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Critical Issue Report: The Role of Organic in Supporting Pollinator Health

The Role of Organic in Supporting Pollinator Health

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Since the development of Colony Collapse Disorder in 2006, declining bee populations have been a top concern of many stakeholders. In the last decade beekeepers have lost over a third of their bee hives, leaving many farmers worried about their ability to meet demands for bee-pollinated crops. Honey bees are responsible for about $12.4 billion worth of crops per year. Without bees many favorite fruits and vegetables would be missing from our supermarket shelves, such as apples, almonds, carrots, pumpkins, onions, or broccoli.

This review paper takes an in depth look at the challenges faced by honey bees and other pollinators. We cover everything from the importance of pollinators to the causes of bee population declines. Perhaps most importantly, we look at organic as a model for supporting pollinator populations and steps that growers can take to foster healthy pollinators. Organic farming requirements prohibit the use of harmful synthetic pesticides and toxic seed treatments while promoting abundant pollinator habitat and plentiful diverse pollinator food sources. These actions have resulted in higher pollinator abundance and diversity on organic farms. Many techniques used by organic growers can be adopted by all growers to support pollinator health, such as crop rotations, hedgerow planting, and the use of integrated pest management techniques.

The Organic Center thanks the many researchers and bee keepers who have reviewed our report, providing us with valuable comments and information that we have incorporated into this final publication. We appreciate your support, and our report is stronger because of your input.

We hope this report acts as a tool to educate growers, consumers, and industry members about this critical issue, and that bee-friendly practices, such as organic farming, become increasingly common in the future.

The Organic Center

Bringing you the science behind organic™

Executive Summary

Seventy-five percent of all crops grown for human consumption rely on pollinators, predominantly bees, for a successful harvest. However, over the last decade, both native and honey bee populations have been declining at alarming rates, raising concerns about the impact on our global food security. To complicate the situation, many of the factors linked to bee population declines are a direct result of commonly utilized agricultural practices. Fortunately, organic farming practices can provide critical solutions that not only decrease risks to pollinators, but actively support the growth and health of our pollinator populations.

Some of the most well-studied factors implicated in declining pollinator populations include:

- Low-level exposure to toxic agricultural pesticides including herbicides, insecticides, and fungicides
- Parasites and pathogens
- Malnutrition through reduced diversity in available food sources—often due to intensive conventional mono-cropping
- Habitat destruction through the conversion of land for anthropogenic use
- Additive effects and synergistic interactions among multiple factors

Large-scale chemically intensive agricultural production has been implicated as a major source of threats to pollinators. Increasingly, scientific research demonstrates that the use of toxic synthetic pesticides, destruction of native habitat, and a decrease in nutritious forage due to extensive use of mono-cropping are detrimental to pollinators. Fortunately, one of the simplest ways to conserve our pollinator populations in an agriculturally reliant world is through organic farming. Organic farming standards not only prohibit the use of synthetic pesticides, many of which are highly toxic to bees and can be persistent in the environment, but also require that organic producers manage their farms in a manner that fosters biodiversity and improves natural resources. These management practices can vary from farm to farm, however one of the most common ways that organic farmers meet these requirements is by planting insectaries that provide habitat and season-long food sources for pollinators.

Organic farmers also use numerous integrative pest management techniques which promote environments that support beneficial insects such as pollinators by providing them with habitat and nutritious floral food sources. A number of studies reviewed here have demonstrated that organic farming practices alleviate many threats to honey bees and that organic farms support significantly more pollinators than conventional farms.

Pollinator health and, in turn, food security have major implications for all of us regardless of our role in food production. While agricultural producers must adjust their practices to incorporate farming techniques that reduce risks for pollinators, consumers can also take action by supporting sustainable organic farming. By shifting towards a more sustainable food production system, we can ensure food security and support thriving agricultural ecosystems long into the future.

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INTRODUCTION

In addition to its many benefits for human health, organic agriculture is also good for many other animals including pollinators. Pollinators play a critical role in crop production around the world. Seventy-five percent of major crops grown for human consumption worldwide rely on insects for pollination. However, with the decline of the domestic honey bee as well as native bee populations, our food security is at risk.

