Attachment 3 to the Neonicotinoid Final Bee Risk Assessments

Residue Bridging Analysis for Foliar and Soil Non-Agricultural Uses of Neonicotinoids

<u>Associated Chemicals</u>

- **Clothianidin (PC code 044309)**
- **Dinotefuran (PC code 044312)**
- **Imidacloprid (PC code 129099)**
- **Thiamethoxam (PC code 060109)**

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1. EXECUTIVE SUMMARY

As part of the registration review of the nitroguanidine-substituted neonicotinoid insecticides (imidacloprid, clothianidin, thiamethoxam, dinotefuran), technical registrants of these chemicals submitted residue data for pollen and nectar in many different agricultural and non-agricultural plant species to the U.S. Environmental Protection Agency (USEPA). Submitted data included a wide variety of agricultural crops (which are discussed in Attachments 2 and 4) and several ornamental plants (discussed in this Attachment). Open literature data are also available for studies involving residential turf and selected ornamentals. The non-agricultural uses represent a wide variety of commercial and residential uses on many plant species. As a result, it was not considered feasible to generate pollen and nectar residue data for every possible chemical-plant-application scenario with the neonicotinoids in a timely fashion. This attachment summarizes the available residue data for non-agricultural uses of the neonicotinoids and describes scientific justification for extrapolating residue data among neonicotinoids, uses, and plants for assessing oral risks to bees. Residue data are summarized differently according to the application method included in the study. This document includes residue data for foliar, soil, and tree injection applications to non-agricultural crops.

For ornamental plants, one study is available for thiamethoxam, eleven studies are available for imidacloprid, and one study is available for dinotefuran. All of the studies for ornamental species were from registrant submissions of unpublished data and were considered either acceptable or supplemental. For turf, one study measuring residues of clothianidin and imidacloprid in blooming weeds was available from open literature. Some of these studies included residues in bee relevant matrices, such as pollen and nectar. Some studies included flower residue data, which can be used as a surrogate for nectar per the analysis conducted in **Attachment 2** to the neonicotinoid risk assessments. Designs varied among studies, with differences in application timing, the number of samples collected, number of sampling periods, number of seasons, number of trials and others.

While many different factors may collectively influence neonicotinoid residues in pollen and nectar, all factors could not be reliably quantified for the purpose of this residue bridging analysis. Therefore, this analysis focuses on a subset of factors that are thought to influence residues in pollen and nectar which could be quantified and evaluated with the submitted data. The influence of the following factors on residues was evaluated in this assessment:

- Chemical,
- Plant Species,
- Plant matrix (pollen, nectar, flower, leaf),
- Season of application,
- Application site,
- Application method, and
- Application timing.

These factors were evaluated using different methods, depending upon the available data. The overall methodology underlying the residue bridging analysis involved controlling for as many of the potentially confounding variables as possible (*e.g.*, application rate, application method, time between application and residue measurement, crop, *etc.*) and conducting appropriate statistical comparisons when sufficient data were available.

In cases where sufficient pollen or nectar residue data were not available, the flower data was used as a surrogate for nectar by multiplying the flower residues by a factor of 0.3 applications as summarized in **Attachment 2**.

The overall conclusions from this analysis of residue data, derived from non-agricultural uses of the four neonicotinoids are as follows:

1. **Influence of Application Method.** Residue data available for non-agricultural uses of the neonicotinoids are too limited in scope to enable a robust evaluation of the relationship between application method and residues in bee-relevant matrices. However, given the strong influence of application method on residues associated with agricultural uses of the neonicotinoids (**Attachment 2**) and the unique types of non-agricultural application methods (*e.g.,* trunk injection), it is recommended that residues associated with non-agricultural uses not be bridged among different application methods.

2. **Influence of Application Rate.** The results from this analysis, although based on limited data, support the hypothesis that residues in pollen and nectar scale in approximate proportion to application rate. This finding is consistent with that found with agricultural uses of the neonicotinoids and supports the normalization of residue values by application rate for bridging and risk characterization purposes.

3. **Influence of Application Timing.** The currently available residue data for non-agricultural uses of neonicotinoids do not permit a conclusive analysis of the effect of application timing (*e.g.,* pre- vs. post-bloom application) on residues in bee-relevant matrices. In absence of data to suggest otherwise, the bridging recommendations made with respect to application timing for agricultural crops (generally separate characterization of pre and post bloom risks) are recommended with non-agricultural uses.

4. **Influence of Plant Species and Chemical.** Although data are limited, the variation in residues observed in pollen and nectar from different plants are comparable to that observed between different sites for the same chemical and plant species. Therefore, application of these data for risk characterization purposes should consider that variation among different ornamental species can range from 1 to 2 orders of magnitude. The currently available residue data for non-agricultural uses of the neonicotinoids do not permit robust analysis of the effect of a chemical on residues in pollen and nectar. Therefore, the recommendation to bridge residues among the 4 neonicotinoids for non-agricultural uses is largely based on results from the agricultural and seed treatment bridging analyses (**Attachments 2 and 4, respectively**) and similarity in their physicochemical properties.

5. **Influence of Site and Season**. Residues in pollen and nectar vary by up to 1 – 2 orders of magnitude when measured at different sites for the same plant species and neonicotinoid chemical. It is noted that "site" in this analysis incorporates multiple factors that could influence residues including weather, soil characteristics, hydrology, agronomic practices and plant variety. These findings support consideration of the number of sites upon which a given risk finding is based, as one line of evidence for characterizing the robustness of risk assessment conclusions.

2. INTRODUCTION

2.1 Background

The nitroguanidine-substituted neonicotinoid insecticides (*i.e*., imidacloprid, clothianidin, thiamethoxam, dinotefuran; referred to in this document as “neonicotinoids”) are currently registered for numerous agricultural and non-agricultural uses in the United States. These compounds are currently undergoing Registration Review by the Office of Pesticide Programs (OPP) within the U.S. Environmental Protection Agency (USEPA)[1]. Under the Registration Review program, all available information pertaining to the use, benefits and risks associated with a pesticide are evaluated every 15 years to ensure that registered uses meet the applicable statutory standards (*e.g.,* no unreasonable risk the environment, taking into account the economic, social, and environmental costs and benefits[2]). Environmental risks are evaluated by OPP for multiple taxa including birds, mammals, fish, aquatic invertebrates, plants and bees. The current analysis is relevant to assessing exposure and risks to bees.

Guidance for quantifying pesticide risks to bees was published by the USEPA in 2014 (USEPA/PMRA/ CDPR, 2014)[3]. For assessing risks to bees resulting from oral exposure (contaminated pollen and nectar), a tiered process is followed in which methods of increasing complexity and environmental realism are introduced at each successive tier. The first tier (tier 1) begins with the use of “default” (high-end) estimates of exposure combined with measures of effect on individual bees in laboratory-based studies, using the honey bee (*Apis mellifera*) as a surrogate. Importantly, these default estimates of exposure (*i.e.,* concentrations in pollen and nectar) can be refined using data derived from field studies that quantify the magnitude of pesticide residues of concern in pollen and nectar of bee-attractive crops. Information from bee-relevant field residue studies can also be used to inform risks at higher assessment tiers, where effects on entire honey bee colonies are evaluated under semi-field (Tier 2) and full-field (Tier 3) conditions. The analysis described below focuses on residues that may be used for refined Tier 1 and Tier 2 assessments.

2.2 Purpose and Scope

This document focuses on the analysis of bee-relevant residue data for non-agricultural uses of the neonicotinoids. Separate residue bridging analyses were conducted and documented for agricultural uses (*i.e.,* foliar/soil applications are described in **Attachment 2** and seed treatments are described in **Attachment 4**). A wide variety of non-agricultural uses are registered for the neonicotinoids, some examples of which include applications to:

- Turf (commercial and residential);
- Ornamentals (nurseries, residential and commercial areas);
- Forestry (including Poplar/Cottonwood and Christmas Tree Plantations);
- Building/perimeter treatments in farms/residential/commercial areas;
- Indoor uses in commercial and domestic dwellings;
- Pet spot-on treatments;
- Poultry litter treatments; and
- Wood treatment.

[1] https://www.epa.gov/pollinator-protection/schedule-review-neonicotinoid-pesticides
[2] Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), 7 U.S.C. §136 et seq. (1996)
[3] https://www.epa.gov/pollinator-protection/pollinator-risk-assessment-guidance

In addition, methods of application for non-agricultural use vary widely (e.g., soil, foliar, trunk injection, application methods) and the application rates differ by unit of measurement (*e.g.,* lb a.i./A, lb a.i./width or height of plant, *etc.*)

Given the wide variety of registered non-agricultural uses, it was not considered feasible to generate pollen and nectar residue data for every non-agricultural use scenario for each neonicotinoid within the time allocated under Registration Review. Furthermore, only a portion of the non-agricultural uses are considered to have the highest potential for bee exposure. For the purposes of this document, the following uses are included in the bridging analysis because they are considered most relevant to potential exposure of bees:

- Ornamentals / Forestry
- Residential turf (assuming blooming weeds are present)

Even with this subset of uses, not every neonicotinoid could be represented for each type of use. As a result, there is the need to extrapolate residue data for non-agricultural uses in order to refine estimates of risk to bees. Therefore, the purpose of this document is to provide the scientific basis for extrapolating residues in bee-relevant matrices among neonicotinoids, plants, and plant species for the non-agricultural uses.

