

Response of non-target epigeal communities in field crops to neonicotinoid seed coatings

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PennState
Entomology

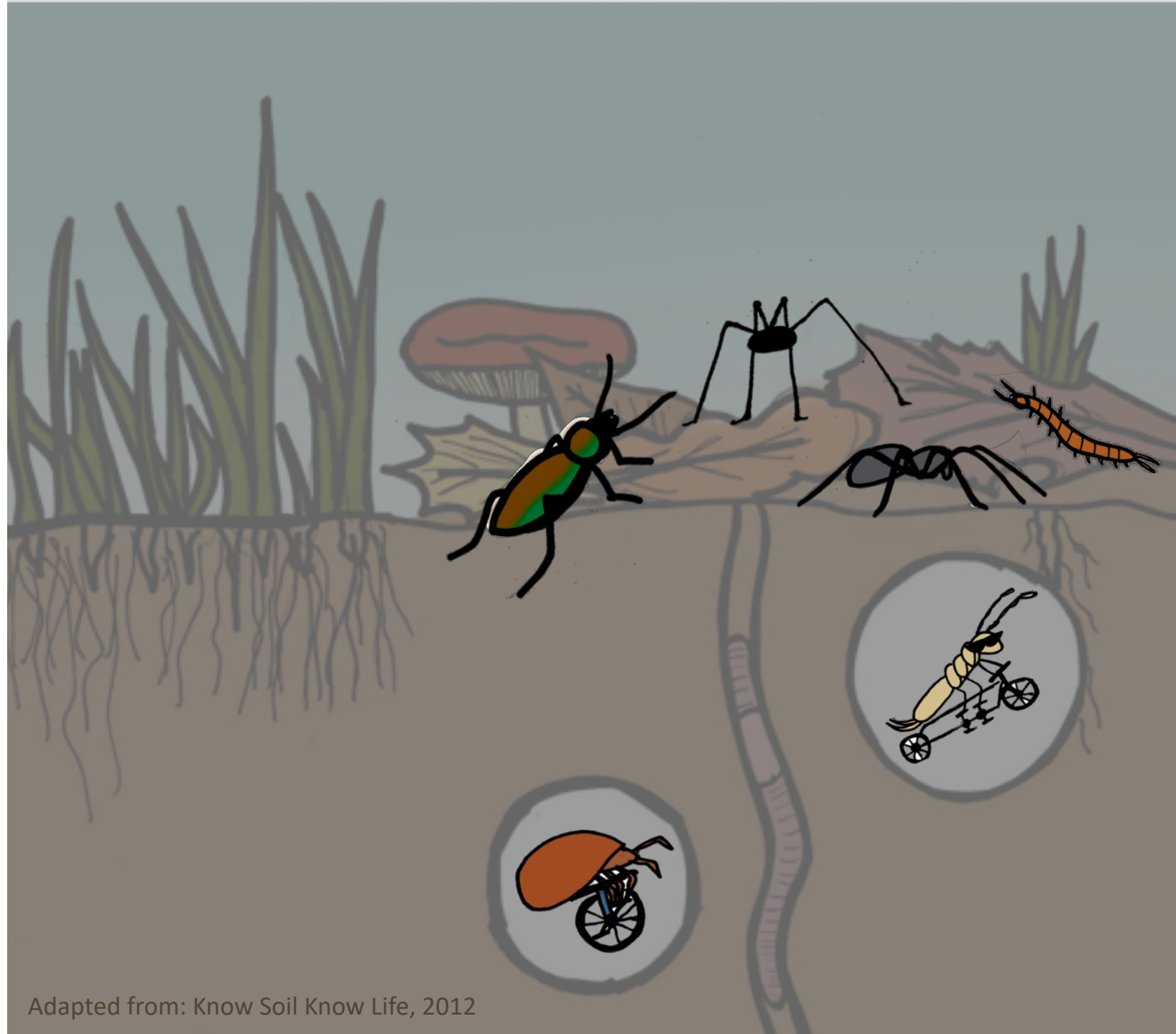
The Epigeal

(Surface-active)