No single factor has been consistently attributed as the cause of honey bee population decline. Instead, a number of factors including exposure to toxic pesticides, parasite and pathogen infections, poor nutrition, and habitat loss likely interact together resulting in lethal consequences for bees. While there is no 'silver bullet' to restore the health of our pollinator populations, organic farming can be part of the solution. Organic farming supports pollinator health by using techniques that improve pollinator habitat, providing more diverse and nutritious forage options, and reducing the use of synthetic pesticides that are toxic to bees. Here we review the science behind bee health, including basic pollination biology, threats to our pollinators and how organic farming benefits our pollinators.

Importance of pollination

Pollination services are essential to crop production and therefore play an important role in global food security and nutrition. Pollination services are valued at $190 billion worldwide,[1] meaning that without pollinators, the global agricultural community would lose $190 billion through decreased food quality and crop yields.

Bees provide a disproportionately large share of pollination services, valued at a total of $16 billion per year in the United States. Of this total, $12.4 billion are attributed by honey bees and $4 billion by native bees and other insects.[2] While many of the most commonly produced crops such as rice, wheat and corn are pollinated by wind, the majority of fruits, vegetables, and nuts—which are of high economic value and supply humans with the vast majority of vitamins and minerals—typically rely on bees for pollination.[3] A few of the important crops relying on insect pollination to produce fruit include apples, avocados, blueberries, cranberries, and cherries.

What is pollination?

Successful pollination is necessary for most plants to produce seeds and fruit. In agriculture, this process is often responsible not only for producing the edible portions of many of our most important crops but also to ensure that seeds are available for the next year's planting. Specifically, pollination refers to the method by which pollen from the male part of a flower (stamen) is transferred to the female part of a flower (stigma) so that fertilization can occur. Pollen can be transferred by way of wind, water, or by animals. Almost 90 percent of flowering plant species are pollinated by animals.[4]

What is a pollinator?

The term pollinator refers to animals that move pollen from one flower to another. Animals visit flowers to collect and eat nectar and pollen, as a brood site for mating, a place to lay eggs, and to collect the oils that give flowers their scent—humans aren't the only animal that likes perfume!

In the process of traveling between multiple flowers, pollinators will inadvertently pollinate them by transferring pollen from the flower on one plant to the flower of another plant. There are about 200,000 animal species that are known to pollinate plants.[5] While animal pollinators include hummingbirds, bats, and small rodents, the majority are insects such as beetles, bees, flies, ants, wasps, and butterflies.

Bee pollinators

Of the estimated 30,000 bee species worldwide, about 4,000 are native to North America, the majority of which do not live in colonies or make honey.[6] Native bees are the primary pollinators for many wild plants and are also important for crop pollination. Studies have demonstrated that when native habitat near agricultural land is conserved, native pollinators are able to provide the majority of pollination services needed for crops.[7] However, where large swaths of land have been converted for intensive agricultural production, native bee populations are not sufficiently large to completely pollinate crops, and therefore must be augmented by managed colonies of the domesticated honey bee.

The domesticated honey bee (*Apis mellifera*) was brought to the United States by European settlers during the 1600s for honey production.[8] They live in large colonies composed of tens of thousands of bees. Every bee in a colony falls into one of three categories: queen bee, worker bee, or drone bee. There is only one queen bee per hive and she is the only bee in the colony with the ability to reproduce. Queen bees can lay up to 2,000 eggs per day.

Fertilized eggs will develop into female worker bees, and unfertilized eggs will become male drone bees. Worker bees, which make up the majority of the bees in the hive, are responsible for a number of important tasks including rearing young bees, building the hive, guarding the nest and collecting pollen and nectar. The final type of bee in the honey bee colony is the drone bee. All drone bees are male, and they are responsible for mating with virgin queen bees from different hives. Each hive generally contains between 300 and 3,000 drones.[9]

Many domesticated honey bee hives are managed by bee keepers for honey as well as to provide commercial pollination services to farmers. Managed hives are transported across the United States to agricultural areas where pollination services are needed.

