GROWING BEE-FRIENDLY GARDEN PLANTS

PROFILES IN INNOVATION

Friends of the Earth

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Acknowledgements

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I. Change In The Wind

Introduction

In response to global pollinator population declines, many concerned citizens have planted "bee-friendly" gardens to provide urban foraging grounds for these vital insects. This movement has the potential to provide an economic boost for producers and sellers of ornamental plants. Yet concerns have arisen about possible hazards to pollinators posed by production techniques, specifically nursery and greenhouse use of persistent, systemic pesticides such as the neonicotinoid insecticides.

Last summer, Friends of the Earth U.S., Friends of the Earth Canada, the Pesticide Research Institute, SumOfUs and organizations in 18 cities across the U.S. and Canada released *Gardeners Beware 2014: Bee-Toxic Pesticides Found in 'Bee-Friendly' Plants Sold at Garden Centers Across the U.S. and Canada*, an international report documenting the prevalence of neonicotinoid insecticides in the flowers of bee-attractive plants commonly purchased by home gardeners.[1] The results of the study demonstrated that the neonicotinoid insecticides widely used in ornamental plant production remain in the plants at the time of sale and pose a potential source of exposure to toxic pesticides for bees and other pollinators. The highest levels detected in flowers could kill pollinators outright, while the lower levels detected have the potential to impair the health and survival of pollinator species.[1]

With consumer and retailer demand for neonicotinoid-free plants increasing, many greenhouse and nursery growers have changed their practices to eliminate use of these insecticides. This report highlights the neonicotinoid-free pest management strategies used by growers we interviewed (refer to Appendix I for interview methods). Most of these growers run small to medium-sized production operations, reflecting the highly fragmented nature of the industry, with many being small and family-owned.[2] Many of the growers we interviewed have committed to reducing or eliminating their use of neonicotinoid insecticides. Not all have made the commitment, noting that changes in greenhouse and nursery production practices take time to develop and implement.

Each nursery grower we interviewed manages between 5 and 2,000 field acres, and each greenhouse grower manages between 13,000 and 65,000 ft^2 of greenhouses. The largest grower interviewed, Monrovia, manages 2,000 field acres over four states and is considered one of the industry's largest companies.

Greenhouse Grower magazine surveyed the one hundred largest greenhouse growers in the industry, and the results of their survey reflect the broad industry trend of reducing or eliminating the use of neonicotinoid insecticides.[3] 31 percent of the growers surveyed are not using neonicotinoids at all, and 38 percent have eliminated neonicotinoid use for some of their plant products. To reduce their use of pesticide chemicals, 84 percent of those surveyed increased their use of Integrated Pest Management (IPM), and 60 percent increased their use of biological control. These results show that both large and small growers are actively responding to customer concerns regarding environmental impacts of growing practices.

Neonicotinoid insecticides widely used in ornamental plant production remain in the plants at the time of sale and pose a potential source of exposure to toxic pesticides for bees and other pollinators

Commonly Used Terms

Bee-toxic	The term "bee-toxic" is used for any pesticide that has an LD_{50} of less than 2 μg/bee, based on the US EPA Toxicity Categories and Levels of Concern for honey bees.[4]
Bee-attractive	Plants that produce pollen and nectar that bees forage on.
Bee-friendly	Bee-attractive plants that do not contain levels of insecticidal residues toxic to bees.
Pesticide	Any substance used to kill, repel, or control insects, weeds, rodents, or microbial pests. Includes insecticides, fungicides, herbicides, rodenticides, and microbiocides.
Neonicotinoid	A class of insecticide that blocks insects' nicotinergic neuronal pathways, and are included in the Insecticide Resistance Action Committee (IRAC) Group 4 category of nicotinic acetylcholine receptor agonists (nAChR).
Systemic pesticides	Pesticides that are sufficiently water soluble to be taken up by the roots of plants and translocated to all parts of the plant through the xylem.
Persistent pesticides	Pesticides that take a long time to degrade in the environment (months to years, rather than days to weeks).

Why Focus On Neonicotinoids?

Managed honey bee declines are thought to be related to multiple factors, including pesticides,[1] parasites,[5] pathogens,[6] climate change,[7] malnutrition,[8] and habitat degradation.[9] A growing body of evidence suggests that persistent, systemic, bee-toxic insecticides such as neonicotinoids pose special hazards to pollinators.[10] Neonicotinoids, manufactured by Bayer CropScience, Syngenta, and Dow AgroSciences, are used extensively in agricultural and urban/suburban areas. The neonicotinoid imidacloprid—introduced in 1994—is among the most widely used insecticides in the world.[11]

Neonicotinoids have been the focus of concerns about bee-toxic pesticides because they are the most acutely toxic group of insecticides to honey bees currently in use in the U.S. Table 1 shows the top ten most bee-toxic pesticides. The top two most bee-toxic pesticides are imidacloprid and clothianidin, both in the neonicotinoid class. Thiamethoxam is fourth and dinotefuran is sixth on the list.

In addition to high toxicity, the neonicotinoids have two special characteristics that make them more hazardous than other bee-toxic pesticides:

The combination of high toxicity, systemic action and persistence means that the flowers of neonicotinoid-treated plants will remain a source of toxic exposure for bees and other beneficial insects throughout the growing season (for annuals) and for several years (for perennials)

1. They are sufficiently water soluble that they can be taken up systemically by the plant through roots and foliage and expressed in pollen, nectar[12] and other plant fluids.[13]
2. They are highly persistent, both in soils and in the plants themselves.

The combination of high toxicity, systemic action and persistence means that the flowers of neonicotinoid-treated plants will remain a source of toxic exposure for bees and other beneficial insects throughout the growing season (for annuals) and for several years (for perennials).

Table 1: Top Ten Registered Pesticides for Acute Toxicity to Honey Bees

Active Ingredient	Honey Bee Oral LD_{50} (μg/bee)*	Chemical Class
Imidacloprid	0.0037	Neonicotinoid
Clothianidin	0.0038	Neonicotinoid
Fipronil	0.0042	Pyrazole
Thiamethoxam	0.0050	Neonicotinoid
Abamectin	0.0090	Macrolide
Dinotefuran	0.0230	Neonicotinoid
lambda-Cyhalothrin	0.0270	Pyrethroid
Cyfluthrin	0.05	Pyrethroid
Fenitrothion	0.0593	Organophosphorus
Resmethrin	0.0654	Pyrethroid

* Pesticides are ranked by oral LD_{50}, which is the estimated dose that would kill 50 percent of the test population exposed by eating contaminated pollen or nectar. A smaller number means it takes less of the chemical to kill 50 percent of the test bees. *Data source*: References 152, 153, and 154.

Most other insecticides and insect growth regulators are also toxic to adult or larval bees, but bees are less likely to be exposed to these chemicals because they are either not systemic, and therefore not found in pollen and nectar (pyrethroids), or they are not persistent, meaning that plants do not remain toxic to bees for long periods of time (organophosphates, carbamates). Nevertheless, use of any bee-toxic pesticides has the potential to harm pollinators and should generally be avoided.

Neonicotinoid insecticides can poison bees directly by attacking their nervous systems, as illustrated by the 2013 and 2014 bumble bee kills in Oregon (see box at right). But even low-level exposure can lead to sublethal effects such as altered learning[14] and navigation,[15] impaired foraging[16] and reproduction,[17] as well as immune suppression,[18] which can exacerbate the lethality of bee pathogen infections.[19] A recent paper authored by Swedish ecologists found reduced wild bee density, solitary bee nesting, and bumble bee colony growth in areas with canola grown from neonicotinoid-coated seeds.[20]

A variety of beneficial organisms beyond pollinators are also susceptible to the toxic effects of neonicotinoids. These insecticides have been shown to kill other helpful insects critical to sustainable food production and components of healthy ecosystems, such as monarch butterflies,[27] dragonflies, lacewings, and ladybugs.[28, 29, 30] Further, this class of insecticides may also be severely impacting populations of wild vertebrates such as birds[31, 32] as well as earthworms,[28] amphibians, and aquatic insects.[33, 34]

The largest amount of neonicotinoid insecticide use is in agriculture. Yet, although nursery and greenhouse use of these insecticides may not be comparable in quantity to agricultural use, it is highly targeted to plants that are grown intentionally for their flowers—plants that are attractive to pollinators. Hence, there are heightened concerns about neonicotinoids in nursery production.

Photo credit: Rich Hatfield, Xerces Society 2013

A High-Profile Bee Kill

In June 2013, more than 50,000 bumble bees, representing at least 300 colonies, were found dead or dying in a Target parking lot in Wilsonville, Oregon.[21, 22] An investigation by the Oregon Department of Agriculture (ODA) concluded that the bee kill was caused by the application of the neonicotinoid dinotefuran on linden trees at the manufacturer-recommended application rate.[23] The application was made to linden trees in full bloom early in the morning on a sunny day. The product label has a restriction on application when bees are "visiting" the treatment area. While the applications themselves were not made while bees were actively visiting (given the early hour), the applicators were charged with "faulty, careless or negligent pesticide application" because they were applying an insecticide that was labeled as residually bee-toxic on a day that bees could reasonably be expected to visit the trees.[24]

One year later, in June 2014, 5,000 bumble bees were killed after a spray application of the neonicotinoid imidacloprid on blooming linden trees on private property.[25] Following this incident—one of seven acute bee kills in Oregon since June 2013—the ODA expanded its restrictions on the application of four neonicotinoid pesticides, prohibiting the application of dinotefuran, imidacloprid, thiamethoxam, and clothianidin to linden trees, basswood trees, and other *Tilia* species on any property in Oregon, public or private.[26]

Avoiding Regrettable Substitutions

Transitioning away from neonicotinoid insecticides to other insecticides will not necessarily result in "bee-friendly" plants. The neonicotinoids are not the only pollinator-toxic pesticides of concern. Any bee-toxic, persistent, systemic pesticides (insecticides and even some fungicides) may not only affect pollinators, but also disrupt biological control programs in nurseries and greenhouses. Broadcast applications of pesticides in general can also impact many non-target insects, including pollinators.

Worker safety should also be considered when selecting pest management methods. Minimizing pesticide use overall and selecting non-chemical solutions when possible is the best way to ensure worker safety. If a pesticide must be used, selection of the option with low bee and mammalian toxicity is preferred. See Table 2 on page 34 for more information on different types of insecticide active ingredients and their effects on human health, as well as whether these chemicals are considered systemic, persistent, or bee-toxic. In general, the best approach for avoiding harm to both workers and pollinators is to utilize cultural, physical and biological controls for pests, thus limiting chemical applications to least-toxic options.

Demand For Neonicotinoid-Free Plants Is Growing

According to a National Gardening Association survey, nearly 90 percent of households think managing residential and public lawns and gardens in an environmentally friendly way is important.[35] There is a growing demand for safe, environmentally friendly alternatives and organic growing methods that are benign to human health and the environment. In light of this increased consumer demand, a number of retailers have decided to be part of the solution to the bee crisis and are taking neonicotinoid products and plants treated with neonicotinoids off their shelves.

Retail Nurseries Work To Meet Consumer Demand

More than twenty nurseries, landscaping companies and retailers across the U.S. have taken steps to eliminate neonicotinoids from their garden plants and products in their stores, including the two largest home improvement retailers in the world—Home Depot and Lowe's.*

Home Depot, the world's largest home improvement store, now requires the labeling of plants treated with neonicotinoids and is working with its suppliers to "find alternative insecticides for protecting live goods and bees."[36]

A bed of succulents at a Home Depot store with tags showing that these plants have been treated with neonicotinoids. Photo credit: Rosemarie Radford.

Lowe's, the second largest home improvement store in the world, committed to phasing out consumer-use products and nursery plants that contain neonicotinoids. Completion of the phase-out is scheduled for the spring of 2019, as suitable alternatives become available. Lowe's also committed to encouraging growers to use biological control programs and providing additional materials to educate customers about pollinator health.[37]

* A list of nurseries, landscaping companies, and retailers who have made a commitment to reduce or eliminate neonicotinoid use and/or provide labeling to inform consumers is available online at: **http://www.foe.org/beeaction/retailers**

BJ's Wholesale Club, with more than 205 locations in 15 states, required all vendors to remove neonicotinoids from their plants by the end of 2014 and/or include a warning label on each plant that states "treated with neonicotinoids, use caution around pollinators."[38]

In October 2014, Whole Foods Market announced its new Responsibly Grown product rating system for conventional produce and flowers, rating them as "good," "better," or "best" based on a number of criteria, including pesticide use.[39] The system identifies pollinator protection as a priority, and a grower can only receive a "best" rating by eliminating use of four neonicotinoid insecticides—imidacloprid, clothianidin, thiamethoxam, and dinotefuran.[40]

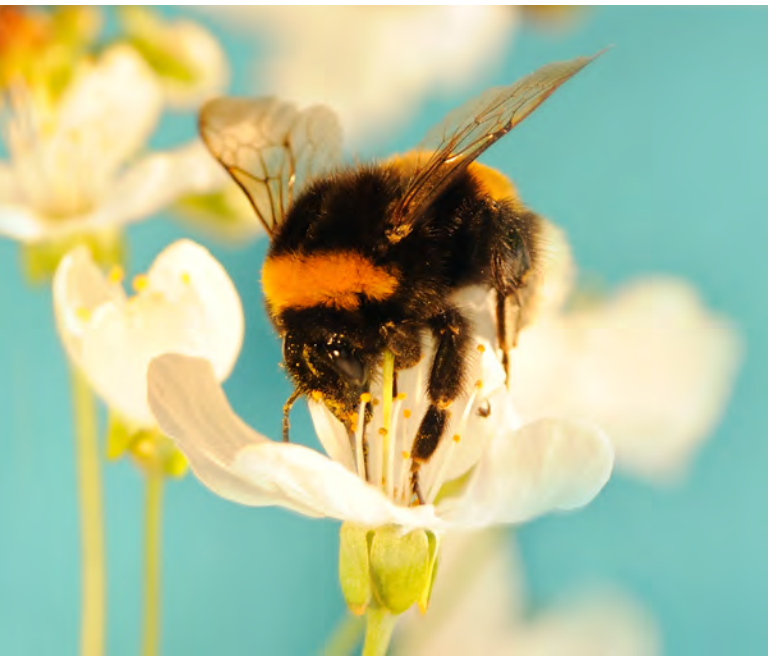
Governments, Universities, Businesses And Consumers Move To Restrict Use Of Neonicotinoids

Retailers and other businesses are not the only actors who are moving quickly to protect pollinators. Based on a scientific review stating that neonicotinoids pose an unacceptably high risk to bees by the European Food Safety Authority (EFSA),[41] the European Union followed recommendations issued by EFSA and placed a continent-wide two-year suspension on the use of neonicotinoids imidacloprid, clothianidin, and thiamethoxam on bee-attractive plants, effective December 1, 2013.[42]

In the U.S., the EPA announced that it is unlikely to approve new and expanded uses of neonicotinoids while it evaluates the risks posed to pollinators,[43] but has not restricted any of the currently registered uses of neonicotinoids. Neonicotinoid insecticide products therefore remain on the U.S. market without a comprehensive data set on pollinator impacts.[44] The EPA has received more than a million public comments urging swift protections for bees, yet the Agency has not committed to modifications to the registered uses of neonicotinoid insecticides until the Registration Review Process is complete, between 2016 and 2019.[45] The EPA instead required that registrants add a bee advisory warning label to outdoor, foliar-use products containing imidacloprid, dinotefuran, clothianidin, or thiamethoxam in August 2013.[46] The directive did not require a warning for granular products, coated seeds, or products used as soil drenches, even though they have been implicated as the source of bee kills.

