best with long-tubed flowers, short-medium tongued species match best with composites or short-tubed flowers)? To complicate matters, bumblebees can show strong preference and avoidance of flowers regardless of their tongue length. For example, milkweed flowers strongly attract *B. griseocollis* foragers but strongly deter physically similar *B. impatiens* foragers. It is for this reason that you should discourage the establishment and persistence of exotic plant species at all cost – not only do we know that they have the potential to steal bumblebee pollinators from native plant species but they also alter competition between bumblebee species, leading to the increased abundance of some and the exclusion of others from the habitat. Not surprisingly, we have found that threatened species such as *B. fervidus*, *B. terricola*, and *B. vagans* tend to be the losers in such scenarios. In contrast to floral resources, we know virtually nothing about how queen bumblebees of different species vary in their preference for hibernation and nesting sites. In fact, most of what we know is based on anecdotal reports contained in publications from the early 1900s. Through cutting-edge biotechnology and an army of 'bee-cologists' across the state, our ongoing work will eventually fill this void, and in doing so, position us to create highly effective strategies for our remaining bumblebee species.

Our story concludes with the hope that you have a greater appreciation of the real problem facing our native pollinators, and the severe ecological consequences if we choose to ignore it, and what it really means to be 'pollinator friendly'. I have fond memories of walking through floral meadows hypnotized by the dull hum of bumblebee foragers carrying out their daily routine. With a simple change in public perception, I am confident that we can ensure that our next generation of nature enthusiasts in Massachusetts is afforded the same pleasure.

The short-tongued Bombus terricola *was considered extirpated from the state, however, Dr. Gegear and his team from WPI found many during their 2017 survey.*

Flights of Bumblebees by Bill Byrne

A bee's wings beat about 200 times per second. This is driven by a combination of muscle contractions and vibration of the thorax, a process that also produces heat. The insulating hairs of bumblebees conserve this heat, warming their bodies so they can remain active during cool weather.



Bombus vagans

Photo © Ellen Pierce

Bombus vagans *is considered a species in decline across its native range. In Massachusetts, it has decreased in numbers and has a reduced range compared to historical records.*

Planting a Bumblebee-Friendly Garden

All bumblebees need adequate sources of floral nectar and pollen throughout their life cycle in order to keep populations humming. As a group, bumblebees are considered foraging generalists because they can exploit flowers of many different plants. However, each species of bee has a unique set of physical, physiological, and life history characteristics, and flower preferences that must be considered when designing a bumblebee garden. Remember, a truly 'bumblebee-friendly' garden is highly diverse. You need to include appropriate native plant 'matches' for all kinds of bees. Using the results of our Bee-cology research project to date, we have begun to create a list of native plants ideal for each type of bumblebee. Our current recommendations are provided in the table on page 13.

Other considerations when planting a bumblebee-friendly garden:

1) Diversity Matters—Bee abundance is not the same as bee diversity; seeing large numbers of bees in your garden is only beneficial if it reflects a large number of different bee species.

2) Avoid cultivars of native plants which don't produce floral nectar. In most plants, you can check for nectar by removing the flower from the base and squeezing it—a bubble of clear liquid means it has nectar. For species with a nectar spur, you can check for nectar by placing a light source behind the flower.

3) Avoid pesticide use, particularly those containing neonicotinoids.

4) Become a Bee-cologist—log observations of bumblebee-plant species interactions on a weekly basis. Note the number of species and whether the bee was collecting nectar or pollen (page 16).

5) ALWAYS avoid exotic plants—they can have dramatic negative effects on bumblebee-native plant relationships and can contribute to bumblebee decline.

6) Design plantings to ensure nectar and pollen are available for bumblebees throughout the entire growing season. Create potential nesting and overwintering sites. A dry, protected cavity containing straw, small clumps of moss, and/or dried grass located above or below ground is ideal.

Recommended Native Plants for Bumblebees

Short/medium tongue bees	Native plants (Nectar)	
B. affinis *B. terricola* *B. ternarius* *B. impatiens* *B. perplexus* *B. griseocollis*	• Milkweed • Goldenrod • Joe-pye weed • Aster • Boneset	• Common buttonbush • Bush honeysuckle • Blue lobelia • Bee balm • Dogbane
Long tongue bees	**Native plants (Nectar)**	
B. vagans *B. bimaculatus* *B. fervidus* *B. borealis* *B. affinis* (nectar robber) *B. terricola* (nectar robber)	• Turtlehead • Wild yellow indigo • Obedient plant • Spotted touch-me-not • Swamp and pasture thistle	• Spiked lobelia • Old field toadflax • Blue flag iris • Giant purple hyssop
All bees	**Native plants (Pollen)**	
	• St. John's Wort • Meadowsweet • Wild raspberry • Carolina rose	• Virginia rose • Goldenrod • Joe-pye weed

