AgInfomatics

The Value of Neonicotinoids in Turf and Ornamentals:

The Value of Neonicotinoids to Turf and Ornamental Professionals

2014

This report series, researched and produced by AgInfomatics, LLC, is a comprehensive analysis of the economic and societal benefits of nitroguanidine neonicotinoid insecticides in North America. The research was sponsored by Bayer CropScience, Syngenta and Valent in support of regulatory review processes in the United States and Canada, with Mitsui providing additional support for the turf and ornamental studies.

AgInfomatics, an agricultural consulting firm established in 1995 by professors from the University of Wisconsin-Madison and Washington State University, conducted independent analyses exploring the answer to the question: *What would happen if neonicotinoids were no longer available?* Comparing that answer to current product use revealed the value of neonicotinoids.

Robust quantitative and qualitative study methods included econometrics modeling of insecticide use, crop yield data and market impacts; surveys of growers, professional applicators and consumers; regional listening panel sessions; and in-depth case studies.

Active ingredients in the study included clothianidin, dinotefuran, imidacloprid and thiamethoxam.

The Value of Neonicotinoids in North American Agriculture

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Estimated Impact of Neonicotinoid Insecticides on Pest Management Practices and Costs for U.S. Corn, Soybean, Wheat, Cotton and Sorghum Farmers

Methods and Assumptions for Estimating the Impact of Neonicotinoid Insecticides on Pest Management Practices and Costs for U.S. Corn, Soybean, Wheat, Cotton and Sorghum Farmers

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A Case Study of Neonicotinoid Use for Controlling Emerald Ash Borer—The Naperville, Illinois, Experience

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Executive Summary

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Executive Summary

The businesses that comprise the turf and ornamental industry are diverse and will have a combined revenue that approached $100 billion in 2014. They include lawn and landscape ornamental management, greenhouse and nursery plant production, floriculture and arboriculture. For all of the industry segments, pest management is an important issue, and neonicotinoid insecticides are widely used. A critical dimension to establishing the value of neonicotinoids in this large and diverse industry would be gained by surveying the professionals who use these insecticides.

To accomplish this objective, an online survey was designed and implemented in the summer of 2014 with the assistance of four professional associations that represented the different segments of the turf and ornamental industry. This effort produced responses from 750 professionals. The survey was composed of questions about insecticides, pests and the implications of losing neonicotinoids. Significant differences in responses from the different industry segments allowed us to organize the results by five principal areas of business emphasis: greenhouse, nursery, lawns, landscape ornamentals and trees.

These professionals were given 15 different criteria by which they could select insecticides; they also had the option of identifying other criteria. Based on survey responses, four criteria stood out above all the others as most important when selecting insecticides: protecting plant quality, consistent pest control, applicator safety and customer safety. When asked to identify the top three most used insecticides in the business, neonicotinoids were the most frequent response (34 percent) among the ten insecticide classes identified. Among the neonicotinoids, three-quarters (75 percent) identified imidacloprid as the most commonly used product.

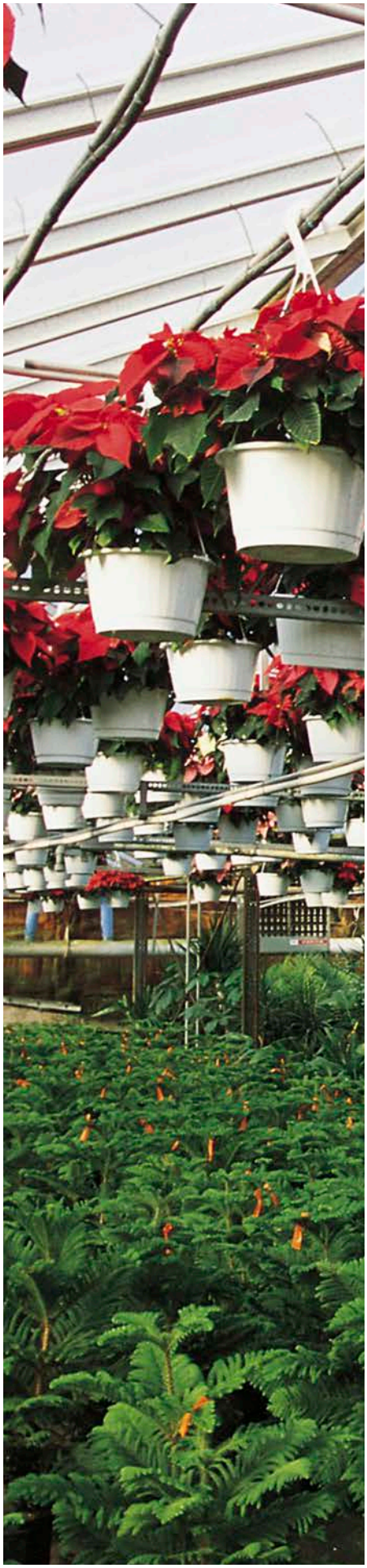
Respondents were then asked about alternative products under the hypothetical scenario that neonicotinoids were no longer available. Almost three-quarters (73 percent) said there were either no acceptable alternatives to neonicotinoids or not enough acceptable alternatives. Between 43-68 percent said that the loss of neonicotinoids would reduce the income of their business, depending on industry segment. These income losses would be related to the need to apply alternative insecticides more frequently or at higher rates, record keeping requirements, lower customer satisfaction, inability to control invasive pests, and a decrease in the quality of the plant products.

The pests that would be most difficult to control without neonicotinoids were identified and varied between industry segments. A single pest complex, white grubs, was identified by over two-thirds of the respondents in the lawn care industry. The other business segments were more diverse in identifying a pest that would be difficult to control. Aphids were the primary pest for the greenhouse (32.9 percent) and the nursery (35.4 percent) industries. Flatheaded borers were the primary pest for landscape ornamentals (37.5 percent) and trees (36 percent).

Survey participants were then asked to identify the alternative insecticides that would be used if neonicotinoids were no longer available. Across industry segments, the selection of pyrethroids as a top three most used insecticide would increase by 7.8 percentage points over current levels, and the

selection of organophosphates would increase by 10.0 percentage points over current levels. There would also be increases in other chemical classes, but none of these are greater than 3 percentage points. Table 10 illustrates that there is significant variation between the industry segments. For example, without neonicotinoids, selection of organophosphates and pyrethroids as a most used product is projected to increase by 11.1 percentage points and 6.0 percentage points respectively in greenhouses, 9.5 percentage points and 13.8 percentage points respectively in landscape ornamentals, 4.7 percentage points and 4.8 percentage points respectively in lawns, 17.1 percentage points and 5.0 percentage points respectively in nursery, and 9.1 percentage points and 15.1 percentage points respectively in trees.

This report highlights some significant changes that would occur in the turf and ornamental industry if neonicotinoids were no longer available. Many of these changes can be tied to the reasons why professionals choose these insecticides in the first place. Most professionals surveyed agreed that their ability to manage insect pests would be significantly curtailed. Moreover, they indicated that safety to the applicator and customer would be a greater concern as some alternative insecticides are used more frequently and at higher rates. They also expect decreased customer satisfaction as the quality of the plants they produce and protect would decrease due to a greater difficulty controlling pests. Respondents indicated that losing neonicotinoids would challenge the management of pest resistance to other chemical classes by limiting the ability to rotate the mode of action.



