GARDENERS BEWARE 2016

Bee-Toxic Pesticides Found in "Bee-Friendly" Plants Sold at Garden Centers Across the U.S.

Friends of the Earth

Acknowledgements

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Friends of the Earth U.S., founded by David Brower in 1969, is the U.S. voice of the world's largest federation of grassroots environmental groups, with a presence in 74 countries. Friends of the Earth works to defend the environment and champion a more healthy and just world. Through our more than 45-year history, we have provided crucial leadership in campaigns resulting in landmark environmental laws, precedent-setting legal victories and groundbreaking reforms of domestic and international regulatory, corporate and financial institution policies. Visit www.foe.org to learn more.

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Gardeners Beware 2016: Bee-Toxic Pesticides Found in "Bee-Friendly" Plants Sold at Garden Centers Across the U.S.

Executive Summary

Bees are essential to the production of one out of every three bites of food we eat. They contribute nearly $20 billion to the U.S. economy, and as much as $577 billion of global annual food production relies on direct contributions from pollinators. Yet, evidence is mounting that the health and productivity of these critical pollinators, along with many wild pollinators, is declining rapidly. The United Nations estimates that 40 percent of invertebrate pollinator species, including bees and butterflies, are on the brink of extinction.

A number of factors — including pesticides, parasites, diseases, loss of forage and habitat and changing climate — have been identified as possible contributors to pollinator declines. However, a growing body of evidence points to exposure to systemic pesticides, particularly neonicotinoid insecticides and some fungicides, as primary drivers of the observed decline in pollinator populations. These water-soluble pesticides are readily absorbed by plant roots and transported systemically in the plant's vascular system to other portions of the plant, including roots, pollen, nectar, leaves, stems and fruit. This systemic action results in the exposure of beneficial, non-target insects such as bees and other pollinators to potentially lethal doses of these pesticides.

In 2013, Friends of the Earth U.S. and the Pesticide Research Institute released "Gardeners Beware: Bee-Toxic Pesticides Found in 'Bee-Friendly' Garden Plants Sold Nationwide," a first-of-its-kind pilot study on the prevalence of highly bee-toxic neonicotinoid pesticides in bee-attractive plants commonly purchased by home gardeners in three U.S. cities. In 2014, we published a new report "Gardeners Beware 2014" that expanded the scope of the pilot study to include 18 locations in the U.S. and Canada and analyzed neonicotinoid concentrations in flowers separately from stems and leaves. The results of these studies demonstrated that many of the seedlings and plants sold in nurseries and garden stores across the U.S. were being treated with neonicotinoids and sold to consumers with no warning that the plants could be toxic to bees and other pollinators.

After the release of these reports, Friends of the Earth and allies in the U.S. and Canada called on Home Depot, Lowe's and other garden retailers to stop selling plants pre-treated with neonicotinoid pesticides and off-the-shelf neonicotinoid products; to make third-party certified organic starts and plants available; and to educate customers about their policies to protect bees and other pollinators. More than one million people signed petitions, and thousands of activists made calls, delivered letters and visited stores in person requesting these changes in cities across the U.S. and Canada.

In the past two years, more than 65 garden retailers, nurseries and landscaping companies, including the two largest home improvement retailers in the world, Home Depot and Lowe's, as well as Whole Foods and BJ's Wholesale Club, have committed to take steps to eliminate neonicotinoids. This shift was documented in *Greenhouse Grower's* 2016 State of the Industry Survey, in which 74 percent of growers who supply mass merchants and home improvement chains said they will not use neonicotinoid insecticides in 2016.

A YouGov Poll conducted in 2016 and released in conjunction with this report found that 67 percent of Americans feel more positively about Home Depot and 66 percent feel more positively about Lowe's because of their formal commitments to eliminate neonics.

In order to determine the state of marketplace progress in eliminating bee-toxic neonicotinoid insecticides from bee-attractive plants, we undertook the current study, Gardeners Beware 2016: Bee-toxic pesticides found in 'Bee-Friendly' Plants Sold at Garden Centers Across the U.S. We worked with 13 organizations in 12 states across the U.S. to sample and analyze 60 plants. Thirteen of these plants were bee-attractive tree or shrub species often used as ornamental street trees in cities and towns. The results of our new report shows that fewer bee-attractive ornamental plants sold at major retailers have been pre-treated with pesticides shown to harm and kill bees.

Findings Include:

- Comparison of 2016 results to 2013 and 2014 results indicates that progress is being made towards reducing the use of neonicotinoids in ornamental plants; only 23 percent of plants were found to contain neonicotinoids in 2016, compared with slightly more than 50 percent in 2013 and 2014.
- The results of this study indicate that 14 out of 60 plants (23 percent) tested positive for one or more neonicotinoid insecticides. Concentrations ranged from 1–890 μg/kg (parts per billion or ppb) imidacloprid equivalents.
- Ornamental flowering trees used in city landscaping — a major source of food for urban and suburban bees — were also tested, with three out of 13 samples testing positive for neonicotinoids. City and county governments, businesses and landscapers planning new tree plantings could be unwittingly creating sources of pesticide exposure for urban pollinators if the trees they plant have been treated with systemic neonicotinoids.
- Imidacloprid and its metabolites were found most frequently, with residues of the parent imidacloprid detected in 11 of the 14 (79 percent) plant samples that tested positive for neonicotinoids.
- Most plants with positive detections contained only a single pesticide; however, two flower samples (14 percent of positive samples) contained two different neonicotinoid insecticides.
- This observation is consistent with a 2015 survey of nursery growers conducted by Friends of the Earth, "Growing Bee Friendly Garden Plants: Profiles in Innovation," which showed that many nurseries are working to meet consumer and retailer demand for neonicotinoid-free plants, choosing biological controls and integrated pest management approaches coupled with the use of lower toxicity insecticides, rather than neonicotinoids.
- The new study reveals that larger retailers like Home Depot and Lowe's, which have made commitments to phase out use of these pesticides in their plants and on their shelves, are making significant progress toward that goal.
- Adoption of formal policies by garden retailers to eliminate the use of neonicotinoids is considered significant by the general public. A YouGov Poll conducted in 2016 and released in conjunction with this report found that 67 percent of Americans feel more positively about Home Depot and 66 percent feel more positively about Lowe's because of their formal commitments to eliminate neonics. Following this survey, half of respondents said they are more likely to shop at Home Depot (50 percent) and Lowe's (51 percent) because of the retailer's commitment. Further, more than a third (39 percent) said they'd feel more negatively about a retailer that had not formally committed to eliminate systemic neonicotinoid insecticides.

This study confirms the continuing presence of neonicotinoids in common garden plants sold to consumers at garden centers across the U.S. However, rates of detection are significantly lower compared with rates in our 2013 and 2014 tests. This reduction is likely due to change in store policies that commit retailers to eliminate or phase-out neonicotinoid use on garden plants. Retailer commitments are having a ripple effect in production methods by suppliers and have resulted in reduced use of neonicotinoids in common garden plants overall. While significant progress has been made, it is also clear that there is still work ahead to transform the entire supply chain and garden industry to move away from use of bee-toxic pesticides in ornamental plants.

Recommendations for Garden Retailers:

- Require neonicotinoid-free vegetable and bedding plants from suppliers and do not sell plants or plant starter mixes pre-treated with these insecticides.
- Offer third-party certified organic starts and plants.
- Do not sell off-the-shelf neonicotinoid insecticides for home garden use.
- Educate your customers on why your company has made the decision to protect bees and other pollinators.

Recommendations for Consumers:

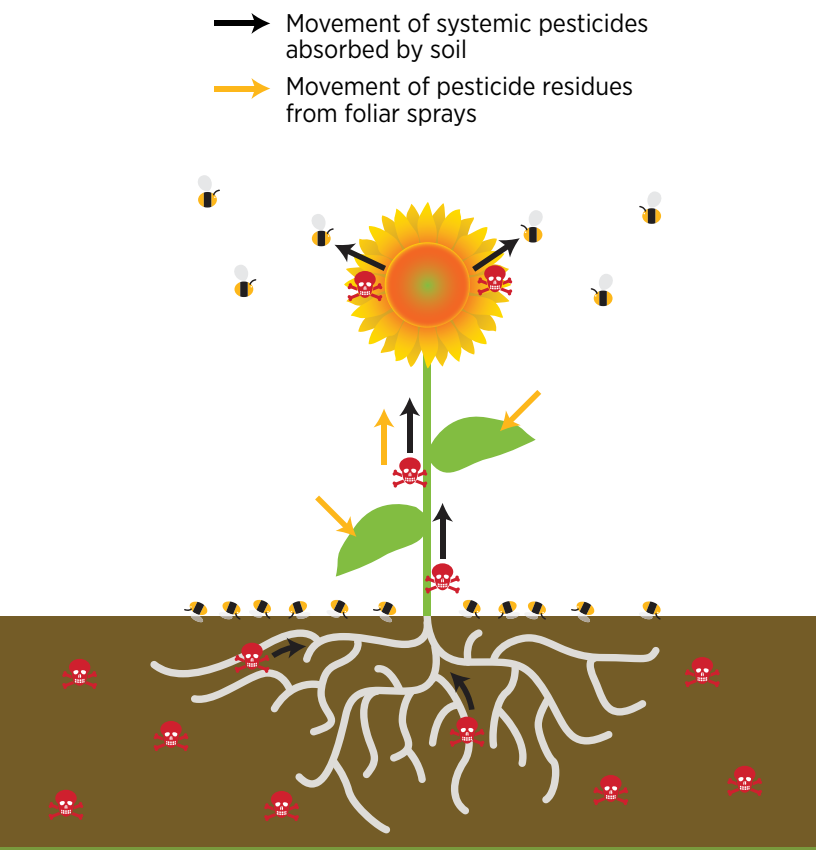
- **Take action and raise your voice locally:** Join the Friends of the Earth U.S. BeeAction campaign at **www.foe.org/beeaction.**
- **Grow bee-safe:** Avoid buying neonicotinoid-treated seeds and seedlings and products that contain neonicotinoids. Purchase organic plant starts or grow your plants from untreated seeds in organic potting soil for your home vegetable and flower gardens.
- **Practice bee-safe pest control:** Avoid the use of systemic bee-toxic pesticides in your garden and use alternative approaches such as providing habitat to attract beneficial insects that prey on pest insects in your garden. For more tips and links to more resources for pollinator and eco-friendly gardening, visit www.foe.org/beeaction and www.garden4bees.com.
- **Do a clean sweep:** See if you have systemic insecticides at home, dispose of them as municipal hazardous waste or take them back to the store where you bought them (see appendix A in Gardeners Beware 2014 for a list of product names).

Rates of detection of neonicotinoids are significantly lower compared with rates in our 2013 and 2014 tests. This reduction is likely due to change in store policies that commit retailers to eliminate or phase-out neonicotinoid use on garden plants. Retailer commitments are having a ripple effect in production methods by suppliers and have resulted in reduced use of neonicotinoids.

For a full set of recommendations for retailers, wholesale nurseries, home gardeners, institutional purchasers, cities, counties, states, the EPA, Congress and consumers, along with all findings and methodology, please see the full report which is available at www.foe.org/beeaction.

I. Introduction and background

Bees are essential to the production of one out of every three bites of food we eat.[1, 2] In fact, 71 of the 100 crops that provide 90 percent of the world's food — from almonds to strawberries — are pollinated by bees.[3] Honey bees and other pollinators contribute nearly $20 billion to the U.S. economy[4] and as much as $577 billion of annual global food production relies on direct contribution from pollinators.[5] Yet, evidence is mounting that the health and productivity of these critical pollinators, along with many wild pollinators, is declining rapidly. The United Nations estimates that in some locations, 40 percent of invertebrate pollinator species, including bees and butterflies, are on the brink of extinction.[6]



SYSTEMIC PESTICIDES ARE ABSORBED FROM THE SOIL BY THE ROOTS AND TRANSPORTED TO OTHER PARTS OF THE PLANT

Bees and systemic insecticides: A deadly combination

A number of factors — including parasites,[7] diseases, loss of forage and habitat,[8] and changing climate[9] — have been identified as possible contributors to pollinator declines. However, a growing body of evidence points to exposure to systemic pesticides, particularly neonicotinoid insecticides and some fungicides, as primary drivers of the observed decline in pollinator populations. These water-soluble pesticides are readily absorbed by plant roots and transported systemically in the plant's vascular system to other portions of the plant, including roots, pollen, nectar, leaves, stems and fruit.[10] This systemic action results in the exposure of beneficial, non-target insects such as bees and other pollinators to potentially lethal doses of these pesticides.

Several of the neonicotinoids are among the most highly toxic chemicals to bees of currently registered pesticides. This high-acute toxicity is responsible for bee-kills such as the 2013 Wilsonville, Oregon event, where the treatment of blooming Linden trees killed more than 50,000 bumblebees.[11]

Even low levels of exposure can impair foraging abilities and navigation;[12] disrupt learning, communication and memory;[13] reduce fecundity[14] and queen production;[15] and suppress the immune systems of bees,[16] making them more vulnerable to disease and pests. Neonicotinoids are persistent, lasting for years in the soil, and systemic, permeating the entire plant, and released in pollen, nectar and other plant fluids.[17]

Bees and other pollinators are exposed not only in agricultural areas where these pesticides are used on crops, but also in urban and suburban landscapes where cities, counties, businesses, schools and homeowners are unwittingly using products containing systemic insecticides. Another route of exposure is through the nectar and pollen of ornamental plants that have been treated with systemic insecticides prior to purchase by the consumer.

Neonicotinoids in ornamental garden plants: Market shift

In 2013, Friends of the Earth U.S. and the Pesticide Research Institute released "Gardeners Beware: Bee-Toxic Pesticides Found in 'Bee-Friendly' Garden Plants Sold Nationwide"[18] — a report documenting our first-of-its-kind pilot study on the prevalence of highly bee-toxic neonicotinoid pesticides in bee-attractive plants commonly purchased by home gardeners in three U.S. cities. In 2014, we published a new report, "Gardeners Beware 2014"[19] that expanded the scope of our pilot study to include 18 locations in the U.S. and Canada and that analyzed neonicotinoid concentrations in flowers separately from stems and leaves. The results of these studies showed that many of the seedlings and plants sold in nurseries and garden stores across the U.S. were being treated with neonicotinoids and sold with no warning that the plants could be toxic to bees and other pollinators.

After the release of these reports, Friends of the Earth and allies in the United States and Canada called on Home Depot, Lowe's and other garden retailers to stop selling plants pre-treated with neonicotinoid pesticides and off-the-shelf neonicotinoid products; to make third-party certified organic starts and plants available; and to educate customers about their policies to protect bees and other pollinators. More than one million people signed petitions, and thousands of activists made calls, delivered letters and visited stores in person requesting these changes in cities across the U.S. and Canada.

In the past two years more than 65 garden retailers, nurseries and landscaping companies, including Home Depot and Lowe's, the world's largest home improvement chains and the primary plant suppliers for home gardeners in the U.S., as well as Whole Foods and BJ's Wholesale Club have committed to taking steps to eliminate neonicotinoids. This shift was documented in Greenhouse Grower's 2016 State of the Industry Survey, in which 74 percent of growers who supply mass merchants and home improvement chains said they will not use neonicotinoid insecticides in 2016.[20]

In 2015, Home Depot announced that it had removed neonicotinoid insecticides from 80 percent of its flowering plants and will complete its phase-out in plants by 2018.[21]

That same year, Lowe's announced its commitment to phase out neonicotinoid-containing consumer-use products and neonicotinoid-treated ornamental plants by spring of 2019.[22]

Several other major retailers, including Walmart, Ace Hardware and True Value Hardware have yet to make commitments to eliminate use of these toxic insecticides in their nursery supply chains.

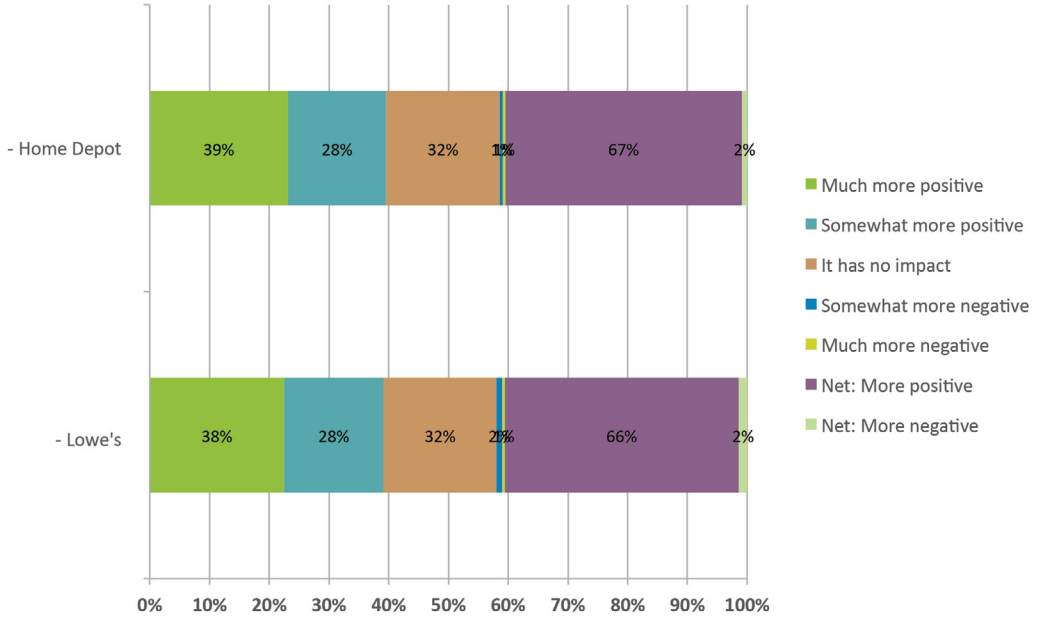
The general public considers the adoption of these formal policies by garden retailers significant. A YouGov Poll conducted in 2016 found that 67 percent of Americans feel more positively about Home Depot and 66 percent feel more positively about Lowe's because of their formal commitments to eliminate neonics. Following this survey, half of respondents said they are more likely to shop at Home Depot (50 percent) and Lowe's (51 percent) because of the retailer's commitment. Further, more than a one-third (39 percent) said they'd feel more negatively about a retailer that had not formally committed to eliminate systemic neonicotinoid insecticides[23] (see next page).

Neonicotinoids in ornamental plants in 2016: How are we doing?

In order to determine the state of progress in eliminating bee-toxic neonicotinoid insecticides from bee-attractive plants, we undertook the current study, working with 13 organizations in 12 states across the U.S. to sample and analyze 60 plants. Because bees in urban areas derive much of their food from flowering trees and shrubs, 13 of these plants were bee-attractive tree or shrub species often used as ornamental street trees in cities and towns. One question we hoped to answer with this study is how effective the major retailer policies have been in reducing neonicotinoid use on nursery plants.

Perception of Home Depot and Lowe's

TSN_q4_grid. Home Depot and Lowe's have recently formally committed to eliminating neonics from their products and plants that are pre-treated with them. Knowing this, to what extent is your overall perception of Home Depot and Lowe's more positive or more negative, or does it have no impact? Please select one option on each row. If you were already aware of this commitment, please let us know to what extent your impression changed when you learned about it.

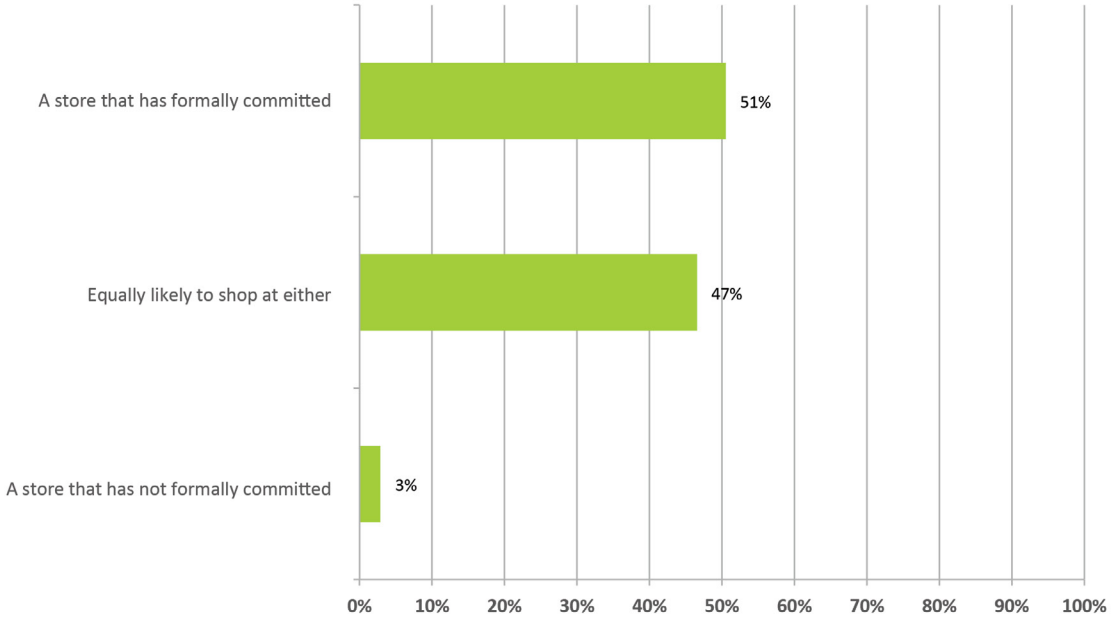


Unweighted base: All US Adults (1119)

YouGov

Likelihood of Shopping at a Formally Committed vs. Not Formally Committed Store

TSN_q7. Would you be more likely to shop at a hardware store that has formally committed to eliminating neonics from their products or one that has not, or would you be equally likely to shop at either?



Unweighted base: All US Adults (1119)

YouGov

II. Study methodology

The flowers used in this study were purchased from major retail outlets (Home Depot, Lowe's and Walmart) and owner-franchised hardware stores affiliated with Ace Hardware and True Value Hardware in all four official U.S. Census regions (14 cities). The state abbreviations below correspond with Table 1 on page 7.

1 U.S. West: Eugene, Oregon (OR); San Francisco Bay Area, California (CA); and Sacramento, California (SAC);

2 U.S. Midwest: Minneapolis, Minnesota (MN); Ann Arbor, Michigan (MI); Detroit, Michigan (MI); and Chicago, Illinois (IL);

3 U.S. Northeast: Portland Area, Maine (ME); and Boston, Massachusetts (MA);

4 U.S. South: Baltimore Area, Maryland (MD); Washington, D.C. (DC); Raleigh, North Carolina (NC); Atlanta, Georgia (GA); and Austin, Texas (TX).

Trees were sampled from a local retail tree nursery in the Bay Area that orders trees from a number of different wholesale nursery suppliers in California.

In each location, pollinator-friendly flowering plants were purchased for neonicotinoid residue analysis. Soft-stemmed (non-woody) flowering plants known to attract both pollinators and pest insects (aphids, etc.) were selected for the study. Flowering trees were selected from those commonly used for landscaping in cities. Samples from different locations were submitted to an accredited analytical laboratory for analysis beginning in late April and ending in early June 2016.

The sampling and analysis methodology is identical to that used for the previous studies and is described in detail in "Gardeners Beware 2014" on pages 24–25 and Appendix B.[19] Flowers were analyzed separately from stems and leaves, and new growth was analyzed for tree samples.

III. Results

Results by plant type

The results of this study indicate that 14 out of 60 plants (23 percent) tested positive for one or more neonicotinoid insecticides. The following pesticides and breakdown products were detected: clothianidin, dinotefuran, imidacloprid, imidacloprid des nitro (lower toxicity degradate), imidacloprid olefin (toxic degradate), and thiamethoxam. Flonicamid was also part of the suite of analytes evaluated by the laboratory and was detected in three samples, but it is not a neonicotinoid pesticide. Imidacloprid and its metabolites were found most frequently, with residues of the parent imidacloprid detected in 11 of the 14 (79 percent) of plant samples that tested positive for neonicotinoids. Most plants with positive detections contained only a single pesticide; however, two flower samples (14 percent of positive samples) contained two different neonicotinoid insecticides.

In order to capture the cumulative toxicity of plants with multiple neonicotinoids of differing toxicities and compare results across samples, results are reported in units of imidacloprid equivalents, as described on pages 26–27 in "Gardeners Beware 2014". Concentrations ranged from 1 to890 μg/kg (parts per billion or ppb) imidacloprid equivalents. Summary data are presented in Table 1 and Figure 1 below. See Appendix A for detailed information on the concentrations of individual pesticides in the flower and stem plus leaf compartments of each plant sample.