In June 2014, President Obama established a new Pollinator Health Task Force, co-chaired by the Secretary of Agriculture and the Administrator of the Environmental Protection Agency.[47] President Obama directed this task force to develop a National Pollinator Health Strategy, calling on the EPA to assess the impacts of pesticides, including neonicotinoids.[48] The Presidential Pollinator Health Task Force released its report in May 2015, with a plan aimed at reversing honeybee and monarch population declines. A central focus of the plan is planting millions of acres of federal land with pollinator-friendly plants and conducting more research into the causes of pollinator declines, including the effects of pesticides on pollinator health.[49]

Certain federal agencies, state and local governments have been active in working to address neonicotinoid use. The U.S. Fish and Wildlife Service announced it will phase out use of neonicotinoids on all national wildlife refuge lands by 2016.[50] In October 2014, the U.S. Council on Environmental Quality released



guidance for federal facilities and federal lands, recommending that these entities not use systemic insecticides or acquire seeds or plants that have been treated with systemic insecticides.[51] These guidelines have the potential to increase the demand by the federal government for pollinator-friendly plants that do not contain neonicotinoid insecticide residues.

In Canada, in November 2014, the Ontario government became the first state or province in North America to announce plans to restrict neonicotinoids to reverse bee declines. The province proposed a reduction in the use of neonicotinoids on corn and soybeans by 80% by 2017.[52] In the past year, the states of Minnesota[53, 54] and Oregon,[55, 56] have passed measures to minimize or eliminate the use of neonicotinoids. In 2015, a number of states introduced legislation to minimize neonicotinoid use, including Massachusetts,[57] Maryland,[58, 59] Virginia,[60] Alaska,[61] Minnesota,[62, 63] California,[64] and Vermont.[65] Because of concerns about groundwater contamination, in 2004 New York State classified as "restricted use" all imidacloprid-containing professional turf, ornamental, nursery and agricultural use products (except seed treatments and fly baits) meaning that these products must be applied by a certified applicator and their use reported to the state.[66] Additionally, all consumer-use products containing imidacloprid other than pet products and potting soil mixes are required to be listed as "Not for use in Nassau, Suffolk, Kings, and Queens Counties."

Cities and counties that have passed pollinator protection policies that minimize or eliminate the use of neonicotinoids on municipal properties include Spokane, WA,[67] Seattle, WA,[68] Thurston County, WA,[69] Eugene, OR,[70] Portland, OR,[71] Cannon Beach, OR,[72] Shorewood, MN,[73] St. Louis Park, MN,[74] Lake Elmo, MN,[75] Stillwater, MN,[76] Andover, MN,[77] Skagway, AK,[78] Sacramento, CA,[79] Ogunquit, ME,[80] Boulder, CO,[81] and Warren County, NC.[82]

A growing number of businesses, universities, cities, counties, and states are taking steps to make their facilities more pollinator-friendly by eliminating use of neonicotinoids on their grounds. Emory University passed a measure in 2014 to eliminate the use of neonicotinoids on campus grounds, including a requirement to buy plants that have not been treated with neonicotinoids.[83] Vermont Law School passed a similar measure in 2014[84] and Southern Oregon University adopted a similar policy in 2015.[85]

Readers' Guide

This report aims to serve as a resource and provide examples for retailers, wholesale nurseries and institutions about successful strategies that others are using to remove pollinator-toxic pesticides from their operations and avoid substituting other harmful pesticides. We recognize that change is not necessarily easy and hope these stories will provide inspiration and guidance for those interested in making change.

The following sections of the report are designed to stand on their own as resources:

Part II: For retail garden centers. Appendices II and IV are accompaniments.

Part III: For nursery and greenhouse growers. Appendices III and IV are accompaniments.

II. Retailers Take The Lead

Garden centers have been at the forefront of the effort to reduce neonicotinoid use in nursery plants. To meet consumer demand for neonicotinoid-free plants, retailers are making extra efforts to increase their understanding of how their suppliers use pesticides, and in many cases, requiring suppliers to label treated plants. Some garden centers purchase only guaranteed neonicotinoid-free plants. Other garden centers are working to eliminate consumer-use neonicotinoid insecticide products from their shelves. Still other retailers have built on the momentum for bee-friendly landscapes by creating comprehensive consumer education efforts focusing on pollinator protection.

Sourcing Neonicotinoid-Free Plants

As the *Gardeners Beware*[1] study showed, residues from neonicotinoid application by wholesale nurseries may persist in plants available at garden centers at levels that may be toxic to bees and other pollinators. With customers now asking for plants that are neonicotinoid-free, retailers are taking steps to ensure that the plants they sell can meet customers' needs.

Sourcing neonicotinoid-free plants requires good communication with nursery plant wholesale and production operations. Below, we present some illustrative examples of the practices and policies retail stores have adopted to verify that they are offering neonicotinoid-free plant options.

Successful Neonicotinoid-Free Plant Sourcing Policies

BJ's Wholesale Club

BJ's Wholesale Club, with more than 205 locations in 15 states, has put together a comprehensive strategy for eliminating neonicotinoids from its plant supply chain.[86] Scott Williams, Assistant Vice President of Quality Assurance and Environmental Stewardship for BJ's Wholesale Club, says that their decision was motivated by a sense of environmental stewardship, rather than profit.[87]

> *With bees serving as an essential part of a healthy ecosystem, it's just the better choice for the environment and for agriculture to move away from these chemicals.*

Williams has been working with BJ's suppliers during the transition. For 2015, BJ's will require its suppliers to use a standard label on any plants that may have had neonicotinoids applied at any stage in propagation or growing. This label will state, "Neonicotinoids applied. Caution around Pollinators." Any suppliers still using neonicotinoids are also required to submit a plan for minimizing the effects of their neonicotinoid applications on pollinators.

In the second year of the program, BJ's will require all of its suppliers to provide plants not treated with neonicotinoids, with a few exceptions for specific plants such as poinsettias (typically placed indoors during the winter season) and blueberry bushes (which are subject to quarantine restrictions in some states). BJ's will also be monitoring compliance by testing unlabeled plants using a third party-certified laboratory.

Williams' goal is to make shopping as convenient as possible for their club members. Rather than forcing members to sort through plants and examine every label, the shopper can just select the plants they wish and feel confident that their yards and gardens will be a source of clean forage for pollinators.

A view of the Harlequin's Gardens New Western Demonstration Garden, managed organically. Photo credit: Mikl Brawner at Harlequin's Gardens

Harlequin's Gardens

Harlequin's Gardens, with one store in Boulder, Colorado, no longer carries any plants that may have been treated with neonicotinoids.[88] In order to ensure that no neonicotinoid residues reach the shelves of Harlequin's, owner Mikl Brawner keeps in contact with suppliers about their neonicotinoid use, requiring them to confirm that they do not use neonicotinoids. Harlequin's does not purchase plant starts ever treated with neonicotinoids. Harlequin's has also hired a grower specifically to grow neonicotinoid-free plants, ensuring they are able to offer the varieties their customers want with the assurance that their plants are neonicotinoid-free. Harlequin's Gardens grows and manages all their purchased plants organically.

Photo Credit: Lori Vollmer, GardenFever!

GardenFever!

GardenFever!, with one location in Portland, Oregon, is a good example of a garden center that has moved to proactively address the neonicotinoid issue.[89] GardenFever! co-owner Lori Vollmer removed neonicotinoid-containing insecticide products from the store's shelves after the June 2013 bee poisoning incident in Wilsonville, Oregon.[23]

In 2014, Lori surveyed her growers and created a comprehensive plan for communicating with customers about whether particular plants in her store were treated with neonicotinoids. She required all growers who said they were not using neonicotinoids on some or all of their plants to sign a pledge. GardenFever! created display posters that identified growers whose products are neonicotinoid-free. For the growers who do not affix a label to their product, the store created a tag that is applied to plants in the store with the words, "Pollinator Friendly" and a "bee-safe logo" indicating that no neonicotinoids were used in production.

Photo credit (this page): Stephanie Fleming at Behnke Nurseries

Behnke Nurseries

Behnke Nurseries, with one location in Maryland, was one of the first garden centers in the nation to make a policy statement about reducing the number of neonicotinoid-treated plants in their retail stores. Larry Hurley, a plant purchaser at Behnke's, is coordinating the effort, and said that the response from growers has been positive overall.[90] Larry noted that some of Behnke's suppliers are working on solidifying their neonicotinoid policies, and he has identified a few growers that can provide neonicotinoid-free plants. Behnke Nurseries plans to promote pollinator-friendly garden plants on display tables, making it easy for pollinator-conscious consumers to purchase those plants.

Boulder, Colorado

The City of Boulder, Colorado, is developing a process for sourcing neonicotinoid-free plants for use on city property.[91] Rella Abernathy, the Integrated Pest Management Coordinator for Boulder, said that city staff and a consultant have contacted wholesale suppliers to gather information about the plants purchased by the city and determine if nursery stock has been pre-treated with neonicotinoids. She explained that it was more straightforward to locate annual plants and bare-root trees that are neonicotinoid-free than potted perennials.[92] However, verification that potted trees had never been treated at any time has proven to be difficult for trees coming from out-of-state, particularly because quarantine restrictions often require treatment. See *Quarantine Restrictions* on page 23.

The City of Boulder adopted a resolution to ban the application of neonicotinoids on city properties on May 5, 2015.[91] The resolution includes a rigorous exemption process for neonicotinoid application only for cases when the life or health of a valuable or significant tree is at risk and there are no other options available or a neonicotinoid is the least impactful option. However, the criteria are so stringent that tree exemptions will rarely be granted.

Institutionalizing A Commitment To Pollinator Health

Developing a store policy on neonicotinoid-treated plants is an important step in generating consumer confidence and ensuring customer loyalty. The process of developing a policy regarding neonicotinoid-treated plants is different for every garden center, but there are some common approaches that are proving effective. Here are some policy options we heard about from retailers:

1. **Purchase only neonicotinoid-free plants:** This approach requires some research on wholesale supplier operations and pest management strategies. See Appendix II for examples.
2. **Separate the neonicotinoid-treated plants from neonicotinoid-free plants:** The plants that have not been treated with neonicotinoids can be placed in a different part of the store than those that have been treated, with signs indicating that the untreated plants are neonicotinoid-free.
3. **Label neonicotinoid-free plants:** A store label indicating that neonicotinoids were not applied to the plant or plants in a particular pot can be created, if it can be verified that the plants are indeed neonicotinoid-free. If some suppliers have completely stopped using neonicotinoids, encourage them to apply a label to their products, or to amend the label they currently use to include this information. This will help differentiate bee-friendly plants, and help the garden center save labor costs.

Appendix II contains more information about the survey techniques others have used in communicating with suppliers. See *Looking Down The Supply Chain: Seeds, Starts And Plugs* for more information about the nursery supply chain, on page 43.

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After developing a store policy on sourcing neonicotinoid-free plants, some retailers have taken additional steps to support their policy decisions:

1. **Verify compliance:** To ensure plants are neonicotinoid-free, some stores are verifying compliance through periodic plant testing. Some stores also ask growers to sign a pledge, or to provide information online about their neonicotinoid policy.
2. **Publicize the policy:** Create a written policy and post it on the company website to allow customers to view it independently.
3. **Train staff:** Store employees will probably encounter questions from customers about the store policy, and should be prepared to provide information about how the policy helps protect pollinators and other beneficial insects. Development of written materials about the policy for employees will provide a point of reference for their work with customers, clarify the motivations for the policy and provide information about the detrimental effects of neonicotinoids on pollinators.
4. **Provide pollinator-protective pesticide options:** Remove neonicotinoid-containing insecticide products from store shelves. Additionally, it is helpful for retailers to ensure a staff member is available who can provide consultation about pollinator-friendly pest-management to customers.

Friends of the Earth

Friends of the Earth maintains a list of garden centers who have made policy statements about their neonicotinoid use on foe.org/beeaction/retailers, and will add garden centers that provide a written statement of their policy.

Cosmetic Damage

About half of the growers we spoke with expressed concern about their customers' low tolerance for pest damage.

Nevin Smith at Suncrest Nursery in Watsonville, California, said:[93]

> *The current cosmetic standards are very high, similar to fruits and vegetables. At this point, people don't tolerate any signs of insects; for example, no holes in the leaves. To maintain these plants in a spotless state requires more sprays.*

Many growers echoed this sentiment: If the tolerance for pest damage were not so low, it would be much easier to reduce overall pesticide use in nurseries and greenhouses. Some growers commented on how the tolerance for pest damage has changed since they began working in the nursery industry 30 years ago, noting that the expectation of an unblemished plant with no pesticide residues is unrealistic.

Katie Tamony at Monrovia, a company that manages nurseries in four states, said:[94]

> *We would love to get people comfortable with seeing a few pests on the leaves, and understanding that it's a healthy relationship. On one hand the consumer is groomed to expect perfection, but on the other they're expecting environmentally friendly plants.*

Some garden centers, such as Harlequin's Gardens in Boulder, Colorado, or GardenFever! in Portland, Oregon, make customer education about pest presence a part of their business.[88, 89]

Tolerance for pest presence depends upon the customer base, but it may benefit garden centers to reconsider their expectations for pest damage and shift emphasis to customer education, where possible.

Educating Customers, Enhancing Market Opportunities

Once a store policy on buying neonicotinoid-containing plants is in place, it is helpful to communicate this information to customers in person and through posters and informational handouts. Educating and informing consumers will help build customer loyalty and trust in the garden center as an environmentally smart place to shop.

Many garden centers have started providing written information for customers who want to plant bee-friendly gardens. Many resources are available online to help retailers compile such information. Find details in Appendix II.

Harlequin's Gardens is very active in educating their customers, offering gardening classes and maintaining demonstration plots.[88] They teach their customers that tolerating 10 percent pest damage (such as holes in leaves or discoloration) is acceptable according to the principles of Integrated Pest Management. They explain to customers that a few aphids on a plant will not significantly damage the plant that will be soon planted outside, and are actually an important component of the food web for birds and beneficial insects. Mikl demonstrates the use of a non-toxic spray, like horticultural oil, in case of population explosions.

Lori Vollmer at GardenFever! also prioritizes consumer education.[89]

> *We give lectures and advertisements about environmental health and pollinator health. It's an important part of our message. The nursery industry knows that the environment is important to protect.*

Providing Customers With Low-Toxicity Pest Management Options

Although removing neonicotinoid-containing garden plants from store shelves is an important first step toward protecting pollinators, a significant part of neonicotinoid exposure for urban and suburban bees comes through consumer use of neonicotinoid insecticide products. Pesticide products approved for cosmetic use in gardens by homeowners have manufacturer-recommended application rates up to 120 times higher than rates approved for agricultural use.[95]

In California, where pesticide use[96] and sales[97] are tracked, consumers account for

a substantial fraction of the total use of neonicotinoid products (see Figure 1). In some years, consumer use comprised more than half of the total neonicotinoid use in California, a state with not only significant agricultural use of neonicotinoids, but also large population centers that may use these products to maintain landscapes. States with a different mix of agricultural, suburban, and urban areas may be different than California, but the fact remains that these products are widely available in retail stores, often as grub-control products for turf, which are applied to large areas.