CAUSES OF DECLINING BEE POPULATIONS

Numerous studies have established that populations of the domesticated honey bee as well as a wide array of wild bees are in decline due to a number of hazards including

pesticides, pathogens, parasites, poor nutrition and habitat loss. Here we describe the phenomenon affecting managed colonies of the domestic honey bee known as colony collapse disorder, and discuss individual factors thought to be involved in bee declines

Colony Collapse Disorder

Unexplained losses of the domesticated honey bee, referred to as Colony Collapse Disorder (CCD), began to be reported in 2006. CCD is characterized by the sudden disappearance of adult worker bees from hives in winter that contain an adequate food supply, a living queen and juvenile bees.[10, 11] While some bee colony losses in winter are considered normal with typical rates ranging from 10–15 percent, the emergence of CCD resulted in much more drastic losses. Between 2007 and 2011, overwintering losses for commercial beekeepers averaged 30 percent per year.[12] However, because no one factor has been identified as the cause of CCD, finding a single solution is complex. Researchers instead have found that a number of factors are correlated with CCD, although the strength of these associations varies by study.

Chemical exposure

Bee exposure to chemical pesticides has been widely implicated as a leading factor in both declining domestic honey bee and native bee populations. Exposure to agricultural insecticides is one of the primary ways in which bees come in contact with toxic chemicals, but herbicides, fungicides and acaricides (pesticides used to treat honey bee hives infected with parasitic mites) may also have negative effects on bee health.[13, 14] In one recent study, a total of 161 different pesticides were identified in pollen, wax and honey of bee hives, many of which were determined to pose a significant health risk to bees. Of the 161 different chemicals, 52 percent were insecticides, 25 percent were fungicides, 17 percent were herbicides, and 6 percent were acaricides.[15] Here we'll review some of the scientific literature on the effects of chemical exposure on bees.

Neonicotinoid insecticides

While a variety of chemicals are used to treat agricultural pests, a growing body of evidence suggests that neonicotinoids, a commonly used class of insecticides, are particularly harmful to bees. Neonicotinoids include imidacloprid, acetamiprid, clothianidin, thiamethoxam, thiacloprid, dinotefuran, nithiazine, and nitenpyram which are marketed under a number of different brand names. Neonicotinoids are neurotoxicants that act by targeting receptors in the insect's nervous system, resulting in death.[16] Because neonicotinoids specifically target insect neurons, they are of relatively low toxicity to humans and other mammals, making them more attractive to farmers than older, more toxic pesticides such as organophosphates.

Upon their introduction to the market, neonicotinoids were rapidly adopted across the agricultural community. The first neonicotinoid registered for use in the United States, imidacloprid, became available for commercial use in 1994[17] and has been widely used since. Newer neonicotinoids continued to be developed with thiamethoxam and clothianidin released on the market in the early 2000s. Today, neonicotinoids are the most widely used insecticide in the world.[18] Unfortunately, because neonicotinoids are broad spectrum insecticides, they may be toxic to all insects that come into contact with them including beneficial insects such as bee pollinators.

Neonicotinoids can be applied to plants as seed coating, or sometimes as a ground application or foliar spray. When seeds are coated with neonicotinoids, they are transferred into developing tissues as the plant grows. While it is expected that this provides the growing plant with sufficient protection against pests without the need for foliar pesticide applications, this is not always the case.

A recent study by the U.S. Environmental Protection Agency[19] found that soybeans planted in Iowa using neonicotinoid coated seeds received no more pest protection than untreated soybeans due to timing differences in chemical release and peak pest activity. Unfortunately, even when neonicotinoid seed treatments do not provide adequate pest protection, they can still cause harm to bees. This is because neonicotinoids are present in plant nectar, pollen and exuded sap known as guttation fluid, all of which provide a source of food for bee pollinators. Bee exposure to neonicotinoid pesticides by way of seed coated crops as well as dust from treated seeds exhausted in to the air by seeders are of particular concern.[20, 21]

A large and still growing body of scientific research strongly suggests that both acute and sub-lethal exposure to neonicotinoids have negative effects on bee health, making them more susceptible to stressors, which, in turn, may lead to high mortality in the hive.

