CHAPTER 3

BEST PRACTICES FOR PESTICIDE USE

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INTRODUCTION

Pesticides are used to control pest populations, and are generally named for the type of organism they control (see "Pesticide Terminology" box). Pesticides are important tools for homeowners, growers, land managers, public health officials and beekeepers to control insect pests, disease vectors (such as mosquitos), disease-causing organisms (bacteria, fungi), weeds, and invasive species that threaten the balance of our natural ecosystems.

However, pesticides can be toxic to non-target species. For example, insecticides used to control insect pests can be toxic to insect pollinators as well as non-insect species (including wildlife and humans). Pesticides can have indirect impacts on non-target species as well. For example, herbicides used to control weeds in fields may reduce the availability of flowering plants on field edges, robbing pollinators of valuable food sources.

Pesticide Terminology:

Pesticides: chemicals used to control pest populations. They are named by the type of pest they target: for example, insecticides are toxic to insects (and often mites), miticides are toxic to mites, herbicides are toxic to plants, and fungicides are toxic to fungi.

Active ingredient: the chemical in a pesticide formulation that is toxic to the targeted pest.

Adjuvant: Chemicals added to a pesticide to enhance the performance of the active ingredient. Adjuvants can allow the pesticide to adhere or spread over the plant and/or leaf more efficiently. Note that adjuvants alone can impact bees in laboratory studies.

Systemic pesticides: pesticides taken up and spread through an organism to kill pests that feed on that organism. For example, a systemic pesticide applied to a plant spreads through its vascular system and kills targeted pests (and sometimes non-pests) that feed on that plant. Pesticide exposure for pollinators occurs through the ingestion of systemic insecticides in plant parts such as nectar, pollen, leaves, and stems. Systemic pesticides can remain in the plant for several weeks to years after application.

Contact pesticides: pesticides which must make direct contact with the pest targeted for control.
Broad spectrum pesticide: a pesticide that can control a wide range of pests.

Residual pesticides: pesticides which can be used when a pest is a continual problem. A "residue" remains active long after it is applied, providing long-term control.

Moreover, long-term exposure to pesticides can facilitate the selection of pesticide-resistant pest populations, which limits the long-term utility of these pesticides.

Thus, it is critical that pesticides be used thoughtfully to reduce off-target impacts and ensure their long-term effectiveness.

Exposure of pollinators to chemicals. Since pollinators actively visit any flowering plants within their foraging range, their exposure rates to pesticides can be quite substantial. Studies from Penn State found that samples from honey bee colonies contained more than 120 pesticides and metabolites.

Pollinators (and other beneficial arthropods) can be exposed to pesticides when:

- Pesticides are sprayed where pollinators are foraging, either on managed flowering plants or flowering weeds.
- Pesticides drift to adjacent regions where pollinators are visiting blooming plants or nesting, during or immediately after pesticide application.
- Pesticide residues remain in the nectar or pollen of flowering plants and are collected by pollinators as food for themselves or their developing larvae. Pesticide residues in flowering plants can result from either a direct application or through pesticide-contaminated soil and water runoff from nearby locations. Indeed, recent studies have found that many pesticides in the pollen and nectar collected by foraging bees come from contaminated wildflowers.
- Pesticide residues are found in the water sources that pollinators drink or bring back to their nest.
- Pesticide residues are found in soil where pollinators are nesting, or contaminating nesting material.

Impacts of exposure to chemicals on pollinators. The impact of chemicals on pollinators depends on the toxicity of the chemical to the pollinator species, the amount of exposure (quantity and duration), and the individual's physiological state (toxicity may vary between adults and larvae, for example, and individuals stressed by other factors may be more sensitive). Furthermore, exposure to other chemicals (other pesticides as well as adjuvants used with pesticide) can increase the sensitivity of an individual to a pesticide (see recent review from Penn State).

Herbicide use may have sublethal impacts on pollinators and can reduce the nutritional resources available to pollinators, by

- Reducing the amount of flowering weedy plants available to pollinators. Several studies have found that these weedy flowering plants are key resources for pollinators.
- Drifting into field margins and delaying the onset of flowering and numbers of flowers of non-target plants visited by pollinators in these areas (see a recent Penn State study).

Insecticide and fungicide exposure can have a variety of impacts on pollinators, including:

- Immediate death, if exposure levels are sufficiently high.