1.0 Introduction

The turf and ornamental industry grows, distributes and provides retail and customer services for flowers, lawns, shrubs and trees. The industry employs hundreds of thousands of people and contributes billions of dollars annually to the U.S. economy. The landscape services segment (involving services ranging from basic lawn mowing and maintenance to landscape design and construction) is comprised of close to 400,000 firms generating an estimated $73 billion in 2014 (IBISWorld, 2014a). The plant and flower-growing segment (greenhouse/nursery) is estimated to have $13 billion in sales in 2014; although according to one report on the industry, income has been falling over the past five years due to drought, related water restrictions and international competition (IBISWorld, 2014b). The grower segment also varies depending on the retail channel. The traditional florist/garden center market is characterized by high-quality products, more services and higher margins; the mass merchant channel is built on higher volumes and lower prices and often is forced to be more competitive and responsive to the demands of large retail chains.

Plant damage and destruction by insect pests is a serious threat across the industry, and turf and ornamental professionals use multiple approaches to control insects and minimize or eliminate their damage. Growers of ornamental plants and sod focus on insect pest threats during plant production and distribution. Professionals in the lawn services segment focus on maintaining healthy residential and commercial turf, and most provide insect pest control as an important value-added service. Public parks, green spaces and athletic fields all benefit from the services of these professionals. Similarly, arborists and other tree care professionals help control insects in residential, commercial and public settings. Additionally, the growing and landscape services segments can be affected by regulations on plant shipments across state and national borders that may require preventative insecticide applications and/or inspections that demonstrate plants are pest free.

It is important to emphasize that these service providers do more than enhance the aesthetic qualities of residential and community settings. Insect pests cause millions of dollars of damage to homes and other structures, and there are untold expenses related to the treatment of medical problems resulting from the bites, stings or allergies caused by certain pests found in and around the home. Psychological well-being is enhanced in well-maintained in diverse urban landscapes (Fuller et. al., 2007). There are also important environmental benefits provided by healthy and diverse landscapes in urban and suburban settings. These include a sink for atmospheric nitrogen deposition (Raciti et al., 2008), offsetting carbon emissions (Golubiewski, 2006), providing stormwater capture and treatment (Dietz and Clausen, 2006), soil erosion control, moderating loud noises and temperatures, and creating wildlife habitats among other benefits.

Meeting these diverse challenges and expectations for insect control across widely varying environments and geographic regions requires careful management to match the appropriate control tool to the specific pest control need. Integrated Pest Management (IPM), which is practiced by most turf and ornamental professionals, emphasizes strategies that blend targeted and selective use of insecticides in rotation to mitigate development of pest

resistance and protect the beneficial insects that are used to suppress pest populations. Balancing this complex biological equation in a way that also meets the expectations of customers presents significant challenges to this industry. It is in this context that we address the value of neonicotinoids to the professionals in these industry segments.

Neonicotinoid insecticides have become a critical piece of the IPM approach practiced by many professionals across the turf and ornamental industry. In nurseries and greenhouses, neonicotinoids are used in rotation with other insecticide classes to help control numerous insect pests (such as whitefly, aphids, thrips, mealybugs, leafminers and borers), including some that have become resistant to chemistries with different modes of action. For lawns, neonicotinoids are widely used for controlling chinch bug and white grub infestations. Neonicotinoids are also used to protect trees from many invasive tree pests, including the emerald ash borer, Asian citrus psyllid and hemlock wooly adelgid.

A defining characteristic of this industry is the close proximity of the customer, their families and pets to plants treated with insecticides. Safety is a primary concern. This study seeks to assess the value of neonicotinoids to this industry by assessing how this class of insecticides is being used and the potential impacts if these insecticides were no longer available.

2.0 Methods

Across the growing and landscape service segments, there are thousands of professional applicators who are responsible for insect control as part of plant production, landscape management and arboriculture in developed urban and suburban settings. An online survey was designed for these professional applicators and business managers to understand how they value neonicotinoid insecticides. Four national professional associations were identified as the leading organizations in the relevant industry segments with membership comprised of professional applicators and business managers targeted for this study. These professional associations are: 1) AmericanHort (http://americanhort.org), representing the interests of nursery and greenhouse growers, landscape firms, distributors, retailers and allied suppliers; 2) PLANET (http://www.landcarenetwork.org), representing lawn care and landscape professionals; 3) Society of American Florists (http://www.safnow.org), representing the floral industry's retailers, growers, wholesalers, importers, manufacturers, suppliers, educators, students and allied organizations; and 4) the Tree Care Industry Association (http://tcia.org), representing commercial tree care firms and affiliated companies. Each association was contacted about the purpose of the study and was asked to survey their professional members. Their input was solicited to develop a valuable and representative survey for their membership.

The survey focused on 12 questions, including several with additional sub-questions. Questions were organized around measuring current insecticide use and costs by industry segment (the primary business focus of the respondents—greenhouse, nursery, lawns, landscape ornamentals and trees), factors used in choosing an insecticide, alternatives if neonicotinoids were not available, pests that will be difficult to manage without neonicotinoids, effect on business income, and an open-ended concluding question to cap-

ture any other concerns. The survey was administered through a commercial web-based survey site, and customized versions were created for each of the four professional associations, allowing each association to have an independent survey. The only differences between each association's versions were the title and the lists of chemicals and pests; those were customized to the likely applications of that association's members (see Appendix 2 for a sample survey questionnaire). Using the same survey questions allowed for analysis across respondents from different associations. Procedures were established to send out a survey link and login access to members of each association within their association's web or newsletter domains. Access to the survey was restricted to organizational members, but no personal identifiers were collected from respondents. A model letter was provided to each association for their use in encouraging the professional applicator and business manager members to participate in the survey (Appendix 3). The survey remained active on the commercial web site for approximately three weeks. During that time, "reminder" communications were provided to the associations to encourage additional participation.

3.0 Results

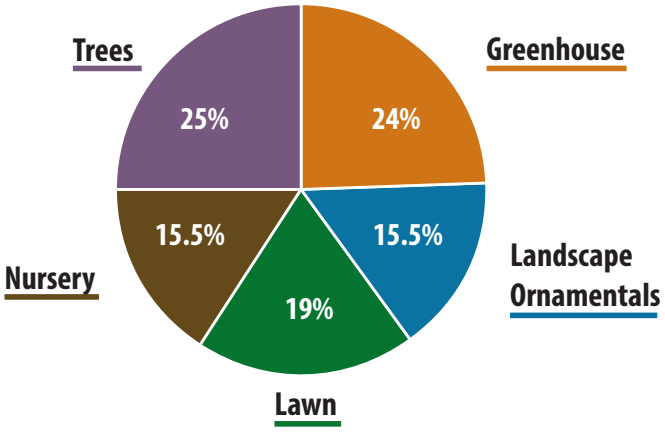
The survey produced 750 responses across the four professional associations as follows: AmericanHort, 351; PLANET, 145; Society of American Florists, 50; and Tree Care Industry Association, 204. Although location was not included as a survey question, the online survey system documented that responses were submitted from 43 states, a number simply identified as the U.S. and a small number from Canada. Of those responding, 87 percent (653) said they use insecticides in their business. Respondents provided responses and comments both for and against neonicotinoid use in their industry segment. The lack of personal identifiers in the data coupled with the confidentiality of membership numbers with the cooperating associations (and the intentional omission of questions about location or other business attributes due to space constraints) preclude analysis that would compare these respondents to determine the extent to which they represent their industry segments. The number of responses varied by question. If representative of the target professional audience, the sample of 750 responses (653 for insecticide users) would produce a +/- 3.6% (+/- 3.9%) margin of error at the 95 percent confidence level.

The respondents were asked to identify the main focus of their business, as most were engaged in multiple settings where neonicotinoids could be used. Across professional associations, respondents identified the main focus of their business as trees (25 percent), greenhouse (24 percent), lawn (19 percent), nursery (15.5 percent) and landscape ornamentals (15.5 percent) (Figure 1). A small number of respondents (<1 percent) indicated interior plantscapes. Many of the summary responses that follow are broken-out by this business focus in order to better illustrate the value of neonicotinoids for each industry segment.

Insecticide Use by Turf and Ornamental Professionals

The turf and ornamental professional respondents were asked to indicate the importance of different factors that influence their decisions when choosing an insecticide. Responses are presented in Table 1. Ten different

Figure 1. Primary business focus of survey respondents.



factors were classified as either "Important" or "Very important" by at least three quarters of the respondents. Four of those factors were rated as either "Important" or "Very important" by more than 90 percent of all respondents: Protecting quality of the plant, 98 percent, Consistent pest control, 96 percent, Safety to applicator, 96 percent and Safety to customer, 95 percent.

After answering the question on relative importance of these factors, respondents were provided a list of all factors that they indicated were "Very Important" and were asked to select the one "Most Important" factor for their business when choosing an insecticide (see question 4a in Appendix 2). The same four "Very Important" factors stood out as the "Most Important" to respondents: Protecting quality of the plant (25 percent), Consistent pest control (20 percent), Safety to the applicator (18 percent) and Safety to customer (12 percent). These are shown Table 1 as shaded rows.

Insecticide cost was split with 50.9 percent saying it was "Important" or "Very Important," and 49.1 percent saying cost was only "Somewhat Important" or "Not Important." Application equipment costs were "Not Important" or only "Somewhat Important" to most (58.0 percent). Whether an insecticide was a Restricted Use Product was "Not Important" to a fifth (22.4 percent) and "Somewhat Important" to just under a quarter (24.3 percent). Those identifying other factors employed in selecting insecticides (the final row in Table 1) presented a wide variety of additional decision criteria (Sidebar 1).

Respondents were provided lists of insecticides commonly used in their industry segment and asked to identify the three insecticide products "Most Used" in their business, based on square footage or plants treated per year. A complete list of the products selected as top-three products is included in Appendix 1, along with the product's active ingredient and mode of action. The chemical list was constructed using products with recognized market share from a leading market research company in turf and ornamentals. Any products that were not specifically mentioned did not meet a minimum market share threshold for recognition. Although identified as specific product trade names in the survey (Appendices 1 and 2), the results are presented in

Sidebar 1. Other factors considered by respondents when selecting an insecticide.

"The effect the insecticide has on the environment, i.e. how much of the chemical escapes into the environment. My major concerns are to water quality and off-target effects."

"Can be applied in hot humid weather without hurting plants."

"Choosing what does the least or no harm to the environment."

"Chemicals come after horticultural, mechanical and biological means. And then only those that are the very least harmful to beneficials, wildlife, water, animals, people."

"How effective is the insecticide? Does it work better than other options?"

"We use the least toxic pesticide possible. We absolutely are not interested in protecting a plant or tree at the expense of the environment."

Table 1. Importance of factors in choosing an insecticide to manage insect pests.

Factor	Not Important	Somewhat Important	Important	Very Important
Insecticide cost	6.4%	42.7%	37.7%	13.2%
Application equipment cost	22.6%	35.4%	34.2%	7.8%
Protecting quality of the plant	0.5%	1.6%	20.3%	77.7%
Consistent pest control	0.7%	3.4%	22.0%	73.9%
Convenience	3.0%	25.5%	47.6%	23.9%
Flexibility in application method (soil, foliar, tree injection or combinations)	7.7%	27.4%	39.1%	25.8%
Pollinator safety	6.6%	18.1%	36.1%	39.2%
Time and labor	2.1%	15.3%	50.2%	32.4%
Long lasting control	3.0%	12.7%	38.4%	45.9%
Safety to beneficial insects	3.6%	17.1%	35.8%	43.5%
Safety to applicator (e.g., personal protective equipment or Restricted Entry Interval)	0.5%	4.3%	21.6%	73.9%
Safety to customer	1.8%	4.1%	22.0%	72.8%
Unique control of a pest or pest spectrum	2.3%	18.6%	48.4%	29.8%
Management of resistant pests	1.8%	12.5%	41.8%	43.9%
Insecticide being a Restricted Use Product	22.4%	24.3%	27.7%	25.6%
Other (please specify)	39.1%	5.5%	15.5%	40.0%

Note: Shaded items were identified as the top four individually most important factors (see question 4a in Appendix 2).

Table 2. Top three "most used" insecticide classes based on square footage or plants treated per year (industry segments combined).

Insecticide Chemical Class	Mode of Action (MoA) Classification*	Percent of Top 3 Products Represented
Neonicotinoid	4A	33.9%
Pyrethroid	3A	22.6%
Avermectin	6	8.3%
Organophosphate	1B	5.5%
Compounds of unknown or uncertain MoA	UN	3.1%
Spinosyn	5	2.9%
Carbamate	1A	2.8%
Nematode, oils, soaps, aerosols*	Not Applicable	3.0%
Pymetrozine	9B	1.3%
Tetradifon	12D	1.0%
Other Product Not Listed**		10.1%
All other classes listed in Appendix 1	All other MoA in Appendix 1	< 1.0% each

* Source: The Insecticide Resistance Action Committee. *Mode of Action Classification Brochure*. Third Edition - February 2012.

** Very few respondents identified specific other products when prompted; those who did generally identified soaps, oils, insect growth regulators and fungal pathogens of insects.

Table 3. Neonicotinoid products identified among top three "most used" insecticide classes based on square footage or plants treated per year (industry segments combined).

Active Ingredient	Percent of Neonicotinoids Represented
Imidacloprid	74.6%
Dinotefuran	17.1%
Clothianidin	3.3%
Thiamethoxam	2.9%
Acetamiprid	2.1%

Neonicotinoids represented 33.9% of the top-three most used products selected.

Table 4. Top three "most used" insecticide classes based on square footage or plants treated per year by industry segment.

Industry Segment	Insecticide Chemical Class	Mode of Action Classification	Percent of Products
Greenhouse	Neonicotinoid	4A	26.4%
	Avermectin	6	13.3%
	Compounds of unknown or uncertain MoA	UN	9.4%
	Pyrethroid	3A	6.7%
	Nematode, oils, soaps, aerosols	Not Applicable	7.9%
	Organophosphate	1B	5.2%
	Spinosyn	5	5.2%
	Pymetrozine	9B	4.6%
	Pyrrole	13	2.4%
	Tetramic acid derivatives or tetronic acid	23	1.8%
	Meti acaracide	21A	1.2%
	Other product not listed*		10.6%
Nursery	Neonicotinoid	4A	28.6%
	Pyrethroids	3A	18.1%
	Avermectin	6	11.0%
	Organophosphate	1B	8.2%
	Carbamate	1A	6.0%
	Compounds of unknown or uncertain MoA	UN	3.9%
	Spinosyn	5	2.8%
	Tetramic acid derivatives or tetronic acid	23	2.2%
	Nematode, oils, soaps, aerosols	Not Applicable	2.8%
	Pymetrozine	9B	1.7%
	2, 4 - diphenyloxzoline derivative	10B	1.1%
	Other product not listed*		12.6%

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Table 4. Continued.

Industry Segment	Insecticide Chemical Class	Mode of Action Classification	Percent of Products
Lawn	Neonicotinoid	4A	43.0%
	Pyrethroid	3A	38.6%
	Tetradifon	12D	4.1%
	Diamide	28	2.8%
	Carbamate	1A	2.5%
	Organophosphate	1B	2.5%
	Phenylpyrazole	2B	1.9%
	Other product not listed*		3.1%
Landscape Ornamentals	Neonicotinoid	4A	37.4%
	Pyrethroid	3A	22.9%
	Organophosphate	1B	7.9%
	Carbamate	1A	5.3%
	Avermectin	6	3.1%
	Nematode, oils, soaps, aerosols	Not Applicable	3.1%
	Spinosyn	5	1.8%
	Pyriproxyfen	7C	1.8%
	Hydramethylnon	20A	1.3%
	Compounds of unknown or uncertain MoA	UN	1.3%
	Other product not listed*		13.2%
Trees	Neonicotinoid	4A	33.7%
	Pyrethroid	3A	25.4%
	Avermectin	6	13.0%
	Organophosphate	1B	5.6%
	Spinosyn	5	3.1%
	Carbamate	1A	1.7%
	Pyriproxyfen	7C	1.1%
	Other product not listed*		12.5%

* Very few respondents identified the specific other product used.

Table 2 and Table 4 by insecticide chemical class and mode of action. Insecticide classes representing less than one percent of products identified were not included in the tables. Table 2 reports that neonicotinoids make up a third (33.9 percent) of the top three "Most Used" insecticide products identified. Following neonicotinoids are pyrethroids at 22.6 percent. None of the remaining insecticide classes reported in Table 2 represented more than 10 percent of the top three insecticides identified by respondents.

Overall, 59 percent of respondents included a neonicotinoid product among their top-three "Most Used" insecticides. For roughly one-sixth (15 percent) of the respondents, two or three out of their three "Most Used"

products were neonicotinoid insecticides. Table 3 shows distribution within the class for each neonicotinoid active ingredient. Imidacloprid (74.6 percent) was the most commonly used neonicotinoid followed by dinotefuran (17.1 percent).

Table 4 illustrates the diversity associated with the use of insecticides within and between the industry segments. The table illustrates use of insecticide classes based on square footage or plants treated per year by industry segment. Neonicotinoids are the primary insecticide class used in each industry segment, ranging from a high of 43 percent in the lawn industry to a low of 26.4 percent in the greenhouse industry. Other insecticides include pyrethroids that varied between a high of 38.6 percent in lawn to a low of 6.7 percent in the greenhouse industry.

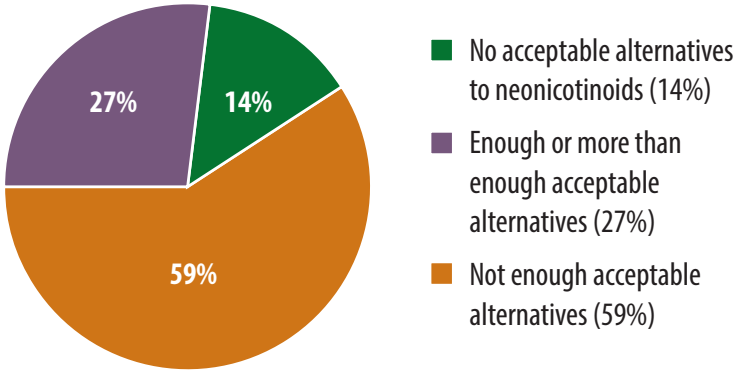
Turf and Ornamentals Without Neonicotinoids

Consistent with a counterfactual logic approach [i.e., a value is deduced by assuming something is no longer available or present (Courtois, 2010; Cowan and Foray, 2002; Ferraro, 2009)], respondents were asked what they would do if neonicotinoids were no longer available. A logical strategy would be product substitution—if neonicotinoids are no longer available, then one would substitute another insecticide for it. However, across all five-industry segments (greenhouse, nursery, lawn, landscape ornamentals and trees), an average of 14 percent indicated there are "No acceptable alternatives to neonicotinoids" for their pest control issues. Another 59 percent said there are "Not enough acceptable alternatives to neonicotinoids," and the remaining 27 percent said there are "Enough" or "More than enough" acceptable alternatives (Figure 2). How this varied between industry segments is illustrated in Table 5. The lawn industry was most likely (19.6 percent) to state there are "No acceptable alternatives." The "No acceptable alternative" responses were 16.8 percent in the greenhouse industry, landscape ornamentals (16.7 percent), trees (9.0 percent) and nursery (8.9 percent). The largest grouping for each industry is found for those who say there is "Not enough acceptable alternatives": nursery (69.6 percent), trees (67.0 percent), lawn (64.1 percent), landscape ornamentals (50.0 percent) and greenhouse (48.4 percent). A small percentage of professionals (1.1 - 13.6%) reported that there are "More than enough acceptable alternatives": landscape ornamentals (13.6 percent), greenhouse (8.4 percent), nursery (7.1 percent), trees (5.0 percent) and lawn (1.1 percent).

Synthesizing the results presented in Table 5 with those in Tables 1 and 4 indicates that professionals select insecticides based on their ability to produce or protect quality plants while providing safety to applicators and customers. As one professional stated, "Chemicals come after horticultural, mechanical and biological means. And then only those that are the very least harmful to beneficial insects, wildlife, water, animals, people." The results in Table 5 indicate that a majority (adding together "No acceptable alternatives" with "Not enough acceptable alternatives") of professionals believe these objectives in selecting an insecticide would be threatened or unattainable if they no longer had access to neonicotinoids.

Professionals completing the survey were asked how the loss of neonicotinoids would influence business income. Across all respondents, 55 percent said the "Loss of neonicotinoids would reduce the income for my

Figure 2. Level of acceptable alternatives if neonicotinoids were not available (industry segments combined).



Sidebar 2. Respondent comments about cost implications of losing neonicotinoids.

"Alternatives are much more expensive and so the cost of the services is going to increase. We currently use neonicotinoids in our program at half rates and they are still effective in our area. We have extensive knowledge and would hate for them to go away."

"Neonics are very flexible products that give us good control at a good price. Our customers are very happy with the results they provide. I honestly don't know how we would provide service without them."

"Adding organic or environmentally-friendly options, while taking more time and often requiring more knowledge, actually are shown to potentially add revenue. Cost is often much less per application; however, more applications are often required , so it evens out relatively well in the end."

business." Respondents estimated that the average income loss would be 15 percent. Eleven percent of respondents indicated the opposite income effect, stating that the "Loss of neonicotinoids would increase income for my business," with an average estimated increase of 10 percent. Table 6 shows differences in potential impact on income in each industry segment. Claiming a reduction in income due to the loss of neonicotinoids varied from lawn (68 percent), nursery (65 percent), trees (52 percent), greenhouse (50 percent) and landscape ornamentals (43 percent). Stating that the "Loss of neonicotinoids would not influences business income" varied between a high associated with those in landscape ornamentals (44 percent) to a low with those in trees (21 percent). Those stating that the "Loss of neonicotinoids would increase business income" varied between the high of 16 percent in trees to the low of 8 percent in nursery and greenhouse (Sidebar 2).

How the loss of an insecticide influences business income could be very complex and specific to individual companies in the different business segments. As reported in Table 6, these impacts could be negative, neutral or positive. To try and gain a general level of understanding of why the professionals reported what they did in Table 6, the survey offered a series of possible impacts that might influence business income. Ten different possible impacts were offered, and respondents were asked to rank each in

Table 5. Acceptability of alternatives if neonicotinoids were not available.

	Industry Segment				
Acceptability Level	**Greenhouse**	**Nursery**	**Lawn**	**Landscape Ornamentals**	**Trees**
There are no acceptable alternatives to neonicotinoids.	16.8%	8.9%	19.6%	16.7%	9.0%
There are not enough acceptable alternatives to neonicotinoids.	48.4%	69.6%	64.1%	50.0%	67.0%
There are enough acceptable alternatives available.	26.3%	14.3%	15.2%	19.7%	19.0%
There are more than enough acceptable alternatives available to neonicotinoids.	8.4%	7.1%	1.1%	13.6%	5.0%

Table 6. Impact on company income if neonicotinoids were not available.

	Industry Segment				
Impact	**Greenhouse**	**Nursery**	**Lawn**	**Landscape Ornamentals**	**Trees**
Loss would reduce income	50%	65%	68%	43%	52%
Loss would not impact income	42%	27%	21%	44%	31%
Loss would increase income	8%	8%	11%	13%	16%

Table 7. Anticipated business impacts if neonicotinoids were not available (industry segments combined).

Business Factor	Large Decrease	Decrease	Stay the Same	Increase	Large Increase	Don't Know
Cost for equipment to apply insecticides	0.3%	1.9%	72.0%	14.6%	4.4%	6.9%
Labor costs associated with making additional insecticide applications, record keeping or training	0.3%	0.5%	28.2%	41.4%	25.5%	4.1%
Costs associated with more frequent application or greater amounts of alternative insecticides	0.3%	1.9%	15.6%	39.1%	38.5%	4.6%
Ability to manage and improve pollinator health	1.4%	9.7%	42.9%	17.5%	10.2%	18.3%
Quality of the plant product or pest management services supplied	6.9%	37.5%	32.2%	9.4%	4.7%	9.4%
Concerns about health and safety risk due to toxicity of alternative chemistries	3.9%	8.5%	35.5%	24.8%	13.5%	14.3%
Ability to practice Integrated Pest Management (IPM)	5.8%	26.3%	39.5%	13.4%	7.9%	7.1%
Ability to control invasive pests	12.2%	32.3%	29.0%	9.7%	6.1%	10.8%
Customer satisfaction with our products or services	9.9%	36.6%	31.7%	6.3%	3.6%	11.8%
Ability to manage pest resistance	9.5%	34.4%	29.3%	9.5%	4.5%	12.8%

terms of effects on the business if neonicotinoids were no longer available. The response choices for each were "Large Decrease"; "Decrease"; "Stay the Same"; "Increase"; "Large Increase" or "Don't Know" relative to the impact on the business.

The responses in Table 6 relative to company income if neonicotinoids were no longer available become more understandable as we examine how the ten factors in Table 7 might influence the business. The largest business impact would be increased costs due to more frequent applications or greater amounts of alternative insecticides being applied. There were 38.5 percent who said this would be a "Large Increase," and another 39.1 percent said it would "Increase." Next was the 25.5 percent who said there would be a "Large Increase" due to costs of labor associated with additional applications, record keeping or training. Another 41.4 percent reported this factor as being a "Large Increase." Related to this are those who report either a "Decrease" (36.6 percent) or a "Large Decrease" (9.9 percent) in customer satisfaction. Few see customer satisfaction as increasing (6.3 percent) or a "Large Increase" (3.6 percent) in this dimension of business success. There were 11.8 percent that did not know how or were uncertain how the loss of neonicotinoids would impact customer satisfaction.

This uncertainty on the impact of losing neonicotinoids is reflected in the factor associated the ability to manage and improve pollinator health. There were 9.7 percent who said ability to manage and improve pollinator health would "Decrease" without neonicotinoids and 1.4 percent who said there would be a "Large Decrease" in this ability. The largest response category was the 42.9 percent who said it would "Stay the Same." There were some who said this ability would "Increase" (17.5 percent) or have a "Large Increase" (10.2 percent). Yet almost one in five (18.3 percent) simply did not know how an absence of neonicotinoids would influence their ability to manage pollinator health.

Much clearer are those who said there would be a "Decrease" (34.4 percent) or a "Large Decrease" (9.5 percent) in the ability to manage pest resistance and a "Decrease" (26.3 percent) or "Large Decrease" (5.8 percent) in the ability to practice IPM. One of the major criteria reported earlier on how professionals select insecticides was the insecticide's effectiveness in controlling pests. Respondents said that without neonicotinoids there would either be a "Decrease" (32.3 percent) or a "Large Decrease" (12.2 percent) in the ability to control invasive pests. One other important response trend found in Table 7 is the percent of respondents who did not know how a specific factor might be affected by a loss of neonicotinoids. Critical factors [such as Health and safety risk due to the toxicity of alternative insecticides (14.3 percent), Ability to control invasive pests (10.8 percent), Customer satisfaction (11.8 percent), Ability to manage pest resistance (12.8 percent), and the Ability to manage pollinator health (18.3 percent)] indicate many respondents have substantial uncertainty about potential impacts.

Respondents were also asked to identify three insect pests that would be most difficult to manage with available alternatives if they could no longer use neonicotinoids. Pests varied by business segment, and the top five pests for each are listed in Table 8. The greenhouse segment will have to develop new strategies to manage aphids (32.9 percent), whitefly (27.1 percent)

Table 8. Insect pests most difficult to manage if neonicotinoids were not available.

Industry Segment									
Greenhouse		Nursery		Lawns		Landscape Ornamentals		Trees	
Pest	%	Pest	%	Pest	%	Pest	%	Pest	%
Aphids	32.9%	Aphids	35.4%	Grubs	68.4%	Borers-Flatheaded	37.5%	Borers-Flatheaded	36.0%
Whitefly	27.1%	Whitefly	25.8%	Chinch Bug	13.9%	Scale-Hard	18.8%	Scale-Hard	22.7%
Thrips	23.5%	Thrips	12.9%	Billbug	10.1%	Leafminer	15.6%	Aphids	22.7%
Mealybug	10.6%	Scale-Hard	12.9%	Mole Cricket	3.8%	Scale-Soft	15.6%	Scale-Soft	12.0%
Scale-Hard	5.9%	Psyllid	12.9%	Cranefly	3.8%	Aphids	12.5%	Leafminer	6.7%

Table 9. Top-three "most used" insecticide classes if neonicotinoids were not available (industry segments combined).

Insecticide Chemical Class	Mode of Action Classification	Percent of Top 3 Insecticides	Change in Percent Use Compared to Table 2
Pyrethroid	3A	30.3%	7.8
Organophosphate	1B	15.5%	10.0
Avermectin	6	8.5%	0.2
Carbamate	1A	5.2%	2.4
Diamide	28	4.6%	3.7
Nematode, oils, soaps, aerosols	Not Applicable	4.0%	1.0
Compounds of unknown or uncertain MOA	UN	4.0%	0.9
Tetramic acid derivatives or tetronic acid	23	3.6%	2.8
Spinosyn	5	3.4%	0.5
Tetradifon	12D	2.7%	1.7
Pymetrozine	9B	2.5%	1.2
Other Product Not Listed		10.1%	0.0
Products in all other classes listed in Appendix 1	All other MoA in Appendix 1	< 1.0% each	

and thrips (23.5 percent). Very similar is the nursery segment that will be dealing with aphids (35.4 percent), whitefly (25.8 percent) and thrips (12.9 percent). The lawn segment will have to find other techniques and products to manage grubs (68.4 percent), chinch bug (13.9 percent) and billbug (10.1 percent). Landscape ornamental professionals highlighted flatheaded borers (37.5 percent), hard scale (18.8 percent) and the leafminer (15.6 percent). In a similar fashion the tree segment will be challenged with flatheaeded borers (36.0 percent), hard scale (22.7 percent) and aphids (22.7 percent).

As with an earlier question, respondents were also asked to select the top three non-neonicotinoid insecticide products they would use most (in terms of square footage applied or number of plants treated) if neonicotinoids were not available. All of the neonicotinoid products listed in Appendix 1 were excluded as available options when respondents were asked to identify alternative products. The insecticide classes for the products selected are listed in Table 9 and broken out by industry segment in Table 10. Both tables include the difference for the chemical class from what was identified in Tables 2 and 4. Overall there would be 7.8 percentage points increase in the pyrethroid products included among their top three "Most Used" insecticides and 10 percentage points increase in organophosphate products identified as a "Most Used" insecticide. Other chemical classes identified that would be used if neonicotinoids were not available include increases for diamides (3.7 percentage points), tetramic acid or derivatives (2.8 percentage points) and carbamates (2.4 percentage points). As expected, Table 10 illustrates that there are differences between industry segments as to the insecticide selected under an assumption that neonicotinoids are no longer available. For example, the products most selected as top three insecticides for the lawn, landscape ornamentals and trees would be pyrethroids, whereas the greenhouse and nursery industry identified organophosphates most frequently.

In the lawn segment, pyrethroids made up 43.3 percent of the top three "Most Used" products identified, which is a 4.8 percentage points increase over the current situation. Next would be diamides (18.3 percentage points) as a top three insecticide, an increase of 15.5 percentage points over the current situation. The next chemical class would be tetradifons where the comparable figures are 12.2 percentage points and 8.2 percentage points, respectively. The landscape ornamentals segment would have 36.7 percent of the top three insecticides as pyrethroids under a no neonicotinoid scenario, and this is a 13.8 percentage points increase over the current selection. Organophosphates as one of the top three insecticides of choice for landscape professionals would be 17.4 percent, a 9.5 percentage points increase over the current situation. A few (6.4 percent) of the "Most Used" products selected would be carbamates, and this is a 1.1 percentage points increase over the current selection. In the tree segment, the shift would be to pyrethroids (40.4 percent), and this would be a 15.1 percentage points increase over what is currently selected as a top three insecticide. The next shift to a chemical class would be avermectins (17.2 percent), which would be a 4.1 percentage points increase over current selections. Organophosphates were identified as 14.7 percent of products, and this is a 9.1 percentage points increase over top three selections at present. Greenhouses would see a shift to organophosphates (16.2 percent) as "Most Used" insecticides, which represents an 11.1 percentage points increase over the current selection. This is followed

Table 10. Top-three "most used" insecticide classes if neonicotinoids are not available (by industry segment).*

Industry Segment	Insecticide Chemical Class	Mode of Action Classification	Percent of Products	Difference in Percentage Points from Table 4
Greenhouse	Organophosphate	1B	16.2%	11.1
	Pyrethroid	3A	12.7%	6.0
	Avermectin	6	10.1%	-3.2
	Compounds of unknown or uncertain MoA	UN	10.1%	0.7
	Pymetrozine	9B	7.0%	2.5
	Nematode, oils, soaps, aerosols	Not Applicable	7.0%	-0.9
	Spinosyn	5	5.3%	0.1
	Tetramic acid derivatives or tetronic acid	23	5.3%	3.4
	Carbamate	1A	3.1%	2.5
	Pyrrole	13	3.1%	0.7
	Juvenile hormone mimic	7A	2.2%	1.3
	Flonicamid	9C	1.8%	1.2
	Meti acaracide	21A	1.3%	0.1
	Other product not listed		11.8%	1.2
Nursery	Organophosphate	1B	25.4%	17.1
	Pyrethroid	3A	23.1%	5.0
	Carbamate	1A	9.2%	3.2
	Tetramic acid derivatives or tetronic acid	23	8.5%	6.3
	Avermectin	6	7.7%	-3.3
	Pymetrozine	9B	3.8%	2.2
	Nematode, oils, soaps, aerosols	Not Applicable	4.6%	1.8
	Compounds of unknown or uncertain MoA	UN	2.3%	-1.5
	Spinosyn	5	1.5%	-1.2
	Other product not listed		12.3%	-0.3
Lawn	Pyrethroid	3A	43.3%	4.8
	Diamides	28	18.3%	15.5
	Tetradifon	12D	12.2%	8.2
	Carbamate	1A	7.2%	4.7
	Organophosphate	1B	7.2%	4.7
	Spinosyn	5	2.8%	1.8
	Phenylpyrazole	2B	2.2%	0.3
	Hydramethylnon	20A	1.1%	0.5
	Other product not listed		4.4%	1.3

Continued on next page

Table 10. Continued.

Industry Segment	Insecticide Chemical Class	Mode of Action Classification	Percent of Products	Difference in Percentage Points from Table 4
Landscape Ornamentals	Pyrethroid	3A	36.7%	13.8
	Organophosphate	1B	17.4%	9.5
	Carbamate	1A	6.4%	1.1
	Compounds of unknown or uncertain MoA	UN	5.5%	4.2
	Avermectin	6	4.6%	1.5
	Nematode, oils, soaps, aerosols	Not Applicable	5.5%	2.4
	Diamide	28	2.8%	2.3
	Other product not listed		16.5%	3.3
Trees	Pyrethroid	3A	40.4%	15.1
	Avermectin	6	17.2%	4.1
	Organophosphate	1B	14.7%	9.1
	Spinosyn	5	4.6%	1.5
	Tetramic acid derivatives or tetronic acid	23	3.5%	3.0
	Carbamate	1A	2.0%	0.3
	Pyriproxyfen	7C	2.0%	0.9
	Diamide	28	1.5%	0.7
	Nematode, oils, soaps, aerosols	Not Applicable	2.5%	1.7
	Thiazolidinone or tetrazine	10A	1.0%	0.7
	Compounds of unknown or uncertain MoA	UN	1.0%	0.2
	Other product not listed		8.6%	-4.0

* Products not listed on the table but found in Appendix 1 represented <1% of the products identified as a top 3 most used product.

by a shift to pyrethroids (12.7 percent), a 6.0 percentage points increase over current selections. Greenhouse professionals also reported that 10.1 percent would shift to avermectins, which is a decrease of 3.2 percentage points from the current. The nursery professionals reported a shift to organophosphates (25.4 percent) representing a 17.1 percentage points increase for this chemical class. This was followed by pyrethroids (23.1 percent) representing a 5 percentage points increase and carbamates (9.2 percent), which is a 3.2 percentage points increase over the current selection of top three insecticides.

Table 11 illustrates the financial diversity of businesses in the turf and ornamental industry through the range of business incomes reported by respondents. The professionals were asked about the total gross income for their business in 2013. The results to this question are reported, but it needs to be noted that only 10 to 27 percent of respondents by industry emphasis provided an answer. This may be because individual survey respondents were associated with field operations rather than managerial functions, or

Table 11. Annual company income by industry segment as reported by respondents.

Category	Average	Median	Minimum	Maximum
Greenhouse	$6,722,468	$1,000,000	$3,000	$90,000,000
Nursery	$10,088,654	$2,977,500	$75,000	$60,000,000
Lawn	$16,033,875	$675,000	$4,000	$850,000,000
Landscape Ornamentals	$63,305,222	$1,250,000	$15,000	$1,000,000,000
Trees	$15,978,221	$1,000,000	$100	$400,000,000

they simply did not want to provide the income information. The intent of this question was to determine if any relationship existed between gross income and likely impacts on business income if neonicotinoids were no longer available (Table 6). The average income loss across the industry segments was expected to be 15 percent, but the low number of responses to the business gross income question precludes further generalization.

4.0 Conclusion

It is not unusual for surveys to generate new questions with the answers to the original survey questions. There were some clear and consistent themes that emerged from this survey, but there were also issues raised that were beyond the design and function of this survey. Before summarizing these themes and unresolved issues, a review of the survey itself is in order. This survey is part of a much larger effort to understand the value of neonicotinoids in both the turf and ornamental industry (or "Green Industry") and North American agriculture. It is not intended to be a comprehensive survey of insecticide use in turf and ornamental applications. Instead, it approached the challenge of establishing value by raising questions on the impacts that might occur if neonicotinoids were no longer available. Our conclusion is that neonicotinoids have significant value in the turf and ornamental industries, primarily by allowing professionals to meet customer expectations.

The following summary of themes and issues demonstrates that answers were found, but that ambiguity associated with unknown and unintended consequences also prevents further conclusions. Simply put, respondents reflected that the removal of neonicotinoids from this industry would lead to outcomes that the survey was not designed to capture fully. Some of these unintended consequences are identified in the issues presented.

Theme – The Choice of Neonicotinoids

The turf and ornamental industry is different in its use of insecticides than firms in agricultural settings (i.e. food and fiber crops). This difference reflects the close connection between the application of insecticides and the customer. Applying insecticides to a residential landscape is different than applying insecticides to a large field crop in a rural area. The professionals who responded to this survey have directly and indirectly (through open-ended comments) pointed out the significance of customer safety in

Sidebar 3. Respondents comments about the challenges of pest management without the use of neonicotinoids.

"We work in urban and suburban environments. We have extensive issues with scale and whitefly invaders in landscape trees. It is hazardous and impractical to spray pesticides 25 feet or more in the air. Injection of a systemic (insecticide) has greatly reduced the potential exposure to people, pets and water. It has also prevented a rain of honeydew from destroying auto finishes and patio furniture. "

"That is understandable if they were prohibited from being sprayed as foliar treatments since root zone treatments have shown not to translocate into flower parts. However, we must be able to maintain its use with soil or trunk injection methods. "

"The use of neonicotinoids as systemic insecticides would be a far greater loss. There are many more alternatives for them as foliar sprays, but very few alternatives that will move within a plant for pests not accessible by foliar application."

"Again, the loss of soil applied systemic will greatly increase the number of foliar applications that will need to be made to control multi-generation insects. This I feel will increase vulnerability to bees and put more pesticides into the environment than necessary. More than if soil applied neonics were allowed."

"These are systemic products which is a very useful mode of action and reduces the risk of drift. They can be used in sensitive areas such as windy places, and near where people frequent."

their responses. These professionals value and choose neonicotinoids because of their performance and safety profile. Neonicotinoids offer systemic properties, exhibit long-term efficacy, and provide a low-risk to the applicators, customers and their pets. Neonicotinoids are not being selected to minimize insecticide purchasing costs. In fact, they can be more expensive but are preferred over alternative products because they address the factors rated most important by the respondents—Plant quality, Consistent pest control and Safety to applicators and customers.

Theme – Customer Satisfaction

Nearly 60 percent of the survey respondents reported that a neonicotinoid was among their top three "Most Used" insecticides. The attributes of neonicotinoids have led to their widespread adoption in the turf and ornamental industry. Customer safety, avoiding the need for multiple applications and providing superior results are critical to this industry. The turf and ornamental industry depends heavily on customer satisfaction with the products and services provided. One of the respondents stated, "Neonics are very flexible products that give us good control at a good price. Our customers are very happy with the results they provide. I honestly don't know how we would provide service without them." There are similarities between this industry and fresh produce markets where customers prefer fruits and vegetables with a clean, healthy appearance (Bunn et al., 1990, Kelly et al., 2001). The professionals completing this survey reinforced this consumer point of view in their responses to both the value of neonicotinoids and the impact if they lost access to this class of insecticides. Customer needs and concerns are also discussed in the case study reports that are part of the overall effort (see *A Case Study of Neonicotinoid Use for Controlling Silverleaf Whitefly in Ornamentals, A Case Study of Neonicotinoid Use for Controlling Chinch Bug in Florida St. Augustinegrass* and *A Case Study of Neonicotinoid Use for Controlling Emerald Ash Borer—The Naperville, Illinois Experience*).

Theme – Relation to IPM and Resistance Management

The professionals indicated how they would respond without neonicotinoids to the challenges of pest management. Without neonicotinoids, we can expect a decrease in the practice of IPM and a decreased ability to rotate the insecticidal modes of action as part of resistance management. These changes are likely for two main reasons: the likely shift from the use of systemic insecticides to those applied by foliar methods and the non-selective characteristics of the primary chemical alternatives to neonicotinoids that were identified in the survey. These two changes may create challenges for pest management that will vary with industry segment, location and the nature of the pest. These and related issues were expressed by some respondents as seen in the Sidebar 3.

Theme – Impacts on Turf and Ornamental Businesses

The survey results showed that a loss of neonicotinoids would have mixed impacts across the industry—negative for many, neutral for others and positive for a few. The negative impacts would be due to both the challenges of managing difficult to control pests in a manner safe to applicators and customers and to the challenges of maintaining customer satisfaction in a very competitive industry with increased costs. The increased costs were

associated with increased applications and quantities of alternative insecticides and with the labor costs linked to record keeping, training and scouting. The average anticipated income loss of 15 percent would challenge the tight profit margins of many businesses. Some respondents said that such impacts may be avoided, and for the businesses built around organic pest control, the loss of neonicotinoids could have a positive impact.

Theme – Decisions Based on Science

Industry professionals use a wide range of scientific principles, including economics, chemistry, entomology, mathematics and statistics, to guide their daily activities when dealing with risk management. Open-ended written comments suggested that they see the scientific evidence for eliminating neonicotinoids as inconclusive, and that emotion and fear were driving much of the attention given to this issue. As one respondent stated, "There is currently not enough peer reviewed, scientific-based evidence to suggest a problem with using neonicotinoids in blooming plants and the direct correlation to pollinator decline." Another stated, "Accurate information needs to be given to the media and consumer. Emotional presentations are not helpful but need to be scientifically-based studies. Present the facts, not the emotional narratives."

Issue – Pollinator Health

The implicit question that is behind this survey, discussions within the regulatory community and an increasingly rancorous public debate is the effect of neonicotinoids on pollinator health. The survey was not designed to address the biology of pollinators and neonicotinoids, but it does illustrate a critical element that needs to be part of the debate. What is often not realized and is exemplified by the results in this survey is that there is no uniform or homogeneous use of neonicotinoids in the turf and ornamental industry. Professionals are making diverse decisions regarding the use of insecticides based on efficacy and safety. Further research about how these insecticides are actually being used and the criteria used to drive those decisions will help clarify potential implications of industry professionals shifting to other insecticide classes. This has been lacking from the discussion, and while this survey offers insight, more needs to be done. The case studies cited earlier provide additional insights on this but are not sufficient. Further in-depth examination is needed to fully capture the diversity of how this chemical class is being used in the turf and ornamental industry and the challenges of replacing the value it brings.

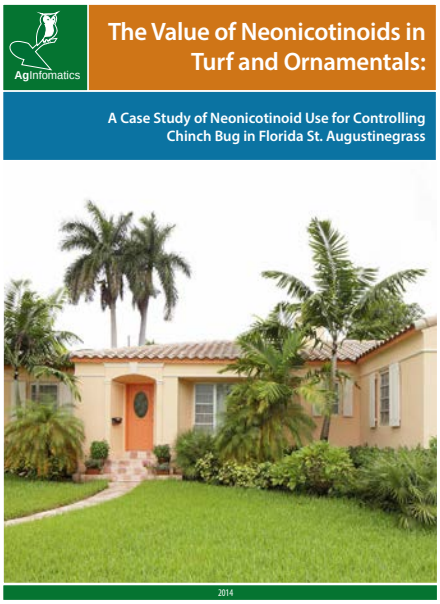
Issue – The Scaling of Pest Management

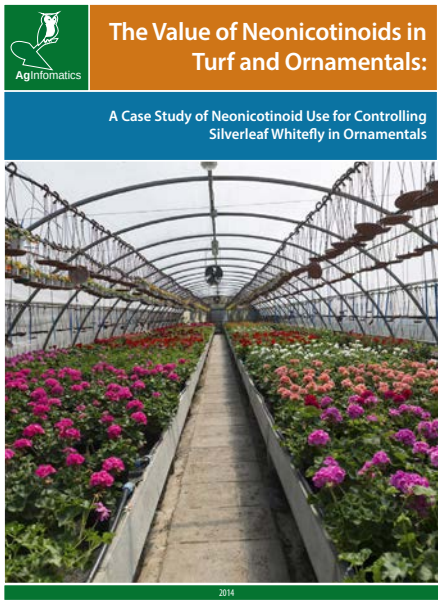
This survey presents the perspective of professionals who use insecticides to address unique pest management needs in their greenhouses, nurseries, lawns, landscape ornamentals and trees. A question not addressed in the survey was that of pest dynamics on a larger scale if neonicotinoids were not available. For example, as highlighted in *A Case Study of Neonicotinoid Use for Controlling Chinch Bug in Florida St. Augustinegrass,* turf management professionals suspect that the chinch bug, which already demonstrates pyrethroid resistance, would rapidly become a regional pest that could not be controlled without neonicotinoids. Residential citrus trees would also be at risk due to the inability to control Asian citrus psyllid, which is the vector

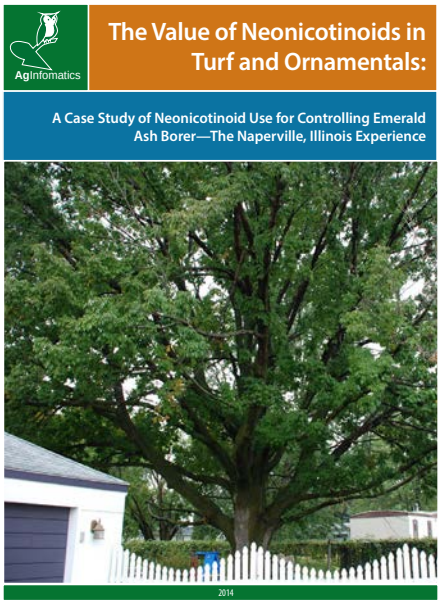
of a bacterial disease that currently threatens all citrus in Florida (see *A Case Study of Neonicotinoid Use in Florida Citrus*). Another example is the emerald ash borer, where individual homeowner pest management decisions are being overwhelmed by the dynamics of pest ecology (see *A Case Study of Neonicotinoid Use for Controlling Emerald Ash Borer—The Naperville, Illinois Experience*). This survey did not attempt to gauge industry perceptions of the benefits that neonicotinoids provide in controlling these and other regional pests. It would be worthwhile for other investigators to model these biological and economic dynamics.

Issue – Uncertainty

Imidacloprid was registered with the EPA in 1994, and the other nitroguanidine neonicotinoids followed. In a relatively short time, they have become the major insecticide chemical class used in the turf and ornamental industry. Professionals have come to depend on them based on experience with the efficacy of these products. Younger professionals in the industry only know these products and have little familiarity with the insecticides that preceded neonicotinoids in the market. This history and context introduce uncertainty in the responses of those who are asked to assume neonicotinoids will not be available and what they would do under these circumstances. This uncertainty was evident in the answers to some questions and in other cases where respondents chose not to answer some questions. We expect this uncertainty to diminish as more information is made available on the role of neonicotinoids in this industry.







5.0 References

Bunn D., L. Lynch, and R. Sommer. 1990. *Consumer Acceptance of Cosmetically Imperfect Produce.* J. Consum. Aff. 24:268–279.

Courtois R. 2010. *Counterfactual*. Regional Focus, First Quarter, Federal Reserve Bank of Richmond.

Cowan R., and R. Foray. 2002. *Evolutionary Economics and the Counterfactual Threat: On the Nature and Role of Counterfactual History as an Empirical Tool in Economics.* J. Evol. Econ. 12: 539–562.

Dietz M.E., and J.C. Clausen. 2006. *Saturation to Improve Pollutant Retention in a Rain Garden.* Environ. Sci. Technol. 40:1335–40.

Ferraro P.J. 2009. *Counterfactual Thinking and Impact Evaluation in Environmental Policy*. In M. Birnbaum & P. Mickwitz (Eds.), *Environmental Program and Policy Evaluation: Addressing Methodological Challenges.* New Directions for Evaluation. 122: 75–84.

Fuller R.A., K.N. Irvine, P. Devine-Wright, P.H. Warren, and K.J. Gaston. 2007. *Psychological Benefits of Greenspace Increase With Biodiversity*. Biol. Lett. 3, 390–394.

Fulton W., R. Pendall, M. Nguyen, and A. Harrison. 2001. *Who Sprawls the Most? How Growth Patterns Differ Across the United States.* Washington (DC): The Brookings Institution. Center on Urban and Metropolitan Policy.

Golubiewski N.E. 2006. *Urbanization Increases Grassland Carbon Pools: Effects of Landscaping in Colorado's Front Range*. Ecol. Appl. 16(2):555–71.

IBISWorld Inc., 2014a. *IBISWorld Industry Report 56173*, Landscaping Services in the U.S. (May).

IBISWorld Inc., 2014b. *IBISWorld Industry Report 11142*, Plant & Flower Growing in the U.S. (July).

Kelly K.M., B.K. Behe, J.A. Biernbaum, and K.L. Poff. 2001. *Consumer Preference for Edible- Flower Color, Container Size and Price.* Hort-Science. 36:801–804.

Raciti S.M., P.M. Groffman, and T.J. Fahey. 2008. *Nitrogen Retention in Urban Lawns and Forests*. Ecol. Appl. 18(7):1615–26.