Pesticides and Decline in Pollinator Populations

Synergistic Effects of Herbicide, Fungicide, and Insecticide Use on Pollinator Populations and Alternatives for Communities and Agriculturists to Reduce Impact Beyond Requirements of Current Regulations

Tag Words: honeybee; honey bee; bee, IPM; Integrated Pest Management; CCD; Colony Collapse Disorder; Pollinator; Native Pollinator; Pesticide; Insecticide; systemic insecticide; Organic Farming; neonicotinoid; neonicotinamide; clothianidin; imidaclopid; permethrin; pyrethroid; agriculture; pesticide alternatives; insecticide alternatives

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Summary:
Domesticated honey bees and wild pollinators, such as native bee, butterfly, moth, and bat species, are key factors in agriculture and ecosystems worldwide. Within recent years, pollinator species, including honey bees, have seen critical population declines worldwide. No one cause can be attributed to this decline, but it has been suggested that a combination of environmental factors, habitat deterioration, disease susceptibility, and exposure to pesticides, specifically insecticides, all play a role in the decline. Although stringent regulations are in place for many pesticides, more can be done to avoid use of harmful pesticides and make use of alternative pest management techniques in agriculture and home use. Our intention is to make available information on alternative pest management techniques and risk minimization for the home and in agriculture. We will present this information specifically to the community of Haycock Township, Pennsylvania in order to help limit traditional pesticide use, harbor pollinator populations, and add to an effort to make the township a Community Certified National Wildlife Federation Habitat. By conducting surveys and collecting pledges to use safer pest control and harbor pollinator populations, we hope to reach a large audience and contribute to efforts to reach these goals on a community level throughout the nation.

Video Link: https://www.youtube.com/watch?v=UMxaUwralUs&feature=channel&list=UL

Decline of Pollinator Populations, Suitable Habitat, and Relation to Pesticide Use

There are many different types of pollinators. They can include hummingbirds, bats moths, butterflies and bees. Some pollinators have specialized relationships with the flowers they pollinate (the madagascar hawk moth is the only creature that can pollinate a certain flower). Honeybees are a domesticated variety of bees and are more generalized in what they can pollinate.

Decline in Pollinator Populations and Potential Causes (RF)

Historically, managed honey bee populations throughout the world have shown periods of high mortality, with unknown or ill understood causes. Most often, it was not possible to correlate
these events with specific causative factors, although many possibilities including poor weather conditions, fungal infections, parasites, lack of food for overwintering, and in later events, chemical pesticides were proposed as possible mechanisms. Much of today's research and strategy is focusing on many of the same possible causes, but even with more advanced scientific technologies, complex ecological interactions are difficult to quantify, and even more difficult to legislate.

A large amount of press and research has been given to a specific “syndrome” affecting managed honeybee populations throughout the United States. The syndrome, dubbed Fall Dwindle Disease or Colony Collapse Disorder (CCD) has not been related to a single factor, but a set of characteristics common to many colonies experiencing major mortality:

1. The rapid loss of adult worker bees from affected colonies as evidenced by weak or dead colonies with excess brood populations relative to adult bee populations
2. A noticeable lack of dead worker bees both within and surrounding the affected hives
3. Delayed invasion of hive pests (e.g., small hive beetles and wax moths) and kleptoparasitism from neighboring honey bee colonies

While much of the general and scientific population's attention has been focused on the specific phenomenon of honey bee Colony Collapse Disorder it is important to direct the public attention not only towards CCD, but the variety of factors which can lead to poor conditions for pollinator populations in general.

Honey bees, although often times vital to agricultural operations, are not the only bee species suffering from population decline. The United States is home to an estimated 4,000 native bee species, which are largely threatened by environmental toxins, and loss of suitable habitat, although much of the scientific literature on populations of these largely solitary bee species is lacking compared to that of the honeybee. Relative abundance of four distinct bumblebee species in the United States have declined by up to 96% and their geographic ranges greatly stunted, within the past 20 years. The species in decline often show higher levels of pathogen presence and decreased genetic diversity in comparison to those species which are not in decline, but these variables are only useful as indicators of dwindling species populations, and do not describe the range of possible factors contributing to their decline.

**Pesticides Commonly Found in Honey Bee Colonies (RF)**

Due to the fact that it is extremely difficult to trace decline in honey bee populations to one pesticide alone, many attempts have been made to identify the chemicals that are most often

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found together in honey bee colonies. It is believed, and highly likely, that some of these chemicals may act in consort to affect honey bee behavior, susceptibility to disease, and overwintering mortality. For the most part, the synergistic effects of multiple pesticides and relative co-contaminant rates are not studied in depth.  

The largest analysis of multiple pesticide concentrations to date, conducted by researchers at Pennsylvania State University, analyzed pesticide concentrations in commercial and local honey bee colonies from 23 different states and one province in Canada. The analysis detected two or more pesticides in over 92% of samples of bee, pollen, and wax samples, with an average number of seven different pesticides detected in pollen samples.

Nearly half of the samples contained one or more systemic insecticide. The most common insecticides detected were of the Pyrethroid family, which has become one of the most common chemicals used in spraying of adult mosquito populations and in home pest control. Common combinations of pesticides included multiple miticides and miticide/fungicide combinations. All but nine of the samples with fungicides present contained at least one other pyrethroid insecticide or organophosphate miticide/insecticide present. The high abundance of multiple insecticide, miticide, and fungicide combinations presented in this study further emphasizes the need to study the synergistic effects that chemicals can have on honey bee health and behavior. Several studies have already shown that the presence of a certain fungicides can amplify the effects of insecticides on pollinator species.

**Insecticide Exposure and Susceptibility to Disease (RF)**

In addition to lethal effects of systemic and contact insecticides, and sublethal effects on behavior of bees that could lead to abandonment of hives and high mortality, recent studies have been directed towards identifying low dose effects on susceptibility of bee populations to common parasites and diseases. Studies on doses of imidacloprid, a systemic insecticide of the neonicotinoid family, too low to elicit any effects on honey bee foraging behaviors or decreased life span have shown significantly higher levels of the gut pathogen *Nosema spp.*, which in itself has the ability to cause decreased survivability of brood (young) and workers, as well as erratic behavior that can lead to colony collapse.

**Routes of Exposure to Systemic Insecticides, Effects on Bees, and Difficulties Determining What is Relevant (RF)**

When systemic insecticides are used, pollinator populations are subject to a larger number of vectors for exposure than mere contact with the pesticide being applied. Field studies have attempted to identify realistic mechanisms under which bee populations may come in contact with lethal or sub-lethal doses of neonicotinoid pesticides. When treated seeds are used in large

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scale annual cropping systems for maize (corn), high levels of the chemicals were observed in equipment exhaust materials, as well as detectable levels in flowering weeds in adjacent fields, and in pollen produced by maize seedlings, which the honey bees readily collected. In the same study, dead bees near colonies and in surrounding fields, pollen stored in nearby hives, and extracts of wax and other comb constituents were observed to contain harmful levels of the systemic insecticide used in the field. This study provides evidence that, even under guidelines for proper application of insecticides of potential harm, there is still a risk of exposure to bees. 

Aside from mortality, exposure to neonicotinoid insecticides can have negative effects on foraging behavior, flight patterns, and possibly reproduction of honey bees and other bee species. One study, which exposed honey bees to varying levels of neonicotinoids, found that honey bees had a lower rate of return to the hive, and those that did return spent more time in the hive between foraging trips to feeders. A study on one bumblebee species observed great defects in reproduction after chronic exposure to clothianidin and imidacloprid over time.

What is difficult in determining the level of harm these chemicals pose to honey bees and other bee species is not what levels will lead to abnormal behaviors, mortality, and decreased colony fitness, but determining what is an environmentally relevant exposure for the insects. Laboratory studies examining sublethal effects on the bees do not necessarily translate directly to effects in the field and the environment, studies on the effects on worker bees do not provide true insight into the true risks to colonies, and limitations on knowledge of bee behavior, such as the tendency to feed on guttation fluid and nectar from treated plants, which would lead to much higher environmentally relevant exposure rates than pollen collection.

