Environmental Horticulture Program

SynRG 2021: Silver Bullets?

Cristi L Palmer

IR-4 Environmental Horticulture Program Manager

RUTGERS

The IR-4 Project

What is IR-4?

The IR-4 Project (or Inter-Regional project number 4) was created in 1963 to facilitate

Photo by Cristi Palmer

registration of sustainable pest management technology for specialty crops and minor uses

Environmental Horticulture Program Elements

Program Element	*Funding Sources*	*Funds since 2004 (18 years)*
Registration Support	NIFA IR-4 Grant 2020-34383-32455 USDA-ARS State Agricultural Experiment Stations Crop Protection Industry	~$22,000,000
Invasive Species	USDA-APHIS	$5,816,465
Pollinator Protection	NIFA SCRI Grant 2016-51181-25399 "Protecting Pollinators with Economically Feasible and Environmentally Sound Ornamental Horticulture"	$6,509,975

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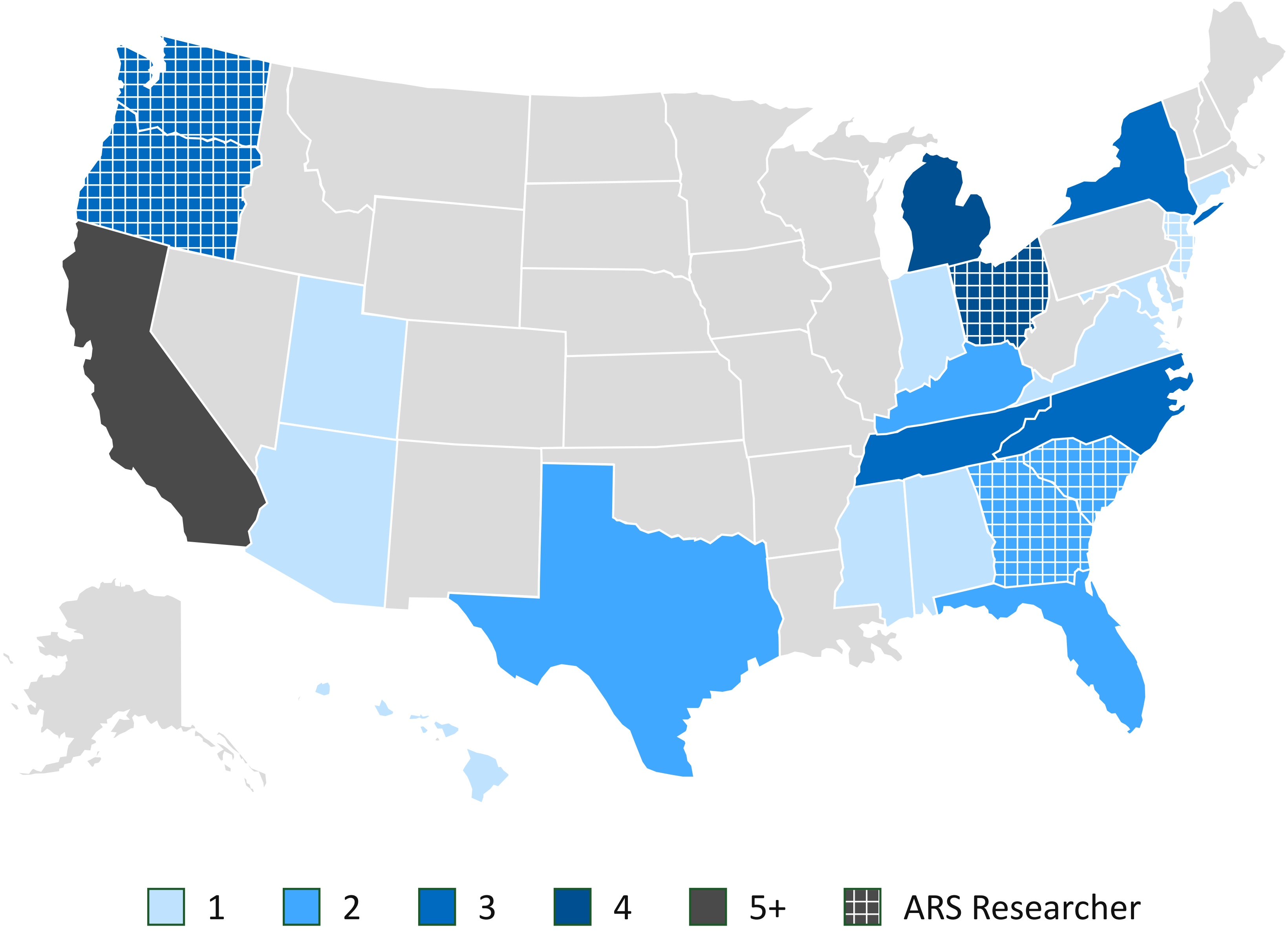
IR-4 Activities on behalf of the Green Industry

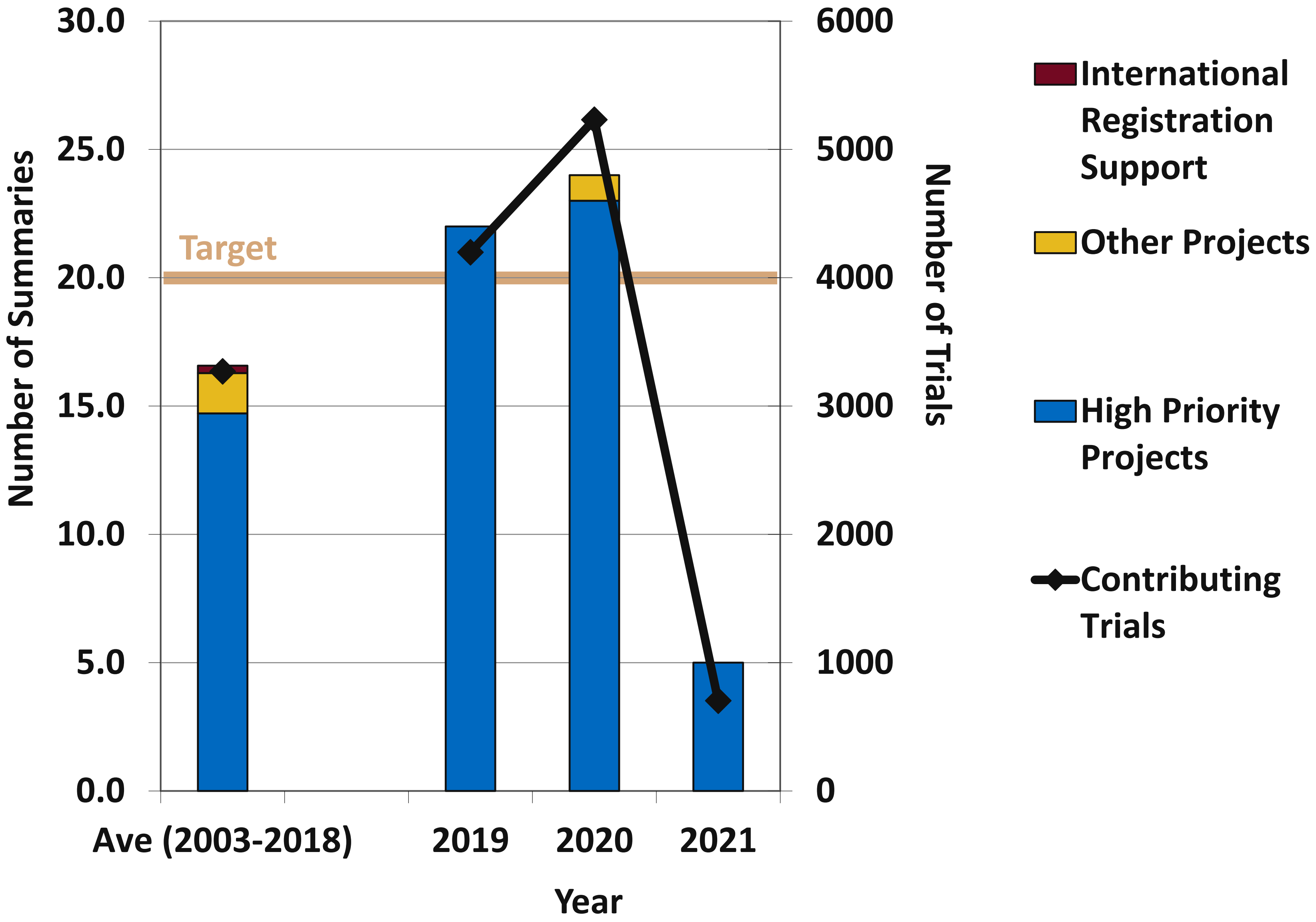
Registration Support

2021 Registration Support Research Network



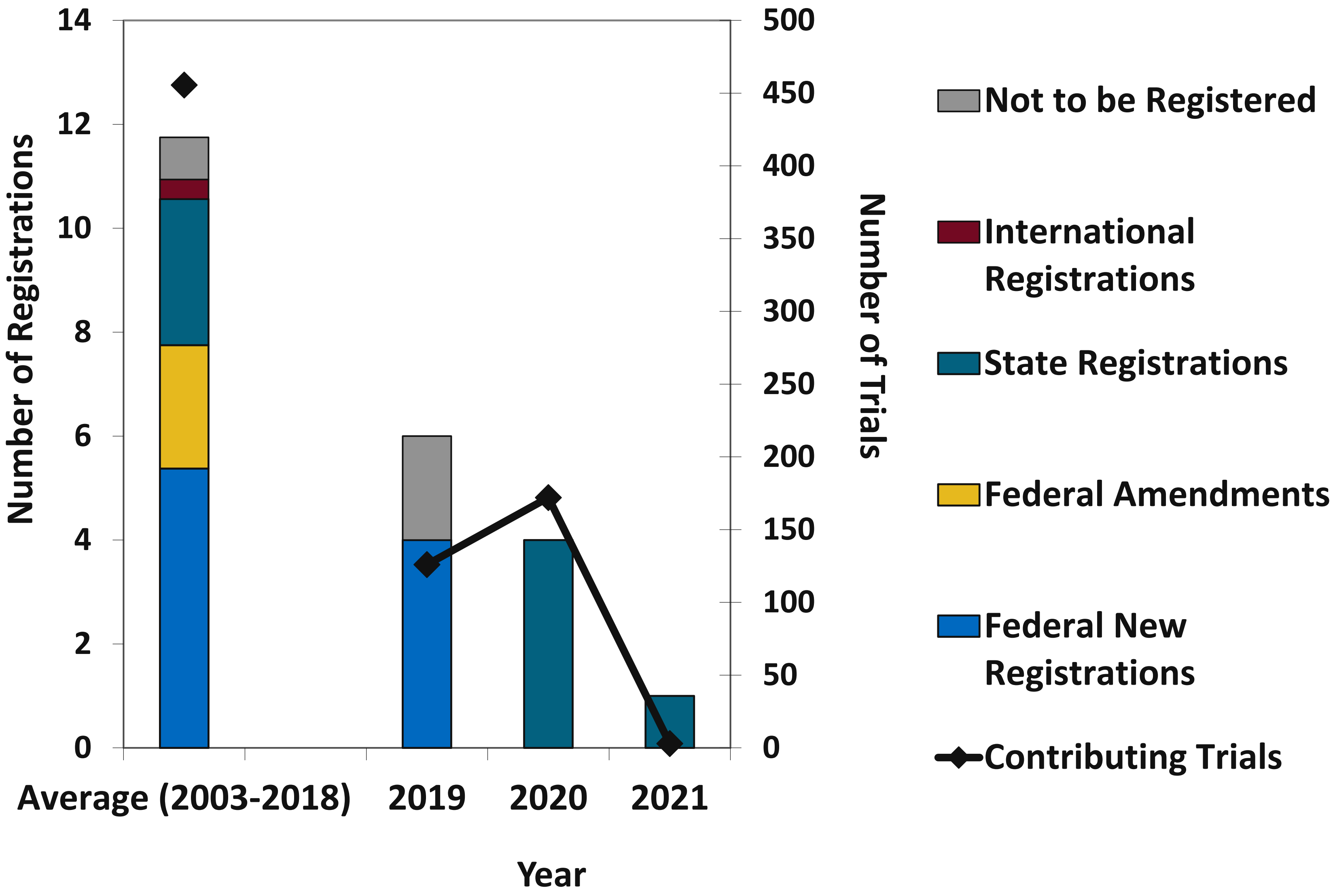
Outcomes & Impacts

Data Summaries 2020



Outcomes & Impacts

Registrations 2021



Outcomes
&
Impacts

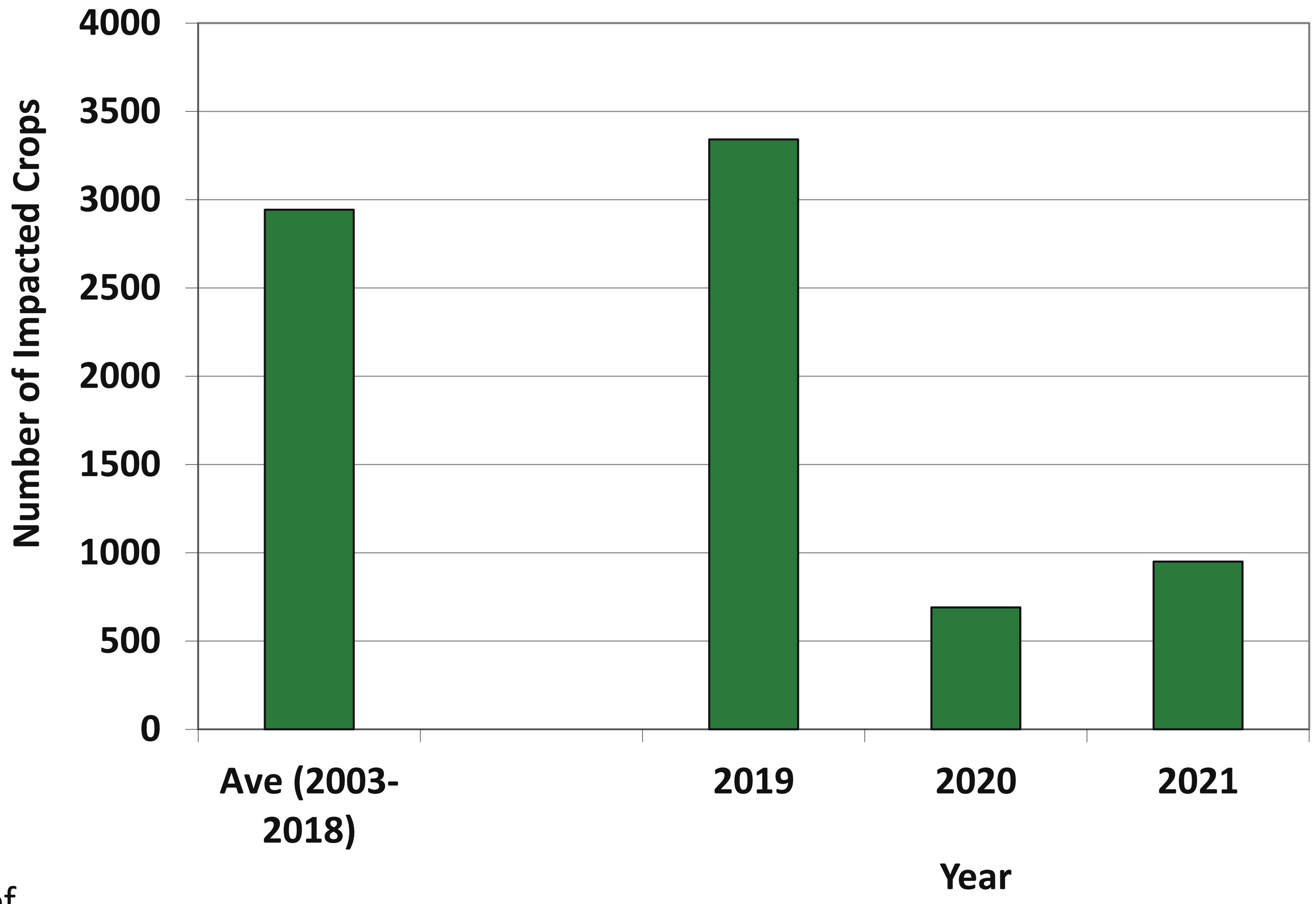
Registrations since 2019

- **Fungicides**
  - Picatina Flora (pydiflumetofen + fludioxanil) **
  - Regime (BLAD)
- **Herbicides**
- **Insecticides/Miticides**
  - Pedestal (novaluron) **
  - Pradia (cyclaniliprole)
  - Sarisa (cyclaniliprole + flonicamid)
  - Ventigra (afidopyropen) **
  - Xxpire (spinetoram + sulfoxaflor)

** IR-4 data supported CA registration

Outcomes & Impacts

Crop Use Impact 2021



57,010
crop uses as of 7/12/2021

Outcomes & Impacts

Reach

What does this mean for **Environmental Horticulture**?

