AgInfomatics

The Value of Neonicotinoids in Turf and Ornamentals:

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

2014

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

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

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

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

The Value of Neonicotinoids in North American Agriculture

Reports include:

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

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

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

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

A Case Study of Neonicotinoid Use in Florida Citrus

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Executive Summary

The Value of Neonicotinoids in Turf and Ornamentals

Reports include:

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

The Value of Neonicotinoids to Turf and Ornamental Professionals

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

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

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

Executive Summary

For more information, please contact AgInfomatics@gmail.com

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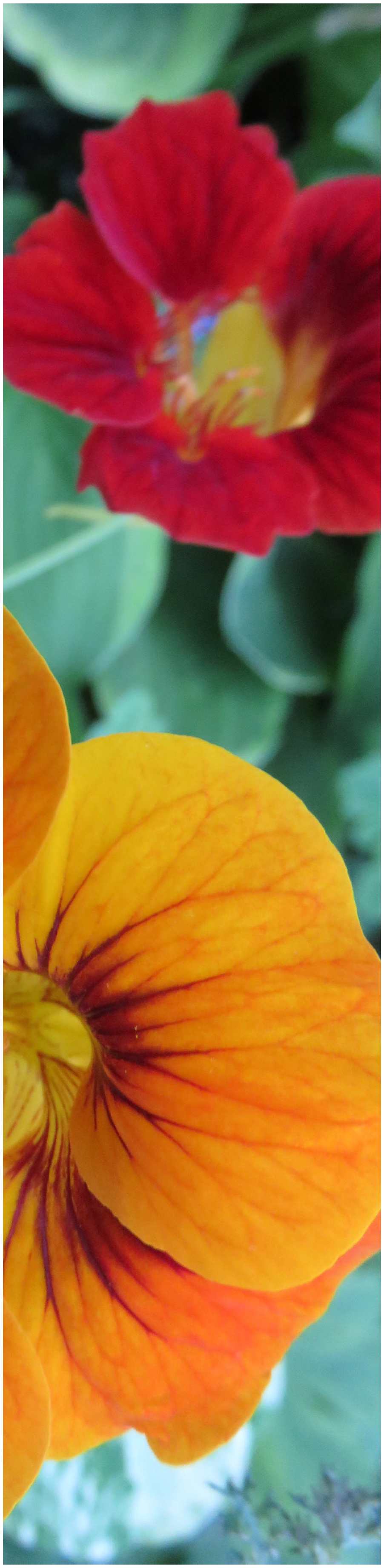
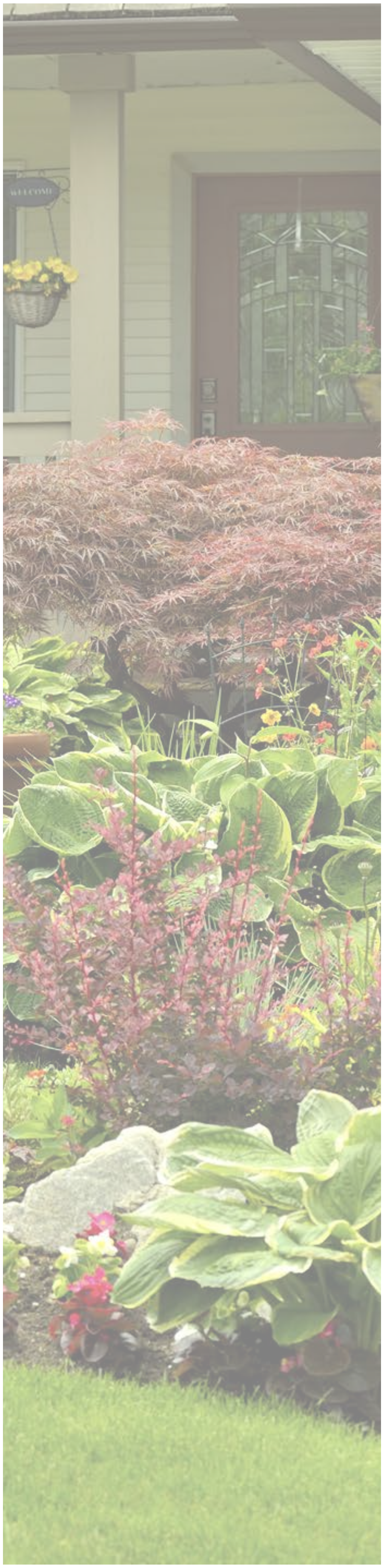


Abstract

Flowers, shrubs, lawns and trees add value to homes through improved aesthetics, recreation, energy conservation and water conservation. However, insect pests can cause substantial loss of or damage to flowers, shrubs, home lawns and trees. Choice Experiment data was collected through online surveys with 19,699 homeowners to elicit their preferences and willingness to pay for nine different attributes of insecticides used to control pests on ornamental plants, trees and lawns in residential landscapes. Of the 19,699 homeowners surveyed, 18,885 (96 percent) agreed to participate in the study and had flowers, shrubs, lawns or trees in their yard. Forty-five percent of the 18,885 homeowners (8,556) reported using insecticides on their homescape. Of the 8,556 homeowners, 7,472 completed the Choice Experiments. Survey results show that homeowners value the key function of insecticides – very high effectiveness and the preventive and curative attribute the most. An insecticide's human, pet and wildlife safety is also valuable. Homeowners are willing to pay premiums for insecticides that are safer to bees, but these premiums are not as large as the premiums they are willing to pay for effectiveness, human, pet and wildlife safety, and the preventive as well as curative attribute. By comparing the attributes of various insecticides on the market, we found homeowners are willing to pay at least $105 per year more on average for neonicotinoid insecticides than other insecticides for flowers or shrubs, $136 per year more on average for neonicotinoid insecticides than other insecticides for home lawns (except for chlorantraniliprole) and $84 per year more for neonicotinoid insecticides than other insecticides for trees (except for emamectin). Homeowners who have insecticides professionally applied prefer the attributes of neonicotinoid insecticides over the attributes of organic products and older chemical alternatives. This study provides useful information for policy makers to weigh when making decisions regarding the use of neonicotinoid insecticides by homeowners.