The Effects of Roundup on Human Health (VR)

Roundup is a herbicide manufactured by the company, Monsanto. It is a potent weed killer and has been touted to be “as safe as table salt” to humans. However, there have been studies showing that this chemical does have some toxic effects on humans.

Ingesting Roundup can cause irritation of the oral mucous membrane and gastrointestinal tract. It has also been shown to cause pulmonary dysfunction, oliguria, metabolic acidosis, hypotension, leukocytosis, and fever. In one study, many people reported digestive problems resulting from overexposure to Roundup. A 1983 study revealed that Glyphosate, the active ingredient, caused a decrease in hepatic levels of cytochrome P-450, monoxygenase activities, and the intestinal activity of aryl hydrocarbon hydroxylase. Glyphosate was also shown to depress liver function.

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10 Cresswell, J.E., (2011) A meta-analysis of experiments testing the effects of a neonicotinoid insecticide (imidacloprid) on honey bees, Ecotoxicology, 20, 149-157. doi:10.1007/s10646-010-0566-0
Even though Roundup is a herbicide, it has a definite effect on humans beings, so it would not be too much of a stretch to assume it can affect pollinators such as honeybees. Honeybees are most likely to encounter Roundup if it has been sprayed when the crops are flowering. With the advent of Genetically Engineered, “Roundup Ready”, crops, farmers no longer have to fear killing their own crops when they spray the chemical.

**Herbicides and Suitable Pollinator Habitat Deterioration (RF)**

In addition to the direct harm that insecticides can have on the bee population, herbicides can often present additional harms from acute toxicity to habitat deterioration. Maintenance of large monocultures in agriculture and lawns leads to a decrease in the total foraging area for honeybees and native bees alike. Pollinator species often make their homes in bare patches in the ground near low growing, weedy flowering species, dead wood, and low traffic areas of vegetation. Destruction of these habitats and the flora pollinators depend upon for foraging, whether intentional or incidental, can lead to lower populations and negative health effects for existing populations.

There are a wide array of herbicidal chemicals available, which can be directly harmful to health of native pollinators or their habitats. Risk is particularly high because the weedy species they often target are prime living and feeding grounds. It is important when using these chemicals that one strives to limit the area exposed, and be mindful of areas which may provide living and foraging habitat to bee populations.

**The Importance of Honeybees in Agriculture and the Environment (VR)**

Honeybees are important pollinators for many agricultural crops and also provide a source of honey for beekeepers. While the major crops in the US are not pollinator dependent, the crops that are dependant can be just as important. A decline in honeybees and other pollinators can impede the fruiting of crops that depend on them.

More than 90 crops rely on honeybees for pollination in the US, and the pollination services have an estimated value of $14 billion per year.\(^{12}\) Specific crops include, apples, peaches, blueberries, cranberries, and strawberries, all of which are major fruit crops grown in New Jersey.

Agriculture is ranked as the third most important industry in New Jersey (after pharmaceuticals and tourism). The state was ranked as the 2nd biggest in blueberry production in 2007 (producing 54 million pounds), and the 3rd in cranberry production in 2009 (where sales accounted for $30.9 million in revenue). The state also produced 70 million pounds of peaches in 2010.

If honeybee populations decrease, all of the above industries would be negatively affected by the change. Fruiting crops rely on pollinators for fertilization to occur, which in turn enables fruit production. Lower fruit production will severely decrease the profitability of the industry and have negative overall impact on the country’s economy.

While honeybees might not always benefit humans directly, they do benefit crops that benefit humans. Without honeybees, fruit production would be more challenging. And many flowering plants will lack the ability to reproduce. Fruits are an important source of nutrition, and honeybees are important in maintaining that food source.

The Decline of Honeybee Pollination Capacity, Can Wild Pollinators Make Up the Difference? (VR)

The world could be heading towards a global pollination crisis due to the decline of honeybees relative to the agricultural crops dependent on them. This is due to a combination of a great increase in crop demand, a decrease in beekeepers, and the death of honeybees due to various causes. However, it is possible for a combination of wild bee pollinators to make up the difference and compensate for the lack of honeybees. Farming methods that facilitate wild pollinators (bumblebees, butterflies, moths, etc.) might be the future of farming.

The evidence for an impending pollination crisis has primarily come from local declines in pollinators or insufficient pollination of crops dependent on pollinators. There has been a 45% increase in honeybee hives compared to a >300% increase in pollinator dependent crops over the past half century. Beekeeper numbers have also declined since the 1950’s. Africanized honeybees have also played a role in this decline by spreading northward and producing more aggressive and less productive hybrids with domestic honeybees.

There is evidence that with a sufficient number of wild pollinators, farms can meet their pollination requirements without needing domestic honeybee colonies. However, the composition of wild pollinators can vary annually, and therefore, biodiversity is required to consistently ensure enough pollination. A study conducted in Yolo County California showed that organic farms that were located near wild areas met their pollination needs without resorting to domestic pollinators, while organic farms farther away from wild areas could still meet about half their needs with wild pollinators. It was the conventional farms that had to resort to domestic honeybees to pollinate their crops.

Organic farming is possibly the best solution to solving the pollination crisis as it will likely facilitate wild pollinators. The reduced pesticide use in organic farming will also be less impactful on domestic bees when they are needed.

More information on pollinator crops and beneficial native bee species can be found in Appendix A.

Why Pesticides are used in Agriculture (VR)

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Pests can come in several varieties and threaten crops in different ways. Weeds (plants pests) can compete with desired crops and even smother them if they grow aggressively enough. Insect pests can feed on different parts of the plant, either impeding its development with damage, or tainting the harvested products (if they feed on fruit). Fungal pests can parasitize the crop and render the harvested portion unfit for consumption. Mammalian pests, such as rodents or deer will also feed on crops or cause other kinds of property damage. In many cases pesticides offer a fast, labor saving, method for killing and controlling different kinds of pests.

Hand weeding is a very laborious process, especially on larger farms with many acres of land. The ability to simply spray a chemical, like Roundup, can save a lot of time in pest control. The alternatives to herbicide use include mulching, and releasing natural enemies (that could feed upon or otherwise negatively impact the weeds). Both can be effective, but neither appears to be as quick or labor saving as spraying pesticides. However, a drawback to using herbicides to control weeds is the effect they will have on the crops.

Insect pests are not always as prevalent as weed pests, but they can be difficult to control without pesticides. However, there are some negative consequences to using pesticides on insect pests. The main one is their ability to quickly develop resistance. Insects have a short generation time and can reproduce rapidly, so resistant genes can quickly spread through the population. Another issue with using insecticides is the negative effect on beneficial insect species, including honeybees.

There are alternative to insecticides. Farmers could rotate crops with those of a completely different family so that insect pests will no longer be able to find their food source in the same area and species that overwintered in the field will starve. However, perennial crops and tree and shrub crops cannot be rotated in a small timescale and pests will have plenty of opportunities to establish themselves in the area.

Natural enemies (as with weeds) are another alternative for weed control, but using them will require that some of the pest population survive to sustain them. It might be difficult to establish natural enemies in a given area, and when established, they might prey upon beneficial insects as well as pests.

Pesticides have long presented a simple and easy solution to controlling pests and moving away from them can be difficult. However, the inadvertent damage they can cause, coupled with pest resistance, might force farmers to reduce their use. However, farmers will likely have to employ a variety of strategies and tools (including a limited application of pesticides) to have the same controlling effect as blanket pesticide use.

**Insecticide Use to Control Mosquitoes and Vectors of Disease (RF)**

One of the most common uses for insecticides in communities is control of adult mosquito populations. There is much debate over this application of insecticides, as many believe the lowered risk of disease is much more important for the community than restricting use of environmentally toxic chemicals. Overall, spraying for adult mosquitoes is very ineffective, even with low density fogger applications which provide a wide spray area. Permethrin, a
A semisynthetic pyrethroid insecticide developed from the extracts of certain plant species is often dubbed a safe, and natural insecticide alternative. It is the most widely used chemical for adult mosquito controls. Despite its derivation from a natural source, it is not organic nor is it natural at concentrations used for large scale insect control. Its widespread use is attributed mainly to its safety compared to organochlorine insecticides to humans, other mammals, birds and wildlife, although it is highly toxic to invertebrates including beneficial insects and aquatic life. Its lifespan in the environment is relatively short and it shows a minimum risk for groundwater contamination due to the fact that it is not highly water soluble or highly volatile and tends to cling to sediments rather than pollute water sources.