Since this Program was started in 1977,

- more than **910** products & numbered active ingredients have been screened for performance
- over **36,500** trials have been conducted
- and more than **57,000** crop uses are now available for growers and landscape managers

Photo by Cristi Palmer

Program statistics as of July 2021

The IR-4 Project

Photo by Cristi Palmer

IR-4 Activities on behalf of the Green Industry

Pollinator Protection

The IR-4 Project

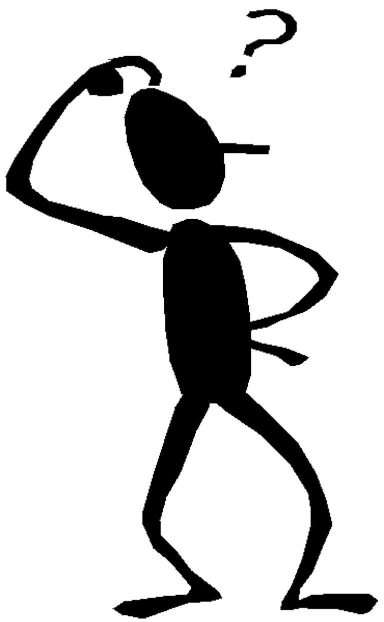
SCRI Protecting Pollinators Research Team

- James Bethke (University of California-ANR)
  - Lea Corkidi, Leah Taylor, Annika Nabors
- Christine Casey (University of California-Davis)
- JC Chong (Clemson University)
- Rich Cowles (Connecticut Agricultural Experiment Station)
- Brian Eitzer (Connecticut Agricultural Experiment Station)
- Dan Gilrein (Cornell Cooperative Extension of Suffolk County)
- Christina Grozinger (Penn State University)
  - Emily Erickson, Doug Sponsler
- Zachary Huang (Michigan State University)
- Hayk Khachatryan (University of Florida)
- Andrea Nurse (University of Maine)
- Elena Nino (University of California-Davis)
- Cristi Palmer (IR-4, Rutgers University)
  - Amy Abate, Jackie Cavaliere, Dave Bodine, Tom Freiberger, Matt Havers, Yu-Han Lan, Carolina Roe-Raymond
- Harland Patch (Penn State University)
- Dan Potter (University of Kentucky)
  - Adam Baker, Bernadette Mach, Carl Redmond
- Dave Smitley (Michigan State University)
  - Erika Hotchkiss, Colin O’Neal
- Kimberly Stoner (Connecticut Agricultural Experiment Station)
- Nishanth Tharayil (Clemson University)
  - Elizabeth Leonard

SCRI Protecting Pollinators Stakeholder Advisory Team

- Jennifer Browning, BASF
- Joe Chamberlin, Valent Corporation
- Harvey Cotten, Horticulture Research Institute
- Stephanie Darnell, Bayer Environ. Science
- Dave Fischer, Bayer Environmental Science
- Rufus Isaacs, Michigan State University
- Gary Mangum, Owner, Bell Nurseries
- Dustin Meador, CfAHR
- Terril Nell, American Floral Endowment
- Randy Oliver, Scientific Beekeeping
- Ed Overdevest, Owner, Overdevest Nurseries
- Jay Overmyer, Syngenta Crop Protection
- Casey Sclar, American Public Gardens Association
- Becky Sisco, IR-4 Western Region
- Tim Tucker, Amer. Beekeeping Federation
- Mark Yelanich, Metrolina Greenhouses, Inc.
- Vickie Wojcik, Pollinator Partnership
- *Ex officio*: Thomas Harty, Tom Moriarty, Tom Steeger, EPA

Pollinator Risk in Environmental Horticulture



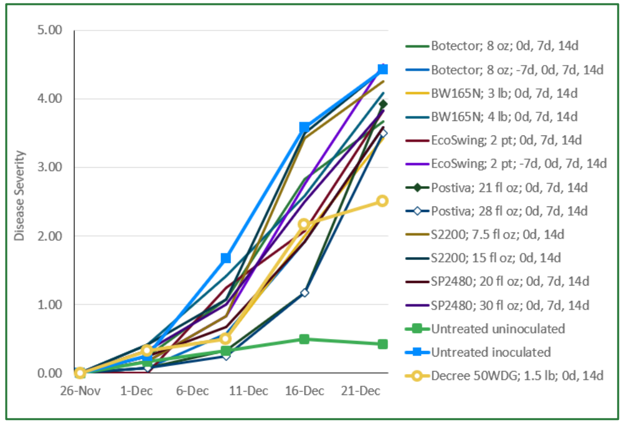
- Through 2015, most regulatory data related to pollinators were generated on large row agriculture
  - concern about seed treatment and dust during application
  - concern about systemic treatments over large acreage
- Sublethal impacts published with high doses in artificial diets
- Highly publicized bumble bee mortalities after misapplications in Oregon landscapes
- Calls for bans of systemic neonicotinoid insecticides

Protecting Pollinators Requires a Multi-prong Approach

- Pollinator Attractiveness of Environmental Horticulture Crops
- Risk Assessment Data Gaps
- Economic, **Efficacy, and Toxicological Comparisons of Alternatives**
- Public Perception of Management Practices & Point-of-Purchase Display Materials
- Development of New BMPs
- Outreach

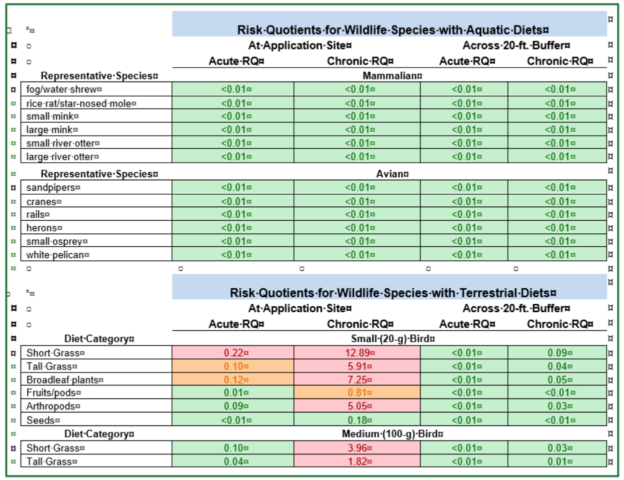
Efficacy & Ecotox. Comparisons

Efficacy Experiments



Product/Active List

Label Rate & Maximum Application Limits

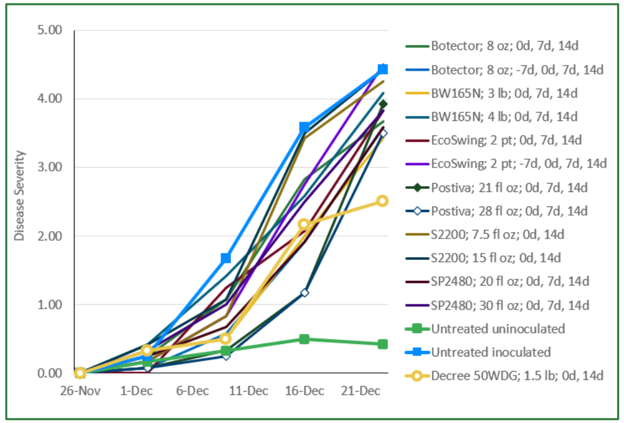


Risk Quotients for Wildlife Species with Aquatic Diets	At Application Site		Across 20-ft. Buffer	
	Acute RQ	Chronic RQ	Acute RQ	Chronic RQ
Representative Species	**Mammalian**			
fog/water shrew	<0.01	<0.01	<0.01	<0.01
rice rat/star-nosed mole	<0.01	<0.01	<0.01	<0.01
small mink	<0.01	<0.01	<0.01	<0.01
large mink	<0.01	<0.01	<0.01	<0.01
small river otter	<0.01	<0.01	<0.01	<0.01
large river otter	<0.01	<0.01	<0.01	<0.01
Representative Species	**Avian**			
sandpipers	<0.01	<0.01	<0.01	<0.01
cranes	<0.01	<0.01	<0.01	<0.01
rails	<0.01	<0.01	<0.01	<0.01
herons	<0.01	<0.01	<0.01	<0.01
small osprey	<0.01	<0.01	<0.01	<0.01
white pelican	<0.01	<0.01	<0.01	<0.01

Risk Quotients for Wildlife Species with Terrestrial Diets	At Application Site		Across 20-ft. Buffer	
	Acute RQ	Chronic RQ	Acute RQ	Chronic RQ
Diet Category	**Small (20-g) Bird**			
Short Grass	0.22	12.89	<0.01	0.09
Tall Grass	0.10	5.91	<0.01	0.04
Broadleaf plants	0.12	7.25	<0.01	0.05
Fruits/pods	0.01	0.81	<0.01	<0.01
Arthropods	0.09	5.05	<0.01	0.03
Seeds	<0.01	0.18	<0.01	<0.01
Diet Category	**Medium (100-g) Bird**			
Short Grass	0.10	3.96	<0.01	0.03
Tall Grass	0.04	1.82	<0.01	0.01

Efficacy & Ecotox. Comparisons

Efficacy Experiments



Target Pests

Aphids
Mites
Fungus Gnats
Thrips
Mealybugs
Whitefly

Efficacy Scale

4 = Excellent Efficacy
3 = Good Efficacy
2 = Fair Efficacy
1 = Not Effective

Process

- Reviewed efficacy experiments
- Assigned treatment outcomes on a scale of 1 to 4
- Entered the range into comparative tables by active ingredient organized by mode of action (IRAC Class)

Contributors

JC Chong, Dan Gilrein, Dave Smitley

Efficacy & Ecotox. Comparisons

Active Ingredient Classes

1A. Carbamates
1B. Organophosphates
3A. Pyrethroids
4A. Neonicotinoids
4B. Butenolides
5. Spinosyns
6. Avermectins
7A. Insect Growth Regulators
9B. Quinazolines
9D. Pyropenes
15. Benzoylureas
16. Buprofezin
21A. METI inhibitors
23. Tetronic & tetramic acid derivatives
28. Diamides
UNE. Unknown plant extracts
UNF. Unknown fungal Agents

Label Information

Use Sites
Maximum rate allowed in one application
Maximum amount of active ingredient allowed per acre per year
Maximum number of applications

Ecotox Risk Quotients (Acute & Chronic)

Wildlife species with aquatic diets
Wildlife species with terrestrial diets
Chronic dietary at application site, across 20 ft buffer

- avian
- mammalian
- soil invertebrates
- honeybees
- aquatic plants

Very Low Risk
Low Risk
Moderate Risk
High Risk
Very High Risk

Risk Quotients for Wildlife Species with Aquatic Diets

	At Application Site		Across 20 ft. Buffer	
	Acute RQ	Chronic RQ	Acute RQ	Chronic RQ
Representative Species	**Mammalian**			
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Ardea Consulting
Matt Havers

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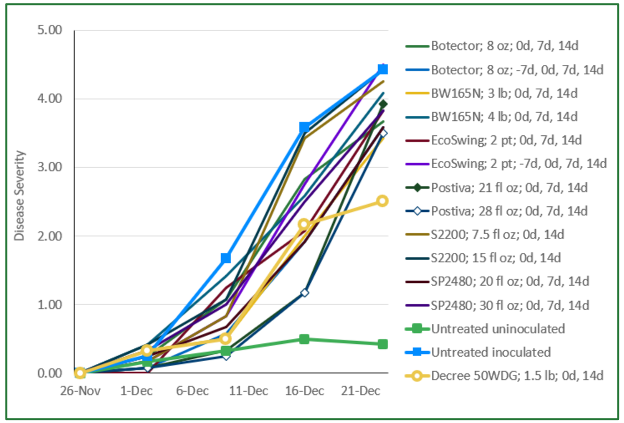

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The IR-4 Project

Comparative Efficacy and Ecotox – Protecting Bees

https://protectingbees.njaes.rutgers.edu/resources/comparative-efficacy-and-ecotox/