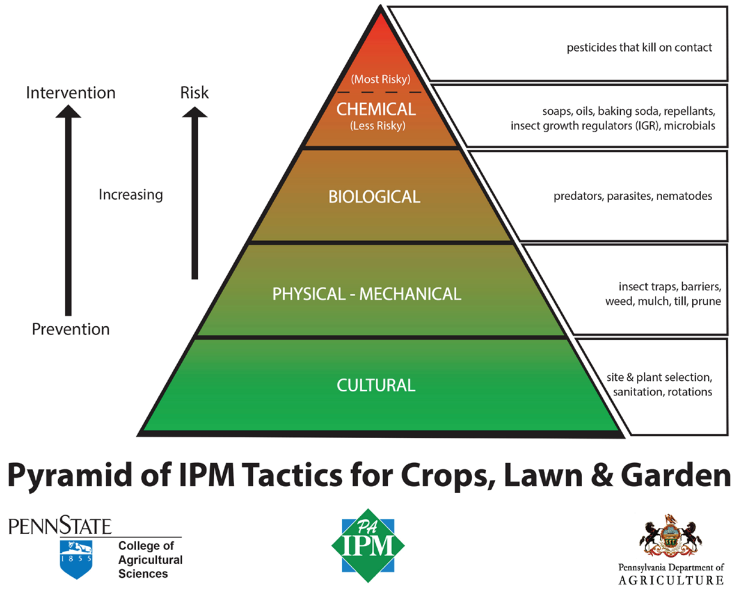
- Decreased life span, if exposure levels are below lethal doses but impair the pollinators' ability to forage, locate their nest site, or combat parasites and pathogens.
- Reduced brood production, if exposure reduces egg production or viability, or if the brood is fed nectar or pollen containing pesticides that cause lethal or sublethal effects.
- Reduced overwintering survival.

Death and decline of bees or other pollinators may be caused by several factors. It is important to investigate any bee kill as soon as possible after it is discovered, so that appropriate samples can be collected and tested. More information can be found in the Pennsylvania Pollinator Protection Plan section on Best Practices for Beekeepers. If pesticide exposure is suspected, the incident should be reported immediately to PDA's Health and Safety Division, 717-772-5231. The U.S. Environmental Protection Agency also encourages reports of all pesticide-related bee kills to beekill@epa.gov.

GENERAL RECOMMENDATIONS FOR PESTICIDE USE

It is strongly recommended that pesticides be used only as part of an **"Integrated Pest Management"** or **IPM** approach. More details can be found on the Pennsylvania IPM website. In general, to use an IPM approach, you should

- Take steps to **prevent the introduction** of pests and diseases (for example, use disease resistant stocks of plants or honey bees).
- **Monitor levels of pests and diseases** to know when it is necessary to use methods to control these populations.
- **Determine a "tolerance" threshold**, above which the damage caused by pests and diseases is not acceptable (for example, treatment is not always



Overview of IPM strategies for controlling pests and diseases in plants.

necessary at the first sign of a pest, but rather should be initiated only when pest or disease levels are unacceptable).

- Use **multiple non-chemical methods** to control pest and disease populations (such as physical removal of pests, weeds, or diseased tissue, as well as encouraging or introducing populations of pathogens or predators that help control pest populations).
- If non-chemical control strategies have not been effective at keeping pests and diseases under a "tolerance" threshold, **use chemicals and chemical application methods which are (a) approved for use in controlling the identified pest/disease and (b) have reduced effects on non-target species.**

When choosing and using a chemical pesticide:

- **Make sure you understand and follow all requirements for pesticide applicator certification in Pennsylvania.** You are required to become certified if you apply any restricted use pesticides (RUPs) or if you perform commercial or public applications. The PA Department of Agriculture (PDA) and Penn State Extension work together in this process. For more information see the Pesticide Education website or the Pennsylvania Pesticide Control Act of 1973.
- **Select a pesticide that is registered for use in Pennsylvania to control the identified pest/disease but has the least toxicity to pollinators, humans, and other wildlife.** To assess the relative toxicity of a pesticide to pollinators, use the "Bee Precaution Pesticide Rating" online tool from the University of California Statewide Agricultural & Natural Resources Integrated Pest Management Program.

  The Pacific Northwest Extension Publication How to Reduce Bee Poisonings from Pesticides (available as a pdf or as an app for your phone) also provides an overview of how both managed and wild bees can be affected by pesticides.

  The Forest Stewardship Council provides guidance on selecting pesticides with decreased risk to wildlife.