Table 1. Results summary for nursery plant sampling in the U.S. in 2016

Location	Proportion of samples with detections[b]	Plant types testing positive for neonicotinoids	Bee-toxic residue level in flowers (μg/kg)[c]	Bee-toxic residue level in stems & leaves (μg/kg)[c]
CA[a] flowers	*1/4*	*Salvia*	*ND*	*27*
CA trees	*3/13*	*Crape Myrtle (red), Crape Myrtle (white), Acacia*	*NA[d]*	*8–862[d]*
DC	*3/4*	*Cosmos, Salvia, Gaillardia*	*1–890*	*57–644*
GA	*1/4*	*Gerbera Daisy*	*7*	*29*
IL	*1/4*	*Gaillardia*	*11*	*31*
MA	*1/3*	*Coreopsis*	*302*	*315*
MD	*1/3*	*Gerbera Daisy*	*64*	*159*
ME	*0/4*	*ND*	*ND*	*ND*
MI	*3/4*	*Zinnia, Trailing Petunia, Geranium*	*3–62*	*34–234*
MN	*0/4*	*ND*	*ND*	*ND*
NC	*0/4*	*ND*	*ND*	*ND*
OR	*0/5*	*ND*	*ND*	*ND*
SAC[a]	*0/4*	*ND*	*ND*	*ND*
TX	*0/3*	*ND*	*ND*	*ND*

ND = No Detections

NA = Not Analyzed

[a] CA = San Francisco Bay Area; SAC = Sacramento, Calif.

[b] Number of whole plant samples (composites of multiple plants) submitted for analysis and testing positive for any neonicotinoid pesticide in the flower and/or stems and leaves sub-samples. Samplers submitted three or four whole plant samples (combination of flower and stem and leaf sub-samples) to the lab for analysis.

[c] Total concentration of bee-toxic neonicotinoids (clothianidin, dinotefuran, imidacloprid, imidacloprid olefin (degradate), and thiamethoxam), expressed in imidacloprid equivalents. See "Gardeners Beware 2014", pages 26–27 for a discussion of imidacloprid equivalents.

[d] Only stems and leaves were tested for all trees, with the exception of bottlebrush where flowers were tested.

Several of the sample residue concentrations exceed or approach the LC_{50} of imidacloprid (150 mg/kg; the concentration of imidacloprid in nectar at which 50 percent of test bees died after one feeding[1]). Higher neonicotinoid concentrations were generally observed in the stems and leaves compared to the flowers (see Figure 2); however, several samples showed comparable or higher levels in the flower compartment compared with the stems and leaves.

1 The acute oral LC_{50} (in μg/kg) was calculated using the acute oral LD_{50} lethal concentration (in μg/bee) from the EPA EcoTox Database[114] and the amount of sucrose solution ingested by a bee in an LC_{50} test (26 mg). Specifically, $LC_{50} = LD_{50} / 26$ mg.[115] The resulting LC_{50} (in mg/mg) is corrected to mg/kg using a conversion factor of 1,000,000. For additional details, see Appendix B.

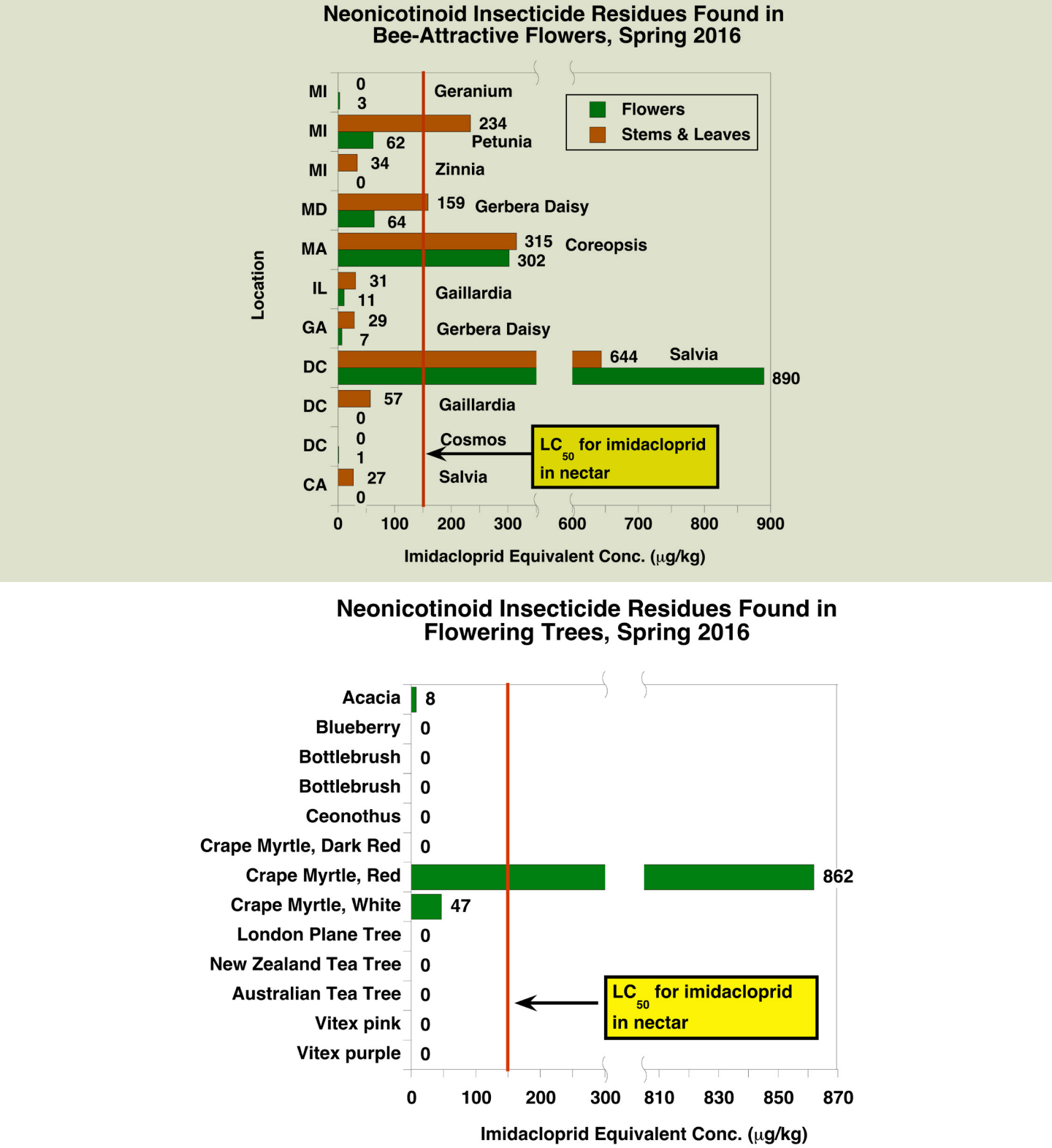


Figure 1: Results by Plant: *The data indicate that 11 out of 47 flower samples (23 percent) and three out of 13 flowering trees or shrubs (23 percent) sampled from retail outlets in North America contained detectable levels of neonicotinoid insecticides. Residue levels ranged from 1 to 890 µg/kg (ppb), in units of imidacloprid equivalents. Toxicity is expressed in imidacloprid equivalents to account for the differing toxicity of the individual pesticides and the cumulative bee toxicity of plants containing multiple insecticides (see pages 26–27 in "Gardeners Beware 2014" report[19]). No neonicotinoids were detected in plants purchased in Oregon, Maine, Minnesota, North Carolina and Texas.*

Higher neonicotinoid concentrations were generally observed in the stems and leaves (see Figure 2), with three samples (Gaillardia, Zinnia and Salvia) having detectable levels of neonicotinoids in the stems and leaves, but not in the flowers. The other Gaillardia and Salvia samples with detections contained residues in both the flowers and stems and leaves, so there is not a consistent trend. There is only a single Zinnia sample, therefore no comparison is possible. One sample (Geranium) contained neonicotinoids in the flowers, but not the stems and leaves; however, the concentration was close to the detection limit for this sample, indicating that normal experimental variability might be responsible for this result.

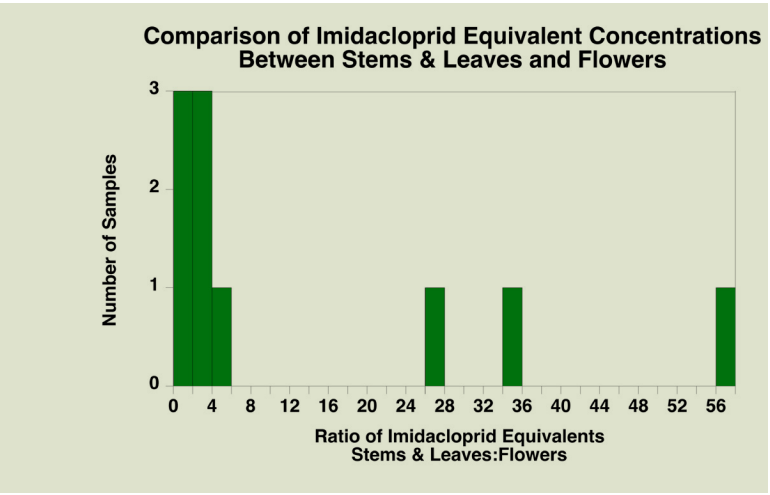


Figure 2: Comparison of residue levels in flowers to stems and leaves: *Most samples had similar concentrations of neonicotinoid pesticides in flowers compared with stems and leaves. The samples with ratios greater than six (Gaillardia, Zinnia and Salvia) only had detectable levels of neonicotinoids in the stems and leaves, but not in the flowers. One sample (Geranium) contained neonicotinoids in the flowers, but not the stems and leaves.*

Results by year

Comparison of 2016 results to 2013 and 2014 results indicates that progress is being made towards reducing the use of neonicotinoids in ornamental plants (see Figure 3), with slightly more than 50 percent of plants found to contain neonicotinoids in 2013 and 2014 and only 23 percent in 2016. This observation is consistent with a 2015 survey of nursery growers conducted by Friends of the Earth, Growing Bee-Friendly Garden Plants: Profiles in Innovation,[24] which showed that many nurseries were working to meet consumer and retailer demand for neonicotinoid-free plants, choosing biological controls and integrated pest management approaches coupled with the use of lower toxicity insecticides, rather than neonicotinoids. This shift was also documented in Greenhouse Grower's 2016 State Of The Industry Survey, in which nearly two-thirds (64 percent) of growers stated that they are eliminating use of neonicotinoids in production this year — 67 percent of small growers, followed by 57 percent of large growers and 56 percent of medium-sized growers.[25]

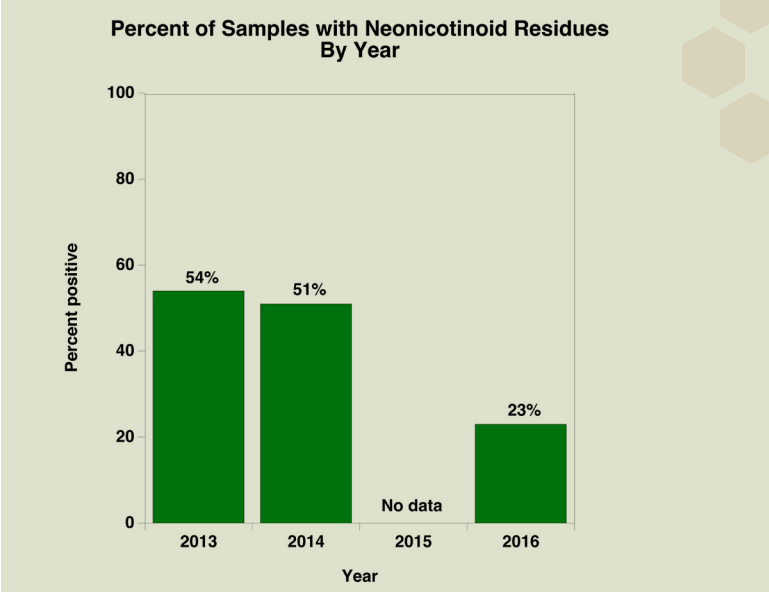


Figure 3: Results by year: *The data indicate a marked change in the number of samples testing positive for neonicotinoids between 2013 and 2016, suggesting that nurseries are making an effort to remove neonicotinoids from their production processes.*

It is clear that the marketplace shift away from selling garden plants treated with neonicotinoids was spurred by Home Depot, Lowe's and other retailers' new formal policies to eliminate or phase out use of neonicotinoids. These retailer commitments are requiring grower vendors to reduce or eliminate neonicotinoid use. These policies are having an impact on the entire garden supply chain and setting unprecedented market trends.

IV. Implications

Corporate policies and market shift

While significant progress has been made, it is also clear that there is still work ahead for the garden industry to move away from bee-toxic pesticides.

This study confirms the continuing presence of neonicotinoids in common garden plants sold to consumers at garden centers across the U.S. However, rates of detection are significantly reduced compared with rates in our 2013 and 2014 tests. This reduction is likely due to change in store policies that commit retailers to eliminate or phase-out neonicotinoid use on garden plants. This is having a ripple effect in production methods by suppliers and has resulted in reduced use overall of neonicotinoids in common garden plants. It appears that nurseries and retailers are making significant progress in pollinator protection, but their job is not yet complete.

The significant reduction in neonicotinoids in the garden industry by both large and small growers and retail stores represents the progress that the industry has made to uphold commitments to protect bees and other pollinators.

Implications for bee health

The reduction in the percentage of plants testing positive for neonicotinoids is good news for bees and other pollinators. Gardeners planting bee-attractive flowers are more likely to be providing clean forage for bees, compared to several years ago. These results indicate that store policies can go a long way towards changing production practices to protect bees.

Nevertheless, the plants that tested positive could still be harmful to bees. Concentrations in pollen and nectar — the flower materials bees actually consume — may be lower than the concentrations detected in whole flowers, as measured in this study. The actual dose of neonicotinoids experienced by either an individual bee or a colony is related to how frequently the bee forages on contaminated plants and how much contaminated food is actually consumed over time. Honeybees forage widely and bring pollen and nectar into the hive from many different sources, so may “dilute” contaminated pollen and nectar with clean forage from other sources. Another confounding factor is that honey bees do not necessarily eat all of the food resources they bring into the hive immediately, so there can be lag time between use of the pesticide in the environment or planting of a treated plant and observed adverse effects.

Acute Effects

Comparison of the imidacloprid-equivalent concentrations measured in nursery plants to the acute honey bee LC_{50} (lethal concentration) for imidacloprid (150 μg/kg in nectar)[1] reveals five samples exceeding this concentration.[26, 27] Whole flowers could potentially have higher residue levels than nectar and pollen, therefore, it is not possible to precisely determine what dose the bees would be receiving in the pollen and nectar of these plants. However, at the levels observed in the flowers sampled, it is possible that consumption of pollen and nectar from the higher concentration samples could lead to significant impairment of bee health and even death.

Figure 4: *Although bee kills are the most visible impacts of systemic insecticides, exposure to levels of neonicotinoids that do not cause immediate bee death can still damage colonies through the less apparent effects on the immune system (making the bees more vulnerable to disease), learning and memory (affecting the bees' ability to find food and return to the hive), and reproduction (reducing queen and male fertility, brood success and survival rate).*

Sublethal effects and chronic toxicity

All of the samples with detections could potentially cause sublethal effects and mortality in pollinators following chronic exposure. Exposures to even small concentrations of neonicotinoids contribute to impairment in reproduction, learning and memory, hive communications and immune response at doses far below those that cause bee kills (see Figure 5). See "Gardeners Beware 2014"[19] for detailed summaries of these studies.

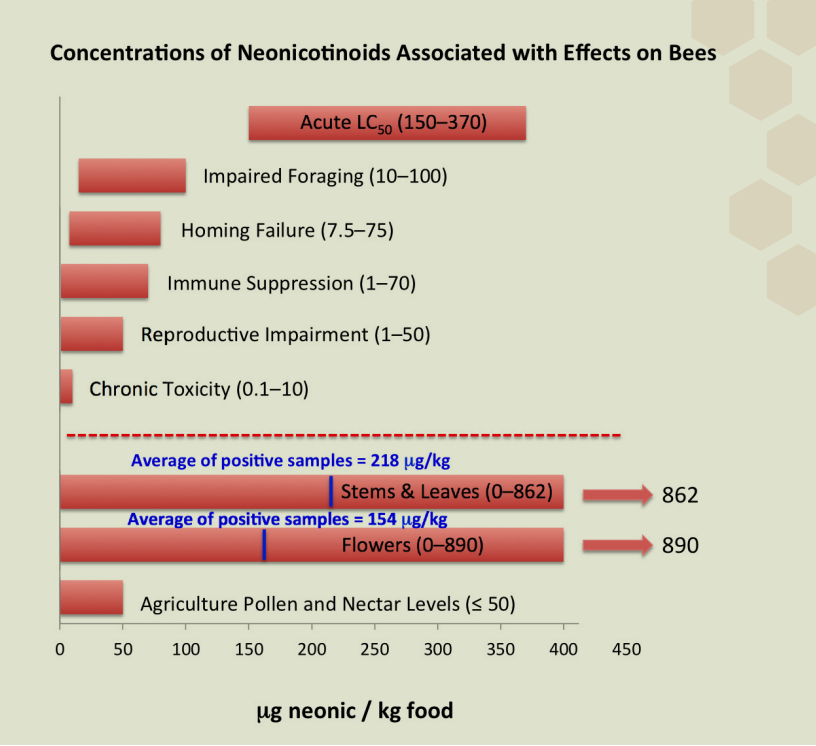


Figure 5: *Neonicotinoids are highly toxic to honey bees and bumblebees, but even at low doses they can impair colony health. Concentrations of neonicotinoids are given in micrograms of pesticide per kilogram of food (μg/kg = parts per billion). The homing failure range is based on honey bee exposure to imidacloprid or thiamethoxam. The reproductive impairment range is based on bumble bee exposure to imidacloprid or clothianidin. All other studies are based on imidacloprid exposure. Chronic toxicity refers to increased bee mortality associated with long-term, low-level exposure.*