Acute and chronic toxicity

Acute toxicity references the toxicity of a chemical to a particular organism when it is exposed to high doses over a short period of time. Neonicotinoids' acute toxicity to bees is evaluated using a standardized method set forth in the U.S. Federal Insecticide Fungicide and Rodenticide Act. Laboratory bioassays are conducted to determine the oral and contact honey bee toxicity of neonicotinoids. Neonicotinoids are most toxic to bees when they are ingested. However, the fact that results for acute toxicity can be quite variable depending on the type of neonicotinoid, the age of bees, the season in which exposure occurs, the nutritional health of the colonies, and physiological variation across subspecies or even across colonies, creates complexity and makes bee-safe pesticide-management decisions difficult.[22–27]

While acute exposures in the field are possible, it is much more common for bee pollinators to be exposed to pesticides at low levels over long periods of time. This makes it important to understand the effects of chronic exposure to pesticides at sub-lethal levels. The most common route for chronic exposure is the ingestion of contaminated nectar or pollen from plants grown from neonicotinoid treated seeds. Low levels of insecticides can also make their way back to the hive where pollen and nectar are stored as food and fed to juvenile bees. Therefore, many studies have examined the long-term effects of low-level neonicotinoid insecticides on bees in the laboratory and the field.

Effects of sub-lethal exposure

There is a growing body of scientific literature demonstrating adverse health effects in bees when they are exposed to field-relevant levels of neonicotinoids. While most of these studies do not report immediate bee mortalities due to sub-lethal exposures, they do demonstrate the wide range of negative impacts that neonicotinoid exposure has on the behavior, cognition, learning ability, and daily function of bees.[28–42]

A study by Williamson *et al.*[43] found that neonicotinoid exposure deteriorated bees' motor skills. When bees were fed low-levels of four different neonicotinoid insecticides, they showed significant motor impairment. The bees were unable to right themselves after falling upside down, and spent an increased amount of time grooming.

Gill and Raine[44] found that when honey bees were exposed to sub-lethal levels of neonicotinoids, their foraging behavior became impaired. Researchers used radio tags to monitor bees' daily behavior when they were exposed to low levels of neonicotinoids. After the initial exposure, subtle differences in bee behavior were observed. However, as the duration of exposure time increased, so did the impairment of individual bees. Over time, impaired bees went on more foraging bouts and spent more time foraging but brought back smaller pollen loads compared to colonies not exposed to pesticides. Additionally, as time passed, the number of worker bees in the pesticide-exposed colonies increased faster than in control colonies. While colonies typically produce more worker bees over time in order to accommodate the growing hive, the authors suggested that hives chronically exposed to neonicotinoids may need to create even more worker bees than hives not exposed to neonicotinoids in order to compensate for reduced foraging efficiency.

Studies examining the effects of neonicotinoid exposure in bees have also observed direct effects on growth and reproduction. Whitehorn *et al.*[45] demonstrated retarded growth rates and lowered queen production in bumble bees exposed to neonicotinoids. Bumble bees were fed field-realistic levels of imidacloprid in the laboratory and subsequently released into the field. Exposed bees experienced significantly lower growth rates as well as an 85 percent decrease in new queen production when compared to control colonies not exposed to neonicotinoids.

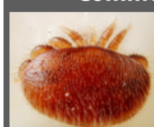
The majority of studies demonstrating alterations in bee behavior focus on the European honey bee. Declines in navigation ability, or motor/sensory skills suggest that sub-lethal exposure to neonicotinoids negatively affects day-to-day functions in bees and likely leads to weaker colonies with poor health, ultimately making them much more susceptible to complete colony collapse.

Research also suggests that the use of neonicotinoid coated seeds may have a disproportionate effect on native bee populations, emphasizing the importance of including data on native bees when assessing the effects of neonicotinoids on pollinators. In a study recently published in Nature[46] researchers used eight pairs of fields: one field in each pair was sown with neonicotinoid-coated oilseed rape seeds and the other pair was sown with seeds coated only with fungicide. They then compared the density of wild bees, the nesting activity of a native solitary bee, the colony development of the bumblebee and the strength of honey bee colonies between each paired field. The study found a decline in the density of bumblebees and solitary bees in fields where neonicotinoid-coated seeds were planted. Researchers also found that the use of neonicotinoid-coated seeds was correlated with reduced nesting in solitary bees, and that bumblebee reproduction and colony growth declined in fields where neonicotinoid seeds were planted. However, these significant declines in colony strength did not carry over to European honey bees. These results suggest that simply using honey bees in environmental risk assessments of neonicotinoids may not accurately reflect the risk to other bee species.

