AgInfomatics

The Value of Neonicotinoids in Turf and Ornamentals:

Executive Summary

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

Reports include:

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

Value of Insect Pest Management to U.S. and Canadian Corn, Soybean and Canola Farmers

A Meta-Analysis Approach to Estimating the Yield Effects of Neonicotinoids

An Economic Assessment of the Benefits of Nitroguanidine Neonicotinoid Insecticides in U.S. Crops

A Summary of Grower and Agri-Professional Perspectives From Regional Listening Sessions in the United States and Canada

A Case Study of Neonicotinoid Use in Florida Citrus

A Case Study of Neonicotinoid Use in Mid-South Cotton

Executive Summary

The Value of Neonicotinoids in Turf and Ornamentals

Reports include:

Estimating the Economic Value of Neonicotinoid Insecticides on Flowers, Shrubs, Home Lawns and Trees in the Homescape

The Value of Neonicotinoids to Turf and Ornamental Professionals

A Case Study of Neonicotinoid Use for Controlling Chinch Bug in Florida St. Augustinegrass

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

A Case Study of Neonicotinoid Use for Controlling Silverleaf Whitefly in Ornamentals

Executive Summary

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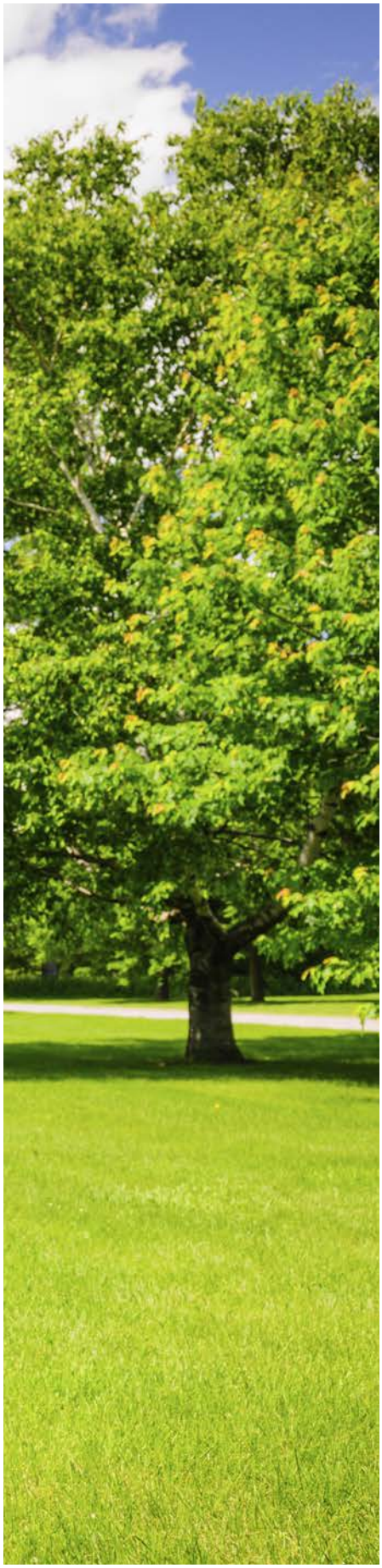


Contents

1.0 Introduction 1

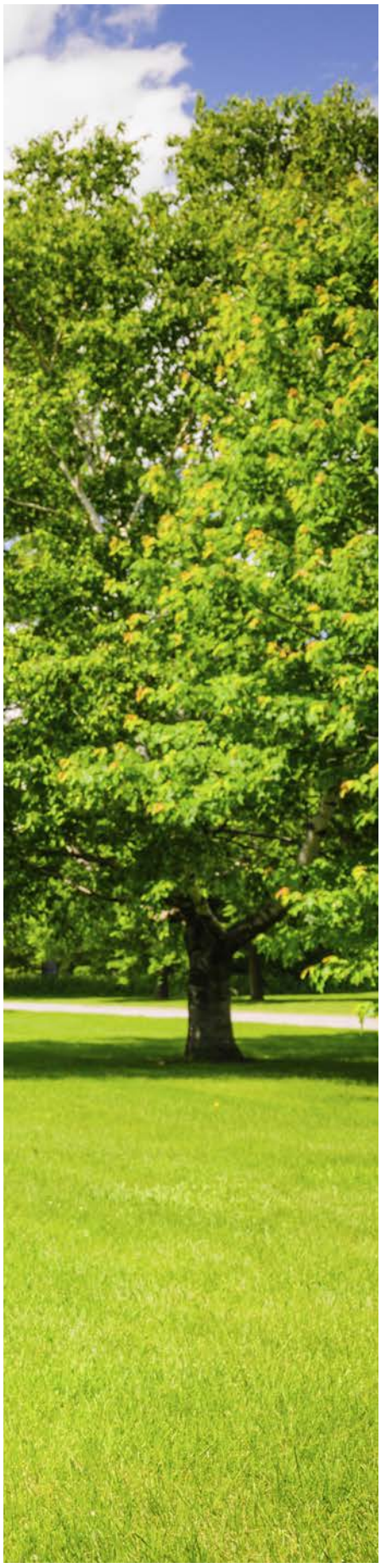
2.0 Research Strategy 2

3.0 Methods and Results for the Turf and Ornamental Industry Reports 4

- Estimating the Economic Value of Neonicotinoid Insecticides on Flowers, Shrubs, Home Lawns and Trees in the Homescape 5
- The Value of Neonicotinoids to Turf and Ornamental Professionals 8
- A Case Study of Neonicotinoid Use for Controlling Emerald Ash Borer—The Naperville, Illinois, Experience 11
- A Case Study of Neonicotinoid Use for Controlling Silverleaf Whitefly in Ornamentals 12

4.0 Conclusion 13

5.0 Footnotes 15

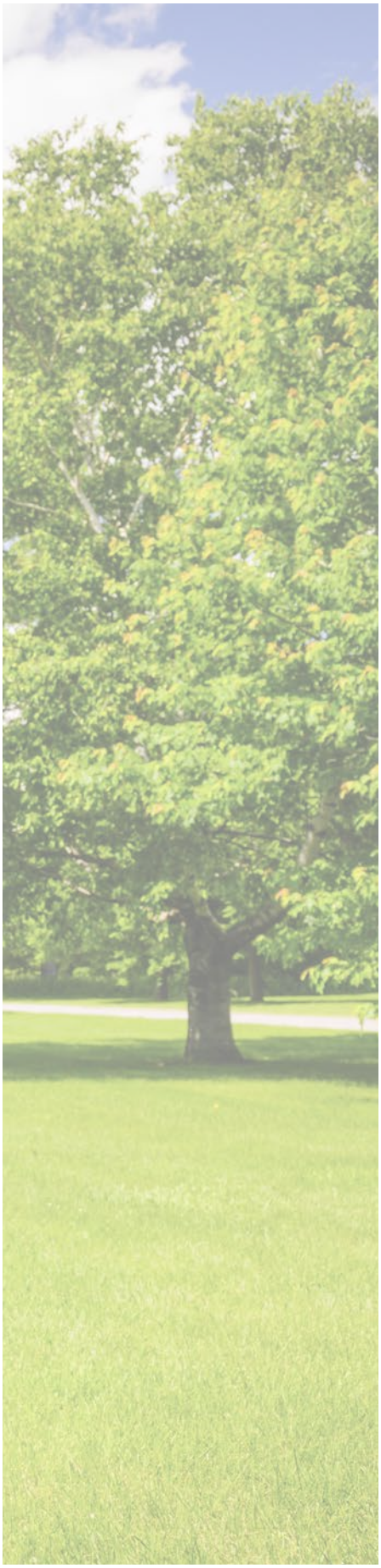


1.0 Introduction

AgInfomatics LLC was charged with providing a comprehensive analysis on the agronomic, environmental and socio-economic benefits of the neonicotinoid insecticides used in the U.S. turf and ornamental industry. The function of the reports from this project is to advance discussions regarding policy that may influence the use of nitroguanidine neonicotinoid insecticides (clothianidin, dinotefuran, imidacloprid and thiamethoxam) in the U.S. and Canadian turf and ornamental industry. Both costs and benefits need to be considered in the policy decisions regarding a technology, program, scheme or product. Value refers to the benefits associated with a good or service and can be expressed in both monetary and non-monetary terms. Monetary value is often expressed in dollars, whereas non-monetary value refers to the importance, preferences, needs or demands that are expressed.

Dr. Fran Pierce, a soil scientist and past President of the American Society of Agronomy, and Dr. Peter Nowak, a rural sociologist who specialized in measuring the adoption of agricultural technologies, are the principals of this firm. Dr. Paul Mitchell, an agricultural economist with extensive experience in quantifying the role of pesticides in modern agriculture, was contracted to join AgInfomatics in this project. As the project was implemented, experts were then hired as sub-contractors. In alphabetical order, the AgInfomatics team includes:

- Dr. Ken Genskow, an associate professor in the department of urban and regional planning, specializes in environmental planning and policy at University of Wisconsin-Madison and has extensive experience in survey research.
- Dr. Russell Groves, an associate professor of entomology at University of Wisconsin-Madison, specializes in the ecology and management of insects of commercial and fresh market vegetable crops and served as a technical advisor on the entomological dimensions of this project.
- Dr. Terry Hurley, an associate professor of agricultural economics at the University of Minnesota-St Paul, specializes in valuation of non-market goods and services.
- Dr. Paul Mitchell, an associate professor in the department of agriculture and applied economics at the University of Wisconsin-Madison, is a leading expert in the field of economic entomology.
- Dr. Pete Nowak, an emeritus professor in the Nelson Institute for Environmental Studies at University of Wisconsin-Madison, is a principal and co-founder of AgInfomatics.
- Dr. Fran Pierce, an emeritus professor at Washington State University, former director of the Center for Precision Agricultural Systems and past-president of the American Society of Agronomy, is a principal and co-founder of AgInfomatics.
- Dr. Bret Shaw, an associate professor in the department of life sciences communication at the University of Wisconsin-Madison, has expertise



in both the private and public sector using quantitative and qualitative measurement techniques.

- Dr. Chengyan Yue, an associate professor in applied economics and also in horticultural science at the University of Minnesota-St. Paul, specializes in consumer choices and sustainable agricultural systems.

2.0 Research Strategy

Counterfactual logic was used to guide the overall analysis on assessing value of neonicotinoids. This approach states that if we assume neonicotinoids are no longer available, the value of these insecticides will then become apparent as alternatives and impacts are identified and measured. The term counterfactual implies, 'contrary to the facts.' By hypothetically removing neonicotinoids, their value becomes apparent by measuring substitutions, adjustments, gains and losses in the quality or quantity of plants, and other impacts related to human safety and the environment.[1]

Counterfactual analyses are commonly used in economic and political disciplines where it is necessary to assess the likely impacts of proposed policies and regulations.[2] Cowan and Foray[3] note that counterfactual condition statements are ubiquitous in any scientific endeavor and discuss the strengths and pitfalls of the approach. The counterfactual analysis used in this project was based on addressing the question, "What would happen to the turf and ornamental industry in the United States if neonicotinoids were not available?"

Identifying the value of neonicotinoids in the turf and ornamental industry required a sophisticated methodology. AgInfomatics selected a strategy of data triangulation to provide the most robust answer to the counterfactual question.[4] Data triangulation uses multiple methods to analyze the same phenomena. In this case, qualitative techniques were used to define the scope of the issues and to provide in-depth perspectives that are not possible with just statistical analyses or data summaries. Multiple quantitative techniques allowed development of specific results that could then be integrated with other results for further analysis or could provide a stand-alone understanding of the value of neonicotinoids. According to Denzin[5], "The combination of multiple methodological practices, empirical materials, perspectives and observers in a single study is best understood as a strategy that adds rigor, breadth complexity, richness and depth to any inquiry." There are two key advantages to data triangulation:

- Measuring the same phenomena using different methods enhances the **validity** of the results through eliminating bias and potential alternative explanations of the research question.
- Methodological triangulation also provides an opportunity to explore unanticipated findings when there is divergence in the results of different methods. Triangulating methods does not mean all the methods generate consistent results, but differences or nuanced discrepancies may lead to further understanding of the phenomena being investigated. Working to understand why different methods may generate different outcomes increases the **credibility** of the analysis.

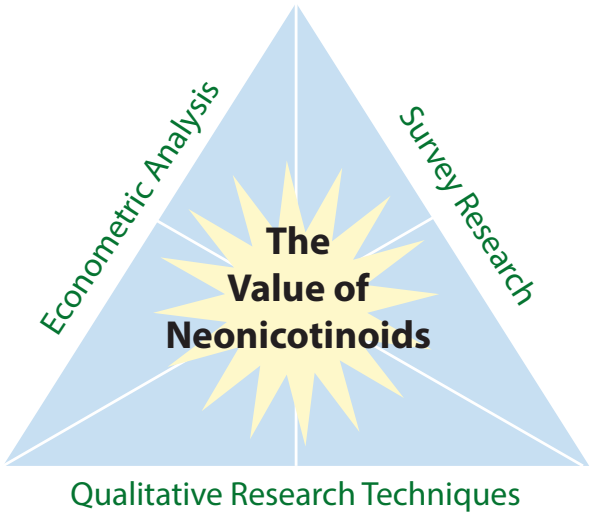
While econometric analysis remains the foundation of the overall effort and other methods build on this foundation, there are examples in the literature where: economic models are triangulated with assessments by experts; different economists' estimates are triangulated with each other; different types of data are used; and different trials of the same technique and different types of technique are combined.[6] Data triangulation can consolidate multiple outcomes into a consistent interpretation of significance. The case study, an important component of this triangulation process, is an in-depth descriptive analysis and investigation of a specific situation. The advantage is the richness and complexity it offers, while the disadvantage is the time and costs it takes to produce this outcome.

In these reports, data triangulation involved the following methods and techniques:

- ***Estimating the Economic Value of Neonicotinoid Insecticides on Flowers, Shrubs, Home Lawns and Trees in the Homescape:*** A national survey of 7,472 U.S. households employing valuation techniques[7] to establish the economic value of neonicotinoids in flowers, shrubs, lawns and trees in the homescape.

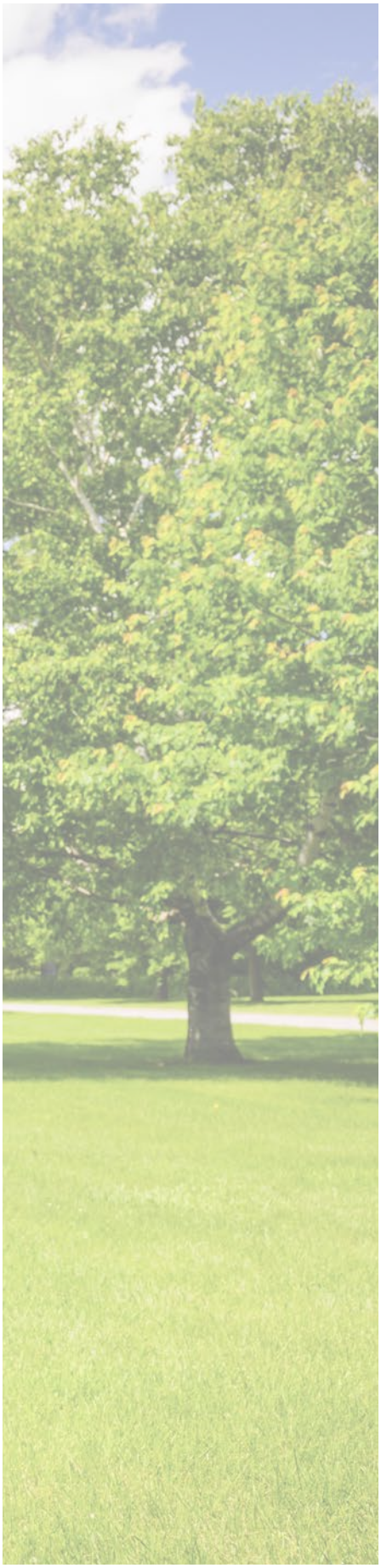
- ***The Value of Neonicotinoids to Turf and Ornamental Professionals:*** A national survey of 750 members of four professional associations whose members use insecticides in commercial turf and ornamental applications.

- ***A Case Study of Neonicotinoid Use for Controlling Chinch Bug in Florida St. Augustinegrass:*** An in-depth case study of the turf industry's battle with the southern chinch bug in Florida.



- ***A Case Study of Neonicotinoid Use for Controlling Emerald Ash Borer—The Naperville, Illinois, Experience:*** A case study based on how Naperville is responding in an innovative fashion to the emerald ash borer (EAB).

- ***A Case Study of Neonicotinoid Use for Controlling Silverleaf Whitefly in Ornamentals:*** A case study on how the ornamental flower and plant industry is responding to the silverleaf whitefly.



3.0 Methods and Results for the Turf and Ornamental Industry Reports

The turf and ornamental industry, also referred to as the Green Industry, is diverse in composition and ubiquitous in its presence across the North American landscape. Most citizens have a direct or indirect contact with some aspect of this industry on a daily basis. Products and services are associated with commercial and residential landscape maintenance; golf courses; floriculture and nursery plant production; athletic fields; maintenance of plants and flowers within retail and office settings; landscape construction; nursery and tree production; irrigation systems; maintenance in public parks, roadsides and green space; tree services; pest control; and branch removal around utility lines.

Formally, the Green Industry complex includes an integrated arrangement of input suppliers that includes ornamental plant producers and sod growers. It also includes wholesale distribution firms that include importers, brokers, re-wholesalers and transporters of ornamental plants. Next in this chain would be the horticultural service firms that provide turf, landscape and urban forestry services, including design, installation and maintenance. Finally, there are the retail operations that range from small independent garden centers and florists to large home improvement centers, mass merchandisers and chain stores.

The IBISWorld Industry Report estimates that U.S. revenues in 2014 will be $72.9 billion, representing almost 400,000 businesses for what they define as landscaping services.[8] These include turf maintenance, planting tree, shrubs and other plants, irrigation and water management, arbor services, and general landscape design and installation. It would also include snow and ice management on a seasonal basis in some regions of the country. For plant and flower growing, IBISWorld estimates $13.2 billion representing 35,340 businesses. Yet these IBISWorld Industry reports may not capture the full extent of the Green Industry complex contribution to the economy.

According to a comprehensive 2005 study, the economic impacts for the U.S. Green Industry in 2002 were estimated at $147.8 billion in output, 1,964,339 jobs, $95.1 billion in value added, $64.3 billion in labor income and $6.9 billion in indirect business taxes.[9] These are all adjusted values to 2004 dollars. This study also examined urban forestry and found:

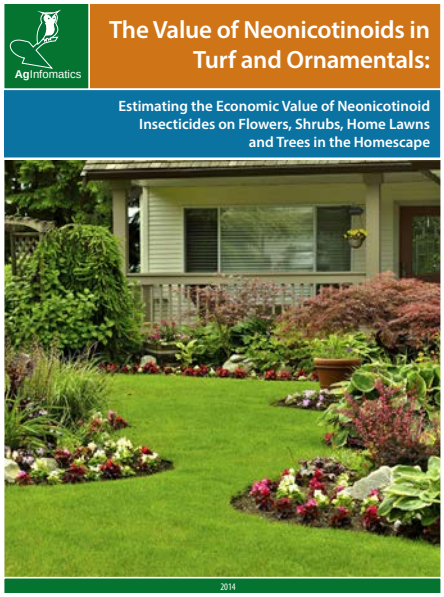
> *"the value of tree production suitable for urban forestry, including deciduous, evergreen, fruit and Christmas trees, was $4.63 billion. The value of tree care services was $9.92 billion, which represented 27.1 percent of the output of the landscaping services sector. The total output of tree production and care services was valued at $14.55 billion, which translated into $21.02 billion in total output impacts, 259,224 jobs, $14.12 billion in value added, $9.93 billion in labor income and $516 million in indirect business tax impacts. To put these numbers into perspective, consider that all of U.S. agriculture had a gross domestic product value of $173 billion for 2011 according to the U.S. Department of Commerce, Bureau of Economic Analysis. The Green Industry is a significant sector of the U.S. economy."*

Hall and Dickson[10] provide an accounting of the Green Industry in ways that are often unrecognized relative to economic, environmental and human health benefits. These benefits are summarized in Table 1.

Table 1. Diverse values of the Green Industry.

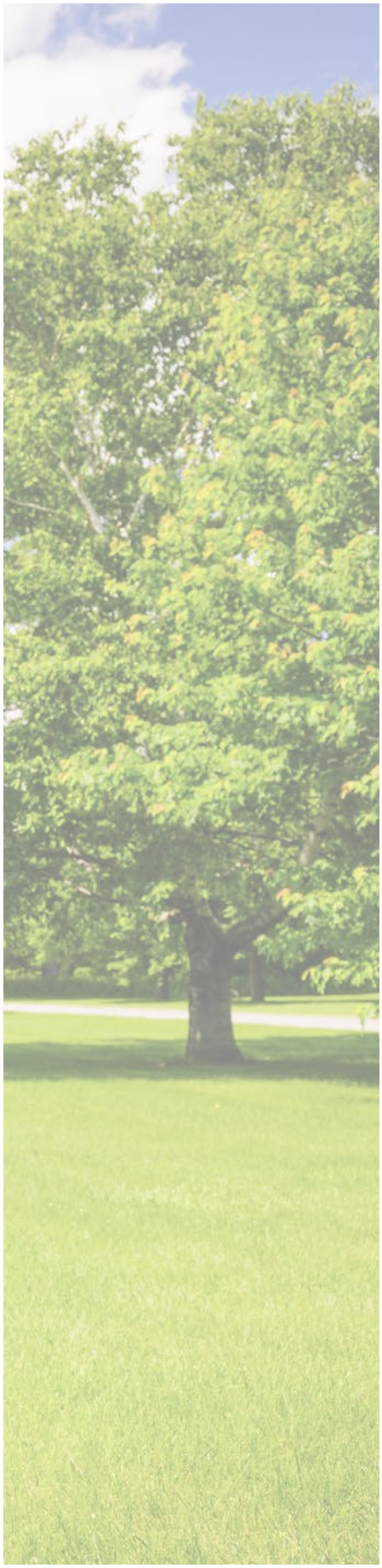
Economic	Environmental	Well-Being
Landscape beautification increases customer base	Green plants sequester carbon	Ornamental landscapes improve concentration and memory
Landscape amenities boost occupancy rates	Wildlife and biodiversity are linked to landscaping	Ornamental plants create positive learning setting
Parks & botanical gardens increase tourism	Save energy by reducing heating and cooling of homes	Flowers increase happiness and well-being
Creating and maintaining green space means jobs	Reduce heat and cold damages to homes	Gardening and landscaping reduce stress
Recreational services reduce health care costs	Provide offset to heat island impacts	Plants accelerate the healing process
Landscaping increases property values	Reduce in noise pollution	Natural settings improve human performance
Higher property values increases tax revenue	Reduce soil erosion and storm water runoff	Landscaping can reduce community crime
Trees along streets reduce need for repairs	Reduce urban glare and provide windbreaks	Beautifying traffic medians improves safety

The AgInfomatics reports begin with a survey of homeowners, who are the focal point of the Green Industry. Understanding the value homeowners place on neonicotinoids based on the attributes is the focus of the first report. Complimenting the homeowner survey is a report summarizing results from a survey of Green Industry professionals. Building on these two reports using survey research are three in-depth case studies. As would be expected with a methodological triangulation strategy, each case study provides a different insight to the value of neonicotinoids in the turf and ornamental industries. The case study in Florida with the chinch bug in St. Augustinegrass illustrates how this pest would overwhelm other management strategies without the use of neonicotinoids. The Naperville case study illustrates a locally-led effort to use neonicotinoid insecticides against the Emerald Ash Borer (EAB), which threatens the aforementioned benefits of trees in local communities. The final case study focuses on the silverleaf whitefly, which threatens plants in the turf and ornamental industry, as well as agricultural crops. Keeping this pest in check involves a coordinated effort of inspection, training, integrated pest management (IPM) and pesticide resistance management. Neonicotinoids play a critical role in this overall strategy.



Estimating the Economic Value of Neonicotinoid Insecticides on Flowers, Shrubs, Home Lawns and Trees in the Homescape

The objective of this report was to estimate the economic value to homeowners of various insecticide attributes in general and neonicotinoid insecticides, specifically when used to protect residential flowers and shrubs, lawns and trees. Any insecticide offers multiple attributes, such as effective-



ness, cost and convenience of application, safety to pets, impact on wildlife and bees, and the risk to the residents. A research method called Willingness To Pay (WTP)[11] was used to establish the value of these attributes and the use of neonicotinoids on residential flowers,shrubs, lawns and trees.

Sample questions were screened and modified based on a focus group of 60 residents from the St. Paul, Minneapolis area. The resulting surveys investigated nine insecticide attributes that were employed in three separate surveys addressing lawns, flowers or shrubs, and trees. One way to think about attributes is they are what consumers look for when selecting an insecticide. Ordinal scales[12] had to be created for each of the attributes to help establish value. Respondents were asked to place a value on the categories of each attribute (e.g., value given to high, medium or low levels of the attribute). These attributes and their categorical values are:

- Effectiveness of control (very high, high, medium)
- Number of applications required for comparable length of control (1 time, 2 to 3 times, 4 or more times)
- Safety to humans, pets and wildlife (excellent, very good, good)
- Safety to bees (high, medium, low)
- Prevention or curative control (prevention only, curative only, both prevention and curative)
- Sold in combination with fertilizer (yes, no)
- Flexibility in application methods (soil only, foliar spray only, spray and soil)
- Speed of control [fast (in hours), medium (in days), slow (in weeks)]
- Cost per year

Qualtrics™, a professional survey company, implemented three separate surveys using online techniques. A total of 19,699 U.S. residents were contacted in the spring of 2014 regarding participation in these surveys. Of those contacted, 19,060 agreed to participate. There were 18,885 of those agreeing to participate who had the requisite lawn, flowers or shrubs, or trees. Of these, 8,556 either applied insecticides themselves, had a professional do so or both. The WTP analysis was based on 7,472 completed surveys among the 8,556 who qualified.

The Respondents

On average, the survey participants were between 35 to 55 years old, had completed at least some college, had an annual household income of $50,000 to $65,000 and had about three people per household. About 65 percent of participants were female, about 35 percent had children under 12 years old at home, 75 percent had pets, and 10 percent were members or past members of environmental organizations. They treated their flowers or shrubs, home lawns and/or trees for insects about 2-3 times per year. On average, do it yourself participants spent about $55-$99 annually on insect control; participants who use professional applicators spent about

$100-$299 annually on insect control, and those who used a combination of doing it themselves and using professionals spent about $100-$199 annually on insect control. Only about 15 percent had heard of neonicotinoid insecticides.

The WTP analysis was organized to determine which of the previous listed attributes were most important based on the dollar value attributed to them by the homeowners. The expressed value was then allocated-out based on the applicator [Do it yourself (DIY), Do it for me (DIFM) or BOTH], and the setting (flowers or shrubs, home lawns, or trees). The value of neonicotinoids versus other potential insecticides is then calculated by attribute for each of the settings. The highest ranked attributes by setting are summarized in Table 2.

Table 2. Value of top three insecticide attributes by setting and applicator*.

Top 3 Attributes	Flowers or Shrubs	Home lawns	Trees
Most Important	Prevents and cures insect pest problems DIY BOTH DIFM $40 $69 $142	Very high level of effectiveness DIY BOTH DIFM $54 $135 $266	Very high level of effectiveness DIY BOTH DIFM $51 $119 $195
2nd Most Important	Very good safety to humans, pets and wildlife DIY BOTH DIFM $35 $85 $81	Very good safety to humans, pets and wildlife DIY BOTH DIFM $51 $118 $174	One application required DIY BOTH DIFM $43 $53 $76
3rd Most Important	Medium safety to bees DIY BOTH DIFM $27 $35 $64	Prevents and cures problems DIY BOTH DIFM $49 $116 $160	Very good safety to humans, pets and wildlife DIY BOTH DIFM $42 $83 $146

* DIY = Do It Yourself, DIFM = Do It For Me (professional application), BOTH = DIY and DIFM

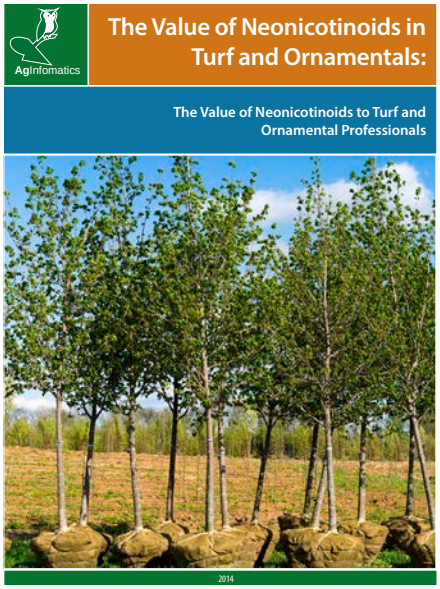
Comparing neonicotinoids to other insecticides was also calculated using the WTP methodology. A 'base' control was established (typically a 'soft' insect control option), and then the value of each insecticide compared to this base was calculated by method of application. For flowers or shrubs where insecticides are DIY, neonicotinoids had values that were $99.60 greater than the other insecticide classes of pyrethroids, carbamates and organophosphates compared to the base of insecticidal soap. This value was $280.60 for DIFM and $133.40 for BOTH. For lawns, using natural nematodes as the base control method, participants are willing to pay premiums of $75 for DIY, $164 for BOTH and $278 per year for DIFM for the attributes of neonicotinoid insecticides. For trees, using horticultural oils as the base, the respondents were willing to pay an annual premium of $59 for DIY, $104 for BOTH, and $128 for DIFM for the attributes of neonicotinoid insecticides.

Another way of thinking of these values is that they represent the financial penalty that homeowners would accrue if neonicotinoids were not available. Using the flower or shrub settings as an example, this means the homeowner

would be paying an annual $99.60 penalty while also not being able to select an insecticide according to the attributes that have the most value to them.

All this translates into the significant value that homeowners are willing to pay for neonicotinoid insecticides in these settings. These decisions are being made due to the considerable valuation placed on the attributes of neonicotinoids versus other available means of insect pest control. This aggregate value will increase in the near future due to the projected growth in the landscape service market:

> *"The five years to 2019 are forecast to experience a rapid construction sector recovery, with housing starts rising at an annualized rate of 7.1 percent. Also, steady per capita disposable income growth averaging 2.2 percent over the period is projected to encourage households to return to outsourcing lawn and yard care, while general economic recovery will likely boost commercial expansion and drive the need for industry operators that can maintain large corporate and resort campuses. … Overall, industry revenue is forecast to rise at an annualized rate of 6.8 percent over the next five years, reaching $101.1 billion in 2019."* [8]



The Value of Neonicotinoids to Turf and Ornamental Professionals

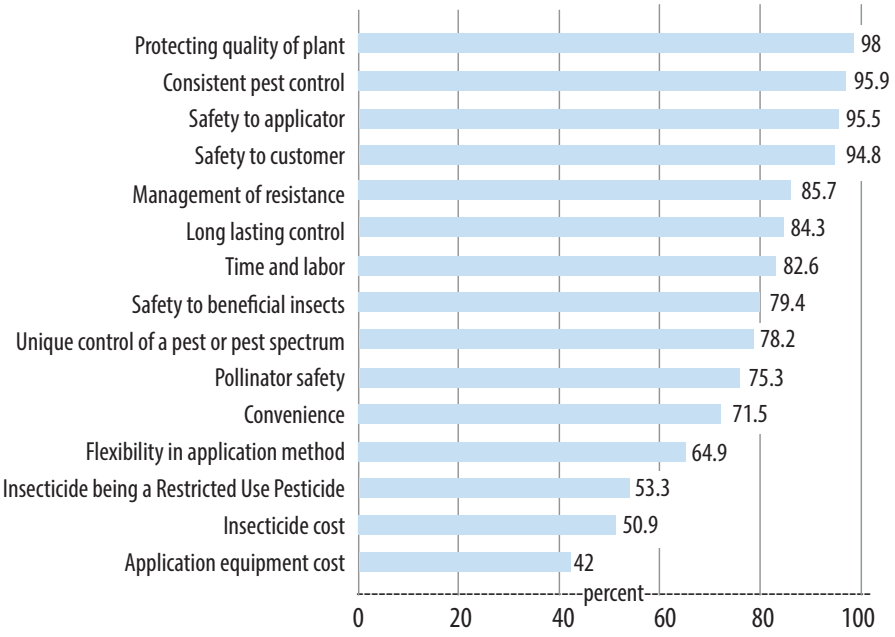
It is logical that any analysis of the value of neonicotinoids in the turf and ornamental industry would include assessments by the professionals who use or depend on these products on a daily basis. These would include professionals in the landscaping and tree services, nurseries, greenhouses and businesses associated with the floral industry. Four key professional associations were selected, and working through their leadership, an online survey was designed and implemented for the membership. These associations were AmericanHort, PLANET, Society of American Florists and the Tree Care Industry Association.

A 12-question survey was administered through a commercial web-based survey site with customized versions for each association. Questions were organized around current insecticide use and costs; factors used in choosing an insecticide; alternatives if neonicotinoids were not available; pests that will be difficult to manage without neonicotinoids; effects on income; and an open-ended concluding question to measure any other concerns. There were 750 responses across the four professional associations including 97 who did not use insecticides. These respondents identified the main focus of their business as trees (25 percent), greenhouse (24 percent), lawn (19 percent), nursery (15.5 percent) and landscape ornamental (15.5 percent). A small number (<1 percent) indicated interior plantscapes.

These professionals were given 15 different criteria by which they could select insecticides; they also had the option of identifying other criteria. 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. These impacts are represented in Figure 1.

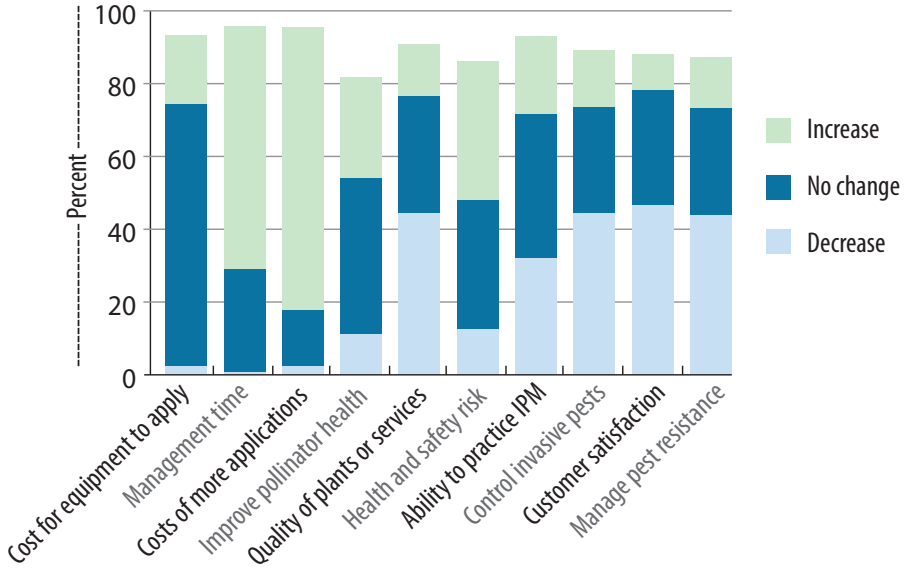
When asked to identify the top three most used insecticides in the business, neonicotinoids were the most frequent response (34 percent) among the ten insecticide classes identified. Among the neonicotinoids, three-quarters (75 percent) identified imidacloprid as the most commonly used product.

Figure 1. Factors considered when selecting insecticides, listed by importance to surveyed professionals.



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. These impacts are represented in Figure 2.

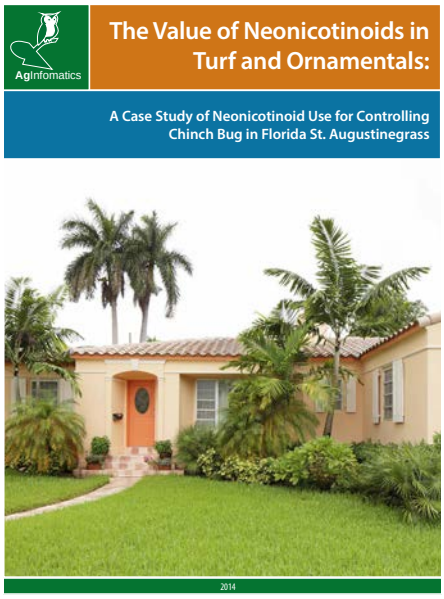
Figure 2. Impact on business if neonicotinoids were no longer available.



The pests that would be most difficult to control without neonicotinoids were identified by 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 varied in identifying pests 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.

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.



A Case Study of Neonicotinoid Use for Controlling Chinch Bug in Florida St. Augustinegrass

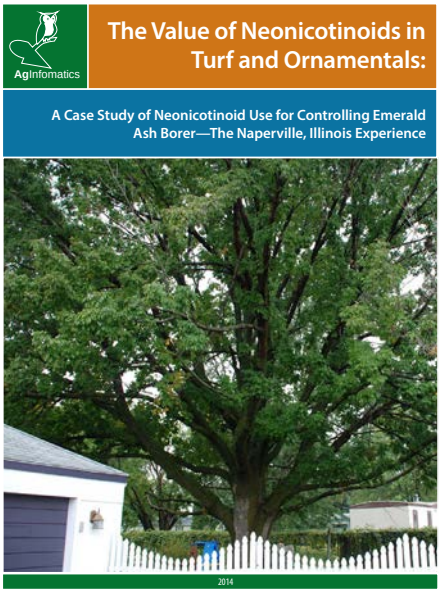
The focus of this case study was southern chinch bug, (*Blissus insularis* Barber), as a pest in St. Augustinegrass (*Stenotaphrum secundatum*) in Florida. This pest was selected as one of many possible examples of pests that are managed in the landscape industry. The reason for selection was that this pest impacts the lawns of millions of homeowners and commercial establishments, primarily in Florida. It is a pest that is increasingly resistant to pyrethroids, the control mechanism of choice in the past. Neonicotinoids are highly effective against pyrethroid-resistant chinch bugs. Finally, there are few effective chemical alternatives for southern chinch bug.

Lawns and turf are important for a number of reasons, including increased property value; runoff and erosion control; cooling effects in hot climates; noise buffers in loud urban settings; filters of dust, pollutants and particulate matter; pollutant (carbon dioxide and sulfur dioxide) absorption; and increased filtration of water to groundwater. Turf management is an integral part of residential and commercial landscapes and makes important contributions to local economies. In Florida alone, the turfgrass industry has an economic impact of $3.3 billion and involves nearly 84,000 jobs, more than 25,000 just in the lawn services sector. It is common for this industry in Florida to place a guarantee behind their maintenance and treatment services,

and failure to control the chinch bug means that St. Augustinegrass must be removed and replaced at a cost of up to $1 per square foot of turf.

What happens if neonicotinoids are no longer available? It has been demonstrated that the southern chinch bug, because of life cycle dynamics, is able to develop resistance to repeated applications of pyrethroids. This has happened with bifenthrin and other pyrethroid products. Without being able to use neonicotinoids in a rotation as part of a pesticide resistance management program, the probability of resistance development is very high. As noted in the case study, "Losing neonicotinoids would raise costs and increase challenges for resistance management. Lawn care providers could lose customers if unable to protect against the pervasive chinch bug lawn pest. They would bear heavy costs for lawn replacement guarantees, and they would lean heavily on other chemical solutions with mixed results."

Other chemical solutions that would be pursued under this scenario would likely have negative impacts on pollinators and other beneficial insects that are not affected by current neonicotinoid uses. The environmental benefits associated with healthy St Augustinegrass would be reduced or lost, and many residents of the Southeast U.S. would lose an important tool to protect home and commercial property values.



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

The consequences of EAB are being realized in an expanding array of communities. Originally detected in the midwestern U.S. in 2002, the scenario shown below-left is occurring in many communities. EAB is an exotic invasive insect species, and ash trees in North America have no native immunity or natural protection, such as predators or parasites that feed on the beetle. Many communities and residents planted ash following the devastation of Dutch elm disease that began sweeping the country a half century ago. Now those mature and beautiful replacement trees are being destroyed by EAB. The economic impacts are significant. One study estimated a total $10.7 billion cost to communities through 2019 for treating, removing and replacing ash trees due to EAB infestation. The probability of these costs emerging in any area experiencing an EAB infestation is captured in the Purdue University Extension EAB Cost Calculator shown below.

This scenario is occurring in many communities due to EAB.

Expected Progression of EAB Damaged Trees and Likelihood of Detection

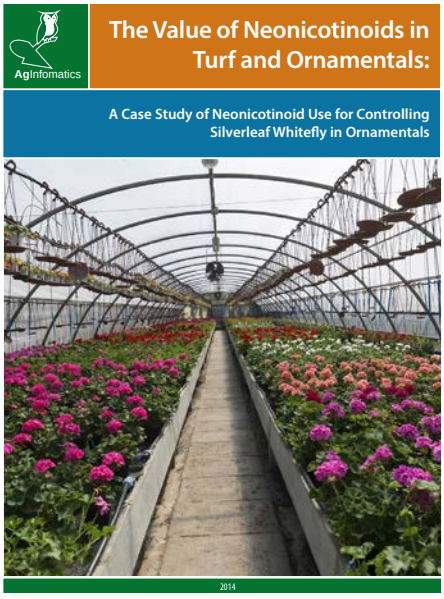
% Ash Trees Affected by EAB	<1	2	4	8	16	32	64	100	100	100	100	100	100
Years Until All Ash Trees Are Damaged or Lost to EAB	8	7	6	5	4	3	2	1	0	0	0	0	0
Likelihood of detection	**Low**			**Medium**		**High**							

An important insight from this cost calculator[13] is that EAB acts like any epidemic where there is often denial and procrastination in the early stages to

fatalism in the latter stages.[14] Inaction results in a 100% probability that the ash trees will be lost. It is in this context that what happened in Naperville is important.

Homeowners and municipal officials have three management options when facing the infestation of EAB: proactive removal of ash trees before infestation; reactive removal of trees after they are infested by EAB; or targeted treatment of ash trees with insecticides. In Naperville, city officials initially removed those trees showing infection when EAB was first detected in 2008. Several years later, it became apparent that the progression illustrated in the above table was beginning with the 15,000 ash trees on public property. Naperville joined the Legacy Tree Project, a pilot program to demonstrate the effectiveness of treating ash trees with dinotefuran (a neonicotinoid) to prevent EAB. A confederation of homeowners associations picked up on the outcome of that demonstration by learning that treatment could be a safe and economically viable option. This association began working with elected leaders to develop a plan to try and save as many of the ash trees on city lands as possible. The economic logic of the strategy was not lost on officials facing a limited budget – treatment costing approximately $100 per tree per year versus $1,200-$1,700 per tree for removal and replanting. Now, two years into the program, more than 90 percent of the parkway ash trees show only minor or no EAB damage contrary to what one would expect in an epidemic context.

The question of what would happen in Naperville without neonicotinoids was answered several different ways in the case study. First, alternative insecticides are more costly, which would have directed the city back to a removal strategy. This would significantly increase costs to the city, commercial establishments and homeowners. Second, consumer products containing neonicotinoids can be purchased at local home improvement or garden stores and do not require special skills or licensing. This is not possible with many of the other non-neonicotinoid alternatives that are used to treat for EAB infestation in ash trees. The cost of application for many of these alternate insecticides would be higher due to the need to use professional applicators. Third, the loss of ash trees in Naperville resulting from the EAB epidemic that would result without the availability of neonicotinoids would negatively impact overall property values, increase home cooling and maintenance costs, decrease overall aesthetic appeal and create safety hazards if dead trees are not removed in a timely fashion.



A Case Study of Neonicotinoid Use for Controlling Silverleaf Whitefly in Ornamentals

This pest was selected for a case study because of its pervasiveness, the significant damage it causes to plants, and the speed in which it has developed resistance to earlier chemical treatments. Ornamental plants are especially vulnerable to the types of damage caused by the silverleaf whitefly. The industry itself is in a fragile position economically as it is directly dependent on the discretionary income of its customers. The industry is on the 'front lines' in preventing invasive pests from entering the U.S. and then being spread through interstate commerce.

Whiteflies are a major pest to both the agricultural and ornamental industries because of the damage caused by the insect and the likelihood of

plant virus transmission by the pest. The ornamental industry is also very dependent on producing high-quality plant materials where the type of damage caused by the silverleaf whitefly is commercially unacceptable. The global nature of the ornamental industry increases the responsibility of industry professionals to use every available tool to control invasive species and associated plant viruses that could be transmitted by the silverleaf whitefly. The industry is well aware of what happened in the mid-1980s when a new strain of silverleaf whitefly (*B. tabaci*- B-biotype) emerged in the Florida poinsettia industry and quickly spread across the U.S., resulting in damages to both ornamental and agricultural crops. Since 1991, according to the Center for Invasive Species Research at the University of California-Riverside, the silver whitefly has cost California agriculture an estimated $500 million. This translates to roughly $774 million in private sector sales, 12, 540 jobs and $112.5 million in personal income. Nationally, silver leaf whitefly damage has been estimated to be in excess of $1 billion.

Another critical lesson that emerged in this case study is how important pesticide resistance management is to an industry dependent on a closed environment. In a natural environment, it is not unusual for an insect pest to go through several life cycles during the growing season. In a greenhouse, however, where production can occur year round, a pest like the silverleaf whitefly can go through seven or more life cycles within a year. This increases the probability of resistance developing to chemical classes that are used repeatedly. Rotating chemical classes is key to resistance management; removing or limiting the neonicotinoid insecticides would be a major setback to resistance management efforts in the industry.

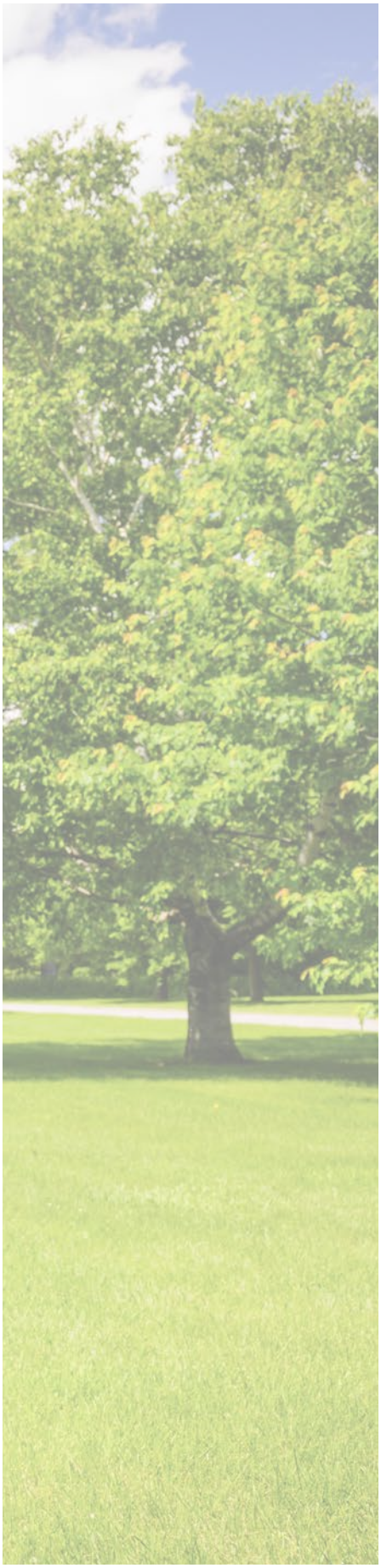
From the interviews and discussions associated with this case study (in response to the question of "What would happen if neonicotinoids were no longer available?"), a number of themes were identified, including economic impacts from higher production costs, inability to maintain quality standards resulting in reduced sales and the loss of many small businesses. The increased use of other insecticides would increase worker exposure to pesticides with higher toxicity and raise concerns about residues. As just pointed out, the pesticide resistance management programs would be greatly affected, and efforts to practice IPM would be impeded.

4.0 Conclusion

Two outcomes emerge from these reports: the Green Industry is a critical sector of the U.S. economy, and neonicotinoids are important tools contributing to the viability of this industry. Several key themes emerge again and again as one reads these reports.

Both homeowners and professionals recognize the value that neonicotinoids bring in terms of maintaining plant quality, as well as for their safety to humans, pets and wildlife. The benefits in monetary terms for neonicotinoids in the homescape were established. However, the monetary value of safety for family and pets was not quantified in either the survey of professionals or in the case studies. This is an important consideration that should be studied to more fully understand the value for neonicotinoids.

Green Industry professionals affirmed that neonicotinoids are a critical tool for the management of destructive and invasive pests in greenhouse and



nursery crops, turf and urban landscapes. Neonicotinoids are viewed as one tool in the pest management tool box used by professionals, but they also consider it an essential tool. The majority of professionals in the Green Industry did not think that neonicotinoids could be replaced or substituted without leaving significant unmet needs..

It is estimated that invasive species in the U.S. cost the economy $120 billion per year.[15] The U.S. Fish and Wildlife Service and the U.S. Department of Agriculture's Animal and Plant Health Inspection Service are charged with defending its borders against the introduction of invasive species, but the shear volume of global trade is overwhelming. The Green Industry plays a vital role in helping government agencies prevent the introduction and subsequent spread of invasive insect pests like silverleaf whitefly and emerald ash borer. And as demonstrated in these reports, neonicotinoids play a vital role in this effort. This critical service also needs to be considered part of the value of neonicotinoids.

The development and use of pesticides is a dynamic process that is driven in part by the natural selection of resistant pest populations. Rotation of insecticides with different modes of action is a key tactic to mitigate the development of resistant pests. Turf and ornamental professionals recognize that neonicotinoids are an important part of insect resistance management programs, and that the loss of neonicotinoids will accelerate development of pest resistance to remaining chemical classes.

Related to this last theme is the important role that neonicotinoids play in IPM programs. The success of IPM programs depends in part on minimizing the exposure of beneficial insects (biological controls) to pesticide residues on plant surfaces. The systemic properties of neonicotinoids minimize the exposure of the beneficial insects that help keep pest populations in check, while at the same time providing targeted pest control. Professionals in the turf and ornamental industry pointed out that the loss of neonicotinoids will create significant obstacles to managing insect pests with biological controls.

Table 1 (page 5) highlights many important benefits contributed by Green Industry products and services in the U.S. These include benefits associated with healthy urban landscapes, such as neighborhood aesthetics; maintenance of property values; and numerous environmental benefits (decreased home cooling cost, soil stabilization and stormwater retention to list a few). Homeowners pointed out these corollary benefits while placing a specific value on neonicotinoids in the homescape. Professionals in the turf and ornamental industry recognize these benefits and use them to help sell their professional services. Each of the case studies also confirmed these benefits. The concluding theme in these reports is that to the extent that neonicotinoids are responsible for the generation and maintenance of healthy plants and landscapes, they are also contributing to the many economic, health and environmental values of such plants and landscapes.

5.0 Footnotes

1. 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.

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

3. 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.

4. Triangulation is a classic method in research; see

   Denzin, N. K., and Y.S. Lincoln. 2000. *Introduction: The Discipline and Practice of Qualitative Research.* In N. K. Denzin & Y. S. Lincoln (Eds.), Handbook of qualitative research (pp. 1–28). Thousand Oaks, CA: Sage.

   Campbell, D. T., and D.W. Fiske. 1959. *Convergent and Discriminant Validation by the Multitrait- Multimethod Matrix.* Psychological Bulletin, 65, 81–105.

5. Denzen, N.J. 2012. *Triangulation 2.0.* Journal of Mixed Methods Research 6: 80-88.

6. Downward, P. and A. Mearman. 2007. R*etroduction as Mixed-Methods Triangulation in Economic Research: Reorienting Economics into Social Science.* Cambridge Journal of Economics, 31, 77–99.

7. See these articles for descriptions and examples of this technique:

   Kerry, T., S. Morse-Jones, and B. Fisher. 2010. *Ecosystem Valuation*. Annals of the New York Academy of Sciences, Vol.11851(1), pp.79-101.

   Fleischer, A., S. Shafir, and Y. Mandelik. 2013. *A Proactive Approach For Assessing Alternative Management Programs For An Invasive Alien Pollinator Species*. Ecological Economics, Vol. 88, pp. 126-132.

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

9. Hall, C.R., A.W. Hodges, and J.J. Haydu. 2005. *Economic Impacts of the Green Industry in the United States*. http://www.ufei.org/files/pubs/EconomicImpactsoftheUSGreen%20Industr(NUCFACfinalreport).pdf

10. Hall, C.R. and M.W. Dickson. 2011. *Economic, Environmental, and Health/Well-Being Benefits Associated With Green Industry Products and Services: A Review*. J. Environ. Hort. 29(2): 96–103. June.

11. The Willingness To Pay technique is derived from the theory of economic valuation and is based on an aggregation of individual preferences and choices to establish a market value. For phenomena where there is not a ready market (e.g., the beauty of a flower in a yard), economists have derived a technique to establish value through assessing how much an individual is willing to pay for the item or situation (e.g., clean water in a local stream); see:

Bernath, K., and A. Roschewitz. 2008. *Recreational Benefits of Urban Forests: Explaining Visitors' Willingness to Pay in the Context of the Theory of Planned Behavior.* Journal of Environmental Management 89: 155–166.

12. An ordinal variable is one where there is a clear ordering of the values, but they are not necessarily of equal spacing as is the case with an interval variable.

13. http://extension.entm.purdue.edu/treecomputer/index.php?page=tutorials/costsAndInfestation.php

14. Strong, P. 1990. *Epidemic Psychology: A Model.* Sociology of Health & Illness. 12: No. 3: 249-259.

15. Pimentel, D., R. Zuniga, and D. Morrison. 2005. *Update on the Environmental and Economic Costs Associated with Alien-invasive Species in the United States.* Ecological Economics. 52: 273-288.