1. Acute oral LC_{50} (in μg/kg) was calculated using the acute oral LD_{50} lethal concentration (in μg/bee) from the U.S. EPA EcoTox Database[26] and the amount of sucrose solution ingested by a bee in an LC_{50} test (26 mg). Specifically, LC_{50} = LD_{50} / 26 mg.[27] The resulting LC_{50} (in μg/mg) is corrected to μg/kg using a conversion factor of 1,000,000 mg/kg. For additional details, see Appendix B in "*Gardeners Beware 2014*".[19]

Trees: Persistent sources of neonicotinoid exposure for pollinators in urban and suburban areas

Flowering trees are beautiful additions to city streets and business campuses, providing nectar for bees, seeds for birds and shade for humans. Unfortunately, the results of this study show that systemic neonicotinoids are commonly used in tree production and could be a major source of exposure for urban pollinators. One Crape Myrtle sample from this study was found to have a concentration of 890 μg/kg of imidacloprid, a value 5.9 times the LC_{50} for honey bees.

Unless a city requests trees free of systemic insecticides from nursery suppliers, it is likely that at least some fraction of the new trees will be treated with neonicotinoid insecticides. Because these pesticides do not degrade readily in trees, they might persist for several years after treatment, representing a continuing source of exposure for urban bees and other pollinators.

For urban or suburban beekeepers, the presence of such trees in the landscape likely means less honey and fewer colonies surviving. For native bees foraging on trees like the Crape Myrtle tested, it could mean disasters on the scale of the bumble bee kill in Wilsonville, Oregon.[29]

This problem should be easy to solve for cities and businesses that are purchasing large quantities of trees. They must require trees free of systemic insecticides from their nursery suppliers. For government projects, there is generally sufficient lead time to ensure that the nurseries growing the trees cooperate with the city and provide a signed agreement verifying that the trees are safe for pollinators. Some tree species that are hosts for invasive pests are required by quarantine regulations to be treated with systemics. Cities should avoid these species, as there are many that do not require treatment.

One Crape Myrtle sample from this study was found to have a concentration of 890 μg/kg of imidacloprid, a value 5.9 times the LC_{50} for honey bees.

V. Recommendations for reducing risks to pollinators

As this study demonstrates, there has been a great deal of progress in the past two years by the garden industry to move away from neonicotinoid pesticides. Two-thirds of the garden industry and nearly three-quarters of the garden industry that supplies mass merchandisers and home improvement chains are eliminating neonicotinoids in 2016. Despite this progress, there is still more work that can be done to improve this sector. Some plants pretreated with neonicotinoid pesticides continue to be sold that may be harming or killing bees and other threatened pollinators essential to food production and ecosystem health.

Unfortunately for bees, other pollinators and for all of us, the now common cosmetic use of neonicotinoid pesticides in gardens, lawns and landscapes is an important factor in declining health of managed and wild pollinators. Friends of the Earth U.S. and allies are leading an ongoing campaign at www.foe.org/beeaction to call on U.S. garden retailers to stop selling products and plants with pesticides linked to declining bee populations and other pollinators and to speed the essential transition to sustainable, just, ecological agriculture and land management. We recommend that the remaining sector of the garden industry, including retailers and suppliers, make formal commitments to eliminating neonicotinoid pesticides as quickly as possible.

We are also asking consumers, institutional purchasers and local, county, state and federal regulators and policymakers to take action to restrict neonicotinoids and other pesticides to help protect bees and other pollinators.

Recommendations for garden retailers:

- Require neonicotinoid-free vegetable and bedding plants from suppliers and do not sell plants or plant starter mixes pre-treated with these insecticides.
- Offer third-party certified organic starts and plants.
- Do not sell off-the-shelf neonicotinoid insecticides for home garden use.
- Educate your customers on why your company has made the decision to protect bees and other pollinators.

Recommendations for wholesale nursery operations supplying retailers:

- Use only untreated seeds for plants grown from seed.
- Do not use neonicotinoid insecticides as soil drenches, granules or foliar treatments when growing vegetable and bedding plants.
- Offer neonicotinoid-free and organic vegetable and bedding plants to your customers and label them as such.
- Educate your customers about why your nursery operation made the choice to limit the use of neonicotinoid pesticides.
- If quarantine regulations require use of systemic insecticides on certain plants that are hosts for invasive pests, treat only those plants, minimize the number of treatments and label treated plants accordingly. Do not use neonicotinoids if less toxic systemic pesticides are approved for use on the target pest. Use pest-exclusion systems wherever possible to avoid having to treat plants with pesticides.

Recommendations for home gardeners and institutional purchasers *(such as schools, universities, private companies, hospitals and others):*

- Stop using all neonicotinoid insecticides and other pesticides harmful to pollinator health on your property and facilities (e.g. landscaping around parking lots, grounds and gardens), and plant pollinator-friendly plants free of neonicotinoid insecticides and other systemic insecticides.
- Specify in contracts with landscaping companies that service your grounds and trees not to use neonicotinoid insecticides and pesticides harmful to pollinator health and not to install plants pretreated with neonicotinoids or other systemic insecticides.
- Provide critical habitat for pollinators by planting pollinator friendly trees and flowers.

Recommendations for cities, counties and U.S. states:

Because trees are such an important part of pollinator forage in urban and suburban areas, we recommend that cities, towns, businesses and other organizations planting trees should specify to their tree suppliers that they will only purchase neonicotinoid-free trees. City staff should learn more about the potential hazards of systemic neonicotinoid insecticides to pollinators and modify their policies to better protect pollinators from inadvertent use of these pesticides on their property. Government entities should also:

- Suspend the use of neonicotinoids and other insecticides for cosmetic purposes on ornamental and landscape plants, like the ban now enforced in Ontario, Canada.[30]
- Pass resolutions to ensure that neonicotinoids and other pesticides harmful to pollinator health are not used on city- and county-owned property, including schools, parks and gardens.
- Require that bee-toxic insecticides be prominently labeled as such in displays of these chemicals at garden centers, hardware stores and nurseries.
- Provide critical habitat for pollinators by planting pollinator-friendly trees and flowers.

Recommendations for EPA:

- Suspend the registrations of neonicotinoids for agricultural as well as cosmetic and other unnecessary uses pending the results of pesticide re-evaluation.
- Require a bee hazard statement on the label of all products containing systemic insecticides toxic to pollinators, including soil drenches and foliar use products.
- Prioritize the systemic insecticides for Registration Review starting in 2016, and ensure inclusion of independent, peer-reviewed research on the acute and chronic effects of systemic insecticides on bees.

- Expedite the development and implementation of valid test guidelines for sublethal effects of pesticides on pollinators and require data from these studies for all currently registered and any new pesticides.
- Require testing and reporting of synergistic effects between pesticides in Registration Review to reduce the probability of interactive effects amplifying the toxicity of neonicotinoid insecticides.

Recommendations for the U.S. Congress:

- Support and pass the Pollinator Recovery Act of 2016, introduced by Senator Jeff Merkley (D-Ore.). This legislation seeks to emphasize the development and adoption of novel integrated pest and vegetation management practices that reduce the application of pollinator-toxic insecticides and herbicides that can impact pollinator health and the abundance of habitat and forage; require the Department of Agriculture to consider regionally appropriate, pollinator-friendly seed mixes when developing and implementing conservation plans for agricultural land holders in areas with highly erodible soils; and offer financial and technical assistance for growers to implement a variety of conservation practices and restoration efforts on active and retired lands.
- Support and pass H.R. 1284, the Saving America's Pollinators Act of 2015, introduced by Representatives John Conyers (D-Mich.) and Earl Blumenauer (D-Ore.). This legislation would suspend seed treatment, soil application or foliar uses of certain neonicotinoid pesticides on bee-attractive plants until all of the scientific evidence is reviewed by the EPA and field studies can be done to evaluate both short- and long-term effects of these pesticides on pollinators.