Parasites and pathogens

A number of pathogens and parasites have been identified as destructive forces in domestic honey bee hives, and a number of viral, fungal and bacterial infections are more severe when they occur in association with parasite infestations. Unfortunately, exposure to pesticides can increase the susceptibility of bees to parasites and pathogens. For more information on this, see the Synergistic interactions section below.

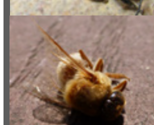
Common Honey Bee Parasites and Pathogens



Varroa destructor
Varroa destructor is the most detrimental pest that infects honey bees. It is a parasite that is not only lethal to bees but it also vectors a multitude of deadly viruses. Infestation is typically controlled with chemical miticides applied to bees and their hives.

Nosema ceranae
Nosema species are fungi which parasitize the guts of adult honey bees and are widespread across the United States. While *Nosema* infections do not directly cause colony losses, infection weakens the bee immune system and adversely impacts nutrient utilization.

Deformed Wing Virus (DWV)
DWV is vectored by the *Varroa* mite, making it particularly widespread. Because the virus replicates within the *Varroa* mite pupae, bees in *Varroa* infested colonies will exhibit deformed wings due to exposure to particularly high DWV viral loads.



Israeli acute paralysis virus (IAPV)
IAPV is vectored by the *Varroa* mite and infections are strongly associated with Colony Collapse Disorder (CCD). In a USDA survey of hundreds of hives, IAPV was found in almost all samples affected by CCD but not in non-CCD colonies.

American foulbrood
American foulbrood is the most destructive of the brood-infecting bacterial diseases. Larvae are infected and die after they eat bacterial spores, but not before millions more spores have been released into the hive.

Photo credits: Mike Linksvayer, Xolani90, Will Thomas, USDA, and Gilles San Martin

Poor nutrition

As with any animal, good nutrition is important for maintaining healthy bee colonies that are able to reproduce and withstand environmental stressors.[47] Pollen and nectar are the two primary food sources for bees. Pollen, the primary source of amino acids, lipids, minerals and vitamins, is essential for bees.[48] Nectar provides bees with a carbohydrate energy source. However, not all nectar and pollen are created equal. The nutritional value of these plant products varies among plant species. In nature, bees forage on a diversity of plant species. When domestic bees are transported to forage in intensive agricultural landscapes, they often are left to forage on only one crop. If that single crop happens to have low-quality pollen or nectar (blueberries for example), the colony may become undernourished.[10] Studies have demonstrated that when colonies do not have access to sufficient pollen resources, fewer juvenile bees are raised and worker bees die younger, ultimately reducing the productivity of the entire colony.[49–51]

Synergistic interactions

Synergy refers to an interaction between two or more factors where the combined effect of the interaction is **greater** than the additive effects of each factor if they had been operating individually. The domestic honey bee is exposed to a large number of antagonists on a regular basis, and the combined effects of multiple stressors can result in high bee mortality. A number of studies have demonstrated that when acting in concert, many of these individual stressors can act synergistically, making them even more deadly to bees. Combined exposure to multiple chemical pesticides, even when they are considered safe for bees, can have additive or synergistic adverse effects on bee health.[44, 52–54] Similarly, chronic exposure to a variety of parasite, pathogen, and pesticide combinations can have particularly severe impacts at the colony level.[55]

Synergistic interactions: Insecticides, Acaricides, Fungicides and Herbicides

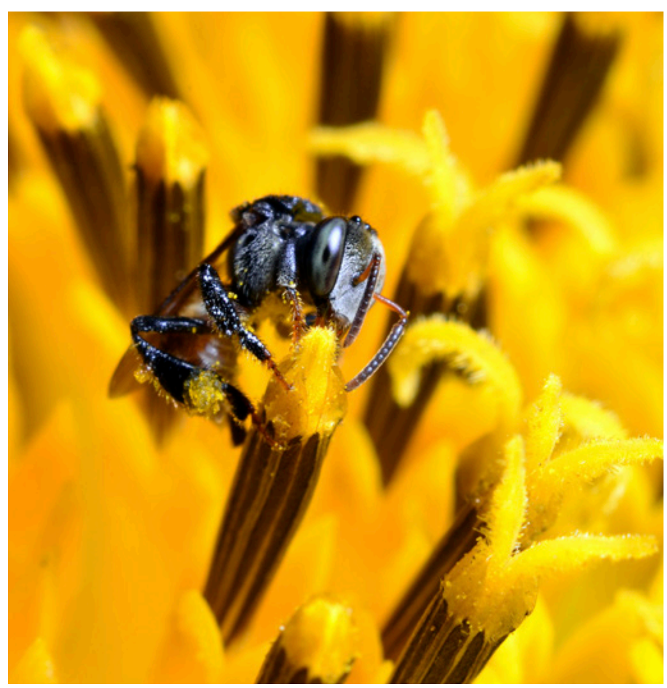
In addition to insecticides, bees are often exposed to acaricides, fungicides and herbicides on a regular basis. Since these pesticides are generally considered safe for bees, they may be applied directly to the hive (in the case of mite control) or to flowering crops during high forage times.[54] Unfortunately, a growing body of literature suggests that these pesticides may have negative effects on honey bee health when bees are exposed to multiple chemicals in concert. Additionally, because many of these pesticides persist in bee hives for long periods of times, synergistic interactions among chemicals may occur even when initial exposures do not coincide.[56]

Acaricides are pesticides commonly used in managed honey bee hives to control *Varroa* mite infestations. While the individual use of an acaricide may only slightly increase the stress in the hive,[57–59] in combination they can become quite toxic for bees. For example, Zhu *et al*.[54] found that acaricides, fungicides and an inert ingredient, all of which are typically considered safe for bees, can become toxic when bee larvae are exposed to more than one of them at a time. This study focused on the four most common pesticides found in bee pollen—fluvalinate and coumaphos which are acaricides, and chlorothalonil and chlorpyrifos which are fungicides. They also tested an inert ingredient found in pesticides called N-methyl-2-pyrrolidone. Chronic toxicity was examined for each pesticide alone and in combinations. They found that the pesticides as well as the 'inert' ingredient, which are supposedly considered safe for bees, significantly increased the mortality of bee larvae. They also found evidence of synergistic toxicity when larvae were exposed to multiple pesticides at once. These results suggest that even 'bee safe' pesticides may have greater health impacts on colony health than previously thought.

Synergistic interactions: Chemical Pesticides, Parasites and Pathogens

Interactions among pesticide exposures, parasite infestations and pathogen infections can also have synergistic effects that could result in bee colony collapse or decline. A multitude of synergistic effects have been observed in bee colonies exposed to pesticides, parasites and pathogens.

Sub-lethal exposure to pesticides can increase bee susceptibility to *Nosema* infections. A study by Pettis *et al*.[60] surveyed pollen from bee hives used to pollinate blueberries, cranberries, cucumbers, pumpkins and watermelons for chemical pesticide residues and *Nosema* infections. They found that bees that consumed pollen with sub-lethal levels of fungicides were more likely to be infected with *Nosema* fungi.



Another recent study by Nazzi *et al.*[61] found that parasite pathogen interactions can cause entire colonies to die. Deformed Wing Virus (DWV) alone is not particularly dangerous to the domestic honey bee. However, when it occurs in conjunction with *Varroa* mite infestation, it becomes deadly. The study showed that healthy honey bee immune systems were capable of suppressing DWV. However, when an additional stressor—mite feeding—was introduced, the bee immune system was not able to deal with the additional strain. As a result, DWV was able to replicate uncontrolled, resulting in transition from a non-deadly virus to one that replicates rapidly and can reach lethal levels.

A number of other studies have also suggested that synergies can occur when malnourished bees are exposed to chemicals. Sub-lethal exposure to pesticides can kill the mid-gut cells of immature bees, likely reducing their ability to absorb nutrients leading to malnourished bees or exacerbating existent nutrient deficiencies.[62, 63]

Decline of native bee pollinators

Native bee populations are also in decline.[64] However, while many studies have focused on the causes of Colony Collapse Disorder and population declines in domesticated honey bees, very few studies have closely examined the factors leading to declining populations in native bees.[65, 66] What work has been done suggests that the decline in native pollinators is primarily driven by humans, with habitat loss being the major causal factor.[67] Wild pollinators rely on natural to semi-natural habitat for nesting and food resources. As a result, lack of landscape heterogeneity and habitat fragmentation act to isolate populations, leading to inbreeding depression or reductions in food availability to the point where the landscape cannot support native pollinator populations.[68, 69]

ORGANIC AS A SOLUTION

A number of studies have demonstrated that organic farms support more pollinators than conventional farms.[7, 70, 71] Organic farming requirements prohibit the use of toxic pesticides, support higher levels of biodiversity than conventional farms, and can contribute to pollinator conservation in a number of ways.