3. OVERVIEW OF AVAILABLE RESIDUE DATA

3.1 Data sources and review

Approximately 16 bee-relevant residue studies are included in this residue bridging analysis based on foliar, soil, or tree injection applications to non-agricultural crops with concurrent measurements in bee-relevant matrices (pollen, nectar, flower). Registrant-submitted studies are the primary source of data used in this analysis. Registrant-submitted studies have raw data available for analysis and are formally reviewed in Data Evaluation Records (DERs) for documenting study quality and classifications. Studies classified as "acceptable" or "supplemental" are used in this analysis. Typically, these studies included 1 to 3 sampling events during the bloom period, although many of the imidacloprid studies are older registrant submitted studies conducted from 2001 to 2006 and often only included 1 sampling event.

Residue data published in the open literature for non-agricultural are also considered, but these studies are generally not used in this analysis because raw data were often not available. In addition, many open literature studies only included residues measured in matrices that representative of oral exposure routes for bees (*e.g.,* bark, leaf, twig, xylem). These studies were excluded from this analysis. For applications to residential turf (where blooming weeds may be present), no registrant-submitted data were available. Therefore, an open literature study was used to characterize residues associated with this use since raw data were available from this study.

3.2 Residue Data Coverage

A summary of neonicotinoid bee-relevant residue data considered in the non-agricultural uses bridging analysis is provided in **Table 3-1**. For foliar applications to ornamentals, data are only available for one chemical (thiamethoxam). For soil applications to ornamentals and tree injections, bee-relevant residue data are available for two chemicals each.

Table 3-1. Available bee-relevant (pollen, nectar or flower) residue data resulting from applications of neonicotinoids for Non-Agricultural crops

Application Method	Imidacloprid	Clothianidin	Thiamethoxam	Dinotefuran
Ornamental (foliar)	NA	NA	Y	NA
Ornamental (soil)	Y	NA	Y	NA
Tree Injection	Y	NR	NR	Y
Turf (foliar)	Y	Y	NA	NA

"Y" indicates that residue data is available
"NA" indicates that residue data is "not available" for this chemical or use
"NR" indicates that the use is not registered for the given chemical

4. METHODOLOGY

Many different factors may be expected to influence neonicotinoid residues in pollen and nectar, such as weather conditions, soil properties, application rate, timing and method, and plant biology; however, only a subset of these factors can be evaluated for this bridging analysis due to limitations in the quantity of available data. In addition, many of these factors co-vary and cannot be easily distinguished with the residue study designs (*e.g.*, soil type and study location/climate). Therefore, this bridging analysis focuses on a subset of factors which can be readily quantified and evaluated based on the submitted data. These factors include:

- Chemical,
- Crop,
- Plant matrix (pollen, nectar, flower),
- Season of application,
- Application site,
- Application method, and
- Application timing.

Ideally, an analysis of how the aforementioned factors affect neonicotinoid residues in pollen and nectar would involve some type of multivariate statistical method(s) for addressing independent and interactive effects. However, the following attributes of the residue study designs constrained the ability to conduct a statistical analysis. These attributes include:

- a small number of replicates per sampling event,
- differences in time between application and residue measurement,
- relatively few sampling events during bloom,
- differences in the location and timing of residue studies, and
- differences in the matrices measured.

In some studies, the small numbers of samples collected per sampling event (less than 3) greatly reduces the ability to conduct statistical comparisons between residue trials with acceptable statistical power. Variability in the timing of residue measurement relative to pesticide application is also a confounding factor both within and among studies. This variability results not only from different study designs, but also from factors beyond the control of the study investigators (*e.g.,* differential effects of climate on the timing of bloom). Therefore, comparisons of residue measurements across trials may not only reflect chemical, site or crop-specific factors, but also differences in the time elapsed from pesticide application to residue measurement. The temporal coverage of pesticide residues measured during the bloom period is relatively coarse, with most trials consisting of 1-3 sampling events during bloom. The matrices used for residue measurement also differed in some cases.

5. FOLIAR APPLICATIONS TO ORNAMENTALS AND FORESTRY USE SITES

Neonicotinoid use on ornamentals and forestry settings encompass a large variety of species and application methods. Application methods include tree trunk injection, foliar spray, and soil drench to trees and ornamentals. Nursery applications are registered for uses on ornamentals grown in containers and in field. Additional ornamental registrations exist for perimeter treatments in industrial, commercial and residential areas.

One challenge with evaluating residue data for ornamental and forestry uses is the variety of units in which the application rates are expressed. For example, tree injection application rates are typically expressed in mass of a.i./DBH (diameter at breast height), whereas as soil drench applications are often expressed in mass a.i./plant height, mass a.i./plant width, mass a.i./stem diameter or mass a.i. per treatment area. Conversion of these application rate units to a common unit requires information on the design of the study that often was not available from the study report. In these situations, comparisons could not be made due to the expected influence residue concentrations in pollen and nectar.

In terms of attractiveness to bees, the ornamental/forestry use category includes a wide variety of flowers, trees and shrubs with different biology/physiology and varying levels of attractiveness to bees. The USDA guidance for pollinator attractiveness (USDA 2017) does not include ornamental and tree species. However, the IR-4 has published a list of over 400 ornamental plants that are considered attractive to pollinators (primarily bees)[4]. Attractiveness of trees is widely variable within the forestry group[5], with some trees being highly attractive to bees (*e.g.,* black locust, maple) and others not attractive (*e.g.,* American hemlock, most conifers).

5.1. Summary of Label Rates/Restrictions

All four neonicotinoids are registered for use on ornamentals with varying application rates and restrictions. Foliar application rates range from 0.23 lb ai/A for thiamethoxam (in clothianidin

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[4] http://campaign.r20.constantcontact.com/render?m=1104982944285&ca=a7e26b54-c915-4491-8bd1-e2aea4ddfb1b

[5] https://www.arborday.org/trees/health/pests/article-trees-for-bees.cfm

equivalents), 0.40 lb ai/A for imidacloprid and clothianidin and 0.54 lb ai/A for dinotefuran. For imidacloprid, some labels limit applications to post bloom, but not all labels include this or other bloom restrictions. For dinotefuran, the labels stipulate that the product is not to be applied while bees are foraging, and that the product is toxic to bees for 38 hours following treatment. Labels for clothianidin have similar language but indicate that the product is toxic to bees for 5 days following treatment. The maximum seasonal foliar application rates for these chemicals are included in **Table 6-1**.

Table 6-1. Maximum seasonal foliar application rates (in lb a.i./A) for neonicotinoids

Use Category	Imidacloprid	Clothianidin	Thiamethoxam	Dinotefuran
Ornamentals	0.40	0.40	0.23*	0.54
Forestry	0.40	0.40	NR	0.54

"NR" indicates that the use is not registered for the given chemical
* indicated values are given in clothianidin equivalents

5.2 Available Residue Data

Pollen, nectar and flower residue data are available from one study for foliar spray application of thiamethoxam to ornamentals (MRID 50425903)[6]. In this study, two foliar applications of Meridian® 25WG (A9584C) at 0.133 lb a.i./A to ornamental plants in separate outdoor plots; the first was 12 days prior to bloom and the second was 7 days later. Data is available for three different species of ornamentals: and stargazer lily (*Lilium orientalis*), mock orange (*Philadelphus lewisii)* and common lilac (*Syringa vulgaris)* tested at three different trial sites (North Rose, NY; Racine, WI; Oregon City, OR); however not all matrices were measured at all three sites. Each trial consisted of a non-treated plot and a treated plot subdivided into three replicate plots, with one plot of each plant species. Three replicate samples were taken of pollen, nectar and whole flower for all species at early, mid- and late bloom.

A summary of the available residue studies for thiamethoxam is available in **Table 6-2.**

Table 6-2. Residue studies for ornamental foliar applications of thiamethoxam (0.133 lb a.i./A x 2 apps.; MRID 50425903)

Crop	Chemical	# Sites (Locations)	Appl. rate in lb a.i./A; # apps (interval)	# Seasons	# Sampling events (per season	MRID (Classification)
Stargazer Lily	Thiamethoxam	3 (NY, WI, OR)	0.133 X 2 (7d)	1	2-3	50425903 Supplemental
Mock Orange	Thiamethoxam	2 (WI, NY)	0.133 X 2 (7d)	1	1-2	50425903 Supplemental
Lilac	Thiamethoxam	2 (NY, OR)	0.133 X 2 (7d)	1	2	50425903 Supplemental

5.3 Bridging Needs (Gaps)

Table 6-3 identifies data gaps for registered foliar applications of neonicotinoids on ornamentals and forestry uses. Clearly, with no data for any other chemical besides thiamethoxam, there is no way to evaluate the impact of chemical on the residue profiles in bee-relevant matrices with these data.

[6] The soil application component of this study is discussed in Section 6.2.

Table 6-3. Residue data gaps for neonicotinoid foliar applications to ornamentals

Crop	Imidacloprid	Clothianidin	Thiamethoxam	Dinotefuran
Ornamentals	No data	No data	50425903	No Data
Forestry	No data	No data	NR	No data

NR = Not registered

5.4 Influence of Application Rates on Residues

Due to the limited data set for ornamental foliar applications with only one application rate for thiamethoxam, an analysis of how the application rates affect the residues cannot be completed. The rates used in the study are consistent with the maximum labeled rates for foliar applications of thiamethoxam (2 applications of 0.133 lb a.i./A; 0.266 lb a.i./A total of 0.23 lb a.i./A in clothianidin equivalents).