1.0 Introduction

Flowers, shrubs, lawns and trees add value to homes through improved aesthetics, recreation, energy conservation and water conservation (Anderson and Cordell, 1985; Behe et al., 2005; Buffington, 1978; Hugie et al., 2012). For example, the New York Department of Environmental Conservation estimates trees can save up to 56 percent on annual air-conditioning costs, and large specimen trees can add 10 percent to property value (New York Department of Environmental Conservation, 2014). However, insect pests can cause substantial loss of or damage to flowers, shrubs, home lawns and trees. Neonicotinoid insecticides (neonic insecticides) were introduced in the 1990s to protect plants against piercing/sucking insect pests (Sánchez-Bayo et al., 2013; Tomizawa and Casida, 2005). They are effective against a variety of important ornamental and turf pests, including emerald ash borer, azalea lace bug, white grub and Japanese beetle (Morales 2009; Sánchez-Bayo et al., 2013). The effectiveness of control coupled with the convenience achieved by neonicotinoid insecticides has resulted in their widespread use in residential settings, as well as in the ornamental and turf industries. An important element missing from the current debate regarding the use of neonicotinoid insecticides is a quantitative estimate of the benefits they provide in both agronomic and non agronomic settings.

Neonicotinoid insecticides are systemic, which means the product controls pests from inside the plant's leaves and stems (Tomizawa and Casida, 2005). Neonicotinoid insecticides have lower toxicity to mammals (such as humans, cats and dogs), fish and birds, compared to some non-neonicotinoid insecticides, such as organophosphates and carbamates (Tomizawa and Casida, 2005; Jeschke and Nauen, 2008). However, some recent scientific research suggests a possible link between the use of neonicotinoid insecticides (along with many other factors) to decreased bee numbers (Cressey, 2013).

This study focuses on the use of neonicotinoid insecticides in the homescape for controlling insect pests on flowers, shrubs, home lawns and trees. Homeowners face the challenge of weighing the use of costly protective measures (such as insecticides) and the potential loss of or damage to plants. When homeowners choose between different insecticides, they also face the challenge of weighing factors, such as an insecticide's effectiveness, convenience of application, safety to pets, wildlife and bees, as well as humans. Our objective is to estimate the economic value to homeowners of various insecticide attributes in general and neonicotinoid insecticides specifically when used to protect residential flowers, shrubs, lawns and trees. Accomplishing this objective is a challenge because homeowners may not accurately recall what insecticides they used or know/understand an insecticide's active ingredients. To tackle this challenge, we employed Choice Experiments to understand homeowners' preferences and willingness to pay (WTP) for various insecticide attributes. Based on their WTP for various attributes, we can then estimate the relative value of alternative insecticides to homeowners.

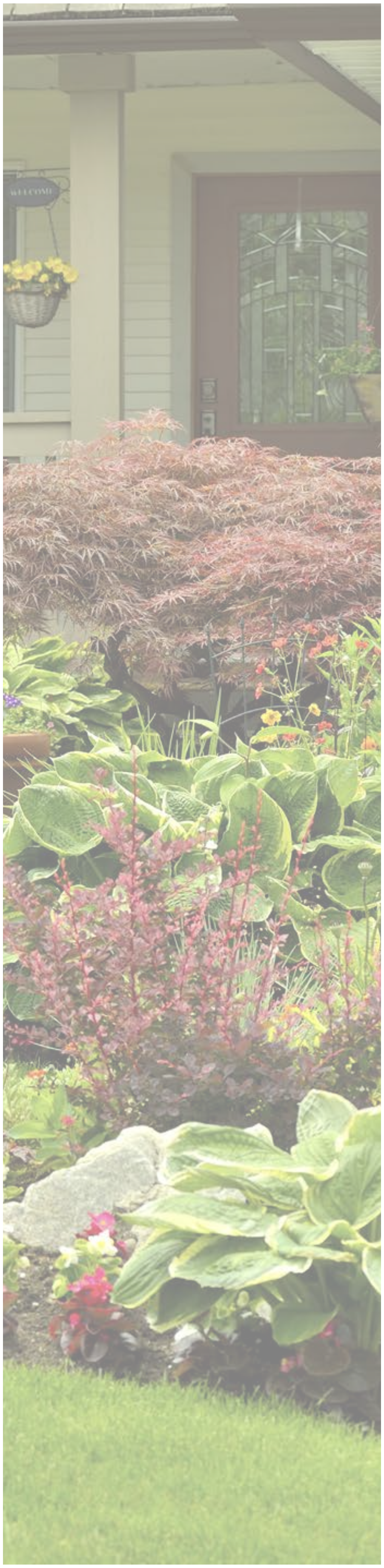
2.0 Methodology

Choice Experiments have been widely used by researchers to study consumer preferences and the WTP for goods (Darby et al., 2008; Tonsor et al., 2009; Rousseau and Vranken, 2013). The theoretical basis of Choice Experiments is that consumers derive utility/satisfaction from attributes of a good rather than from the good itself (Lancaster, 1966). Choice Experiments represent goods with a combination of attributes, so researchers can estimate the value for various attributes simultaneously. Additionally, Choice Experiments are similar to an actual purchasing situation in which experimental subjects make choices from a number of goods (Lusk and Schroeder, 2004). After the values for each attribute are elicited, the value of the good can be estimated by summing up the value for each attribute.

The Choice Experiment data was collected through online surveys of a representative sample of U.S. homeowners provided by Qualtrics™, a professional survey company. The sampled homeowners did not know the surveys were about insecticide use when they were contacted. Before participants completed the surveys, they answered three screening questions: 1) Do you agree to participate in the survey? 2) Do you have flowers or shrubs (home lawn or trees) in your yard? 3) Are insecticides applied to your flowers or shrubs (home lawn or trees) by yourself or by another party? Only those who answered "yes" to these three questions were allowed to continue and finish the surveys. We also asked homeowners if they applied insecticides themselves [hereafter referred to as "DIY" (Do It Yourself)] or employed a professional service [hereafter referred to as "DIFM" (Do It For Me)] or both (hereafter referred to as "BOTH"). Based on their choices, they were asked to answer different sets of questions.

The nine insecticide attributes included in the Choice Experiment were:

- 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



Following previous research, the effectiveness of control was illustrated using plant images showing different levels of insect pest damage (Burgess et al., 2012; Jetter and Paine, 2004; Sadof and Raupp, 1987; Yabiku et al., 2007).

The attributes and attribute levels included in the three different surveys varied according to the use sites or use patterns. For example, the speed-of-control attribute was only included in the Choice Experiment for trees, and sold/applied in combination with fertilizer was only included in the Choice Experiment for home lawns. These attributes and attribute levels were identified after conducting focus group discussions with about 60 homeowners.

In addition to the Choice Experiment questions, the surveys included questions related to participants' use of insecticides on their flowers and shrubs, home lawns and trees, their perception about the importance of different attributes and their demographic background information. The surveys were pre-tested with about 300 homeowners before the final data were collected.

3.0 Results

The number of initial contacts, homeowners agreeing to participate in the surveys, participants with the plants of interest (flowers or shrubs, lawns or trees) in their yards, participants who applied insecticides to the plants of interest and participants who completed the surveys are summarized in Table 1.