Although most think of bees forming colonies in exposed hives hanging high up in trees, the majority of native bee species are actually ground dwellers. They make homes either in solitude or in colonies in small burrows in the soil near edge habitats where flowering weeds and grasses are likely to occur. These areas are where Ultra Low Volume sprays, used to deliver the majority of adult mosquito control chemicals from trucks and other road equipment, are likely to deposit the majority of their chemical.

In mosquito adulticiding, permethrin is often applied with Piperonyl Butoxide (PBO) which does not have insecticidal qualities in itself, but acts as an enzyme inhibitor in insects and other organisms alike, increasing the time that the permethrin spends in the environment before breakdown, and increasing the toxicity and exposure time for the insects.

**Attempted Solutions to Limit Use of Pesticides and Effects on Pollinator Populations**

There have been many different attempts to minimize the environmental harm done by pesticides, limit their use, and even ban some pesticides that are of particular harm to the pollinator population. The following are some routes that have been taken to minimize or stop use of pesticides harmful to the honey bee population, and increase pollinator habitat.

**Integrated Pest Management (IPM)**

Integrated Pest Management (IPM) is a system of pest management that assimilates several pest management tools to deal with a pest problem. An important tenet of it is that pesticides are to be used only as a last resort and only as necessary. Another aspect of it is that the some pest damage is deemed economically acceptable because the total eradication of pests is unfeasible.

The IPM model of pest management allows for pesticide use, but it places strict limits on what kinds of pesticides can be used and when they can be used. This model favors selective pesticides (only target intended pest) that have a minimal impact on the environment and are not persistent (remain in the environment long). Unselective pesticides with high persistence, volatility, and other side effects are prohibited. If a pesticide has a high risk of pest resistance, anti-resistance measures must be taken. These measures include maintaining a safe haven for pest with a lack of resistance so that they can dilute the gene pool, as well as alternating the kind of pesticide used.
## IPM Pesticides:

### Unacceptable Pesticides
- Pyrethroid insecticides or acaricides
- Broad spectrum organophosphate & carbamate insecticides
- Organochlorine insecticides and acaricides (if safer alternatives exist)
- Acaricides harmful to phytoseiid mites
- All acaricides that are toxic to phytoseiid mites
- Dithiocarbamate fungicides
- Toxic, water polluting or very persistent herbicides
- Sulfur and copper
- Fungicides with high potential for resistance

### Pesticides Allowed with Restrictions (& in the absence of safer alternatives)

## Organic Farming (VR)

Organic farming tries to minimize off-farm inputs (such as fertilizers and pesticides), and often goes hand-in-hand with IPM programs. Due to the significantly lower levels of pesticide use in organic farming, this method has been shown to have a positive effect on pollinators. This is important because pollinators have a positive effect on the production of the crops they pollinate.

The pesticide-minimizing approach of organic farming might be able to mitigate damage to pollinators by accommodating greater biodiversity. One notable difference between organic and conventional methods of farming is that organic methods involve elaborate crop rotations which almost always include nitrogen-fixing legumes.

A Swedish experiment found that organic farms had greater pollination success for strawberry plants. The experiment involved 12 Swedish farms, which were either recently converted to organic production, long established organic farms, or farms using conventional methods. Strawberry plants were used to measure pollination success, and the study found higher rates of pollination on organic farms. However, there was no noticeable difference between established and recent organic farms in terms of pollination success. This suggests that pollination improves shortly after conversion to organic farming.

## Responsible Pesticide Use in Managing an Invasive Species (RF)

Although insecticide use can have detrimental effects on cultured and native insect populations such as honeybees, and subsequent amplified effects on the organisms in an ecosystem that rely on them for food sources or reproduction, insecticide and herbicide use is often deemed

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necessary when attempting to control the spread of invasive, non-native plant and animal species into our ecosystems.

In September 2009 a proposal was introduced to the Massachusetts Pesticide Board calling for the spread of more than one million gallons of imidacloprid solution to a fifteen square mile area in Greater Worcester. This proposal would have allowed the USDA to use more than one third the regulated amount of imidacloprid in order to contain the spread of the Asian Longhorn Beetle. This non-native species poses a major threat to hardwood tree populations, including maple trees which are a major economic species in New England and Canada. Due to cost considerations and a potential imminent threat of breaking the quarantine of the beetle, the USDA Asian Longhorn Beetle National Program suggested a soil drenching method which would cover the most area and reach the most trees, as opposed to injections of infected and at-risk trees with an imidacloprid solution. Citizens and beekeepers were concerned over the large scale application of this pesticide due to possible harm to the bee populations and contamination of groundwater, which had been documented in New York, where the infestation was thought to originate. Concerned parties contacted organizations including SafeLawns, the Toxics Action Center of Boston, and the Pesticide Action Network of North America, resulting in a letter, read aloud to the board to consider the deny the proposal and consider alternative application methods. By action on the part of these organizations and concerned citizens, a decision on the proposal was postponed pending further review of potential ecological harms caused by the application method.

Although invasive species are a large threat to natives and the ecological balance that has been established over years of undisturbed natural selection, it is still necessary to practice damage control to whatever extent possible when using a pesticide such as this. Although this community and grassroots action only resulted in a postponed decision and more extensive review of costs and benefits of the intended action, it illustrates how community action and education can lead to greater precautions in dealing with difficult situations such as this. More precautionary approaches to dealing with this potentially harmful invasive pest are included in the USDA’s 2011 Asian Longhorned Beetle Cooperative Eradication Program in Essex, Norfolk and Suffolk Counties, Massachusetts Environmental Assessment, including guidelines on determining the most responsible methods of application of imidacloprid for containing the population as well as alternatives, are a reflection of prudent decision making and analysis incited by scientific and community concern for potential harms posed by these chemicals.


Beekeepers and Environmental Organizations Call on EPA to Ban Pesticide Suspected to Contribute To Decline of Bee Population (RF)

There have been great efforts on the federal state and local levels to take action against pesticides that are of particular concern to honey bee populations, pollinators, and the apiarists who keep
the pollinator populations thriving. The United States Environmental Protection Agency, as well as State Department of Environmental Protections and other regulatory bodies conduct continual review and risk assessment of pesticides registered for private, state, and agricultural use.

In a letter addressed to the United States Environmental Protection Agency's Office Of Pesticides Programs December 8, 2010, the National Honey Bee Advisory Board, American Beekeeping Federation, American Honey Producers Association, Beyond Pesticides, Pesticide Action Network North America and the Center for Biological Diversity petitioned for a stop use order against the systemic insecticide Clothianidin. The letter cited a link between Clothianidin and a “severe and dangerous decline in the pollinator population”, and a failure on the agency's behalf to adequately evaluate the ecological risk of the product prior to providing the manufacturer a conditional registration. In addition to the call for a stop use order, the letter urged the department to establish protocols that take into account synergistic effects of multiple chemicals, as well as extended exposure and persistence.

The Director of the Office of Pesticide Programs responded to the request, highlighting the main reasons why their demands could not be met. The director acknowledged the study that was mentioned in the petition for removal, and how the chronic exposure could not be linked to honey bee colony collapse and the general decline in the pollinator population. The director also referenced how Clothianidin poses less risk to other wildlife, workers, and humans than previously used insecticides such as those in the organo-chlorine family and warning labels on clothianidin products approved for foliar application.

The original letters can be accessed on the following EPA website under Quick Resources: [http://www.epa.gov/opp00001/about/intheworks/clothianidin-registration-status.html](http://www.epa.gov/opp00001/about/intheworks/clothianidin-registration-status.html)

This case illustrates some of the reasons why it is often times difficult and impractical to rely solely on regulatory bodies to limit the use and exposure of honey bees and other wildlife to potentially harmful synthetic pesticides, especially when there is less risk to humans than with alternative chemicals, as well as gaps in the information available through scientific literature. Because of these hindrances, it is especially important to focus efforts on lower level decision makers and potential applicators when making ecologically minded decisions to limit insecticide use.