5.5 Influence of Sampling Day (Time) on Residue Values

Plots of the thiamethoxam residue data (expressed as clothianidin equivalents) resulting from foliar application to ornamentals are shown in **Figure 6-1.** Evidence of a trend in thiamethoxam concentrations in pollen over time within each crop and site is not apparent with these data, with the possible exception of lilac at the OR site. With nectar, there appears to be a slight declining trend in residue concentrations over time with stargazer lily in WI and OR (within 2X from the first to the last measurement).

It is noted that within each site/species combination, measurements were typically made only at 2-3 sampling events, with the exception of pollen/lilac at the Oregon site which had 6 sampling events. In addition, the span of time covered by the residue sampling is also limited, often 5 days or less. Therefore, these data are considered very limited for discerning a possible effect of time on the magnitude of residues of thiamethoxam in pollen and nectar. These data are considered insufficient to derive meaningful analysis of residue kinetics.

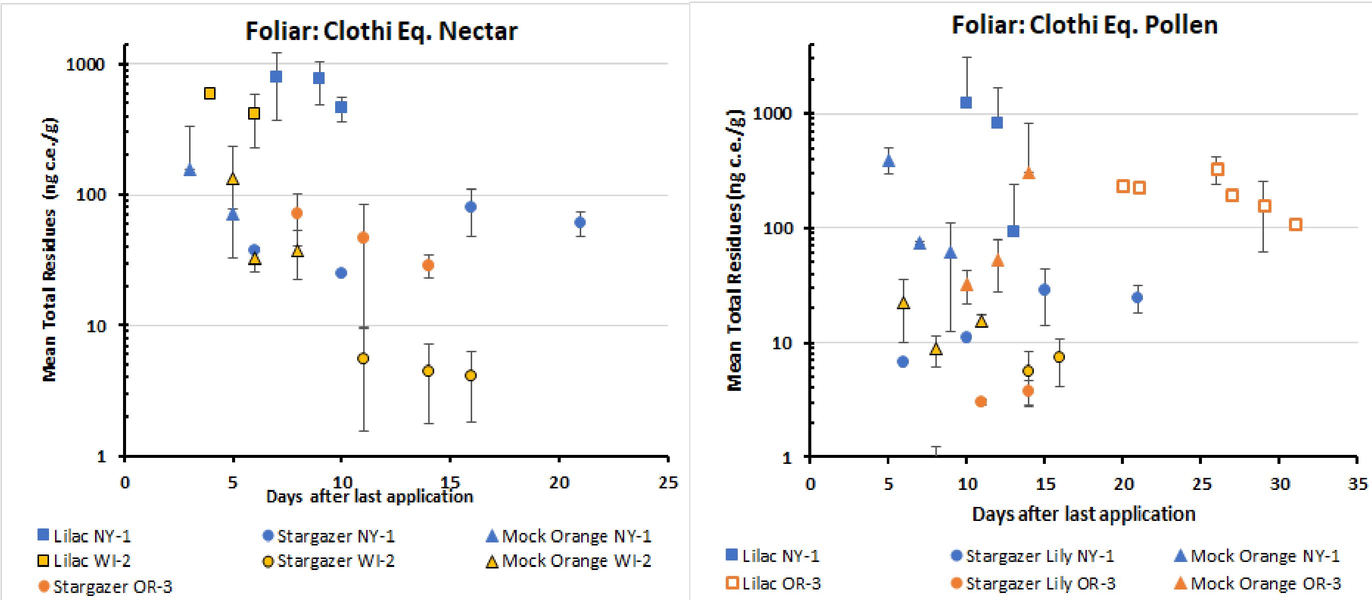


Figure 5-1. Mean daily measured concentrations of thiamethoxam (expressed as clothianidin equivalents, ng c.e./g) in nectar (left) and pollen (right) of ornamental plants following foliar spray of 0.133 lb a.i./A x 2 apps. Error bars = 95% confidence limits.

5.6 Influence of Crop and Site on Residue Values

Table 6-4 provides summary statistics of residues in individual ornamental plant species at each site to allow for comparison to determine if site or plant species influences the magnitude of the residues in nectar and pollen. Since the effect of time on residue concentrations is not evident or is relatively small at best (see previous section), mean residues for the entire sampling period are calculated along with 95% confidence intervals. Mean values with non-overlapping confidence intervals are considered significantly different. Formal statistical comparisons were not performed because the sample size within a crop and site is very small (n=3 to 6).

Table 6-4. Mean measured concentrations of thiamethoxam (expressed as clothianidin equivalents) in pollen and nectar of ornamental plants following foliar spray of 0.133 lb a.i./A x 2 apps)

Site	Stat.	Pollen			Nectar		
		Lilac	Stargazer Lily	Mock Orange	Lilac	Stargazer Lily	Mock Orange
NY-1	Mean	**788****	17.9	146	**674****	59	98.2
	95% CI	97-1480	5.2-30	13-279	462-885	36-82	42-154
	N	3	4	3	3	3	3
WI-2	Mean	NA	6.5	17.6	**495****	**4.7***	68.2
	95% CI		4.6-8.4	7.0-28	372-617	4.0-5.3	3.4-133
	N		2	3	2	3	3
OR-3	Mean	**210****	**2.4***	96.3	NA	49	NA
	95% CI	150-270	0.9-4.0	15-177		24-73	
	N	6	3	3		3	

* **Bold values** with a single asterisk indicate non-overlapping CI among sites within the same ornamental species.
** **Bold values** with a double asterisk indicate non-overlapping CI among ornamental species within a site.

Regarding the effect of site on pollen residues, mean residue concentrations for lilac, stargazer lily and mock orange are within a factor of 3X, 8X and 6X across sites, respectively (**Table 6-4,** comparing rows within a column). Among sites, a significant effect of site on mean residues in pollen is seen only for lily from the OR site (2.4 ng c.e./g), which is significantly lower than mean residues at the WI site (6.9 ng c.e./g) and the NY (17.9 ng c.e./g) based on non-overlapping 95% confidence intervals. There is uncertainty in this conclusion given the close proximity of CIs among mean values among these sites and the extremely low sample size used in their calculation. With nectar, mean residue concentrations for lilac, lily and mock orange are within a factor of 2X, 10X and 2X across sites, respectively. Of these, only the mean nectar residue in lily at the WI site (4.7 ng c.e./g) are significantly lower than those in the NY site (59 ng c.e./g) and the OR site (49 ng c.e./g). Notably, these site-to-site differences are within one order of magnitude and are similar to those commonly observed with applications to agricultural crops (**Attachment 2**).

The stargazer lily is the only ornamental species with mean residues in both pollen and nectar from all three sites. Based on non-overlapping confidence intervals, mean residues of pollen at the OR site are significantly lower than the other two sites, but this does not occur with nectar, where the WI site has significantly lower mean residue values. Therefore, with these data, the influence of site on thiamethoxam residues from foliar applications to 3 species of ornamentals appears limited to one order of magnitude, and trends among sites are not consistent among the two matrices evaluated. Clearly, however, these data are limited in scope and as a result, these findings should be interpreted with caution.

Regarding the effect of crop (plant species) on mean residues of thiamethoxam, lilac shows significantly higher residue values (10X-100X) compared to stargazer lily within each of the sites for both pollen and nectar (**Table 6-4,** comparing columns within a row). Smaller differences occur in mean residues between lilac and mock orange (< 8X) and non-overlapping confidence intervals only occur with mean residues in nectar at the NY and WI sites. Therefore, based on this limited data set, there appears to be evidence that the species of ornamental can have a strong (up to 100X) impact on thiamethoxam concentrations in both pollen and nectar resulting from foliar applications.

5.7 Bridging Recommendations for Foliar Applications to Ornamentals/Forestry

5.7.1 Effect of Chemical and Application Rate

Residue data resulting from foliar applications for the ornamental crop group are available for three ornamental species from a single thiamethoxam study (MRID 50425903). With these data, it is not possible to evaluate the effect of chemical or application rate on residue levels in pollen or nectar. Based on the results from foliar applications of neonicotinoids on agricultural crops, a chemical-specific effect on residue levels in pollen and nectar was not evident in the vast majority of cases (*e.g.,* cucurbits, orchard crops, berries; **Attachment 2**). Furthermore, there is no reason to expect the proportionality of residue concentrations with application rate observed with agricultural crops not to apply similarly to ornamental plants. Therefore, it is recommended that these residue data for thiamethoxam foliar applications ornamental plants be bridged to imidacloprid, clothianidin, dinotefuran) and scaled in proportion to application rate.

5.7.2 Effect of Site and Plant Species

Similar to conclusions made with bridging residue data with agricultural crops (**Attachment 2**), it appears that "site" can make a difference in residue concentrations (*e.g.,* up to 10X), although this difference does not appear to be consistently expressed among the pollen and nectar matrices. The apparent influence of "site" may reflect other factors (*e.g.,* weather) that could have differential impacts on residues in pollen vs. nectar. Thus, this analysis supports the expectation that "site" can result in at least an order of magnitude difference in mean residue concentrations among sites with different geographical and climatic conditions. It is therefore recommended that the number of sites supporting a risk conclusion based on residue data be considered as one factor in evaluating its overall strength of evidence.