Additionally, USDA's National Organic Program specifically ensures that organic farming supports the health of our pollinators in the following four key ways:

1. Exposure to toxic chemicals

One of the biggest threats to bee health is exposure to toxic chemicals. Bees are exposed to numerous chemicals through a variety of routes. Neonicotinoids exposure most frequently occurs when bees consume pollen and nectar from crops grown using neonicotinoid coated seeds or from dust created by pesticide coated seeds during planting. Additional chemical exposures include herbicides and fungicides that are applied directly to the leaves and flowers of crops. While singular exposure to synthetic toxins intended to kill fungus or plants are typically not considered dangerous to bees, numerous studies have shown that interactions between multiple chemicals can increase their toxicity to bees.

Organic farming directly addresses these issues and supports pollinator health by reducing bee exposure to toxic chemicals. Organic farmers are prohibited from using synthetic substances as a general rule, and must use integrated pest management (IPM) techniques to control pests instead of relying solely on pesticides. The use of IPM techniques is mandated by organic regulations at 7 CFR 205.206, requiring organic producers to develop and implement a preventive pest management program before any pest control materials are used. Only after these preventive practices have failed is an organic farmer allowed to use allowed non-synthetic pest management products.

Additionally, organic producers are prohibited from using seeds treated with toxic pesticides, even when they cannot find a particular seed in organic form and are allowed to use a conventional version of the seed. At no time may an organic producer plant a seed that has been treated with prohibited synthetic pesticides. By maintaining an agricultural landscape that supports beneficial insects which feed on pests, organic farmers reduce the number and quantity of pesticides necessary to protect their crops. When they do use pesticides, these are less toxic and persist in the environment for a shorter amount of time than most synthetic pesticides.

2. Pollinator habitat and landscape biodiversity

Lack of habitat and nutritional food sources are also important factors in pollinator decline. Native bees rely on undisturbed patches of native habitat as well as habitat 'corridors' which enable them to travel between patches. Additionally, both native and domesticated honey bees need a diversity of nutritious plants where they can collect sufficient pollen and nectar to support the hive.

Organic farming supports pollinator health by providing a more diverse landscape that affords more abundant and higher-quality food and habitat to both native and managed bees. Organic farms are required to manage their operations in a manner that "maintains or improves the natural resources of the operation" [7 CFR 205.200], which include the health of pollinators. Farmers meet this requirement by implementing techniques such as crop rotations, cover crops, and multi-functional insectary hedge rows which provide foraging bees a more diverse array of nutritious plants from which to collect pollen and nectar. Additionally, organic farms tend to support more native wild plants than conventional farms. For instance, Kehinde and Samways,[71] examining the number of insect-flower interactions that occurred on organic and conventional farms, found that because organic farms tended to have a higher abundance of flowering plants, they also had a higher number of plant/pollinator interactions.

3. Exponential benefit

While we understand that increasing pollinator habitat and food sources on any farm is going to be better than nothing, reducing pesticide usage and increasing habitat heterogeneity at the same time have a compounding effect in benefiting pollinators. Anderson *et al*.[70] found that pollinator services to crops on organic farms increased when habitat heterogeneity was increased. Surprisingly, this same trend was not seen on conventionally farmed land. The study authors suspect this likely occurred simply because the lack of synthetic fertilizers and pesticides make organic farms more pollinator friendly. By increasing habitat and food sources available to bees in agricultural landscapes while reducing the applications of toxic chemicals (practices that are federally regulated requirements of organic certification), organic farms can increase the health of our pollinators and, in turn, help improve food security.

4. Organic apiculture

The National Organic Standards Board (NOSB) in 2010 released recommendations for developing organic apiculture, and USDA has announced it will release draft standards for organic apiculture this year. Until these new standards are passed, organic beekeepers are operating under livestock standards. Current regulations for organic livestock do not allow the use of synthetic pesticides, a requirement that carries over to hive management. We anticipate that the new standards will additionally bolster efforts to reduce bee exposure to pesticides by establishing forage and surveillance zones.