**Other Steps to Protecting Bees from Pesticides**

1. Only use pesticides when absolutely necessary.
2. Don’t use pesticides when crops are in bloom.
3. Don’t apply pesticides when bees are most active (8 am to 5 pm).
4. Don’t use pesticides that would contaminate the water.
5. Use compounds that are less toxic to honeybees.
6. Check to make sure there are no other blooming plants that could attract bees before pesticide application.

Organic Certified Pesticides and a False Sense of Security (RF)

Organic is a term that people are using more and more every day, and for the most part it gets coupled with ideas like safe for consumption and safe for the environment. Although this is generally true, certain pesticides certified for organic use can actually be quite toxic to bees and beneficial insects, especially if not used in a manner that minimizes exposure to non-target insects.

Diatomaceous earth, insecticidal soaps, mineral oils, Pyrethrins (a group of concentrated plant extracts), Spinosad, Sabadilla, and Rotenone are all insecticides that are certified organic, but are highly toxic to most bee species.18 Sabadilla, Rotenone, and Pyrethrins all have the potential to persist for quite some time after application, so can be a lasting threat to pollinators and other beneficial insects.18 As with all insecticides, precautions should be taken when using soaps, diatomaceous earth, mineral oils, and Spinosad, to avoid flowering plants and other bee habitats and peak activity time for pollinators and beneficial insects.18


Alternative to Synthetic Chemical Insecticides for Turf Management, Gardening, and Agriculture (RF & VR)

Many alternatives to synthetic chemical insecticides are extremely effective at controlling unwanted insect populations, and may be of less harm to beneficial insects and the environment. These include introduction and conservation of natural predators, application of microbial insecticides and biological controls such as nematodes, homemade sprays using garlic, vinegar, or pepper, insecticidal soaps, horticultural oils, pheromone traps catch to insects and disrupt reproduction, and maintaining an overall less desirable habitat for nuisance insects. Specific information on the positives and negatives of these alternatives, and information on different pests and control options is available in Appendix B.

Planting Native Flowering Species (RF)

In addition to adding clover and other low growing plant species to lawns, another solution is to cut back on your lawn area altogether. Native flowering plant species are an excellent source of nourishment and habitat for pollinators and other native insects that can keep pests at bay, and trading some lawn area for a bed of native perennials can provide greater aesthetic and ecological value to your property.

Planting native species helps to ensure that your work will not go to waste, as they are well adapted to the conditions in your area. Most bee populations have evolved with the native flora, and sometimes one plant species is dependent almost exclusively on a certain bee species, and vice versa. Ecologists, entomologists, conservation groups, and USDA agricultural extension offices have gone to great lengths to suggest native plant species for specific regions across the country that can increase habitat area for pollinators.

The Xerces Society For Invertebrate Conservation offers information on Flowering Species and other resources for promoting bee habitats through their Pollinator Conservation Resource Center Website: [http://www.xerces.org/pollinator-resource-center/](http://www.xerces.org/pollinator-resource-center/)

Through partnerships with the native seed industry, Xerces also offer seed mixes for native wildflowers and grasses that promote pollinator habitat: [http://www.xerces.org/pollinator-seed/](http://www.xerces.org/pollinator-seed/)


**Pollinator Friendly Lawns (RF)**

A green, uniform, well manicured lawn is a source of great pride for many homeowners, and has long been the quintessential sign of one who takes great pride in the maintenance of their personal outdoor space. Despite the aesthetic benefit a monoculture of low growing turf grasses provides to a community, it does extremely little to help pollinator populations and promote ecological diversity. Upkeep of a traditional lawn often requires massive water resources, industrially produced fertilizers, and a plethora of herbicides and insecticides to maintain its pristine state.

Planting a combination of tradition turf grasses and other low growing species like clover can make lawn maintenance a much more simple, low input task. The roots of most clover species are home to beneficial microbes that have the ability to fix nitrogen, that is, to fertilize your lawn naturally and reduce the need for high nitrogen fertilizers. Adding some variety and letting some of those “weeds” grow in your lawn can help to minimize groundwater pollution from excess fertilizer use, and also provides a better home and food source for bees and other beneficial insects.

A mixed bag of plant species also means less susceptibility to many common pests of turfgrass, such as the infamous soil dwelling “white grubs” and other insect larvae that may hurt your lawn as well as present addition destruction in their adult forms. Limiting the use of high nitrogen fertilizers and making use of the fertilizing properties of nitrogen fixing plants can allow your grass to devote more of its energy and nutrients to developing a robust root system, which makes a less desirable habitat for many of these soil dwelling pests, and cuts down on the need to use traditional, harmful insecticides to keep the bugs at bay. A mixed lawn can also be more effective at crowding out weeds than a bed of single seed turf grasses.

Other methods that can be employed to reduce the risk of weed and grub infestation in the lawn, and limit dependence on chemicals include:
- Mowing higher and less frequently to decrease the amount of exposed soil
- Watering less frequently (~once a week), but thoroughly and deeply to ensure strong root growth
- Overseeding lawns with mixed seeds in early spring or fall to reduce bare spots
- Fertilizing lightly with phosphorus to encourage ideally balanced nutrient levels
- Leaving a portion of grass clippings on the lawn to decompose and maintain more steady nutrient levels

**Service Project**

As part of our service project, we will be contributing to efforts to make Haycock Twp., PA a National Wildlife Federation Certified Wildlife Habitat by providing information for community members to use in limiting pesticide use and promoting habitats for pollinator species.

**NWF Certified Wildlife Habitat For Haycock Twp, Bucks County, PA (RF)**

The National Wildlife Federation offers programs to register gardens, homes, schools, parks, and even entire communities as Certified Wildlife Habitats. Haycock Township is currently in the process of building programs and support to meet all of the point requirements needed to make Haycock one a bona-fide, certified habitat for wildlife.

Much of Haycock Township’s 22 square miles of land is made up of preserved wildlife areas, such as Lake Nockamixon State Park and acres of State Game Lands. It is bordered by Lake Nockamixon, and is home to two farms preserved by the state of PA. This makes it an excellent candidate for this type of certification, as well as a good target for community action to restore pollinator habitat and decrease use of pesticides. In fact, particular ecological and environmental concerns cited by the initiative to attain this certification include:

1. Decline in the Bee and Bat Populations
2. Invasive Plant Species/Lack of Varietal Plants to Support and Sustain Wildlife
3. Overuse of Herbicides and Insecticides

Part of the certification process is registering a number of individual homes as Certified Wildlife Habitats, so it is important to reach the residents with information on how to increase suitable, unpolluted habitat for wildlife, which coincides with the certification requirements of the NWF. By collecting the survey information and pledges submitted by residents of Haycock Twp. in particular, we will be able to judge the progress towards this requirement and see who is doing what to make their property safe and certifiable.

**Bucks County Agriculture**

In Bucks County, there are farms that grow crops which depend on bees. Pollinator crops grown in Bucks County include peaches, apples, pears, strawberries, pumpkin, squash, tomatoes, peppers, melons, plums, pears, ornamental plants, native species, and much more.¹⁹

county is also home to a variety of organic, pesticide free, and CSA (community supported agriculture) farms.\(^\text{19}\) Orchards and Farms could benefit greatly from an enhanced native pollinator population, and reduced pesticide use overall. Farms that are certified organic and chemical free, run a risk of contamination of their crops from irresponsible use of chemical herbicides and insecticides nearby. Even when these chemicals are being used for legitimate reasons such as disease vector control, they pose a risk, and these farms could be helped keep true to their organic status and meet their pollinator needs from decreased chemical use and an enhanced native pollinator habitat.