Regarding the influence of ornamental plant species, even with these limited data, there appears to be an impact of plant species on residues in both pollen and nectar (up to 100X). This effect does not appear related to other factors such as timing between application and residue measurement or site. Therefore, application of these data for risk characterization purposes should consider that variation among different ornamental species can extend 1 to 2 orders of magnitude. It is noted that considerable uncertainty exists in extrapolating the results from these ornamental plants to those forestry uses. Although consideration was given to bridging from orchard crops, substantial differences also exist in agronomic practices and biology of orchard crops vis a vis trees grown and treated in forestry settings. Furthermore, the magnitude of residues resulting from pre-bloom, foliar applications of the neonicotinoids to agricultural crops (woody or herbaceous; **Attachment 2**) result in similarly high residue concentrations as observed with these ornamentals. Therefore, the impact of this uncertainty associated with bridging residues to forestry uses should be considered in the context of the magnitude by which colony-level effect levels are exceeded by residue values.

6. SOIL APPLICATIONS TO ORNAMENTALS AND FORESTRY USE SITES

6.1 Summary of Label Rates/Restrictions

Like the foliar spray use, clothianidin, dinotefuran, imidacloprid and thiamethoxam are registered for soil application to ornamentals and forest sites. The label restrictions stipulated for soil applications of the neonicotinoids are the same as those discussed previously for foliar applications. Maximum soil application rates range from 0.23 lb a.i./A for thiamethoxam (in clothianidin equivalents), 0.40 lb a.i./A for imidacloprid and clothianidin, 0.5 lb a.i./A for dinotefuran (**Table 6-5**).

Table 6-1. Maximum seasonal soil application rates (in lb a.i./A) for neonicotinoids

Non-Ag	Imidacloprid	Clothianidin	Thiamethoxam	Dinotefuran
Ornamentals	0.40	0.40	0.23*	0.54
Forestry	0.40	0.40	NR	0.54

NR= Not registered; *indicates values are given in clothianidin equivalents

6.2 Available Residue Data

Bee-relevant residue data are available for soil applications of thiamethoxam and imidacloprid to multiple species of ornamentals among multiple studies (**Table 6-6)**. In the thiamethoxam study, soil applications were made 12 days before bloom (in 2016) and additional application was made 7 days later (5 days before bloom) using a single application of 0.133 lb a.i./A. This rate is lower than maximum single application rate of 0.23 lb a.i./A for thiamethoxam. Pollen, nectar and flower data are available for thiamethoxam use as a soil spray on four species of ornamentals: sargent crabapple (*Malus sargentii)*, hedge cotoneaster (*Cotoneaster lucidus)*, common lilac (*Syringa vulgaris*) and stargazer lily (*Lilium orientalis*). Pollen residue data are not available for hedge cotoneaster and nor are nectar residue data available for the sergeant crabapple.

With imidacloprid, most of the residue data are from soil applications to *Rhododendron sp*. Grown outdoors involving 5 different studies with 5 different application rates. The rates used in the studies range from 0.2 g/m plant height to 4.3 g/m plant height; the maximum labeled rate for imidacloprid ornamental soil applications 1.5 g/m plant height (this is equivalent to 0.5 lb a.i./A). Additional available residue data for 6 other ornamental species are also available for soil applications of imidacloprid, as summarized in **Table 6-6**. An important limitation to these imidacloprid ornamental studies is that residues are available only for flowers. In addition, the ornamental data set for imidacloprid is confounded by differential expression of application rates (*e.g.,* mass ai/plant height, mass ai/ stem diameter, mass ai/area). Due to limitations in the information provided in these studies, conversion of application rates to a common unit was not possible within and among the imidacloprid and thiamethoxam studies.

Table 6-2. Residue studies for ornamental with soil applications of thiamethoxam and imidacloprid

Crop	Chemical	# Sites (Locations)	Appl. rate in lb a.i./A; # apps (interval)	# Seasons	# Sampling events (per season	MRID (Classification)
Stargazer Lily (*Lilium orientalis)*	Thiamethoxam	3 (NY, WI, OR)	0.133 lb ai/A X 2 (7d)	1	2-3	50425903 Acceptable
Hedge Cotoneaster (*Cotoneaster lucidus)*	Thiamethoxam	3 (NY, WI, OR)	0.133 lb ai/A X 2 (7d)	1	3	50425903 Acceptable
Lilac *(Syringa vulgaris)*	Thiamethoxam	2 (NY, OR)	0.133 lb ai/A X 2 (7d)	1	2	50425903 Acceptable
Sargent Crabapple *(Malus sargentii)*	Thiamethoxam	3 (NY, OR, WI)	0.133 lb ai/A X 2 (7d)	1	2-3	50425903 Acceptable
Rhodo-dendron sp.	Imidacloprid	1	5 g/m plant height X 1	1	3	47303401/ 47303404 Supplemental
	Imidacloprid	1	2.5 g/m plant height X 1	1	3	47303401/ 47303404 Supplemental
	Imidacloprid	1	0.2 g/m plant height X 2 (7 days)	1	3	47303401/ 47303404 Supplemental
	Imidacloprid	1	4.3 g/m plant height X 1	1	1	47303405 Supplemental

Crop	Chemical	# Sites (Locations)	Appl. rate in lb a.i./A; # apps (interval)	# Seasons	# Sampling events (per season	MRID (Classification)
	Imidacloprid	1	2.15 g/m plant height X 1	1	1	47303405 Supplemental
	Imidacloprid	1	4.3 g/m plant height X 1	1	1	47303406 Supplemental
	Imidacloprid	1	4.3 g/m plant height X 1	1	1	47303407 Supplemental
	Imidacloprid	1	2.15 g/m plant height X 1	1	1	47303407 Supplemental
	Imidacloprid	1	1.1 g/m plant height	1	1	47303407 Supplemental
	Imidacloprid	1	4.3 g/m plant height X 1	1	1	47303412 Supplemental
	Imidacloprid	1	2.15 g/m plant height X 1	1	1	47303412 Supplemental
Hibiscus *(Hibiscus syriacus)*	Imidacloprid	1	4.3 g/m plant height X 1	1	1	47303406 Supplemental
Shadbush *(Amelanchier sp.)*	Imidacloprid	1	4.3 g/m plant height X 1	2	1	47303402 Supplemental
	Imidacloprid	1	2.15 g/m plant height X 1	2	1	47303402 Supplemental
Cornelian Cherry (*Cornus mas*)	Imidacloprid	1	4.3 g/m plant height X 1	2	1	47303403 Supplemental
	Imidacloprid	1	2.15 g/m plant height X 1	2	1	47303403 Supplemental
Horse Chestnut *(Aesculus hippocastanum)*	Imidacloprid	1	0.28 g/cm stem diameter X 1	2	1	47303408/ 47303413 Supplemental
Lime Tree (*Tilia europaea)*	Imidacloprid	1	0.28 g/cm stem diameter X 1	1	3	47303410 Supplemental
	Imidacloprid	1	0.14 g/cm diameter X 1	1	3	47303410 Supplemental
Apple Tree (*Malus sp)*	Imidacloprid	1	0.28 g/cm stem diameter X 1	1	1	47303411 Supplemental
	Imidacloprid	1	0.14 g/cm stem diameter X 1	1	1	47303411 Supplemental

6.3 Bridging Needs (Gaps)

Table 6-7 identifies data gaps for registered soil applications of neonicotinoids on ornamentals and forestry uses. Three plant species were available for thiamethoxam and 7 species are available for imidacloprid. There are no bee-relevant residue data available for clothianidin or dinotefuran that are associated with soil applications.

Table 6-3. Residue data gaps for neonicotinoid soil applications to ornamentals

Crop	Imidacloprid	Clothianidin	Thiamethoxam	Dinotefuran
Ornamentals	47303401-47303414	No data	50425903	No Data
Forestry Uses	No data	No data	NR	No data

NR = Not registered

6.4 Influence of Application Rates on Residues

As seen in **Table 6-6**, the thiamethoxam soil/ornamental study assessed a single application rate, and thus additional analysis considering the influence of application rate on the magnitude of the residues in pollen and nectar is not possible with this study.

For imidacloprid, 5 studies are available from which to evaluate the influence of imidacloprid application rates on residues in flowers following a soil application to *Rhododendron sp*. In these studies, imidacloprid was applied via a soil drench at rates ranging from 1.1 g/m plant height to 5.0 g/m plant height. In the top panel of **Figure 6-1**, total residues of imidacloprid[7] are estimated in nectar by multiplying residues in flowers by 0.3, as described in **Attachment 2**. In the bottom panel of **Figure 6-1**, total imidacloprid residues estimated in nectar are normalized to a maximum application rate of 4.6 g a.i./m plant height. For mean residues measured between 126 and 356 DALA, a reduction in the range of mean residues of total imidacloprid is seen with the normalized vs. non-normalized data. This suggests that normalizing total imidacloprid residues by application rate is appropriate for reducing variance among studies due to differences in application rate.

One residue study is available with the Cornelian cherry (*Cornus mas*) and another with shadbush with shadbush (*Amelanchier sp)* that evaluated residues associated with different application rates that differ by approximately 2X. In the top panel of **Figure 6-2**, total residues of imidacloprid[8] are estimated in nectar by multiplying residues in flowers by 0.3, as described in **Attachment 2**. In the bottom panel of **Figure 6-2**, total imidacloprid residues estimated in nectar are normalized to a maximum application rate of 4.6 g a.i./m plant height. The impact of normalizing by application rate with these data is equivocal, having only slight impacts on residue concentrations relative to non-normalized values.