Row	IRAC Group No.	Chemical Class	Active Ingredient	Selected Trade Names	Application Type	Use Site	REI (hours)	Ecotox: Aquatic	Ecotox: Avian	Ecotox: Mammals	Ecotox: Bees	Two-Spotted Spider Mite *Tetraychus urticae*	Notes
7	1A	Carbamates	Carbaryl	Sevin SL	Foliar	G, N, L	12h					3	High Risk to Freshwater and Marine Inverts
26	3A	Pyrethroids	Fenpropathrin	Tame 2.4 EC	Foliar	G,N,L,I	24					2.3 (1-4)	Refer to label for additional ecological impacts
28			Esfenvalerate	Scimitar GC/CS	Foliar	G,N,L	24h					4; 1(egg)	Highly toxic to bees exposed to direct treatment or residues on blooming crops
31			Tau- Fluvalinate	Mavrik Aquaflow	Foliar	G,N,L,I	12 h					3.7 (3-4)	Refer to label for ecological impacts
35		Pyrethroid and Pyrethrins	Bifenthrin	Talstar S/Nursery G	Foliar	G,N,L,I	12h					2.5 (1-4)	High Risk to Aquatic Organisms; Highly toxic to bees exposed to direct treatment or residues on blooming crops
69	5	Spinosyns	Spinosad	Conserve SC	Foliar	G, N	4 h					3.3 (1-4)	High Risk to Freshwater Fish and Invertebrates, Bees
72	6	Avermectins	Abamectin	Avid 0.15EC	Foliar	G, I, N, S	4 h					3.6; 3.1 (egg)	High Risk to Aquatic Organisms & Bees with Chronic Exposure
82	10A	Clofentezine	Clofentezine	Novato	Foliar	G,N	12 h					3.5; 3 (egg)	Refer to label for ecological impacts
83			Hexythiazox	Hexygon	Foliar	G,N,L,I	12 h					3.2; 2.7 (egg)	Refer to label for ecological impacts
85	10B	Mite Growth Inhibitor	Etoxazole	TetraSan 5 WDG	Foliar	G,N,L,I	12 h					3.5; 2 (egg)	Refer to label for ecological impacts
89	13	Pyrroles	Chlorfenapyr	Pylon	Foliar	G	12 h					3.8; 4(egg)	Refer to label for ecological impacts
95	20B	Acequinocyl	Acequinocyl	Shuttle 0/15SC	Foliar	G,N,L,I	12					4; 3.5 (egg)	Refer to label for ecological impacts
96	20D	Bifenazate	Bifenazate	Floramite	Foliar	G,N,L,I	12 h					3.8; 4 (egg)	Refer to label for ecological impacts
100	21A	METI acaricides and insecticides	Pyridaben	Sanmite	Foliar	G.N	12 h					3.8	Refer to label for ecological impacts
101		Mitochondrial complex I	Fenazaquin	Magus	Foliar	G,N,L,I	12 h					3.8; 4 (egg)	Very High Risk to Honeybees from Direct Exposure
102			Fenpyroximate	Akari 5SC	Foliar	G, N, I	12 h					3; 4 (egg)	High Risk to Freshwater Invertebrates with Chronic Exposure
106	23	Tetronic and tetramic acid derivatives	Spiromesifen	Forbid 4F	Foliar	L						3.4; 4 (egg)	
107				Judo 2SC, Savate	Foliar	G,N	12 h					3; 4 (egg)	
108	25	Beta-ketonitrile	Cyflumetofen	Sultan	Foliar	G,N,L,I	12 h					3.2; 3.3 (egg)	Refer to label for ecological impacts
131	Unknown (UN)	Tetranortriterpenoid	Azadirachtin	Azatrol	Foliar	G,N,L,I	4 h					3.3; 3 (egg)	
136		Botanical Essence	Neem Oil	Triact	Foliar	G, N, L, I	4 h					2.5 (2-3)	Refer to label for additional ecological impacts
142	MISC	Miscellaneous	Mineral, Paraffin, or Petroleum Oil	Ultra-Pure Oil	Foliar	G, N, L, I	4 h					2.1; 1 (egg)	Refer to label for ecological impacts
146	FRAC 33	Horticulture Soap	Potassium salts of fatty acids	M-Pede	Foliar	G,N,L	12 h					2.5; 3.7 (egg)	High Risk to Aquatic Invertebrates

	A	B	C	D	E	F	G	H	I	J	K	L
1												
2	IRAC Group No.	Chemical Class	Active Ingredient	Selected Trade Names	Application Type	Use Site	REI (hours)	Ecotox				Two-Spotted Spider Mite
3								Aquatic	Avian	Mammals	Bees	*Tetraychus urticae*
7	1A	Carbamates	Carbaryl	Sevin SL	Foliar	G, N, L	12h					3
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83			Hexythiazox	Hexygon	Foliar	G,N,L,I	12 h					3.2; 2.7 (egg)
85	10B	Mite Growth Inhibitor	Etoxazole	TetraSan 5 WDG	Foliar	G,N,L,I	12 h					3.5; 2 (egg)
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89	13	Pyrroles	Chlorfenapyr	Pylon	Refer to label for ecological impacts
95	20B	Acequinocyl	Acequinocyl	Shuttle 0/15SC	Refer to label for ecological impacts
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Comparisons Take aways

- New tool now available pulling together efficacy and ecotoxological comparisons for commonly used insecticides and miticides across multiple mode of action classes
- Every active ingredient appears to have some impact on non-target organisms, even environmentally friendly and pollinator friendly ones
- Consider growing situation and whether potential impact outweighs pest management benefits

Protecting Pollinators Requires a Multi-prong Approach

- Pollinator Attractiveness of Environmental Horticulture Crops
- **Risk Assessment Data Gaps**
- Economic, Efficacy, and Toxicological Comparisons of Alternatives
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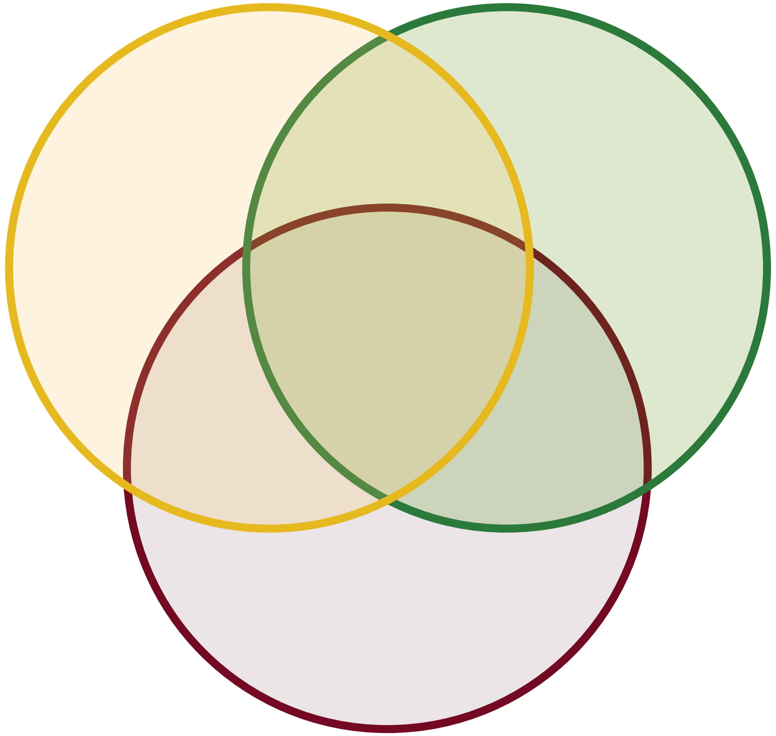
Systemic insecticides and pollinator risk

Pollinator

What and how much do insect (bee) pollinators eat?

What are pollinator foraging patterns?

Are they social or solitary?



Plant

Are plants good forage materials for insect (bee) pollinators?

How many are available in the landscape?

Are plants treated to manage pest insects?

Insecticide

How impactful is the active to pollinator health?

When are applications needed to manage pests, protect pollinators?

How much is needed?

Systemic insecticides and pollinator risk

Pollinator

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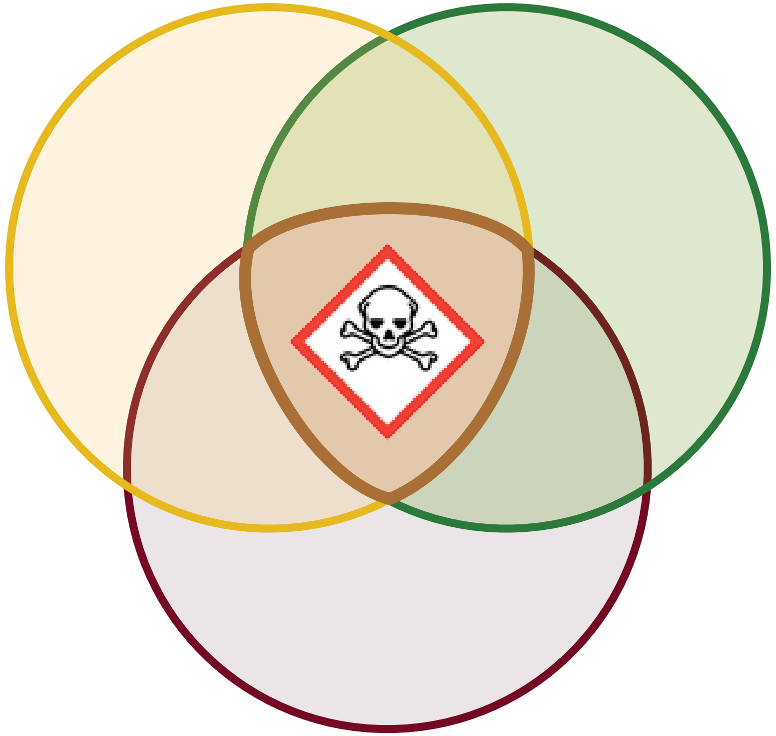

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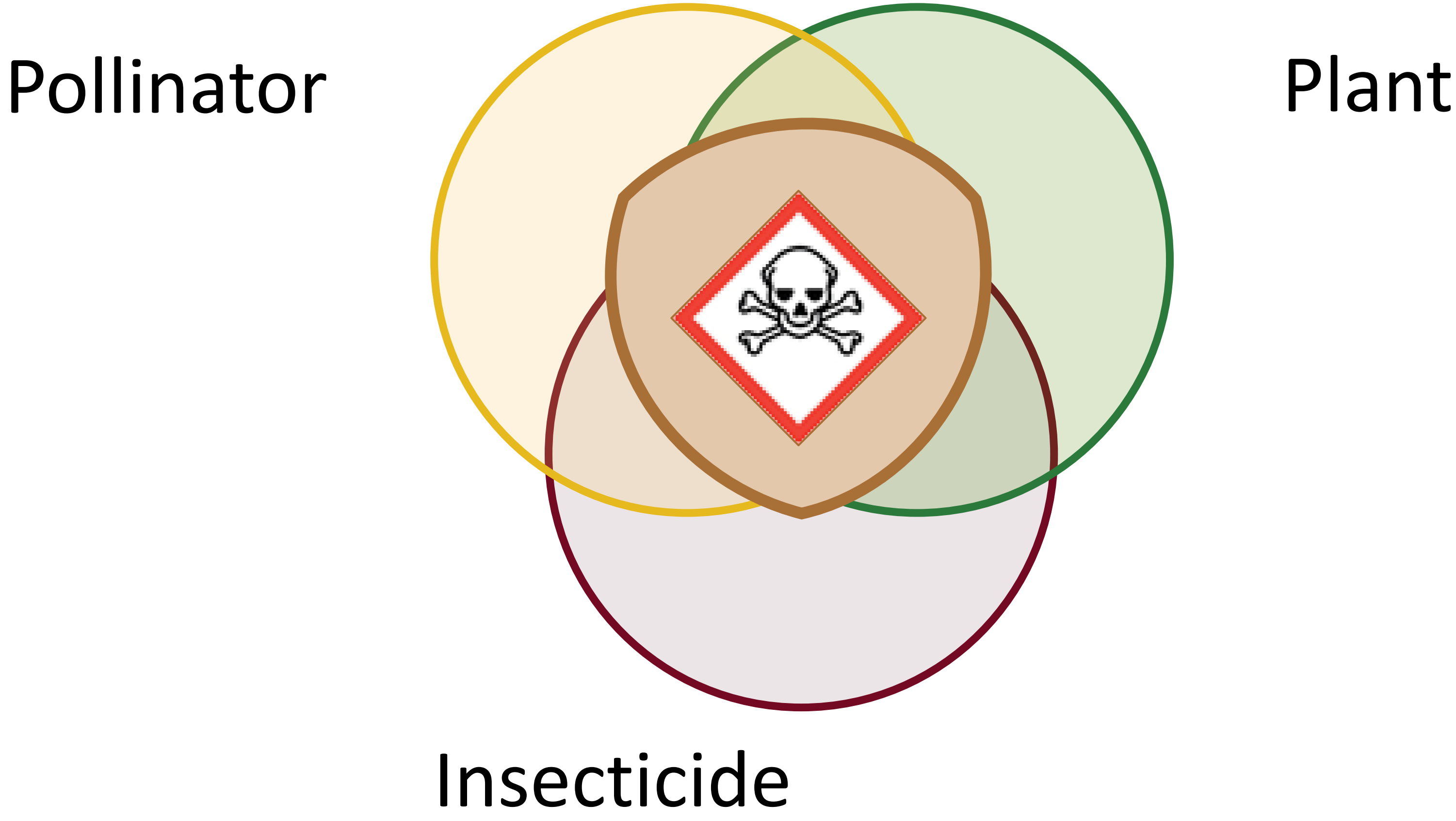
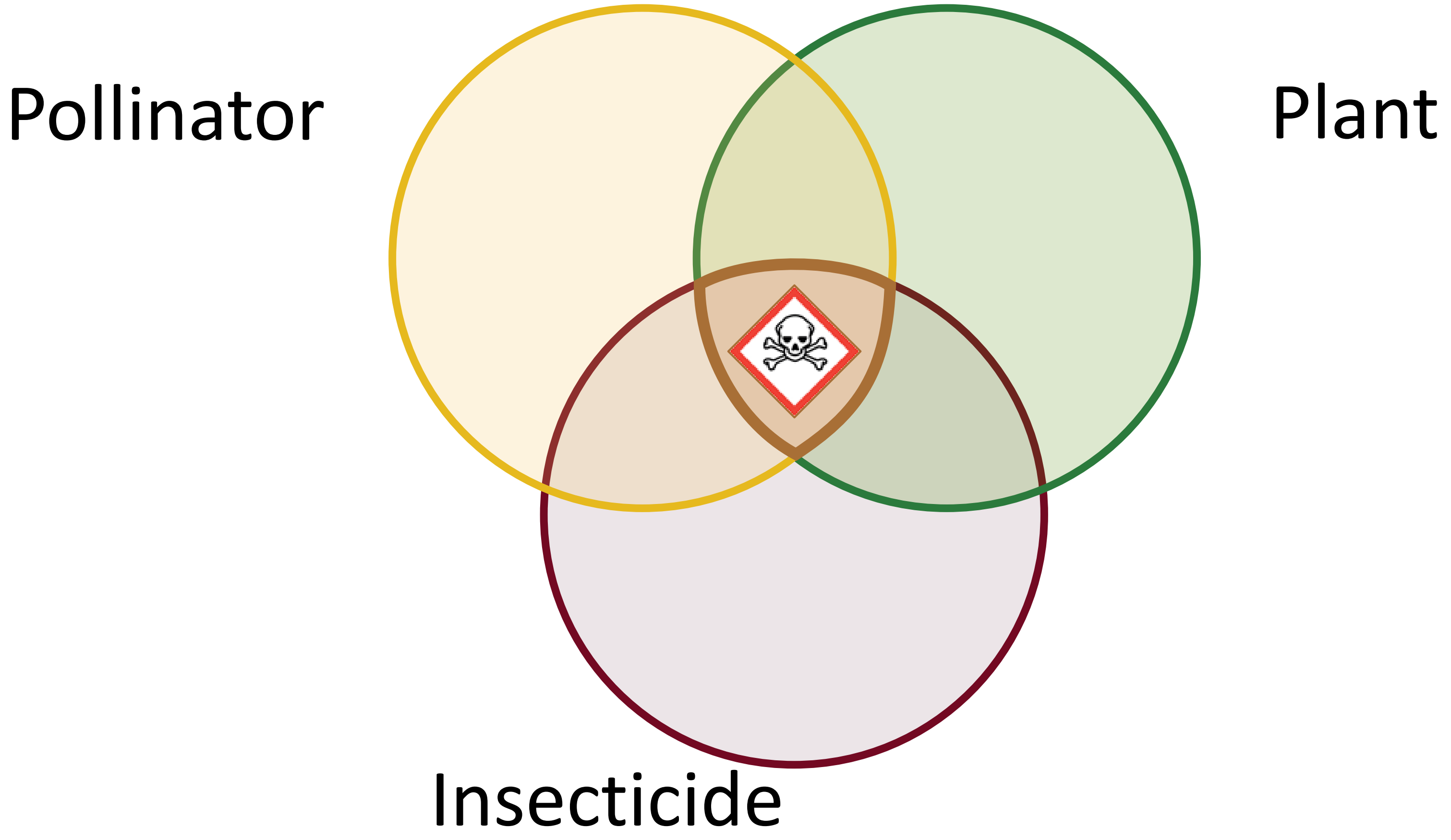
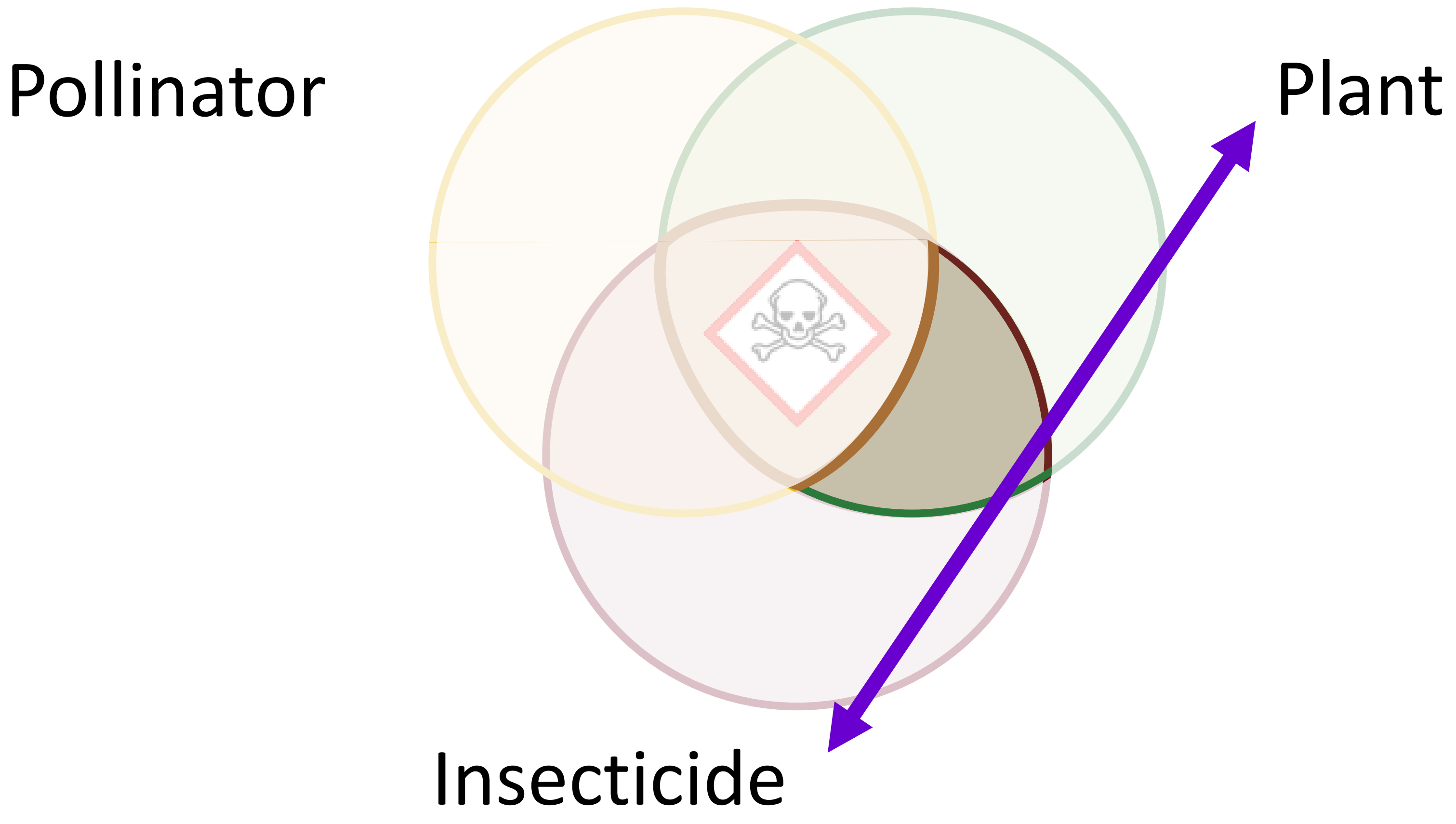
Systemic insecticides and pollinator risk



Systemic insecticides and pollinator risk



Systemic insecticides and pollinator risk



When can applications of systemic insecticides be applied for pest management and still protect pollinators??

Residue Analysis: Planned Model Crops

Plant Type	Pollen	Nectar
Annual	Sunflower 'Taiyo' (*Helianthus sp.*)	Annual salvia (*Salvia splendens*) Snapdragon (*Antirrhinum majus*)
~~**Herbaceous Perennial**~~	~~Dahlia 'Bishop' series (*Dahlia sp.*)~~	*Red Hot Poker (Kniphofia uvaria)* Salvia 'Black & Blue'
Woody Perennial	Rhododendron PJM or *R. catawbiense boursault*	Rhododendron PJM or *R. catawbiense boursault*

Systemic Insecticide Application Rates

Product (active ingredient)	Application Methodology	Rates (according to label with exception of those highlighted to provide a minimum of ½ x for a rate range)	
		Product 1	Product 2
Marathon (imidacloprid) + Altus (flupyradifurone)	Foliar	0.85 fl oz per 100 gal	7 fl oz per 100 gal
		1.7 fl oz per 100 gal	14 fl oz per 100 gal
	Drench	0.85 fl oz per number of pots in sufficient volume to wet pot without loss of liquid **	14 fl oz per acre **
		1.7 per number of pots in sufficient volume to wet pot without loss of liquid **	28 fl oz per acre **
Safari (dinotefuran)	Foliar	4 oz per 100 gal	n/a
		8 oz per 100 gal	
	Drench	12 oz per acre **	
		24 oz per acre **	
Flagship (thiamethoxam) + Mainspring (cyantraniliprole)	Foliar	2 oz per 100 gal water	1 fl oz per 100 gal water
		8.5 oz per 100 gal water	16 fl oz per 100 gal water
	Drench	4 oz per 100 gal water**	6 fl oz per 100 gal water**
		8.5 oz per 100 gal water**	12 fl oz per 100 gal water**

NJ2018 Snapdragon. C. Palmer

CA2019 Snapdragon. L. Corkidi

Snapdragon
Systemic Insecticide
Residue Experiments

Snapdragon Methodology Differences

	CA2019	NJ2018	NJ2019
Cultivar/Pot Size	Sonnet White in 4" Deepots	Sonnet Yellow in 1.5 gal pots	Sonnet Yellow in 1.5 gal pots
Application Timing	Applied sprays or drenches when flower buds had developed on majority of plants		
Volume per Nominal Gal of Soil	4 fl oz	4 fl oz	4 fl oz
Collection Timing	2, 4, 6, 8 weeks after treatment	2, 6, 10 weeks after treatment	
Collection Methodology	Harvest flowers and collected nectar in the lab	Pipette nectar from flowers with multiple collections over time	
Range of Volume Collected	0.1 to 0.5 ml	0.6 to 1 ml	0.4 to 0.5 ml

NJ2018 Snapdragon. C. Palmer

CA2019 Collected Nectar. L. Corkidi

Annual Salvia & Snapdragon Outcomes: Brix %

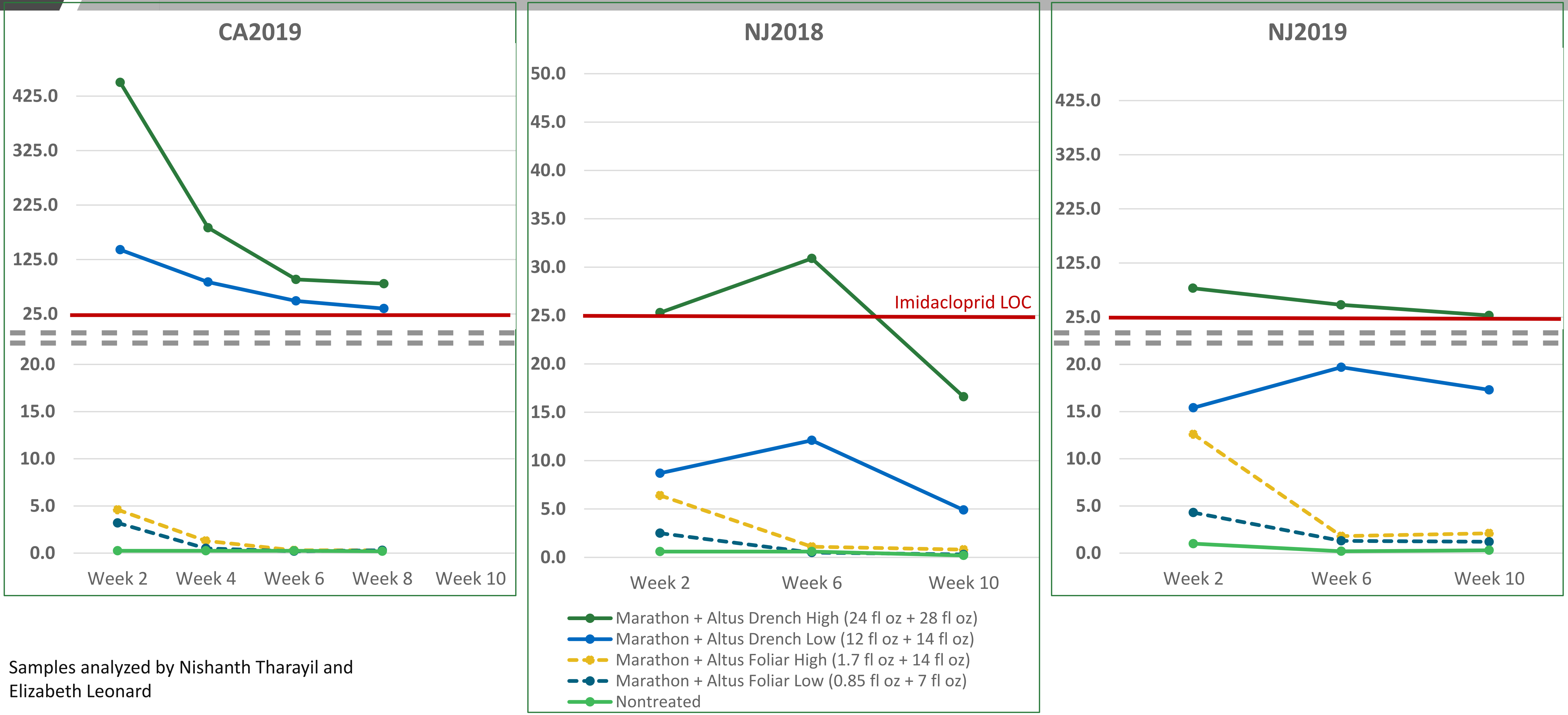
- Percent brix is a measure of how much sugar is in nectar and can vary depending on time of day, relative humidity, and plant turgor from irrigation
- Five annuals experiments with different Brix% averages in each

Crop	Experiment	Brix%
Snapdragon	CA2019	42.9
Snapdragon	NJ2018	21.5
Snapdragon	NJ2019	32.6
Annual Salvia	CA2019	13.0
Annual Salvia	SC2017	20.3

- Normalized ppb to average brix within each experiment

Imidacloprid + Olefin (ppb) Residues in Snapdragon Nectar

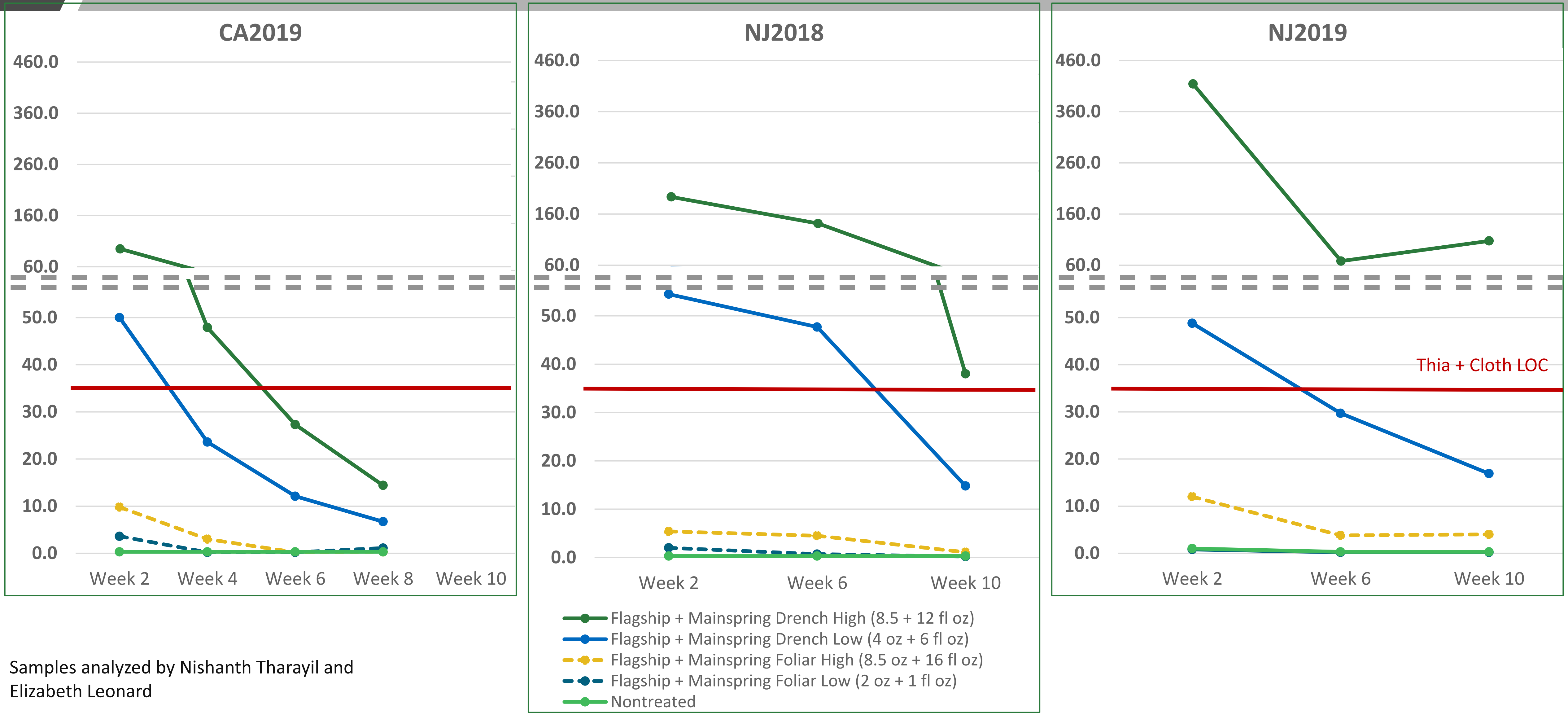
– adjusted to average brix in experiment and using half LOQ where residues had been detected in at least one rep



Samples analyzed by Nishanth Tharayil and Elizabeth Leonard

Thiamethoxam + Clothianadin (ppb) Residues in Snapdragon Nectar

– adjusted to average brix in experiment and using half LOQ where residues had been detected in at least one rep



Samples analyzed by Nishanth Tharayil and Elizabeth Leonard

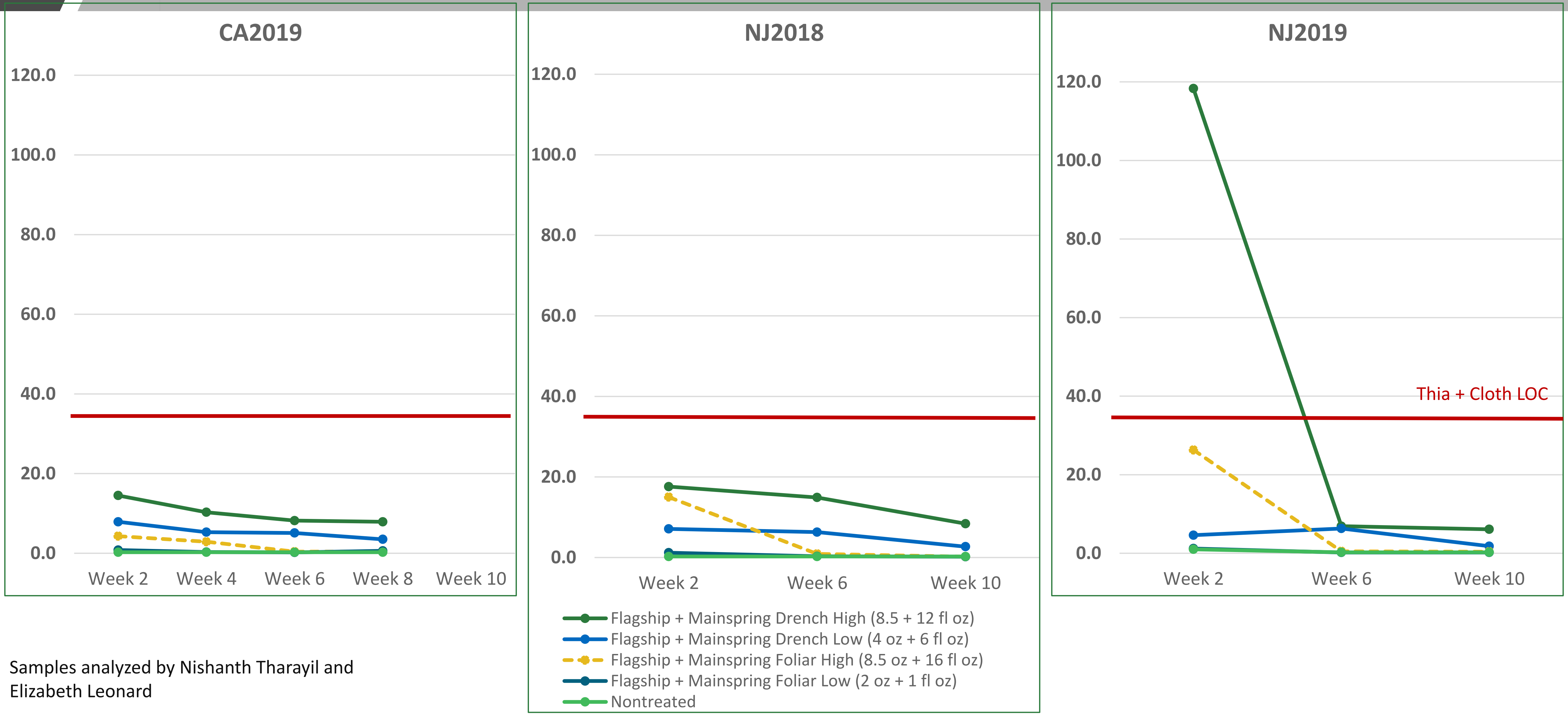
Dinotefuran (ppb) Residues in Snapdragon Nectar

– adjusted to average brix in experiment and using half LOQ where residues had been detected in at least one rep

Samples analyzed by Nishanth Tharayil and Elizabeth Leonard

Cyantraniliprole (ppb) Residues in Snapdragon Nectar

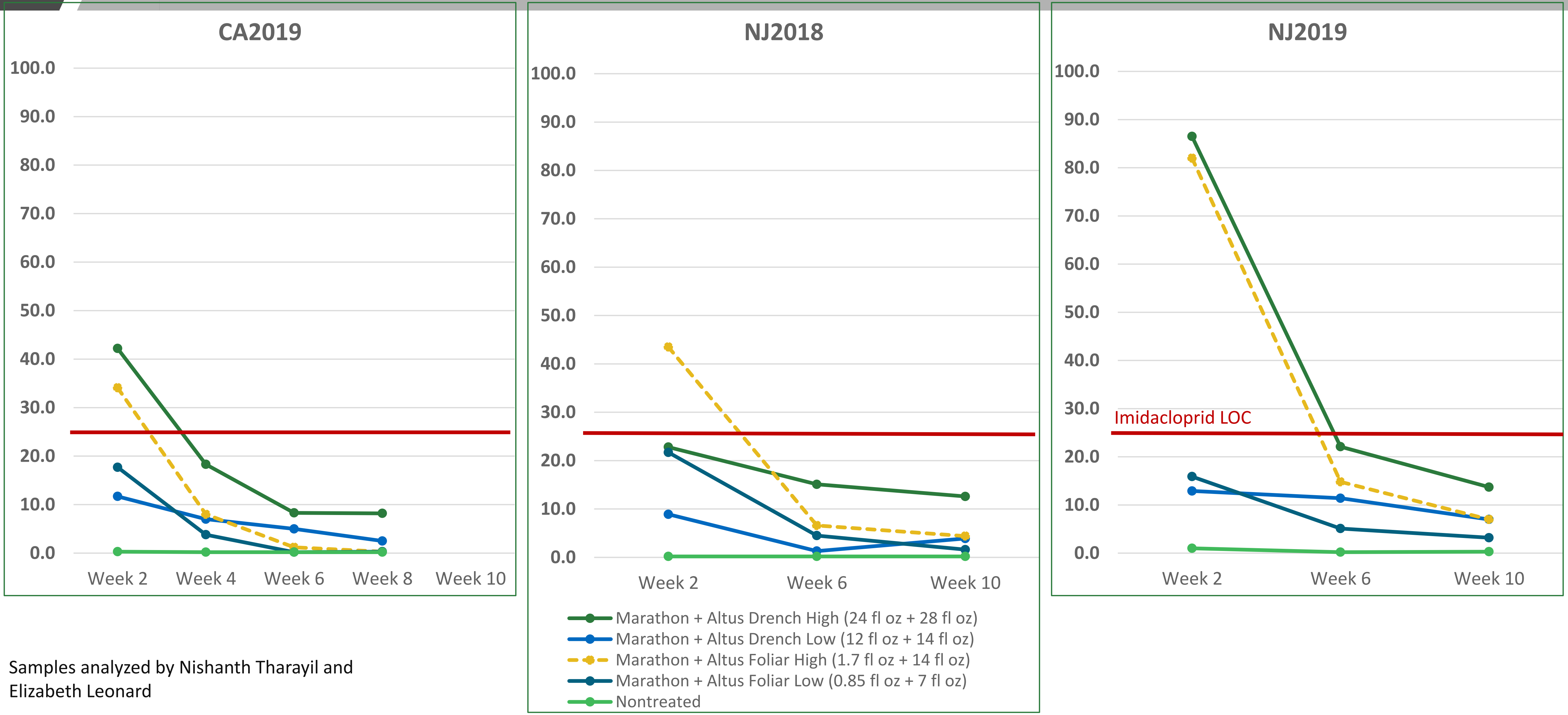
– adjusted to average brix in experiment and using half LOQ where residues had been detected in at least one rep



Samples analyzed by Nishanth Tharayil and Elizabeth Leonard

Flupyradifurone (ppb) Residues in Snapdragon Nectar

– adjusted to average brix in experiment and using half LOQ where residues had been detected in at least one rep

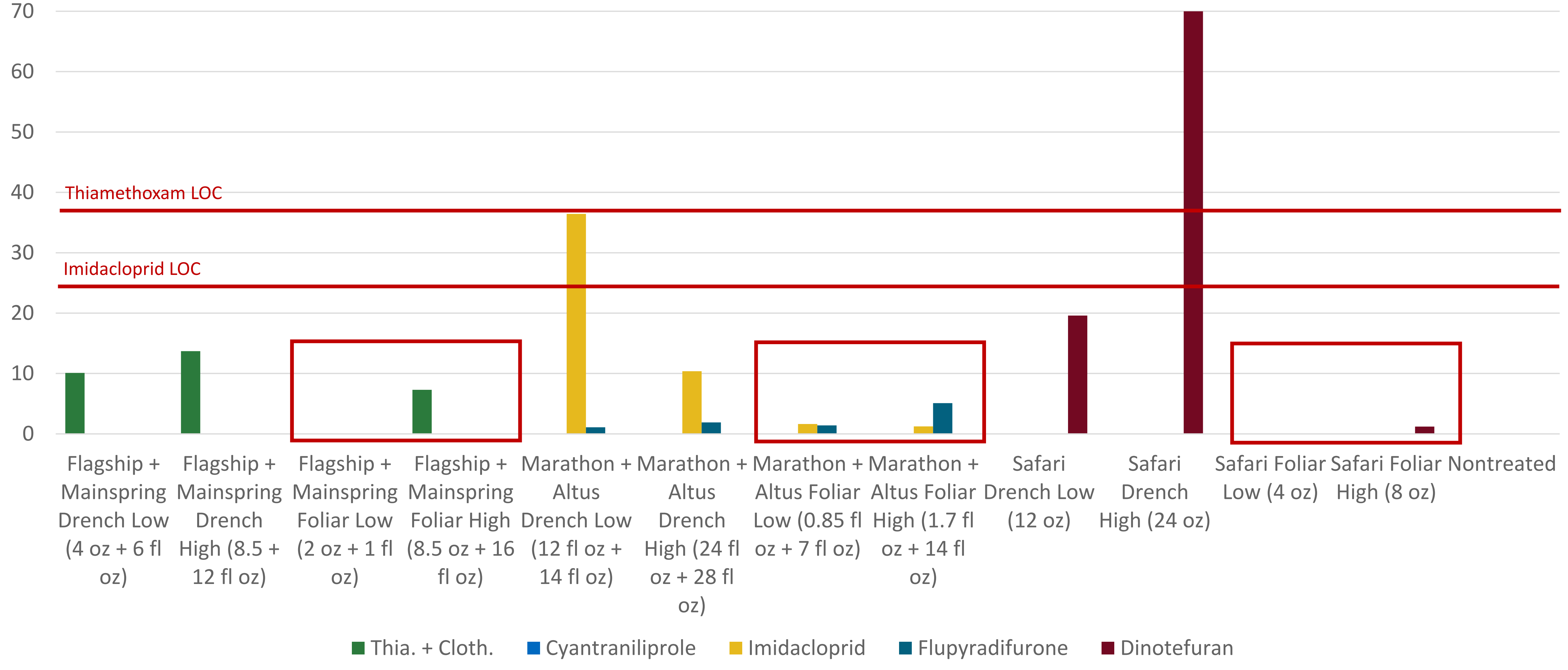


Samples analyzed by Nishanth Tharayil and Elizabeth Leonard

2018 Perennial Salvia Fall Treatment/Collections

- Salvia potted in 2.5 gal pots
- Baseline collections in Aug 2018
- Treatments in early Sept 2018
  - Drench treatments were 10 fl oz solution per pot
- First collections in early Oct 2018 for fall drenched plants
  - Team: Amy Abate, Dave Bodine, Tom Freiberger, Cristi Palmer, Carolina Roe-Raymond

2018 Perennial Salvia Fall Collection Nectar Residues (ppb) *– using half LOQ where residues had been detected in at least one rep*

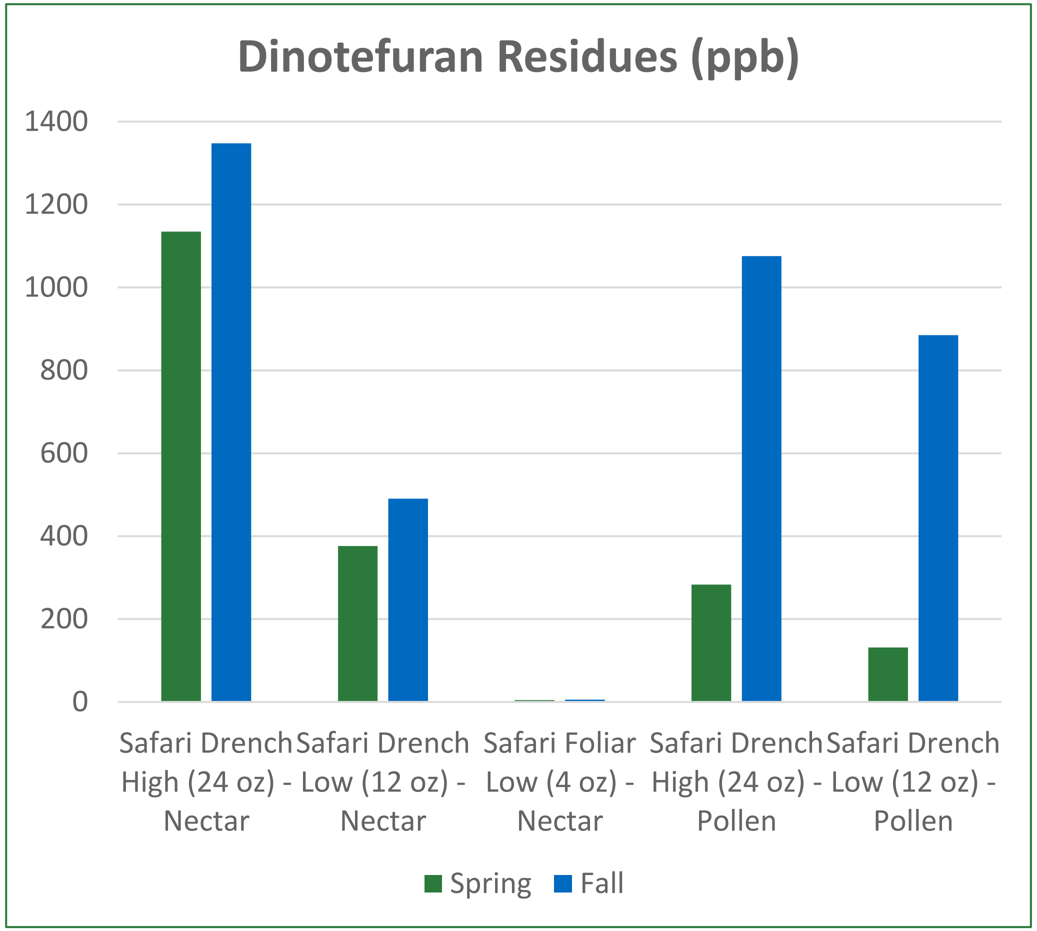


2017/2018 Rhododendron Pollen/Nectar Collections

- Very few flowers so we pooled baseline collections.
- Out of baseline 12 nectar samples, only two were above LOQ: dinotefuran at 1.2 and 1.7 ppb
- In the 3 baseline pollen samples, no actives were above LOQ
- 10 gal pots drenched with 40 fl oz solution per pot

2017/2018 Rhododendron Pollen/Nectar Collections

- Rhododendron plot infected with *Phytophthora sp.* and plants started dying
- Collected from available plants in single rep
  - Weather was a factor
- Restarted in 2019 … with some changes



Note: single rep collected from spring and fall plants
Spring collections were ~11 months after treatment
Fall collections were ~8 months after treatment

- Collection Teams for 2017 & 2018: Amy Abate, Dave Bodine, Tom Freiberger, Yu-Han Lan, Cristi Palmer, Carolina Roe-Raymond