**Mosquito Control in Bucks County**

Control of the mosquito population in Bucks County is a joint effort by the Department of Health and Pennsylvania’s Department of Environmental protection. It is undoubtedly quite an important endeavor, as 35 mosquitoes collected in Bucks county, one in Haycock Twp., have tested positive for West Nile Virus.\(^\text{20}\) The effort currently involves larval controls of mosquito populations using Bti, a microbial insecticide, as well as adulticiding in areas of reported outbreaks.\(^\text{21}\)

Spraying for adult mosquitoes is carried out by the health department, using ultra low density “foggers” to spray from the road. The insecticide mixtures used vary slightly from application to application, but most often Biomist or Masterline Kontrol is used, which are mixtures of permethrin and piperonyl butoxide (PBO).\(^\text{21}\)

Although Bucks County takes the most ecologically prudent approach to dealing with mosquito populations, it would be beneficial to inform residents about preventative measures and larval control that can be used around the home, in order to reduce the number of problem areas that require adult mosquito spraying. There are also no “opt-out” programs for those people who do not want their property sprayed with pesticides. The closest thing offered, which is available to all Pennsylvania residents, is inclusion on a list of “highly susceptible” individuals, as determined by a doctor, in which case individuals will be notified ahead of time in order to take precautions such as closing all windows and doors. Since this is the case, it is especially important to take community-efforts to limit mosquito breeding, before populations get out of control.

**Haycock Wildlife Habitat Weblog Entries**

Entries will be made in the following categories to help educate the community about alternatives to conventional herbicides and insecticides, preventative measures against pests, and how to create a local habitat that provides forage and living space for important pollinators and other animal species.

The information will be posted at: [http://haycockwildlifehabitat.wordpress.com/](http://haycockwildlifehabitat.wordpress.com/)

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- Importance of Honey Bees and Native Bee Species in Agriculture and Environment
- Insecticides of Particular Harm to Bee Species
- Integrated Pest Management: What is it? General Guidelines
- Alternatives to Traditional Insecticides: Biological Controls, Natural Predators
- Home Insecticide and Herbicide Remedies
- Native Flowering Species and Habitat Restoration
- Cultural Controls: Preventative Measures Against Undesired Insects and Weeds in Lawn and Garden Maintenance
- Controlling Disease: Methods to Suppress Mosquito Populations Without Broad Spectrum Insecticides

Pledge Form (VR & RF)

We plan on creating a pledge that the residents of Bucks County can sign. The pledge will be linked to the blog where all the relevant information will be posted so that the residents can make informed decisions. There will be a checklist on the pledge and residents can check whichever ones they wish and pledge to only comply with those. The terms of the pledge will relate either to promoting local pollinators or using alternatives to the pesticides being sprayed. (VR)

Survey of Communities and Pest Management Practices

We will use the information below to determine some of the methods that people already use to deal with their pest problems, including chemical pesticide use, and application of alternative methods. We can use these different categories of information to determine the types of communities and people the the information we post reaches, and which are most willing/able to use alternative methods to chemical pesticide application and take steps towards increasing habitat for native bee species and other beneficial organisms.

Information to Be Collected:
- Residence Information
  - Home type
    - House - Owned
    - House - Rented
    - Condo/Townhome
    - Apartment
    - Resident of Haycock Twp, Bucks County, PA, Others
- Do you live near, or know of any honey bee keepers (industrial or hobbyist) in your area?
  - What is your distance from these beekeepers?
• Which types of chemicals/pesticides currently used?
  ○ Insecticides for Lawn / Garden Care (grub killer, bug sprays, fertilizer/insecticide combinations)
  ○ Insect Repellents for Personal Use (Off!, etc.)
  ○ Herbicides for Weed Control (Roundup, etc.)
  ○ Insecticides for indoor use (Raid, etc.)
• What types of biological controls, if any, have you used to limit pest populations?
  ○ Birds, Bats, etc. (provided nesting habitats, attractions for insect eating animals)
  ○ Release of beneficial insects (grasshoppers, praying mantis, ladybugs, lacewings, etc.)
  ○ Safe Microbial Insecticides (B.t. formulations, Nematodes)
• What types of cultural control methods have you used?
  ○ Mulching / laying sheeting in gardens and beds
  ○ Flowers, vegetables, other plants known to keep harmful pests away
• If you have you used an exterminator, landscaping service, or other registered pesticide applicator to deal with your pest problems, have you:
  ○ Asked about environmentally friendly alternatives to the chemicals they use
  ○ Looked around for environmentally friendly pest services
  ○ Asked about the removal of pest habitat as an alternative
• Do you have standing water on your property (ponds, swimming pools, birdbaths, drainage basins, poor drainage areas, etc.) that might be a source for breeding mosquito?
• Do you plant any flowering crops or native flowering species in your garden or flower beds?
• Are you allergic to bee stings?
• What other methods, if any, have you used to protect native pollinators or honey bee colonies around your home? (Open ended)

Personalizable Pledges

What courses of action are you willing to take in order to decrease your use of pesticides in and around your home? By selecting one or more of the options below, I agree to take the initiative to use these methods to help protect native bee populations and limit my dependence on chemical pesticides.

• Plant pollinator attracting, native plant species / Use low maintenance flowering ground cover such as clover as an alternative to traditional turf grass
• Leave designated low traffic areas open for ground nesting bee species
• Encourage natural predators of local pests by providing suitable habitat (Birds, bats, predatory insects)
• Use mechanical/manual methods of weed management in order to limit destruction of plants beneficial to pollinators
  ○ Pulling weeds by hand or “weed wacking”
  ○ Preventative measures (mulching/sheeting flower beds and gardens, plants that provide shade and limit weed growth, overseeding lawns in fall to limit spring weed growth)
• Use only pest-specific/environmentally friendly controls for cases where certain pests become overwhelming
  ○ microbial insecticides
  ○ species specific pheromone traps
  ○ Home Remedies (garlic/pepper sprays, insecticidal soaps, oils)
• Reduce use of high-nitrogen fertilizers to limit weed growth and soil dwelling pests in lawns/gardens, reduce contamination of groundwater
• Take preventative measures to avoid potential disease carrying insects such as mosquitos
  ○ staying inside during peak mosquito hours
  ○ protective netting/tents
  ○ wearing long clothing
  ○ natural, personal insect repellents
• Eliminate standing water on your property or treat with B.t. larval insecticides to reduce need for adult mosquito spraying
• Write to local Pest Control/Departments of Health concerning spray practices

**Extending The Reach of Our Pledges and Survey**

In order to reach the largest number of concerned individuals possible with our information and solution pledges, the survey will be distributed to a number of organizations online publications, to be embedded in emails, newsletters, blogs, web pages, and whatever other mediums are possible.

Although some of the information is tailored towards Bucks County and Haycock Twp., most of it is applicable in most any area, with a bit of personalization. By increasing the reach we will hopefully educate and inspire citizens and communities to take action by limiting their use of pesticides and providing suitable habitat for pollinator species on a potentially nationwide scale.
APPENDIX A - Pollinator Dependent Crops

List of Crops dependent on Honeybees and other pollinators (Not a complete list) (VR)

<table>
<thead>
<tr>
<th>A</th>
<th>H</th>
<th>O</th>
<th>V</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfalfa</td>
<td>Honeydew</td>
<td>Onion</td>
<td>Olives</td>
</tr>
<tr>
<td>Almonds</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Apples</td>
<td>Apricot</td>
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</tr>
<tr>
<td>Asparagus</td>
<td>Avocados</td>
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<td>B</td>
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<td>P</td>
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<tr>
<td>Blueberries</td>
<td></td>
<td>Peaches</td>
<td>Watermelon</td>
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<tr>
<td>Broccoli</td>
<td></td>
<td>Pears</td>
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<td></td>
<td></td>
<td>Plums</td>
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<td></td>
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<td>Pumpkins</td>
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<tr>
<td>C</td>
<td>J</td>
<td>Q</td>
<td>X</td>
</tr>
<tr>
<td>Canola (Rapeseed)</td>
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<tr>
<td>Cantaloupe</td>
<td></td>
<td></td>
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<tr>
<td>Carrots</td>
<td>Cauliflower</td>
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<tr>
<td>Celery</td>
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<tr>
<td>Cherries</td>
<td>Citrus Fruits</td>
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<tr>
<td>Cotton</td>
<td>Cranberries</td>
<td></td>
<td></td>
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<tr>
<td>Cucumber</td>
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<tr>
<td></td>
<td>Kiwi Fruit</td>
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<tr>
<td></td>
<td>Legume Seeds</td>
<td>Soybeans</td>
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<tr>
<td></td>
<td></td>
<td>Squash</td>
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<tr>
<td></td>
<td></td>
<td>Strawberries</td>
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<tr>
<td></td>
<td></td>
<td>Sugar Beets</td>
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<td></td>
<td></td>
<td>Sunflower</td>
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<td>F</td>
<td>M</td>
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<tr>
<td></td>
<td>Macadamia Nuts</td>
<td></td>
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<td>G</td>
<td>N</td>
<td>U</td>
<td></td>
</tr>
<tr>
<td>Grapes</td>
<td>Nectarines</td>
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</tr>
</tbody>
</table>