[7] Includes imidacloprid, 5-hydroxy-imidacloprid and imidacloprid olefin

[8] Includes imidacloprid, 5-hydroxy-imidacloprid and imidacloprid olefin

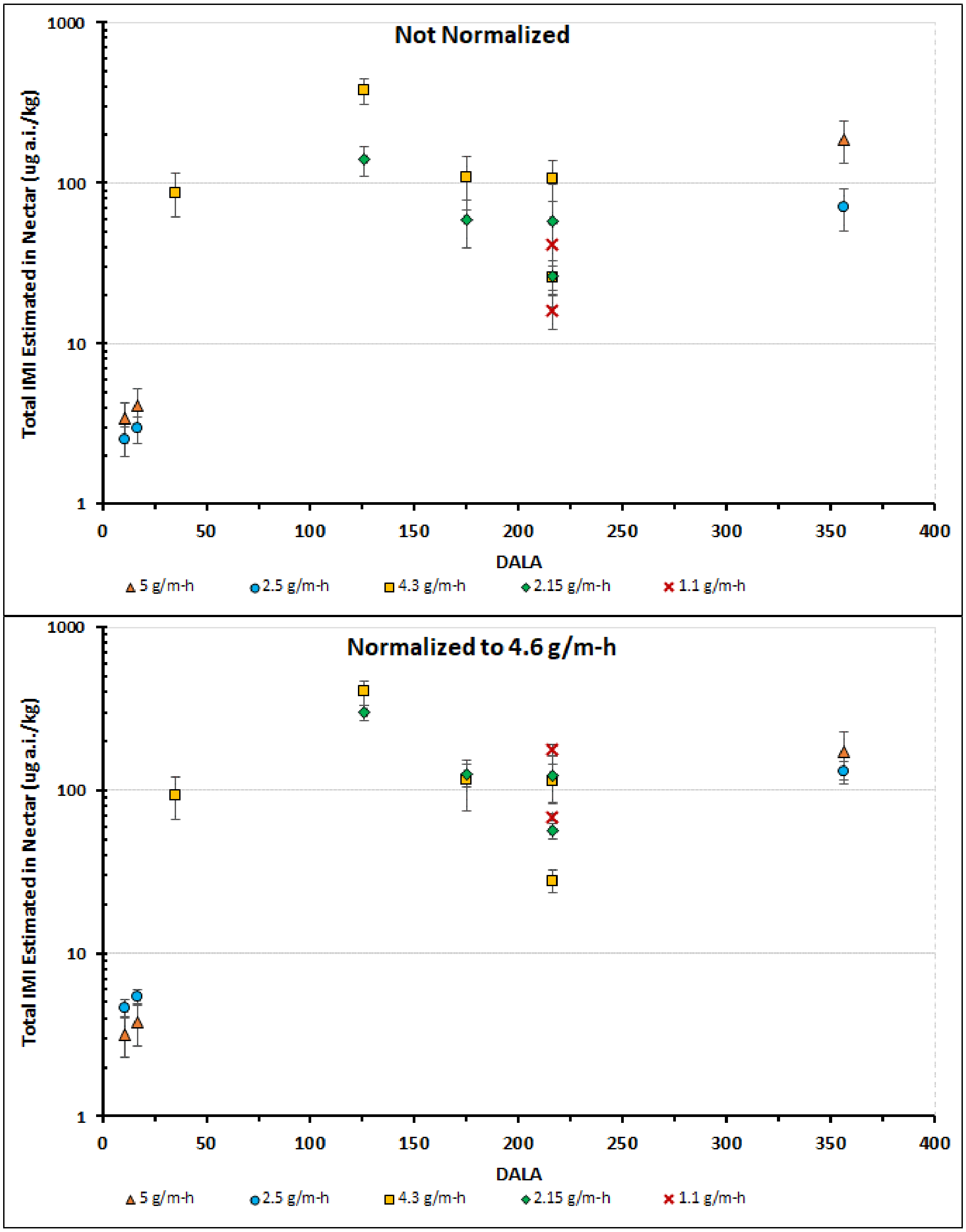


Figure 6-1. Mean measured residues (+/- 95% C.L.) of total imidacloprid estimated in nectar of *Rhododendron sp*. before (top panel) and after (bottom panel) normalizing to a maximum application rate of 4.6 g/m-plant height. Nectar concentrations are estimated by multiplying flower concentrations by 0.3.

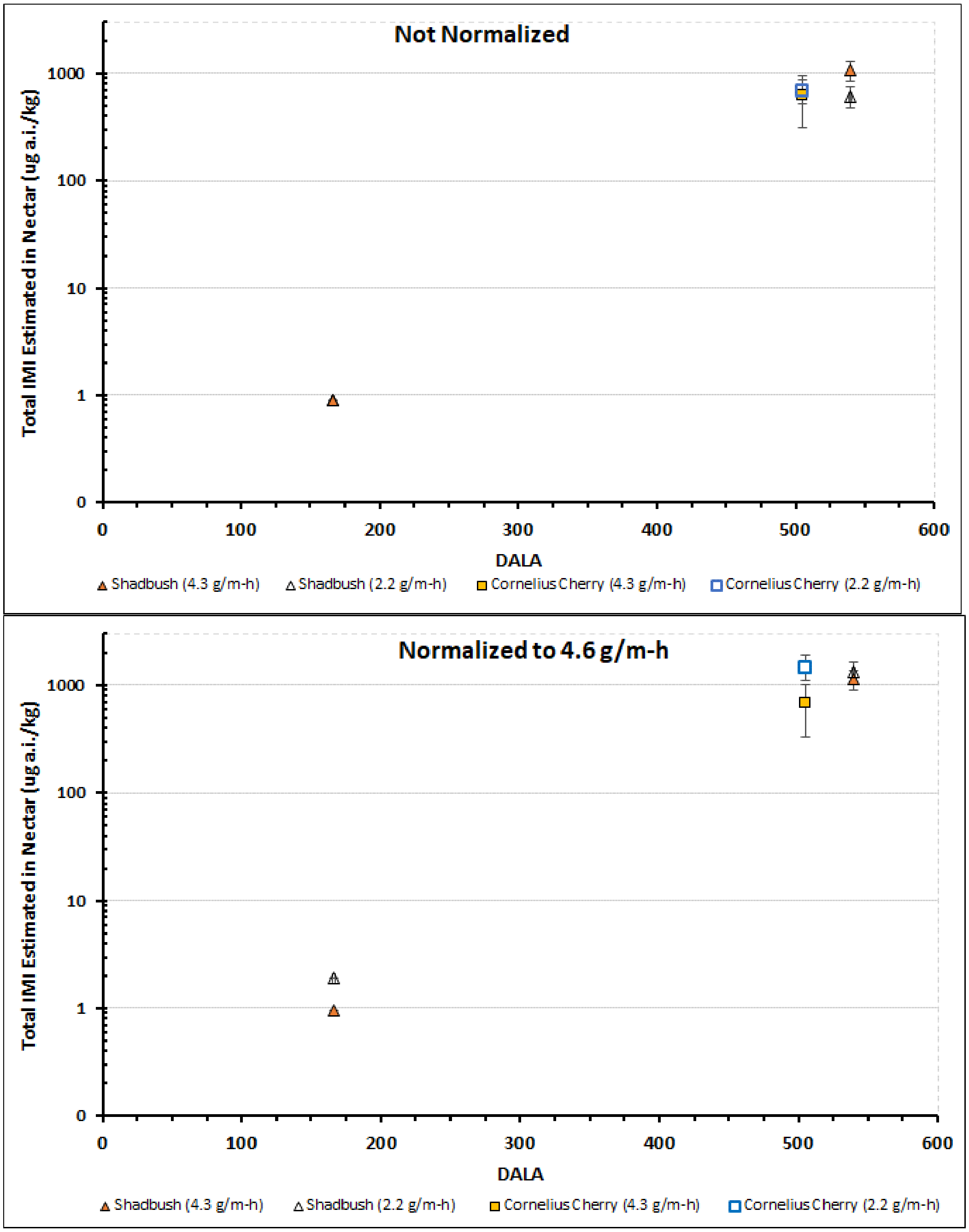
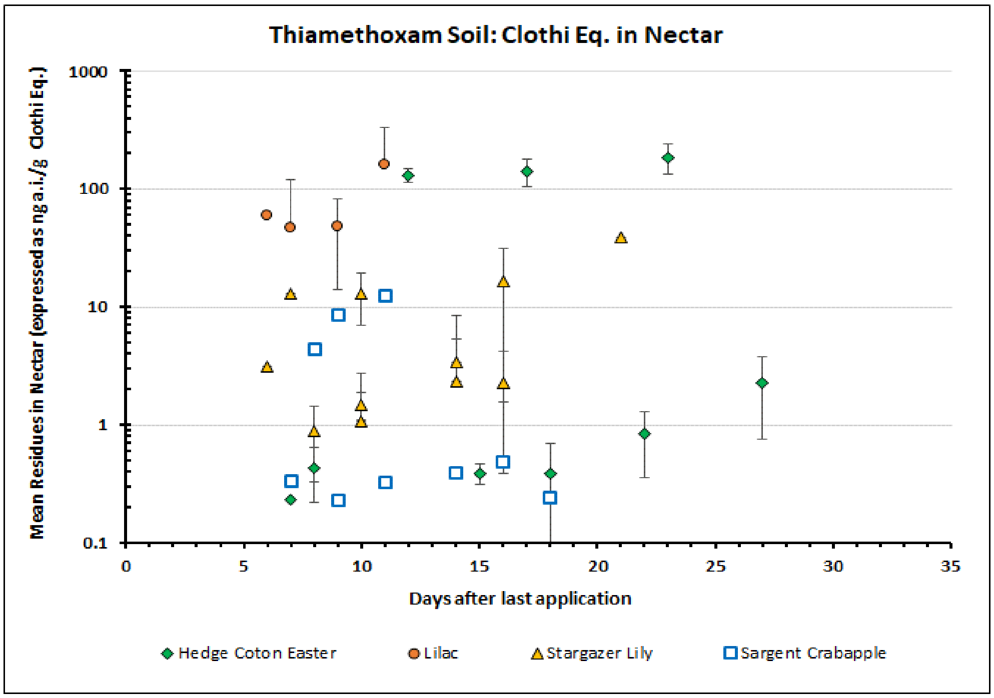


Figure 6-2. Mean measured residues (+/- 95% C.L.) of total imidacloprid estimated in nectar of Cornelian cherry and shadbush before (top panel) and after (bottom panel) normalizing to a maximum application rate of 4.6 g/m-plant height. Nectar concentrations are estimated by multiplying flower concentrations by 0.3.