Developing an Integrated Pest Management (IPM) strategy to control an invasive pest. In 2014, the Pennsylvania Department of Agriculture and Pennsylvania Game Commission confirmed the presence of the Spotted Lanternfly (Lycorma delicatula) in Pennsylvania. This pest can utilize more than 70 plant species, 25 of which occur in PA. It can cause significant damage to key crops, including cultivated grapes, tree fruits, and hardwoods. It is found in all landscapes, from urban to natural.

The PA Department of Agriculture has initiated a comprehensive program to educate members of the public on the Spottled Lanternfly, promote detection of infestations, and implement an Integrated Pest Management strategy which spans mechanical control, host tree reduction, and trap trees. This IPM strategy successfully contrzols populations of this devastating pest while minimizing off-target impacts on other insect species.

Relative toxicity of different pesticides is also provided in "Wild Pollinators of Eastern Apple Orchards And How to Conserve Them" (pg 17). and in Purdue Extension's guide to Protecting Honey Bees from Pesticides.

The Xerces Society has created a database of research articles related to the impacts of pesticides on pollinators and other invertebrates.

- **The label is the law!** Read the label and follow instructions before handling and applying a pesticide.
- **Check the label (under "Environmental Hazards") for any pollinator or bee language (i.e. "highly toxic to bees").** Some pesticides now include an "EPA Pollinator Protection Box" which includes a bee and pollinator hazard icon and explains restrictions that should be addressed when applying the pesticide. It also gives instructions on minimizing drift and limiting pesticide exposure to bees and other pollinators.
- **Use application methods and approaches that minimize the exposure of pollinators to the pesticide.**

  - Target spray or use approaches that reduce drift of pesticides to surrounding areas.

  - Pesticides should ideally be applied when pollinators are not foraging, either at dusk or when a plant is not flowering.

  - Consider how long a pesticide remains active before it degrades or how it may spread through the plant: systemic pesticides may provide long-lasting protection against pests but also may contaminate the nectar and pollen of flowers.

- **Know where managed bee colonies are and notify beekeepers when you are applying pesticides nearby.**

  - It is strongly recommended that applicators notify beekeepers with registered apiaries in the area prior to pesticide applications. Bees will forage across several miles. Therefore, pesticide applicators should identify and notify beekeepers within five (5) miles of a treatment site at least 48 hours prior to application or as soon as possible. Timely notification will help ensure ample time for the beekeeper and applicator to develop a mutually acceptable strategy to manage pests while mitigating risk to honey bees. This may include covering hives, moving hives, or choosing the time of day to apply. Notifying beekeepers does not exempt applicators from complying with pesticide label restrictions. Many insecticide labels prohibit use if pollinators (bees) are present in the treatment area or the crop is in bloom.

- The PDA has created an interactive searchable map on the PAPlants website where pesticide applicators can identify and obtain contact information for registered apiaries (locations where honey bee colonies are kept). Businesses or individuals registered in PAPlants can search this site by county, township or spray location to identify nearby hive locations and work with their owners to protect the bees.

In addition to the general guidelines outlined above, below we provide specific considerations for pesticide use in different environments. We also provide guidelines for pesticide applicators to minimize potential negative impacts on honey bee colonies.

BEST PRACTICES FOR PESTICIDE USE IN URBAN AND SUBURBAN AREAS

In urban and suburban areas, homeowners, businesses, landscapers, park managers and public health officials may need to control the spread of pests and diseases, to ensure healthy, and attractive landscapes, to optimize yield from fruit and vegetable gardens, and to help control human pests and disease vectors, such as ticks and mosquitos. **In all cases, an IPM approach is critical for ensuring goals are met while minimizing non-target damage.**

For more detailed information on pollinator-friendly control of pests and diseases in lawns, ornamental plants, vegetable gardens, and parks see "agricultural areas" and "natural areas" sections in the Pollinator Protection Plan. Additional information on managing golf courses (there are over 660 in Pennsylvania alone) for pollinators can be found in "Optimizing Pest Management Practices to Conserve Pollinators in Turf Landscapes: current practices and future research needs" and in the Audubon Cooperative Sanctuary Program for Golf.

Human Pests and Disease Vectors. Individuals can protect themselves from human pests and disease vectors by using an IPM approach, which can reduce populations of these pests around homes, schools and businesses and/or greatly reduces the chances of individuals being exposed to these pests. This, in turn, decreases broad spectrum pesticide usage that can negatively impact pollinators. Information on key public health pests can be found on the Penn State Extension website.

Ticks can vector a number of human diseases, including Lyme disease. However, tick bites can be avoided using a number of basic precautions, thereby reducing or eliminating the need for large-scale pesticide treatments of properties. Individuals should:

- Avoid wooded or brushy areas (where ticks or more common)
- Wear long sleeves and pants, hats, use appropriate pest repellants (such as those containing DEET, see the EPA repellant website for more information) if spending time in areas where there may be ticks
- Inspect themselves for ticks and remove any ticks promptly.
- If bitten, individuals should be carefully monitored for signs of disease and contact a physician if symptoms develop.
- More information can be found on the PA Department of Health website.

One of the most concerning and widespread vectors of human disease are mosquitos. In the US, some mosquito species can carry West Nile Virus, which can infect humans, birds, and horses, and was identified in Pennsylvania in 2000. In 2015, it was reported that mosquitos transmitted Zika Virus, causing an outbreak in Brazil which led to increased reports of birth defects. The main mosquito vector for the Zika Virus is *Aedes aegypti*, which is not established in Pennsylvania. A related mosquito species, *Aedes albopictus*, is found in southeast and southcentral Pennsylvania, but it is not as efficient a vector of the virus. Thus far (May 2017), there have been no reported cases of local Zika transmission in Pennsylvania from mosquito bites.

Pennsylvania has developed comprehensive response plans for both West Nile Virus and Zika Virus. These plans rely heavily on an IPM approach to reduce pesticide use and off-target impacts of pesticide exposure.

Individuals can control mosquito populations around their homes, businesses, and schools and reduce their exposure to mosquitos through the following practices:

- Mosquitos breed in standing water, and thus the most effective way to reduce mosquito populations is to remove standing water, add predatory fish to standing water, and/or use *Bacillus thuringiensis* subspecies *israelensis* (BTI), a naturally occurring bacteria found in soils that is wildly available for purchase, and is toxic to mosquito larvae in water, but has a relatively low toxicity to other insects and humans.
- Homeowners are encouraged to prevent mosquitos from entering their homes by using screens and keeping doors and windows sealed.

- Individuals can prevent bites by staying inside during periods of peak mosquito activity (dawn and dusk, though note that *Aedes albopictus* is active during the day), wearing long-sleeved shirts and clothing, or using an insect repellant.
- Before spraying their property with insecticide, homeowners should consult with their local West Nile County Coordinator.
- If public health officials determine that spraying is necessary, precautions should be taken to notify beekeepers (using the PA Plants site to identify nearby beekeepers) and members of the public, and use pesticides with reduced toxicity to bees and other wildlife.

Additional information for managing mosquito populations can be found at:

- Ecologically Sound Mosquito Management in Wetlands
- Help Your Community Create an Effective Mosquito Management Plan

BEST PRACTICES FOR PESTICIDE USE IN ROADSIDES AND RIGHTS OF WAY

Roadsides cover more than 10 million acres of land in the US. Pennsylvania has more than 40,000 miles of roads, and is one of the top five states in the nation for road miles. More than 100,000 acres of roadside lands are managed in Pennsylvania. The landscapes must be managed to support the needs of drivers, utility companies, and other stakeholders (eg, ensuring visibility and access) but can also provide excellent habitats to support pollinator populations.

Managing weedy and invasive plant species in roadsides and rights of way can be challenging. The Pennsylvania Department of Transportation utilizes biological/cultural, chemical and mechanical/manual methods which collectively form an **Integrated Vegetation Management (IVM) program:**

- Mowing operations are the cornerstone to controlling invasive species and to maintaining a safety-first roadside.
- Tree removal operations account for over sixty percent of the IVM budget to control the forest invasion of the roadside.
- While accounting for only twenty percent of the IVM expenses, the herbicide application program handles the bulk of the vegetation management controls.

Information on the Pennsylvania Department of Transportation's IVM approaches can be found in PennDOTs "Invasive Species Best Management Practices" publication.

More details on programs supporting land management in roadsides and rights of way can be found in the "Best Practices for Forage and Habitat in Roadsides and Rights of Way" section of the Pennsylvania Pollinator Protection Plan. Additional information on managing invasive and weedy species can be found below, in the "Best Practices for Pesticide Use in Natural Areas" section.

BEST PRACTICES FOR PESTICIDE USE IN AGRICULTURAL AREAS

Approximately 75% of major agricultural crops require or benefit from pollinators to set seed and produce fruit, and all crops can benefit from the arthropods that prey on or parasitize pest species, thereby reducing the negative impacts of these pest populations. Thus, there can be tremendous economic advantages to conserving and expanding populations of beneficial arthropods (managed and wild pollinators, predatory and parasitoid species) in agricultural landscapes. Unfortunately, many beneficial arthropods are also sensitive to the chemicals that are used in these agricultural landscapes. However, use of insecticides, fungicides, and herbicides is critical in many agricultural systems to control pests.

Here, we provide an overview of best practices for pesticide use in agricultural systems, to help growers maximize the yield and economic benefits they receive from beneficial arthropods, and minimize the cost of pesticide applications. However, agricultural crop production is obviously a highly specialized process, requiring integration of information on crop-specific requirements, soil, weather and climatic conditions, and current and future pest and disease pressures. Thus, these recommendations are quite general, and growers are encouraged to contact Penn State extension specialists for more detailed information.

Additional information can be found from the Pennsylvania Vegetable Growers Association, the State Horticultural Association of Pennsylvania the Pennsylvania Association for Sustainable Agriculture, and Food Alliance.

Integrated Pest and Pollinator Management (IPPM). Using an "Integrated Pest and Pollinator Management" approach helps growers both manage pests and promote populations of pollinators and other beneficial arthropods, to maximize their yields and economic benefits (see review from Penn State researchers). Integrated Pest Management is a well-established approach which uses multiple methods (biological, cultural, physical and chemical) to control pest populations below economic thresholds. IPPM integrates pollinators into this established framework. IPPM recommendations will be specific for certain crops, regions, and agricultural practices. However, there are several basic principles that can be consistently applied to balance the use of pesticides and pollination services (see online resources from Xerces Society)

- **Pesticides should only be used when pest and disease levels exceed a pre-determined economic threshold, and after other options (biological, physical, and cultural control) have been deployed.** While no one uses pesticides unless there is a perceived need, there are certainly differences in perception of need. For example, some believe that pesticides should be used prophylactically as an 'insurance' against pest build-up. Because this practice can increase overall pesticide use and the likelihood of off-target effects, growers are encouraged to refrain from pesticide use unless a pest or disease threat is clearly imminent.
- **Adjust the timing of pesticide treatment** to minimize exposure risk to pollinators. This may include using pesticides before bloom or spraying at night, taking into consideration the half-life of pesticides.
- **Adjust pesticide application methods** to reduce drift, and avoid aerial spraying. Pesticides should not be sprayed under conditions with high wind (> 9 mph), to minimize drift. Proper droplet size, ensuring spray equipment is properly calibrated, and lowering the boom to be right above the canopy are also key in minimizing drift.
- I**nclude buffer zones** between treated areas and habitat. Recommendations range from 40 feet (for ground-based applications), to 60 feet (for air-blast sprayers) to 125 feet (for crops treated with pesticides known to be highly toxic to pollinators). Windbreaks can be used to minimize aerial drift, and filter strips can minimize runoff.

- **Select pesticides with reduced toxicity to pollinators.** Several online tools and websites provide information about the relative toxicity of pesticides to pollinators and other wildlife; these are listed on page 5.
- Using **tank mixes** of different pesticides can reduce the cost of applying pesticides (in terms of labor and fuel) and reduce exposure of pollinators to the applied pesticides (as they would be exposed during a single application period versus multiple applications). However, there is increasing concern that combinations of pesticides have synergistic impacts on pollinators. Additionally, combining pesticides in a single application may encourage the prophylactic use of pesticides as "insurance", to avoid an additional application at a later time. Thus, it is important to again balance the costs and benefits of tank mix applications. More information can be found in a seminar from Professor Reed Johnson, Ohio State University. Additionally, the "Bee Precaution Pesticide Rating" online tool provides information about the toxicity of pesticide mixtures.

Crop-specific IPPM recommendations have been developed for tree fruit, squashes, pumpkins and gourds, and other crops.

Case Study: Negative Impacts of Prophylactic Pesticide Use

Neonicotinoids have been incorporated into seed coatings for field crops, under the premise that these systemic pesticides will be incorporated into the growing plant and protect the plant from herbivore damage over a long period of time. There has been a tremendous increase in the use of neonicotinoids in recent years, largely driven by their use in seed treatments for field crops such as corn and soybeans (see recent study from Penn State).

However, several studies, including those at Penn State, have demonstrated that in northern temperate climates, neonicotinoid seed treatments in soybeans are either not effective, because they do not provide protection against major crop pests that attack older plants, or can actually reduce yields by reducing populations of predatory species, resulting in increased populations of slugs, which feed on soybean seedlings and are not impacted by neonicotinoid exposure. Additional studies found no yield benefit of neonicotinoid seed treatments in corn. Furthermore, neonicotinoids are highly water soluble and can persist for months or years in the soil. Thus, while there are situations in which pest pressure warrants the use of neonicotinoid seed coatings, these coatings should be used cautiously and only when needed. Highly charged public debate on neonicotinoids has led to calls to limit their use, which is unfortunate because in many contexts, and when used responsibly, neonicotinoids can be more effective and safer to wildlife than other pesticide classes. For more details, see Best Management Practices for Handling Seeds Treated with Neonic Pesticdes and Xerces Neonic and information from the Xerces Society.

BEST PRACTICES FOR PESTICIDE USE IN NATURAL AREAS

The use of pesticides in natural areas such as forests is sometimes needed to protect ecosystem biodiversity, forest resources, watersheds, stream buffers, and threatened habitats from significant damage by various forest pests and competing native vegetation. The principal targeted pests for treatment in Pennsylvania are non-native invasive species such as the gypsy moth, hemlock woolly adelgid, elongate hemlock scale, emerald ash borer, and invasive plants. In addition, competing vegetation in some locations requires control so that forest regeneration can proceed according to established silvicultural practices. In all cases, an **Integrated Pest Management (IPM)** and **Integrated Vegetation Management (IVM)** approach must be used along with site-specific environmental reviews, to protect pollinators and other beneficial organisms from unnecessary harm.

Furthermore, Pennsylvania State Forests are independently certified according to the Forest Stewardship Council (FSC) standards, and the Pennsylvania Department of Conservation and Natural Resources(DCNR) Bureau of Forestry follows the best management practices guidelines provided by the FSC. The FSC provides extensive guidelines on pesticide use and alternative pest control strategies that are required for certification.

To illustrate Best Management Practices (BMP) for pesticide use in natural habitats, programs utilized by the PA DCNR are briefly described below, with an emphasis on pollinator protection and mitigation practices for non-target species. The approaches discussed here can be used by private landowners for their forested areas. Use of biological control and other management strategies are highlighted to describe the IPM and IVM approaches to pest management.

Gypsy Moth. Gypsy moth, an exotic species introduced to the United States in 1868, causes tremendous damage to forest trees. A gypsy moth suppression program in Pennsylvania began in 1972 to minimize gypsy moth defoliation and prevent tree decline and mortality in targeted areas. The program is request-based, whereby the landowner or managing agency requests areas to be treated. The DCNR Bureau of Forestry has very specific criteria, operations manuals, participation guidelines, environmental review process, and pre- and post-treatment evaluations.

The program currently uses three insecticides to treat forest areas: *Bacillus thuringiensis* subspecies *kurstaki* (BTK) (Foray 76B - based on a naturally occurring bacteria that can only affect certain species of lepidopteran larvae), tebufenozide (Mimic 2LV - an insect growth regulator which also only affects lepidopteran larvae), and Gypchek (the gypsy moth virus). Gypcheck is specific for gypsy moth, but since it is in limited supply it is only used when there are other lepidopteran species of concern present. Biocontrol programs are also in place, which take advantage of disease organisms, parasitoids and predators.

Hemlock Woolly Adelgid and Elongate Hemlock Scale. The Pennsylvania Hemlock Conservation plan was developed to provide a sustainable conservation strategy for eastern hemlock. While the primary focus is currently on DCNR-managed hemlocks in State Forests and State Parks (Cook Forest State Park is an example of a high value hemlock site), the IPM approach is applicable to private forest lands. See DCNR Bureau of Forestry Hemlock Conservation Plan for full details.

Neonicotinoids are used to protect eastern hemlocks from hemlock woolly adelgid (HWA) and the elongate hemlock scale (EHS) in high value focus areas. The use of systemic insecticides is needed to keep hemlocks alive long enough so that predatory beetle populations can become well enough established to control these pests. Hemlock trees only have to be treated once every 5 to 7 years to prevent HWA infestations from building up.
If neonicotinoid treatment is required, precautions are taken to minimize potential non-target impacts. These include:

- Avoiding flowering plants (e.g., mountain laurel) and flowering trees (e.g., basswood) if they are next to a treatment tree.
- Preferentially injecting the soil surrounding the tree, but only if sufficient organic matter is present around the base of the tree. Neonicotinoid insecticides, if bound to organic matter, only move about 18 inches in the soil. Thus it is critical that sufficient organic matter be present around a hemlock tree before the soil injection method is used.
- If a hemlock is next to a stream, or does not have sufficient organic matter, or if the water table is too high, direct stem injection can be used to limit the exposure.

Emerald Ash Borer. The Pennsylvania DCNR Bureau of Forestry has developed a comprehensive strategy to control Emerald Ash Borer populations and conserve ash trees in Pennsylvania forests as part of a national strategy to control EAB.

The strategy includes the use of the systemic insecticide ememectin benzoate (Tree-age), identifying "lingering ash" or surviving trees for breeding resistant populations, and releasing EAB parasitoids. Ememectin benzoate has the advantage of preventing attack by EAB, protecting the tree for 3 to 5 years, and becoming concentrated in the sapwood of the tree. Ash is wind pollinated, so the impact of the insecticide to pollinators is minimal. Ememectin benzoate is a restricted use pesticide, so only certified licensed applicators can use this insecticide to inject ash trees. More information on the use of insecticides to protect ash trees from EAB.

Invasive Plants.

The PA DCNR Bureau of Forestry is committed to managing invasive plant species across all state forest lands and has developed a comprehensive program. The goals of the Bureau of Forestry's invasive plant management program are to 1) control and eradicate novel and high threat invasive plant species populations, and 2) limit the spread of additional invasive species that threaten forest and wetland ecosystems or forest management activities.

However, managing invasive plant species in natural landscapes can be challenging, time-consuming, and expensive, and typically requires an individualized approach for each plant species. It is often not possible to simply remove all individuals of an invasive plant population, and there are often multiple invasive species. Thus, to prioritize invasive species management, it is necessary to determine a "treatment threshold" (as in all IPM and IVM approaches), which requires a full evaluation of the potential threat to the ecosystem, the density and scale of the infestation, how recently the species was introduced, whether the location has been targeted for management, and the available resources that can be used for managing a particular species.

For a list of plants that are not native to the state, grow aggressively, and spread and displace native vegetation, see the DCNR Invasive Plants List. Fact sheets with information on how to identify and control invasive plants are available at the DCNR Invasive Plants Website. Specific information on locations of invasive species and control efforts can be found at iMapInvasives.

When a population of invasive plant species has been identified for management, they can be physically removed or treated with herbicides. The Forest Stewardship Council provides guidance on selecting pesticides with decreased risk to wildlife.

Competing Vegetation Treatment Program on State Forest Lands. The DCNR Bureau of Forestry Silviculture Section coordinates vegetation treatments each year on State Forest Lands where the end goal is to regenerate a forested area by replacing undesirable native and exotic invasive vegetation with a desirable mix of trees, shrubs, and small herbaceous plants. Regenerated forests provide sustained ecological, economic, and social values. For more details, see the Pennsylvania Bureau of Forestry Planting and Seedling Guidelines.

The following plant species are often targeted for control:

- Common invasive woody species such as striped maple, American beech root sprouts, sweet birch, pin cherry, red maple, witch hazel, mountain laurel, and a host of exotic invasive species such as tree-of-heaven, paulownia, Japanese angelica, Japanese honeysuckle, multiflora rose, Japanese barberry, etc.
- Common herbaceous species such as Hayscented and New York fern, Japanese stiltgrass, mile-a-minute vine, Japanese knotweed, etc.

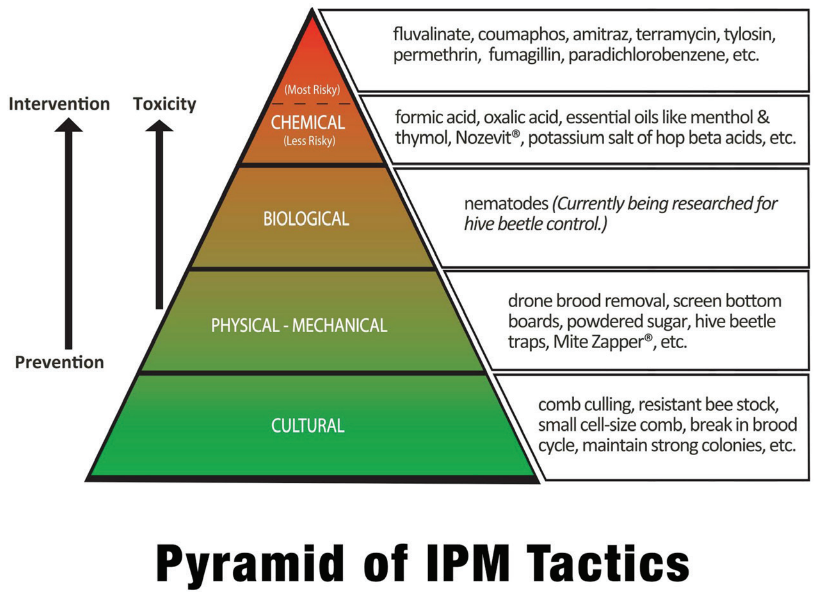
Forest regeneration is accomplished by:

- **Mechanical control**, which is used preferentially to minimize competing vegetation.
- **Biological control**, which is used for mile-a-minute vine, spotted knapweed, tree-of-heaven, and purple loosestrife (biological control for garlic mustard is pending).
- When needed, **herbicides labeled for forestry use by the rules of a Forest Stewardship Council (FSC) Certified Forest may be used.** It should be noted that the herbicide treatments used rarely eradicate the presence of invasive vegetation from the site. Herbicide operations are meant to open a window of opportunity to establish a diversity of desirable regeneration on the forest floor. These operations usually buy foresters three to five years of time to establish desirable vegetation.
- **Hand-planting of desired seedlings**
- **Deer-exclosure fencing**

Upon sufficient control of these undesirable forest plants, DCNR Foresters are able to establish a new cohort of desirable trees, shrubs, and herbaceous plants that will in turn create the forest of the future.

BEST PRACTICES FOR PESTICIDE USE ASSOCIATED WITH HONEY BEE COLONIES

Using pesticides to control pests in honey bee colonies. Honey bee colonies in Pennsylvania are hosts to many parasites and pathogens that can weaken colonies and lead to colony losses. The most important parasite is the Varroa mite (*Varroa destructor*), and uncontrolled Varroa mite populations are strongly associated with overwintering colony losses in the United States and Europe. It is strongly recommended that beekeepers monitor and manage Varroa populations using an Integrated Pest Management (IPM) approach.



IPM tactics to control Varroa populations in honey bee colonies.

Honey bees are also parasitized by Nosema microsporidia (*Nosema apis* and *Nosema ceranae*) which are intestinal parasites that weaken colonies and have been linked to large-scale colony losses in Europe. Wax moths (*Galleria mellonella*) are commonly found in very weak or abandoned colonies and can damage brood, honey stores, and wax comb. In some parts of Pennsylvania, small hive beetles (SHB) (*Aethina tuminda*) are found in honey bee colonies; SHB can contaminate honey stores and, at high population levels, lead to colony losses. Honey bees in the United States also host more than 20 different types of viruses, many of which can infect other pollinator species as well.

Several of these (Deformed Wing Virus and Israeli Acute Paralysis Virus) have been correlated with honey bee colony losses. Finally, brood diseases such as American Foulbrood (*Paenibacillus larvae*), European Foulbrood (*Melissococcus plutonius*), and Chalkbrood (*Ascosphaera apis*), can kill brood. While Chalkbrood and European Foulbrood are typically "stress" diseases and strong colonies can recover from these, American Foulbrood is the most virulent and contagious and requires immediate notification of the Pennsylvania Apiary Inspection Program, and Pennsylvania State Beekeepers Association and treatment.

Details about these and other parasites and pathogens can be found in the "Field Guide to Honey Bees and their Maladies", produced by Penn State Extension. This guide provides details about how to recognize and monitor levels of these pests and diseases and approaches to prevent infestation. Finally, the USDA offers a free diagnostic screening service to help beekeepers monitor for mites, Nosema and brood diseases.

To manage pests and diseases in a honey bee colony, an IPM approach is critical. Many of the chemicals used to control these parasites in honey bee colonies can be toxic to honey bees and humans, and can lead to increased levels of parasites in some cases. Moreover, extensive use can facilitate the selection and spread of resistant pest populations. For example, many populations of Varroa are now resistant to fluvalinate (a pyrethroid), coumaphos (an organophosphate), and amitraz (an amidine) which are commonly used for Varroa control.

If a chemical treatment is warranted, it is important for bee keepers to read and follow all pesticide label directions. It is also important to understand the risks involved in using products not registered by EPA or FDA for use on or around managed bees.

Information on how to employ an IPM approach for managing Varroa levels can be found in the IPM Pyramid above. Detailed information (including videos) for how to monitor and treat for Varroa can be found at the Honey Bee Health Coalition. Additional information about using IPM approaches to manage Nosema infections can be found here. Beekeepers should contact experienced beekeepers in their local bee clubs, the PA Department of Agriculture Apiary Program or Penn State Extension for more detailed information about current best practices to manage pests and diseases.

More useful information can be found on best management practices to reduce pesticide exposure to managed bee colonies in the Best Practices for Beekeepers section of the Pennsylvania Pollinator Protection Plan.