Consumers interested in insect control are often not aware of the adverse effects products can have on pollinators and other beneficial insects—they simply purchase a product from the available selection. Retailers can change this dynamic by eliminating neonicotinoid-containing products from their shelves and replacing them with alternatives that have lower toxicity to pollinators. This action alone can contribute significantly to making urban and suburban landscapes safe for pollinators.

The ideal selection of insect-control products for retailers interested in protecting pollinators includes horticultural soaps and oils, microbial products comprised of bacteria toxic to specific insects, beneficial nematodes and low-toxicity

Photo credit: June Condruk at Cedarglen Floral Company

In some years, consumer use comprised more than half of the total neonicotinoid use in California

FIFRA-exempt† products containing essential oils or other botanical extracts. For more information about tools for selecting low-toxicity pesticides, see Appendix IV.

† FIFRA-exempt products are those exempted from US EPA registration requirements through Section 25(b) of the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) and include products containing active ingredients such as peppermint oil, clove oil, corn oil, garlic, and other compounds of botanical origin.

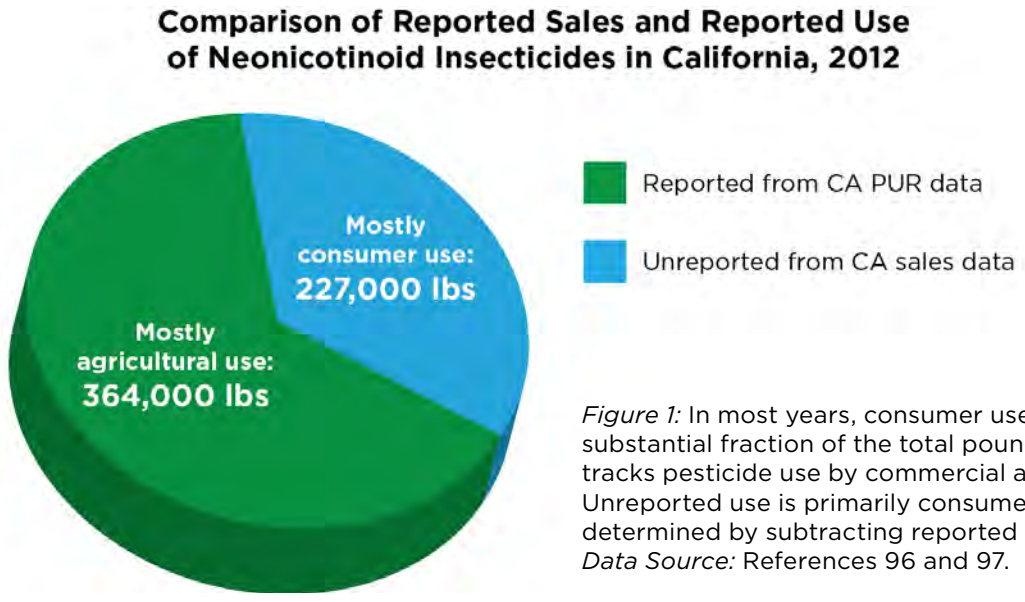


Figure 1: In most years, consumer use of neonicotinoids accounts for a substantial fraction of the total pounds used in California, a state that tracks pesticide use by commercial applicators, as well as total sales. Unreported use is primarily consumer use for these chemicals and was determined by subtracting reported use from reported sales. *Data Source:* References 96 and 97.

Bee-Friendly Practices For Landscapers

Neonicotinoid use in landscaping can be a primary source of exposure for urban pollinators. Eliminating or reducing such use will expand the amount of clean forage for pollinators.

Bill Melvin, the owner of Ecoscape Environmental Design in Boulder, Colorado, explained his decision to stop using neonicotinoid insecticides:[98]

> *For us, it's a simple decision, ethically and environmentally speaking. To think that these plants might harm our pollinators goes against all my beliefs and the reason we created Ecoscape.*

Bill has committed to never using neonicotinoids in his landscaping practice. Instead, Ecoscape emphasizes treating the problem that is enabing the pest to thrive through nurturing the soil, as well as incorporating plants that attract beneficial insects and act as pest deterrents (such as chives and oregano) into landscape design.

Avoiding Soil Treatments

Neonicotinoids are often applied as granules to soil, as a soil drench, or by trunk injection in landscaping for trees with hard-to-reach foliage.[99] Landscapers and consultants sometimes prefer the soil drench to a foliar spray because of the possibility that a foliar spray might drip, creating an additional source of exposure for humans and wildlife. In some cases, such as treatments for the emerald ash borer (EAB), a neonicotinoid soil drench is the only option recommended by USDA and its IPM Centers to non-licensed pesticide applicators such as homeowners.[100, 101]

However, soil drenches and injections —even if they are applied immediately after the tree stops blooming to avoid pollinator impacts— may persist in the soil and the plant, creating a source of long-term exposure for pollinators the next year and beyond. An evaluation of the flowers from the linden trees that poisoned the bumble bees in Wilsonville, Oregon, a year later indicates that residues can persist for more than one year at levels that are potentially problematic to foraging bees.[102] The aerobic

half-life* of dinotefuran is 138 days,[103] indicating that the plant may continue absorbing the chemical from the soil for many months after the initial soil application resulting in contamination of nectar when the tree blooms the following year.

Reducing Or Eliminating The Use Of Neonicotinoids In Landscaping

In landscaping, the physical removal of pests and the application of soap and oil insecticides where necessary will reduce potential harm to pollinators and people. If foliar sprays are not an option, in the case of hard-to-reach trees, neem-based products are available as a soil drench. Neem degrades more quickly than neonicotinoid insecticides, but care should still be taken to avoid treatment prior to bloom.

Many neonicotinoid treatments of tree pests are unnecessary—for example, an aphid infestation left untreated will normally draw natural enemies into the area, which will reduce the populations of aphids. Some tree pests, such as Japanese beetle, cause severe damage in absence of treatment, but there are alternatives that have shown efficacy in controlling them, including pheromone traps and beneficial nematodes that infect Japanese beetle larvae in the soil. Where possible, biological and cultural control methods are the preferred option for control of all pests. Applications of any insecticides to trees prior to or during tree bloom may lead to direct pollinator exposure.

Sourcing Neonicotinoid-Free Plants

Landscaping companies and institutional landscapers purchase many plant starts and may tolerate a higher threshold of pest damage than the average consumer. Landscaping companies can commit to pollinator protection by asking suppliers about their use of neonicotinoids and only buying from wholesale nurseries and garden centers that offer neonicotinoid-free plants.

* The half-life is the time it takes for half of the pesticide to degrade.

Emerald Ash Borer

Photo Credit: Forest Service, USDA, via Wikimedia Commons

The emerald ash borer (EAB) is an important invasive species that has spread as far west as Colorado, and is present in most of the eastern United States.[101] Preventing infestation by emerald ash borer is difficult, and if a tree is left untreated, the emerald ash borer causes tree mortality within a few years of infestation. By the time 50 percent of the tree canopy is gone, it is probably too late to save the tree using insecticides. EAB girdles the tree trunk, blocking the transmission of both water and the systemic insecticide.[101]

USDA-recommended EAB treatments for homeowners include over-the-counter neonicotinoid pesticides, which can result in contaminated soils that serve as a source of neonicotinoids for other plants in the area. Alternatives to neonicotinoids for a tree infested with EAB include tree removal, and application of other restricted use pesticide by a registered applicator.[100, 104] One OMRI-certified product is also available for tree injection by professional tree care companies (Tree-Azin). Biocontrol parasitoid wasps are also being released in some locations, where they are becoming established and showing promise for eventually controlling emerald ash borer.[105]

III. Nursery And Greenhouse Growers Take Action To Protect Pollinators

The rising tide of consumer demand has created a new environment for wholesale nurseries and greenhouses. Those able to adapt quickly to the changing market conditions will have an advantage over their competitors. These growers are showing that eliminating neonicotinoids from ornamental plant production is not only possible, but also strengthens their market position.

Nurseries across the nation are taking a proactive, precautionary stance on neonicotinoid use. According to a survey conducted by *Greenhouse Grower* magazine, 52 percent of greenhouse growers have chosen not to use neonicotinoids this year

Nurseries across the nation, large and small, are taking a proactive, precautionary stance on neonicotinoid use. According to a survey conducted by *Greenhouse Grower* magazine, 52 percent of greenhouse growers that responded to the survey have chosen not to use neonicotinoids this year.[106] This is an important step in pollinator protection—the application of neonicotinoid insecticides on nursery stock can leave chemical residues that remain in the plant long after it has left the greenhouse. Wholesale and production nurseries thus play a central role in ensuring that bee-toxic plants do not reach the unsuspecting consumer hoping to plant a "bee-friendly" garden.

We spoke with many nursery owners about their neonicotinoid use policies and pest management strategies. Find more information about our methods in Appendix I.

Some of the nursery owners we spoke with were disturbed to learn that the insecticides they had considered environmentally benign were in fact harming pollinators, and took action to remove these insecticides from their practices immediately. Others have taken similar actions in response to the growing tide of consumer and retailer demand for neonicotinoid-free plants. Still others are hesitating, on the edge of making the decision to eliminate neonicotinoids from their practices, but unsure about the best way to move forward.

Cavano Perennials in Maryland moved to eliminate neonicotinoids from their plant production in 2014. Ferenc Kiss, the president of Cavano's, said:[107]

> *After collecting as much information as we could and listening to our customers' concerns, we made the intelligent, rational decision to not use any neonics at Cavano's at the beginning of June 2014.*

Blooming Nursery in Oregon also took early action. Grace Dinsdale, the manager at Blooming, said that they considered the possibility that neonicotinoids were hurting bees to be sufficient reason to take action.[108] "It's a no-brainer for us," Kelly Grummons from Timberline Nursery, Colorado, said.[109] "Our customers are asking for it." Both Blooming and Timberline eliminated neonicotinoids in 2014. Dave Vincent, the owner of Cal Color Growers, said:[110]

> *We appreciate how serious Colony Collapse Disorder is and the overall health of the bees. Neonicotinoids are one of the newer generation of pesticides considered to be safer for humans and birds. It's disconcerting that they are possibly aiding in the demise of bees.*

Other nurseries are moving away from using neonicotinoids because one or more of their vendors are requiring that neonicotinoid-treated plants be labeled with a tag that indicates that they may contain traces of neonicotinoids.

Challenges In Neonicotinoid-Free Nursery Production

The greenhouse and nursery environment poses unique pest management challenges that differ from region to region and from year to year. Pests that are not problematic in home gardens can have a devastating impact in intensive growing operations spread over dozens of acres. While every grower and geographic region has unique challenges, there are some pest issues that are common across the nursery and greenhouse industry and were mentioned by the growers we interviewed.

Insecticides As Prevention

Neonicotinoids have been widely used as a preventative treatment because they offer an easy, one-time application with a short Restricted Entry Interval due to their low acute toxicity to humans. The persistence of these chemicals means that one application in the early season may be able to suppress most pest outbreaks until the product is sent to retailers. Removing these insecticides from the production process requires rethinking pest management from top to bottom.

Management Of Hard-To-Monitor Or Resistant Pests

Neonicotinoids are also popular because they provide control for hard-to-monitor pests, such as root aphids and weevils. Because the chemical is in the plant tissue, even pests with resistance to contact insecticides are exposed by feeding. This means that neonicotinoids provide control for some insects with natural protective coverings, such as mealybugs, that may be more difficult to control using contact insecticides, soaps, or oils.[111] Removing neonicotinoids from the production process may complicate monitoring programs, and require growers to creatively reassess management strategies for hard-to-monitor or resistant pests.

Problematic Pests

Without neonicotinoids, many growers expressed concern about achieving adequate control of "true bugs"—insects from the order Hemiptera—which feed through piercing and sucking mechanisms. Specific Hemiptera pests that growers mentioned most often were aphids,[112] whiteflies,[113] and scale. Western flower thrips, which are in the order Thysanoptera, were also a commonly mentioned pest.[114, 115]

Some growers are also concerned about leafminers, leafrollers (Light Brown Apple Moth), leafhoppers (Glassy-winged sharpshooter),[116] weevils (Black Vine Weevil), root aphids, psyllids (Asian Citrus Psyllid), and beetles (Japanese beetle and emerald ash borer).

Quarantine Restrictions

Some pests are subject to quarantine restrictions, which can significantly impact growing operations. In the case of the Asian Citrus Psyllid (ACP), a neonicotinoid treatment is actually mandated by the State of California in order to ship plants that may be ACP hosts out of quarantine areas.[117] Fortunately, most annual bedding plants are not hosts for these invasive pests, so no treatments are required for quarantine purposes; however, ornamental perennials such as trees and shrubs that may serve as host plants must be treated.

The Light Brown Apple Moth (LBAM) California State quarantine requires that all nurseries that ship outside of the quarantine area pass rigorous inspections for LBAM larvae, eggs, and female adults.[118] Nevin Smith at Suncrest Nurseries said:[93]

> *Because of the requirements of this program, all nurseries that are shipping outside the quarantine areas are forced into a far higher use of insecticides. LBAM continues to spread, and hasn't been shown to be a threat to any major California crop. It's making good IPM programs impossible, because we're killing all the predatory insects at the same time that we kill whatever few LBAM are in the nursery.*

Despite these challenges, Suncrest Nurseries in Watsonville, California has been able to eliminate neonicotinoids from their growing operation.[93]

In addition to the common themes that emerged from our conversations with growers, several challenges specific to certain types of growing operations were also mentioned.

The barriers to implementation of bee-friendly growing may seem intimidating, but many growers across the nation are addressing them successfully

Outdoor Nurseries

The process of shifting away from use of neonicotinoids is different depending upon whether the growing environment is in greenhouses or outdoors. Outdoors, both pests and beneficial natural enemies may be introduced from adjoining areas, depending on nearby agricultural operations and normal fluctuations in pest populations. Seasonal weather changes play a role in plant health, so careful timing of plantings and monitoring new growth are important considerations for outdoor growers.

Greenhouses

Growing in greenhouses poses a unique set of challenges, but the physical structure of greenhouses can also provide some protection against the wide variety of pests that may appear in outdoor nurseries.[119] Greenhouse design can influence the prevalence of some pests, with screening and airlock technologies available for limiting pest entry.

Moving Forward

The barriers to implementation of bee-friendly growing may seem intimidating, but many growers across the nation are addressing them successfully. The opportunity to reassess daily operations can improve other aspects of the growing operation along the way, producing a better product and increasing economic sustainability over the long term.

Alternative Pest-Management Strategies Used By Nurseries

Many growers have eliminated neonicotinoids from their production without needing to make other changes in their management practices. Others have taken the opportunity to rethink all of their pest management strategies, experiment with new practices and products, and take a new look at their daily management regimes.

We interviewed growers across the nation, who highlighted some innovative solutions to pest management in a neonicotinoid-free production environment. Some of the growers we interviewed were able to control each of the pests of concern with judicious cultural practices, the release of beneficial insects appropriate to the pest, and careful application of “soft” insecticides such as soaps and oils.

Every grower we spoke with said that they implement Integrated Pest Management (IPM) techniques to reduce pest pressure. Each IPM program is different, depending upon the location, growing environment and the people involved. This report is not meant to be a comprehensive guide to IPM in ornamental production. There are a number of IPM manuals for nurseries developed by pest management experts.[120, 121, 122, 123, 124] Instead, we highlight below the most commonly mentioned IPM practices from our interviews with growers.