6.5 Influence of Sampling day (time) on Residue Values

Plots of the thiamethoxam residue data (expressed as clothianidin equivalents) resulting from soil application to ornamentals are shown in **Figure 6-3.** Evidence of a trend in thiamethoxam concentrations in pollen over time within each crop and site is not apparent with these data. Similarly, with nectar, no consistent trend in residue values with time are evident. It is noted that within each site/species combination, measurements were typically made only at 2-3 sampling events. In addition, the span of time covered by the residue sampling is also limited, often 10 days or less. Therefore, these data are considered very limited for discerning a possible effect of time on the magnitude of residues of thiamethoxam in pollen and nectar following soil applications.



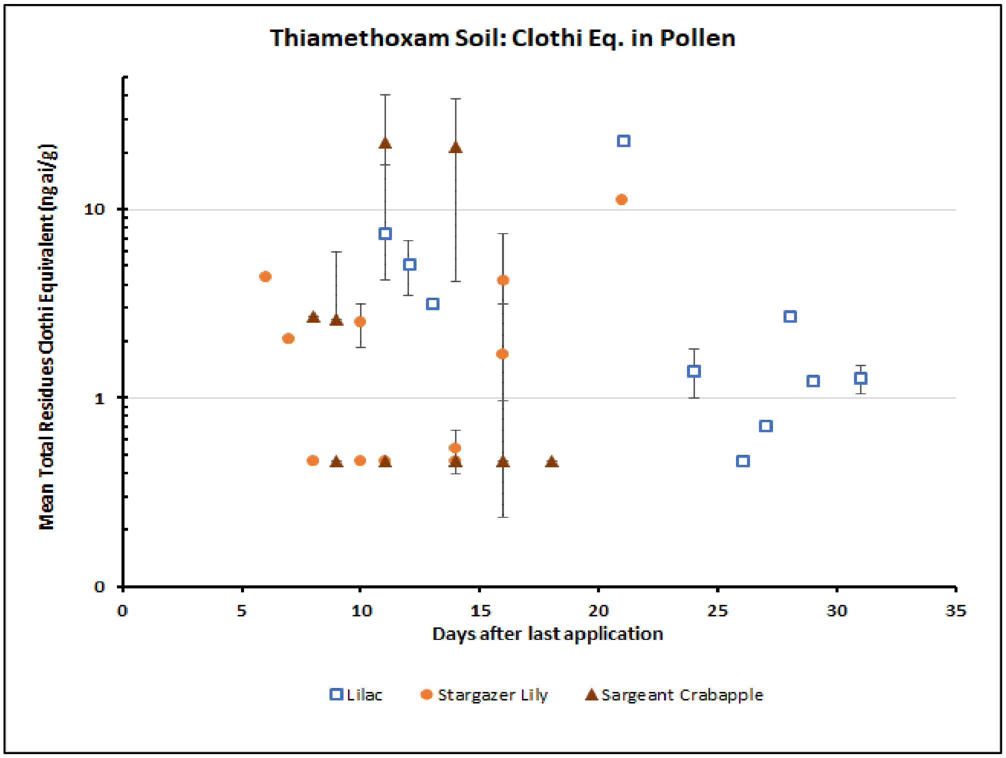


Figure 6-3. Mean daily measured concentrations of thiamethoxam (expressed as clothianidin equivalents) in nectar (top panel) and pollen (bottom panel) of ornamental plants following soil application of 0.133 lb a.i./A x 2 apps. (MRID 50425903).

6.6 Influence of Crop and Site on Residue Values

Summary statistics of site-specific data are provided in **Table 6-8** below. Since the effect of time on residue concentrations was not evident, mean residues for the entire sampling period were calculated along with 95% confidence intervals. Mean values with non-overlapping confidence intervals were considered significantly different. Formal statistical comparisons were not performed due to the small sample size within a crop and site.

Regarding the effect of site on pollen residues, only the mean residue concentration for lily in the NY site (5.0 ng c.e./g) was significantly different than in the OR site (0.49 ng c.e./g) based on non-overlapping confidence intervals. With nectar, the mean residue concentration for hedge cotoneaster in NY (153 ng c.e./g) was significantly greater than those measured in the OR or WI sites, by about a factor of 100X. Similarly, the mean concentration in lily from the NY site (17 ng c.e./g) was significantly greater than those of the OR or WI site by a factor of 10X. These findings are suggestive that conditions associated with the NY site resulted in greater residues than those of the OR or WI sites at least in two ornamental species.

Regarding the effect of crop (plant) on mean residue values, lilac shows higher residue values (10X) compared to the lily within the OR site for pollen (4.4 vs 0.49 ng c.e./g, respectively), although 95% confidence intervals overlap. With nectar, mean concentrations in the hedge cotoneaster are significantly greater than lily (by 10X), but not lilac. Therefore, based on this limited data set, there appears to be evidence that both species and site can have a significant impact on thiamethoxam concentrations in both pollen and nectar resulting from soil applications.

Table 6-4. Mean measured concentrations of thiamethoxam (expressed as clothianidin equivalents) in pollen and nectar of ornamental plants following soil application of 0.133 lb ai/A x 2 apps.)

Site	Stat.	Pollen (ng c.e./g)			Nectar (ng c.e./g)		
		Lilac	Crabapple	Stargazer Lily	Lilac	Stargazer Lily	Hedge Cotoneaster
NY-1	Mean	5.2	12.3	**5.0***	79	17*	**153****
	95% CI	2.8 - 7.7	1.4 - 23	0.84 – 9.1	26-132	5.2-29	120-186
	N	3	4	4	4	5	3
WI-2	Mean	NA	0.46	0.87	NA	2.2	0.96
	95% CI		NC	0.07 – 1.7		1.0-3.5	0-2.2
	N		3	3		3	3
OR-3	Mean	4.4	0.46	0.49	NA	1.6	0.55
	95% CI	0 - 10.6	NC	0.45 – 0.53		0.8-2.4	0.3-0.8
	N	7	3	4		3	3

* **Bold values** with an asterisk indicate non-overlapping CI across sites within the same species
****Bold values** with a double asterisk indicate non-overlapping CI across species within a site

6.7 Influence of Chemical on Residue Values

Because the units for the residues within the thiamethoxam and imidacloprid studies could not be converted to a common metric, cross-chemical comparisons could not be conducted with the available data.

6.8 Bridging Recommendations for Soil Applications to Ornamentals/Forestry

6.8.1 Effect of Chemical and Application Rate

Residue data resulting from soil applications to ornamentals are available for 2 chemicals (thiamethoxam, imidacloprid) for multiple species. With these data it is not possible to evaluate the effect of chemical on the residue levels due to unresolvable differences in the units of application rate. Based on the results from soil applications of neonicotinoids on agricultural crops, a chemical-specific effect on residue levels in pollen and nectar was not evident in the vast majority of cases (*e.g.,* cucurbits, orchard crops, berries; **Attachment 2**). Imidacloprid data from multiple studies on Rhododendron support the assumption that residues scale in proportion to application rate for both pollen and nectar. Therefore, it is recommended that these data for thiamethoxam be bridged to evaluate risk associated with soil applications of the other three neonicotinoids (imidacloprid, clothianidin, dinotefuran) and scaled among application rates.

6.8.2 Effect of Site and Plant Species

Similar to conclusions made with bridging residue data with agricultural crops (**Attachment 2**), it appears that "site" can make a difference in residue concentrations (*e.g.*, up to 100X). One site in particular (NY) tended to have the greatest concentration in both pollen and nectar. The apparent influence of "site" may reflect other factors (*e.g.,* weather) that could have differential impacts on residues in pollen vs. nectar. Thus, this analysis supports the finding that "site" can result in 1-2 orders of magnitude difference in mean residue concentrations among sites with different geographical and climatic conditions. It is therefore recommended that the number of sites supporting a risk conclusion based on residue data be considered as one factor in evaluating its overall strength of evidence.

Regarding plant species, even with these limited data, there appears to be an impact of plant species on residues in both pollen and nectar (up to 10X). This effect does not appear related to other factors such as timing between application and residue measurement or site. Therefore, application of these data for risk characterization purposes should consider that variation among different ornamental species can extend at least 1 order of magnitude.