Recommendations for consumers:

- **Take action:** Join the Friends of the Earth U.S. BeeAction campaign and sign our petition to garden retailers asking that they stop selling neonicotinoid treated plants and products that contain neonicotinoids. You can find actions, bee-friendly gardening tips and bee-friendly retailers at **www.foe.org/beeaction**.
- **Raise your voice locally:** Let your local nursery manager know that you will only purchase plants free of neonicotinoids, and ask the manager to communicate your request to their corporate headquarters and suppliers who grow the plants they sell. Find a sample letter for U.S. companies and more ideas for action at **www.foe.org/beeaction**.
- **Grow bee-safe:** Avoid buying neonicotinoid-treated seeds and seedlings. Purchase organic plant starts or grow your plants from untreated seeds in organic potting soil for your home vegetable and flower gardens.
- **Practice bee-safe pest control:** Avoid the use of systemic bee-toxic pesticides in your garden and use alternative approaches such as providing habitat to attract beneficial insects that prey on pest insects in your garden. If pest pressure is too high, use insecticidal soaps or oils and other eco-friendly pest control products. For more tips and links to more resources for pollinator and eco-friendly gardening, visit www.foe.org/beeaction and www.garden4bees.com.
- **Do not buy products that contain neonicotinoids:** Read the label and avoid using off-the-shelf neonicotinoid insecticides in your garden. These products may contain acetamiprid, clothianidin, imidacloprid, thiamethoxam and dinotefuran as active ingredients. See Appendix A at the end of this report for a list of common consumer products containing neonicotinoids.
- **Do a clean sweep:** See if you have systemic insecticides at home, dispose of them as municipal hazardous waste, or take them back to the store where you bought them (see appendix A in Gardeners Beware 2014 for a list of product names).

VI. Conclusion

This study shows that the use of neonicotinoid insecticides in growing "bee-friendly" plants is declining. Market data for 2016 demonstrates that two-thirds of the garden sector is moving away from growing plants with neonicotinoids but has not yet gone to zero. This shift has been spurred by retailers, including the two largest garden retailers in the U.S., Home Depot and Lowe's, that have made formal commitments and adopted store-wide policies to eliminate systemic neonicotinoids on plants and products.

This shift is overwhelmingly supported by the general public. Survey data indicate that customers prefer to shop at stores that have made formal commitments to eliminate these pesticides. However, both ornamental flowers and trees continue to be sources of neonicotinoid exposure for bees and other pollinators. Until the remaining largest garden retailers in the country, including Ace Hardware, True Value and Walmart, adopt formal store policies to eliminate the use of neonicotinoids on plants and off-the-shelf products, bees and other pollinators will continue to be exposed to these pesticides via our backyards and gardens.

Appendix A: Comprehensive table of results by location and plant type

Location	Sample type	Sub-sample	Chemicals and concentrations (mg/kg)
CA—flowers	*Salvia*	*Flowers*	*ND*
CA—flowers	*Salvia*	*Stems & leaves*	*Imidacloprid (27)*
CA—flowers	*Rosemary*	*Flowers*	*ND*
CA—flowers	*Rosemary*	*Stems & leaves*	*ND*
CA—flowers	*Candytuft*	*Flowers*	*ND*
CA—flowers	*Candytuft*	*Stems & leaves*	*ND*
CA—flowers	*Lavender*	*Flowers*	*ND*
CA—flowers	*Lavender*	*Stems & leaves*	*ND*
CA—tree	*Acacia*	*Tree leaves*	*Dinotefuran (45.4)*
CA—tree	*Blueberry*	*Shrub leaves, new growth*	*ND*
CA—tree	*Bottlebrush*	*Tree flowers*	*ND*
CA—tree	*Bottlebrush*	*Tree leaves, new growth*	*ND*
CA—tree	*Ceonothus*	*Tree leaves, new growth*	*ND*
CA—tree	*Crape Myrtle, White*	*Tree flowers*	*Imidacloprid (47.4)*
CA—tree	*Crape Myrtle, Red*	*Tree leaves, new growth*	*Imidacloprid (852), Imidacloprid olefin (59.1)*
CA—tree	*Crape Myrtle, Dark Red*	*Tree leaves, new growth*	*ND*
CA—tree	*London Plane*	*Tree leaves*	*ND*
CA—tree	*New Zealand Tea Tree*	*Shrub leaves, new growth*	*ND*
CA—tree	*Australian Tea Tree*	*Shrub leaves, new growth*	*ND*
CA—tree	*Vitex pink*	*Tree leaves, new growth*	*ND*
CA—tree	*Vitex purple*	*Tree flower buds*	*ND*
DC	*Cosmos*	*Flowers*	*Imidacloprid (0.5)*
DC	*Cosmos*	*Stems and leaves*	*ND*
DC	*Gaillardia*	*Flowers*	*ND*
DC	*Gaillardia*	*Stems and leaves*	*Imidacloprid (56.5)*
DC	*Salvia*	*Flowers*	*ND*

Location	Sample type	Sub-sample	Chemicals and concentrations (mg/kg)
DC	*Salvia*	*Flowers*	*Imidacloprid (889), Imidacloprid olefin (5)*
DC	*Salvia*	*Stems and leaves*	*ND*
DC	*Salvia*	*Stems and leaves*	*Imidacloprid (603), Imidacloprid olefin (244)*
GA	*Coreopsis*	*Flowers*	*ND*
GA	*Coreopsis*	*Stems and leaves*	*ND*
GA	*Gaillardia*	*Flowers*	*ND*
GA	*Gaillardia*	*Stems and leaves*	*ND*
GA	*Gerbera Daisy*	*Flowers*	*Imidacloprid (7.3)*
GA	*Gerbera Daisy*	*Stems and leaves*	*Dinotefuran (49), Imidacloprid (20.4)*
GA	*Salvia*	*Flowers*	*ND*
GA	*Salvia*	*Stems and leaves*	*ND*
IL	*Gaillardia*	*Flowers*	*Dinotefuran (64.2)*
IL	*Gaillardia*	*Stems and leaves*	*Dinotefuran (185)*
IL	*Gerbera Daisy*	*Flowers*	*ND*
IL	*Gerbera Daisy*	*Stems and leaves*	*ND*
IL	*Salvia*	*Flowers*	*ND*
IL	*Salvia*	*Stems and leaves*	*ND*
MA	*Coreopsis*	*Stems and leaves*	*Imidacloprid (268), Imidacloprid des nitro HCl (238), Imidacloprid olefin (275),*
MA	*Coreopsis*	*Flowers*	*Imidacloprid (301), Imidacloprid olefin (5),*
MA	*Daisy*	*Flowers*	*ND*
MA	*Poppy*	*Flowers*	*ND*
MD	*Gerbera Daisy*	*Flowers*	*Flonicamid[a] (29.1), Thiamethoxam (82.5)*
MD	*Gerbera Daisy*	*Stems and leaves*	*Clothianidin (23.7), Flonicamid[a] (128), Thiamethoxam (172)*
MD	*Salvia*	*Flowers*	*ND*
MD	*Salvia*	*Stems and leaves*	*ND*
MD	*Scabiosa*	*Flowers*	*ND*
MD	*Scabiosa*	*Stems and leaves*	*ND*
ME	*Information not provided*	*Flowers*	*ND*
ME	*Information not provided*	*Flowers*	*ND*
MI	*Geranium*	*Flowers*	*Imidacloprid (3.3)*
MI	*Geranium*	*Stems and leaves*	*ND*
MI	*Phlox*	*Flowers*	*ND*
MI	*Trailing Petunia*	*Flowers*	*Imidacloprid (62.1)*

Location	Sample type	Sub-sample	Chemicals and concentrations (mg/kg)
MI	*Trailing Petunia*	*Stems and leaves*	*Imidacloprid (234)*
MI	*Zinnia*	*Flowers*	*ND*
MI	*Zinnia*	*Stems and leaves*	*Imidacloprid (34.2)*
MN	*Gerbera Daisy*	*Flowers*	*ND*
MN	*Gerbera Daisy*	*Flowers*	*ND*
MN	*Gerbera Daisy*	*Stems and leaves*	*ND*
MN	*Gerbera Daisy*	*Stems and leaves*	*ND*
MN	*Salvia*	*Flowers*	*ND*
MN	*Salvia*	*Stems and leaves*	*ND*
MN	*Scabiosa*	*Flowers*	*Flonicamid[a] (21.6)*
MN	*Scabiosa*	*Stems and leaves*	*Flonicamid[a] (12.2)*
NC	*Coreopsis*	*Flowers*	*ND*
NC	*Coreopsis*	*Stems and leaves*	*ND*
NC	*Daisy*	*Flowers*	*ND*
NC	*Daisy*	*Flowers*	*ND*
NC	*Salvia*	*Flowers*	*ND*
NC	*Salvia*	*Stems and leaves*	*ND*
OR	*Alyssum*	*Flowers*	*ND*
OR	*Gerber daisy*	*Flowers*	*ND*
OR	*Gerber daisy*	*Stems & leaves*	*ND*
OR	*Salvia*	*Flowers*	*ND*
OR	*Salvia*	*Stems and leaves*	*ND*
OR	*Scabiosa*	*Flowers*	*ND*
OR	*Scabiosa*	*Stems and leaves*	*ND*
OR	*Verbena*	*Flowers*	*ND*
SAC	*African Daisy*	*Flowers*	*ND*
SAC	*Coreopsis*	*Flowers*	*ND*
SAC	*Coreopsis*	*Stems and leaves*	*ND*
SAC	*Lavender*	*Flowers*	*ND*
SAC	*Lavender*	*Stems and leaves*	*ND*
SAC	*Scabiosa*	*Flowers*	*ND*
SAC	*Scabiosa*	*Stems and leaves*	*ND*
TX	*Buddelia*	*Flowers*	*ND*
TX	*Buddelia*	*Stems and leaves*	*ND*
TX	*Daisy*	*Flowers*	*ND*
TX	*Gaillardia*	*Flowers*	*ND*
TX	*Gaillardia*	*Stems and leaves*	*ND*

