Neonicotinoid insecticides in New York State

economic benefits and risk to pollinators




Cornell CALS College of Agriculture and Life Sciences

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Outline

1. Introduction to neonics: why are they controversial and why was this report written?

2. Economic benefits of neonics

3. Risk to pollinators from neonics

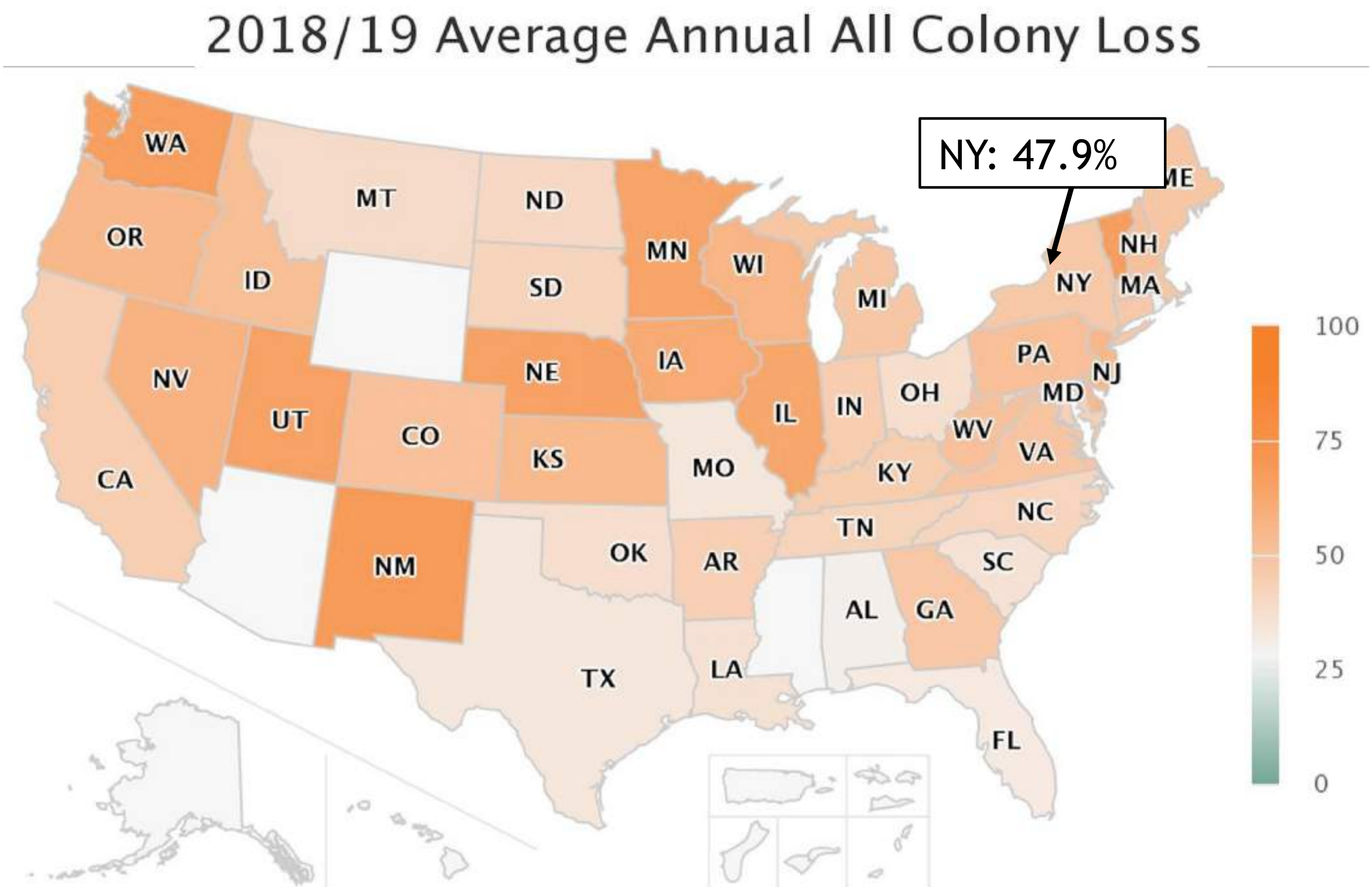
4. Take-home messages

Neonicotinoids: the most widely used insecticides in the world

- Highly effective at controlling target pests.
- Versatile: seed coating, foliar spray, soil drench, trunk injection.
- Relatively safe for humans.

- Highly toxic to beneficial non-target organisms, including pollinators.
- Systemic: accumulate in pollen and nectar.
- Relatively persistent in the environment.

Between 40-68% of New York honey bee colonies have died each year since 2006



https://bip2.beeinformed.org/loss-map/

New York is home to 414 species of wild bees

At least 53 species (13%) are in decline

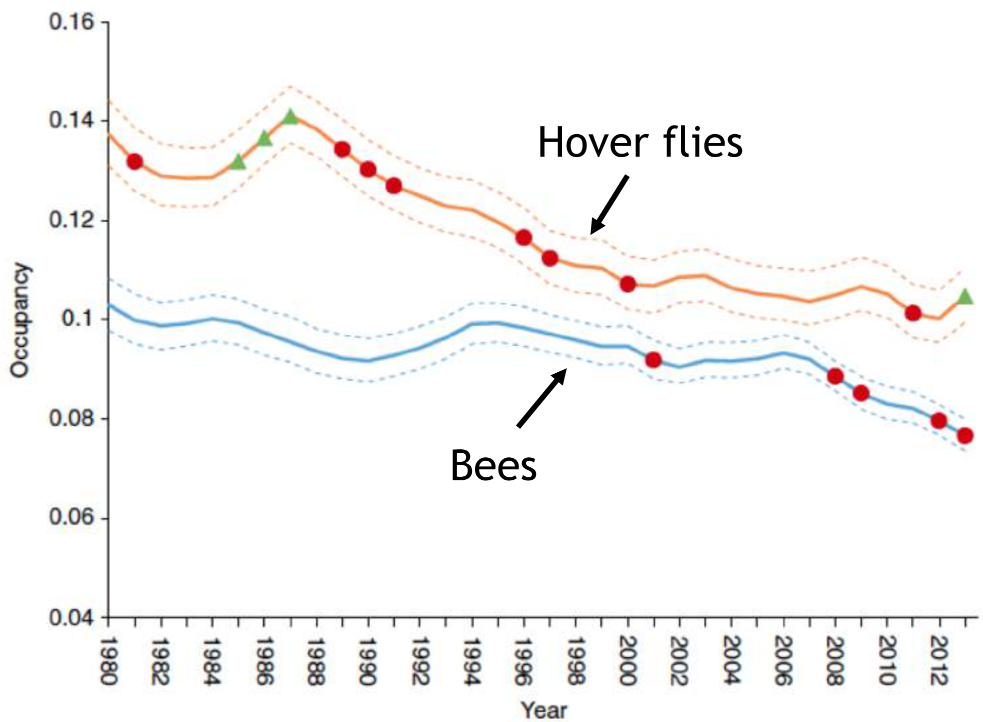
It’s not just bees… other pollinators are also declining

ARTICLE

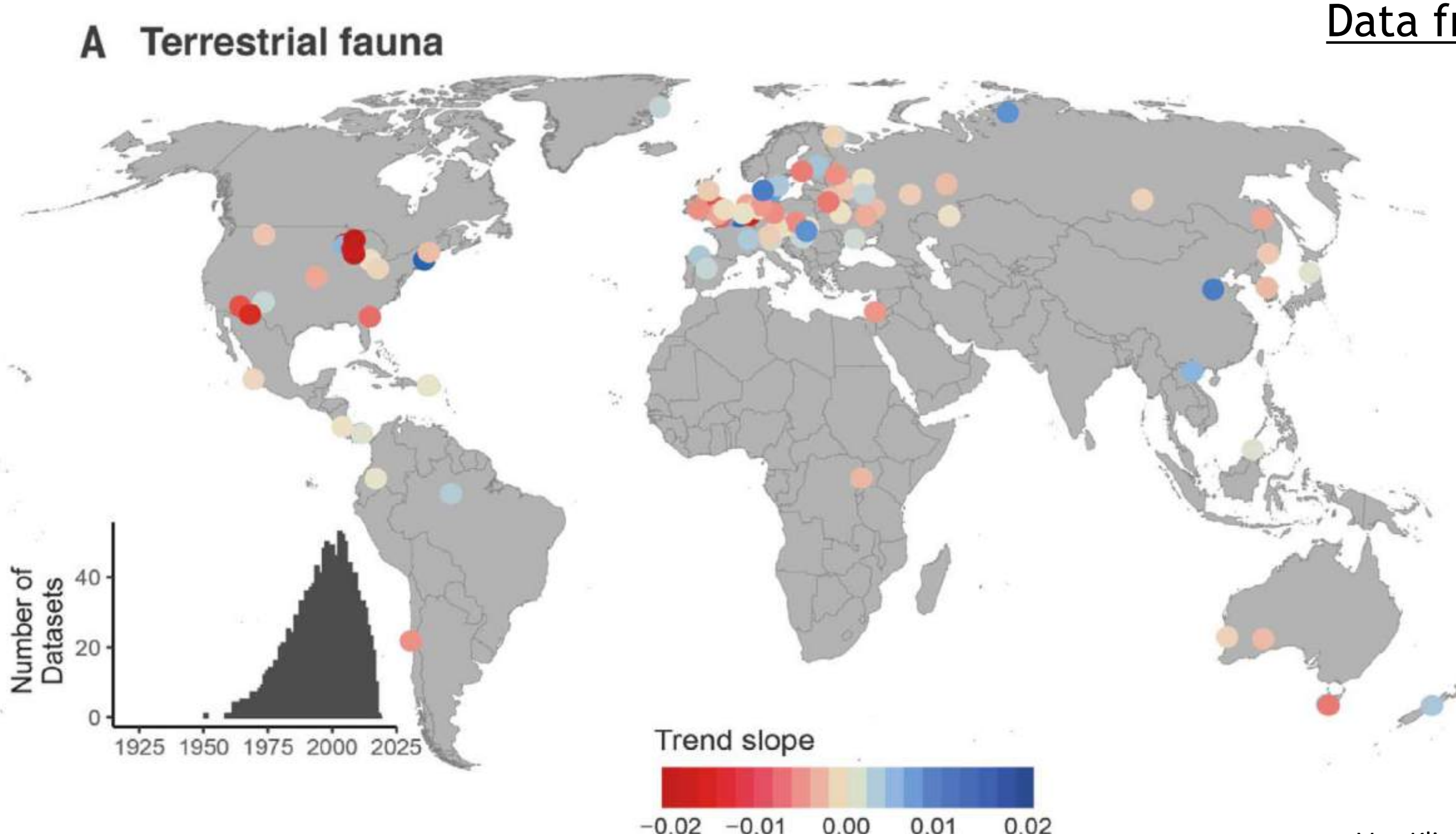
https://doi.org/10.1038/s41467-019-08974-9 OPEN

Widespread losses of pollinating insects in Britain

Gary D. Powney[1], Claire Carvell[1], Mike Edwards[2], Roger K. A. Morris[3], Helen E. Roy[1], Ben A. Woodcock[1] & Nick J. B. Isaac[1]



In fact, there's clear evidence that terrestrial *insect* declines are occurring



Data from 166 studies

Terrestrial = 9% decline per decade

Van Klink et al. 2020 *Science*

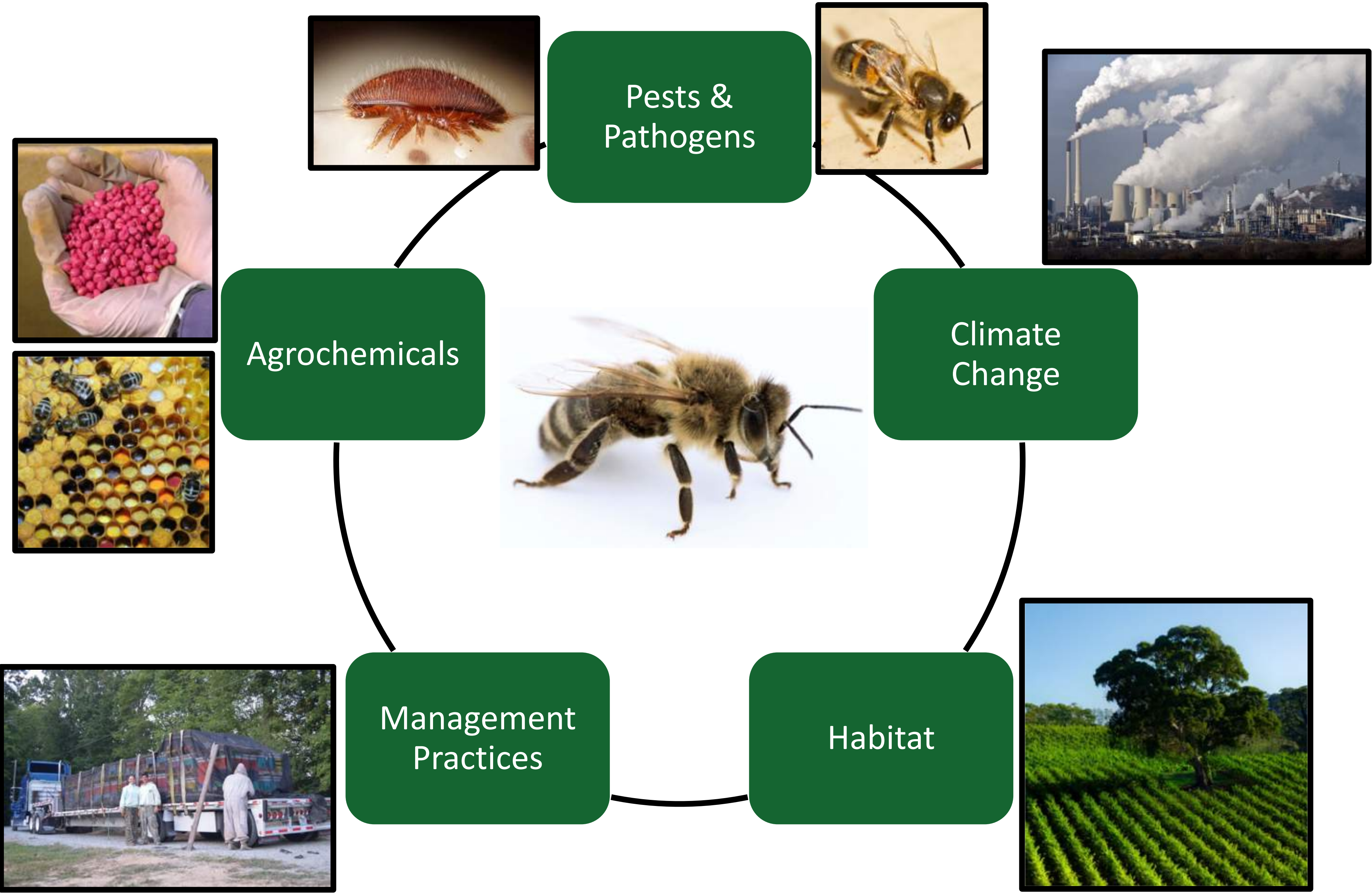
New York crops dependent on pollination

Values from: New York State Agricultural Overview. 2014, USDA

Pollinators contribute ~$400M in services annually in New York

Values from: New York State Agricultural Overview. 2014, USDA

Why are pollinators doing so poorly?



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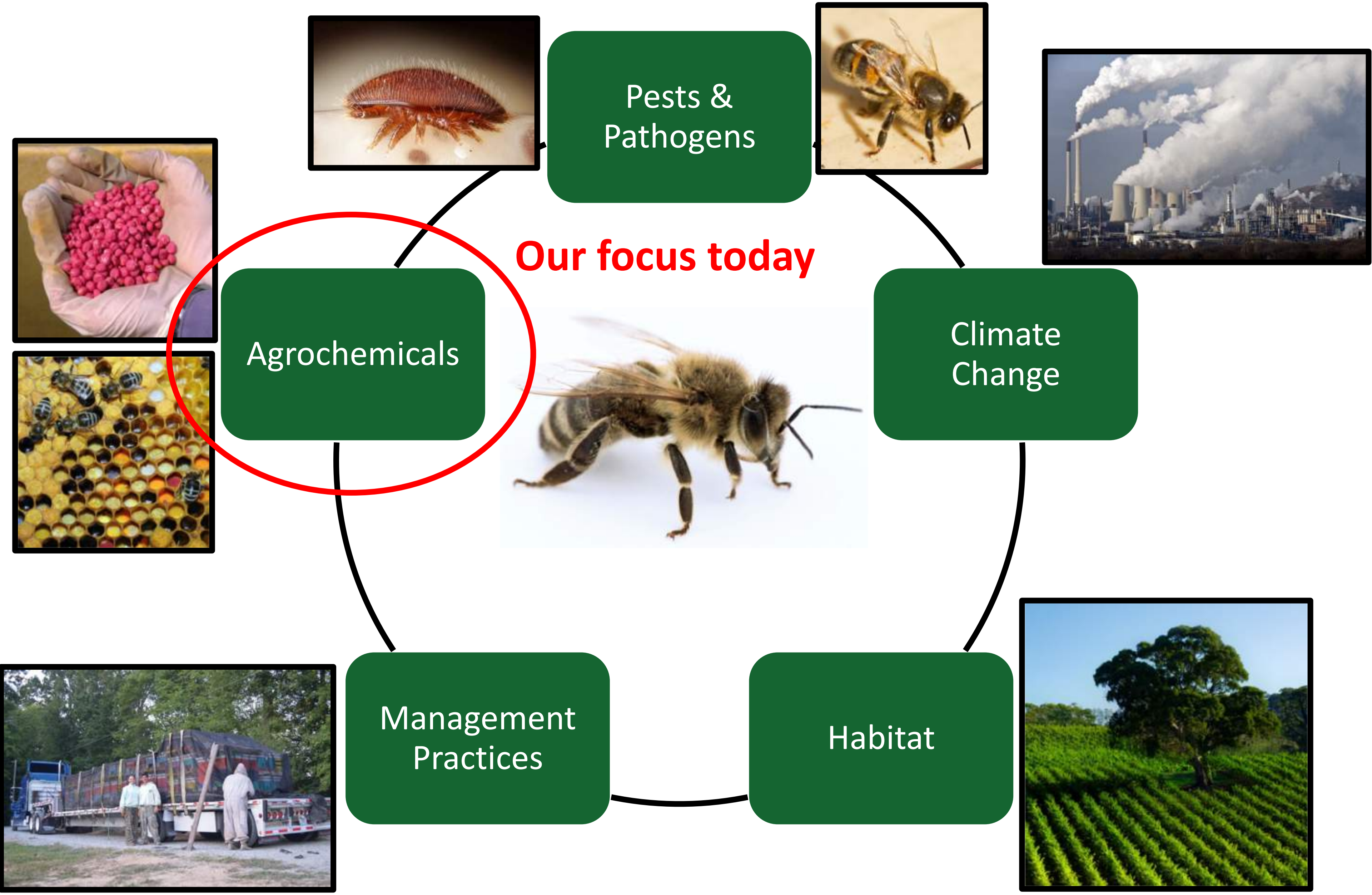
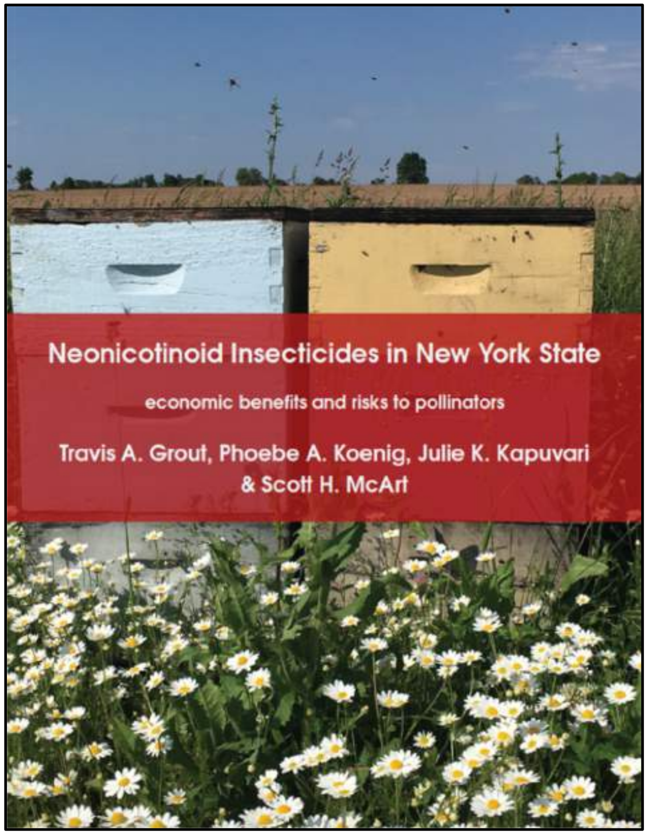


So how bad are neonics for pollinators, and how much do users benefit?



Wait, don't we already know this?

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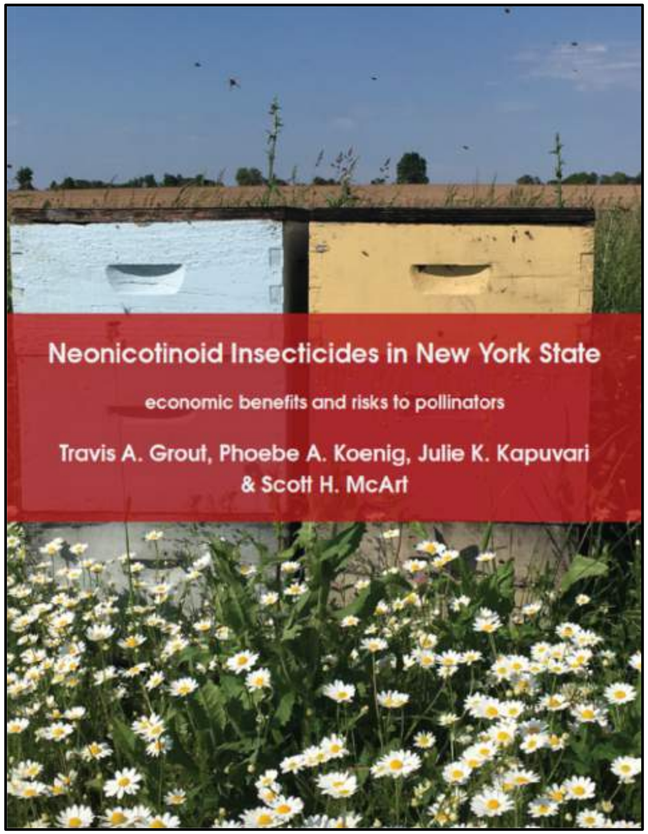

Wait, don't we already know this?

- Simple answer: No

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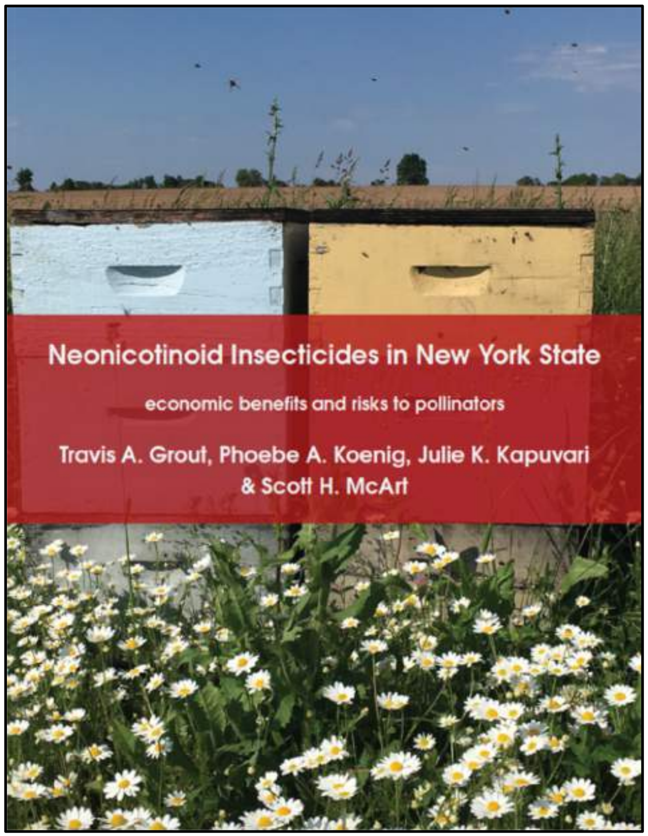

<u>Wait, don't we already know this?</u>

- Simple answer: No
- More complex answer:
  - <u>Pollinators</u>: USEPA, EU, Canadian Provincial Governments, and others have assessed risk to pollinators, ***but not using comprehensive exposure data for multiple application contexts***.
  - <u>Users</u>: Lots of individual studies have been conducted, ***but no economic benefits synthesis currently exists for each application context***.

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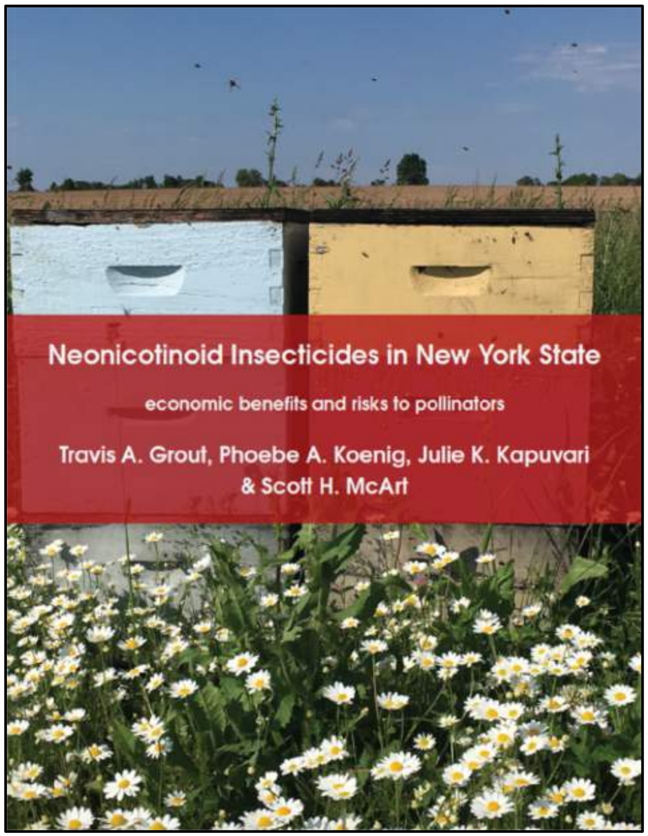

<u>How this document is unique (and hopefully useful!):</u>

- Comprehensive side-by-side analysis of economic benefits and risks to pollinators in:
  - **Field Crops** (corn, soybean, wheat)
  - **Fruit Crops** (e.g., apple, strawberry, blueberry)
  - **Vegetable Crops** (e.g., squash, pumpkin)
  - **Ornamentals, Turf, & Landscape Management** (e.g., golf courses, ornamental plant nurseries)
  - **Conservation & Forestry**

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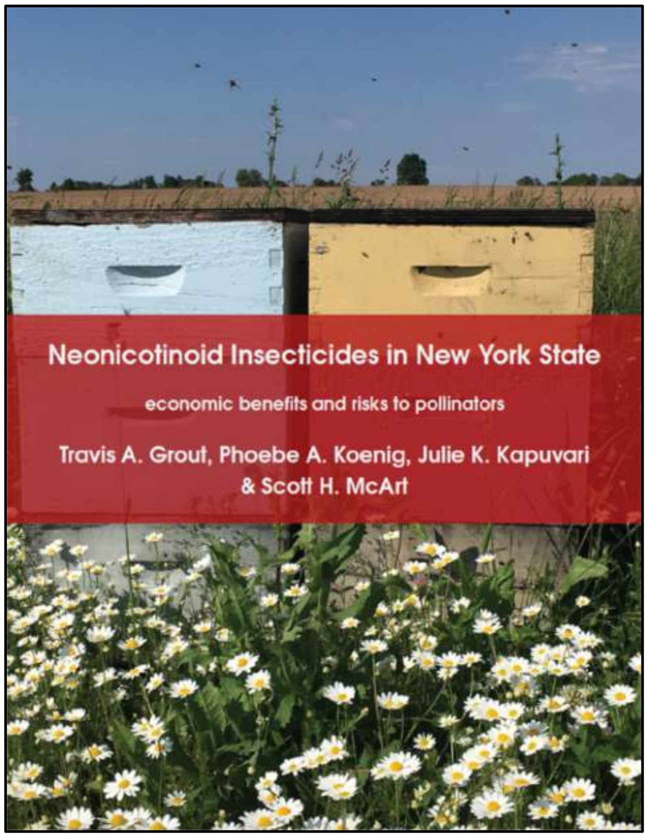

- Conducted as research via the NYS Pollinator Protection Plan under NYS Environmental Protection Fund

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Economic benefits: data sources

- Drew on **550 studies** that reported performance of neonicotinoid-based treatment(s) and at least one alternative or untreated control at a given site
- Included peer-reviewed and extension service publications
- Allowed **5,271 pairwise comparisons**

By location:

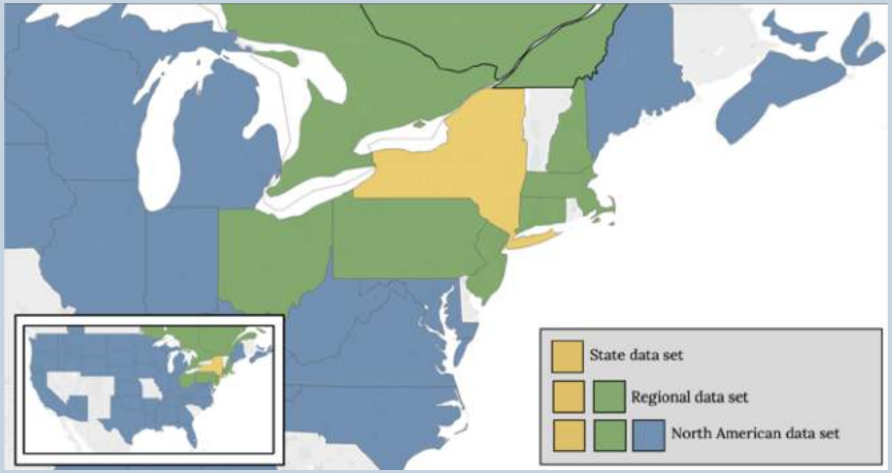
6% in New York, 42% in region

By crop:

23% field corn, 34% soybean, 10% fruit crops, 25% vegetable crops, 7% turfgrass

By comparison:

63% alternative insecticides, 11% "fungicide-only" controls, 26% untreated controls



Economic benefits: analysis

Considered three types of outcomes:

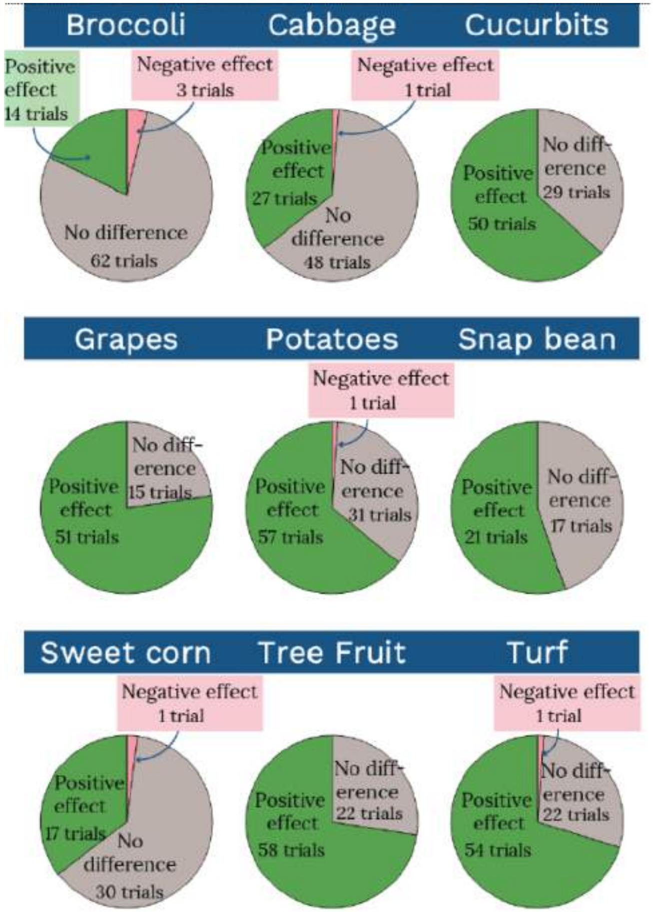
1. **Crop yield** (preferred, related most closely to farm income)
2. **Pest damage**
3. **Pest population**

Used several analytical tools depending on quality of data set:

- **Count:** *what proportion of field trials observed significantly better (or worse) outcomes in neonic-treated plots compared to comparison plots?*
- **Sign test:** *do neonics out-perform (or under-perform) alternatives in a significant majority of field trials?*
- **ANOVA and signed-ranks tests:** *are differences in outcomes statistically significant?*
- **Economic modelling:** *what is the expected difference in net income for farmers using neonics compared to an alternative?*

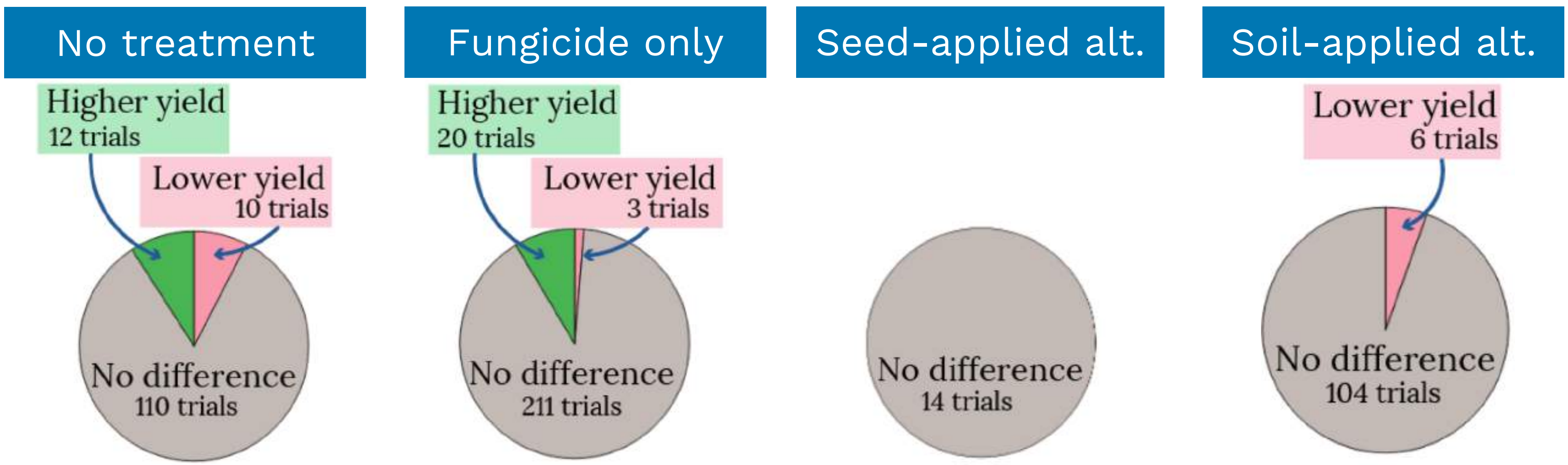
Benefits: fruit and vegetable crops

- Compared to no-insecticide controls, neonicotinoid-based products consistently produced better outcomes
  - Includes all North American field trials measuring yield, crop damage, or pest control
- Effective chemical alternatives available for **most** common pests of New York fruit and vegetable crops
  - Even when alternatives exist, however, neonicotinoids are not necessarily "expendable"
- For a handful of important pests, there are few or no practical alternatives to neonicotinoids
- In some foliar applications, the neonicotinoid **acetamiprid** may be a less-toxic option



Benefits: field corn seed treatments

Results of regional yield trials comparing neonicotinoid-treated seeds to:



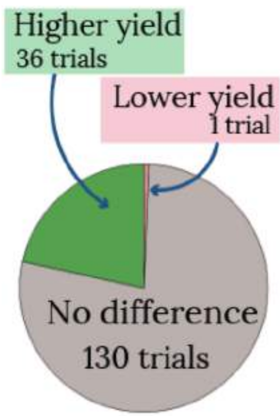
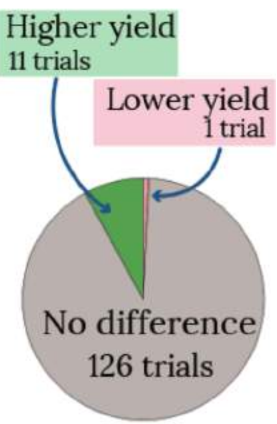
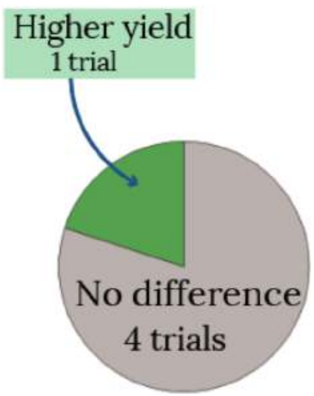
<u>Changed expected net income per acre</u>:

- ***No difference*** compared to **untreated seeds**
- \+ $13 to + $24 (2.0% to 3.7%) compared to **fungicide-treated seeds**
- ***No difference*** compared to **soil-applied tefluthrin**

Under a range of yield assumptions, considering differences in labor, equipment, scouting, & product costs

Benefits: soybean seed treatments

Results of regional yield trials comparing neonicotinoid-treated seeds to:

No treatment	Fungicide only	Foliar insecticides
		

Changed expected net income per acre:

- ***No difference*** compared to **untreated seeds**
- + $16 to + $27 (3.8% to 6.5%) compared to **fungicide-treated seeds**
- + $13 to + $19 (1.8% to 4.4%) compared to **foliar lambda-cyhalothrin**

Under a range of yield assumptions, considering differences in labor, equipment, scouting, & product costs

Benefits: non-agricultural users

- **In the near term, there are no viable alternatives to neonicotinoid-based products for control of hemlock woolly adelgid**
  - Unchecked spread of HWA would have catastrophic impact on Eastern Hemlocks, the third most common tree in NYS
  - Also irreplaceable for Asian longhorned beetle
- Key landscape and turfgrass management pests: **white grub**, viburnum leaf beetle, and armored scale insects
- For white grub, only viable preventive treatment anthranilic diamides, but much more expensive and not permitted on Long Island.
  - Merit 0.5G (imidacloprid): $125/acre
  - Acelepryn G (chlorantraniliprole): $365/acre

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Risk to pollinators: methods

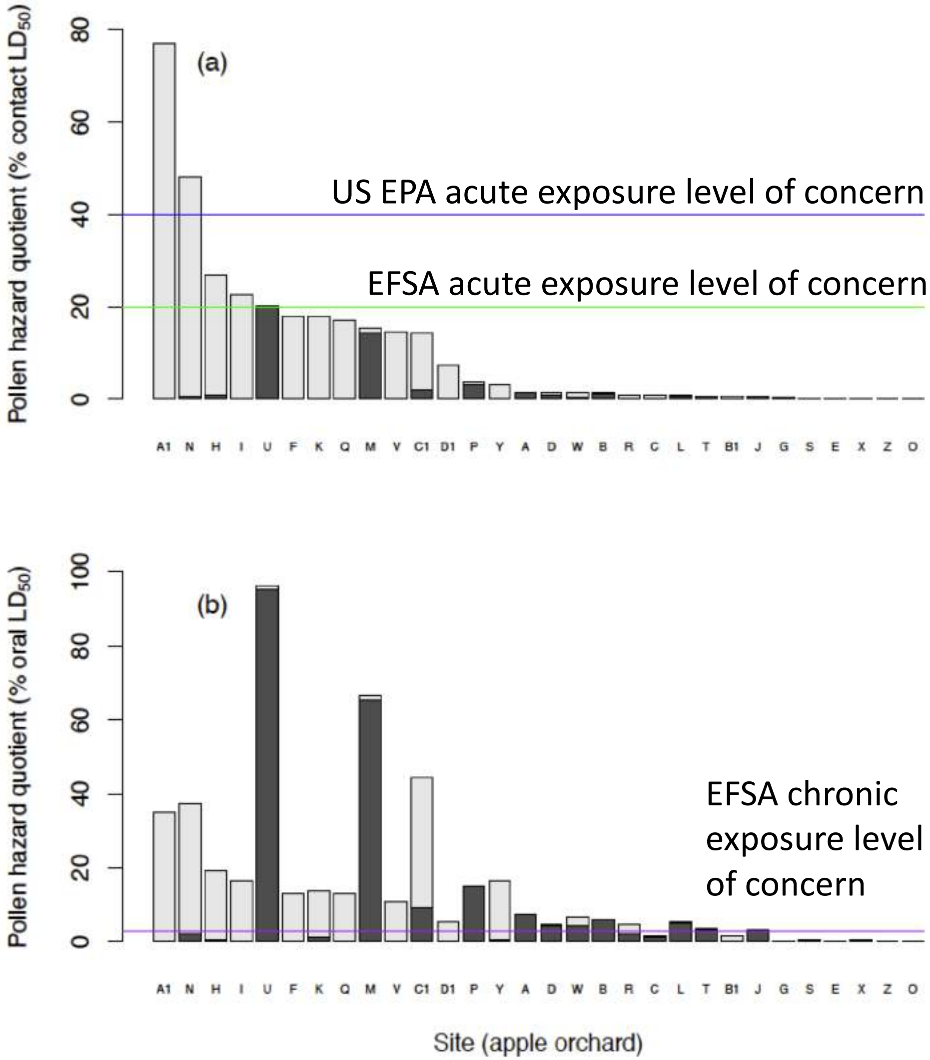
1. Hazard Quotient (HQ) for our own New York data:

Assesses risk of bees dying from exposure

Risk to pollinators: HQ results (NY apple)

Contact exposure

Oral exposure



Risk from neonicotinoids

Risk from other pesticides

1. Acute risk can be high.
2. Neonics: 15.1% of risk from contact exposure, but 50.4% of risk from oral exposure.
3. **Acetamiprid** found in more than a third of samples (mean = 160 ppb), but **contributes little to risk**.
4. **Thiamethoxam** found in only 5 samples (mean = 21 ppb), but **contributes greatly to risk**.

Adapted from McArt, Fersch, Milano, Truitt & Boroczky 2017 *Scientific Reports*

Risk to pollinators: HQ results (NY apple)

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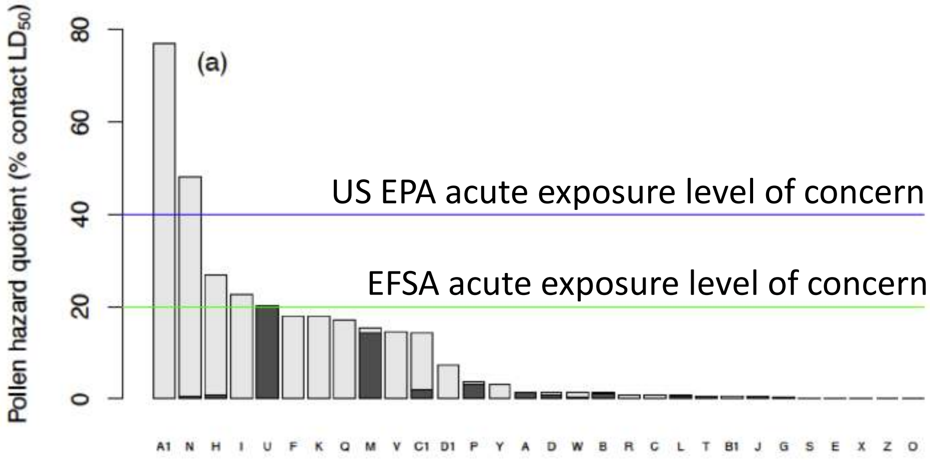
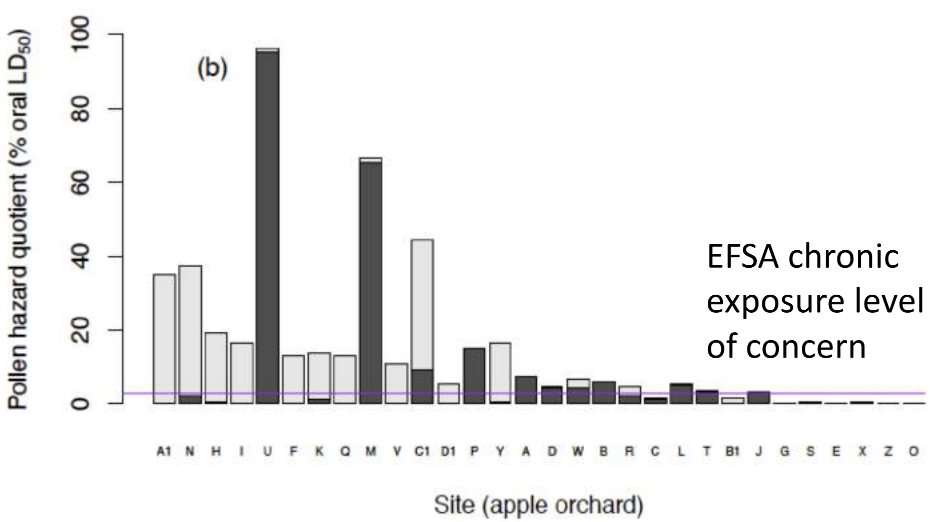


Oral exposure



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Risk to pollinators: methods

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Assesses risk of bees dying from exposure

Not useful for assessing sublethal risk (e.g., effects on reproduction)
<u>Multiple sublethal stressors are currently thought to be driving pollinator declines**</u>**

Risk to pollinators: methods

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Assesses risk of bees dying from exposure

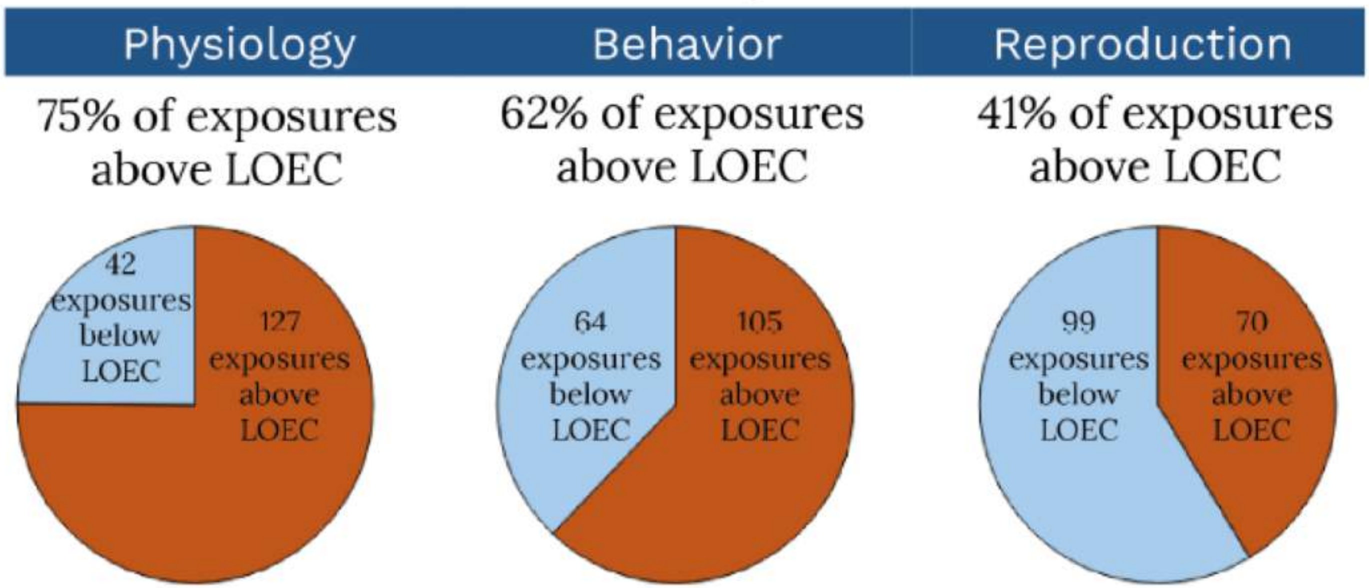
Not useful for assessing sublethal risk (e.g., effects on reproduction)
<u>Multiple sublethal stressors are currently thought to be driving pollinator declines</u>

2. Systematic literature review and quantitative analysis of sublethal risk (327 peer-reviewed studies):

Assesses sublethal risk: exposures impacting bee physiology, behavior, or <u>reproduction</u>

Risk to pollinators: LOEC results

All application contexts

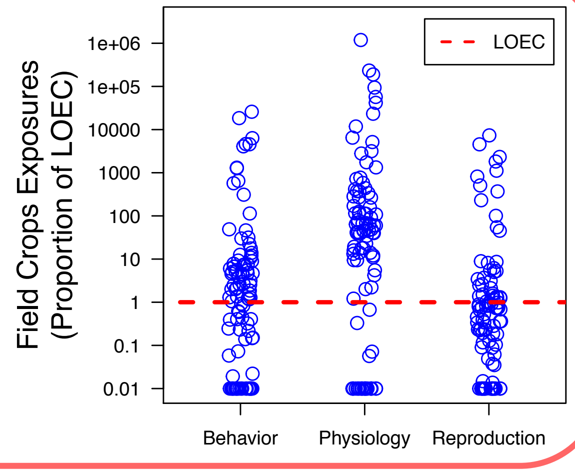


Data from 169 documented neonicotinoid exposures to bees

Risk to pollinators: LOEC results

<u>Field crops (***n* = 96**)</u>
74% physiology
58% behavior
37% reproduction

Clearest result



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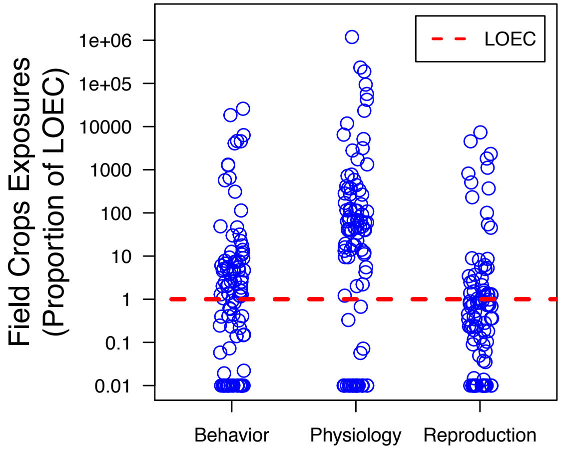
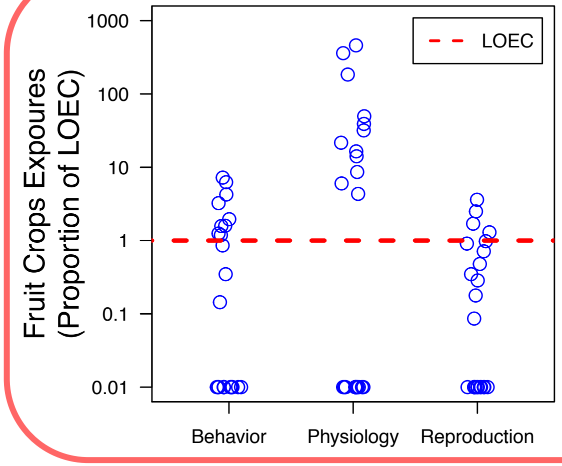
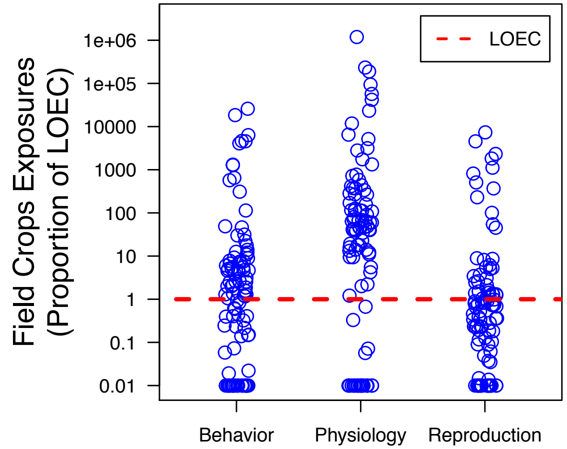




Fruit crops (***n* = 24**)
50% physiology
38% behavior
17% reproduction

Risk to pollinators: LOEC results

Field crops (***n* = 96**)
74% physiology
58% behavior
37% reproduction



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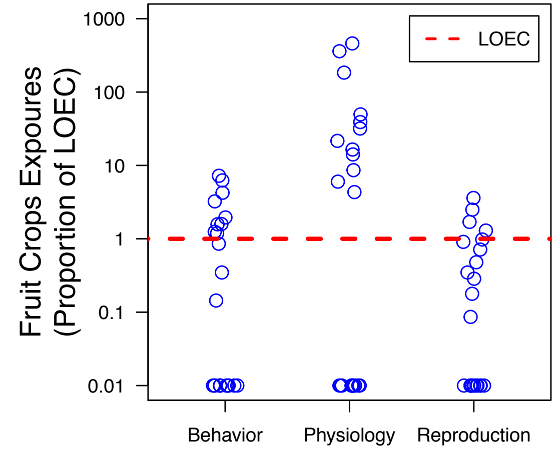
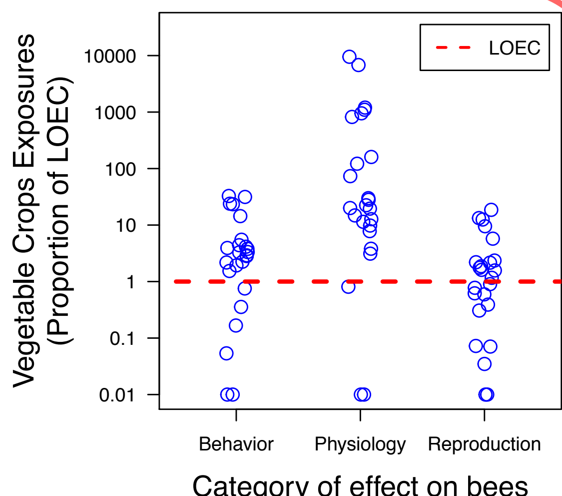


Fruit crops (***n* = 24**)
50% physiology
38% behavior
17% reproduction

Vegetables (***n* = 24**)
88% physiology
75% behavior
54% reproduction

Universally high risk in cucurbits

2nd clearest result



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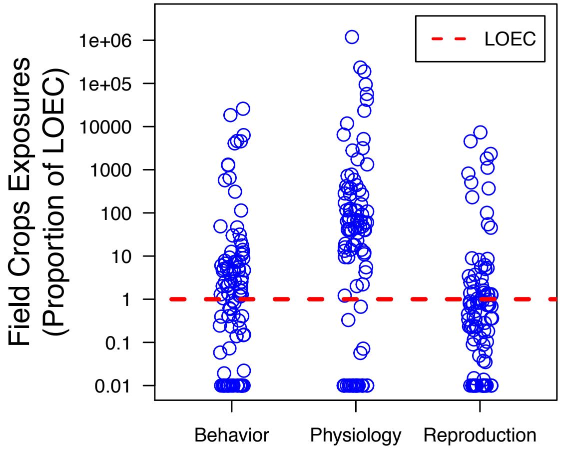

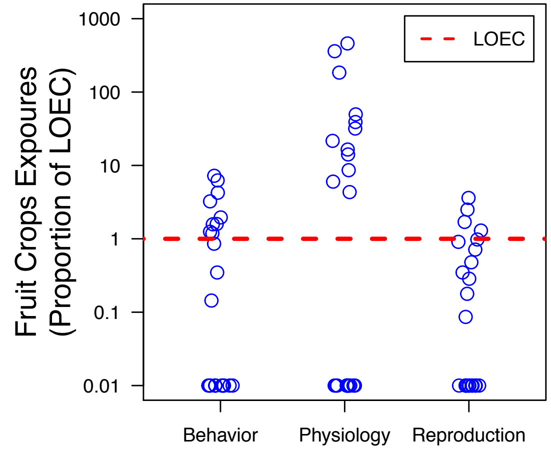

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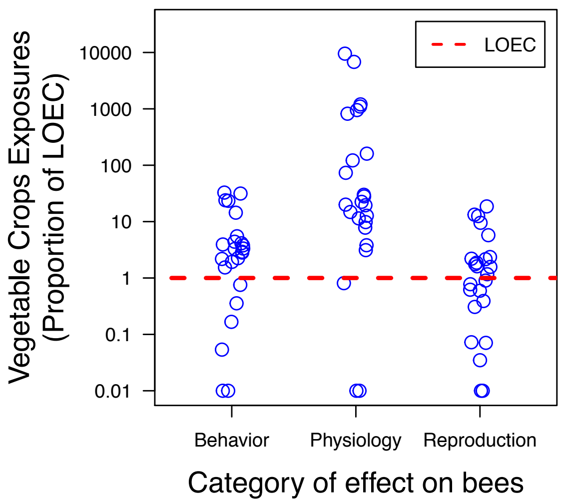

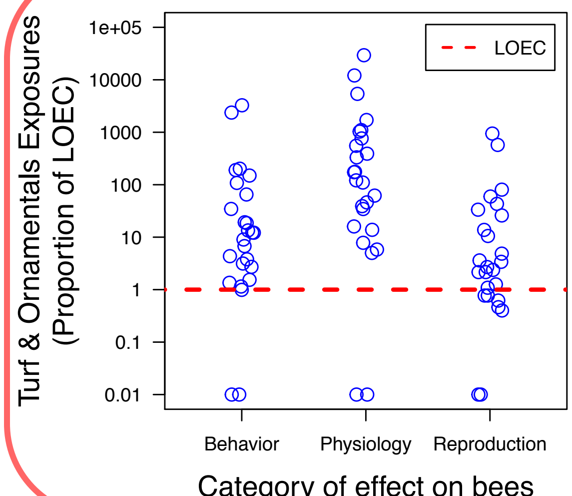

Turf & Ornamentals (***n* = 25**)
92% physiology
88% behavior
72% reproduction

Generally high risk in ornamentals

3rd clearest result

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Take-home messages

1. **The most robust benefit *and* risk data exist for field crops**
   - Benefits of using neonicotinoid seed treatments exist for a small proportion of fields ("~10% of fields"), but benefits for that small proportion of fields are real.
   - Risk to pollinators in and near neonicotinoid seed-treated corn and soybean fields is real.
     - Dust during planting gets a lot of attention, but long-term contamination of soils and movement to surface water, weeds, etc. presents more consistent risk (*ground-nesting bees*).

2. **Less comprehensive benefit *and* risk data exist for other application contexts**
   - Benefits almost always exist in terms of pest control or reduced crop damage.
   - Risk to pollinators can be high, but data are surprisingly limited.
     - Risk via soil applications for cucurbits is consistently high (*recognized by EPA*).
     - Risk from acetamiprid is much lower than from nitroguanidine neonicotinoids.

3. **Alternative chemical insecticides exist for nearly all target pests**
   - Anthranilic diamides are especially promising in turf and field crops settings.
   - But for handful of pests, no viable alternatives exist.
   - Broader development and adoption of IPM methods and non-chemical alternatives is needed. Promising new technologies are highlighted!