7. TREE INJECTION APPLICATIONS

7.1 Summary of Label Rates/Restrictions

Imidacloprid and dinotefuran are registered for tree injection uses with ornamentals and forestry. For imidacloprid injection uses in cottonwood, labels restrict applications to post bloom and when bees are not foraging. Injection applications are similarly restricted for linden, basswood, or other *Tilia* species with imidacloprid and dinotefuran. Other labels do not contain restrictions on timing of application. The maximum rates for tree injection applications of these chemicals are included in **Table 7-1**.

Table 7-1. Tree Injection application rates (in g/cm dbh) for the neonicotinoids

Non-Ag	Imidacloprid	Clothianidin	Thiamethoxam	Dinotefuran
Ornamental and Forest Trees	0.09	NR	NR	0.2

NR= Not registered; dbh = trunk diameter at breast height

7.2 Available Residue data

For dinotefuran, residue data are available in nectar, pollen and flower following tree injection applications, and flower data are available for imidacloprid **(Table 7-2*)***. For dinotefuran, one trunk injection application was made to cherry using a rate of 2 g product per inch of trunk diameter (0.16 g a.i./cm dbh) tested at three different sites. Flower, nectar, pollen and leaf data was collected for all sites in the spring following fall (post bloom) trunk injections. For imidacloprid, one tree injection study is available with horse chestnut involving pre-bloom application of 0.06 g a.i./cm dbh at 1 site in Germany. Samples of flowers only were collected 2, 7 and 351 days after application during May 2001. This study is considered only for qualitative use in risk assessment due to its many limitations.

Table 7-2. Residue studies for ornamental tree injection applications for imidacloprid and dinotefuran

Crop	Chemical	# sites (Locations)	Appl rate	# Seasons	# Sampling events	MRID (Classification)
Cherry	Dinotefuran	3 (NY, CA, OR)	0.16 g a.i./cm stem diameter*	1	3	50145706 Acceptable
Horse Chestnut	Imidacloprid	1	0.06 g a.i./cm stem diameter	1	3	47303409/ 47303414 (Supplemental)

*this value was calculated based on application rate of 2g product/ in (20% a.i.)

7.3 Bridging Needs (Gaps)

Table 7-3 identifies data gaps for registered tree injection applications of neonicotinoids on ornamentals. There are residue studies available for both of the chemicals that have registered trunk injection applications although data are available for only 1 species for each chemical.

Table 7-3. Residue data gaps for neonicotinoid trunk injection applications to ornamentals and forestry

Crop	Imidacloprid	Clothianidin	Thiamethoxam	Dinotefuran
Ornamental Tree	47303414 47303409	NR	NR	50145706
Forest Trees	No Data			No Data

NR = Not registered

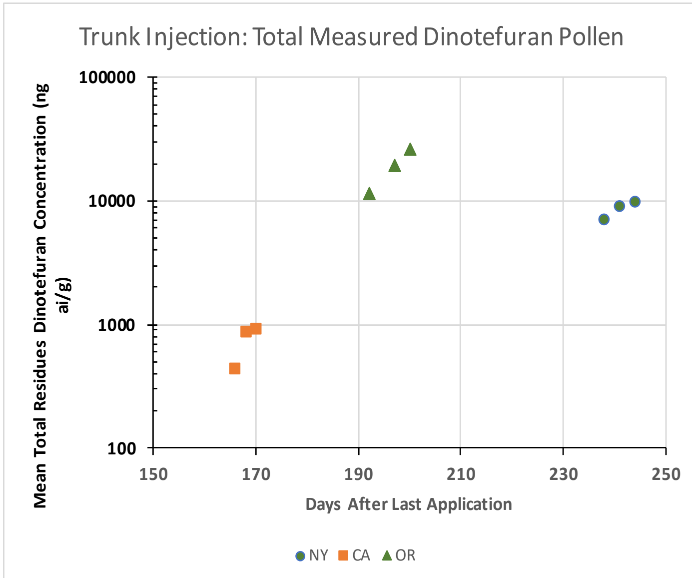
7.4 Influence of application rates on residues

The influence of application rate on the magnitude of nectar and pollen residues for trunk injection applications in ornamentals cannot be determined based on the available data set. Both the imidacloprid and dinotefuran studies only included a single application rate.

7.5 Influence of Sampling Day (Time) on Residues

The influence of sampling over time can be examined for dinotefuran since there are 3 sampling events per site for both pollen and nectar **(Figure 7-1.)**. The initial residue measurements in pollen and nectar were taken approximately 160 and 170 days after application and were lowest at this time point. Residue concentrations taken at subsequent measurements (~DALA 190-200 and DALA 240) increased relative to the first measurement, but there was no consistent trend over time following the first measurement. Within each residue trial, samples were taken over a brief time interval (only a few days apart). Therefore, the ability to discern the influence of time on residues within a trial is very limited. Furthermore, it was not possible to perform an analysis of kinetics for determining dissipation rates with these data.

The imidacloprid trunk injection residue data are similarly limited for evaluating the dependency of residue values on time after application **(Figure 7-2)**. It is noted that concentrations in nectar are estimated as concentrations in flowers multiplied by a factor of 0.3 per the analysis presented in **Attachment 2**.



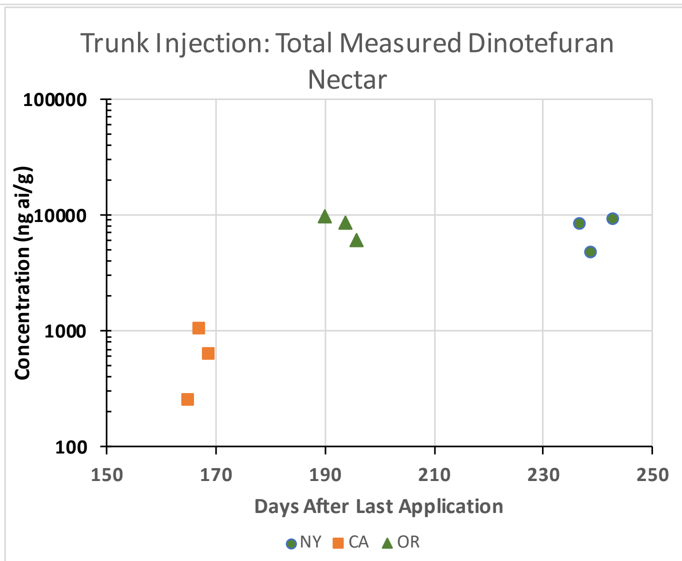


Figure 7-1. Mean daily measured dinotefuran concentrations by site in cherry pollen (top) and nectar (bottom) following trunk injection of 0.157 g/cm stem diameter (MRID 50145706).

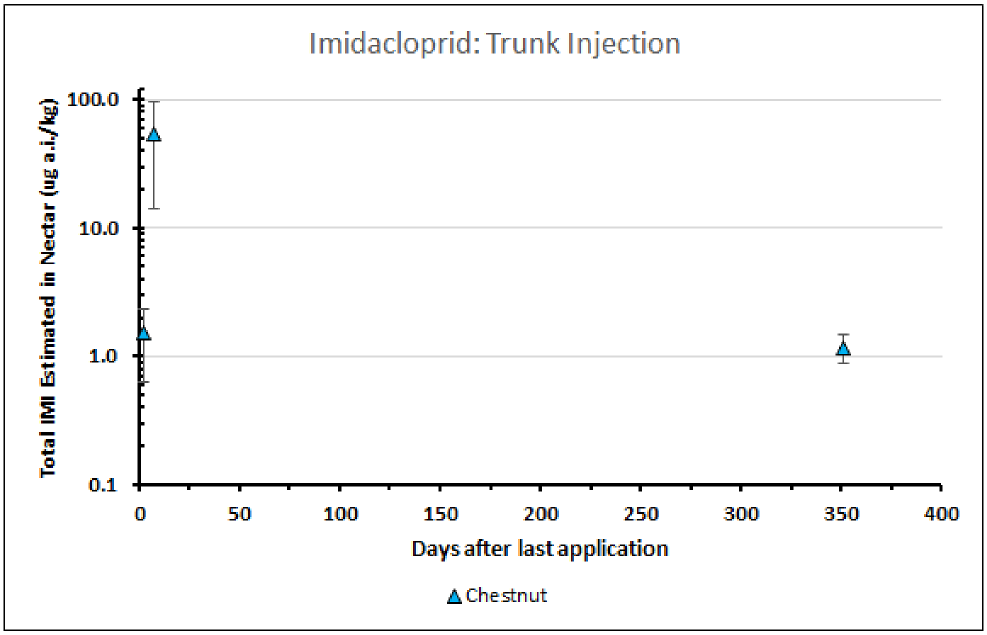


Figure 7-2. Mean (=/- 95% CL) of total imidacloprid residues estimated in nectar of horse chestnut following pre-bloom application of 0.06 g a.i./cm stem diameter (MRID 47303414).

7.6 Influence of Site on Residue Values

An analysis of the influence of site on residues values cannot be completed using the imidacloprid data set. However, the dinotefuran study was conducted using three different sites and can be used to assess the influence of site on residue following trunk injection.

For all sites within the dinotefuran study, post bloom trunk injections were made at the same period relative to bloom. The peak residue values for nectar and pollen came from the Oregon site. Based on visual inspection of **Figure 7-1,** it appears that concentrations of dinotefuran measured at the NY and OR sites are approximately an order of magnitude greater than those measured in the CA site for both pollen and nectar. There is a difference in timing of the residue measurements (~165 DALA for CA; ~200 DALA for OR; ~240 for NY) which might contribute to part of this variability.