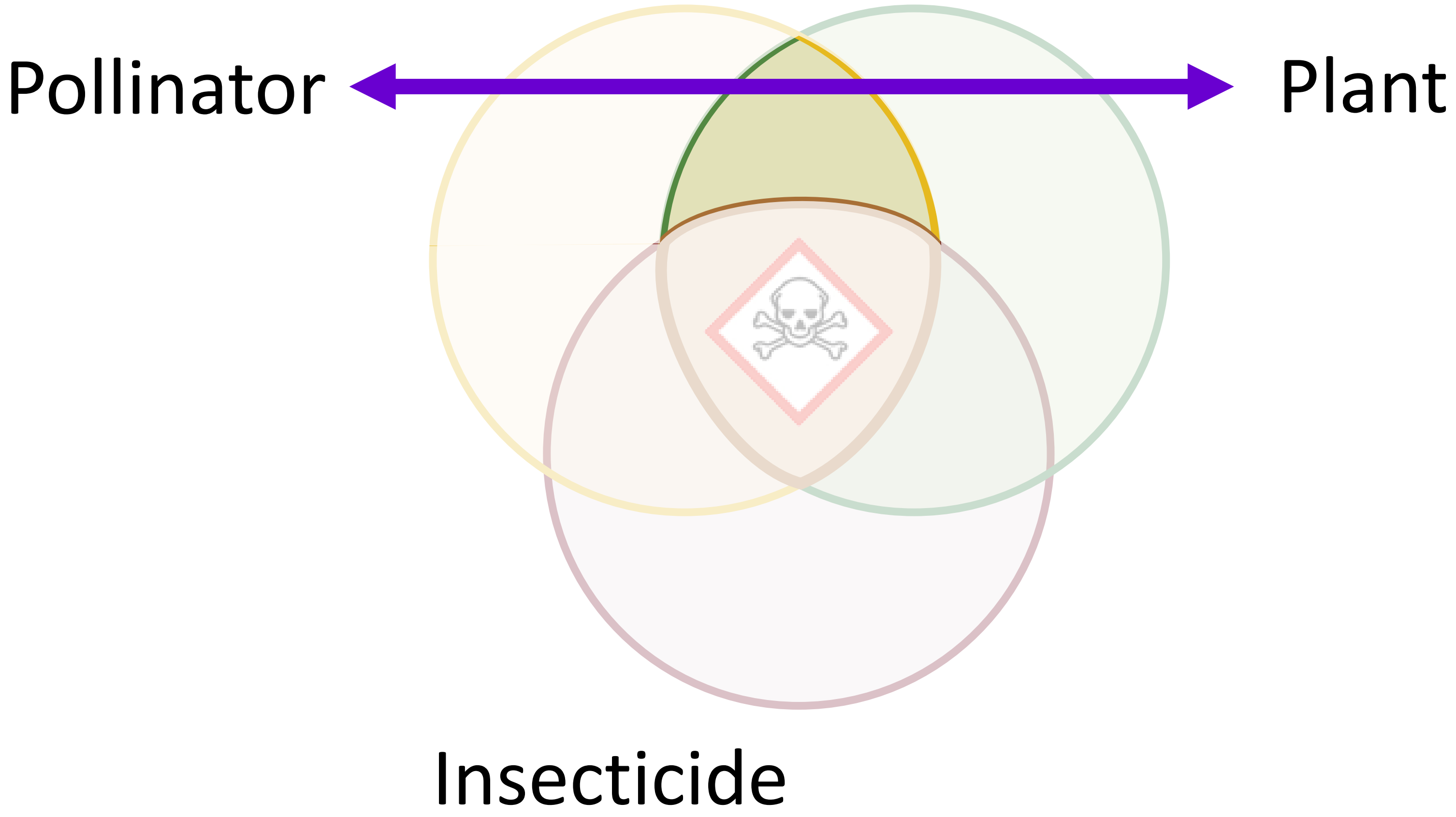
Residue Analysis Take aways

- Foliar applications of neonicotinoids to snapdragon were less than EPA levels of concern even as early as 2 weeks after application
- Drench applications of neonicotinoids may exceed EPA levels of concern
- Annual Salvia tends to have higher neonicotinoid residues with drench applications than Snapdragon
- Some unusually high residues observed in some experiments but not others
  - Foliar residues of dinotefuran in SC2017 annual Salvia consistent with drench applications
- Cyclaniliprole and flupyradifurone residues when detected are lower than the EPA level of concern for imidacloprid (25 ppb)

Protecting Pollinators Requires a Multi-prong Approach

- **Pollinator Attractiveness of Environmental Horticulture Crops**
- Risk Assessment Data Gaps
- Economic, Efficacy, and Toxicological Comparisons of Alternatives
- Public Perception of Management Practices & Point-of-Purchase Display Materials
- Development of New BMPs
- Outreach

Systemic insecticides and pollinator risk



How many environmental horticulture plants are forage for pollinators?

Pollinator Visitation

Scientists in six locations throughout the United States are studying the top 20 to 25 annuals and perennials grown in the US. They are counting the number of each pollinator group visiting of 3 to 5 cultivars of each plant species.

Researchers: Drs. Jim Bethke, Christine Casey, JC Chong, Christina Grozinger*, Harland Patch*, Dan Potter, Dave Smitley, Kim Stoner*

States: CA, CT, KY, MI, PA, SC

2017 MSU Pollinator Attractiveness Plots for Annuals.

2016 PSU Pollinator Attractiveness Plots for Annuals. Photo by Nick Sloff.

USDA NASS Census of Horticulture 2014: Top Crops by Units Sold

Top 25 Annual & Seasonal Potted Crops

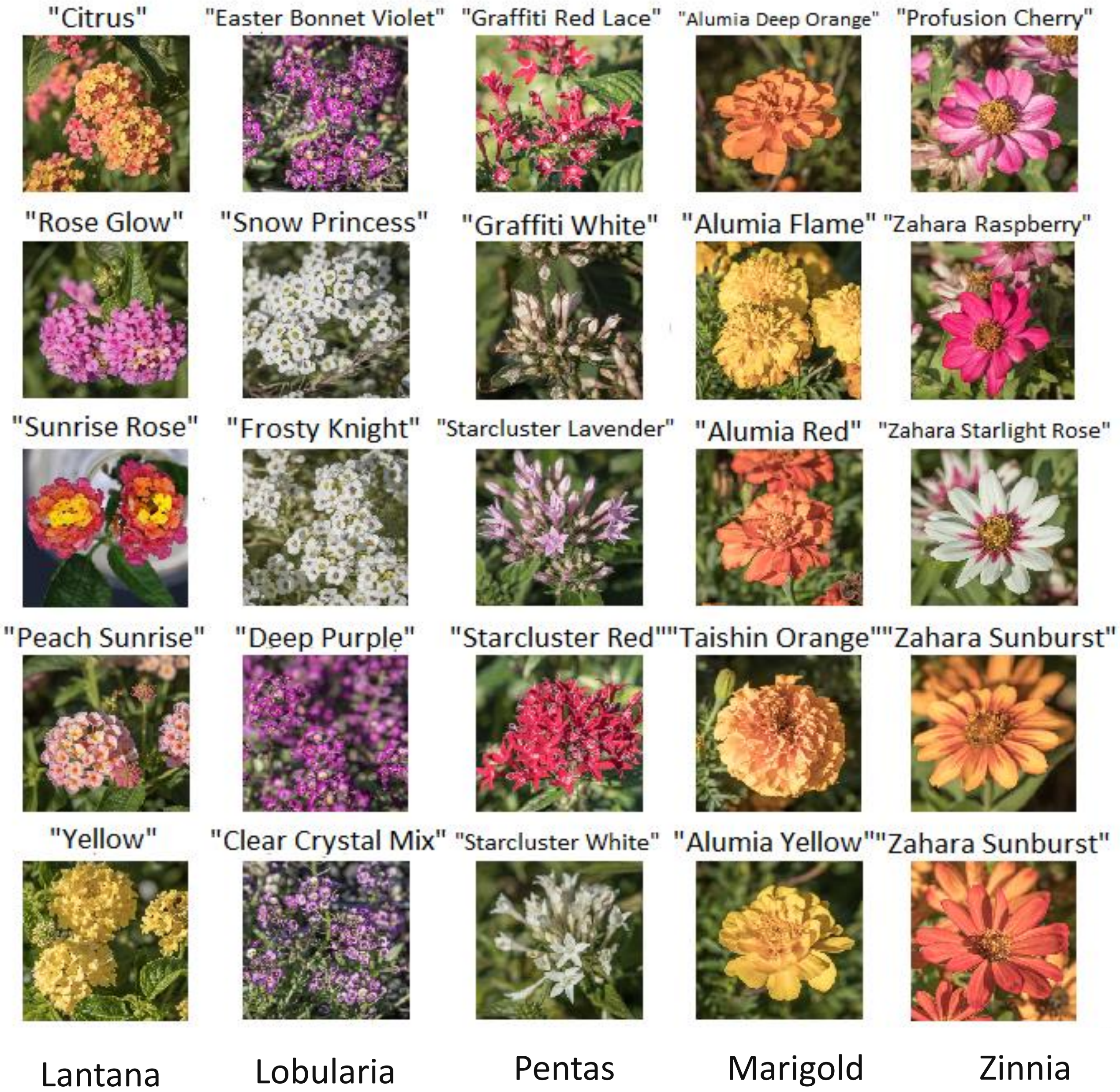
1. **Pelargonium**
2. **Viola (Pansy)**
3. **Petunia**
4. *Euphorbia (poinsettia)*
5. **Begonia**
6. **Impatiens**
7. **Tagetes**
8. *Phalaenopsis*
9. *Chrysanthemum / Dendranthema*
10. **Catharanthus**
11. *Lilium*
12. *Rosa (miniature roses in pots)*
13. Gerbera
14. Kalanchoe
15. **Calibrachoa**
16. *Hibiscus*
17. **Solenostemon (Coleus)**
18. *Caladium*
19. *Tulipa*
20. *Rhododendron (greenhouse pots of azalea)*
21. *Hydrangea*
22. *Saintpaulia*
23. Cyclamen
24. **Zinnia**
25. **Salvia**

26. Pentas, 27. Verbena, 28. Dahlia, 29. Antirrhinum, 34. Celosia, 35. Portulaca, 37. Lobularia

Top 25 Herbaceous Perennial Crops

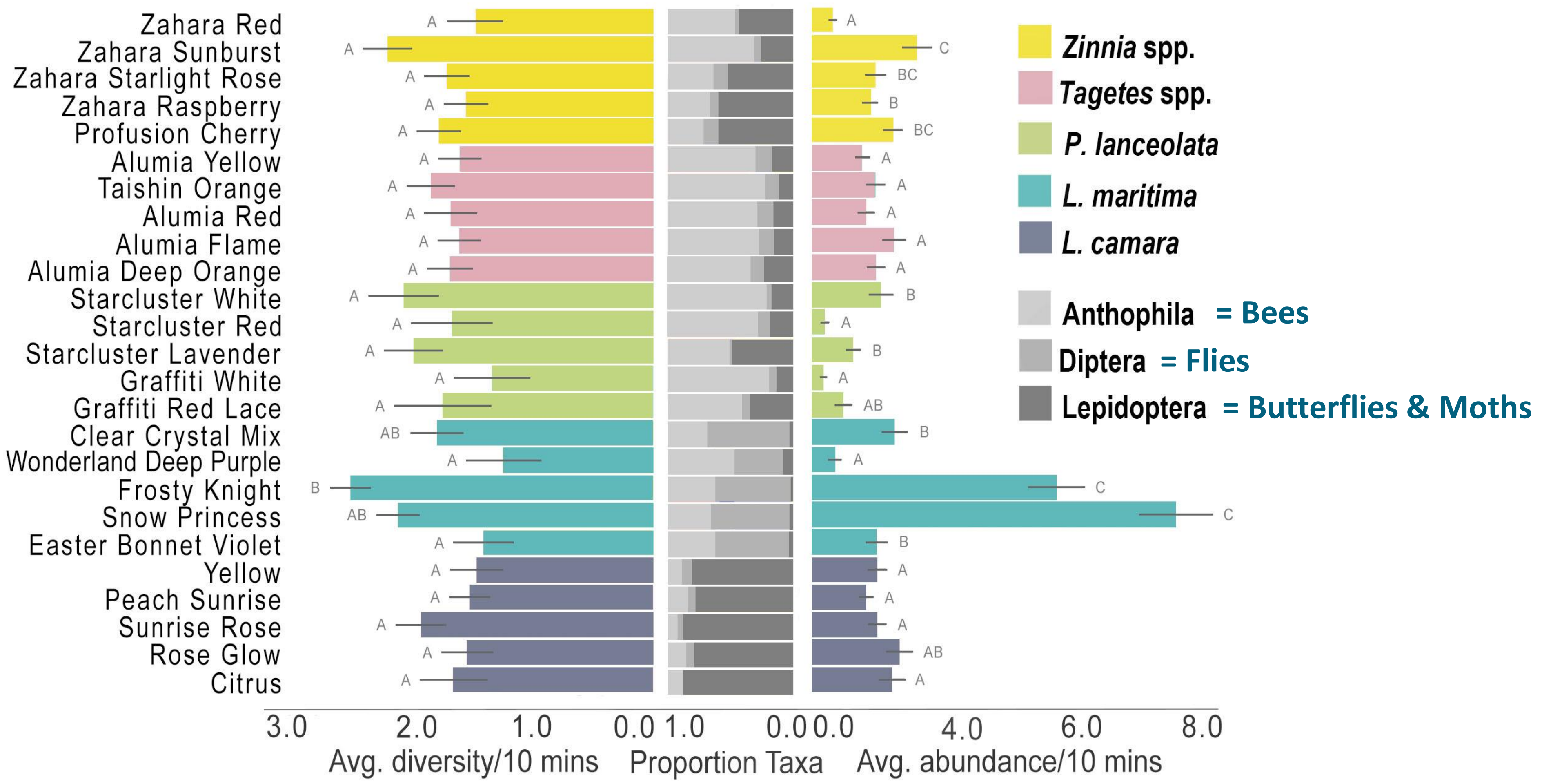
1. **Chrysanthemum/ Dendranthema**
2. Hosta
3. **Hemerocallis**
4. **Sedum**
5. **Dianthus**
6. **Salvia**
7. **Phlox**
8. **Coreopsis**
9. **Lavandula**
10. **Echinacea**
11. **Heuchera**
12. **Rudbeckia**
13. Leucanthemum
14. **Astilbe**
15. Delphinium
16. Gaillardia
17. Aquilegia
18. **Veronica**
19. **Iris**
20. **Paeonia**
21. **Penstemon**
22. Digitalis
23. **Perovskia**
24. **Hibiscus**
25. **Achillea**