Bombus bimaculatus

Life cycle of the Bumblebee

Photo © Ellen Pierce

Bombus borealis

The annual life cycle of the bumblebee begins in the early spring when queens carrying fertilized eggs emerge from their overwintering sites. Emergence occurs when nighttime temperatures are consistently above approximately 35 degrees Fahrenheit. Among the different bee species, emergence times vary with *Bombus affinis*, *B. terricola* and *B. bimaculatus* typically the first bees to emerge. Depending on the species, spring queens actively search for a nesting site located either above or below ground, or both. Suitable nest sites for below-ground nesters are typically abandoned rodent nests. Above-ground nesters search for piles of straw, moss, or grass structured such that it provides an inner cavity protected from the elements. Once nest sites are chosen, queens begin to stockpile pollen and nectar. If you see a queen carrying and/or collecting pollen, that's a sure sign she has chosen a nest site. Once enough pollen is collected, she lays her first batch of eggs, that when hatched, comprise the first set of worker bees (all females) for the new colony. Workers perform various duties for the colony including collecting and storing nectar and pollen. From this point on, the queen remains in the nest colony laying eggs to produce more workers and later reproducing bees until the end of the cycle. The size of the colony will continue to expand throughout the summer months, limited only by the amount of food available. At the end of the cycle (mid-summer to early fall), the colony switches from producing worker bees to hatching reproductive bees—males and virgin queens. The number of queens and workers produced during this time period depends on the amount and quality of pollen stores in the colony. Males use olfactory and visual cues to locate virgin queens. They will commence mating if the queen deems the male an acceptable suitor. The fertilized queens search for a suitable overwintering site and remain there for the duration of the winter. The original colony, comprised of the founding queen and workers, all die with the arrival of freezing temperatures or a lack of food in late fall, thus ending the cycle.

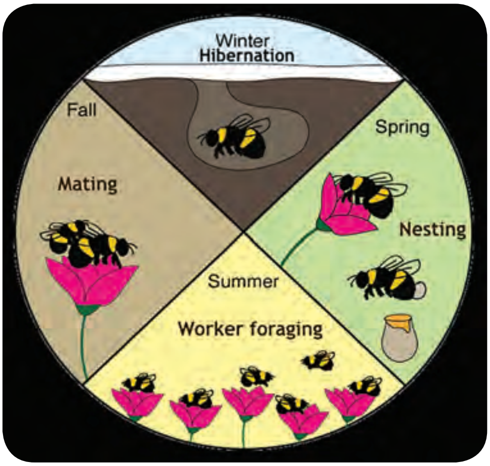
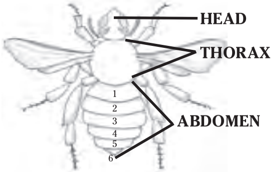
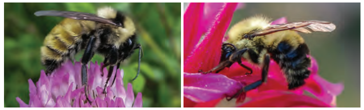


Illustration courtesy of Robert J. Gegear/WPI

MASSACHUSETTS BUMBLEBEES (WORKERS)

Parts of a bee





Bumblebee

Honeybee

Carpenter bee

Wasp

Species?

Amount of black on the abdomen?

	More than half	About half	Less than half
Short tongue		 *Bombus affinis*, *Bombus terricola*	 *Bombus ternarius*
Med. tongue	 *Bombus impatiens*, *Bombus griseocollis*	 *Bombus perplexus**	 *Bombus perplexus**
Long tongue	 *Bombus bimaculatus*	 *Bombus vagans*, *B. pensylvanicus*	 *Bombus fervidus*, *Bombus borealis*

**Two common color variants of Bombus perplexus.*

Identification chart courtesy of Robert J. Gegear/WPI

Bee-cology Project

Bumblebees and other bee pollinators native to New England are declining at an unprecedented rate due to unknown human-introduced environmental stressors. In Massachusetts alone, half of our native bumblebee species have become rare over the past decade. All of our native bees play a critical role in functioning of natural ecosystems as 'keystone species', meaning their continued loss will have cascading negative effects on the survival and reproduction of many of our native plants and animals, ultimately leading to ecosystem collapse. However, we presently lack ecological data on native bees needed to develop highly effective conservation and restoration strategies for threatened species, and assess the impact of reductions in native bee diversity on ecosystem health.

The Bee-cology Project aims to rapidly fill this critical knowledge gap by training citizen 'bee-cologists' to collect information on the habits of native bees during key life cycle stages. The first phase of the project is focused on bumblebee species native to Massachusetts, with subsequent phases expanding the project to other New England states and native bee groups. The Bee-cology app can either be run as a web application on the project website, http://beecology.wpi.edu, or downloaded from the site onto a smartphone. The app facilitates the rapid collection of bumblebee data in mixed floral environments and is designed to automatically transfer data to a central database at Worcester Polytechnic Institute, where it will be stored with data from other bee-cologists. Through a variety of online visualization and analysis tools, users will then be able to use the database to test for key ecological similarities and differences among bumblebee species. Armed with this crowdsourced information, scientists will be better positioned to protect our native bee diversity and keep our natural ecosystems humming for years to come.

How the App Works

Most bumblebee encounters last less than 20 seconds, making it difficult to visually identify the species in such a short time. The Bee-cology app enables users to digitally photograph a bee on a flower and then helps to quickly identify both bee and flower to the species level through a series of simple yes or no questions. The app then uploads the information to a central database where it, along with species information gathered by other bee-cologists, can be viewed using a variety of visualization tools. Males, workers, and queens of each species can have multiple variations, or morphs. Some morphs are much more common than others, so the app focuses on the most common morphs of the 11 species historically found in the Massachusetts area. The focus on common morphs greatly simplifies the identification system.

Another useful aspect of the app is its "Bee-dex" function. It provides basic information about each species of bumblebee, including a visual description of the bee, the months in which the bee is typically seen, and, if applicable, a list of similar looking species.

About the Author

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