APPENDIX A - Pollinator Dependent Crops

Most Efficient Native Bees for Top Regional Fruits and Vegetables (PA & NJ)
<table>
<thead>
<tr>
<th>Bee Species</th>
<th>Crops</th>
<th>Apple</th>
<th>Blueberry</th>
<th>Cranberry</th>
<th>Cucumber</th>
<th>Muskmelon</th>
<th>Pepper</th>
<th>Squash</th>
<th>Strawberry</th>
<th>Tomato</th>
<th>Watermelon</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Andrena</em> (multiple species)*</td>
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<tr>
<td><em>Augochlorella pura</em></td>
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<tr>
<td><em>Augochlorella striata</em></td>
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<tr>
<td><em>Bombus</em> (multiple species)</td>
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<tr>
<td><em>Bombus impatiens</em></td>
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<tr>
<td><em>Ceratina</em> (multiple species)</td>
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<tr>
<td><em>Colletes inaequalis</em></td>
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<tr>
<td><em>Habropoda laboriosa</em></td>
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<tr>
<td><em>Halictus confusus</em></td>
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<tr>
<td><em>Lasioglossum</em> (<em>Dialictus</em>)</td>
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<tr>
<td><em>Pepo</em> <em>pruinosa</em></td>
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<tr>
<td><em>Xylocopa virginica</em></td>
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</tbody>
</table>

Bee importance for crop pollination

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<thead>
<tr>
<th></th>
<th>Good</th>
<th>Better</th>
<th>Best</th>
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</tbody>
</table>
## Appendix B - Insecticide Control Options

### Insect Pest Control Chart

<table>
<thead>
<tr>
<th>Method</th>
<th>Pro</th>
<th>Con</th>
</tr>
</thead>
</table>
| **Natural Enemies**                   | -Can restore ecological balance in the case of reintroducing a native predator to former range,  
                                        -If population remains secure and stable, labor costs can fall to zero.  
                                        -Reduce hazards to health and environment involved with chemical insecticides | -It may take time for natural enemies to establish.  
                                        -Small amounts of the pest must be maintained to support natural enemy population.  
                                        -Introduction of natural enemies can backfire and cause ecological damage.  
                                        -Potential escape from application area |
| **Chemical Insecticide**              | -Fast and labor conserving way to eliminate pests.  
                                        -High short-term effectiveness.                                                      | -Has a high chance of pests becoming resistant in the long term.  
                                        -Can cause collateral damage by killing/harming beneficial species.  
                                        -Many chemicals harmful to humans  
                                        -Some accumulate in environment and persist for long periods of time in sediments, atmosphere, groundwater |
| **Mating Disruption & Hormone Traps** | -Low chance of collateral damage  
                                        -Highly pest-specific                                                                  | -Exerts a selective pressure that pests can adapt to.  
                                        -Hormone traps can attract large numbers of pests to an area  
                                        -Typically effective only against one gender  
                                        -Can be costly to implement                                                                |
| **Cultural Control**                  | -A consistently inhospitable habitat for the pest will discourage pest presence in the long term | -Can demand labor to maintain the necessary conditions.  
                                        -Could cause harm to other species that share the pest’s habitat requirements.  
                                        -Costs may be high, depending on the amount of change necessary.                     |
| **Microscopic Biological Controls**   | -Highly pest specific  
                                        -Can develop colonies and work long term to control pest insects  
                                        -Virtually non-toxic to humans, most pets                                               | -Require specific environmental conditions  
                                        -Some not practical for storage  
                                        -Often effective only if ingested by insect of concern  
                                        -Ineffective for many pest species                                                     |
| **Insecticidal Soaps**                | -Limited environmental toxicity  
                                        -Highly toxic to bees if applied directly  
                                        -Effective on plant surfaces                                                            | -No long term effectiveness  
                                        -Potential to damage some plants  
                                        -Not effective against most larger insects                                               |
Home Remedy Insecticide Sprays (garlic, pepper, onion concoctions)  
-Effective against small, soft bodied pests (aphids, whiteflies, certain mites)  
-limited harm to bees and most insects  
-can be used to control aphids and some garden pests  
-must be reapplied consistently  
-limited effectiveness on most insects

Mineral and Plant Oils  
-some useful and nontoxic for person insect repellent  
-relatively harmless to environment  
-harmful in direct contact to pollinator species  
-relatively large amounts must be used for effective control in lawns and gardens

### Bacillus spp. - Species Specific Microbial Insecticides

<table>
<thead>
<tr>
<th>Pathogen</th>
<th>Product Names</th>
<th>Affected Pests</th>
<th>Uses and Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Bacillus thuringiensis</em> var. <em>kurstaki</em> (Bt)</td>
<td>Bactur®, Bactospeine®, Bioworm®, Caterpillar Killer®, Dipel®, Futura®, Javelin®, SOK-Bt®, Thuricide®</td>
<td>caterpillars (larvae of moths and butterflies)</td>
<td>Effective for foliage-feeding caterpillars (and Indian meal moth in stored grain). Deactivated rapidly in sunlight; apply in the evening or on overcast days and direct some spray to lower surfaces or leaves. Does not cycle extensively in the environment. Available as liquid concentrates, wettable powders, and ready to use dusts and granules. Active only if ingested.</td>
</tr>
<tr>
<td><em>Bacillus thuringiensis</em> var. <em>israelensis</em> (Bti)</td>
<td>Summit 111-5 Mosquito Dunks®, Aquabee®, Bactimos®, Gnatro®, LarvX®, Mosquito Attack®, Skeetal®, Teknar®, Vectobac®</td>
<td>larvae of Aedes and Psorophora mosquitoes, black flies, and fungus gnats</td>
<td>Effective against larvae only. Active only if ingested. Culex and Anopheles mosquitoes are not controlled at normal application rates. Activity is reduced in highly turbid or polluted water. Does not cycle extensively in the environment. Applications generally made over wide areas by mosquito and blackfly abatement districts.</td>
</tr>
<tr>
<td><strong>Bacillus thuringiensis var. tenebrinos</strong></td>
<td>Foil®, M-One®, M-Track®, Novardo®, Trident®</td>
<td>larvae of Colorado potato beetle, elm leaf beetle adults</td>
<td>Effective against Colorado potato beetle larvae and the elm leaf beetle. Like other Bts, it must be ingested. It is subject to breakdown in ultraviolet light and does not cycle extensively in the environment.</td>
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</tr>
<tr>
<td><strong>Bacillus thuringiensis var. aizawai</strong></td>
<td>Certan®</td>
<td>wax moth caterpillars</td>
<td>Used only for control of wax moth infestations in honeybee hives.</td>
</tr>
<tr>
<td><strong>Bacillus popilliae and Bacillus lentimorbus</strong></td>
<td>Milky Spore Disease, Doom®, Japidemic®, Grub Attack®</td>
<td>larvae (grubs) of Japanese beetle</td>
<td>the annual white grub, Cyclocephala sp. is NOT susceptible to milky spore disease. The disease is very effective against Japanese beetle grubs and cycles effectively for years in the soil.</td>
</tr>
<tr>
<td><strong>Bacillus sphaericus</strong></td>
<td>Vectolex CG®, Vectolex WDG®</td>
<td>larvae of Culex, Psorophora, and Culiseta mosquitoes, larvae of some Aedes spp.</td>
<td>Active only if ingested, for use against Culex, Psorophora, and Culiseta species; also effective against Aedes vexans. Remains effective in stagnant or turbid water. Commercial formulations will not cycle to infect subsequent generations.</td>
</tr>
</tbody>
</table>