NOSB recommendations would require organic bee keepers to draw up plans that take into account risks to bees on land surrounding the hives. During forage season colonies must be maintained within a forage zone, a 1.8-mile radius surrounding organic bee hives where there is no significant risk of contamination by prohibited materials. A surveillance zone of an additional 2.2 miles outside the forage zone must also be established and monitored for high-risk activities that might pose harm to the hive (such as the presence of golf courses, landfills, human housing or power plants).

New standards are also expected to regulate building materials specifically used in apiculture operations in order to reduce bee exposures to prohibited substances in hive building and management materials. These new regulations—combined with existing requirements that organic beekeepers take a preventative approach to managing their colonies for infestations of pests and diseases and prohibit the use of synthetic pesticides—will reduce stress honey bees experience in the field.

Lessons learned from the organic field

While organic farming clearly provides the greatest benefit to our pollinator communities, it is not realistic to expect that the entire U.S agricultural system completely change overnight. Fortunately, many of the pollinator-friendly techniques that organic farmers utilize can also be incorporated into conventional farming systems.

By introducing plant heterogeneity into farming systems by way of crop rotations, hedge row planting, and by fostering native plant diversity within and around farmland, any farm can combat pollinator malnutrition and habitat degradation. Additionally, the incorporation of integrated pest management techniques that encourage beneficial pest predators can help conventional farmers reduce the quantity of chemical pesticides used and, in turn, the level of bee exposure to pesticides. Finally, organic farming benefits all of agriculture simply by supporting healthier pollinator communities essential to nutritious food production regardless of farming method.

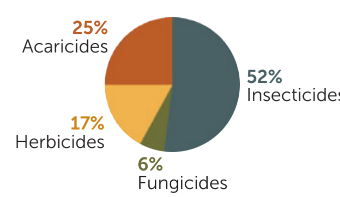
BENEFITS of ORGANIC
FOR POLLINATORS

Diversity of HABITAT

On average, organic farms have more diverse landscapes than conventional farms, providing favorable habitat for pollinators.

Avoidance of TOXIC CHEMICALS

Organic farming supports pollinator health by reducing bee exposure to toxic chemicals. One study found 161 different pesticides in bee hives, including insecticides, fungicides, herbicides, and acaricides. These chemicals can pose a significant health risk to bees.



Abundance of FOOD SOURCES

Organic farms have more food for pollinators, because they tend to use techniques such as crop rotations and cover crops which provide a diverse array of nutritious plants from which to collect pollen and nectar.

SYNERGISTIC effects

Organic farming combines increased pollinator habitat and food sources with reduced pesticide exposure. This can have a synergistic effect, resulting in farms that have a large-scale beneficial impact on pollinator health.

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Table 1. Crops dependent upon or benefited by insect pollination
(adapted from NRCS 2005 Native Pollinators—fish and wildlife habitat management leaflet)

Legumes
Beans
Cowpea
Lima beans
Mung beans
Green beans
Golden Gram beans
Soybean

Vegetables
Artichoke
Asparagus
Beet
Broccoli
Brussels Sprouts
Cantaloupes
Carrot
Cauliflower
Celeriac
Celery
Cucumber
Eggplant
Endive
Green Pepper
Leek
Lettuce
Okra
Onion
Parsnip
Pumpkin
Radish
Rutabaga
Squash
Tomato
Turnip
White Gourd

Fruits, berries, and nuts
Berries
Almonds
Apple
Apricot
Avocado
Blackberry
Blueberry
Cacao
Cashew
Cherry
Chestnut
Citrus
Coffee
Coconut
Crabapple
Cranberry
Currant
Date
Fig
Gooseberry
Grapes
Guava
Huckleberry
Kiwi
Kola nut
Litchi
Macadamia
Mango
Olive
Pawpaw
Papaya
Passion fruit
Peach
Pear
Persimmon
Plum
Pomegranate
Raspberry
Strawberry
Tung
Vanilla
Watermelon

Herbs and spices
Allspice
Anise
Black pepper
Caraway
Cardamom
Chive
Clove
Coriander
Dill
Fennel
Lavender
Mustard
Nutmeg
Parsley
Pimento
Tea
White Pepper

Oils, seeds and grains
Alfalfa
Buckwheat
Canola
Flax
Oil Palm
Safflower
Sesame
Sunflower

Forage
Clover

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