Prevention, Cultural, And Physical Controls

There are many pest prevention tactics that can be adopted to reduce pest pressure and keep populations below threshold levels.

Setting action thresholds: The nursery industry has particularly low tolerance for pest damage, but low levels of pest presence are acceptable. Identifying an acceptable level of pest presence and setting action thresholds enables growers to avoid using disruptive control methods such as pesticide applications, except when determined to be necessary. Few recommended action thresholds exist for nursery pests, but managers can use detailed records of past pest outbreaks to establish action thresholds.[111]

Controlling the pest outbreak becomes necessary when pest levels reach an established threshold level. Many growers we interviewed stressed the importance of using mechanical, cultural, and biological controls before resorting to chemical control. John Keller, the lead grower at Monrovia, a national nursery grower, said:[94]

> *If there are other ways to prevent a pest, we like to use those. For example, we use beneficial insects and sanitation before resorting to pesticides.*

Sanitation: Keeping the nursery area clean of plant litter removes pest hiding places; utilizing concrete flooring makes it easier to keep the nursery clean.[125] John Keller at Monrovia described Monrovia's sanitation practices in detail:[126]

> *Debris that could harbor diseases and pests is cleaned from the beds. Dead or diseased plants are removed (called "rouging-out") from production beds to prevent spread of pests and diseases. Recycled irrigation water is disinfected to prevent spread of diseases. Roads and beds are maintained to eliminate areas of standing water that could promote disease. Propagation flats and pots are steam sterilized. Cuttings and propagation material is dipped in a chlorine solution for disinfection. Propagation tables and surfaces are cleaned daily. Pruning shears are dipped in disinfectant when pruning disease-prone plants. Recycled soil and green waste is composted to eliminate pests and weed seeds.*

Nevin Smith noted that during propagation, Suncrest Nursery employees remove any dead stock plants to prevent the spread of disease.[93] Tim McGinty at North Creek Nursery summed up their sanitation process: [127]

> *Start clean, work clean, finish clean.*

Physical exclusion and trapping: Cherie Siegmund at Cedarglen Floral Company said that they exclude pests using row covers and greenhouse screening.[128] Cedarglen and Blooming Nursery also use sticky material to trap pests, reducing pest prevalence.[108]

Use of clean plant material: Starting with clean plant material is also important, as Rick Watson at The Perennial Farm in Maryland emphasized. The Perennial Farm inspects all new shipments of plants, and either rejects the shipment or quarantines the plants if an infestation is discovered.[129] Ensuring that plants brought into the production area are free of pests, and quarantining new shipments of plants for an appropriate period are critical for preventing new infestations.[111]

John Keller described their practices at Monrovia:[126]

> *Tissue culture is used for certain plants that are susceptible to viruses or other diseases. We maintain strict control of plant materials that come onto the property and maintain traceability of all incoming plant materials, even sample plants of new varieties, for our US Nursery Certification Program.*

Photo Credit: Frank Peairs, Colorado State University, Bugwood.org [CC BY 3.0], via Wikimedia Commons

Thrips: Catching The Flower Infiltrators

Half of the growers we spoke with mentioned thrips as a pest of concern. Thrips cause plant damage and may transmit plant viruses, making control of thrips essential.[114] Sticky traps, which trap adult insects, help growers detect thrips presence before damage is visible. Because feeding thrips transmit incurable plant viruses, the tolerance level for thrips populations is very low.[111, 114, 115]

North Creek Nursery uses *Steinernema feltia*—a beneficial nematode that infects thrips pupae before emergence—to control Western flower thrips in the soil.[127] Desert Canyon Nursery and Suncrest Nurseries also use nematodes to control Western flower thrips.[130, 93] Tim McGinty at North Creek Nursery and Chris Hartung at Desert Canyon Farm indicated that these nematodes also help control fungus gnats,[127, 134] but that nematodes must be applied regularly (about every three weeks) for effective control. Nematodes are also very sensitive to light and heat, and should be applied according to labeled guidelines. Lloyd Traven, an organic grower in Pennsylvania, indicated that some products with beneficial nematodes are not effective against the Western flower thrips at Peace Tree Farms, and recommended *Beauveria bassiana* as an alternative.[133]

Nematodes in combination with preventative applications of predatory mites may help keep thrips populations below the very low action threshold. Soaps and oils are likely to be less effective as control methods, as it is difficult to contact these insects due to their preferred feeding locations.[111, 131] Instead, a rotation of low-risk, IPM-compatible inseticides such as azadirachtin (neem oil), spinosad, *Beauveria bassiana* (beneficial fungus), and cinnamaldehyde can help control thrips.[111] Thrips populations will develop resistance rapidly, so rotating between modes of action is particularly important in managing this common pest.[111]

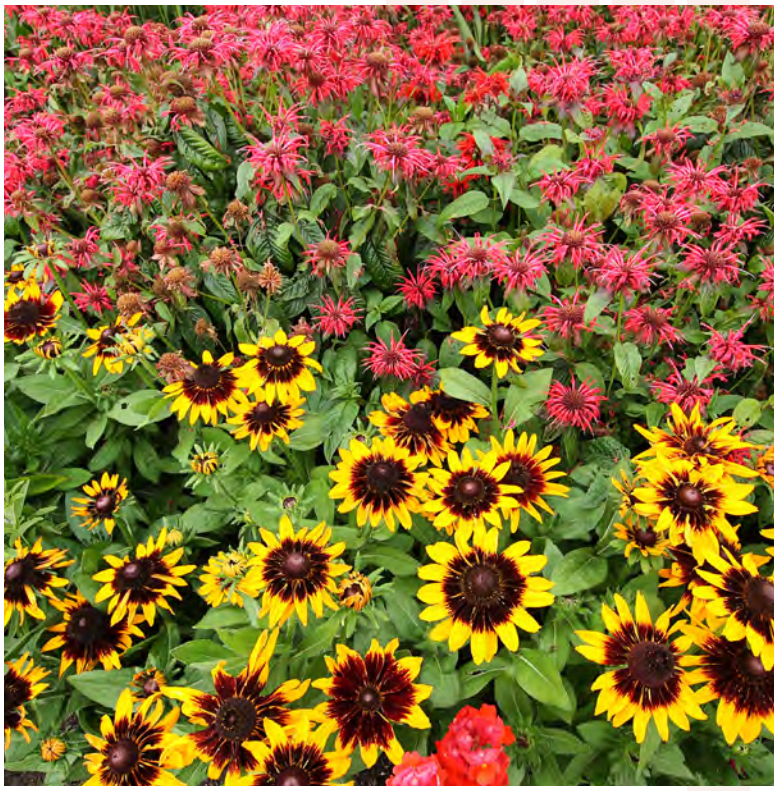
Healthy plants: Several growers pointed out that growing healthier plants by carefully monitoring levels of fertilization, heating, cooling, lighting, ventilation, and drainage makes pest management easier. John Keller at Monrovia said:[126]

> *Strong, vigorous plants are more likely to resist pests and disease. We often see that stressed plants are more susceptible to pests.*

Nevin Smith at Suncrest Nurseries said:[93]

> *Even out in the field, most of the plants sit on clean granite gravel, which helps reduce habitat for insects and diseases. We also try to keep the plants well-spaced. If the plants are touching, that provides a breeding habitat for insects and disease. We prune plants when they get close to touching.*

Photo Credit: June Condruk, Cedarglen Floral Company



Resistant cultivars: Many growers are modifying the selection of plants they grow to include plants less susceptible to pests. Liz Smith at Westwind Gardens, a larger greenhouse grower in Portland, Oregon, said that they would consider shifting the types of plants they grow:[132]

> *If we have a plant that gets a lot of aphids or thrips, we just won't grow it, and instead grow the plants that are more pest-free.*

This is not always possible, but exercising flexibility in plant inventory may make the transition to neonicotinoid-free growing easier.

Irrigation management: Ensuring that plants receive the correct amount of irrigation water can make them less susceptible to insect pests.[111] Too little stresses the plants and may make them more vulnerable to pest attacks. Too much water encourages fungal growth, which can also increase vulnerability to insect pests. Lloyd Traven from Peace Tree Farms, an organic grower in Pennsylvania, emphasized the importance of irrigation management in an IPM program and uses an automated sub-irrigation system to reduce pressure from fungi.[133]

Photo Credit: CSIRO [CC BY 3.0], via Wikimedia Commons

Whiteflies: Dispelling The Cloud

Whitefly is a main pest of concern for many greenhouse and nursery growers, especially those growing poinsettias. The pest is not known to transmit any viruses—and may not cause as much feeding damage as many other pests—so establishing an appropriate action threshold is an important part of whitefly management.[111] According to a survey conducted by UC IPM, more than 80 percent of poinsettia growers had some whitefly-infested plants, and 35 percent of all plants had one or more whiteflies at the time of sale.[111]

While establishing a threshold level of pest pressure is important, control is equally important. Some growers have mentioned that a whitefly infestation on nursery stock can be a nuisance, and a heavy infestation is noticeable to the consumer even without readily visible damage, because adult whiteflies fly out of the plant when jostled. It may be particularly important to keep a clean poinsettia stock. Excess irrigation and fertilization can make certain crops more susceptible to whiteflies.[111]

According to UC IPM guidelines, plants such as poinsettia can be treated with chemicals most effectively at the very beginning of propagation when they can grow out of damage from chemical phytotoxicity, so experts recommend that growers tolerate fewer pests when the plants are young.[111] UC IPM Guidelines indicate that insecticides should be avoided as a management technique for whitefly because it is often difficult to target whiteflies without affecting non-target organisms. Whiteflies also rapidly develop pesticide resistance.[113]

Oil insecticides will kill whiteflies at all life stages, but must be applied on the underside of leaves where whiteflies feed.[111, 113] There are many beneficial insect species that have shown efficacy against the whitefly, such as *Encarsia formosa* and *Eretmocerus eremicus*. Refer to Appendix III for more information on biological controls.

Plant removal: Removal of highly infested plants from the growing area is an important management strategy. Chris Hartung at Desert Canyon, an organic nursery in Cañon City, Colorado, said his operation removes older mealybug- or scale-infested stock plants used as sources for cuttings, and replants these stock plants regularly, to reduce pressure from scale insects.[134] Kelly Grummons at Timberline Nursery described his approach to scale insects:[109]

> *You can't really see root scales, including mealybugs and root aphids, unless you dig up the plant. There are three or four species of plants that get the aphids, so we constantly pull those plants up and monitor them. If we see that the aphids are established, we destroy the plant.*

Staff engagement: An important step in establishing a successful IPM program is ensuring that nursery staff are aware of their responsibilities in the program. Where possible,

hiring a staff person to oversee the scouting program will help to support effective scouting at the nursery. Suncrest Nurseries has a dedicated scout who monitors pest pressure to help enable nursery staff respond to outbreaks while they are still small.[93] North Creek Nursery has a scout that monitors sticky cards and the plants, determines the best response to the infestation, and applies beneficial organisms if a response is needed.[127]

Rotating between cultivars: Nevin Smith said that the growers at Suncrest Nurseries strive to avoid successive plots of the same type of plant to discourage pest population buildup. Smith notes:[93]

> *The diversity itself (we grow over 3,000 plant selections) also helps; the nursery is not a gigantic monoculture.*

Dipping plants pre-propagation: One way of reducing pest incidence is treating plant starts by dipping them in low toxicity, contact insecticides before propagation. Tim McGinty at North Creek Nurseries said:[127]

> *From time to time, if we have a thrips infestation in some stock plants, we do a pre-propagation dip in soy-based oil, mixed with water, for a few minutes.*

Using trap plants: Cherie Siegmund at Cedarglen Floral Company said that they use trap plants, selecting plants that are attractive to or preferred by the pest, and then removing those plants and bagging them to reduce pest prevalence.[128]

The approaches described here were specifically mentioned by the growers we interviewed. There are many other techniques and approaches for IPM in nurseries and greenhouses. They include: Excluding pests using field cages; mass trapping; and using nurse plants (discussed in *Biological Control* on page 30). More resources for pest prevention in nurseries and greenhouses can be found in Appendix III and reference 111.

Photo Credit: Inzyx 2013

Aphids: Stemming The Tide

Aphids are one of the main pests of concern for the nurseries and greenhouses managers we interviewed. Aphids can reproduce asexually, which means that even unmated females can reproduce, leading to rapid population increases.[112]

Grace Dinsdale and Terry Menniger at Blooming Nursery in Oregon provided a vivid description of the situation with aphids:

> *We are going into the spring hyper-vigilant. When there is an explosion of aphids and we have to ship in a week, we have a loss of sales. Herbaceous annuals are ephemeral, and they're easy prey. We have a short sales window, and we really have to make sure they're pest-free when they hit that sales window.*[108]

Operators use soaps and oils as well as several parasitoids and predators to achieve effective control. See Table 3 in Appendix III for a full list of biological control species that were mentioned by the growers we interviewed. These beneficial insects will suppress pest populations and reduce the frequency of "explosions," while soaps or oils can help achieve a pest-free product before sale.

Biological Control

After removing neonicotinoids from their practices, many growers are now exploring the potential of biological control for pest management. Many beneficial organisms are available in easy-to-apply spray solutions, drenches, and cards. There are several different types of biological control agents:

1. **Natural predators** are insects that prey upon pests, reducing pest populations.
2. **Beneficial parasitoids** are insects that lay eggs in or on a pest insect. The larvae of these insects consume the pest.
3. **Beneficial microorganisms** infect pest insects, causing the pest to die. This includes beneficial bacteria, nematodes, and fungi.

A sachet of predatory mites, used to control certain pests. This is one of many methods for distributing biological control agents in greenhouses and nurseries. Photo Credit: June Condruk, Cedarglen Floral Company

Photo credit: Tammi Hartung at Desert Canyon Farms

There's no resistance against being eaten

—Chris Hartung, Desert Canyon Farm

The use of biological control to address pest pressure is also an excellent way to combat pesticide resistance. Chris Hartung at Desert Canyon Farm said:

> *The use of beneficials during the off-season breaks the resistance to the limited amount of sprays I use in the rest of the year. There's no resistance against being eaten.*[134]

Care must be taken to optimize survival of beneficials. For example, Tim McGinty at North Creek Nurseries pointed out that beneficial nematodes should not be applied to soil when there is direct sunlight, as the ultraviolet light kills the nematode.[127] Consultation with beneficial insect suppliers will facilitate the successful adoption of a biological control program.

It is critical for survival of beneficial organisms to ensure that toxic pesticide residues are not being introduced into the growing operation though plugs and starts purchased from other growers. Checking with suppliers about the pesticide products they have applied (both insecticides and fungicides) will help mitigate unintended pesticide exposures from pesticides that were applied before the plants entered the nursery.

Banker Plants

In a biological control program, it is sometimes difficult to maintain natural enemy populations at times of low pest density. There are some innovative new ways of addressing this issue. Lloyd Traven at Peace Tree Farms, a national expert on biological control in greenhouses, highlighted a new method:[133]

> *We grow banker plants like mullein to encourage the beneficial organisms. We use Orius banker plants for thrips control, aphid banker plants, and certain other plants where we know they'll live, like Alyssum.*

These banker plants provide a source of food for beneficial insects, so that they can persist in a crop in sufficient numbers to respond to increasing pest pressure.[135, 136, 137] In some cases, beneficial insects feed on the nectar of the banker plant. In others, such as aphid banker plants, the grower actually maintains a population of prey insects on the banker plant. These prey insects are selected so they are unlikely to become a pest in the crop, but are food for the parasitoid. Some banker plants, such as *Alyssum*, may improve the vigor of natural enemies by providing nectar, depending upon their feeding patterns.[138, 139] With a population of beneficial organisms already present, pest populations may be suppressed more quickly.

Several growers noted that many common fungicides may also harm beneficial insects. Nicole Blevins and Tim McGinty explain the problem in these terms:

> *When using beneficials, disease management becomes more challenging because many of the common fungicides and bactericides will harm our good bugs.*[140]

Chris Hartung at Desert Canyon in Colorado avoids hurting his beneficial insects by introducing them during the fall and winter months, and avoiding pesticide sprays at that time. During the spring growing season, he does not introduce beneficial insects, and applies only Organic Materials Review Institute (OMRI)-approved pesticides.[130, 134] The prevention and cultural control methods outlined above can also help prevent disease outbreaks.

Using biological control successfully requires attention to the compatibility of the beneficial organism with both the chemical controls used and the other beneficial organisms in the growing environment. For example, co-application of both praying mantises and lacewings will result in predation of the lacewings by the praying mantises. It is helpful to consult with suppliers of beneficial organisms to determine any incompatibilities and decide on the optimum timing of releases. For outdoor nurseries, it is important to consult with the local agricultural extension office before selecting a beneficial insect for use, as there may be location-specific concerns regarding the introduction of particular control agents, and licensing may be required in order to release some biological control agents.

In general, releases of beneficial insects offer better control inside greenhouses than releases in field nurseries, since greenhouse structures contain the beneficial insect in the area of pest pressure. Temperature regulation inside the greenhouse is an important consideration when releasing particular types of beneficial insects; for example, some predatory mites don't tolerate low temperatures, while their intended targets may be quite successful at lower temperatures.[127]

A number of state university and extension programs have ongoing research on how best to use beneficial insects in greenhouse and nursery production. The University of California, Riverside,[141] University of California, Davis,[142] and University of Massachusetts, Amherst[143] have particularly active biological control research programs for ornamental production. Vineland Research and Innovation Centre is also a place to watch for new research on biological controls.[144]

An employee at North Creek Nurseries carefully applies predatory mites in a feeding mixture, which boosts their effectiveness. Photo credit: Heather Wheatley at North Creek Nurseries

Many of the growers we spoke with are actively utilizing beneficial organisms, and each of them emphasized that any chemical controls must be chosen carefully to avoid impacting the populations of beneficial insects, both within their nursery and in adjoining fields. Please see Appendix III for a list of resources for biological control information and a table of specific beneficial organisms used for nursery pests.

Chemical Controls

In the transition away from neonicotinoids, many nurseries are simply selecting different insecticides that are not neonicotinoids.[145] Yet these insecticides may also be toxic to pollinators and other beneficial organisms, persistent in the environment, and/or taken up systemically by plants, leading to potential harm to pollinators. This section focuses on ways to minimize use of chemical controls and instituting best practices for mitigating impacts.

Ferenc Kiss at Cavano Perennials described the process of moving away from neonicotinoids:[107]

> *We started to re-educate ourselves by using more bio-pesticides, using beneficial insects in our program, and continuing to use other chemicals. We were good applicators before, and now we are even better due to the learning curve we went through. The learning curve in reference to finding the right balance of bio and non-bio pesticides is a steep one, but we keep pushing ourselves to become better.*

There are a number of approaches to minimizing chemical use and associated non-target impacts, including applying with calibrated equipment and appropriate spray nozzles to reduce pesticide drift, applying only after pest populations exceed thresholds, using spot treatments, and careful timing of applications. All of these approaches result in overall pesticide use reduction, which limits worker exposure, decreases the opportunities for development of resistance, and reduces potential for toxic runoff or drift from the production facility.

Applying Only When Pest Populations Exceed Thresholds

Many of the growers we interviewed said the only preventative insecticide application that they used was neonicotinoids. After they eliminated neonicotinoids from their pest management practices, all applications of insecticides were in response to an observed infestation above threshold levels. This approach means that chemicals are only used when considered necessary, which aligns more closely with the principles of IPM.

An important exception to this rule is the application of beneficial insects such as nematodes and fungi. Beneficial insects must be introduced regularly to be effective, and many growers mentioned that their program was entirely responsive, with the exception of beneficial nematodes. Grace Dinsdale and Terry Menniger at Blooming Nursery said:[108]

> *Without the use of neonics, all of our insecticide applications are responsive, except for spider mites. For spider mites, we are applying Beauveria bassiana preventatively. Spider mites were a primary pest last year. There wasn't a nursery in the Northwest that didn't have problems with spider mites last year, because it was hot and dry for a long time.*

Liz Smith at Westwind Gardens also said that they only apply insecticides preventatively:[132]

> *For insects, we release beneficials preventatively, but we never apply preventative insecticide sprays. We do some preventative sprays for downy mildew, which is a big problem with us in the Pacific Northwest. Once you get it, it's not curable, it's a crop loss.*

Any chemical has the potential of fostering resistance in a pest population, and the more frequently a chemical is applied, the more likely it is that a pest population will develop resistance. Applying only when pest pressure exceeds thresholds is also an effective method for resistance management.

Utilizing Spot Treatments

Many of the growers we interviewed highlighted spot treatments as an important part of their strategy for reducing overall pesticide use. These growers targeted the area of the pest outbreak, rather than making an indiscriminate broadcast application throughout the nursery. Spot-spraying can help minimize pesticide impacts on beneficial insects, and in the case of pesticide products with longer Restricted Entry Intervals, allows staff to continue working in other parts of the greenhouse or nursery.

Tim McGinty said that North Creek Nurseries uses spot spraying exclusively.[127]

> *We are out constantly scouting. If we have to apply synthetic pesticides, we make sure that we are out there to make sure that the pesticide was effective. We make spot applications to the area of pest pressure. We always select the least-persistent option. This way, you can get migration of beneficials back in.*

Timing Pesticide Applications

Consideration of pest life cycles presents opportunities to take advantage of lower toxicity products that may work selectively on a particular life stage of the pest. Several growers also mentioned that they schedule any pesticide applications carefully in order to avoid impacting pollinators. This means that insecticide applications are never made when the plant is flowering. For broadcast applications of contact insecticides, this means scheduling the application during "no-fly" times, such as at night. If environmental conditions allow, it is best to schedule pesticide applications when the temperature outside is below 50°F.[146]

Selecting Only Low-Impact Pesticides

Careful selection of pesticide products is essential to minimizing impacts of pesticide applications. Horticultural soaps and oils, microbial products comprised of bacteria or fungi toxic to specific insects, and low-toxicity FIFRA-exempt† products containing essential oils or other botanical extracts are the least toxic to pollinators. Insect growth regulators with low persistence are also less likely to cause non-target impacts.

It is important to avoid pesticides that have the potential to become water pollutants, are persistent, and are toxic to pollinators and workers. Table 2 on page 34 provides an overview of commonly used pesticides for insect control in nursery and greenhouse settings, along with hazard information for humans and pollinators, persistence, systemic activity, and water pollution potential.

Find more information about tools for selecting least-toxic pesticides in Appendix IV.

Developing Successful Control Methods Takes Time

It may take some time to find the right mix of control measures for a particular nursery, and a method that works well for one grower may be unsuccessful in a different climate or region. The successful grower will continue experimenting with different beneficial insects and low-toxicity chemistries until finding the right mix for their operation.

† FIFRA-exempt products are those exempted from US EPA registration requirements through Section 25(b) of the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA).

Table 2: Insecticides Used In Nursery Production: Toxicity and Properties Affecting Pollinator Exposure Potential

Pesticide Group	Active Ingredients[a]	Bee Toxicity Rating[b]	Systemic Activity	Persistence Rating[c]	Water Pollution Potential[d]	Human Health Effects[e]
Soaps	Potassium and ammonium salts of fatty acids (e.g., potassium laurate, ammonium nonanoate)	Low	No	Low	Low	**Low.** Minimal acute toxicity by oral, dermal or inhalation exposure. Severe eye irritation and skin corrosion are possible.
Botanical Insecticides and Essential Oils	Pyrethrins	High	No	Low	Low	**Low.** Based on results of toxicity tests, risks to human health are low from use of these active ingredients.
	Neem oil	Moderate	Yes			
	Eugenol (clove oil), capsaicin, limonene, garlic, rosemary oil, peppermint oil		No			
Microbials and Beneficial Nematodes	*Bacillus thuringiensis, Bacillus sphaericus, Chenopodium ambrosioides, Bacillus popilliae, Metarhizium anisopliae, Paecilomyces fumosoroseus, Pasteuria usage, Steinernema feltiae*	Low	No	Low	Low	**Low**. Data is unavailable because of the minimal likelihood of adverse human health effects.
	Beauveria bassiana, Chromobacterium subtsugae	High				
Horticultural Oils	Mineral oil, summer oil, dormant oil, stylet oil, vegetable oils	Low	No	Low to Moderate	Low to Moderate	**Low** to **Moderate**. Mild skin irritation possible. Untreated/mildly treated mineral oils are classified as "carcinogenic to humans" according to IARC.[f] Refined mineral oils are not classified as carcinogenic.
Neonicotinoids and similar IRAC Group 4 compounds (Nicotinyl Acetylcholine Receptor Agonists, nAChR)	Imidacloprid, clothianidin, thiamethoxam, dinotefuran, acetamiprid, sulfoxaflor,[g] flupyradifurone[g]	Moderate to High[h]	Yes	High	Moderate to High	**Low** to **Moderate**. Neonicotinoids and related chemicals generally exhibit low to moderate acute toxicity to humans. Poisoning symptoms include headaches, dizziness, nausea, muscle weakness and other neurotoxic effects. Imidacloprid and acetamiprid have shown indications of developmental neurotoxicity potential.[147] Several studies have also demonstrated the toxicity of imidacloprid and clothianidin on the reproductive organs of adult and developing male rats.[148, 149]
Pyrazoles	Fipronil	High	Yes	High	Moderate	**Moderate.** Pyrazole insecticides exhibit acute systemic toxicity when administered orally and through the inhalation route of exposure. Acute dermal toxicity as well as eye and skin irritation is generally low for this chemical class; fipronil may cause slight irritation if applied to the skin or eyes. Fipronil is classified as a possible human carcinogen.
	Fenpyroximate	Low	No	Low to Moderate	Low	
	Chlorfenapyr, tolfenpyrad	High				

Table 2: Insecticides Used In Nursery Production: Toxicity and Properties Affecting Pollinator Exposure Potential (continued)

Pesticide Group	Active Ingredients[a]	Bee Toxicity Rating[b]	Systemic Activity	Persistence Rating[c]	Water Pollution Potential[d]	Human Health Effects[e]
Pyrethroids	Allethrin, bifenthrin, cyfluthrin, cypermethrin, deltamethrin, esfenvalerate, fenpropathrin, tau-fluvalinate, cyhalothrin (lambda, gamma, zeta), permethrin, prallethrin, sumithrin (d-phenothrin), tetramethrin	High	No	Low to Moderate	Low	Low to Moderate. Slightly toxic to practically non-toxic via the oral, inhalation and dermal routes according to anticipated exposure levels. Symptoms of poisoning include dizziness, headache, nausea, twitching, numbness, tingling, reduced energy and other neurological effects. US EPA classified permethrin as "likely to be carcinogenic to humans" by the oral route of exposure.
Carbamates	Carbaryl, methiocarb, propoxur	High	No	Low to Moderate	Low to High	High. N-methyl carbamate insecticides such as methiocarb are highly toxic by the oral route, moderately toxic by inhalation and slightly toxic by dermal exposure. Symptoms of poisoning are consistent with cholinesterase inhibition and include constricted pupils, dizziness, headache, confusion, tremors, convulsions, salivation, and labored breathing.
Organophosphates (OPs)	Chlorpyrifos, diazinon, dimethoate, malathion, naled, phosmet, acephate	High	No	Low to Moderate	Low to Moderate	Moderate to High. Chlorpyrifos and diazinon are moderately to highly toxic following acute oral, dermal and inhalation exposures. Symptoms of poisoning are consistent with cholinesterase inhibition and include constricted pupils, dizziness, headache, confusion, tremors, convulsions, salivation, and labored breathing.
Anthranilic Diamides	Chlorantraniliprole	Moderate	Yes	High	High	Low. No significant acute toxicity via the oral, dermal and inhalation routes of exposure. Not eye or skin irritants, and do not cause skin sensitization.
	Cyantraniliprole	High				
Insect Growth Regulators	**Persistent:** Clofentezine, methoxyfenozide, buprofezin	Low (adult bees) High (larval bees)	No	Moderate to High	Low to Moderate	Low. IGRs have low acute toxicity by the oral, dermal and inhalation routes of exposure. Clofentezine is a mild eye irritant and a weak dermal sensitizer, but not a skin irritant. US EPA classified clofentezine and hexythiazox as possible human carcinogens. The non-persistent IGRs are mildly irritating to non-irritating to the eyes and skin, and none are considered dermal sensitizers.
	Non-Persistent: Chlorfenson, diflubenzuron, etoxazole, hexythiazox, (S)-methoprene, (S)-kinoprene, pyriproxyfen			Low	Low	

Table 2: Insecticides Used In Nursery Production: Toxicity and Properties Affecting Pollinator Exposure Potential (continued)

Pesticide Group	Active Ingredients[a]	Bee Toxicity Rating[b]	Systemic Activity	Persistence Rating[c]	Water Pollution Potential[d]	Human Health Effects[e]
Macrocyclic Lactones	Emamectin benzoate	High	Yes	Moderate to High	Low to Moderate	Moderate to High. Macrocyclic lactones can have high to moderate acute toxicity by the oral route, high acute toxicity by the inhalation route, and low acute toxicity by the dermal route. Emamectin benzoate is a severe eye irritant and avermectin is slightly irritating to the skin. Symptoms of poisoning include dizziness, nausea, vomiting, shakiness, and sweating.[150]
	Abamectin (avermectin), milbemectin		No			
Keto-enols	Spirotetramat	Low (adult bees) High (larval bees)	Yes	Low	Low	Low to Moderate. In general, these chemicals have low acute toxicity via the oral, dermal and inhalation routes of exposure. Spirotetramat is an eye irritant and exhibits a skin-sensitization potential in experimental animals and humans. Symptoms of poisoning include headache, nausea, dizziness, upset stomach, vomiting, chest tightness, difficulty breathing, and blurry vision.[150]
	Spiromesifen		No			
Spinosyns	Spinosad	High	Yes	Low	Low	Low. Spinosyns have low acute toxicity via the oral and dermal routes of exposure. They are not dermal sensitizers, nor inhalation, primary eye or primary skin irritants.
	Spinetoram			Moderate	Moderate	

a The list of active ingredients for each insecticide group is representative of chemicals that are currently formulated into pesticide products used for the production of ornamental plants or greenhouse/nursery production. Use information was obtained from the US EPA Pesticide Product Information System.[151]

b Bee-toxicity ratings were assigned based on the lower (most protective) of acute oral and contact LD_{50} values, the dose of pesticide per bee that results in the death of 50 percent of a group of test bees in the laboratory. Data are from the US EPA Ecotox database[152], the European Union Pesticide Properties Database,[153] and the Pesticide Manual[154] and were classified as High, Moderate or Low toxicity to bees using the US EPA Toxicity Categories and Levels of Concern for honey bees: High (LD_{50} < 2 µg/bee), Moderate (LD_{50} 2–10.99 µg/bee), or Low (LD_{50} ≥11 µg/bee).[4]

c Persistence ratings were assigned based on the average aerobic soil half-lives (DT_{50}) obtained from California Department of Pesticide Regulation Groundwater Status Reports[155] and the European Union Pesticide Properties DataBase[156] according to the following criteria: High (DT_{50} >90 days), Moderate (DT_{50} 30–90 days); Low (DT_{50} <30 days).

d Water pollution potential was assigned based on an assessment of water solubility and soil mobility data obtained from California Department of Pesticide Regulation Groundwater Status Reports.[155]

e Human health information was obtained from US EPA Registration Decision documents for a representative sampling of chemicals included in each insecticide group, except where noted otherwise.[157]

f According to the most recent US EPA review of mineral oils, most manufacturers are using modified refining and cleanup processes to remove toxic components and generate refined mineral oils.[158] Refined mineral oil is "not classifiable as to its carcinogenicity to humans" according to IARC.

g Sulfoxaflor and flupyradifurone are generally classified as a sulfoximine and butenolide, respectively; however, these insecticides share a common mode of action with neonicotinoids involving blockage of insects' nicotinergic neuronal pathways, and thus are included in the same category of nicotinic acetylcholine receptor agonists (nAChR), according to the Insecticide Resistance Action Committee (IRAC).[159] All the IRAC class 4 insecticides share the same binding site on the nicotinic acetylcholine receptors and therefore are considered to share the same mode of action. Sub-classification is based on structural differences of the insecticide molecules and slight differences in insect metabolism.

h Acetamiprid is moderately toxic to bees on an acute contact exposure basis. Flupyradifurone is highly toxic to bees via the acute oral exposure route.

Unknowns Regarding Chemical Controls And Pollinator Health

An evaluation of the research literature regarding pesticide impacts on pollinator health reveals large data gaps in our knowledge of systemic, persistent compounds used as insecticides, insect growth regulators, and fungicides in horticultural production. In particular, questions remain about the distribution and persistence of systemic pesticides in plants, the effects of neonicotinoids on beneficial insects and pollinators at label-prescribed application rates, and the potential hazards of simply swapping one insecticide for another. In order to grow truly "bee-friendly" plants now and into the future, we need to understand more about how pesticides move through plants and the environment and the pathways for pollinator exposure.

Toxicity Of Treated Nursery Plants To Pollinators And Beneficial Insects

We know from the Wilsonville, Oregon, incident that killed more than 50,000 bumble bees (see box on page 8) that label rates of both soil and foliar neonicotinoid applications to flowering *Tilia* species result in pesticide residues in nectar sufficient to kill pollinators on the spot. However, there are very few published studies evaluating the effects of neonicotinoids applied to landscape plants on pollinators and other beneficial insects that rely on nectar and pollen for food.

Krischik, *et al.*[160] recently published a study evaluating the concentrations of imidacloprid in milkweed plants treated at the label-recommended rates for nursery production 21, 37 and 51 days after treatment.

The major findings of the study include:

- Measured concentrations of imidacloprid in milkweed and buckwheat flowers ranged from 5,000–32,000 μg/kg (parts per billion, ppb). If present in nectar and pollen, this range of concentrations would far exceed the 150 μg/kg level that is the LD_{50} for honey bees the lethal dose for 50 percent of the test bees in a laboratory test.
- Imidacloprid concentrations decreased slowly over time, averaging 61 percent of the starting concentration for plants treated at the label rate 51 days after treatment. Imidacloprid metabolite concentrations changed only slightly over time.
- Measured concentrations from nursery applications were several orders of magnitude higher than those resulting from agricultural applications through seed treatments, and as such represent a higher risk to pollinators.

The researchers also evaluated the toxicity of treated plants to lady beetles and butterflies, assessing effects on survival, egg hatch, and larval survival for several species of lady

beetles, Monarch butterflies, and Painted lady butterflies. Soil-applied imidacloprid reduced the survival of three of the four lady beetle species tested. The treatment did not reduce survival of adult Monarch or Painted lady butterflies, an observation that was attributed to the butterflies' inability to metabolize imidacloprid. However, butterfly larvae of both species had significantly lower survival when feeding on leaves of treated plants. Previous work from the Krischik lab demonstrated that applications of imidacloprid at greenhouse/nursery application rates killed adult lacewings,[161] parasitic wasps,[29] and adult lady beetles, all important beneficial insects.[162]

Persistence And Distribution Of Neonicotinoids In Ornamentals

Many insecticides and fungicides toxic to pollinators are persistent in plants and in the soil, lasting for months to years before degrading into non-toxic substances. The amount and distribution of pesticide in the plant depends on a number of factors, including:

- **Application rate and frequency:** The higher the application rate and the more often pesticides are applied, the higher the residues.
- **Application method:** Soil-applied pesticides typically result in higher concentrations integrated over time compared to foliar-applied products.
- **Pesticide physical properties:** The properties of the specific pesticide being applied have an effect, with some pesticides being more water soluble than others (which affects the rate of uptake by plants) and some pesticides being more persistent than others.
- **Soil type:** Pesticides dissipate faster in sandy soils with fewer binding sites, compared to clay or loam soils that provide multiple binding sites for pesticide molecules.
- **Plant variety:** Plant species absorb and distribute pesticides differently.
- **Age and size of plant:** Smaller plants may have higher concentrations because the pesticide cannot be "diluted" over a larger volume. Conversely, while plants further along in the growing cycle may be larger, they will also have had time to absorb more pesticide from the soil, if treated with a soil drench.
- **Part of the plant being tested:** As shown in the *Gardeners Beware 2014*[1] report, pesticide concentrations vary depending on whether flowers, stems, or leaves are tested. No common patterns were found, and residue concentrations in different plant parts, including pollen and nectar, likely depend on a combination of factors such as the type and age of the plant.
- **Time since treatment:** Because it takes time for pesticides to be absorbed through the roots, residues in treated plants may be low initially for soil-applied pesticides. In contrast, foliar treatments result in high concentrations initially, decreasing over time. In potted plants, water-soluble pesticides may be "washed out" of the pot over time with flood watering.

With all of these variables, much research remains to be done to fully understand the impact of these factors on pesticide residues in plants and potential to harm pollinators.

One question that is being discussed among producers of nursery plants is whether they

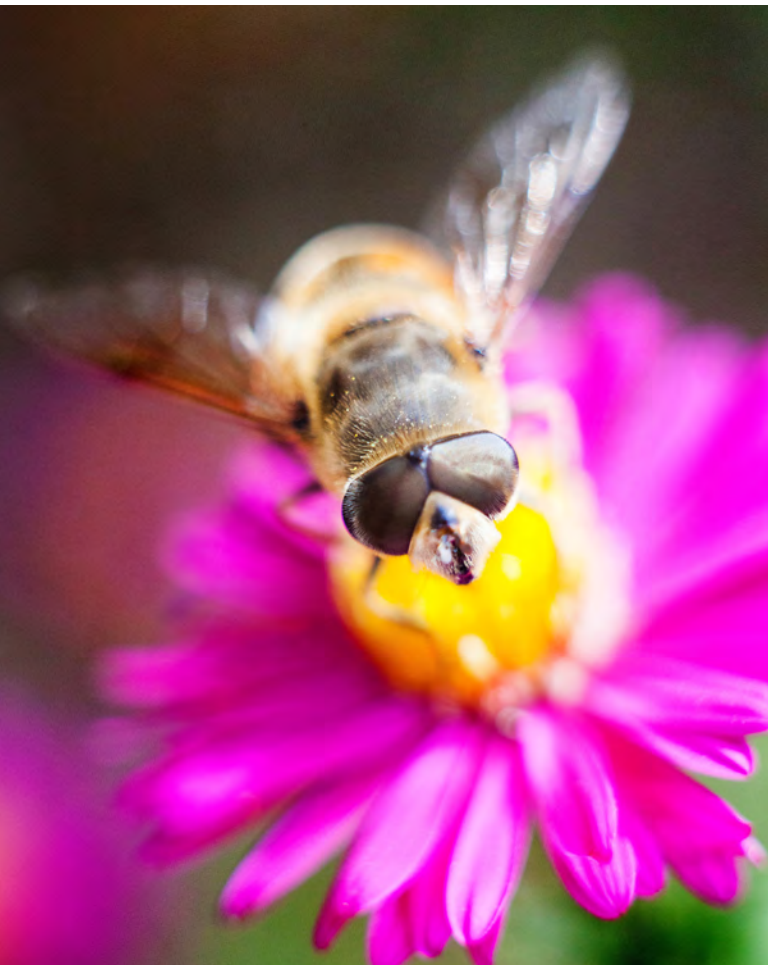
can continue to use neonicotinoids for early stages of production and still sell the plant as "neonicotinoid-free." Will the neonicotinoid residues have time to dissipate by market date after an early treatment? While a definitive answer to that question for all plant species is not yet available, the Krischick study[160] described in the previous section indicates that these pesticides can persist in potted plants at concentrations high enough to kill pollinators and beneficial insects for longer than 51 days. We also know that when neonicotinoids are applied in a soil drench, they may remain in the soil and continue to be taken into the plant over time.[162] Granular applications of neonicotinoids seem to be equally persistent. Moreover, the degradation of some neonicotinoids to equally or more highly bee-toxic compounds may exacerbate the adverse effects associated with neonicotinoid treatments over time.[164] Finally, neonicotinoid residues dissipate at different rates depending upon the plant type, soil type, watering regimen and the other factors mentioned above, making it much more difficult to predict how long residues will remain in plant tissue.[95] Until further research is conducted, the only way to ensure that plants are not providing a source of neonicotinoid exposure for bees is by eliminating neonicotinoid treatments.

Professor Dave Smitley at Michigan State University has been very active in the national dialog about neonicotinoid use in nurseries,[165] and has been working with nursery growers to help them produce plants that are safe for bees. He has emphasized the importance of producing plants that are "bee-friendly," meaning that they both provide nectar and pollen resources for pollinators, and do not contain pesticide residues that would be harmful to pollinators.[166]

Smitley is conducting field trials to determine the persistence of neonicotinoid residues in flowering plants.[167] While his initial study on imidacloprid drenches in hanging baskets was inconclusive, he was able to determine that it may be possible to apply imidacloprid as a foliar spray earlier than three weeks before shipping, and produce a flower that is unlikely to expose honey bees to neonicotinoids. Plants treated with soil drenches of neonicotinoids have higher residues for a longer time after treatment and could still pose risks to bees.

Based on initial studies, Smitley compiled a set of guidelines aimed at protecting pollinators from neonicotinoid residues, without completely eliminating their use.

1. Do not spray plants in the last three weeks before shipping.
2. Do not apply soil drenches of imidacloprid to hanging baskets any later than five weeks before shipping. Do not exceed the label rate.
3. Do not use imidacloprid soil drenches at all on flowering trees and shrubs attractive to bees.
4. Read bee warning information on pesticide labels and avoid practices that are harmful to bees.



Recently, the Horticultural Research Institute (HRI)[168] announced that it will fund additional work by Smitley to develop Best Management Practices for growing bee-friendly plants in greenhouses. HRI funded a number of other research projects focused on learning more about pesticide impacts and pollinator stewardship, including:

- **Residues of and Rapid Assessment of Toxicity for Neonicotinoid Insecticides in Pollen and Nectar in Model Plant Systems.** Dr. Richard Cowles of the Connecticut Agricultural Experiment Station in Windsor, CT, will conduct pesticide residue analysis in pollen and nectar from treated plants.
- **Assessing Bee Attractiveness of Woody Landscape Plants and Mitigating Potential Bee Hazard from Neonicotinoid Insecticides.** In this project, Dr. Daniel Potter of the University of Kentucky in Lexington, KY, aims to inform best management practices by which producers and landscape managers can protect plants from pests while mitigating the risk to bees.
- **Understanding the Opportunities Present for Bees from Commercial Plant Material.** This project, led by Dr. Victoria Wojcik from The Pollinator Partnership in San Francisco, CA, and Dr. Christina Grozinger with Pennsylvania State University in University Park, PA, addresses the interactions of bees with landscape plants in order to be better informed on which specific cultivars and varieties bees most frequent.

Stories From The Field

North Creek Nurseries

North Creek Nurseries in Pennsylvania eliminated neonicotinoids in 2006.[127] Tim McGinty, the Chief Operating Officer, explains that it became obvious that the persistence of neonicotinoid residues on plants makes it impossible to use treated plants in many landscaping and ecological restoration projects. Since this is an important market for North Creek, they simply stopped using neonicotinoids altogether.

Photo credit: Heather Wheatley at North Creek Nurseries, 2015

North Creek Nurseries offers plugs and starter plants (liners) of perennials, grasses, and ferns that are completely neonicotinoid-free.[140] North Creek follows an IPM program that prioritizes preventative applications of biological control organisms and low-toxicity solutions to pest problems. If a pest control product is deemed necessary, they use the following priority list:

1. Biological product.
2. Biorational insecticide such as soap or oil.
3. Insect Growth Regulator, to "disrupt the insect's ability to molt or feed," with an effect "specific to the target pest."[140]
4. Low toxicity synthetic that is non-systemic and has the shortest-term residual effect possible.

Tim McGinty, operations manager at North Creek, said that establishing acceptable threshold levels of pest present is an important part of North Creek's pest management approach.[140]

> *We had a lot of bumps in the road, but biological control is more effective in controlling pests than pesticides are, even biorational pesticides.*[127]

Photo Credit: Tammi Hartung at Desert Canyon Farm

Desert Canyon Farm

Desert Canyon Farm in Cañon City, Colorado, has been a certified organic wholesale nursery for 19 years.[134] Desert Canyon specializes in culinary herbs, vegetables, and bedding plants, including ornamentals. Chris and Tammi Hartung, the owners of Desert Canyon Farm, say that they directly benefit from pollinator activity, and they value their native pollinators as well as the managed bee colonies on their property. Chris described his control methods:

> *I use primarily organic sprays in the spring and summer, when pressure is highest and life cycles are shorter, and I have a larger inventory of plants. There are so many plants going from seed to sale for that period of time. With organic sprays, they are most effective when used before a problem becomes too big. It's been my experience that if you're spraying, you have to do it every week. We use soaps or paraffin-based oils, neem, or Beauveria bassiana. We also release Aphidius wasps to control aphids during the spring season.*

Photo Credit: June Condruk, Cedarglen Floral Company

Blooms Wholesale Nursery

Blooms Wholesale Nursery in Glen Ellen, California might be the first wholesale nursery to begin labeling their potted plants with a "neonicotinoid free" label. Nursery partner Peter Bloom explained that the nursery stopped using neonicotinoids once they heard about the potential impacts of neonicotinoids on bees.[169] Bloom said that they decided to discontinue the use of neonicotinoids after hearing that neonicotinoids might affect bees. "We didn't want our customers to wonder if they are hurting the bees," he said.[169]

Instead, Blooms Nursery takes a low-impact approach to pest management. They monitor indicator plants for warning signs of particular pests; for example, Bloom said that Western flower thrips appear first on pink and white petunias at their nursery. They use beneficial nematodes (*Steinernema feltiae*) and fungi (*Beauveria bassiana*) as their primary methods of pest control, and fall back on low-toxicity chemistries in times of high pest pressure. Bloom said that they avoid spraying any insecticides after the flowers begin to open, to protect pollinators from being exposed through contact with the flowers. Blooms Nursery has been successful in achieving pest control without the use of neonicotinoids or other harmful chemistries.

Photo Credit: June Condruk, Cedarglen Floral Company

Cedarglen Floral Company

Cherie and Eric Siegmund of Cedarglen Floral Company in Damascus, Oregon are certified organic growers of vegetables, and they grow annual flowering plants using the same principles.[128]

The Siegmunds published a statement about their use of neonicotinoids that also explains their pest management strategies at Cedarglen.[170] They follow IPM principles by setting action thresholds, monitoring and identifying pests, using preventative measures first, and then selecting control options.

> *When making control decisions, we will always select a biological product first. If one is not available or effective, we will then move to soaps or oils, then an insect growth regulator (IGR), which disrupts the insect's ability to molt or feed and its effect is specific to the target pest. If these attempts at control fail, we will then select a low toxicity synthetic that is non-systemic and has the shortest term residual effect possible and is most often an OMRI listed product.*

Cedarglen releases beneficial insects in its greenhouses weekly, a full list of which is available in Appendix III. Mrs. Siegmund said:

> *We are striving to follow sustainable growing practices. We live near a creek that leads to a main waterway. We've always tried to be sensitive and aware of the chemicals we use on our plants. Once we start our plants out with beneficials in the propagation greenhouse, we find that we have good results throughout our growing season.*

Peace Tree Farms

Lloyd Traven of Peace Tree Farms, a USDA-certified organic nursery in Pennsylvania, is a leading expert on biological control in greenhouses. He said:[133]

> *Fifty-two weeks a year, we provide a beautiful environment for insect pests to survive. It's warm, bright, long days, and a giant assortment of plant material, each of which has its own insects and diseases. We have to be prepared to deal with all of those without chemicals.*

His first recommendation for other growers is to be very rigorous about sanitation.

> *We are ruthlessly clean, never see a weed. We sweep all the time, and wash our tools and hands. Sanitation first, always.*

Peace Tree Farms has an automated greenhouse environment with subirrigation and a sophisticated water filtration system to discourage disease, enabling Peace Tree Farms to use only biological fungicides. Traven said:

We have compost that carries huge amounts of biology, and that's a big part of our initial defense. Living soil, sterile water.

Step away from the sprayers, the biologicals work a lot better

—Lloyd Traven, Peace Tree Farms

Speaking to growers who are just starting out a beneficial organism program, he gave this advice:

You will shoot yourself in the foot at least once when you start out. You're going to have this huge outbreak and you'll panic, but you just have to believe in the bugs. You have to learn to identify when the battle is on, and when the tide is turning. A few days later, the battle is over. Step away from the sprayers, the biologicals work a lot better.

Traven provided a list of the beneficial insects he uses, which is available in Appendix III.

Committing To Pollinator Health

Although many nurseries have chosen to produce neonicotinoid-free plant material, not every nursery has the same neonicotinoid policies. Several common strategies emerged from our interviews with growers.

Develop a Neonicotinoid Use Policy: Most of the growers we interviewed made the decision to completely eliminate use of neonicotinoid insecticides on any plants, at all stages of the propagation and growing process. See page 37 *Unknowns Regarding Chemical Controls and Pollinator Health* for more information about best management practices that are emerging from research efforts.

Source Pesticide-Free Seeds, Starts and Plugs: Purchasing starts from a grower who continues to use neonicotinoids may lead to residues in plant stock. Some growers surveyed their suppliers, and only purchased plants from suppliers who guaranteed their stock to be neonicotinoid-free. Purchasing starts and plugs that are Certified Organic will help guarantee that stock is free of harmful chemicals. See the informational box on seeds, starts and plugs (below).

Looking Down The Supply Chain: Seeds, Starts And Plugs

The persistence of neonicotinoid insecticides makes it more difficult for growers who have committed to eliminating use of neonicotinoids to ensure that their product does not, in fact, contain any residues of these chemicals. Many nursery plants pass through several stages of production in different nurseries before reaching the end consumer. Tracking each plant through this process can be challenging.

As a grower, the best way to ensure that neonicotinoid-free plants are being produced is by making starts and plugs internally, within the growing operation, with untreated seeds. If that is not an option, buying starts and plugs from a supplier that does not use neonicotinoids on any of their products, and does not use neonicotinoid-treated seeds, will ensure that plants are neonicotinoid-free. If producing starts and plugs in-house and finding a neonicotinoid-free supplier are both impossible, communicating with suppliers and identifying plugs and starts that are neonicotinoid-free is the next step. Suppliers might only apply neonicotinoids at a certain stage of propagation or only on particular plant starts.

Verifying that the supply chain is completely neonicotinoid-free is a very important part of the process of transitioning away from neonicotinoid use. Due diligence should be performed before labeling plants as neonicotinoid-free. Sending an occasional sample to be tested is an excellent way of assuring compliance.

Label Neonicotinoid-Free Plants: After eliminating neonicotinoids from production practices, successful growers made it easy for consumers at garden centers to find neonicotinoid-free plants by labeling them. Blooms Wholesale Nursery in California applies a neonicotinoid-free label to all of their plants. A label provides differentiation and spreads the word about neonicotinoids to consumers. See Appendix III for suggested wording for labels.

Quarantine Limitations: In some cases, neonicotinoids are a required treatment for shipping product out of quarantine zones, either within states or across state borders, which makes it difficult for nurseries to stop all neonicotinoid use. A different label can be used for plants that have a mandatory neonicotinoid treatment, indicating that customers are purchasing a potentially bee-toxic plant. Example label language is available in Appendix III.

Spread The Word: Successful growers ensured that their sales departments were familiar with the company's neonicotinoid policy and were prepared to communicate this information to retailers. If the grower was applying a "bee-friendly" label indicating that a plant has not been treated with neonicotinoids, they informed their vendors about the label.

As consumer awareness of the hazards posed to pollinators by insecticide-treated nursery plants increases, so will the demand for truly bee-friendly plants. Despite some challenges, innovative nurseries, retailers and landscapers are finding new ways to move toward least-toxic production practices that provide a quality product that will not harm pollinators. The resources in this report are intended to help nurseries as they begin to transition away from pest control practices that may cause harm to pollinators, and work to adopt practices that reflect the sense of environmental stewardship that unites gardeners and nursery growers.

Friends of the Earth

Friends of the Earth maintains a list of nurseries who have made policy statements about their neonicotinoid use on foe.org/beeaction/retailers, and will add nurseries that provide a written statement of their policy.

Appendices

Appendix I: Survey And Methodology

Pesticide Research Institute and Friends of the Earth reached out to over one hundred and fifty nurseries in the United States to speak with them about their neonicotinoid policies, of whom eighteen responded. For growers, we conducted a phone interview in which we asked a series of structured questions about their management techniques and growing operations. The growers we spoke with were largely small to medium-sized, with around 50 field acres and around 40,000 ft^2 of greenhouses. While many of the growers we interviewed have committed to reducing or eliminating their use of neonicotinoids, the inclusion of quotes from growers does not necessarily mean that they have made a policy commitment about neonicotinoid use.

We also reached out to some garden centers and other nursery retailers, conducting phone and in-person interviews on their neonicotinoid policies, procedures, and planned enforcement.

We spoke with fourteen growers over the phone and asked the Grower Interview Questions (replicated below). We received written statements about policies and pest pressures from four growers, and in those cases we attempted to extrapolate their answers to the Grower Interview Questions. Three growers provided us with additional material about their management techniques and practices. Six growers provided us with a list of the beneficial organisms that they used in their growing operations, which is included in Appendix III: Resources for Growers.

Grower Interview Questions

Tell us about your operation

1. What types of plants does your operation grow?
2. What is the size of your operation in acres?
3. Does your operation grow your plants in greenhouses, outdoors, or a combination of the two?
4. What retailers does your operation sell to (names of retailers, or types of stores, like big box, small nurseries, or institutions)? Does your operation sell directly to consumers?
5. Does your operation only grow your own ornamental plants, or does your operation also serve as an intermediary connecting other growers to retailers?
6. Has your operation had retailers or consumers ask you specifically for neonicotinoid-free plants or labels indicating neonicotinoid use?

Appendix I: Survey And Methodology (continued)

How does your operation do pest control now?

1. What types of insect pests does your operation have to manage?
2. Is your operation actively implementing IPM? Explain what your operation does.
3. Does your operation use targeted releases of beneficial insects? Who was your supplier, and what is your assessment of your success?
4. What level of cosmetic damage is acceptable to your buyers?
   a. Leaf damage on flowering plants?
   b. Are some plants more problematic than others?
5. Which pesticides does your operation use most often, and what are their targets?
6. How does your operation manage pesticide resistance?
7. How much of your pesticide use is preventative, and how much is in response to an infestation?
8. Is your operation trying to reduce use of neonicotinoids/systemic insecticides?
   a. If yes, what is your operation doing instead of neonicotinoids/systemic insecticides?
9. Are there specific plants that really need neonics/systemic insecticides? How important are they to your operation?

Challenges

What challenges do you expect in moving away from systemic insecticides? If you are not moving away from systemic insecticides, what are the reasons for your choice?

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Appendix II: Resources For Retailers (continued)

Sample Text For Grower Survey

An important part of developing a neonicotinoid policy in a retail store is surveying suppliers regarding their neonicotinoid use.

Information To Include In Cover Letter

Be sure to include the following information in your cover letter:

1. How you plan to use the information you have gathered.
2. What your planned neonicotinoid policy is.
3. How you plan to communicate this information to your customers.
4. The date by which you expect to have the survey returned.

[Letterhead]

[Author or owner name]

[Date]

Dear Valued Grower,

In the coming year, **[insert garden center name]** plans to kick-off a new "bee friendly" plant program. In this program, we will provide customers with information about plants that can be purchased at our nursery to attract honeybees and native bees to their gardens. We are concerned about the potential for pesticide contamination in the plants we purchase, as we want our customers to be confident that they are not exposing pollinators to toxic residues.

Neonicotinoids (neonics for short) are water-soluble systemic insecticides that can move into the nectar and pollen of plants. Neonics are extremely toxic to bees, even at low doses, and can cause altered learning and navigation, impaired foraging and reproduction, and immune suppression. Recent reports suggest that neonics may play a role in driving pollinator decline, including bee declines. We have listed some articles below if you are interested in reading more about the recent studies on this subject.

We are aware that some growers use neonicotinoid insecticides during plant production. We are asking you to check your records, then fill out and return the attached questionnaire. For your convenience we have attached a list of common names of products that contain neonicotinoids to this letter [Find in Appendix IV].

Our goal at **[insert garden center name]** is to minimize any adverse impact on our environment and to maintain healthy populations of pollinators, including bees. While we value our relationship with you, and have selected your company because of its quality and service, ultimately our customers are the source of our livelihood. We respect their opinions and wish to provide them with accurate information.

Please take a moment to respond to our questionnaire by **[insert date]**. You can email it to **[insert email address]**, or send it to the address found in the letterhead. Many growers share our concern and have eliminated neonics from their pest management program. We hope that you will consider doing this as well.

Regards,

[Author or owner name]

Be sure to attach the list of common names of neonicotinoid-containing products so that the grower can refer to it.

Appendix II: Resources For Retailers (continued)

The following survey questions were developed by Paul Doty and Laura Ward at Berkeley Horticultural Nursery and used to create a list of bee-friendly plants that are both bee-attractive, and not treated with neonicotinoids.[171]

Suggested Survey Questions

1. Does your nursery use neonicotinoids? (refer to the list of common names of neonicotinoid-containing products)
   a. We never have and never will use neonicotinoids
   b. We have used neonicotinoids, but stopped using them on (date)_____
   c. We currently use neonicotinoids, but plan to stop using them on (date)_____
   Please attach a list of plants that are not treated with neonicotinoids, if any.
   d. We currently use neonicotinoids, and plan to continue using them.
   Please attach a list of plants that are not treated with neonicotinoids, if any.
   e. We do not currently use them, but we may use them in the future.
2. Are your plants USDA-certified organic?
   a. Yes, all of our plants are certified organic.
   b. Yes, some of our plants are certified organic (*please attach organic plant list*)
   c. No, none of our plants are certified organic.
3. Does your nursery purchase plugs or plants from other growers that may have been treated with neonicotinoids, or may have been grown from neonicotinoid-treated seed?
   a. The plugs and plants we purchase are not treated with neonicotinoids.
   b. The plugs and plants we purchase are treated with neonicotinoids.
   c. The plugs and plants we purchase may be treated with neonicotinoids.
4. If you grow plants from seed, do you use neonicotinoid-treated seed?
   a. Yes
   b. No
   c. Unknown
5. Tell us about your pest management strategies. Do you follow IPM principles, and what does this mean in your nursery?

_____

_____

_____

_____

_____

_____

Appendix II: Resources For Retailers (continued)

Sample Informational Materials

Poster or informational handout indicating that the store does not carry any plants that were treated with neonicotinoids

_____ garden center does not carry any plants that were treated with neonicotinoids, which have been implicated in global bee declines. _____ garden center is committed to sustainability and protecting the environment. Since bees are essential pollinators and critical for one in three bites of food we eat everyday, _____ garden center has decided to join other responsible retailers and stop selling plants treated with neonicotinoid insecticides.

Here is a great example of an informational handout provided by Larry Hurley at Behnke Nurseries:[90]

Bees & Neonicotinoids

Behnke Policy Statement

Behnke Nurseries is aware that neonicotinoid insecticides have been implicated as part of a complex of factors, including mites and viruses, which collectively cause bee colony collapse disorder. We also are aware that the misapplication of many other pesticides will weaken or kill foraging bees and other non-target organisms.

In order to reduce damage to bees and other pollinators, we have developed a **Behnke Policy** on pesticides:

1) **Application of Neonicotinoid-Containing Insecticides at Behnke Nurseries:**

"We pledge to never apply neonicotinoid pesticides to plants on the Behnke property, either in ground or in pots."

2) **Sale of Insecticides in General:**

"We will recommend use of least-toxic effective remedies: soaps, horticultural oils, neem oil, pyrethrin, etc."

3) **Sale of Neonicotinoid-Containing Pesticides:**

"We have discontinued sales of all neonicotinoid-containing products intended for outdoor use."

4) **Pesticide-Application Safety Warnings:**
(The following warning signs are posted in our chemical sales areas.)

WARNING: PESTICIDES MAY KILL BEES AND OTHER POLLINATORS

How can you help?

- Know what pest insect you are trying to control and make sure the product you are using is the correct one — bring a sample and ask us for advice.
- Always follow label instructions.
- Don't apply pesticides to plants when they are in bloom.
- Insecticides containing neonicotinoids (e.g. Imidacloprid or Merit) are implicated as a factor in bee colony collapse disorder. Be particularly cautious in your use of these products.
- Behnke Nurseries has discontinued the sale of neonicotinoid-containing insecticides labeled for outdoor use.

The Behnke Nurseries Co. Since 1930 M 21

Appendix II: Resources For Retailers (continued)

Label, sign, or poster text that indicates that neonicotinoids were not applied to the plant or plants in a particular pot:

> These plants were never treated with neonicotinoid insecticides, which are toxic to pollinators. Use caution around bees and other pollinators.

Poster or informational handout with the names of the growers who do not use neonicotinoids or the specific plants that you carry that have not been treated, allowing your customers to select those plants:

_____ nursery/grower is committed to protecting bees and other pollinators. The following growers do not use neonicotinoid insecticides on their plants. For truly bee-friendly plants, select from the following list:

_____ (list growers)

Resources For Compiling Pollinator-Friendly Planting Guides

- Xerces Society for Invertebrate Conservation: Attracting Native Pollinators. http://www.xerces.org/announcing-the-publication-of-attracting-native-pollinators/
- Xerces Society for Invertebrate Conservation: California Plants for Native Bees. http://www.xerces.org/wp-content/uploads/2008/11/california_plants_for_native_bees_xerces_society_factsheet.pdf
- USDA. Gardening for Pollinators. http://www.fs.fed.us/wildflowers/pollinators/gardening.shtml
- BEE Protective: http://www.beyondpesticides.org/pollinators/LandscapesforPollinators.php
- UC Berkeley Urban Bee Lab: http://www.helpabee.org/best-bee-plants-for-california.html
- Pesticide Research Institute: Bee-Friendly Gardening. https://www.pesticideresearch.com/site/?page_id=9990
- Pollinator Partnership: Regional Planting Guides. http://www.pollinator.org/guides.htm

Appendix III: Resources For Growers

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Appendix III: Resources For Growers (continued)

Resources For Transitioning To Neonicotinoid-Free Production

The resources below encompass a representative set of available resources. This is not a comprehensive list.

The local agricultural extension office is a great resource for growers who are considering making a change in their pest management practices. Local extension offices have access to information about pests of concern, pesticide registration status, and other local information. Find your local extension office at: https://search.extension.org/

University of California Cooperative Extension
The University of California has a large team of experts in integrated pest management for agricultural pests. The University of California Statewide IPM Program has published two authoritative guides on pest management, *Integrated Pest Management for Floriculture and Nurseries*, and *UC IPM Pest Management Guidelines: Floriculture and Ornamental Nurseries*.[111, 170] In addition, the Statewide IPM Program also continuously updates Pest Notes on key nursery pests.[173] These guides are based on field research and provide recommendations for growers in California that may be applied with care in IPM programs across the country.

- Online resources include pest profiles for many common nursery pests. http://www.ipm.ucdavis.edu/PMG/selectnewpest.floriculture.html
- Integrated Pest Management for Floriculture and Nurseries: A comprehensive guidebook for establishing an integrated pest management program in a nursery. http://anrcatalog.ucdavis.edu/Details.aspx?itemNo=3402
- How to establish treatment thresholds. http://www.ipm.ucdavis.edu/PMG/r280390211.html

Oregon State University
Oregon State has been working with growers in Oregon who are shifting away from neonicotinoids and has hosted several workshops on the transition, providing a list of reduced-risk pesticides for use in neonicotinoid-free nurseries. Their website, Pacific Northwest Nursery IPM, is a rich and invaluable resource for nursery managers on nursery pest control in the Pacific Northwest.

- Pacific Northwest Nursery IPM: A complete resource for growers in the Pacific Northwest on pests of concern, including photographs and links to additional resources on pests. http://oregonstate.edu/dept/nurspest/index.htm
- Nurse Plants. http://oregonstate.edu/dept/nurspest/Insectary_plants.htm

Michigan State University

- Nursery Insect Management. http://msue.anr.msu.edu/news/nursery_insecticide_product_recommendations_for_key_nursery_pests
- Alternatives to neonicotinoid insecticides. http://msue.anr.msu.edu/news/greenhouse_insect_management_without_neonicotinoids

Cornell University. New York State Integrated Pest Management Program. http://www.nysipm.cornell.edu/%5C/nursery_ghouse/default.asp

- Greenhouse Scout. App for phones to help track scouting and coordinate biological control programs.
- https://itunes.apple.com/us/app/greenhouse-scout/id879950583?mt=8

Appendix III: Resources For Growers (continued)

- https://play.google.com/store/apps/details?id=com.pocketipm.greenhousescout&hl=en

University of Maryland Extension. IPM for Commercial Horticulture. https://extension.umd.edu/ipm

Purdue Extension

- Pest identification and photographs. http://extension.entm.purdue.edu/
- Purdue Plant Doctor Apps. https://www.purdueplantdoctor.com/

University of Florida IFAS Extension

- IPM in the Commercial Ornamental Nursery. http://edis.ifas.ufl.edu/ig144

USDA. Regional IPM Centers. http://www.ipmcenters.org/CropProfiles/cropprofiles.cfm

Texas Agricultural Extension Service. hortIPM. http://hortipm.tamu.edu/

Oregon Department of Agriculture. Resources for alternatives to neonicotinoids (scroll to the bottom). http://www.oregon.gov/oda/programs/Pesticides/RegulatoryIssues/Pages/PollinatorIssues.aspx

National Sustainable Agriculture Information Service (ATTRA). IPM in greenhouses. https://attra.ncat.org/attra-pub/summaries/summary.php?pub=48#crop

Ontario Ministry of Agriculture. Guide to Nursery and Landscape Plant Production. http://www.omafra.gov.on.ca/english/crops/pub841/p841order.htm

GreenhouseIPM.org. Informational portal about pests and biological control in greenhouses. GreenhouseIPM.org.

Pesticide Action Network UK. Alternatives to neonicotinoids.

- http://savehoneybees.info/alternatives
- http://bees.pan-uk.org/assets/downloads/Bee_factsheet6.pdf

Biological Controls

A number of state extension programs and other orgnaizations have developed guidelines on how best to utilize biological control agents in nursery production.

GreenhouseIPM.org has a custom biocontrol agent search. http://www.greenhouseipm.org/BiocontrolAgents.aspx

Cornell University, 2015.
The Biological Control Site. http://www.biocontrol.entomology.cornell.edu/index.php

Penn State:
http://extension.psu.edu/pests/ipm/agriculture/greenhouse/greenhouse-manual

University of Connecticut:
http://ipm.uconn.edu/documents/raw2/html/608.php?aid=608

University of Massachusetts, Amherst Extension:
https://extension.umass.edu/floriculture/fact-sheets/pest-management

University of California, Riverside,
http://biocontrol.ucr.edu

University of California, Statewide Integrated Pest Management Program.

Appendix III: Resources For Growers (continued)

http://www.ipm.ucdavis.edu/PMG/r280390111.html

Cornell University, 2015. The Biological Control Site.
http://www.biocontrol.entomology.cornell.edu/index.php.

University of Vermont. Greenhouse Pests, Biological Controls/Natural Enemies & Plant-Mediated IPM Systems.
http://www.uvm.edu/~entlab/Greenhouse%20IPM/pestsandbiocontrols.html

M. H Malais, W. J Ravensberg. Knowing and Recognizing: the Biology of Glasshouse Pests and Their Natural Enemies. Hardcover. 2003. Available:
https://www.koppertonline.com/showitem.asp?item=product&id=126.

Beneficial insect supplier lists:

BugLady Consulting.
http://www.bugladyconsulting.com/suppliers%20of%20beneficial%20insects.htm

California Department of Pesticide Regulation.
http://www.cdpr.ca.gov/docs/pestmgt/ipminov/bensuppl.htm

Horticultural Sciences Department at the University of Florida.
http://hos.ufl.edu/research/protected-agriculture-project/beneficial-insect-suppliers

Table 3 below provides representative beneficial organisms mentioned by growers we interviewed as successful treatments for pest infestations.

Table 3: Representative Beneficial Organisms Used In Nursery Pest Management

Name	Type of organism	Control target(s)	Nursery that recommended	Notes
Amblyseius californicus	Predatory mite	Used preventatively for spider mites	Cavano, North Creek	
Amblyseius cucurmis	Predatory mite	Western flower thrips, mites	Peace Tree, Monrovia, Cavano	
Amblyseius fallacis	Predatory mite	Western flower thrip	Cedarglen, Blooming	
Amblyseius swirskii	Predatory mite	Western flower thrips	Monrovia, North Creek, Peace Tree	Used in high temperature, summer months
Aphidius colemani	Parasitic wasp	Aphids, thrips and whiteflies	Cedarglen, North Creek, Blooming, Monrovia	
Aphidius matricariae	Parasitic wasp	Aphids	Blooming, Cedarglen, North Creek	
Aphidoletes aphidimyza	Predatory gall midge	Aphids	Monrovia	
Atheta coriaria, Dalotia coriaria, or Rove Beetle	Rove Beetle	Small insects, mites, fungus gnats, shore flies, Western flower thrips, and other soil-dwelling pests	Cedarglen, Peace Tree, Monrovia	
Bacillus thuringiensis	Bacterial pathogen	Soil pests	Suncrest, Blooms	
Beauveria bassiana, strain GHA	Fungal pathogen	Many	Blooms, Cal Color Growers, Peace Tree, Cavano	

Appendix III: Resources For Growers (continued)

Table 3: Representative Beneficial Organisms Used in Nursery Pest Management (continued)

Name	Type of organism	Control target(s)	Nursery that recommended	Notes
Chrysoperla carnea	Green lacewing	Many	Cavano, Peace Tree, Monrovia, Desert Canyon	
Coccinellidae	Ladybug	Aphids	Desert Canyon, Peace Tree	
Encarsia formosa	Parasitic wasp	Whitefly	Desert Canyon, Blooming, Monrovia, Suncrest	
Eretmocerus eremicus	Parasitic wasp	Whitefly	Monrovia	
Feltiella acarisuga	Predatory gall midge	Spider mites and other mites	Peace Tree	
Heterorhabditis bacteriophora	Beneficial nematodes	Japanese beetle, weevils, many grubs	Cavano, Monrovia	
Neoseiulus fallacis	Predatory mite	Mites	Monrovia	
Orius	Minute pirate bug	Thrips	Peace Tree	
Phytoseiulus persimilis	Predatory mite	Spider mites	Blooming, North Creek, Peace Tree	Used when pressure is high
Steinernema feltiae	Beneficial nematodes	Western flower thrips	Blooming, Suncrest, Cavano, Blooms, North Creek, Sandy's Plants	
Steinernema kraussei	Beneficial nematodes	Black Vine Weevil	Monrovia, Suncrest	
Strateolaelaps scimitus	Predatory mite	Fungus gnats and Western flower thrips	Desert Canyon, Cedarglen, Monrovia	Acts by eating thrips pupae and fungus gnat larvae in the plug media

Suggested Text For Informational Materials

An example label used by a grower (Image on left)

Label, sign, or poster text that indicates that neonicotinoids were not applied to the plant or plants in a particular pot:

> These plants were never treated with neonicotinoid insecticides, which are toxic to pollinators. Use caution around bees and other pollinators.

Sample Neonicotinoid-Treated Plant Labels

> Warning: This plant could harm or kill bees because it has been treated with neonicotinoid insecticides.

Sample Label For Citrus And Other Carriers Of Asian Citrus Psyllid

> This plant has been treated with neonicotinoid insecticides, which can harm or kill bees. Neonicotinoid treatment is mandated by law for all plant hosts of the Asian Citrus Psyllid, an invasive pest.

Suggested Text Of Educational Materials For Retailers

> _____ nursery/greenhouse does not sell any plants that were treated with neonicotinoids.
> _____ nursery/greenhouse is committed to sustainability and protecting the environment.
> Since bees are essential pollinators and critical for one in three bites of food we eat every day, _____nursery/greenhouse has decided to join other responsible growers and stop selling plants treated with neonicotinoid insecticides.

Appendix IV: Resources For Information On Pesticide Products

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Appendix IV: Resources For Information On Pesticide Products (continued)

Internet Resources for Pesticide Product Information

- Pesticide Research Institute (PRI) Pesticide Product Evaluator (professional version) provides detailed information on pesticide product hazards, including toxicity to pollinators: http://www.pesticideresearch.com/site/evaluator/
- Pesticide Research Institute (PRI) Pest Smart Web (contains a subset of the information in the PRI Product Evaluator, for quick reference): http://www.pesticideresearch.com/site/pestsmart/
- PRI Pest Smart App for iOS: https://itunes.apple.com/us/app/pest-smart/id976412743?ls=1&mt=8
- National Pesticide Information Center provides active ingredient fact sheets, and many other resources about pesticide hazards: http://www.npic.orst.edu/ingred/aifact.html
- GrowSmart, GrowSafe is a website and app that provides information for consumers about pesticide products used in garden and lawn care. http://www.growsmartgrowsafe.org/
- Pesticide Action Network Pesticide Database. http://www.pesticideinfo.org/

Appendix IV: Resources For Information On Pesticide Products (continued)

Common Names Of Neonicotinoid Insecticide Products

PRODUCT NAME	ACTIVE INGREDIENT(S)
ADVISE	Imidacloprid
ALLECTUS	Bifenthrin, Imidacloprid
ALOFT	Clothianidin, Bifenthrin
ARENA	Clothianidin
BITHOR	Bifenthrin, Imidacloprid
BOUNTY	Imidacloprid
BRIGADIER	Bifenthrin, Imidacloprid
CARAVAN	Thiamethoxam, Azoxystrobin
CLOSER SC	Sulfoxaflor
CORETECT	Imidacloprid
DERBY	Thiamethoxam, lambda-cyhalothrin
DINO	Dinotefuran
DOMINION	Cyhalothrin, lambda, Imidacloprid
EQUIL ADONIS	Imidacloprid
FLAGSHIP	Thiamethoxam
FLOWER, ROSE & SHRUB CARE	Clothianidin, Tebuconazole, Imidacloprid
GAUCHO	Imidacloprid
GRUB-NO-MORE	Imidacloprid
GRUBOUT	Thiamethoxam, lambda-cyhalothrin
GRUBEX 2	Imidacloprid
I MAXXPRO	Imidacloprid
IMI	Imidacloprid
IMA-JET	Imidacloprid
IMD-FS	Imidacloprid
IMICIDE	Imidacloprid
IMIGOLD	Imidacloprid
IMISOL	Carbendazim, Imidacloprid
LADA	Imidacloprid
LANCER GOLD	Acephate, Imidacloprid
MALICE	Imidacloprid
MALLET	Imidacloprid
MANTRA	Imidacloprid
MARATHON	Imidacloprid
MERIDIAN	Thiamethoxam
MERIT	Imidacloprid
NUPRID	Imidacloprid

Appendix IV: Resources For Information On Pesticide Products (continued)

PRODUCT NAME	ACTIVE INGREDIENT(S)
OPTIGARD FLEX	Thiamethoxam
OPTROL	Imidacloprid
ORTHO MAX TREE & SHRUB	Imidacloprid
PASADA	Imidacloprid
POINTER INSECTICIDE	Imidacloprid
PREMISE 2 INSECTICIDE	Imidacloprid
PRONTO	Imidacloprid
PROTHOR	Imidacloprid
SAFARI	Dinotefuran
SAGACITY	Dinotefuran
SCORPION	Dinotefuran
SPINNER	Thiamethoxam, Cyantraniliprole
STARKLE	Dinotefuran,
TEMPRID	Cyfluthrin, Imidacloprid
TANDEM	Thiamethoxam, lamda-cyhalothrin
TRIMAX	Imidacloprid
THE ANDERSONS GRUBOUT	Imidacloprid
TRIPLE CROWN	Bifenthrin, Cypermethrin, Imidacloprid
TRISTAR	Acetamiprid
TURFTHOR	Imidacloprid
TwinGuard	Sulfoxaflor, Spinetoram
V-10170	Clothianidin
XYTECT	Imidacloprid

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