**Use Of Nematodes as Biological Insecticides**

Retrieved from Cornell University Department of Entomology Biological Controls Webpage [http://www.biocontrol.entomology.cornell.edu/pathogens/nematodes.html](http://www.biocontrol.entomology.cornell.edu/pathogens/nematodes.html)

Information Provided By: David I. Shapiro-Ilan, USDA-ARS, SEFTNRL, Byron, GA & Randy Gaugler, Department of Entomology, Rutgers University, New Brunswick New Jersey
<table>
<thead>
<tr>
<th>Pest Common name</th>
<th>Pest Scientific name</th>
<th>Key Crop(s) targeted</th>
<th>Efficacious Nematodes *</th>
</tr>
</thead>
<tbody>
<tr>
<td>Artichoke plume moth</td>
<td><em>Platyptilia carduidactyla</em></td>
<td>Artichoke</td>
<td>Sc</td>
</tr>
<tr>
<td>Armyworms</td>
<td>Lepidoptera: Noctuidae</td>
<td>Vegetables</td>
<td>Sc, Sf, Sr</td>
</tr>
<tr>
<td>Banana moth</td>
<td><em>Opogona sachari</em></td>
<td>Ornamentals</td>
<td>Hb, Sc</td>
</tr>
<tr>
<td>Banana root borer</td>
<td><em>Cosmopolites sordidus</em></td>
<td>Banana</td>
<td>Sc, Sf, Sg</td>
</tr>
<tr>
<td>Billbug</td>
<td><em>Sphenophorus</em> spp. (Coleoptera: Curculionidae)</td>
<td>Turf</td>
<td>Hb, Sc</td>
</tr>
<tr>
<td>Black cutworm</td>
<td><em>Agrotis ipsilon</em></td>
<td>Turf, vegetables</td>
<td>Sc</td>
</tr>
<tr>
<td>Pest</td>
<td>Scientific Name</td>
<td>Hosts</td>
<td>Common Names</td>
</tr>
<tr>
<td>-------------------------------</td>
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</tr>
<tr>
<td>Black vine weevil</td>
<td><em>Otiorhynchus sulcatus</em></td>
<td>Berries, ornamentals</td>
<td>Hb, Hd, Hm, Hmeg, Sc, Sg</td>
</tr>
<tr>
<td>Borers</td>
<td><em>Synanthedon</em> spp. and other sesiids</td>
<td>Fruit trees &amp; ornamentals</td>
<td>Hb, Sc, Sf</td>
</tr>
<tr>
<td>Cat flea</td>
<td><em>Ctenocephalides felis</em></td>
<td>Home yard, turf</td>
<td>Sc</td>
</tr>
<tr>
<td>Citrus root weevil</td>
<td><em>Pachnaeus</em> spp. (Coleoptera: Curculionidae)</td>
<td>Citrus, ornamentals</td>
<td>Sr, Hb</td>
</tr>
<tr>
<td>Codling moth</td>
<td><em>Cydia pomonella</em></td>
<td>Pome fruit</td>
<td>Sc, Sf</td>
</tr>
<tr>
<td>Corn earworm</td>
<td><em>Helicoverpa</em> zeae</td>
<td>Vegetables</td>
<td>Sc, Sf, Sr</td>
</tr>
<tr>
<td>Corn rootworm</td>
<td><em>Diabrotica</em> spp.</td>
<td>Vegetables</td>
<td>Hb, Sc</td>
</tr>
<tr>
<td>Pest Name</td>
<td>Scientific Name</td>
<td>Host/Environment</td>
<td>Common Name</td>
</tr>
<tr>
<td>---------------------------</td>
<td>-----------------------</td>
<td>---------------------------</td>
<td>-------------</td>
</tr>
<tr>
<td>Cranberry girdler</td>
<td><em>Chrysoteuchia</em> topiaria</td>
<td>Cranberries</td>
<td>Sc</td>
</tr>
<tr>
<td>Crane fly</td>
<td>Diptera: Tipulidae</td>
<td>Turf</td>
<td>Sc</td>
</tr>
<tr>
<td>Diaprepes root weevil</td>
<td><em>Diaprepes abbreviatus</em></td>
<td>Citrus, ornamentals</td>
<td>Hb, Sr</td>
</tr>
<tr>
<td>Fungus gnats</td>
<td>Diptera: Sciaridae</td>
<td>Mushrooms, greenhouse</td>
<td>Sf, Hb</td>
</tr>
<tr>
<td>Grape root borer</td>
<td><em>Vitacea polistiformis</em></td>
<td>Grapes</td>
<td>Hz, Hb</td>
</tr>
<tr>
<td>Iris borer</td>
<td><em>Macronoctua onusta</em></td>
<td>Iris</td>
<td>Hb, Sc</td>
</tr>
<tr>
<td>Large pine weevil</td>
<td><em>Hylobius albietis</em></td>
<td>Forest plantings</td>
<td>Hd, Sc</td>
</tr>
<tr>
<td>Insects</td>
<td>Scientific Name</td>
<td>Hosts</td>
<td>Damage Levels</td>
</tr>
<tr>
<td>---------------------------------</td>
<td>----------------------------------</td>
<td>--------------------------------</td>
<td>---------------</td>
</tr>
<tr>
<td>Leafminers</td>
<td><em>Liriomyza</em> spp. (Diptera: Agromyzidae)</td>
<td>Vegetables, ornamentals</td>
<td>Sc, Sf</td>
</tr>
<tr>
<td>Mole crickets</td>
<td><em>Scapteriscus</em> spp.</td>
<td>Turf</td>
<td>Sc, Sr, Scap</td>
</tr>
<tr>
<td>Navel orangeworm</td>
<td><em>Amyelois transitella</em></td>
<td>Nut and fruit trees</td>
<td>Sc</td>
</tr>
<tr>
<td>Plum curculio</td>
<td><em>Conotrachelus nenuphar</em></td>
<td>Fruit trees</td>
<td>Sr</td>
</tr>
<tr>
<td>Scarab grubs**</td>
<td>Coleoptera: Scarabaeidae</td>
<td>Turf, ornamentals</td>
<td>Hb, Sc, Sg, Ss, Hz</td>
</tr>
<tr>
<td>Shore flies</td>
<td><em>Scatella</em> spp.</td>
<td>Ornamentals</td>
<td>Sc, Sf</td>
</tr>
<tr>
<td>Strawberry root weevil</td>
<td><em>Otiorhynchus ovatus</em></td>
<td>Berries</td>
<td>Hm</td>
</tr>
<tr>
<td>Small hive beetle</td>
<td><em>Aethina tumida</em></td>
<td>Bee hives</td>
<td>Yes (Hi, Sr)</td>
</tr>
<tr>
<td>-------------------</td>
<td>-----------------</td>
<td>-----------</td>
<td>-------------</td>
</tr>
<tr>
<td>Sweetpotato weevil</td>
<td><em>Cylas formicarius</em></td>
<td>Sweet potato</td>
<td>Hb, Sc, Sf</td>
</tr>
</tbody>
</table>

* At least one scientific study reported 75% suppression of these pests using the nematodes indicated in field or greenhouse experiments. Subsequent/other studies may reveal other nematodes that are virulent to these pests. Nematodes species used are abbreviated as follows: Hb=Heterorhabditis bacteriophora, Hd = H. downesi, Hi = H. indica, Hm= H. marelata, Hmeg = H. megidis, Hz = H. zealandica, Sc=Steinernema carpocapsae, Sf= S. feltiae, Sg=S. glaseri, Sk = S. kushidai, Sr=S. riobrave, Sscap=S. scapterisci, Ss = S. scarabaei.

