Multistate Research Fund
IMPACTS

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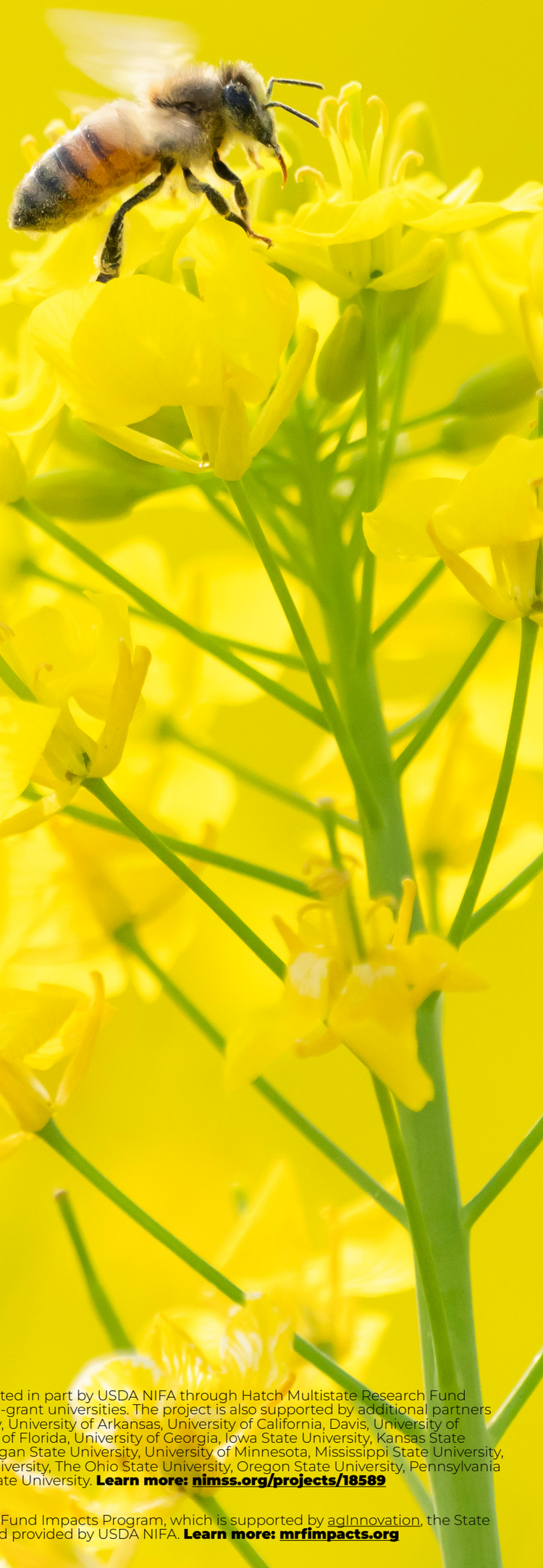
Supporting & Sustaining Bee Health



Healthy bee populations are critical for functioning ecosystems and sustainable agriculture. About 2 million managed honey bee colonies are rented and placed in nearly 100 different crops across the U.S. each year. Other managed bees and unmanaged wild bees also pollinate crops.

Pests and pathogens, poor habitat and forage quality, exposure to agrochemicals, changing weather patterns, and other factors threaten bee abundance and health. Since the mid-2000s, beekeepers have consistently experienced annual honey bee colony losses of 31-46%. Currently available management tools are costly and may not be sufficient to sustain colonies in the long term. Wild bee populations have also declined in recent decades.

Land-grant universities across the U.S. are working together and with other partners to raise awareness about the importance of bees, identify factors associated with population declines, and develop tools and practices that help beekeepers, farmers, landowners, scientists, and the general public protect bees and their habitats.

Bringing together researchers and Extension educators from multiple states and disciplines is necessary for a holistic understanding of bee health and solutions that work for different stakeholders and settings. This multistate project enables members to share tools, expertise, and other resources and coordinate efficient research, Extension, and education.