Summary statistics of site-specific data can be seen in **Table 7-4** below. With pollen, mean residues are significantly different based on non-overlapping 95% confidence levels at each of the three sites, although the confidence intervals for the NY and OR sites are very close to overlapping. With nectar, only the CA site is significantly different from the NY and OR sites. The consistently lower residue concentrations for pollen and nectar in the CA site suggests that site can make a difference; in this case, up to 10X.

Table 7-4. Summary of daily mean concentrations (ng a.i./g) of dinotefuran in pollen and nectar by site for cherry injection study

Site	Stat.	Pollen (ng a.i./g)	Nectar (ng a.i./g)
NY	Mean	**8,490** (B)	**7,440** (B)
	95% CI	6,950-10,040	4,790-10,100
	N	3	3

Site	Stat.	Pollen (ng a.i./g)	Nectar (ng a.i./g)
CA	Mean	**735** (A)	**634** (A)
	95% CI	437-1,030	192-1,080
	N	3	3
OR	Mean	**18,700**(C)	**8,140** (B)
	95% CI	10,700-26,800	5,940-10,300
	N	3	3

Mean values shown in **bold**. Means with a different letter indicate non-overlapping CI across sites

7.7 Influence of Plant Species and Chemical on Residue Values

The available studies for both dinotefuran and imidacloprid only measure residues for a single tree species within each study, thus it is not possible to assess the influence of crop on the magnitude of nectar and pollen residues from trunk injection applications separate from potential chemical differences among these two studies. Similarly, the effect of chemical on residue value cannot be determined with these data apart from the potential influence of different plant species. However, it is noted that residues of dinotefuran are in the parts per million (ppm) range which 1 to 3 orders of magnitude greater than residues associated with soil or foliar spray applications to agricultural crops (**Attachment 2**). Thus, for dinotefuran, residue levels in cherry are of such a high magnitude that risk conclusions are not likely to be sensitive to uncertainty regarding tree-specific differences in residue values. Given the unique nature of trunk injection studies, bridging results from other types of application methods is not recommended. Notably, however, a lack of consistent chemical-specific influence on neonicotinoid residues in pollen and nectar was observed with foliar, soil and seed treatment applications agricultural crops and ornamentals (**Attachment 2, 3 and 4**). Thus, in the absence of data to indicate otherwise, it is recommended the trunk injection data for dinotefuran be bridged to imidacloprid (the only other neonicotinoid with trunk injection uses) as a line of evidence to be considered in risk characterization.

8. RESIDENTIAL TURF

8.1 Plants of Concern for Bees

Turfgrass itself is not attractive to honey bees and other non-*Apis* bees. However, flowering weeds such as clover and dandelions are commonly distributed among turfgrass and are considered attractive to bees. These weeds are limited to residential turfgrass because in commercial turfgrass production (*e.g.,* sod farms), agronomic practices including mowing and broadleaf weed control greatly limit the presence of blooming weeds to the point of complete eradication. Therefore, commercial turf is not considered to be a likely exposure scenario of concern; however, the weeds present in residential turf scenarios are considered to be a concern.

8.2 Summary of label Rates/Restrictions

All neonicotinoids are registered for use on residential and commercial turf with varying application rates and label restrictions. Maximum application rates are 0.23 lb ai/A for thiamethoxam (in clothianidin equivalents), 0.40 lb ai/A for clothianidin, 0.5 lb ai/A for imidacloprid and 0.54 lb ai/A for dinotefuran. The maximum single soil application rates for these chemicals are included in **Table 8-1**.

Table 8-1. Maximum Application Rates (in lb ai/A) and number of applications for turf uses of neonicotinoids

Non-Ag	Imidacloprid	Clothianidin	Thiamethoxam	Dinotefuran
Ornamentals	0.5 lb ai/A	0.40 lb ai/A	0.23 lb ai/A*	0.54 lb ai/A

* indicated values are given in clothianidin equivalents

8.3 Available Residue Data

No registrant-submitted residue data on imidacloprid in blooming weeds associated with turfgrass application were available for assessing risks to bees. An open literature study was available which quantified residues of imidacloprid and clothianidin in white clover following application to turfgrass (Larson *et al.* 2015). In their study, Larson *et al.* (2015) quantified residues of imidacloprid and clothianidin in nectar of white clover following a single application of 0.4 lb a.i./A (MERIT™ 75 WSP: X% imidacloprid) and Arena 50™ in separate plots. Separate trials were conducted in June and August 2013 (4 replicates per trial) in which applications were made during bloom of clover in the turfgrass. Residues of imidacloprid (parent only) were measured in nectar 1 day after application and again 21 days later in newly blooming clover after mowing. Raw data were provided by the study authors for independent verification of results. A summary of these data is provided in **Table 8-2.**

Table 8-2. Summary of imidacloprid and clothianidin residues in white clover nectar following foliar applications to turfgrass

Species	App Method	App rate	Application Timing	Measurement DALA	Conc. in Nectar (µg ai/kg) (1)	Conc. in Pollen (µg ai/kg)	Reference (Classification)
IMIDACLOPRID							
Kentucky Blue Grass & Tall Fescue with 30% White Clover (Trifolium repens)	Foliar	0.4 lb a.i./A (MERIT 75 WSP)	June 3 Aug 15	1 1	5,493 ± 1040 6,588 ± 752	NA	**Larson *et al.* (2015)** (Qualitative)
			June 3 Aug 15	21 (after mowing) 21 (after mowing)	8.4 ± 2.2 26 ± 10	NA	
CLOTHIANIDIN							
Kentucky Blue Grass & Tall Fescue with 30% White Clover (Trifolium repens)	Foliar	0.4 lb a.i./A (ARENA 5 WDG)	June 3 Aug 15	1 1	2,992 ± 541 2,882 ± 228	NA	**Larson *et al.* (2015)** (Qualitative)
			June 3 Aug 15	21 (after mowing) 21 (after mowing)	6.2 ± 2.1 18 ± 15	NA	

(1) mean ± SE (n=4). Parent imidacloprid only

8.4 Bridging Needs (Gaps)

Table 8-3 identifies data gaps for registered soil and foliar applications of neonicotinoids on turf grass. One open literature study is available for imidacloprid and clothianidin. There is no data available for thiamethoxam and dinotefuran.

Table 8-3. Residue data gaps for neonicotinoid foliar and soil applications to turfgrass

Crop	Imidacloprid	Clothianidin	Thiamethoxam	Dinotefuran
Turf	Larson *et al.,* 2015	Larson *et al.,* 2015	No data	No Data

NR = Not registered

8.5 Influence of Application Rates, Sampling Time, Site, Plant Species on Residues

Based on the data set available, it is not possible to assess the influence of application rates on the magnitude of residues in pollen and nectar for soil applications on turfgrass because a single application rate was tested within the study. Similarly, a single species of clover was evaluated at a single site; therefore, these factors also cannot be evaluated.

Regarding sampling time, only limited information regarding sampling time is available from the study. Samples were taken 7 DALA and 21 DALA; since residues were not measured in between these times, the duration of the magnitude of the residues not known with precision and thus it is not possible to understand the influence that the sampling time may have on the magnitude of residue values in pollen and nectar. Furthermore, DALA 21 samples reflect mowing and re-growth of the clover, which confounds interpretation of residue dissipation in absence of mowing after DALA 7.

8.6 Influence of Chemical on Residue Values

A very broad comparison of the influence of chemical on the magnitude of residue values can be completed. Within the Larson study, treatments of imidacloprid and clothianidin were made on turf. Mean residues in the first sampling ranged from 5,500 to 6,600 ng a.i./g for imidacloprid and 3,000 to 2,800 ng a.i./g for clothianidin; 21 days later, the second samples ranged from 8-26 ng a.i./g for imidacloprid and 6-18 ng a.i./g for clothianidin. Based on the available information in the study, no further analysis can be conducted. However, with this limited information it seems that chemical does not have an influence on the magnitude of the residue values for pollen and nectar for turf applications.

8.7 Bridging Recommendations

Residue data resulting from soil and foliar applications to turf is limited to qualitative data for a single study. The utility of quantitatively comparing the residues to make cross chemical comparisons is limited.

Results from Larson *el al.,* (2015) indicate relatively high levels of imidacloprid residues occur in clover nectar 1 day after receiving direct foliar spray application. Mean residues in 2 trials ranged from approximately 5,500 to 6,600 ng a.i./g; however, 21 days later, mean residues of imidacloprid in nectar of newly bloomed clover after mowing were orders of magnitude lower (8-26 ng a.i./g). Since residues were not measured in between these times, the duration of the magnitude of the residues not known with precision. Notably, concentrations of clothianidin, applied at the same application rate as imidacloprid, are within 2X of imidacloprid during both sampling times. This finding suggests that the uptake and translocation of imidacloprid and clothianidin in white clover are comparable, which is consistent with their similar physicochemical and fate properties.

In the absence of data and given the lack of lack of consistent chemical-specific influence on neonicotinoid residues in pollen and nectar was observed with foliar and soil applications to agricultural crops and ornamentals, it is recommended that the available data for clothianidin and imidacloprid should be used to qualitatively characterize the potential risks from exposure to turf from foliar and soil treatments of neonicotinoids (clothianidin, dinotefuran, imidacloprid, and thiamethoxam) based on registered uses. Residue values should be scaled according to application rate.