** Efficacy of various pest species within this group varies among nematode species.
## Appendix C - Native Plants to Attract Pollinator Species

### Landscaping With Native Plants

Weekly bloom chart for twenty native perennial plants in central Pennsylvania. Dates may vary in other locations.

<table>
<thead>
<tr>
<th>Species</th>
<th>Early Season</th>
<th>Mid-Season</th>
<th>Late Season</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Early Season</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wild blue phlox</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Canadian columbine</td>
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<td></td>
<td></td>
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<tr>
<td>Talus slope penstemon</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ohio spiderwort</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Mid-Season</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Butterfly milkweed</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wild bergamot</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>American senna</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Culver’s root</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Prairie blazing star</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Common boneset</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Narrowleaf mountainmint</td>
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<td></td>
<td></td>
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<tr>
<td>Eastern purple coneflower</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Giant ironweed</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Scented joe-pye weed</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Late Season</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tall tickseed</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bigleaf aster</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blue mistflower</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Wrinkleleaf goldenrod</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>New York aster</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>New England aster</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

= species in bloom, ■ = week of peak bloom, = highly attractive to bees

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Penn State University. (2009). Agroecology in Practice: Conserving Wild Bees in Pennsylvania. Full Fact Sheet available at: [http://pubs.cas.psu.edu/FreePubs/pdfs/uf023.pdf](http://pubs.cas.psu.edu/FreePubs/pdfs/uf023.pdf)
The USDA-NRCS plants database lists *Crisium discolor*, a native field thistle, as potentially weedy or invasive. Though you should not encourage large populations, it is a valuable pollinator foraging resource and can be managed as such. Its seeds are not commercially available.

### Photograph Credits
- Elaine Haug @ USDA-NRCS PLANTS Database (Lobelia spicata, Asclepias syriaca, Pycnanthemum tenuifolium)
- Patrick J. Alexander @ USDA-NRCS PLANTS Database (Apocynum cannabinum)
- Jeff McMillian @ USDA-NRCS PLANTS Database (Erigeron strigosus, Prunella vulgaris)
- Jim Stasz @ USDA-NRCS PLANTS Database (Scutellaria integrifolia, Verbena hastata)
- Seabrooke Leckie (Solidago odora)
- Thomas Barnes (University of Kentucky) @ USDA-NRCS PLANTS Database (Agalinis purpurea, Cirium discolor)
- William Justice @ USDA-NRCS PLANTS Database (Vernonia noveboracensis)
- Janet Novak @ Connecticut Botanical Society (Eupatorium maculatum)
- Robert H. Mohlenbrock @ USDA-NRCS PLANTS Database (Euthamia graminifolia)
- www.botanik.uni-karlsruhe.de/garten/fotos-hassler/ (Potentilla norvegica)
- Bryn Mawr College and Rutgers University. (May 2009). Native Bee Benefits for Pennsylvania and New Jersey Farmers. Pg 6


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**Editorials**

Editor
To the Editor,

My College professor, who is a resident of Haycock Township in Bucks County, has been trying to limit pesticide use in her county. One issue she has drawn my attention to is the effect of pesticides on honeybees and other pollinators. Even non-insecticide pesticides can have some influence on honeybees, and many crops in the United States are dependant on pollinators. Here in New Jersey, the 5 primary fruits crops (apples, peaches, blueberries, strawberries, and cranberries) all depend on pollinators to produce fruit.

Integrated Pest Management (IPM) employs several methods of pest control and only incorporates pesticides as a last resort. When using pesticides, there is not only a danger of collateral damage, but also of pests developing resistance. Alternate pest management strategies can include mulching (for weeds), natural enemies (predators & parasitoids) mating disruption, and crop rotation (impractical with perennial crops). An IPM based system also allows for small amounts of pest damage and only requires action once damage reaches economically damaging levels. Organic farming, which frequently employs IPM, has been shown to positively affect pollinators

I believe that the effect of pesticides on pollinators needs to be brought up more often because of the important role pollinators play in agriculture. Please spread the message of this letter to the people of Bucks County.

Vighnesh Raman
35 Debra Drive, Dayton, NJ
1-845-837-9237
vighnesh@eden.rutgers.edu
Limitting Pesticide Usage to Help Beneficial Bee Populations

Pesticides, such as herbicides and insecticides, have offered many benefits to society throughout the years. They help us control insects that transmit disease, keep invasive species at bay, keep weeds out of our gardens and lawns, and keep yields of agricultural crops at all time highs. Despite the many benefits that these chemicals can offer us, there are quite a few downsides. Some of these chemicals can contribute to hormone imbalance, illness, and neurological disorders in humans. There are also ecological effects to take into account, and one group of animals has received a great amount of attention recently due to decline in population sizes and range. Who are they? Well, they can be quite busy, they buzz around flowers, don bright striped suits, and have sometimes been known to ladle honey onto our breakfast cereals. You guessed it, it's the bees.

Recently, domestic honey bees and native pollinator species have been in decline worldwide. Although these population drops have happened in the past, current declines have been more widespread and significant than ever before. Although a multitude of different factors including climate patterns, habitat loss, and disease can contribute to these declines, beekeepers and scientists have identified one factor common to most all of the pollinator decline we have seen, insecticide use.

With large populations and large appetites, insecticides play a larger role in agriculture today than ever before. However beneficial they may be, they have the potential to adversely affect many beneficial insects, invertebrates, and other critters in the environment, especially the bees. Systemic insecticides can build up in pollen and various plant matter, and be highly toxic to bees in direct contact, as well as back home in the hive. It has been said that one in every three bites of food that every American consumes can be attributed to pollination by native bees or domesticated honey bees. So with these great advances in new systemic pesticides, will we see proportionate increases in agricultural yield and limited infestation? Not if the bees have any say in it.

Monmouth, Middlesex, and Ocean counties together make up 9%, 24%, and 40% of New Jersey’s total pesticide use in agriculture, golf courses, and lawn care, respectively, as reported by NJDEP. The second most prevalent insecticide in lawn care, imidacloprid, is a chemical that has been intensely studied and shows an especially significant threat to the bee population.

As much of this pesticide use comes from the home, and many attempts by grassroots organizations and concerned citizens to strengthen regulations against certain pesticides of particular harm have been ineffective, it is placed upon citizens of local communities to take action. By limiting their use of insecticides and herbicides, planting alternative ground covers
that are more resistant to grub infestation than traditional turf grasses, or trading some lawn area for a flower bed of native species or a vegetable garden, citizens can do a great part to limit pesticide use in the state of New Jersey and help keep the beneficial insects we rely upon thriving and buzzing. Many sources are available on different ways to limit pesticide use around the home and harm to beneficial insects through the USDA agricultural extension office at Rutgers University, NJDEP, and USEPA.

-Ryan Fantasia
07/16/2012

Dear Ryan Fantasia,

I am pleased to inform you that you have successfully completed the Rutgers University Human Subjects Compliance Program. This educational program includes information on the regulations, history, policies, procedures, and ethical practices pertaining to research involving human subjects, which will be helpful as you conduct your research.

Your approval date is 07/16/2012. Duration of approval will be based on federal requirements which are not yet determined. Well in advance of the expiration date of your approval period, you will be notified so that you may continue your education regarding the protection of human subjects.

Additional information will also be provided on the IRB list-serve and posted on the human subjects website: [http://irb.rutgers.edu/humans](http://irb.rutgers.edu/humans).

Please retain this letter of certification. It will be required for submitting human subjects protocols, and continuing review forms. When submitting a funding request to NIH, the certification date will be required for inclusion on a different certification letter, which may be requested by contacting the IRB Administrator, by email at [human SUBJECTS@orip.rutgers.edu](mailto:human SUBJECTS@orip.rutgers.edu) or by phone at (848) 932-0150. Thank you for your cooperation.

Sincerely,

Sheryl N. Goldberg
Director
Office of Research and Sponsored Programs
07/16/2012

Dear Vighaesh Raman

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Sincerely,

Sheryl N. Goldberg
Director
Office of Research and Sponsored Programs

References:


