UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON D.C., 20460

OFFICE OF CHEMICAL SAFETY
AND POLLUTION PREVENTION

December 11, 2019

MEMORANDUM

SUBJECT: Review of "The Value of Neonicotinoids in Turf and Ornamentals" prepared by AgInfomatics, LLC for Bayer CropScience, Mitsui, Syngenta, and Valent

FROM: R. Murphey Coy, Ph.D., Entomologist
Biological Analysis Branch

Charmaine Hanson, Economist
Economic Analysis Branch
Biological and Economic Analysis Division (7503P)

THRU: Monisha Kaul, Chief
Biological Analysis Branch

Tim Kiely, Chief
Economic Analysis Branch
Biological and Economic Analysis Division (7503P)

TO: Matthew Khan, Chemical Review Manager (Clothianidin, Thiamethoxam)
Steven Snyderman, Chemical Review Manager (Dinotefuran, Imidacloprid)
Marianne Mannix, Acting Team Leader
Risk Management and Implementation Branch 1
Pesticide Reevaluation Division (7505P)

CC: Ricardo Jones, Team Leader
Risk Management and Implementation Branch 1

PRODUCT REVIEW PANEL DATE: June 12, 2019

Summary

The registrants of neonicotinoid insecticides commissioned a series of reports, prepared by the agricultural consulting firm AgInfomatics in 2014, on the value of neonicotinoids, or equivalently the impacts of a ban on their use on turf and ornamentals in the United States and Canada. The reports quantified the agronomic, environmental, and socio-economic values of

neonicotinoids using a Choice Experiment to homeowners and professionals who manage turf and ornamentals. The turf and ornamental industries in the U.S. account for over 400,000 businesses, millions of jobs, and billions in annual revenues. Turf and ornamentals add value to the homes of consumers through various means such as aesthetics, recreation, energy and water conservation. Insects can damage areas with turf and ornamentals, and thus reduce their value to consumers. Over 19,000 homeowners were surveyed by AgInfomatics and segmented into three markets based on the predominate "homescape" type: "flowers and shrubs," "lawns," and "trees." Over 700 turf and ornamentals professionals were surveyed through various professional associations and segmented into five business types: trees, greenhouse, lawn, nursery, and landscape ornamentals.

The results of the homeowner survey, Yue (2014) showed that homeowners value this class of insecticides. The top concerns of homeowners applying insecticides to their homescape center around efficacy and safety (humans, pets, wildlife and bees) according to the data gathered in the choice experiment. The results showed that when given a choice between two options, both of which are efficacious and safe for humans, the homeowners preferred the option that had the additional attribute of being safe on bees.

The results of the professional survey, Nowak and Genskow (2014) suggests that professionals value the neonicotinoids because professionals reported that neonicotinoids offer systemic properties; exhibit long-term efficacy; and provide a low-risk to the applicators, customers and their pets. The most used neonicotinoid active ingredient was imidacloprid (75% of survey respondents), followed by dinotefuran (17%), clothianidin (3%) and thiamethoxam (3%). Based on the results of this report, the most difficult pests to manage in the absence of neonicotinoids would be aphids, borers, white grubs, armored scales and whiteflies, respectively. Professionals stated that the negative business impacts from the absence of neonicotinoids would be driven mostly by the cost increases associated with the use of alternatives (e.g., chemical and labor costs) and lower customer satisfaction. The possible alternatives in the absence of the neonicotinoids in order of preference are pyrethroids, organophosphates, avermectins, carbamates, and diamides.

Results from the econometric analysis using the Choice Experiment indicated that homeowners had different willingness to pay values for pesticides based on their attributes. Although the authors used a rigorous approach, there were inconsistencies between model results and interpretation of results in the text, which are addressed later in this document.

In addition to the homeowner and professionals surveys, there were three case studies completed by AgInfomatics:

- Genskow (2014a) reported that southern chinch bugs are the most serious insect pest of St. Augustinegrass in Florida. The pest has the potential to become a greater regional nuisance if not adequately controlled. Chinch bugs have developed resistance to many classes of insecticides. If chinch bugs populations reach elevated levels in a given lawn, then chemical treatment will likely be needed, or the homeowner may have to pay for removal and replacement of damaged turf later. Neonicotinoids are a good option for

treating this pest. In addition to neonicotinoids, alternative insecticide treatment options include pyrethroids, organophosphates and carbamates.

- Genskow (2014b) concluded that for communities like Naperville, Illinois, who have invested in controlling their emerald ash borer (EAB) populations, neonicotinoids are valued higher than other non-chemical options such as tree removal. Neonicotinoids may even have higher benefits than alternative chemical options, like emamectin benzoate and acephate, which can be more expensive in terms of product price and/or time (and thus labor-hours) needed for treatment. Some extension documents may now recommend that many EAB infested trees should be removed, but for those who want to keep their trees, neonicotinoids are a good control option and cheaper than other chemicals.
- Shaw (2014) stated that the silverleaf whitefly, an invasive, disease vectoring species is one of the most damaging pests to many floriculture and ornamental crops. They feed on a wide range of agronomic and commonly-grown greenhouse crops. The silverleaf whitefly can go through many life cycles in the protected environment of a greenhouse and can develop insecticide resistance quickly if not properly controlled. Losing neonicotinoids as a class would raise costs and increase challenges for insecticide resistance management programs.

Background

The Federal Insecticide Fungicide and Rodenticide Act (FIFRA) Section 3(g) mandates that EPA periodically review the registrations of all pesticides to ensure that they do not pose unreasonable adverse effects to human health and the environment. This periodic review is necessary in order to consider scientific advancements, changes in policy, and changes in use patterns that may alter the conditions underpinning previous registration decisions. In determining whether effects of pesticide use are unreasonable, FIFRA requires that the Agency consider the risks and benefits of any use of the pesticide.

The nitroguanidine neonicotinoids are a class of insecticides that are derived from the nicotine molecule in which the nitroguanidine moiety makes the molecule more selective to insect receptors than to other organisms. Other nicotine derivitives utilize a different moiety, resulting in different sensitivity among different types of insects. The nitroguanidine neonicotinoids, consisting of clothianidin, dinotefuran, imidacloprid, and thiamethoxam, are classified as Group 4A by the Insecticide Resistance Action Committee (IRAC, 2019). They are insecticides with both contact action and systemic properties that are used against economically important insect pests. For simplicity, this document refers to these four active ingredients (AIs) as 'neonicotinoids.'

EPA has completed human health and ecological risk assessments for the four neonicotinoid insecticides: clothianidin, dinotefuran, imidacloprid, and thiamethoxam. No human health risks have been identified for the use of clothianidin and dinotefuran in turf and ornamental settings. The Human Health Draft Risk Assessment identified potential exceedances for multiple turf and ornamentals scenarios for imidacloprid and thiamethoxam. Specifically, an exceedance was identified for liquid/foliar applications through the mixing, loading, applying of dry flowable formulations with mechanically-pressurized handgun for landscaping, trees, shrubs, and bushes.

There are also potential human health risks from imidacloprid use in residential turf. Potential ecological risks were identified for the four neonicotinoid insecticides, to terrestrial and aquatic invertebrates, as well as to birds and mammals. Risks to pollinators have emerged as a particular concern.

As part of the public comment period on the risk assessments and risk management rationale, the Neonicotinoid Consortium, an association of firms holding registrations for various neonicotinoid insecticides, submitted an assessment they commissioned on the benefits of neonicotinoids in U.S. turf and ornamental areas, both residential and non-residential, to homeowners and professionals. The assessment was prepared by AgInfomatics, LLC and consists of six reports. The assessment is available at https://www.regulations.gov/, docket EPA-HQ-OPP-2011-0581-0060.

The Value of Neonicotinoids in Turf and Ornamentals:

1. Executive Summary for the Value of Neonicotinoids in Turf and Ornamentals (Nowak, 2014)
2. Estimating the Economic Value of Neonicotinoid Insecticides on Flowers, Shrubs, Home Lawns and Trees in the Homescape (Yue, 2014)
3. The Value of Neonicotinoids to Turf and Ornamental Professionals (Nowak and Genskow, 2014)
4. Case Study of Neonicotinoid Use for Controlling Chinch Bug in Florida St. Augustine grass (Genskow, 2014a)
5. Case Study of Neonicotinoid Use for Controlling Emerald Ash Borer [EAB] —The Naperville, Illinois Experience (Genskow, 2014b)
6. Case Study of Neonicotinoid Use for Controlling Silverleaf Whitefly in Ornamentals (Shaw, 2014)

This review first presents a brief summary of the results and methodology of the entire AgInfomatics study pertaining to the value of neonicotinoids in U.S. turf and ornamentals (Section I). Then, BEAD summarizes the specific methodology and results of the individual reports. The sections are:

II. Report 2, which estimates the value of neonicotinoids in the homescape.
III. Report 3, which estimates the value of neonicotinoids to turf and ornamental professionals.
IV. Reports 4, 5, and 6 which are case studies on turf and ornamental pests.

We discuss the methodology of each report's assessment of the benefits of neonicotinoids. The methodological choices have important implications to the appropriate interpretations of the results. Each review also discusses the relevance of the AgInfomatics' assessment to EPA's registration review decision. A final Section V presents BEAD's overall conclusions and caveats as to AgInfomatics' study and conclusions.

I. VALUE OF NEONICOTINOIDS IN U.S. AND CANADIAN TURF AND ORNAMENTALS

Report 1, "Executive Summary" (Nowak, 2014)

The report used econometric (statistical) methods to quantify the agronomic, environmental, and socio-economic values of neonicotinoids to the turf and ornamental industries in the U.S. and Canada. Specifically, a choice experiment was used with survey data to quantify various attributes associated with a pesticide. Unlike agronomic crops, the values of turf and ornamental crops are not as strongly correlated with yields, which may also be complicated or impossible to quantify. The values of neonicotinoids may be expressed monetarily or in non-monetary terms from the importance, preferences, needs or demands that are expressed from an individual or group. For example, turf and ornamentals add value to the homes of consumers through various means such as aesthetics, recreation, energy and water conservation (Nowak, 2014). AgInfomatics addressed this issue by developing a "sophisticated methodology" to attempt to triangulate data from many sources into a stand-alone value of neonicotinoids (Nowak, 2014). To accomplish this, AgInfomatics gathered data through surveys of homeowners and professional applicators, which were analyzed using econometric modeling methods of insecticide use, crop yield data, and market impacts. AgInfomatics also used the data to derive the qualitative benefits associated with neonicotinoids. These values were determined by posing a counterfactual scenario to homeowners and professional applicators where neonicotinoids were unavailable for pest control in turf and ornamentals (Nowak, 2014). The report was also complemented with case studies specific to these industries where neonicotinoids play a key role in pest management strategies and resistance management programs. Multiple reports on the turf and ornamental industries have estimated that these sectors represent roughly 2 million employees, annual revenues of over $147 billion, $64.3 billion in labor income, nearly $7 billion in indirect business taxes, and over $95 billion in value added (Haydu et al. 2006; IBISWorld, 2014). Roughly half of the revenues, jobs, and over 400,000 businesses are associated with landscape services (IBISWorld, 2014).

The final value or benefits of neonicotinoids in turf and ornamental areas for homeowners and professionals were estimated by incorporating industry reports, survey data (e.g., professional association questionnaires), and willingness to pay [WTP] premiums derived from survey data (Nowak, 2014). The three case studies presented situations in which neonicotinoids are the key or vital tool for pest control of a specific niche pest.

II. ESTIMATING THE ECONOMIC VALUE OF NEONICOTINOID INSECTICIDES ON FLOWERS, SHRUBS, HOME LAWNS AND TREES IN THE HOMESCAPE

Report 2, "Homeowners Study" (Yue, 2014)

The report's objective was to ascertain the economic value of neonicotinoids to homeowner consumers via a "quantitative estimate of the benefits [neonicotinoids] provide in non-agronomic settings," such as homes and the "homescape" (Yue, 2014). Typical ways that ornamentals add value to the homes of consumers include "aesthetics, recreation, energy conservation and water

conservation" (Yue, 2014). Insects can damage ornamentals and thus reduce their value to consumers. Use of insecticides can reduce this damage and thus provide value to consumers or homeowners. To gain insight into what homeowners prefer in term of insecticide attributes, this study was conducted using choice experiments that estimated WTP for a given insecticide or insecticide class based on their attributes (Yue, 2014). Study results suggest that neonicotinoids are a class of insecticides that have a mix of attributes that consumers most prefer when compared to other classes of insecticides (Yue, 2014).

BEAD determined that the data in this report were not always clearly presented, summarized, or connected to AgInfomatics' stated objective of determining the stand-alone value of neonicotinoids based on AgInfomatics' methodology. For example, Yue (2014) concluded that "neonicotinoids are more valuable to homeowners than the alternative insecticides that are safer for bees;" however, neonicotinoids were not the top choice for homeowners in all scenarios based on survey results.

Data and Methodology

The data for this study were gathered via internet surveys of a sample of U.S. homeowners through Qualtrics, a research data company (Yue, 2014). Given that many homeowners may not be aware of an insecticide's active ingredient or key characteristics, this study was conducted using choice experiments and WTP to understand which of the insecticide attributes were most important to homeowners, what homeowners were willing to pay for various individual attributes, and what the relative value of different insecticides/insecticide classes are, based on an aggregation of their individual attributes (Yue, 2014). The choice experiment provided respondents with two choices. Each choice contained some attributes of an insecticide and its cost per year. The WTP for attributes was estimated based on these choices so that the relative value of various insecticides (by class) could be determined (Yue, 2014). Sometimes the surveys used an individual insecticide and other times an insecticide class was used for choice experiment comparisons.

The surveys were distributed to over 20,000 potential respondents (Yue, 2014). The potential survey respondents (hereafter referred to "homeowners" if they met the selection criteria and completed the survey) were subdivided into nine subgroups (three sets of three) based on two selection criteria: (1) the types of plants in their yard and (2) who applied the insecticides to their home or "homescape" (Yue, 2014) The three categories of plant types were "flowers and shrubs," "lawns," and "trees" (Yue, 2014). The three applicator or 'who applied' subgroups were "Do It Yourself" (DIY) for those homeowners who apply insecticides themselves, "Do It For Me" (DIFM) for those homeowners who do not apply insecticides and hire professionals, and "BOTH" for homeowners who both apply themselves and hire professionals to apply insecticides (Yue, 2014).

The attributes and attribute levels were pre-selected based on focus group discussions with about 60 homeowners (Yue, 2014). Additionally, the final questions were pre-tested with 300 homeowners (Yue, 2014). The choice experiment questions covered insecticide use on their homescape plant type, preferences regarding their use, and demographic data (Yue, 2014). The

surveys and the attributes included were not the exact same for all three plant type subgroups since the use patterns are different. There were nine attributes in total used across all surveys conducted in Yue (2014), which are listed below:

- 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/applied 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

Each insecticide (class) option was assigned a given "level" for these attributes (e.g., "very high, high, medium,"; "yes, no"; "soil only, foliar spray only, spray and soil") based on that insecticide's individual characteristics (Yue, 2014). These levels are included above in parenthesis after the attribute name. The top insecticides were chosen based on the homeowners preferred level for various attributes. Each insecticide can be categorized as a particular 'bundle of pesticide attributes.' The preferred attribute levels chosen by the homeowners were associated with a specific insecticide with a bundle of attributes that matched the homeowners stated preferences (Yue, 2014).

BEAD notes some areas related to the AgInfomatics' data and methodology in Yue (2014) that could have used additional clarity. Whether or not the homeowners surveyed are representative of U.S. homeowners is not mentioned until the conclusion of the report. Even then, it is merely stated that the study conductors think the homeowners are representative based on the demographic backgrounds of the sampled participants. More disaggregated information should have been provided on the homeowners surveyed. It may be the case that one state or region of the U.S. was over(under)sampled. Additionally, it was not clear to BEAD from the reports or supporting documentation how the attributes and their levels were determined and defined apart from their origination in focus group discussions. It was also not always clear which active ingredient (AI) in a given class was being used for comparison. It is possible, but unlikely, that all AIs in a given class, e.g., neonicotinoids, pyrethroids, or OPs, are equally available to each market segment.

Homeowners Study Results

<u>Flowers and Shrubs</u>

Out of the 6,000 people contacted, 5,800 were homeowners who agreed to do the survey and had *Flowers and Shrubs* in their homescape (Yue, 2014). Of these, 2,700 were homeowners who had insecticides applied to their *Flowers and Shrubs* and completed the survey. The proportion of

homeowners by applicator subgroup was DIY – 70%, BOTH – 13%, and DIFM –17% (Yue, 2014).

The DIY subgroup was most price sensitive with lower average annual spending on insecticides and the lowest WTP for all insecticide attributes.

The top insecticide attributes desired by the DIY subgroup were 1.) preventative and curative control; 2.) very good safety to humans, pets and wildlife; and 3.) medium safety to bees (Yue, 2014). The top attributes desired by both the DIFM and BOTH subgroups were 1.) preventative and curative control; 2.) very high effectiveness of control; and 3.) very good safety to humans, pets and wildlife (Figure 1; Yue, 2014).

Figure 1. Table 2 from Report 2, "Homeowners Study" (Yue, 2014)

Table 2. WTP[a] premiums for insecticide attributes relative to the base attribute levels for flowers or shrubs.

		----------DIY----------		-------BOTH--------		--------DIFM--------	
Attribute	**Attribute levels**	Attribute ranking[b]	WTP ($/year)	Attribute ranking	WTP ($/year)	Attribute ranking	WTP ($/year)
Prevents or cures	Prevents and cures	1	40.14	1	69.29	1	142.47
	Cures only		Base[c]		Base		Base
Safety to humans, pets and wildlife	Very good	2	35.40	3	45.14	3	80.81
	Good		Base		Base		Base
Safety to bees	Medium	3	26.53	4	34.86	5	64.50
	Low		Base		Base		Base
Number of applications required for comparable length of control	1 time	4	24.74	5	34.67	4	72.39
	2 to 3 times		7.58		26.66		41.66
	4 or more times		Base		Base		Base
Effectiveness of control	Very high	5	20.88	2	49.74	2	117.21
	High		17.49		38.70		90.66
	Medium		Base		Base		Base
Application method	Spray or soil	6	3.47	6	7.60	6	---[d]
	Soil only		2.48		10.91		---[d]
	Spray only		Base		Base		Base

[a] WTP means willingness to pay, DIY means homeowners who applied insecticides themselves, DIFM means homeowners who hired professional services to apply insecticides, BOTH means homeowners who both applied insecticides themselves and hired professional services to apply insecticides.

[b] 1 = Most valuable, 6 = Least valuable.

[c] The WTP for the base attribute level was set to zero for model estimation purposes. The WTP values for other attribute levels were all relative to the base level.

[d] Not significantly different from zero at 10% significance level.

When the attributes were aggregated across the *Flowers and Shrubs* plant type market segment, the results show that overall this group prefers the attributes associated with neonicotinoids, followed by insecticidal soap (*baseline) with a 3-way tie for third: organophosphates (OPs) (e.g., acephate) /carbamates (e.g., carbaryl) /pyrethroids (Yue, 2014). The neonicotinoids had more favorable attribute levels than insecticidal soaps in four areas: effectiveness, number of

applications (1 vs 4), application method (2 vs 1), and flexibility (preventative and curative control) (Yue, 2014). Insecticidal soaps ranked better on safety to bees (Yue, 2014).

Lawns

Out of the 4,900 people contacted, 4,700 were homeowners who agreed to do the survey and had *Lawns* in their homescape (Yue, 2014). Of these, 2,300 were homeowners who had insecticides applied to their *Lawns* and completed the survey (Yue, 2014). The proportion of homeowners by applicator subgroup was DIY – 63%, BOTH – 12%, and DIFM –25% (Yue, 2014).

The DIY subgroup was most price sensitive with lower average annual spending on insecticides and the lowest WTP for all insecticide attributes.

The top attributes desired by all three applicator subgroups (DIY / DIFM / BOTH) were 1.) very high effectiveness of control; 2.) very good safety to humans, pets and wildlife; and 3.) flexibility (preventative and curative control) (Figure 2; Yue, 2014).

Figure 2. Table 4 from Report 2, "Homeowners Study" (Yue, 2014)

Table 4. WTP[a] premiums for insecticide attributes relative to the base attribute levels for home lawns.

		----------DIY----------		-------BOTH--------		--------DIFM--------	
Attribute	**Attribute levels**	Attribute ranking[b]	WTP ($/year)	Attribute ranking	WTP ($/year)	Attribute ranking	WTP ($/year)
Effectiveness of control	Very high		53.63		134.64		265.75
	High	1	42.86	1	89.16	1	212.82
	Medium		Base[c]		Base		Base
Safety to humans, pets and wildlife	Excellent		50.77		118.19		173.85
	Very good	2	27.44	2	50.70	2	90.44
	Good		Base		Base		Base
Prevents or cures	Prevents and cures	3	48.76	3	115.74	3	159.96
	Cures only		Base		Base		Base
Number of applications required for comparable length of control	1 time		40.90		74.78		41.78
	2 to 3 times	4	15.96	5	---[d]	6	---[d]
	4 or more times		Base		Base		Base
Safety to bees	Very high		35.08		93.67		153.36
	High	5	34.60	4	81.16	4	149.40
	Medium		Base		Base		Base
Sold/applied in combination with fertilizer	Yes	6	6.33	6	---[d]	5	46.77
	No		Base		Base		Base

[a] WTP means willingness to pay, DIY means homeowners who applied insecticides themselves, DIFM means homeowners who hired professional services to apply insecticides, BOTH means homeowners who both applied insecticides themselves and hired professional services to apply insecticides.

[b] 1 = Most valuable, 6 = Least valuable.

[c] The WTP for the base attribute level was set to zero for model estimation purposes. The WTP values for other attribute levels were all relative to the base level.

[d] Not significantly different from zero at 10% significance level.

When the attributes were aggregated across the *Lawns* plant type segment, the results show that overall this group prefers the attributes associated with chlorantraniliprole, followed by neonicotinoids, beneficial nematodes (*baseline), OPs (trichlorfon), and pyrethroids (Yue, 2014). The neonicotinoids had a more favorable attribute level than chlorantraniliprole in one area, being sold with fertilizer (Yue, 2014). Chlorantraniliprole had a more favorable attribute level than the neonicotinoids in one area, safety to bees (Yue, 2014).

Trees

Out of the 8,700 people contacted, 8,500 were homeowners who agreed to do the survey and had *Trees* in their homescape (Yue, 2014). Of these, 2,500 were homeowners who had insecticides applied to their *Trees* and completed the survey (Yue, 2014). The proportion of homeowners by applicator subgroup was DIY – 59%, BOTH – 14%, and DIFM –27% (Yue, 2014).

The DIY subgroup was most price sensitive with lower average annual spending on insecticides and the lowest WTP for all insecticide attributes.

The top attributes desired by the DIY subgroup were 1.) very high effectiveness of control; 2.) number of applications; and 3.) very good safety to humans, pets and wildlife (Yue, 2014). The top attributes desired by both the DIFM and BOTH subgroups were 1.) very high effectiveness of control; 2.) very good safety to humans, pets and wildlife; and 3.) safety to bees (Figure 3; Yue, 2014).

Figure 3. Table 6 from Report 2, "Homeowners Study" (Yue, 2014)

Table 6. WTP[a] premiums for insecticide attributes relative to the base attribute levels for home lawns.

		----------DIY----------		-------BOTH--------		--------DIFM--------	
Attribute	**Attribute levels**	Attribute ranking[b]	WTP ($/year)	Attribute ranking	WTP ($/year)	Attribute ranking	WTP ($/year)
Effectiveness of control	Very high		51.03		118.97		194.86
	High	1	40.39	1	107.85	1	156.40
	Medium		Base[c]		Base		Base
Number of applications required for comparable length of control	1 time		42.67		52.86		76.16
	2 to 3 times	2	23.30	5	44.97	5	50.95
	4 or more times		Base		Base		Base
Safety to humans, pets and wildlife	Very good	3	41.52	2	82.56	2	146.14
	Good		Base		Base		Base
Safety to bees	Very high		35.99		75.19		121.51
	High	4	26.52	3	63.13	3	93.52
	Medium		Base		Base		Base
Speed of control	Fast		34.42		69.26		107.32
	Medium	5	25.06	4	51.58	4	82.29
	Slow		Base		Base		Base
Application method	Spray or soil		11.68		23.77		---[d]
	Soil only	6	---[d]	6	---[d]	6	---[d]
	Spray only		Base		Base		Base

[a] WTP means willingness to pay, DIY means homeowners who applied insecticides themselves, DIFM means homeowners who hired professional services to apply insecticides, BOTH means homeowners who both applied insecticides themselves and hired professional services to apply insecticides.

[b] 1 = Most valuable, 6 = Least valuable.

[c] The WTP for the base attribute level was set to zero for model estimation purposes. The WTP values for other attribute levels were all relative to the base level.

[d] Not significantly different from zero at 10% significance level.

When the attributes were aggregated across the *Trees* plant type segment, the results show that overall this group prefers the attributes associated with emamectin benzoate, followed by neonicotinoids, OPs (not acephate) and pyrethroids, horticultural oils (*baseline), and OPs (acephate) (Yue, 2014). The neonicotinoids were ranked higher than emamectin benzoate on one factor: application method (2 vs 1) (Yue, 2014). Emamectin benzoate ranked better on effectiveness and safety to bees (Yue, 2014).

Homeowner Study Conclusion

In summary, Yue (2014) concludes that

> "[w]hile homeowners are willing to pay premiums for an insecticide's better safety to bees, the premiums are dominated by the premiums they place on an insecticide's very high effectiveness, safety to humans, pets and wildlife, and the preventative and curative attributes. Essentially, in theory, when homeowners make an insecticide selection for pest control, they are conscious of the choices available and prefer products that most closely align with their values and desired results. However, in many instances the selected product may not adequately address all of their considerations and homeowners make

compromises based on an overall evaluation of the product's attributes. Overall, neonicotinoids are more valuable to homeowners than the alternative insecticides that are safer for bees."

BEAD Review of Homeowner Study

BEAD does not have data or methods to adequately assess pest management or insecticide preferences of homeowners, so AgInfomatics' survey of homeowners provided useful information to the Agency regarding homeowner preferences and associated values of insecticides used in the homescape. AgInfomatics provided some details regarding the composition of the homeowners in their study, but did not provide enough support to demonstrate effectively that these homeowners are representative of the relevant population (i.e., homeowners who use insecticides). Respondent knowledge of pesticides was low and only about 15% of respondents were familiar with neonicotinoids (Yue, 2014). AgInfomatics did not provide information on which subgroup (DIY, DIFM or Both) the respondents familiar with neonicotinoids were in. Further, AgInfomatics' survey did not identify a target pest spectrum and whether or not insecticides (neonicotinoids or alternatives) identified would be appropriate control options. Given the relatively low pesticide knowledge within the homeowner group, there is uncertainty regarding their ability to properly identify insect pests and/or damage within the homescape for proper insecticide selection. However, BEAD does acknowledge that familiarity with an insecticide's chemistry or grouping is not a requirement for homeowner products as long as the user reads and follows the label. For example, homeowner familiarity with a particular insecticide was outside the scope of survey since it was designed to determine the most desirable attributes associated with insecticides to homeowners. Based on the data AgInfomatics provided, BEAD is unable to independently verify if the survey is an accurate representation of U.S. homeowners, but it may be a sufficient approximation for homeowners who use insecticides in their homescape. BEAD determined that despite its flaws and the additional clarity needed in key areas that overall the conclusions are generally correct, even if the exact conclusions drawn do not always follow from the results.

The general conclusions of Yue (2014) in terms of the insecticidal attributes most preferred by homeowners are correct. However, the assertion that neonicotinoids best fit this preference is somewhat misleading given the results and data presented in this AgInfomatics study. Nevertheless, BEAD does agree with AgInfomatics that neonicotinoids are a useful tool and often a top choice for pest control in these settings.

Next in this section, BEAD will discuss the implied decision drivers for each of the three market segments and how this comes to bear on the conclusions that can be drawn from the report versus the conclusions stated by AgInfomatics in the report. Then the value of neonicotinoids to homeowners will be discussed followed by the relevance to the registration review decision.

<u>Implied Insecticide Decision Drivers by Market Segment</u>

Within the *Flowers and Shrubs* market segment, the homeowner subgroups had the highest WTP for the attributes associated with neonicotinoids (Figure 4). There were three attributes highly

ranked by two or more *Flowers and Shrubs* homeowner subgroups: effectiveness of control, flexibility, and very good safety to humans, pets, etc. The neonicotinoids had the best attribute levels for effectiveness of control, number of applications, and flexibility (i.e., preventative and curative control of insect pests) (Figure 4). For this market segment, the neonicotinoids are more valuable to homeowners than the alternatives that are safer to bees (i.e., insecticidal soaps).

It should be noted that the "safe for bees" option or insecticidal soap was next favored option after neonicotinoids. However, not disclosed in the survey was that many pests are not effectively controlled with insecticidal soaps or that many landscape plants are sensitive to phytotoxic or other adverse effects from single or repeated applications. Therefore, although insecticidal soap was second, its WTP may be overvalued and its alternatives, undervalued.

Figure 4. Table 3 from Report 2, "Homeowners Study" (Yue, 2014)

Table 3. The major types of insecticides for flowers or shrubs, the insecticides' attribute levels and homeowners' relative WTP for different insecticides compared to soap insecticides.

	----------Major insecticides for Flowers or Shrubs----------				
Attribute	**Neonicotinoid**	**Pyrethroid**	**Carbamate** (e.g. carbaryl)	**Soap**	**OP** (e.g., acephate)
Effectiveness of control	Very high	High	High	Medium	High
Number of applications required for comparable length of control	1 time	2 to 3 times	2 to 3 times	4 or more times	2 to 3 times
Safety to humans, pets and wildlife	Very good	Good	Good	Very good	Good
Application methods	Spray or soil	Spray only	Spray only	Spray only	Spray only
Safety to bees	Low	Low	Low	Medium	Low
Flexible: Can be used to prevent or solve pest problems	Prevents and cures	Cures only	Cures only	Cures only	Cures only
DIY participants' relative WTP compared to Soap ($/year)	$62.7	-$36.9[a]	-$36.9	Base	-$36.9
BOTH participants' WTP compared to Soap ($/year)	$118.8	-$14.6	-$14.6	Base	-$14.6
DIFM participants' WTP compared to Soap ($/year)	$267.6	-$13.0	-$13.0	Base	-$13.0

[a] The negative values mean homeowners' WTP values are less than their WTP values for soap insecticides.

Within the *Lawns* market segment, the homeowner subgroups had the highest WTP for the attributes associated with chlorantraniliprole (Figure 5). Based on the top three attributes desired by each *Lawns* homeowner subgroup within the market segment, the homeowner preference for chlorantraniliprole was mostly likely driven by its higher safety to bees, since both neonicotinoids and chlorantraniliprole are ranked the same on the top three attributes that *Lawns* homeowners most preferred, i.e., effectiveness of control, flexibility, and very good safety to humans, pets, etc. (Figure 5). It is important to note that AgInfomatics' survey did not identify the pest spectrum controlled by each insecticide class or alternative product. While many of the neonicotinoid alternatives may control a similar suite of pests, the alternatives included may not

always be appropriate control options for specific pest(s) targeted within the homescape. For example, while the pest spectrum controlled by neonicotinoids and chlorantraniliprole overlap, neonicotinoids are an appropriate insecticide for mole cricket control, whereas chlorantraniliprole is appropriate for the control of several turf-infesting caterpillars. Further, while entomopathogenic nematodes may provide good control under favorable conditions, most commercialized species have a limited host range (Held and Potter, 2012).

Figure 5. Table 5 from Report 2, "Homeowners Study" (Yue, 2014)

Table 5. The major types of insecticides for home lawns, the insecticides' attribute levels and homeowners' relative WTP for different insecticides compared to beneficial nematodes insecticides.

	----------Major Insecticides for Home Lawns----------				
Attribute	**Neonicotinoid**	**Chlorantraniliprole**	**OP** (Trichlorfon)	**Pyrethroid**	**Beneficial Nematodes**
Effectiveness of control	Very high	Very high	High	Medium	Erratic (Medium is assumed)
Number of applications required for comparable length of control	1 time	1 time	2 to 3 times	4 times or more	2 to 3 times
Safety to humans, pets and wildlife	Very good	Very good	Good	Good	Excellent
Safety to bees	Medium	Very high	Very high	Medium	Very high
Flexible: Can be used to prevent or solve pest problems	Prevents and cures	Prevents and cures	Cures	Cures	Cures
Sold/applied in combination with fertilizer	Yes	No	No	No	No
DIY participants' relative WTP compared to Beneficial Nematodes ($/year)	$75.3	$104.0	-7.9 [a]	-$101.8	Base
BOTH participants' WTP compared to Beneficial Nematodes or services using Beneficial Nematodes ($/year)	$164.0	$257.7	-$29.0	-$211.9	Base
DIFM participants' WTP compared to services using Beneficial Nematodes ($/year)	$277.5	$384.1	$39.0	-$327.2	Base

[a] The negative values mean homeowners' WTP values are less than their WTP values for beneficial nematodes insecticides.

Within the *Tree* market segment, the homeowner subgroups had the highest WTP for the attributes associated with emamectin benzoate (Figure 6). There were two attributes highly ranked by two or more *Tree* homeowner subgroups: effectiveness of control and very good safety to humans, pets, etc. Based on the top three attributes desired by each homeowner subgroup the *Tree* market segment, the homeowner preference for emamectin benzoate was mostly likely driven by its higher effectiveness and safety to bees. Emamectin benzoate ranked better than neonicotinoids on both of these attributes (Figure 6). They both ranked the same on very good safety to humans, pets, etc (Figure 6). One important caveat is that, the survey did not

disclose that emamectin benzoate must be injected into the tree and applied by a licensed professional. The omission of this information is likely to have biased the survey results by overestimating the preference for emamectin benzoate and underestimating the preference for neonicotinoids within the DIY (59% of respondents) and possibly the BOTH (14% of respondents) subgroups, which roughly accounted for three-quarters of respondents for this market segment.

Figure 6. Table 7 from Report 2, "Homeowners Study" (Yue, 2014)

Table 7. The major types of insecticides for trees, the insecticides' attribute levels and homeowners' relative WTP for different insecticides compared to hort oils insecticides.

	Major Insecticides for Trees					
Attribute	**Neonicotinoids**	**Pyrethroids**	**OP** (Acephate)	**Emamectin**	**Hort Oils**	**OP** (Chlorpyrifos)
Effectiveness of control	High	Very high	High	Very high	Medium	Very high
Number of applications required for comparable length of control	1 time	2 to 3 times	2 to 3 times	1 time	4 or more times	2 to 3 times
Speed of pest control	Medium/slow (Medium is assumed)	Fast	Fast	Medium	Fast/ medium (Fast is assumed)	Fast
Safety to humans, pets and wildlife	Very good	Good	Good	Very good	Very good	Good
Application methods	Spray or soil	Spray	Spray	Inject[a]	Spray	Spray
Safety to bees	Medium	Medium	Medium	High	High	Medium
DIY participants' relative WTP compared to Hort Oils ($/year)	$58.9	$6.3	-$4.4[b]	$84.3	Base	$6.3
BOTH participants' WTP compared to Hort Oils ($/year)	$103.7	$18.3	$7.1	$154.2	Base	$18.3
DIFM participants' WTP compared to Hort Oils ($/year)	$127.5	$6.1	-$32.3	$246.0	Base	$6.1

[a] We did not include "inject application" in the application methods. "Soil application" is used for calculation. Because homeowners' WTP values for different application methods are not significantly different from each other, the assumption of "soil application" does not significantly affect the results.

[b] The negative values mean homeowners' WTP values are less than their WTP values for hort oils insecticides.

The conclusion's statement in Yue (2014) that "neonicotinoids are more valuable to homeowners than the alternative insecticides that are safer for bees" is misleading since neonicotinoids were not the top choice for two out of three of the market segments. Moreover, in those two market segments where the neonicotinoids were not the top choice, a "safer for bees" alternative was the top choice. Given the discrepancy between the results and their presentation in this report, it does seem that the report appears to have predetermined the value of neonicotinoids to homeowners rather than presenting an empirical basis for the value that homeowners assign to neonicotinoids.

Based on the results, a more reasonable and accurate conclusion might be that homeowners prefer insecticides that are safe and efficacious. To the extent that neonicotinoids fulfil these two criteria, they are of value to homeowners. When homeowners are presented with two options that are equal on these two fronts, the additional attribute of being "safer on bees" acts as a sort of a tiebreaker between top insecticide options (e.g., high WTP in this study). Some caveats must be added to these statements. It is not clear that the drawbacks of the "safer on bees" (e.g., injection needed or the phytotoxicity issues associated with applications of insecticidal soaps) alternatives were properly communicated to survey respondents. Additionally, in the real-world, it is possible that other attributes such as 'ease of use, 'brand/familiarity/reputation' or 'relative cost of product' (i.e., as opposed to the more abstract dollars spent per year) might be more important to homeowners than "safety to bees."

Since neonicotinoids had high premiums but were not the top option for most of the market segments surveyed, this analysis may have benefited from some real-world data, e.g., comparative sales data for neonicotinoids and their alternatives. While the report acknowledges that it focused on the demand side of the pesticide market and that this has its limitations, there was no explanation for why the stated preferences of the homeowners were not supplemented with revealed preferences or sales data. Just as there was no explanation of the selection process for the insecticides included in the study and their attributes and levels aside from a few details of discussion related to using a focus group to narrow the scope and refine questions. This report provided information on why consumers might buy certain insecticides based on the attributes needed or desired. Comparative sales data would have given a picture of what consumers actually do, which would have shown that the WTP estimates in this study have some connection to the buying patterns of consumers who purchase insecticides for use outside their homescape. This data may have helped to show that the conclusion is correct, that neonicotinoids are more valuable to homeowners than the alternative insecticides that are safer for bees.

The Value of Neonicotinoids to Homeowners

Decorative plants, tress, and lawns add value to the homescape in a myriad of ways. Yue (2014) stated that "[f]lowers, shrubs, lawns and trees add value to homes through improved aesthetics, recreation, energy conservation and water conservation." Homeowners will attempt to maintain this value through chemical means, if necessary. When it comes to insect pests that may damage or kills these plants, and thus reduce value, homeowners have many insecticides to choose from. Some factors or attributes that they may consider include "effectiveness, convenience of application, safety to pets, wildlife and bees, as well as humans" (Yue, 2014). AgInfomatics report stated that neonicotinoids became popular after their introduction in the 1990's because of their effectiveness of control, convenience, and lower mammalian toxicity than some other alternatives like OPs and carbamates (Yue, 2014). This favorable mammalian toxicological profile is likely to have influenced consumers to the extent that they were aware of this fact. The most current market data for consumer markets does show this to be case with some neonicotinoids; imidacloprid was one of the top seven insecticides used by

consumers/homeowners outdoors in 2016 by pounds applied (approximately 40,000 lbs) (NMRD, 2017).

The results of the AgInfomatics report show that the top concerns of homeowners applying insecticides to their homescape are their efficacy and safety to humans, pets and wildlife. To the extent that neonicotinoids fulfil these two criteria, they are of value to homeowners. Nevertheless, when homeowners are given a choice between insecticide options that have both of these attributes, homeowners prefer to go with the option that has the additional attribute of being safer on bees (i.e., chlorantraniliprole).

Relevance to Registration Review Decision

Homeowners with flowers and shrubs in their yards prefer the attributes associated with neonicotinoids. Therefore, this market segment would be negatively impacted if neonicotinoids were no longer available. BEAD reviewed costs of commonly available alternative products available to homeowners and determined many have similar price points to neonicotinoids and include insecticidal soaps, OPs (e.g., acephate), carbamates (e.g., carbaryl), and pyrethroids (e.g., bifenthrin) (Kline, 2012a). The impacts on homeowners selecting alternative products if neonicotinoids were no longer available may include reduced effectiveness and flexibility, increases in the number of applications required for control, or increases in costs if alternatives are more expensive.

Homeowners with lawns most prefer the surveyed attributes associated with chlorantraniliprole, followed by neonicotinoids. If neonicotinoids were no longer available, then these homeowners might use alternatives such as chlorantraniliprole, beneficial nematodes, OPs (trichlorfon) and pyrethroids (Yue, 2014). Several public comments received (discussed in Section IV) from homeowners and professionals stated that a benefit of neonicotinoids over alternative insecticides or practices (e.g., chlorantraniliprole, re-sodding) was their cost (i.e., affordability).

Homeowners with trees in their yards most prefer the surveyed attributes associated with emamectin benzoate, followed by neonicotinoids. If neonicotinoids were no longer available, then these homeowners might use alternatives such as emamectin benzoate, OPs, pyrethroids, and horticultural oils (Yue, 2014). In this scenario, AgInfomatics' likely underestimated the value of neonicotinoids because they failed to disclose to homeowners that the control of certain tree pests with emamectin benzoate or OPs require the application to be injected into the tree by a licensed applicator, which may increase costs and reduce the feasibility of these alternatives, especially for those who fall into price-sensitive user segments like DIY.

The report determined that over half of the homeowners contacted apply insecticides outdoors to their homescape type, and that over half of these homeowners fall into the DIY subgroup (approximately 60% or more of each market segment) (Yue, 2014). The DIY subgroup was the most price sensitive. The neonicotinoids were a top option for all homeowner subgroups. If neonicotinoids were no longer available, then these homeowners might use alternatives such as OPs, chlorantraniliprole, emamectin benzoate and pyrethroids (Yue, 2014).

III. THE VALUE OF NEONICOTINOIDS TO TURF AND ORNAMENTALS PROFESSIONALS

Report 3, "Professionals Study" (Nowak and Genskow, 2014)

A study was done to ascertain the value of neonicotinoids to professionals in the turf and ornamental industries (Nowak and Genskow, 2014). A survey was sent out to professional associations related to these two industries. Since plant injury and death can be caused directly or indirectly by insect pests, certain pests are considered a "serious threat" by professionals who manage or treat areas in these industries. The report acknowledged that "professionals use multiple approaches to control insect pests and minimize or eliminate their damage" (Nowak and Genskow, 2014). The report emphasized that the issues caused by these insect pests are not just aesthetic. "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" (Nowak and Genskow, 2014). Neonicotinoids were noted as being helpful with integrated pest managment (IPM) as practiced by these professionals (Nowak and Genskow, 2014). In the conclusion, Nowak and Genskow (2014) highlighted themes and issues arising from the survey results, and the fact that this report was intended as a report of pesticide value and not of pesticide usage. The themes highlighted included reasons for why consumers and professionals choose neonicotinoids, the importance of science-based decisions, customer satisfaction, IPM and resistance management (Nowak and Genskow, 2014). Issues highlighted by AgInfomatics' survey in Nowak and Genskow (2014) were centered around pollinator health and uncertainties for pest management practices in the absence of neonicotinoids. In addition, the report describes the anticipated impacts on turf and ornamental industries from the loss of neonicotinoid insecticides (Nowak and Genskow, 2014).

Data and Methodology

A survey of professional applicators was conducted in coordination with various related trade groups, associations, and organizations through their membership websites. Four professional organizations were contacted: AmericanHort (351 respondents); PLANET (145 respondents); Society of American Florists (50 respondents); and Tree Care Industry Association (204 respondents) (Nowak and Genskow, 2014). While it is unknown if these respondents are representative of their respective industries/associations, respondents from over 43 states in the U.S. are represented. Of those surveyed, 87% of respondents use insecticides (Nowak and Genskow, 2014). The respondents answered the survey based on the self-reported main focus on their business: tree (25% of respondents), greenhouse (24% of respondents), lawn (19% of respondents), nursery (15.5% of respondents) and landscape ornamentals (15.5% of respondents) (Nowak and Genskow, 2014). These are the five business segments used to parse the survey results.

There were 12 questions on the survey with some of these having sub-questions. General demographic and business information were also collected in the survey. "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 capture any other concerns" (Nowak and Genskow, 2014). The report did not estimate a pecuniary value for neonicotinoids as was done with the homeowner survey; this report only presented the results and analysis of the professional survey.

BEAD reviewed publicly available references cited in AgInfomatics' report and conducted literature searches to determine if claims made in the report were scientifically supported. Additional materials reviewed by BEAD included turf and ornamental pesticide applicator training materials from university extension services and peer-reviewed publications such as Boyd et al. (2013) and Held and Potter (2012). The information presented in these materials are incorporated into BEAD's analysis of AgInfomatics' assessment on the value of neonicotinoid insecticides in the turf and ornamental industries.

Professionals Study Results

There are many factors that may influence a professional's use of a particular insecticide. Sixteen factors were presented for ranking by the professional respondents to the survey. The report highlighted four of these factors since they were rated as either "Important" or "Very important" by more than 90% of all respondents: Protecting quality of the plant (98%); consistent pest control (96%); safety to applicator (96%); and safety to customer (95%) (Nowak and Genskow, 2014).

<u>Most Used Insecticides by Business Segment</u>

Respondents were provided representative lists of insecticides typically used in their business segment and were asked to rank their top three most used insecticide products. This pre-selected chemical list was compiled using products with recognized market share from a leading market research company in turf and ornamentals (Nowak and Genskow, 2014).

The most used insecticide classes based on square footage or plants treated per year (for all business segments combined) were neonicotinoids (34%), pyrethroids (23%), and avermectins (8%) (Nowak and Genskow, 2014). The most used neonicotinoid active ingredient was imidacloprid (75%), followed by dinotefuran (17%), clothianidin (3%) and thiamethoxam (3%) (Nowak and Genskow, 2014). The preferred insecticides varied by business segment, but generally the preference was for neonicotinoids, pyrethroids, and avermectins, respectively (Table 1). Professionals managing landscape ornamentals were the only market segment to include organophosphates. AgInfomatics' list of insecticides included tetradifon; however, the registration of this AI was cancelled in 1990 (EPA, 2006). Tetradifon was the third insecticide choice of lawn professionals, albeit distantly (Table 1). The inclusion of this AI by AgInfomatics and the subsequent selection of this AI by professionals may suggest that professionals are more familiar with the names of products they use than their respective chemical name and class.

Table 1. Most Used Insecticides by Business Segment

Business Segment	Top Choice	Second Choice	Third Choice
Greenhouse Professionals	Neonicotinoids	Avermectins	Pyrethroids[1]
Nursery Professionals	Neonicotinoids	Pyrethroids	Avermectins
Lawn Professionals	Neonicotinoids	Pyrethroids	Tetradifon*
Landscape Ornamentals Professionals	Neonicotinoids	Pyrethroids	Organophosphates
Tree Professionals	Neonicotinoids	Pyrethroids	Avermectins

1 – "Unknown" was the actual 3rd choice response.
*All registrations and uses of this insecticide were cancelled in 1990 (EPA, 2006).

Imidacloprid was one of the top five insecticides used in terms of pounds applied (approximately 300,000 lbs) by professionals managing turf and ornamentals in 2011 (Kline, 2012b).

Impacts from the Loss of Neonicotinoids by Business Segment

Overall, the majority of respondents in each of the five business segments, i.e., 66% or greater, reported that there were not enough alternatives or that there were no alternatives to the neonicotinoids (Nowak and Genskow, 2014). Lawn survey respondents were the most 'pessimistic' about the availability of alternatives with only 16% saying that there are enough or more than enough alternatives to neonicotinoids (Nowak and Genskow, 2014). Greenhouse and landscape ornamentals survey respondents were the most 'optimistic' about the availability of alternatives, with 33% and 35% respectively, saying that there are enough or more than enough alternatives to neonicotinoids (Nowak and Genskow, 2014). In a similar trend, 68% of lawn respondents said that the loss of neonicotinoids would negatively impact their business income, while a lower percentage, 50% of greenhouse respondents, and, 43% of landscape ornamentals respondents said the same (Nowak and Genskow, 2014).

One survey question dealt with the possible business impacts that would be associated with the loss of the neonicotinoids. Ten factors were presented for all survey respondents to rate on a scale: "Large Decrease"; "Decrease"; "Stay the Same"; "Increase"; "Large Increase" or "Don't Know" relative to the impact on the business (Nowak and Genskow, 2014).

As a group, professionals reported that there would be an "increase" or "large increase" in the cost of applications (78% of respondents), labor costs (67% of respondents), and concerns about the toxicity of alternatives (38% of respondents) (Nowak and Genskow, 2014). They also reported that there would be a "decrease" or "large decrease" in customer satisfaction (47% of respondents), control of invasive pests (45% of respondents), the quality of plant product/pest management services (44% of respondents), and management of pest resistance (44% of respondents) (Nowak and Genskow, 2014). For management of pollinator health, 11% of respondents reported a decrease or large decrease in pollinator health, 42% of respondents said

the same, 28% of respondents reported an increase or large increase, and 18% of respondents reported 'don't know' (Nowak and Genskow, 2014).

The respondents answering "don't know" for the 10 business impact factors ranged from 4% to 18%. The three possible impacts with the most uncertainty or "don't know" responses were ability to manage pollinator health (18%), concerns about toxicity of alternatives (14%), and management of pest resistance (13%) (Nowak and Genskow, 2014).

Troublesome Pests and Alternatives

The respondents reported the top three pests that would be difficult to manage with available alternatives if the neonicotinoids were no longer available. There were 25 pests listed for respondents to choose from, but only 14 unique pests were represented in the top five pests listed for each of the five segments (i.e., 25 pests total for all segments, but only 14 unique pests chosen by respondents) (Nowak and Genskow, 2014). All pests selected for the survey were appropriate targets of neonicotinoids and commonly encountered pests of these business segments (Held and Potter, 2012; Boyd et al., 2013).

The top pests varied by business segment. The most difficult pests to manage for greenhouse and nursey professionals were aphids, whiteflies, and thrips (Nowak and Genskow, 2014). The most difficult pests to manage for lawn professionals were white grubs, chinch bugs, and billbugs (Nowak and Genskow, 2014). The most difficult pests to manage for landscape ornamentals and tree professionals were flatheaded borers and armored scales (Nowak and Genskow, 2014).

The possible alternatives in the absence of the neonicotinoids for these pests overall are pyrethroids, organophosphates, avermectins, carbamates, and diamides, respectively (Figure 7). The specific likely alternatives differed based on the business segment. For greenhouse respondents, the top likely alternatives were organophosphates, pyrethroids, and avermectins, respectively (Nowak and Genskow, 2014). For nursery respondents, the top likely alternatives were organophosphates, pyrethroids, and carbamates, respectively (Nowak and Genskow, 2014). For lawn respondents, the top likely alternatives were pyrethroids, diamides, and tetradifon, respectively (Nowak and Genskow, 2014). However, as noted previously, the registration of tetradifon was previously cancelled. For landscape ornamental respondents, the top likely alternatives were pyrethroids, organophosphates, and carbamates, respectively (Nowak and Genskow, 2014). For trees respondents, the top likely alternatives were pyrethroids, avermectins, and organophosphates, respectively (Nowak and Genskow, 2014).

Figure 7. Table 9 from Report 3, "Professionals Study" (Nowak and Genskow, 2014)

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	

Financial Information

The report also included some financial data for the respondents (i.e., annual company income) by business segment. The reporting rate was too low for further extrapolation, so the data were only summarized, with a presentation of the average, median, minimum and maximum incomes by business segment (Nowak and Genskow, 2014).

Professionals Study Conclusion

In summary, Nowak and Genskow (2014) concludes "that neonicotinoids have significant value in the turf and ornamental industries, primarily by allowing professionals to meet customer expectations. The survey results showed that a loss of neonicotinoids would have mixed impacts across the industry that ranged from "negative" for most, "neutral" for others, or "positive" for a minority of professionals" (Nowak and Genskow, 2014).

AgInfomatics' conclusion summarized a few themes and issues that arose while analyzing the data from the survey that they wanted to discuss in more detail qualitatively. The themes highlighted were: choice of neonicotinoids, customer satisfaction, IPM and resistance management, and science-based decisions. The issues highlighted were pollinator health, scaling

up pest management in the absence of neonicotinoids, and uncertainty (Nowak and Genskow, 2014).

BEAD Review of Professionals Study

The themes and issues highlighted in the conclusion of the report are similar to the "homeowners" report and case studies (discussed in Section IV) submitted by AgInfomatics. Overall, the conclusion that neonicotinoids are important to this industry is supported by Nowak and Genskow (2014). "Neonicotinoids offer systemic properties, exhibit long-term efficacy, and provide a low-risk to the applicators, customers and their pets" (Nowak and Genskow, 2014).

Although the methodology and general conclusions of Nowak and Genskow (2014) seem reasonable, BEAD has concerns in a few areas. Data in this report were not always clearly presented, summarized, or connected to AgInfomatics' stated objective of determining the stand-alone value of neonicotinoids based on the methodology's approach of triangulating data from many sources.

<u>Areas of Concern</u>

The introduction letter by the survey conductors to the respondents mentions both bee health and neonicotinoids. This could have influenced or "primed" the respondents, thus introducing a possible area of bias into the results. The survey is such that, without this information and questions about the use of pyrethroids (another high use insecticide class for these professionals), it could have focused on general insecticide use or on highly used or "major" insecticides in general.

Similar to the homeowner study report, it is not known how representative the surveyed professionals are of applicators in general or for their respective organizations. However, this limitation is addressed in the study report and is a function of the respondent organizations wanting privacy in terms of membership details, not an oversight by the report authors.

It is not always clear how the criteria/factors/impacts were chosen for the multiple-choice questions in the survey. At times, such as with the typical insecticides used, a vague acknowledgement is made to reputable sources, but not always. Although BEAD does not think that the multiple-choice questions were structured to steer respondents in a specific direction, it is nevertheless a possibility that cannot be immediately dismissed out of hand given the level of transparency presented about how this report's survey was designed and its data compiled.

In the conclusion, AgInfomatics highlighted that this study was undertaken to "understand the value of neonicotinoids" and not a "comprehensive survey of insecticide use" in the turf and ornamental industries (Nowak and Genskow, 2014). Actual usage is a strong indicator of value and would have helped to support some of the study's findings. In addition, explicit acknowledgement that usage data of some sort was used in refining the questions and active ingredients presented to the respondents is better than the few vague references to data sources presented in the report.

A more appropriate conclusion (with miscellaneous and sundry "issues and themes") would have included information about the *relative* value neonicotinoids. The case is made for the *absolute* value of neonicotinoids as being useful to this industry. Without more information on the comparative risk, cost, efficacy, ease of use, or residual activity, etc. of alternatives to the neonicotinoids, it is hard to put this information about the absolute value into proper context. This is important for gaging the general accuracy of other claims found in the survey results such as the increase in direct costs (e.g., more applications and quantity of product needed) and indirect costs (e.g., labor for record keeping, scouting, training) of alternatives if neonicotinoids are not available for use.

Additionally, in regard to the relative value of neonicotinoids and their likely alternatives, there was also some information from the surveys that could have been better incorporated into the body of the report. A few topics touched on, but not fully developed include: availability of foliar versus systemic alternatives, the optics of using certain alternatives (given that these insecticides are used in urban, not rural settings), and the trade-off (e.g., number of applications, time to apply, pounds needed) between using a foliar versus a systemic insecticide.

Given that this "value report" was not intended to be a "comparative usage report," it is understandable that some of the aforementioned elements are missing, but it seems that it would have been useful to include this information in a way that augments and supports their conclusion that neonicotinoids are beneficial to this industry. What happens to pest management within the turf and ornamental industries in the absence of neonicotinoids is at the very least a function of what alternatives are available, their cost, and their efficacy. The availability of substitute pest control methods influences a given pesticide's benefits or value. Pesticides for which there are few or poor substitutes have a higher value.

<u>The Value of Neonicotinoids to Professionals</u>

The report concludes that neonicotinoids have significant value in the turf and ornamental industries, primarily by allowing professionals to meet customer expectations (Nowak and Genskow, 2014). Some of the reasons for the value provided by neonicotinoids include: their systemic and contact properties; high efficacy, especially for certain pests; and their relative safety to applicators, customers and their pets (Nowak and Genskow, 2014). The information provided in the report generally agrees with university extension and peer-reviewed publications reviewed by BEAD regarding the use and value of neonicotinoids to professionals who apply insecticides in the turf and ornamental industries (Held and Potter, 2012; Boyd et al., 2013).

Professionals in the Lawn Care and Landscape Industries

The conclusion that neonicotinoids are valuable to professionals applying insecticides in the lawn care and landscape industries is supported by data and analysis as presented in the report. It is also supported by data available to BEAD regarding the pounds of active ingredient used by professionals in the landscape and lawn care industries. Landscape contractors use insecticides to treat for insects that attack turf, trees, and other ornamental plants (Kline, 2012b). Lawn care operators (LCOs) apply insecticides to the lawns and/or ornamental plantings that they maintain (Kline, 2012b). These professional groups are most similar to the landscape ornamentals and lawn professionals categories surveyed for the report. While pyrethroids (permethrin or

bifenthrin) were the primary choice for landscape contractors and LCOs, a neonicotinoid (imidacloprid) was second, followed by a carbamate (carbaryl) in terms of pounds applied (Table 2) (Kline, 2012b). Approximately 300,000 lbs of imidacloprid was used by professionals managing turf and ornamentals (Kline, 2012b). It must be noted that since application rates and pest spectrums are different between these chemicals, most pounds applied may not be equivalent to most chemical used or highest importance in terms of acres treated or pests targeted. Nevertheless, it is expected that the chemicals on both lists (i.e., most pounds applied and most used/important) would be similar even if their relative rankings might change a bit between the lists.

Pyrethroids, like bifenthrin, are typically the most used in terms of pounds and acre-treatments, but a neonicotinoid, e.g., imidacloprid, typically leads in terms of value of sales (Kline, 2012b). Pyrethroids are typically slightly cheaper than neonicotinoids, so professionals may be willing to pay a premium for the neonicotinoids (Kline, 2012a). Grubs, ants and "general" insects are top targeted pests, respectively, by landscape and lawn care professionals (Kline, 2012b). Imidacloprid is the top choice for preventive control of white grubs; whereas pyrethroids and carbamates are effective for targeting caterpillars and ants (Held and Potter, 2012; Kline, 2012b). These pests and alternatives are similar to what was presented in the report (Nowak and Genskow, 2014).

Table 2. Top Insecticides Used by Professionals in the Landscape and Lawn Care Industries by Pounds, 2012

Landscape	**Pounds Applied***	**Lawn Care Operators (LCOs)**	**Pounds Applied**
Bifenthrin (SyP)	28,900	Permethrin (SyP)	185,200
Imidacloprid (Neo)	18,400	Imidacloprid (Neo)	130,100
Carbaryl (Car)	13,300	Bifenthrin (SyP)	125,000
Trichlorfon (OP)	6,400	Carbaryl (Car)	77,100
Malathion (OP)	5,800	Malathion (OP)	70,300

Key: Car = Carbamate, Neo = Neonicotinoid, OP = Organophosphate, SyP = Synthetic Pyrethroid
Source: Kline, 2012b

Professionals in the Greenhouse and Nursery Industries

The conclusion that neonicotinoids are valuable to consumers and professionals applying insecticides to turfgrass and ornamentals is supported by data and analysis as presented in the report. It is also supported by data available to BEAD regarding the pounds of active ingredient used by greenhouses and nurseries or the horticultural industry. This industry encompasses businesses that produce bedding and garden plants, nursery plants, cut flowers and florist greens, potted flowering plants, foliage plants, and other similar nursery crops, but does not include sod farms, mushroom farms, or seed producers (Kline, 2012b). The information for this group is most similar to what was reported above for the greenhouse and nursery (GHN) professionals.

A neonicotinoid (imidacloprid – 5.7% of total insecticide pounds applied) was the fourth most used active ingredient by GHN professionals in terms of pounds applied, and was preceded by acephate (51%), chlorpyrifos (8.3%), and carbaryl (5.9%) (Kline, 2012b). Insects treated in

greenhouses and nurseries include aphids, whiteflies, spider mites, thrips, mealybugs, fungus gnats, and scales (Kline, 2012b). The top pests targeted are aphids, thrips, spider mites, and whiteflies, respectively. Neonicotinoids are a top (3) option for control of aphids, thrips, and whiteflies (Kline, 2012b). The list of pests and alternatives is similar to what was presented in the report (Nowak and Genskow, 2014).

Relevance to Registration Review Decision

According to AgInfomatics, the most difficult pests to manage in the absence of neonicotinoids would be aphids, borers, white grubs, armored scales and whiteflies, respectively (Nowak and Genskow, 2014). Aphids were listed as a 'Top 5' pest for every segment except lawns, and it was the top pest for the greenhouse and nursery segments. Borers were listed as the top pest for the landscape ornamental and tree segments. White grubs were listed as the top pest for the lawns segment. Armored scales were listed as a 'Top 5' pest for every segment except lawns. Whiteflies were listed as the second top pest for the greenhouse and nursery segments. (Nowak and Genskow, 2014)

Given that the 'Top 5' pests listed for the lawns business segment did not overlap with any of the other four segments, AgInfomatics may have understated the value of neonicotinoids in this industry segment. Lawn and turfgrass professionals often deal with unique suite of pests, such as ants, white grubs, billbugs, chinch bugs, and mole crickets, that may not overlap into other industry or agricultural market segments. Often, control regimens for these pests (e.g., white grubs, mole crickets) rely more heavily on neonicotinoids than other insecticide alternatives (Held and Potter, 2012). This could help to explain why this subgroup felt "most pessimistic" in the event that the neonicotinoids are no longer available.

The business impacts based on the 10 factors presented to professionals are mostly driven by the cost increases associated with the use of alternatives (chemical cost and labor cost for applications) and lowered customer satisfaction, which could lead to lower revenues in the future (Nowak and Genskow, 2014). While the specific alternatives differed based on the business segment, in general, pyrethroids, organophosphates and avermectins were the most selected alternative options according to respondents and current usage reports (Figure 7 and Table 2) (Nowak and Genskow, 2014).

Based on the survey of professionals, the cancellation of neonicotinoids would increase the use of organophosphates and pyrethroids, which are reflected in the survey responses (Nowak and Genskow, 2014). Three possible business impacts with the most uncertainty or "don't know" survey responses reported in Nowak and Genskow (2014) were the ability to manage pollinator health (18% of survey respondents), concerns about toxicity of alternatives (14% of survey respondents), and management of pest resistance (13% of survey respondents), which likely reflects the re-adoption of older chemistries, the use of which these industry segments have attempted to reduce or replace with neonicotinoids.

IV. Case Studies

Reports 4, "A Case Study of Neonicotinoids Use for Controlling Chinch Bugs in Florida St. Augustinegrass (Genskow, 2014a), Report 5, "A Case Study of Neonicotinoid Use for Controlling Emerald Ash Borer- The Naperville Experience (Genskow, 2014b), and Report 6, "A Case Study of Neonicotinoid Use for Controlling Silverleaf Whitefly in Ornamentals" (Shaw, 2014)

The case studies were supplemental to the AgInfomatics' other reports and present a detailed look at specific pests of turfgrasses, trees, and ornamentals. Two of the pests highlighted are invasive species (Genskow, 2014b; Shaw, 2014). The case studies identified certain attributes of neonicotinoids which makes them valuable to homeowners and industry professionals when making pest management decisions (Genskow, 2014a; Genskow, 2014b; Shaw, 2014). The reports reached many of the same conclusions as previous reports regarding the value of neonicotinoids due to their ability to be used in preventative and curative control measures for native and invasive species, their target pest selectivity, systemic and residual activity, cost, savings in time and labor, ease of use, lack of specialized equipment, and human and environmental safety (Genskow, 2014a; Genskow, 2014b; Shaw, 2014). All case studies were conducted in 2014 and may not accurately reflect advances in science, market trends, or regulatory actions since their completion.

<u>Methodology</u>
There were three case studies included in the package of reports regarding the value of neonicotinoids to the turf and ornamental industries for a specific production or managed system. The majority of benefits highlighted were qualitative. Each case study presented an overview of an industry segment and identified specific pest pressures that influence pest control decisions in the managed system relating to the emerald ash borer, chinch bug, and silverleaf whitefly. The studies also identified likely alternatives and impacts if neonicotinoids were cancelled.

In the following sub-sections, a summary of the report will be provided followed by a BEAD analysis of relevant insights, takeaways, and caveats regarding the case study.

The Value of Neonicotinoids in Turf and Ornamentals: A Case Study of Neonicotinoid Use for Controlling Chinch Bug in Florida St. Augustine grass

Report 4, Chinch Bung Case Study, (Genskow, 2014a)

Summary

AgInfomatics provided information in support of the claim that the turfgrass industry supports nearly a million jobs and has an annual economic impact around $58 billion (Genskow, 2014a). In Florida alone, the turfgrass industry has an annual economic impact of $3.3 billion and accounts for roughly 84,000 jobs (Haydu et al., 2006). Southern chinch bugs, *Blissus insularis* Barber, are an important turf pest of St. Augustinegrass, which is primarily grown in Florida and Texas. Southern chinch bugs have the potential to become a wider regional pest throughout Gulf Coast and other southern states (Genskow, 2014a). While St. Augustinegrass is mostly grown

around the Gulf Coast and other coastal areas, southern chinch bugs may feed on other turfgrasses common in the Southern U.S (Genskow, 2014a). Low infestations of this pest can be maintained with proper lawn care and maintenance. If southern chinch bug populations reach elevated levels, then chemical treatment will likely be needed, or the homeowner may have to pay for removal of damaged turf later (Genskow, 2014a). Costs for removal and typical yard sized for Orlando homes are given at $1 per square foot of removed turf and an average yard size of 6,500 square feet (Genskow, 2014a). In addition to neonicotinoids (imidacloprid, clothianidin, and thiamethoxam), alternative insecticide treatment options include pyrethroids, organophosphates and carbamates. Chinch bugs have developed resistance to pyrethroids in some parts of Florida (Genskow, 2014a). Biological controls have been tried, but are not effective by themselves. One resistant variety of St. Augustinegrass, 'Floratam' was developed; however, southern chinch bugs have adapted to it (Genskow, 2014a). Genskow (2014a) noted that "St. Augustine grass does not produce flowers that attract bees, and it is unlikely that bee attractive flowers would be present in managed lawns treated by neonicotinoids." Losing neonicotinoids would raise costs and increase challenges for resistance management (Genskow, 2014a).

Discussion

Relevance to Registration Review Decision

Turfgrasses provide vital ecosystem services and are the most important cover crop in the U.S., as they cover an area three times greater than any other irrigated crop (Milesi et al., 2005; Held and Potter, 2012). Since their introduction, neonicotinoids have been widely utilized in turfgrass, largely replacing organophosphates and carbamates for the management of a myriad of pest complexes (Genskow, 2014a). Southern chinch bugs have as many as 10 generations per year, placing substantial selection pressure on populations, increasing the likelihood for the development of insecticide resistance. In addition to overcoming a resistant St. Augustinegrass variety (Floratam), chinch bug populations have developed resistance to pyrethroids, organophosphates, carbamates, and some neonicotinoids (Genskow, 2014a; White, 2018; APRD, 2019). While the case study established that neonicotinoids along with pyrethroids and carbamates were a vital part of the chemistry rotation for southern chinch bug management, Genskow (2014a) did not clearly state if neonicotinoids were the primary or key chemistry for control or just a rotational partner. While a university extension specialist stated that growing and maintaining St. Augustinegrass and managing insecticide resistance would be difficult without the rotation of pyrethroids and neonicotinoids, especially clothianidin and thiamethoxam in Genskow (2014a) the report did not provide additional support. The underdeveloped thesis made it appear that there are viable alternatives to neonicotinoids for control of this pest, and that the main result of a loss of neonicotinoids would be increased challenges to resistance management. However, neonicotinoids are the primary university extension recommendation for southern chinch bug control in Florida. They are reported to be efficacious with longer residual activity than alternatives and fewer risks to non-targets (Buss et al., 2018). Neonicotinoids are critical tools for southern chinch bug management; however, there are other economically damaging and widespread turfgrass pest complexes on a national or regional scale (e.g., white grubs, billbugs, and mole crickets) that could have been used to better demonstrate the benefits

of neonicotinoids in turfgrass. For example, neonicotinoids are commonly applied preventively and curatively in turfgrass and ornamentals for the control of Japanese beetles and other white grubs (Held and Potter, 2012). Annual control expenditures for Japanese beetle adults and grubs are estimated to be in excess of $460 million with more than $78 million spent on grub control in turf (USDA APHIS, 2015a). Costs associated with replacing damaged turfgrass due to grubs are estimated to be nearly $160 million annually (USDA APHIS, 2015a).

During the public comment period, the Agency received comments on the value and benefits of neonicotinoids (i.e., imidacloprid) in turf and lawn insect managment programs. Neonicotinoids were reported to provide benefits to homeowners and professionals based on product efficacy and pest spectrum controlled, costs, ease of use, incorporation into IPM and resistance management programs. The comments received support and expand on the benefits of neonicotinoids stated by AgInfomatics to the turfgrass industry and specific market segments. For example, comments submitted by McKeel (2018) and Sherrington (2018) reported that the costs to treat golf courses and amenity turfgrass with imidacloprid (mainly for white grub control) were $9-15 per acre which was more economical than the cost to treat with chlorantraniliprole ($120-240 per acre), reseeding grass ($800-4,000 per acre), or installing new sod ($15,000-40,000 per acre). The establishment of new grass on golf courses would have additional economic impacts from lost revenues.

Several comments (e.g., Fredericks and Plevelich, 2017; McKeel, 2018) also highlighted the development and implementation of best management practices (BMPs) within the industry to address risks to non-targets. For example, BMPs for the turfgrass industry were developed by members of academia, industry, and applicator groups and subsequently published in Larson et al., (2016). Additional comments also highlighted the important role neonicotinoids play in the management of public health pests by homeowners and professionals in landscapes, within the home, and/or on pets (Anonymous, 2017b; Fredericks and Plevelich, 2017; Getty, 2018; Van Steenwyk, 2018).

The Value of Neonicotinoids in Turf and Ornamentals: Case Study of Neonicotinoid Use for Controlling Emerald Ash Borer [EAB] —The Naperville, Illinois Experience

Report 5, EAB Case Study (Genskow, 2014b)

Summary

Genskow (2014b) likened emerald ash borer (EAB), *Agrilus planipennis* [Fairmaire], damage to Dutch elm disease, which decimated elm tree populations decades ago. A model cited in Genskow (2014b) predicated the spread of EAB into 25 states, the death of 17 million ash trees, and an economic impact approaching $11 billion from associated costs of treatment, removal, and replacement of trees (Kovacs et al., 2009).

The focus of the case study was the EAB management program for Naperville, Illinois, a city with over 15,000 ash trees on public property (Genskow, 2014b). The community had three treatment options: proactive removal of ash trees, reactive removal of ash trees after infestation, or targeted treatment with insecticides (Genskow, 2014b). Removal and replanting of trees costs

ranged $1,200 to $1,700 with an average cost of $1,500 per tree (Genskow, 2014b). Insecticide treatment options were soil injection or drench treatments with imidacloprid; soil injection, drench, or basal trunk spray with dinotefuran, or trunk injections with emamectin benzoate or acephate (Genskow, 2014b). Treatments with neonicotinoids for EAB protection require an annual application, take 1-2 minutes to apply, do not require specialized equipment unless applied as a soil injection, and may be applied by a homeowner or licensed professional (Genskow, 2014b). In Naperville, neonicotinoids (imidacloprid and dinotefuran) with an approximate cost of $100 per tree and emamectin benzoate (cost not reported) were applied by a licensed professional (Genskow, 2014b). Non-neonicotinoid EAB control options of emamectin benzoate or acephate are applied as trunk injections and can take up to 45 minutes to apply, require specialized equipment, and must be applied by a licensed professional (Genskow, 2014b). The Naperville community found neonicotinoids to be very helpful in controlling EAB and protecting/preserving their ash trees (Genskow, 2014b). It was also more cost-effective than removing the trees ($100 versus $1500) which had been the predominate control method (Genskow, 2014b). The study noted that ash trees are wind pollinated and not considered attractive to pollinators (Genskow, 2014b).

Discussion

Relevance to Registration Review Decision

The comparison of EAB to Dutch elm disease in Genskow (2014b) is appropriate given the extent and impact EAB has had on ash trees in the U.S. The USDA has classified EAB as the most destructive invasive forest insect in North America (Herms and McCullough, 2014). Ash trees often comprise more than 50% of landscape and street trees where they provide vital ecosystem services related to improved water quality; carbon sequestration and filtration of other pollutants; as well as from increasing public health, sentimental, and property values; aesthetics; and decreasing cooling costs (Kane and Kirwan, 2009; Donovan et al., 2013; Herms and McCullough, 2014; Herms et al., 2019; McCullough et al., 2019). Since its introduction and subsequent detection in 2002, EAB has killed millions of ash trees and spread to 35 states and the District of Columbia (Herms et al., 2019; USDA APHIS, 2019). In some areas, EAB infestations have resulted in the death of over 99% of ash species (Herms and McCullough, 2014). The spread of EAB into more states than predicted by the model proposed by Kovacs et al. (2009) likely suggests that the impacts on ash tree decline and economics has been greater than anticipated. While estimates of economic impacts resulting from EAB infestations are quantifiable, the impacts of EAB on social and cultural values are not easily quantifiable. For example, several Native American and Frist Nation tribes have deep cultural and spiritual ties to black ash (Herms and McCullough, 2014).

Successful management of EAB relies heavily on insecticides and is challenging due to several factors. For example, it is difficult to detect low-density EAB populations in addition to the fact that treatment programs that begin too early result in a waste of money and unnecessary insecticide use whereas programs that begin too late, fail to avoid tree death (Herms and

McCullough, 2014; Herms et al., 2019). However, economic analyses have consistently shown that treatment with insecticides is less costly than tree removal (Herms et al., 2019).