The IR-4 Project



Photos by Nick Sloff

Visitor Abundance and Diversity

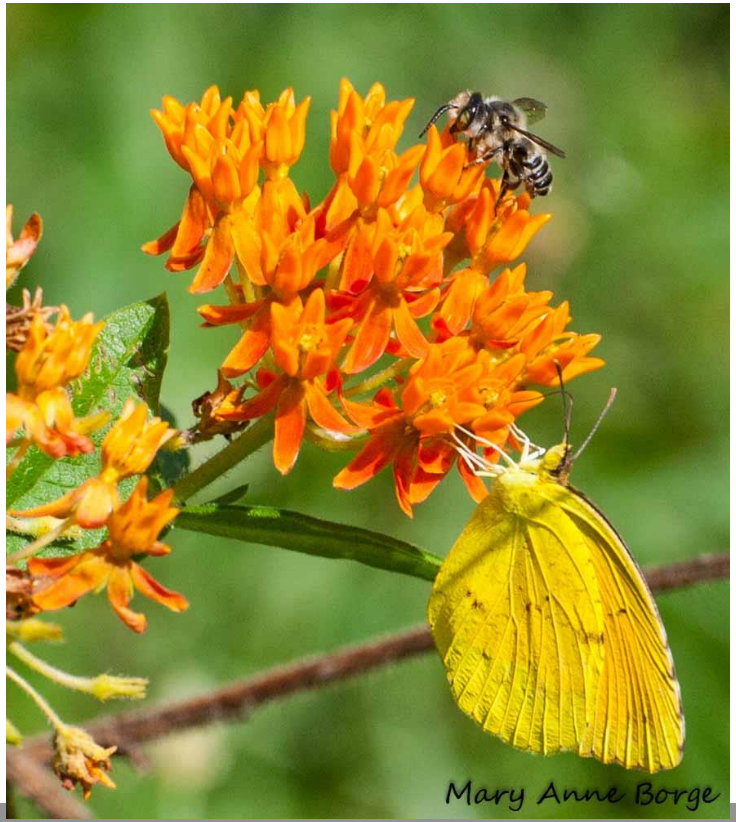


What we learned

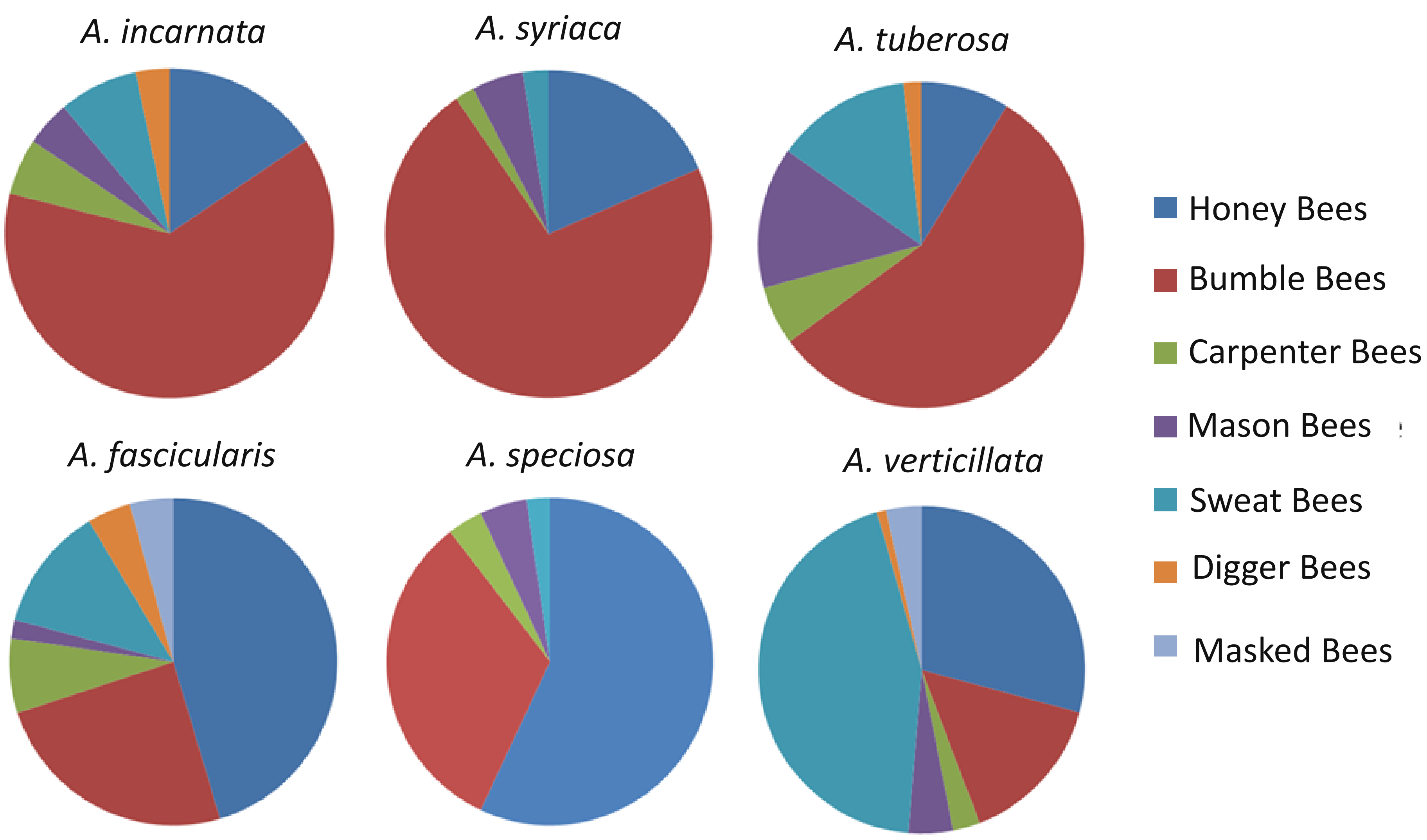
- For some genera there is notable variation in the attractiveness of cultivars that likely corresponds to floral traits
- The attractiveness of the plants in this study vary based on time and space
- Some annual ornamental plants attract a range of all generalist pollinator species

Milkweed – it's not just for monarchs!

The ideal conservation garden supports other pollinators, too!



Bees Use Milkweed!



Best milkweeds for wide variety of bees

Butterfly weed
(*Asclepias tuberosa*)

Whorled milkweed
(*Aclepias verticillata*)

Location of Woody Plant Study

- Urban areas in central Kentucky & southern Ohio, 373 sites

Street trees

Municipal and institutional landscapes

Cemeteries

Arboreta

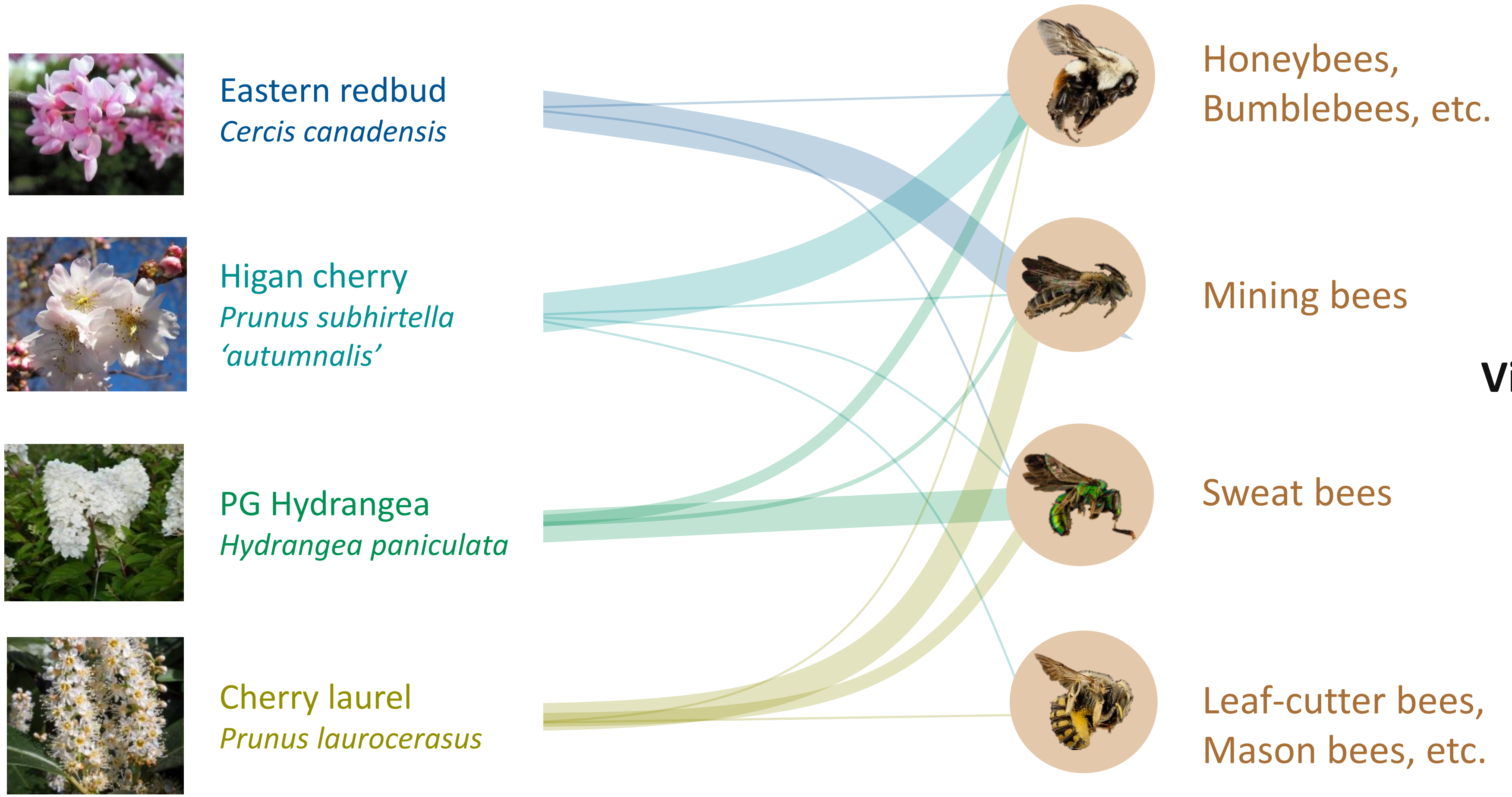
Home landscapes

Observed Trees and Shrubs

- 72 woody plant species, 5 separate sample sites for each

Different woody plants have different number and species of bees

Woody Plants



Number and Types of Bee Visitors Recorded

Flower Form Matters

Prairie rose

Hydrangea paniculata

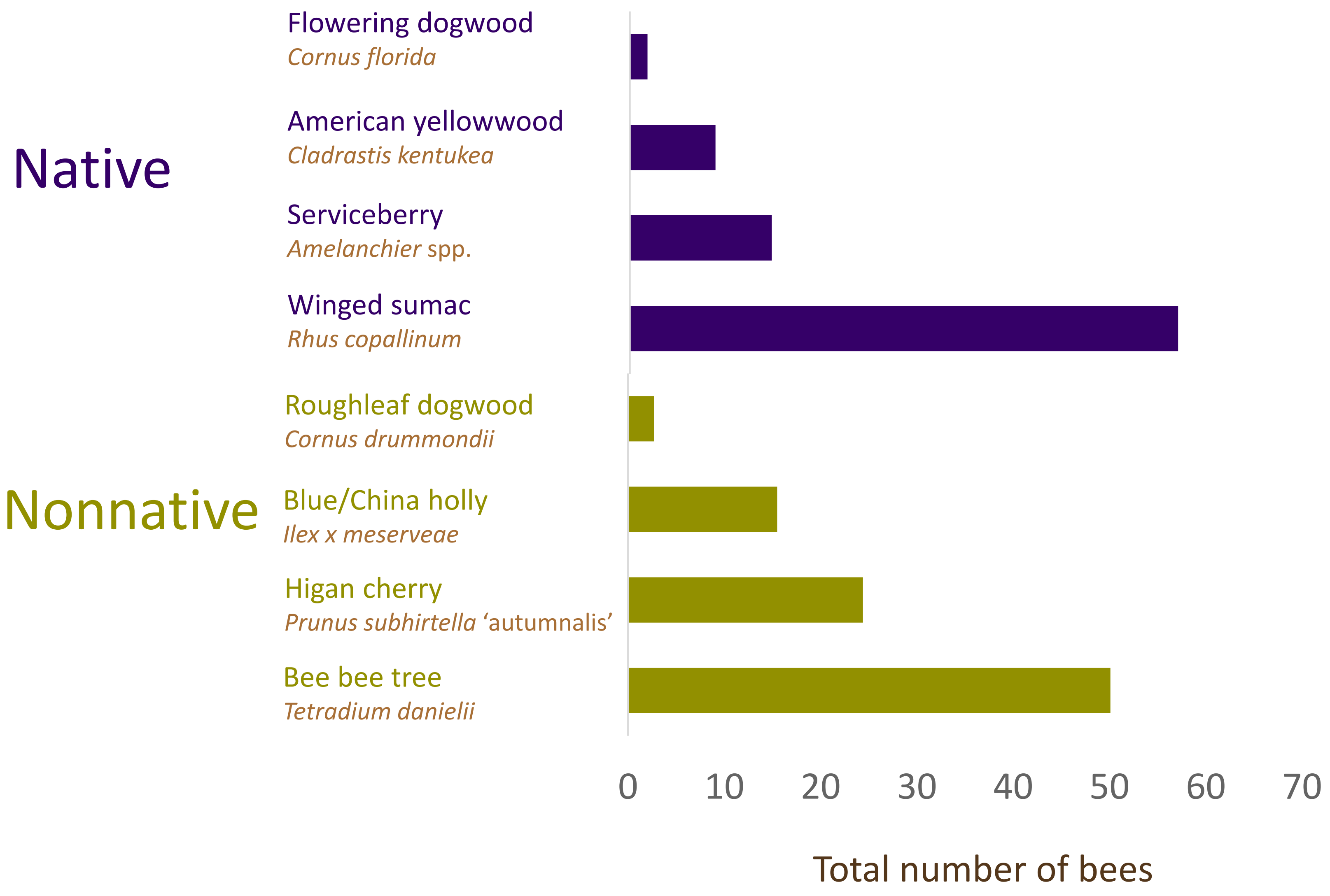
Good!

Hybrid tea rose

Hydrangea arborescens

Pretty useless

Both native and non-native woody plants can attract low or high numbers of bees



Slide courtesy of Dr. Dan Potter, University of Kentucky

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Both native and non-native woody plants can attract diverse bee communities

Native

Eastern redbud

Devil's walking stick

Bottlebrush buckeye

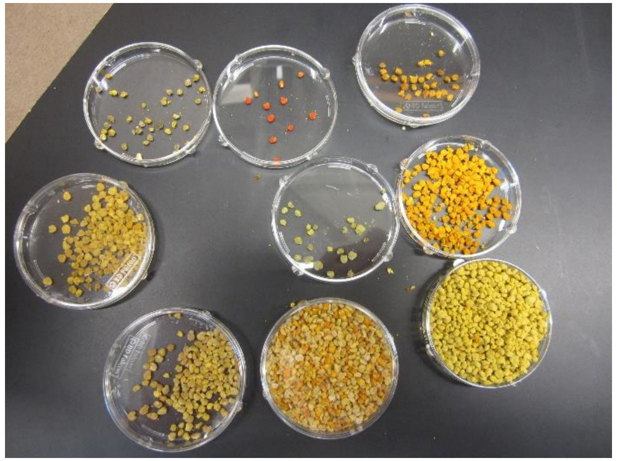
Non-native

Seven-Son flower

Chaste tree

Cornus mas

Pollen Collection & Analysis



2017 CT Pollen Collection. Photos by Alejandro Chiriboga

In Connecticut, honey bee hives were placed in three commercial plant nurseries and pollen was collected through the season from May to September.

The pollen was tested for pesticides, and the samples with the highest pesticide toxicity to honey bees were sorted by color and each color was tested again for pesticides.

The pollen is now being identified to identify 1) what ornamental plants honey bees use as pollen sources 2) what ornamental plants contribute the most pesticide residue to honey bees through their pollen.