For the flower or shrub survey, 6,086 people were contacted for survey participation, out of which 5,866 agreed to participate and 5,800 had flowers or shrubs in their yard. Of these 5,800 people, 2,837 had insecticides applied to any of their flowers or shrubs either by themselves or by other parties and were asked to complete the survey (49 percent). Of these 2,837 participants, 2,698 completed the survey (95 percent).

For the lawn survey, 4,882 people were contacted for survey participation and 4,664 agreed to participate. Out of these 4,664 people, 4,624 had lawns in their yards. For these people with lawns, 2,678 had applied insecticides by themselves or by another party (58 percent). Of these 2,678 people, 2,268 completed the survey (85 percent).

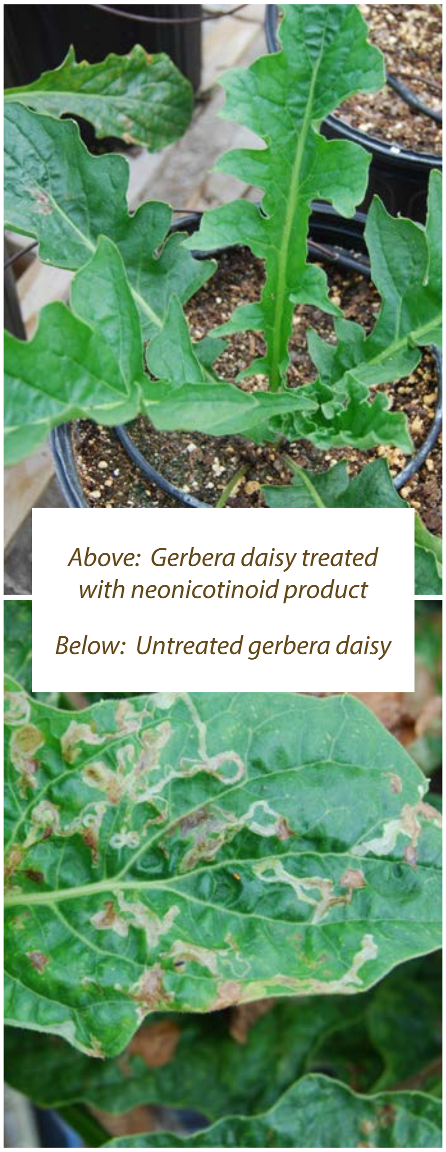
For the tree survey, 8,731 people were contacted for survey participation and 8,530 agreed to participate. Out of these 8,530 people, 8,461 had trees in their yards. Of these people, 3,041 had applied insecticides by themselves

Table 1. Number of initial contacts and number of survey completes for each survey.

	Homeowners invited to participate in the survey	Homeowners agreeing to participate	Participants with plants of interest in their yard	Participants who applied insecticides to the plants of interest	Participants who finished the surveys
Flower or shrub survey	6,086	5,866	5,800	2,837	2,698
Lawn survey	4,882	4,664	4,624	2,678	2,268
Tree survey	8,731	8,530	8,461	3,041	2,506

or by another party (36 percent). Of these 3,041 people, 2,506 completed the survey (82 percent).

On average, survey participants were between 35 to 55 years old, had completed at least some college, had an annual household income of $50,000 to $65,000 and had about 3 people per household. About 65% of participants were female, about 35 percent had children under 12 years old at home, 75 percent had pets and 10 percent were members or past members of environmental organizations. They treated their flowers or shrubs, home lawns and/or trees for insects about 2 to 3 times per year. On average, DIY participants spent about $55-$99 annually on insect control; DIFM participants spent about $100-$299 annually on insect control, and BOTH participants spent about $100-$199 annually on insect control. Only about 15 percent had heard of neonicotinoid insecticides.



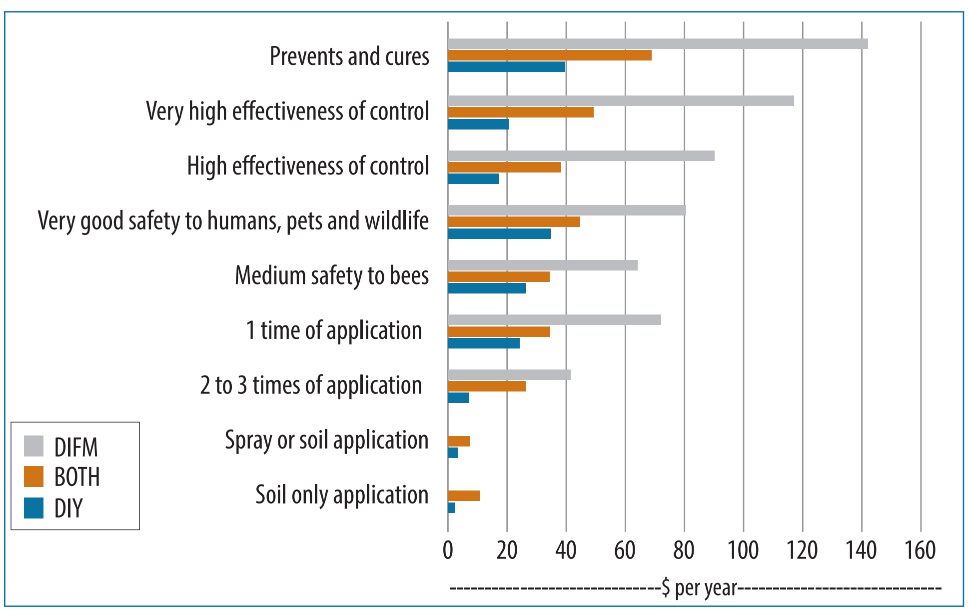
Above: Gerbera daisy treated with neonicotinoid product

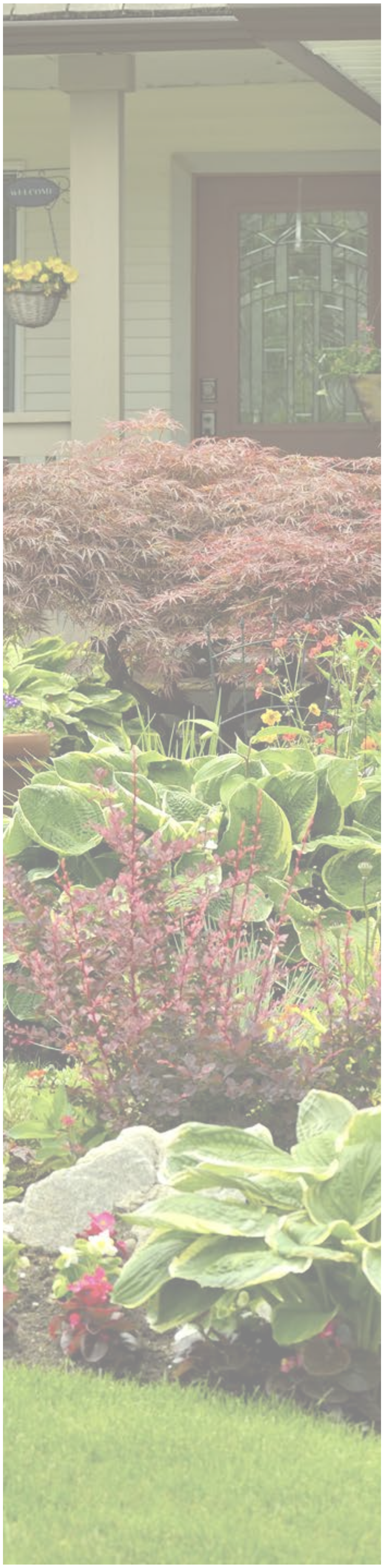
Below: Untreated gerbera daisy

Flowers and shrubs

Table 2 and Figure 1 show the relative preference ranking of the attributes and the WTP values in comparison to the base levels of the attributes for flowers or shrubs. We found several similarities that exist among DIY, BOTH and DIFM participants. First, on average, participants valued the attribute that the insecticides can both prevent and solve pest problems the most, while valuing the application method (soil or foliar spray) the least. Compared to insecticides that only cure pest problems, the annual premiums for insecticides that can both prevent and cure are $40, $69 and $142 for DIY, BOTH and DIFM participants, respectively. Second, all participants highly value insecticide safety to human, pets and wildlife (the annual premiums are $35, $45, $81 for DIY, BOTH and DIFM participants, respectively). Third, insecticide safety to bees is important to participants (with annual premiums of $27, $35 and $65 for DIY, BOTH and DIFM participants, respectively), but this attribute is not as valuable as the prevention and cure attribute and safety to humans, pets and wildlife. Fourth, the very high effectiveness of insecticides are very valuable to BOTH and DIFM participants ranking

Figure 1. WTP premiums ($/year) for insecticide attributes relative to the base attribute levels for flowers or shrubs.





second among the six attributes (with annual premiums of $50 and $117). Lastly, low number of applications is not as valuable as attributes such as prevention and cure, and safety to humans, pets and wildlife.

Based on the WTP values in Table 2, we can compare homeowners' relative WTP values for neonicotinoid insecticides with those for alternative insecticides. The results are shown in Table 3. We used soap insecticides, which have a better safety level to bees, as the base for comparison. Compared to soap insecticides, DIY, BOTH and DIFM participants are willing to pay the premiums of $63, $119 and $268 per year for the attributes of neonicotinoid insecticides, respectively. Compared to soap insecticides, DIY, BOTH and DIFM participants discount the attributes of pyrethroid, carbamate and OP insecticides by $37, $15 and $13 per year, respectively. The relative values are also shown in Figure 2. Based on the attributes included in this study, homeowners value the attributes of neonicotinoid insecticides the most compared to alternative flower or shrub insecticides.

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

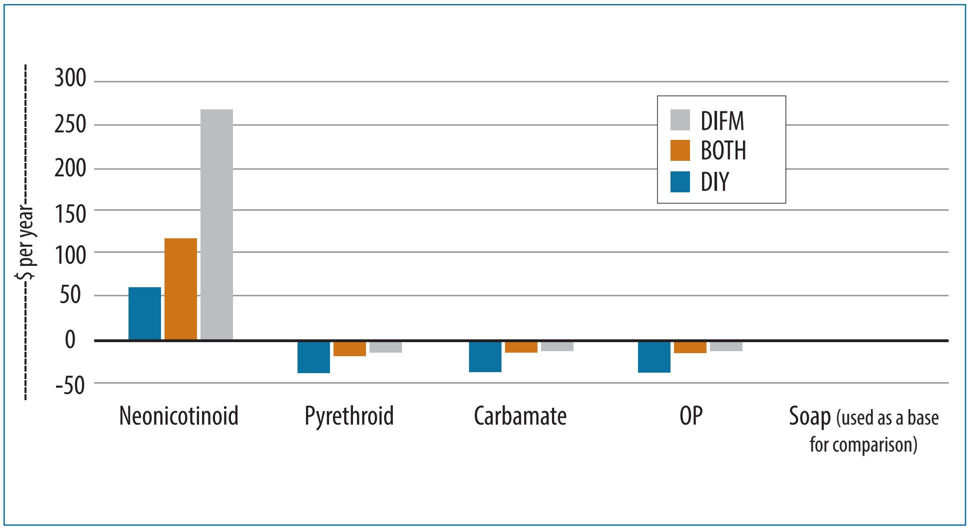
[a] WTP means willingness to pay, DIY means homeowners who applied insecticides themselves, DIFM means homeowners who hired professional services to apply insecticides, BOTH means homeowners who both applied insecticides themselves and hired professional services to apply insecticides.

[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.

Figure 2. Homeowners' relative WTP for different insecticides compared to soap insecticides for flowers or shrubs.



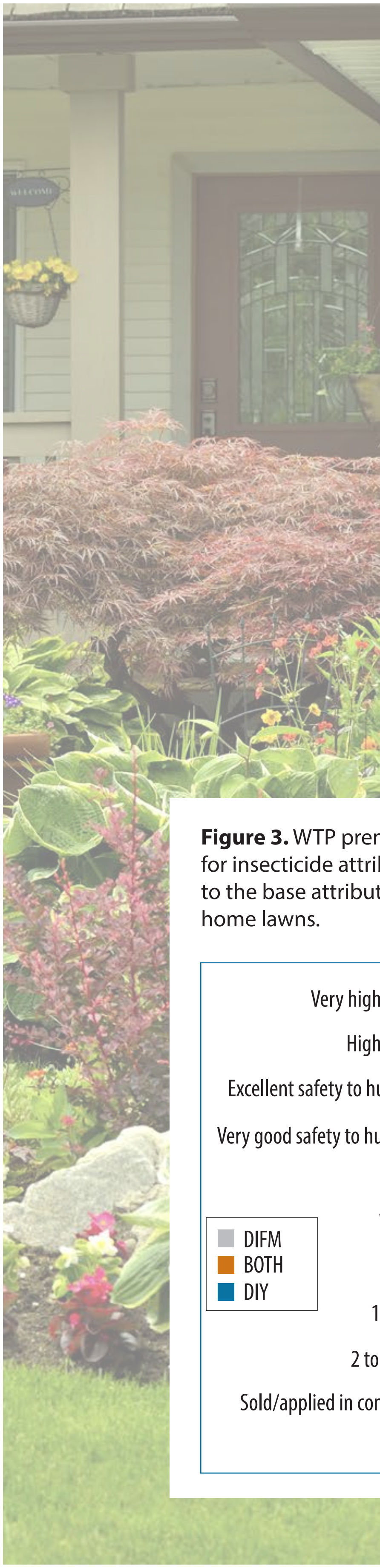
Above: Poinsettia treated with neonicotinoid product

Below: Untreated poinsettia

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

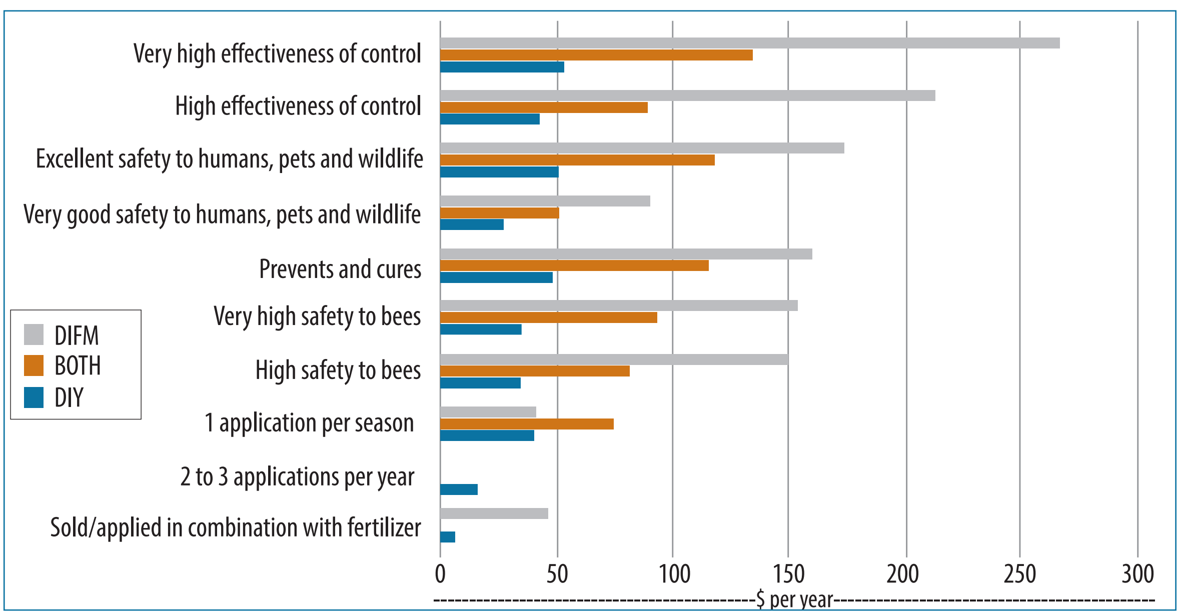
[a] The negative values mean homeowners' WTP values are less than their WTP values for soap insecticides.



Home lawns

Larson (2014) concluded lawn insecticides are of low hazard to bees. Therefore, we included three levels of safety to bees: very high, high and medium (there is no "low" level for this attribute). From Table 4 and Figure 3, we can see that DIY, BOTH and DIFM lawn survey participants are quite similar in terms of their rankings for the lawn insecticide attributes. First, on average, participants rank very high effectiveness of control first, safety to humans, pets and wildlife second, and prevention and cure third; and they are willing to pay significant price premiums for these attributes. For example, compared to medium effectiveness of control, DIY, BOTH and DIFM participants are willing to pay premiums of $54, $135, and $266 per year for very high effectiveness of control, respectively. Compared to "good" safety to humans, pets and wildlife, DIY, BOTH and DIFM participants are willing to pay $51, $118 and $174 per year more for "excellent" safety to humans, pets and wildlife. Second, the attribute sold/applied in combination with fertilizer is the least valuable to home lawn participants among the attributes included in the Choice Experiments. Third, safety to bees is not among the top three most important attributes to home lawn participants, ranked fifth by DIY participants and fourth by BOTH and DIFM participants. Lastly, a low number of applications is ranked fourth by DIY participants, fifth by BOTH and sixth by DIFM participants.

Figure 3. WTP premiums ($/year) for insecticide attributes relative to the base attribute levels for home lawns.



Above: Home lawn treated with neonicotinoid product

Below: Untreated home lawn

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.

Table 5 describes the major types of insecticides for home lawns and their corresponding attribute levels. We used beneficial nematodes insecticide, which has a better safety level for bees, as the base for comparison. Compared to beneficial nematodes, DIY, BOTH and DIFM participants are willing to pay the premiums of $75, $164 and $278 per year for the attributes of neonicotinoid insecticides, respectively. Compared to beneficial nematodes, DIY, BOTH and DIFM participants are willing to pay premiums of $104, $258 and $384 per year for the attributes associated with chlorantraniliprole insecticides, respectively. Compared to beneficial nematodes, DIY, BOTH and DIFM participants discount the attributes associated with pyrethroid insecticides by $102, $212 and $327 per year, respectively. Compared to beneficial nematodes, DIY and BOTH participants discount the attributes of OP (trichlorfon) insecticides by $8 and $29 per year, respectively. DIFM participants are willing to pay $39 per year more for the attributes of OP (trichlorfon) insecticides. The relative values are also shown in Figure 4. Based on the attributes included in this study, among the available insecticides for home lawns, homeowners value the attributes of neonicotinoid insecticides second following chlorantraniliprole insecticides.

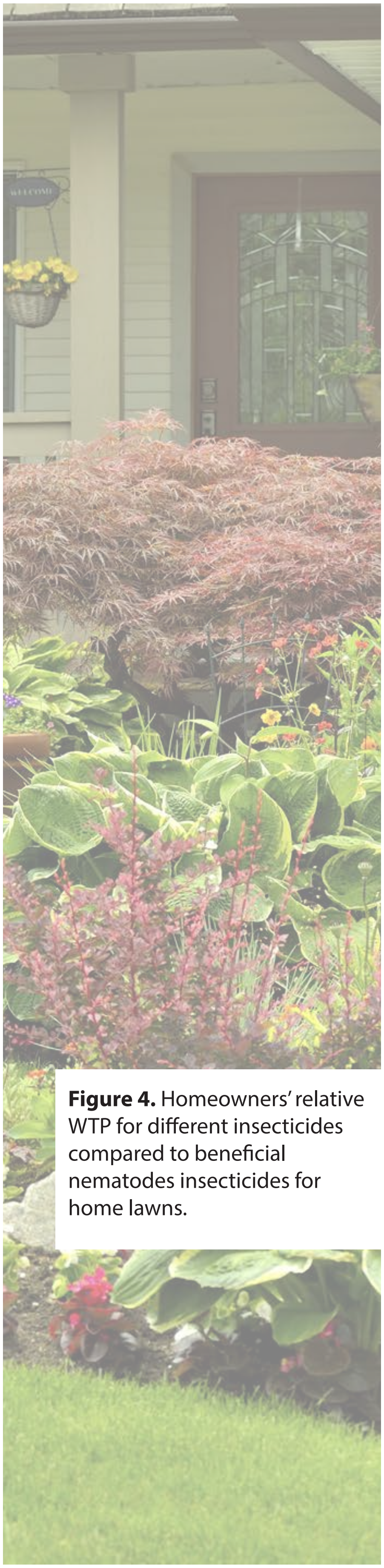
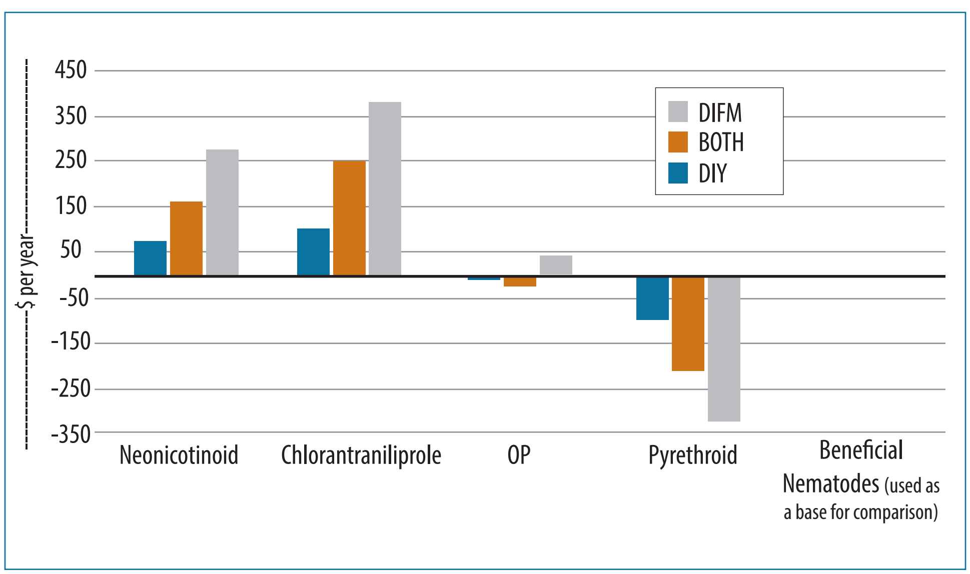


Table 5. The major types of insecticides for home lawns, the insecticides' attribute levels and homeowners' relative WTP for different insecticides compared to beneficial nematodes insecticides.

	-----------------------Major Insecticides for Home Lawns---------------------				
Attribute	**Neonicotinoid**	**Chlorantra-niliprole**	**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.

Figure 4. Homeowners' relative WTP for different insecticides compared to beneficial nematodes insecticides for home lawns.



Trees

From Table 6 and Figure 5, we see that several obvious similarities and differences for tree insecticide attributes exist among DIY, BOTH and DIFM participants. First, on average, participants value "very high" effectiveness of control the most, while valuing the application method (spray or soil) the least. For example, compared to "medium" effectiveness of control, DIY, BOTH and DIFM participants are willing to pay the premiums of $51, $119 and $195 per year for "very high" effectiveness. Second, safety to humans, pets and wildlife is a valuable attribute to participants ranking third for DIY participants and second for BOTH and DIFM participants with the premiums of $42, $83 and $146 per year, respectively. Third, a low number of applications is very valuable to DIY participants ranking second with a premium of $43 per year compared to high number of applications. But a low number of applications is not ranked as high by BOTH and DIFM participants (it is ranked fifth). Fourth, safety to bees ranks third for BOTH and DIFM participants and fourth for DIY participants. Lastly, speed of control is not as valuable to participants ranking fifth for DIY participants and fourth for BOTH and DIFM participants.

Above: Untreated ash tree

Below: Ash tree treated with neonicotinoid product

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.

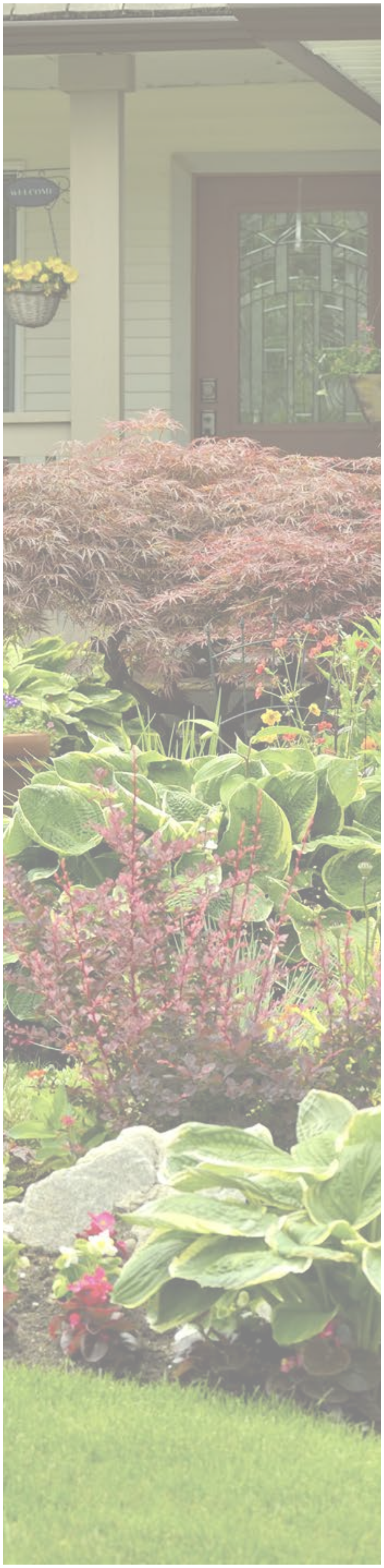


Table 7 describes the major types of insecticides for trees and their corresponding attribute levels. We used hort oils, which have a better safety level to bees, as the base for comparison. Compared to hort oils, DIY, BOTH and DIFM participants are willing to pay premiums of $59, $104 and $128 per year for the attributes of neonicotinoid insecticides, respectively. Compared to hort oils, DIY, BOTH and DIFM participants' premiums for pyrethroid and OP chlorpyrifos insecticide attributes are $6, $18 and $6 per year, respectively. Compared to hort oils, DIY and DIFM participants discount OP acephate attributes by $4 and $32 per year, respectively, while BOTH participants are willing to pay the premium of $7 per year for OP acephate insecticides. The relative values are also shown in Figure 6. Based on the attributes included in this study, homeowners value the attributes of neonicotinoid insecticides second following emamectin insecticides among the available tree insecticides.

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.

Figure 5. WTP premiums ($/year) for insecticide attributes relative to the base attribute levels for trees.

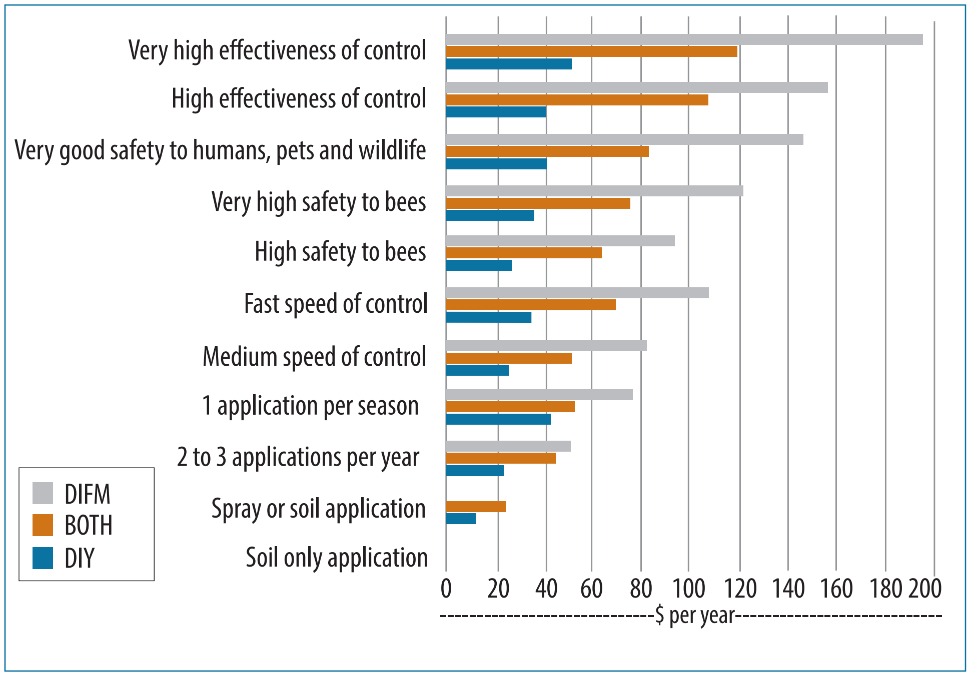
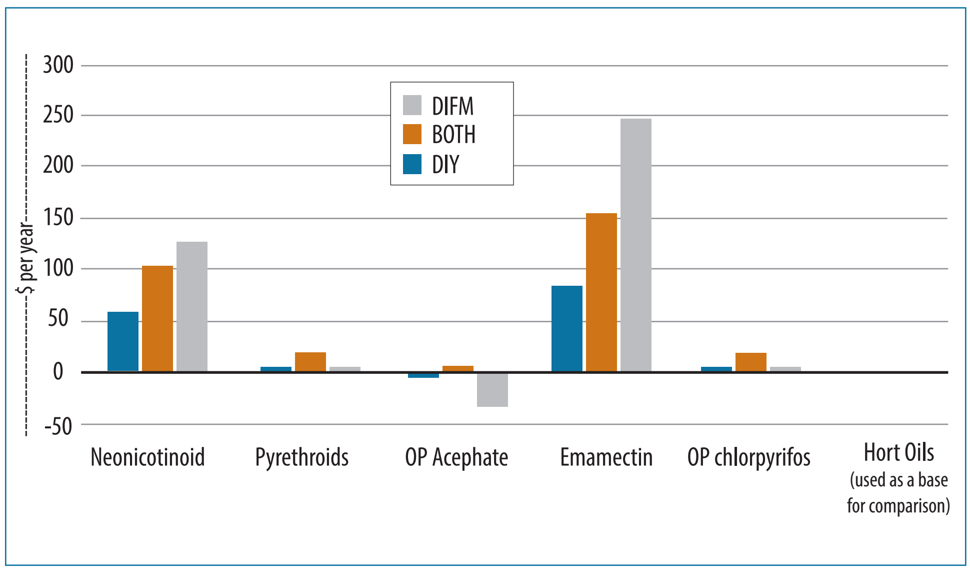


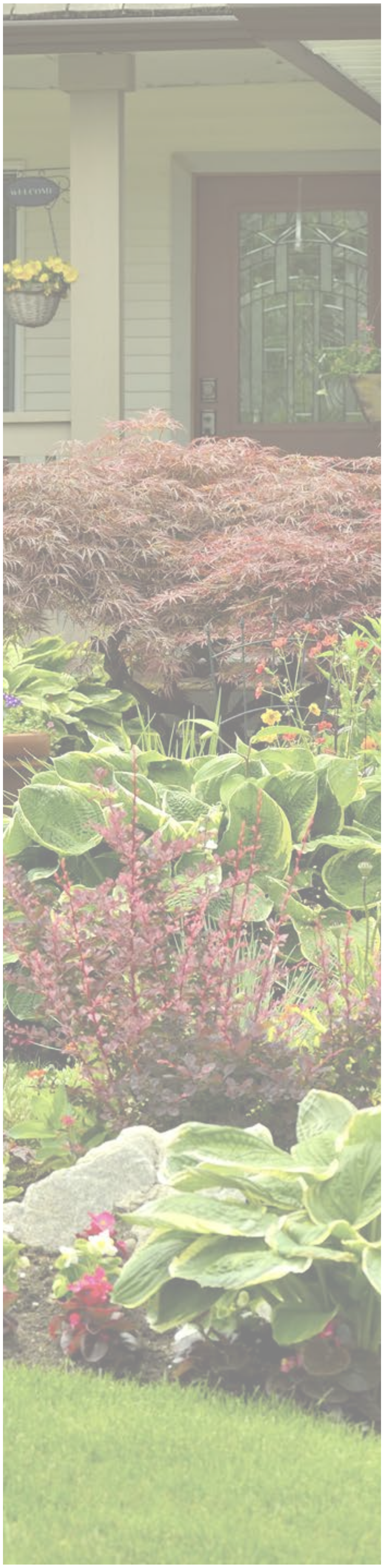
Figure 6. Homeowners' relative WTP for different insecticides compared to hort oils insecticides for trees.



4.0 Discussion and Conclusions

This study used an online Choice Experiment to elicit homeowners' preferences and WTP for key insecticide attributes. In total, 19,699 homeowners were sampled for the survey, and 7,472 homeowners who use insecticides completed the surveys.

Based on the Choice Experiment results, we found that homeowners valued high effectiveness of control as the most important insecticide attribute. They also highly valued an insecticide's ability to both prevent and cure insect pest problems and its safety to humans, pets and wildlife. Although homeowners value safety to bees and are willing to pay premiums for insecticides that are safer to bees, these premiums are not as large as premi-



ums for very high effectiveness, safety to humans, pets and wildlife, and the preventive and curative control attribute.

We compared the attributes of the available insecticides and estimated the value of neonicotinoid insecticides relative to these alternative insecticide classes, including the insecticides that have lower toxicity to bees. We find that for flowers or shrubs, DIY, BOTH and DIFM homeowners are willing to pay at least $63, $119 and $268 per year more for the attributes of neonicotinoid insecticides compared to insecticides that are safer to bees. When we take the weighted average of these premiums based on the proportions of DIY, BOTH and DIFM participants (70.5 percent, 12.5 percent and 17 percent based on our flower or shrub survey data), the average value of neonicotinoid insecticides is at least $105 per year more than alternative insecticides for flowers or shrubs in the market. For home lawns, DIY, BOTH and DIFM homeowners are willing to pay at least $75, $164 and $277 per year more for the attributes of neonicotinoid insecticides compared to insecticides that are safer for bees (except for chlorantraniliprole insecticides, which have very high effectiveness, very good safety to humans, pets and wildlife and very high safety to bees). When we take the weighted average of these premiums based on the proportions of DIY, BOTH and DIFM participants (63.1 percent, 11.7 percent and 25.2 percent based on our home lawn survey data), the average value of neonicotinoid insecticides is at least $136 per year more than alternative insecticides for home lawns in the market (except for chlorantraniliprole insecticides). For trees, DIY, BOTH and DIFM homeowners are willing to pay at least $59, $104 and $127 per year more for attributes of neonicotinoid insecticides than alternative insecticides that are safer to bees (except for emamectin insecticides which has very high effectiveness, very good safety to humans, pets and wildlife and high safety to bees). Given the proportion of DIY, BOTH and DIFM participants (59 percent, 14 percent and 27 percent based on the tree survey), the weighted average value of neonicotinoid insecticides is at least $84 per year more than alternative insecticides for trees.

Our findings have important policy implications. While 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 prevention and curative attributes. Overall, neonicotinoid insecticides are more valuable to homeowners than the alternative insecticides that are safer for bees. Homeowners who use or have insecticides professionally applied in their yards prefer insecticides with the attributes neonicotinoid insecticides provide over both organic and older chemical alternatives. The consideration of these benefits to homeowners is important for accurately assessing both the economic and environmental benefits and costs of policies regarding the use of neonicotinoid insecticides.

It is worthwhile to point out that our study focuses on the homeowners' preferences and WTP, which reflect the demand for insecticides. The real market prices of different insecticides (what homeowners really pay and spend) also depends on the supply of insecticides. Based on the demographic backgrounds of the sampled participants, we are confident that our samples are representative of U.S. homeowners. One limitation of this study is that the Choice Experiments we used are hypothetical, which means that participants do not need to make real purchases in these experiments. However, Lusk and Schroeder (2004) concluded that the potential biases associated with hypothetical Choice Experiments are minimal when the choice questions are framed in a way that is similar to real purchase situations, which is what we did when we framed the Choice Experiment questions.

Poinsettias … are the top-selling potted flower plant in the United States, with over 120 varieties produced commercially. The principal market for poinsettias is at Christmas, when millions of plants are purchased for decorative purposes. In 2007, wholesale poinsettia sales tracked in 15 of the leading poinsettia-producing states in the U.S. totaled more than $180 million … During the production process, poinsettias are vulnerable to attack from several arthropod pests, including whiteflies, thrips, fungus gnats and mites. The whitefly (Bemisia tabaci) is a particularly serious problem … Chemical insecticides are often the only effective form of control for B. tabaci.

Page 260, Byrne, F. J., Oetting, R. D., Bethke, J. A., Green, C., & Chamberlin, J. 2010. *Understanding the dynamics of neonicotinoid activity in the management of Bemisia tabaci whiteflies on poinsettias*. Crop Protection, 29(3), 260–266. doi:10.1016/j.cropro.2009.11.007

As trees increase in size they require higher insecticide dosage rates to fully protect the tree … A deep understanding of the dose/tree size/pest relationships can lead to optimal use of these insecticides in the environment and therefore reduce the risk of non target impacts.

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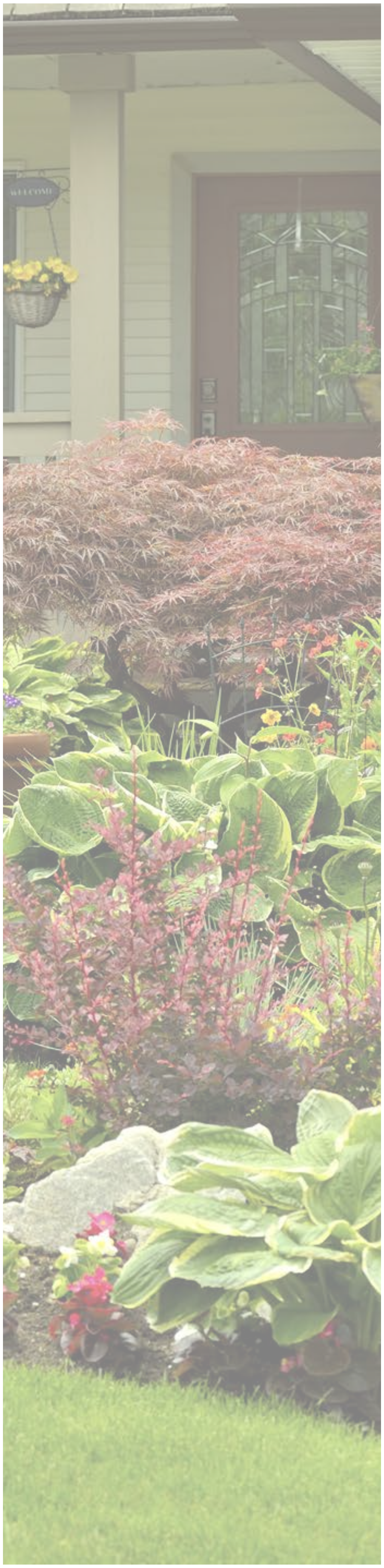

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Neonicotinoid solubility in water and their systemic movement within the plant reduces direct pesticide exposure to the applicator and reduces drift into the environment. Because of systemic activity, they can be applied using a wide range of application techniques at very low doses. They present advantages in pest control including efficacy against boring insects and root-feeding insects, both of which cannot easily be controlled using foliar sprays of non-systemic compounds.

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Neonicotinoids that are labeled for greenhouse ornamentals include … imidacloprid, thiamethoxam, acetamiprid and dinotefuran. One other neonicotinoid, clothianidin, is not currently used in greenhouses but is used in other green industries. Many neonicotinoid products are also currently available to home gardeners.

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