Several factors such as the number of trees; tree condition, size, location; application equipment; time and labor; and budgetary or associated values influence treatment decisions of urban trees. Applications of neonicotinoids to ash trees by homeowners and professionals have been widely used for managing EAB and have been included in USDA control efforts (McCullough et al., 2019). Results with neonicotinoids have been variable based on active ingredient used, application rate, timing of application, number of applications, and application method (Herms et al. 2019; McCullough et al., 2019). Applications of neonicotinoids may be preferable over trunk injections of other insecticides due to costs, the time it takes to apply, being readily available to homeowners and professionals, and no requirement for special application equipment. Further, some applicators prefer to use neonicotinoids over trunk injections, which requires drilling holes into the tree and subsequent wounding, although research has not substantiated long-term tree health concerns from this application method (Herms et al., 2019). Not mentioned in Genskow (2014b) is the importance of insecticide timing and the rate of transport (i.e., speed of control) of insecticides moving from the root zone or trunk to the canopy. Studies have shown trunk injections are more readily transported than trunk and soil applications (Herms et al., 2019). Of the application methods for neonicotinoids, trunk sprays of dinotefuran are transported faster than soil applications of imidacloprid to the canopy (Herms et al., 2019). Efficacy trials evaluating neonicotinoids have shown them to be viable options for EAB control; however, studies have shown emamectin benzoate to be the most effective treatment (Herms et al., 2019; McCullough et al., 2019). While applications of emamectin benzoate to a single tree may take up to 45 minutes and must be made by a licensed applicator, it consistently provides 3 years of protection (Genskow, 2014b; Herms et al., 2019; McCullough et al., 2019). While not always the most efficacious control option, neonicotinoids are often the most feasible tool for EAB control providing benefits to urban landscape and forest pest management and insecticide resistance programs.

Neonicotinoids have been critical tools for managing insect pests of trees in landscapes and forests. Genskow (2014b) clearly demonstrated the high value or benefits provided by neonicotinoids in the city of Naperville's EAB management program over tree removal; however, the benefits over alternative chemistries, like emamectin benzoate were less clearly defined in the report. The case study highlighted by AgInfomatics regarding the value of neonicotinoids in managing invasive landscape and tree pests is also applicable to other landscape and tree pests.

During the public comment period, the Agency received comments on the value and benefits of neonicotinoids (i.e., imidacloprid, dinotefuran) for effective control in management programs for EAB and additional landscape and forestry pests such as hemlock woolly adelgid, *Adelges tsugae* [Annand]; lobate lac scale, *Paratachardina pseudolobata* [Kondo and Gullan]; spotted lanternfly, *Lycorma delicatula* [White]; and Asian longhorned beetle, *Anoplophora glabripennis* [Motschulsky] (Anonymous, 2016, 2017a, 2017b; Calabro, 2017a, 2017b, 2018; El-Lissy, 2018; Fournier et al., 2017; Hobbs, 2017, 2018; Kawate and Tarutani, 2017; McKeel, 2018; Tatum, 2016; Van Handel, 2017; Van Steenwyk, 2018). El-Lissy (2018), which was submitted on behalf of USDA, noted the importance of imidacloprid and dinotefuran in plant protection and

quarantine (PPQ) programs targeting invasive species attacking trees on federal lands. The comment described target pest(s), host ranges, use rates, application methods, treatment frequency or maximum treatments per year, locations and area treated, alternatives, cost of the program, economic or cost/benefit analysis, and the value of protected commodities. As an example, the spotted lanternfly is an invasive pest and an emerging problem for certain industries. This pest could seriously harm the country's grape, orchard, and logging industries because of its ability to reduce plant vigor and promote sooty mold growth with its honeydew (USDA APHIS, 2015b). The proposed spotted lanternfly eradication program primarily involves basal trunk sprays of dinotefuran (USDA APHIS, 2015b). Additional comments reviewed by BEAD supported and expanded on the benefits of neonicotinoids demonstrating the diversity and overlap of industries and market segments pertaining to pest control in ornamentals, trees, and forestry.

The Value of Neonicotinoids in Turf and Ornamentals: A Case Study of Neonicotinoid Use for Controlling Silverleaf Whitefly in Ornamentals

Report 6, Silverleaf Whitefly Case Study (Shaw, 2014)

Summary

This case study focused on the control of the invasive silverleaf whitefly, *Bemisia tabaci* [Gennadius], in the floriculture and ornamental industry or green industry (Shaw, 2014). The green industry is economically important representing over 430,000 jobs and $27 billion in annual revenues (Hodges et al., 2007). The segments of this industry encompass many crops, including but not limited to: bedding plants, potted flowering plants, foliage plants, fresh-cut flowers, shrubs and trees (Shaw, 2014). Silverleaf whiteflies are one of the most damaging pests to many of these ornamental crops and is also damaging to several agronomic crops (e.g., cotton) (Shaw, 2014). Silverleaf whiteflies feed and transmit viruses on a wide range of commonly-grown greenhouse crops, including poinsettia, gerbera daisy, hibiscus and mandevilla (Shaw, 2014). In protected environments like greenhouses, silverleaf whiteflies can have continuous generations and can develop insecticide resistance quickly if not properly controlled. In fact, the Q-type silverleaf whitefly is partially or fully resistant to pyrethroids, organophosphates, insect growth regulators (IGRs), and neonicotinoids (Shaw, 2014). Systemic control is often critical in floricultural and nursery crops where tight plant spacing makes it difficult to penetrate dense crop canopies with foliar sprays, so neonicotinoids are often applied to soils or containers (Shaw, 2014). The availability of non-neonicotinoid systemic insecticides is limited (Shaw, 2014). Shaw (2014) further states that many ornamental plants grown for indoor use never make it outdoors where pollinators might be exposed to them, and those that are for planting in outside landscapes are not bee-attractive or are treated before they flower so there is minimal risk to pollinators, a claim that is supported by research, but not ubiquitous (Garbuzov et al., 2017; Mach and Potter, 2018).

Discussion

<u>Relevance to Registration Review Decision</u>

Since neonicotinoids were introduced in the 1990s they have been widely adopted in the green industry as an alternative or replacement for organophosphates, carbamates, and to a lesser

extent, pyrethroids for many pest complexes. Neonicotinoids are widely used for the control of many commonly encountered or invasive green industry pests including, but not limited to, whiteflies, psyllids, leafminers, scales, mealybugs, thrips, Japanese beetles, and the spotted lanternfly. Many of these pests are vectors, multivoltine, and have documented insecticide resistance, indicating neonicotinoids provide high pest management value and benefits insecticide resistance management programs within this industry. According to the case study, neonicotinoids are often preferred over older chemistries due to their lower risks to workers, efficacy, longer residuals, and impacts on non-target organisms, such as ladybugs and lacewings, which are commonly used biocontrol agents in this industry (Shaw, 2014). The manner in which information was presented in Shaw (2014) made it unclear if neonicotinoids were the primary control measure or an important rotational tool for silverleaf whitefly control. However, public comments submitted to the Agency on behalf of AmericanHort and the Horticultural Research Institute stated that neonicotinoids, especially dinotefuran, are often the first line of defense for pest control due to its rapid plant uptake (Calabro, 2017a; Calabro 2017b; Calabro, 2018). The comments also provided details on industry important pests controlled by neonicotinoids, host plants, application rates, number of applications, application methods, treatment locations (states), alternatives, value to industry, and additional parameters. Another comment, Hansen (2017), provided general support for the benefits of neonicotinoids within the flower and nursery industries.

Conclusion

Studies were completed to determine the value of neonicotinoids to homeowners and professionals who manage turf and ornamentals. Turf and ornamentals add value to the homes of consumers through various means such as aesthetics, recreation, energy conservation and water conservation. Insects can damage areas with turf and ornamentals, and thus reduce their value to consumers. Insecticides, including neonicotinoids, control insect pests and avoid or lessen the damage they cause. Over 19,000 homeowners were surveyed and segmented into three markets based on their predominate "homescape" type: "flowers and shrubs," "lawns," and "trees." Over 700 turf and ornamentals professionals were surveyed through various professional associations and segmented into five business types: trees, greenhouse, lawn, nursery, and landscape ornamentals.

The results of the homeowner survey, Yue (2014) showed that the top concerns of homeowners applying insecticides to their homescape center around efficacy and safety. To the extent that neonicotinoids fulfil these two criteria, they are of value to homeowners. Nevertheless, when homeowners are given a choice between insecticide options that have both of these attributes, homeowners prefer to go with the option that has the additional attribute of being safer on bees. In two out of the three market segments, the top choice for homeowners was a "safe for bees" option and the second choice was a neonicotinoid. In the last remaining segment, flowers and shrubs, the top choice was a neonicotinoid. Homeowners preferred the attributes associated with neonicotinoids, but also organophosphates, pyrethroids, and "safe on bees" options like emamectin benzoate and chlorantraniliprole.

The results of the professionals survey, Nowak and Genskow (2014) suggests that professionals value the neonicotinoids because professionals feel that neonicotinoids offer systemic properties, exhibit long-term efficacy, and provide a low-risk to the applicators, customers and their pets.

The most used neonicotinoid active ingredient based on the survey results was imidacloprid (75% of survey respondents), followed by dinotefuran (17%), clothianidin (3%) and thiamethoxam (3%). Based on the results of this report, the most difficult pests to manage in the absence of neonicotinoids would be aphids, borers, grubs, armored scales and whiteflies. Professionals stated that the negative business impacts from the absence of neonicotinoids would be driven mostly by the cost increases associated with the use of alternatives (e.g., alternative applications directly and alternatives labor costs) and lower customer satisfaction. The possible alternatives in the absence of the neonicotinoids are pyrethroids, organophosphates, avermectins, carbamates, and diamides.

In addition to the homeowner and professionals surveys, there were also three case studies:

- In Genskow (2014a), the southern chinch bugs case study, it appeared that there are viable alternatives to neonicotinoids, but that resistance management could be more challenging without the neonicotinoids, especially if pyrethroid resistance became more widespread. Research reviewed by BEAD showed that the case study's conclusions may have understated the benefits of the neonicotinoids because, for southern chinch bugs and other lawn pests, such as Japanese beetles and other white grubs, the neonicotinoids are a key chemistry for control. Several public comments reviewed by BEAD highlighted the value of neonicotinoids in regard to product costs and pests controlled in lawns and amenity turfgrasses relative to alternative options.
- Genskow (2014b) reported that for communities like Naperville, IL facing an increase in emerald ash borer (EAB) populations or with ash trees at risk, neonicotinoids (i.e., imidacloprid, dinotefuran) appear to provide high benefits when compared to alternatives, both chemical and non-chemical options, such as tree removal. BEAD found that the neonicotinoids benefits highlighted in this case study are representative of the high benefits for other problematic tree pests such as hemlock woolly adelgid, the spotted lanternfly, and the Asian longhorned beetle. Additionally, a comment from USDA APHIS noted the reliance on neonicotinoids in plant protection and quarantine (PPQ) programs to protect trees on federal lands from invasive species.
- Shaw (2014) demonstrated that the ability of the silverleaf whitefly to rapidly develop resistance to insecticides and limited access to efficacious alternatives in the floriculture and ornamental industry means that neonicotinoids are important to the many ornamental crops impacted by this pest. Additional information submitted by stakeholders such as AmericanHort and HRI provided further evidence on the value of neonicotinoids to combat this pest within the industry, specifically dinotefuran.

Although the reports, methodology, results, and general conclusions seem reasonable in scope and execution, there were a few areas for improvement in the reports. For example, there appeared to be some inconsistencies between the results presented and the conclusions drawn from those results. Also, some key points could have been developed more fully (e.g., lack of alternatives to the neonicotinoids for certain niche pests) and other relevant key points were not mentioned in the body of the report, but appear in the conclusion (e.g., the importance of being a systemic insecticide). Nevertheless, as a qualitative assessment, AgInfomatics' reports and case studies provide reasonable insights into the advantages of neonicotinoids in comparison to other

pest control measures. According to these reports, neonicotinoids provide effective, broad-spectrum control at low cost and they contribute to insecticide resistance management as rotation partners with other classes of insecticides. BEAD agrees with AgInfomatics that the neonicotinoids are a useful tool and often a top choice for pest control in the turf and ornamental industries.

REFERENCES

Anonymous. 2016. Public comment submitted. Available at https://www.regulations.gov/, docket EPA-HQ-OPP-2008-0844-0152.

Anonymous. 2017a. Public comment submitted. Available at https://www.regulations.gov/, docket EPA-HQ-OPP-2008-0844-1095.

Anonymous. 2017b. Public comment submitted. Available at https://www.regulations.gov/, docket EPA-HQ-OPP-2008-0844-1097. Arthropod Pesticide Resistance Database (APRD). 2019. https://www.pesticideresistance.org/search.php. Accessed May 29, 2019.

Boyd, D., J.D. Hopkins, B. McPeake, and S. Vann. 2013. *In* Ornamental, Tree, and Turf Pest Control. J.D. Hopkins (Ed.). University of Arkansas Extension Publication AG 1158. https://www.uaex.edu/farm-ranch/pest-management/docs/training-manuals/AG1158.pdf. Accessed June 12, 2019.

Buss, E.A. B.M., Whitman, and A.G. Dale. 2018. Managing Southern Chinch Bug in Warm Season Turfgrasses. UF/IFAS Extension ENY-325. https://edis.ifas.ufl.edu/pdffiles/LH/LH03600.pdf. Accessed May 29, 2019.

Calabro, J. 2017a. Public comment submitted on behalf of AmericanHort and the Horticultural Research Institute. Available at https://www.regulations.gov/, docket EPA-HQ-OPP-2008-0844-1215.

Calabro, J. 2017b. Public comment submitted on behalf of AmericanHort and the Horticultural Research Institute. Available at https://www.regulations.gov/, docket EPA-HQ-OPP-2011-0920-0611.

Calabro, J. 2018. Public comment submitted on behalf of AmericanHort and the Horticultural Research Institute. Available at https://www.regulations.gov/, docket EPA-HQ-OPP-2008-0844-1443.

Donovan, G.H., D. T. Butry, Y.L. Michael, J.P. Prestemon, A.M. Liebhold, D. Gatziolis, and M.Y. Mao. The Relationship Between Trees and Human Health: Evidence from the Spread of the Emerald Ash Borer. Am. J. Prev. Med. 44: 139-145. https://doi.org/10.1016/j.amepre.2012.09.066.

El-Lissy, O. 2018. Public comment submitted on behalf of United States Department of Agriculture, Animal and Plant Health Inspection Service, Plant Protection and Quarantine (USDA-APHIS-PPQ). Available at https://www.regulations.gov/, docket EPA-HQ-OPP-2011-0920-0719

Environmental Protection Agency (EPA). 2006. Benzaldehyde, Captafol, Hexaconazole, Paraformaldehyde, Sodium dimethyldithiocarbamate, and Tetradifon; Tolerance Actions. 71 FR 24586. Available at https://www.regulations.gov/, docket EPA-HQ-OPP-2005-0322-0004.

Fournier, A., P. Ellsworth, and W. Dixon. 2017. Public comment submitted on behalf of Arizona Pest Management Center. Available at https://www.regulations.gov/, docket EPA-HQ-OPP-2011-0920-0100.

Fredericks, J., and J.B. Plevelich. 2017. Public comment submitted on behalf of National Pest Management Association (NPMA). Available at https://www.regulations.gov/, docket EPA-HQ-OPP-2008-0844-1200.

Garbuzov, M., K. Alton, and F.L.W. Ratnieks. 2017. Most Ornamental Plants on Sale in Garden Centres are Unattractive to Flower-Visiting Insects. PeerJ. 5: e3066. https://peerj.com/articles/3066/.

Getty, G.M. 2018. Public comment submitted. Available at https://www.regulations.gov/, docket EPA-HQ-OPP-2008-0844-1492.

Genskow, B. 2014a. Case Study of Neonicotinoid Use for Controlling Emerald Ash Borer [EAB] —The Naperville, Illinois Experience. Report 4 of The Value Neonicotinoids in Turf and Ornamentals. Study sponsored and submitted by the Neonicotinoid Consortium. Available at https://www.regulations.gov/, docket EPA-HQ-OPP-2011-0581-0060.

Genskow, B. 2014b. Case Study of Neonicotinoid Use for Controlling Chinch Bug in Florida St. Augustine grass. Report 5 of The Value Neonicotinoids in Turf and Ornamentals. Study sponsored and submitted by the Neonicotinoid Consortium. Available at https://www.regulations.gov/, docket EPA-HQ-OPP-2011-0581-0060.

Hansen, H. 2017. Public comment submitted on behalf of Washington Friends of Farms and Forests. Available at https://www.regulations.gov/, docket EPA-HQ-OPP-2011-0920-0104

Haydu, J.J., A.W. Hodges, and C.R. Hall. 2006 Economic Impacts of the Turfgrass and Lawncare Industry in the United States. UF/IFAS Extension FE 632. http://edis.ifas.ufl.edu/pdffiles/FE/FE63200.pdf. Accessed May 30, 2019.

Held, D.W., and D.A. Potter. 2012. Prospects for Managing Turfgrass Pests with Reduced Chemical Inputs. Ann. Rev. Entomol. 57:329–54. https://www.annualreviews.org/doi/pdf/10.1146/annurev-ento-120710-100542. Accessed June 12, 2019.

Herms, D.A., and D.G. McCullough. 2014. Emerald Ash Borer Invasion of North America: History, Biology, Ecology, Impacts, and Management. Ann. Rev. Entomol. 59: 13-30. https://doi.org/10.1146/annurev-ento-011613-162051.

Herms, D.A., D.G McCullough, C.S. Clifford, D.R. Smitley, F.D. Miller, and W. Cranshaw. 2019. Insecticide Options for Protecting Ash Trees from Emerald Ash Borer. North

Central IPM Center Bulletin. 3rd Edition. http://www.emeraldashborer.info/documents/Multistate_EAB_Insecticide_Fact_Sheet.pdf. Accessed May 30, 2019.

Hobbs, A. 2017. Public comment submitted on behalf of Responsible Industry for a Sound Environment (RISE). Available at https://www.regulations.gov/, docket EPA-HQ-OPP-2011-0920-0108.

Hobbs, A. 2018. Public comment submitted on behalf of Responsible Industry for a Sound Environment (RISE). Available at https://www.regulations.gov/, docket EPA-HQ-OPP-2011-0581-0239.

Joseph, S.V., S.K. Braman, J. Quick, and J.L. Hanula. 2011. The Range and Response of Neonicotinoids on Hemlock Woolly Adelgid, *Adelges tsugae* (Hemiptera: Adelgidae) J. Environ. Hort. 29: 197-204. https://hrijournal.org/doi/abs/10.24266/0738-2898-29.4.197.

Kane, B., and J. Kirwan. 2009. Value, Benefits, and Costs of Urban Trees. Virginia Cooperative Extension Publication 420-181. http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.180.3602&rep=rep1&type=pdf. Accessed May 30, 2019.

Kline. 2012a. Kline & Company: Consumer Markets for Pesticides and Fertilizers 2012: U.S. Market Analysis and Opportunities.

Kline. 2012b. Kline & Company: Professional Turf and Ornamental Markets for Pesticides and Fertilizers USA.

Kovacs, K.F., R.G. Haight, D.G. McCullough, R.J. Mercader, N.W. Siegert, and A.M. Liebhold. 2010. Cost of Potential Emerald Ash Borer Damage in U.S. Communities, 2009-2019. Ecol. Econ. 69: 569-578. https://doi.org/10.1016/j.ecolecon.2009.09.004.

Kwate, M., and C. Tarutani. 2017. Public comment submitted on behalf of University of Hawaii at Manoa. Available at https://www.regulations.gov/, docket EPA-HQ-OPP-2008-0844-1229.

Larson, J., D. Held, and R.C. Williamson. 2016. Best Management Practices for Turf Care and Pollinator Conservation. North Central IPM Center. https://ncipmc.org/action/bmpturf.pdf. Accessed September 5, 2019.

Mach, B.A., and D.A. Potter. 2018. Quantifying Bee Assembles and Attractiveness of Flowering Woody Landscape Plants for Urban Pollinator Conservation. PLoS ONE 13(12): e0208428. https://doi.org/10.1371/journal.pone.0208428.

McCullough, D.G., T.M. Poland, A.R. Tluczek, A. Anulewicz, J. Wieferich, and N.W. Siegert. 2018. Emerald Ash Borer (Coleoptera: Buprestidae) Densities Over a 6-Yr Period on Untreated Trees and Tree Treated with Systemic Insecticides and 1-, 2-, and 3-Yr Intervals in a Central Michigan Forest. J. Econ. Entomol. 112: 201-212. https://doi.org/10.1093/jee/toy282.

McKeel, C.E. 2018. Public comment submitted on behalf of Golf Course Superintendents Association of America (GCSAA). Available at https://www.regulations.gov/, docket EPA-HQ-OPP-2008-0844-1547.

Milesi, C., S.W. Running, C.D. Elvidge, J.B. Dietz, B.T. Tuttle, and R.R. Nemani. 2005. Mapping and modeling the biochemical cycling of turf grasses in the United States. Environ. Manag. 36: 426-438. https://doi.org/10.1007/s00267-004-0316-2. Accessed June 12, 2019.

Neonicotinoid Consortium. 2017. Public comment with a series of reports submitted on behalf of Bayer CropScience L.P., Mitsui Chemicals Agro, Inc., Syngenta Crop Protection, LLC, and Valent U.S.A. LLC. Available at https://www.regulations.gov/, docket EPA-HQ-OPP-2011-0581-0060.

Non-agricultural Market Research Data (NMRD). 2017. Data on Consumer and Professional Pest Control Markets Collected and Sold by a Private Market Research Firm.

Nowak, P. 2014. Executive Summary for the Value of Neonicotinoids in Turf and Ornamentals. Report 1 of The Value Neonicotinoids in Turf and Ornamentals. Study sponsored and submitted by the Neonicotinoid Consortium. Available at https://www.regulations.gov/, docket EPA-HQ-OPP-2011-0581-0060.

Nowak, P., and B. Genskow. 2014. The Value of Neonicotinoids to Turf and Ornamental Professionals. Report 3 of The Value Neonicotinoids in Turf and Ornamentals. Study sponsored and submitted by the Neonicotinoid Consortium. Available at https://www.regulations.gov/, docket EPA-HQ-OPP-2011-0581-0060.

Shaw, B. 2014. Case Study of Neonicotinoid Use for Controlling Silverleaf Whitefly in Ornamentals. Report 6 of The Value Neonicotinoids in Turf and Ornamentals. Study sponsored and submitted by the Neonicotinoid Consortium. Available at https://www.regulations.gov/, docket EPA-HQ-OPP-2011-0581-0060.

Sherrington, C. 2018. Public comment submitted on behalf of Lawn Doctor Inc. Available at https://www.regulations.gov/, docket EPA-HQ-OPP-2008-0844-1442

Tatum, V. 216. Public comment submitted on behalf of National Council for Air and Stream Improvement Inc. (NCASI). Available at https://www.regulations.gov/, docket EPA-HQ-OPP-2008-0844-0904.

Van Handel, J. 2017. Public comment submitted on behalf of SBM Life Science Corp. Available at https://www.regulations.gov/, docket EPA-HQ-OPP-2008-0844-1212.

Van Steenwyk, D. 2018. Public comment submitted on behalf of Pest Control Operators of California (PCOC). Available at https://www.regulations.gov/, docket EPA-HQ-OPP-2008-0844-1446.

United States Department of Agriculture (USDA) Animal and Plant Health Inspection Service (APHIS). 2014. Pest Alert: Spotted Lanternfly (*Lycorma delicatula*). Plant Protection and Quarantine. https://www.aphis.usda.gov/publications/plant_health/2014/alert_spotted_lanternfly.pdf. Accessed June 4, 2019.

United States Department of Agriculture (USDA) Animal and Plant Health Inspection Service (APHIS). 2015a. Managing the Japanese Beetle: A Homeowner's Handbook. https://www.aphis.usda.gov/plant_health/plant_pest_info/jb/downloads/JBhandbook.pdf. Accessed June 6, 2019.

United States Department of Agriculture (USDA) Animal and Plant Health Inspection Service (APHIS). 2015b. Spotted Lanternfly Eradication Program in Berks, Lehigh and Montgomery Counties, Pennsylvania. United States Department of Agriculture. Animal and Plant Health Inspection Service. https://www.aphis.usda.gov/plant_health/ea/downloads/2015/slf-berks-lehigh-montgomery-pa.pdf. Accessed June 4, 2019.

United States Department of Agriculture (USDA) Animal and Plant Health Inspection Service (APHIS). 2019. Emerald Ash Borer. https://www.aphis.usda.gov/aphis/ourfocus/planthealth/plant-pest-and-disease-programs/pests-and-diseases/emerald-ash-borer. Accessed June 3, 2019.

United States Department of Agriculture (USDA) Forest Service (FS). 2017. Emerald Ash Borer. https://www.nrs.fs.fed.us/disturbance/invasive_species/eab/control_management/systemic_insecticides/. Accessed June 3, 2019.

White, C. 2018. Chinch Bug Resistance Still a Problem. UF/IFAS Extension. https://blogs.ifas.ufl.edu/orangeco/2018/07/31/chinch-bug-resistance-still-a-problem/. Accessed May 29, 2019.

Yue, C. 2014. Estimating the Economic Value of Neonicotinoid Insecticides on Flowers, Shrubs, Home Lawns and Trees in the Homescape. Report 2 of The Value Neonicotinoids in Turf and Ornamentals. Study sponsored and submitted by the Neonicotinoid Consortium. Available at https://www.regulations.gov/, docket EPA-HQ-OPP-2011-0581-0060.