[a] Flonicamid was part of the analysis conducted by the laboratory, but this chemical not a neonicotinoid insecticide. It has a different mode of action and is classified by US EPA as having low acute toxicity to honey bees.

VII. References

1 Klein AM, Vaissiere B, Cane JH, Steffan-Dewenter I, Cunningham SA, Kremen C (2007) Importance of crop pollinators in changing landscapes for world crops. Proceedings of the Royal Society B: Biological Sciences 274: 303–313.

2 Buchmann S, Nabhan GP. 1996. The Forgotten Pollinators. Island Press, New York.

3 United Nations Food and Agriculture Organization. 2005. Protecting the pollinators. FAO Spotlight. http://www.fao.org/ag/magazine/0512sp1.htm.

4 Calderone NW. 2012. Insect Pollinated Crops, Insect Pollinators and U.S. Agriculture: Trend Analysis of Aggregate Data for the Period 1992–2009. PLoS ONE 7(5): e37235. doi:10.1371/journal.pone.0037235

5 Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES). "Press Release: Pollinators Vital to Our Food Supply Under Threat." 26 February 2016. Web. http://www.ipbes.net/article/press-release-pollinators-vital-our-food-supplyunder-threat

6 Food and Agriculture Organization of the United Nations. "Pollinators vital to our food supply under threat." FAO. 26 Feb. 2016. Web. www.fao.org/news/story/en/item/384726/icode/

7 Cox-Foster DL, Conlan S, Holmes EC, Palacios G, Evans JD, Moran NA, et al. 2007. A metagenomic survey of microbes in honey bee colony collapse disorder. Science 318: 283–287; doi:10.1126/science.1146498.

8 Naug D. 2009. Nutritional stress due to habitat loss may explain recent honeybee colony collapses. Biological Conservation 142: 2369–2372.

9 Potts SG, Biesmeijer JC, Kremen C, Neumann P, Schweiger O, Kunin WE. 2010. Global pollinator declines: Trends, impacts, and drivers. Trends in Ecology & Evolution 25: 345–353; doi:10.1016/j.tree.2010.01.007.

10 Dyer A, Johnston J, Tharp C, Burrows M. 2012. Small Grain Seed Treatment Guide. Montana State University Extension. Retrieved June 12, 2013 from http://msuextension.org/publications/AgandNaturalResources/MT199608AG.pdf

11 Xerces. 2013. Scientists Call for an End to Cosmetic Insecticide Use After the Largest Bumble Bee Poisoning on Record. The Xerces Society for Invertebrate Conservation. http://www.xerces.org/2013/06/27/scientists-call-for-an-end-to-cosmetic-insecticide-use-after-the-largest-bumble-bee-poisoning-on-record/

12 Henry M, Beguin M, Requier F, Rollin O, Odoux J-F, Aupinel P, et al. 2012. A Common Pesticide Decreases Foraging Success and Survival in Honey Bees. Science 336: 348–350; doi:10.1126/science.1215039

13 Williamson SM, Wright GA. 2013. Exposure to multiple cholinergic pesticides impairs olfactory learning and memory in honeybees. Journal of Experimental Biology 216: 1799–1807; doi:10.1242/jeb.083931

14 Straub L, Villamar Bouza L , Selina B, Chantawannakul P, Gauthier L, Khongphinitbunjong K, Retschnig G, Troxler A, Vidondo B, Neumann P, Williams G. 2016. Neonicotinoid insecticides can serve as inadvertent insect contraceptives. Science 283: 1834; DOI: 10.1098/rspb.2016.0506

15 Whitehorn PR, O'Connor S, Wackers FL, Goulson D. 2012. Neonicotinoid Pesticide Reduces Bumble Bee Colony Growth and Queen Production. Science 336: 351–352; doi:10.1126/science.1215025

16 Alaux C, Brunet J-L, Dussaubat C, Mondet F, Tchamitchan S, Cousin M, et al. 2010. Interactions between Nosema microspores and a neonicotinoid weaken honeybees (Apis mellifera). Environmental Microbiology 12: 774–782; doi:10.1111/j.1462-2920.2009.02123.x

17 Krupke CH, Hunt GJ, Eitzer BD, Andino G, Given K. 2012. Multiple Routes of Pesticide Exposure for Honey Bees Living Near Agricultural Fields. G. Smaggheed. PLoS ONE 7:e29268; doi:10.1371/journal.pone.0029268.

18 Brown TJ, Kegley SE, Archer L. Gardeners Beware: Bee-Toxic Pesticides Found in "Bee-Friendly" Plants Sold at Garden Centers Nationwide. Friends of the Earth-U.S. August 2013. http://libcloud.s3.amazonaws.com/93/88/f/3354/Gardeners-Beware-Report-11.pdf.

19 Brown TJ, Kegley SE, Archer L., Finck-Haynes T, Olivastri B. Gardeners Beware 2014: Bee-Toxic Pesticides Found in "Bee-Friendly" Plants Sold at Garden Centers Across the U.S. and Canada. Friends of the Earth-U.S. June 2014. http://libcloud.s3.amazonaws.com/93/3a/3/4738/GardenersBewareReport_2014.pdf

20 Drotleff, Laura. Dowload Greenhouse Grower's 2016 State of the Industry Whitepaper. Greenhouse Grower. 23 February 2016. http://www.greenhousegrower.com/business-management/download-greenhouse-growers-2016-state-of-the-industry-whitepaper/

21 Home Depot. 2015. Honey Bees & Insecticides. http://www.ecooptions.homedepot.com/healthy-home/organic-gardening/

22 PR Newswire. 2014 CSR Report Highlight Lowe's 'Shared Responsibility'. PR Newswire Association LLC. 9 April 2015. http://www.prnewswire.com/news-releases/2014-csr-report-highlights-lowes-shared-responsibility-300063613.html

23 All figures, unless otherwise stated, are from YouGov Plc. Total sample size was 1,119 adults. Fieldwork was undertaken between 28th - 29th April 2016. The survey was carried out online. The figures have been weighted and are representative of all US adults (aged 18+).

24 Radford R, Finck-Haynes T, Brown TJ, and Kegley SE. Growing Bee-Friendly Garden Plants: Profiles in Innovation. Friends of the Earth-U.S. June 2015. http://webiva-downton.s3.amazonaws.com/877/f6/6/5821/GrowingBeeFriendlyReport_web.pdf

25 Greenhouse Grower. 2016 State of the Industry Whitepaper. Greenhouse Grower. http://files.greenhousegrower.com/pdf/2016/2016-SOI-Whitepaper.pdf

26 U.S. EPA. 2011. OPP Pesticide Ecotoxicity Database, hosted by National Information System – Regional IPM Centers. U.S. Environmental Protection Agency. http://www.impcenters.org/Ecotox/.

27 Fischer DL, Chalmers A. 2007. Neonicotinoid Insecticides and Honey Bees: Technical Answers to FAQs. Bayer CropScience. http://www.bee-quick.com/reprints/imd/BayerFAQ.pdf.

28 City of San Francisco, Planning Department. Urban Forest Plan. http://sf-planning.org/urban-forest-plan [Accessed 28 July 2016].

29 Oxford T. <<Title>>, <<Date>>, Urban Bee San Francisco, <<Website>>.

30 Ontario Ministry of the Environment, 2009. Pesticide licenses and permits. https://www.ontario.ca/environment-and-energy/pesticide-licences-and-permits.