NC1173: Sustainable Solutions to Problems Affecting Bee Health is supported in part by USDA NIFA through Hatch Multistate Research Fund allocations to participating State Agricultural Experiment Stations at land-grant universities. The project is also supported by additional partners and funding sources. Participating institutions include: Auburn University, University of Arkansas, University of California, Davis, University of California, Riverside, Central State University, Cornell University, University of Florida, University of Georgia, Iowa State University, Kansas State University, Purdue University, University of Massachusetts Amherst, Michigan State University, University of Minnesota, Mississippi State University, Montana State University, University of Nebraska, North Carolina State University, The Ohio State University, Oregon State University, Pennsylvania State University, Rutgers University, Texas A&M University, Washington State University. **Learn more: nimss.org/projects/18589**

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Monitoring Bee Populations

Monitoring the presence and abundance of bee species across landscapes sheds light on population changes and guides solutions. In recent years, members of this multistate project:

- Found significant pollination limitation in food crops in the U.S. and worldwide. Insufficient pollen transfer can lead to lower crop yields and quality (Rutgers University).
- Developed standardized protocols for monitoring wild bees and their interactions with resources and diseases (University of California, Davis, Pennsylvania State University, Cornell University).
- Initiated Project GNBee to record ground-nesting bees across the U.S. Over 3,000 observers have submitted nearly 8,000 observations for 440 species. Identifying and mapping bee nest sites is key to protecting them (Cornell University).
- Provided information about the status of capped brood, the wax-capped honey comb cells where honey bee pupae develop into adult bees and parasitic *Varroa* mites often reproduce and feed, helping beekeepers plan ahead for management needs (Auburn University, Cornell University, Central State University, University of Florida, University of Georgia, Mississippi State University, Oregon State University, Pennsylvania State University, University of Tennessee, Texas A&M University, USDA-ARS).
- Developed the BeeMachine, which has used computer vision and artificial intelligence to identify over 15,000 bees for over 5,000 users (Kansas State University).
- Designed an automated tool that uses machine learning to monitor bees based on sound (University of Massachusetts Amherst and The Ohio State University).

Honey Bee Breeding & Stock Maintenance

Genetic diversity and certain traits can help honey bee colonies survive. To facilitate the selection, maintenance, and production of honey bee stock, project members:

- Established the Genomic Testing Facility, providing a centralized service to help beekeepers and regulators worldwide test the genotypes of their honey bees and understand the genetic composition of their colonies so they can make informed breeding choices (Purdue University).
- Coordinated breeding programs focused on *Varroa* mite resistance, which resulted in over 100 colonies that have survived at least one winter without chemical treatments (Purdue University, University of Minnesota).
- Shared techniques and tools that helped beekeepers locally produce and commercialize breeding queens (Purdue University).

Protecting the Queen Bee

Healthy queen bees are key to colony survival. To support queen bees, project members:

- Taught beekeepers queen breeding and production skills, including grafting, nutrition, and insemination (Central State University, Pennsylvania State University, Purdue University, Texas A&M University).
- Determined that plastic cups used to rear queens should come in a standard size that does not compromise the queen's physical qualities (Mississippi State University).
- Created a model that helps beekeepers mitigate the negative effects of premature queen failure and replacement (North Carolina State University).
- Developed technologies that use sound or electronic detections to track queens in honey bee colonies, providing critical data on colony stability (Michigan State University).

Parasites, Pathogens & Pests

Project members studied the effects of parasites, pathogens, and pests on bee health and explored management options. For example, researchers:

- Showed how the life cycles of bee pests relate to seasonal variations in the environment. These data guide models that predict when and where to target pest treatments (University of Florida).
- Developed a promising new technique that screens honey bee colonies for pests and pathogens using environmental DNA (University of Florida and collaborators).
- Found that new, more virulent forms of deformed wing virus dominate the U.S. honey bee landscape and more nuanced surveillance techniques may be needed to maintain an accurate picture of the viral landscape (University of Minnesota, University of Maryland, Oregon State University).
- Showed that thyme oil and thymol can stimulate honey bee immune response to viral infections and reduce levels of deformed wing virus (Montana State University).
- Collaborated with industry to combine bee vaccines with supplemental feeding for pathogen control (University of Georgia).
- Influenced a company to sell bee boxes with rough, grooved interior walls that bees can more easily coat in natural, antimicrobial resin, forming a protective layer against pests and pathogens (University of Minnesota).
- Tested the effectiveness and safety of various chemical products to control *Varroa* mites and explored alternatives, such as inhibiting salivary proteins to prevent mite feeding and pathogen transmission; mixing a hormonal analog in beeswax to reduce mite offspring; fumigating hives with vaporized oxalic acid; and using a natural fungus to parasitize mites (Auburn University, University of Georgia, University of Florida, Michigan State University, The Ohio State University, and others).

Varroa mites attach to and feed on bees, causing deformities and transmitting viruses that impair or even kill bees. Infestations can lead to colony collapse. USDA-ARS photo.

As a colony's sole egg layer, a queen honey bee has a major influence on colony growth and genetic fitness. She also produces pheromones that foster colony unity and help guide the behavior of worker and drone bees.

Bee Foraging & Nutrition

Project members studied how forage quality and bee nutrition can affect health. For example, they:

- Operated the Honey and Pollen Diagnostic Lab, which uses DNA metabarcoding to identify plants bees have been foraging. Since fall 2023, the lab has analyzed 3,500 samples from 43 states and 7 countries (Pennsylvania State University).
- Identified the most attractive and nutritionally beneficial species of plants for bees in urban and agricultural or semi-natural settings (Pennsylvania State University).
- Found that symbiotic yeasts present in foraged pollen and nectar benefit bumble bee health (University of California, Davis).
- Showed that malnutrition and insecticide exposure interact and negatively affect bee fitness and immunity traits (Auburn University).
- Quantified the additional stress of limited food resources on blue orchard bees affected by pesticide exposure (University of California, Davis).
- Found that nutritional stress during the larval stage can have long-lasting effects on honey bee health, including their ability to respond to viral infection as adults (Iowa State University).
- Evaluated commercial protein supplements available for honey bees (University of Georgia, Oregon State University).
- Developed the Pennsylvania Pollen Library, a sortable, online digital database of flowering plants and their pollen grains, which beekeepers, land managers, educators and gardeners can use to identify the nutritional needs of pollinators at their sites (Pennsylvania State University).
- Began work on the first nationwide database of the nutritional content of pollen from crop and non-crop plants (Washington State University, Oregon State University).
- Published a supplemental feeding guide for beekeepers (Washington State University).

Pesticide Exposure

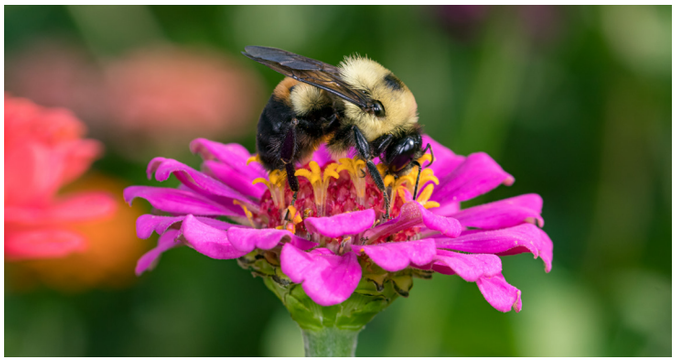
Bees are exposed to pesticides through direct contact and ingestion. Looking at pesticide exposure levels and impacts on bee health, project members:

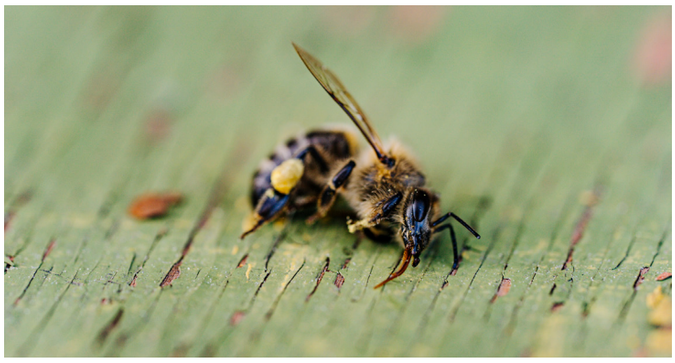
- Integrated data from government databases to provide a measure of the total toxicity of all the pesticides applied to a particular crop in a particular state. Using this index, researchers found a significant increase in toxic load over the last 20 years, due primarily to neonicotinoid seed treatments (Pennsylvania State University).
- Created and tested a model for predicting honey bee and bumble bee pesticide exposure. This model could help extend predictions from the local field scale to the landscape, supporting environmental risk assessments and mitigation decisions (University of California, Davis).
- Demonstrated that even low-level pesticide exposure can lead to disease outbreaks in honey bees (University of Georgia).
- Found less pesticide residue on pollen from urban sites compared to agricultural areas (University of Florida, Michigan State University, Texas A&M University).
- Identified in pesticide formulations and spray adjuvants that are labeled “inert” but are toxic to bees (The Ohio State University).
- Showed that mosquito control chemicals can negatively affect honey bee broods and identified which mosquito control chemicals are high-risk and low-risk to honey bee adults and larvae (University of Florida).
- Discovered that bees are exposed to pesticides that leach into the environment through improper disposal of large amounts of pesticide-treated seeds for ethanol production (University of Nebraska-Lincoln).