Researchers: Dr. Kim Stoner*, Brian Eitzer, Rich Cowles

States: CT

Pollinator Visitation – Data Review

- 43 published manuscripts
- 4 years of non-published field plot data from research team
- Average pollinator visitation rating is based on applying a scale of high (3), moderate (2), low (1), or virtually no (0) visitors

Rating	Numerical	Number Visitors per 10 Minutes
High	3	10 or more pollinators
Moderate	2	3 to 10 pollinators
Low	1	1 to 3 pollinators
Virtually None	0	Less than 1 pollinators

- A relative scale was employed for identification of pollen collected by bumble bees, honeybees, and mason bees.

Comparing Plants Sold with Attractiveness Ratings

Pollinator Attractiveness Ratings for Crops

Numerical Rating	Description	# Bees per 10 Minutes
0	Not or virtually not attractive	< 1
1	Minimally attractive	1 < 3
2	Moderately attractive	3 < 10
3	Highly attractive	10 +

2012 CENSUS OF AGRICULTURE

Census of Horticultural Specialties (2014)

Volume 3 • Special Studies • Part 3

AC-12-SS-3

Issued December 2015

United States Department of Agriculture
Tom Vilsack, Secretary
National Agricultural Statistics Service
Joseph T. Reilly, Administrator

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Comparing Bee Attractive with Top Crops

Plants with Bee Attractive Counts/Ratings

Hylotelephium spectabile
Rosa 'cultivar name'
Tagetes patula
Tagetes sp.

→ **Plant Genera** ←

Crops Listed in 2014 NASS Census of Horticulture

Sedum
Rose
Marigold

Preliminary overview of commercial plant attractiveness to pollinators for all crops listed in the 2014 USDA-NASS Census of Horticulture

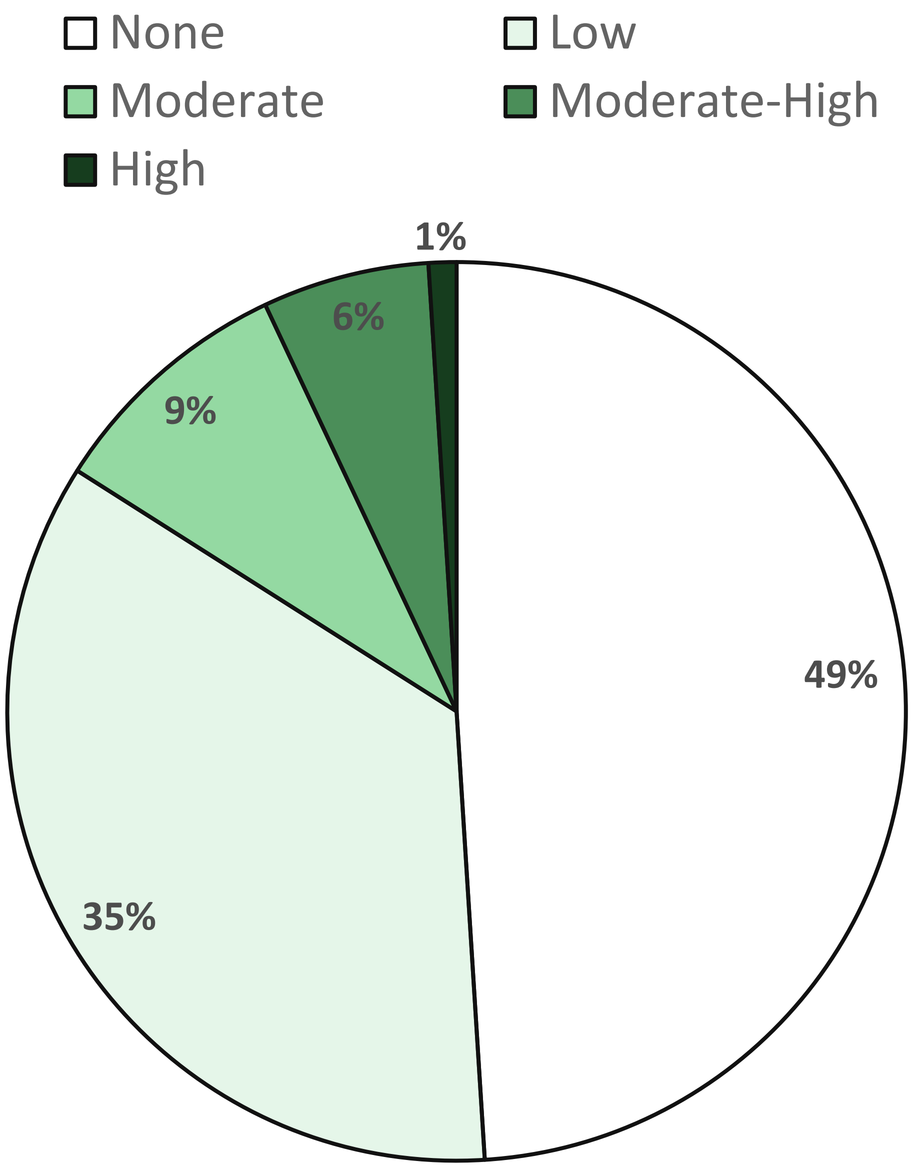
Crop Type	Number Crops included in NASS 2014 Census of Horticulture [z]	Units Sold of Listed Crops	Units Sold Excluding those without Visitation Data [z]	Units Sold (Percent) with Moderate (2.0) or Higher Attractiveness Rating Average to any "Bee"
Annuals	70	523,660,691	444,579,051	897,899 (**0.2%**)
Herbaceous Perennials	37	134,241,000	130,141,000	9,242,000 (**7.1%**)
Woody Perennials	45	195,065,571	143,066,423	23,755,693 (**16.6%**)
Combined	152	858,350,262	806,370,937	33,895,592 (**4.8%**)

[z] Number of crop per category do not equal total crops because some genera are included in multiple categories.
Units sold were excluded to better estimate percentage of units attractive to bees based on whether attractiveness data were available with the exception of species grown primarily as houseplants, conifers, and other trees primarily pollinated via wind.

[y] Roses attractive to bees are those that have single open flowers. A large but unknown percentage of roses in the US market have double flowers with nectaries and pollen largely unavailable for foraging. If 25% of the rose units sold are included the percent attractive increases to 20.2% for woodies and 5.6% for all crops.

[x] Sedum nomenclature has recently split this genus into multiple genera. Some are attractive to bees, in particular *Hylotelephium spectabile* 'Autumn Joy'. Without knowing the actual units sold, we assumed 50% of the perennial Sedum units were attractive.

Percent Crop Genera Attractive to Bees & Syrphid Flies for All Plants Screened/ Reviewed



16% Crop Genera had Moderate to High Attractiveness (at least 3 pollinators in 10 min)

35% Crop Genera had Low Attractiveness (1 to 3 pollinators in 10 min)

49% Crop Genera had No Visitation (less than 1 pollinator in 10 min)

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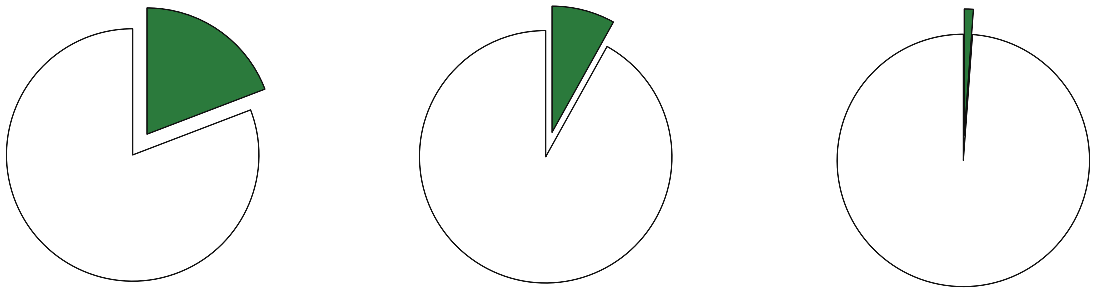
Percent Crop Genera Attractive to Bees & Syrphid Flies for All Plants Screened/ Reviewed

Crop Type (#)	Moderately Attractive (2.0)
Annuals (54)	10%
Herbaceous Perennials (82)	30%
Woody Perennials (65)	8%
Combined (202)	19%
Rating scale	3 or more bees in 10 min



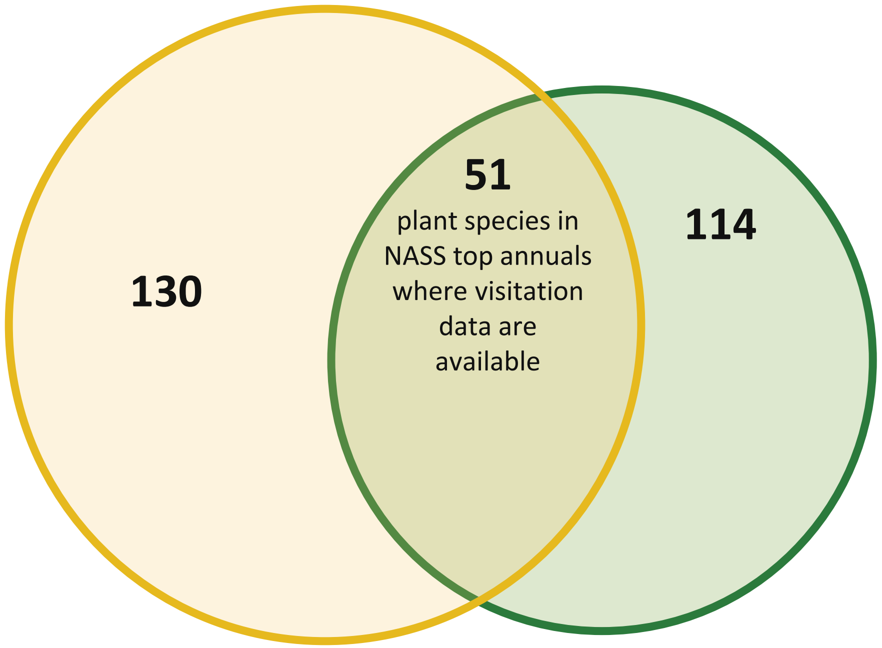
Pollinator Visitation Take aways

- A majority of plants sold in the trade are not good pollinator forage
  - Woodies > herbaceous perennials > annuals
  - Some annuals are pollinator forage such as some cultivars of lobularia, snapdragon, zinnia and more
- Flower form is important with open accessible single flowers versus doubles
- Non-native plants can support pollinator abundance and diversity

Systemic insecticides and pollinator risk for Annuals

Pollinator

~130 annual plant species where visitation data are available



Plant

~114 plant species in NASS top "25" annuals

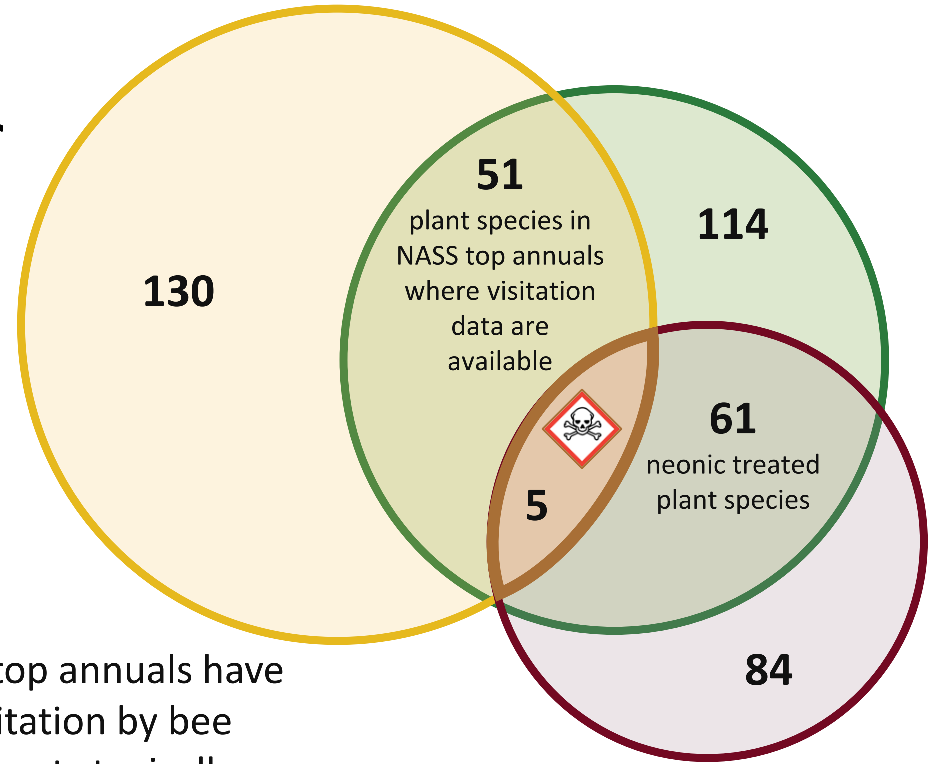
Systemic insecticides and pollinator risk for Annuals

- 51 annual plant species in the NASS plant lists where pollinator visitation data are available
- Genera with moderate visitation (3 or more bees in 10 minutes)
  - Ranunculus
  - Helianthus
- Genera with low visitation (1 to 3 bees in 10 minutes)
  - Salvia
  - Celosia
  - Brassica
  - Scaevola
- Woody genera placed in annuals for cut flowers & seasonal potted crops
  - Rosa, Hydrangea, Rhododendrons

Systemic insecticides and pollinator risk for Annuals

Pollinator

~130 annual plant species where visitation data are available



Plant

~114 plant species in NASS top "25" annuals

5 plant species in NASS top annuals have moderate level of visitation by bee pollinators and have pests typically managed by neonics –
3 are woodies used as cutflowers

Insecticide

84 plant species where pest species information is available;
105 pest species for top NASS Annuals;
36 pest species typically treated with neonics

Bottom Lines

- There are no silver bullets!
  - Every tool has some drawback
- Most plants we grow are not pollinator forage
- Balance pest management needs with local environment to select the optimal tools for your situation … making sure that your program includes multiple mode of actions

Specific Recommendations

- Annual Crops
  - When neonicotinoid insecticides are the best option:
    - Apply drenches early in the crop
    - Foliar applications can be applied later up to 2 weeks prior to shipment/bloom
  - When there are options, use those that represent less hazard for pollinators for pollinator friendly plants. Read the product labels.
- Herbaceous Perennials and Woody Shrubs & Trees
  - When neonicotinoid insecticides are the best option:
    - Apply drenches, soil injections or trunk injections after bloom
    - Apply foliar sprays when pollinators are not present
  - When there are options, use those that represent less hazard for pollinators for pollinator friendly plants. Read the product labels.

Resources

- IR-4 Project: www.ir4project.org Go to Environmental Horticulture page!
- ProtectingBees: www.protectingbees.njaes.rutgers.edu
- Oregon Bee Project: www.oregonbeeproject.org
- Penn State Center for Pollinator Research: www.ento.psu.edu/research/centers/pollinators
- Pollinator Partnership: www.pollinator.org
- AmericanHort Horticultural Research Institute: www.hriresearch.org/Pollinate-Research-and-Resources
- IR-4 Site for Project Information Sheets: www.ir4project.org/ehc/ehc-registrationsupport-research/env-hort-extension-resources

The IR-4 Project

Thank you!

Questions?

NIFA SCRI Grant 2016-51181-25399
"Protecting Pollinators with Economically Feasible and Environmentally Sound Ornamental Horticulture"