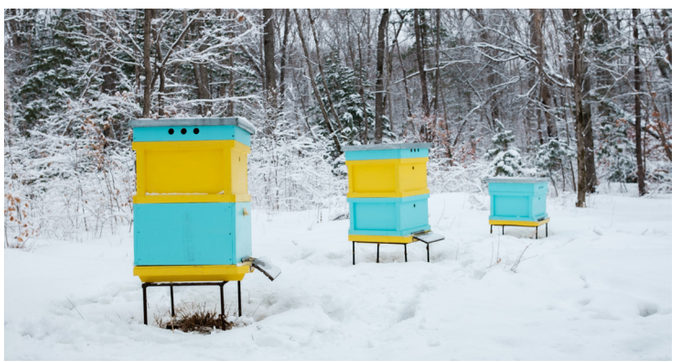
Weather Stress & Habitat Change

Environmental conditions, including weather and landscape features, can affect bee health in a variety of ways. As part of this multistate project, scientists:

- Evaluated the effects of high heat and changes in humidity on honey bees and wild bees (University of California, Davis, Iowa State University, University of Massachusetts Amherst, Pennsylvania State University).
- Demonstrated that weather instability and extreme weather events are key drivers of honey bee colony losses in the U.S. (Auburn University, Pennsylvania State University, Texas A&M University).
- Showed that the negative impacts of poor weather conditions on bees could be buffered by increasing the amount of herbaceous grassy land (Michigan State University, Pennsylvania State University, University of Wisconsin, USGS).
- Found that honey bees experience positive health effects if nearby crop fields integrate prairie strips (Iowa State University).
- Showed that grazing can augment wild bee abundance and richness in tallgrass prairie (Kansas State University).
- Revealed wildflower plantings could help mitigate the effects of pesticide exposure on bees (University of California, Davis).
- Developed Beescape, which helps users across the U.S. explore landscape quality for bees at their selected sites, and BeeWinterWise, which helps beekeepers reduce colony losses over the winter season (Pennsylvania State University).
- Studied how transportation stress impacts honey bees in colonies that are rented by and shipped to growers (Michigan State University).







Education & Outreach

By sharing best practices, tools, and other resources via websites, fact sheets, webinars, workshops, courses, and more, this project is helping beekeepers, growers, land managers, and communities support healthy bee populations, and efforts to recruit and train beekeepers are increasing pollination capacity. For example, project members:

- Shared a highly effective protocol for managing honey bee colonies using organic approaches (Pennsylvania State University).
- Worked with 28 state and national organizations and stakeholder groups to develop the Pennsylvania Pollinator Protection Plan (Pennsylvania State University).
- Provided a virtual beekeeping seminar series for over 2,300 participants. According to surveys, 89% of participants in 2020 planned to implement learned practices, and 69% said that attendance will save them money moving forward (Auburn University with support from scientists at University of Florida, University of Georgia, Kentucky State University, Louisiana State University, Mississippi State University, North Carolina State University, University of Tennessee, Texas A&M University, and USDA-ARS).
- Led Great Plains Regional Training For Beginning Beekeeping Farmers courses. In 2020, 65.6% of participants who responded said they intend to expand their business because of information and tools shared during the courses (University of Nebraska-Lincoln).
- Trained Beekeepers Association members, Master Gardeners, Master Beekeepers, and other commercial and backyard beekeepers.
- Established the Heroes to Hives program to provide beekeeping training for military veterans (Michigan State University).
- Trained state bee inspectors and beekeepers about the threat posed by the invasive parasitic mite *Tropilaelaps mercedesae*, which recently spread from Asia to Europe (Auburn University).
- Reached pre-K and K-12 students, 4H members, Girl Scouts, and other young people through visits to schools, camps, and clubs as well as exhibits and events at local libraries and museums.
- Received a grant to develop internship programs that will support the U.S. beekeeping industry (University of Florida and collaborators).
- Educated, mentored, and provided hands-on experience and professional development to graduate and post-doctoral students, fostering the next generation of scientists who will continue work to sustain bee health.
- Shared over 3,000 photos of honey bees on various plants via Beetography.com, which receives about 250,000 visits each year (Michigan State University).