Community

Predators

Nutrient & Carbon
Cyclers



The Epigeal

(Surface-active)

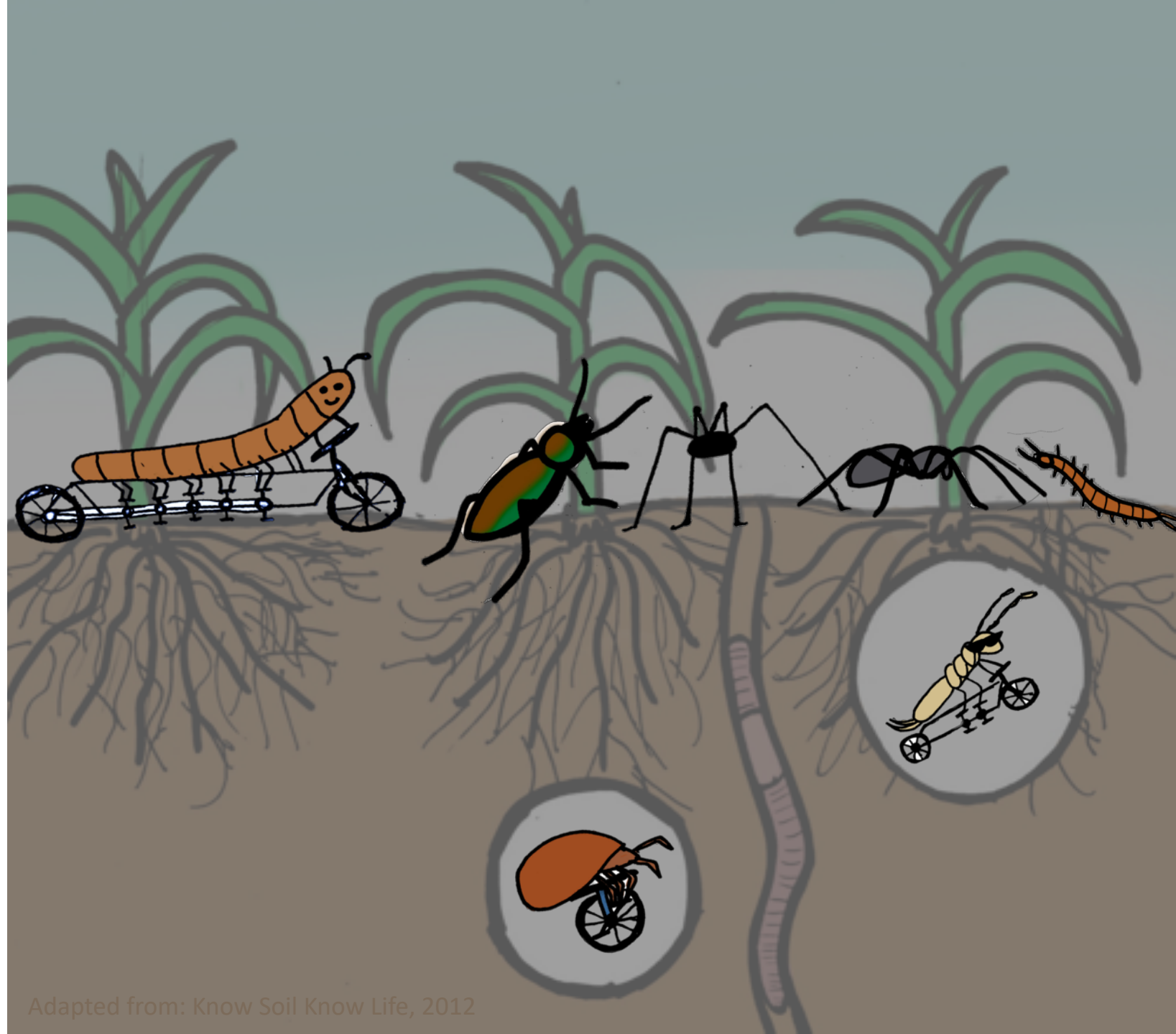
Community

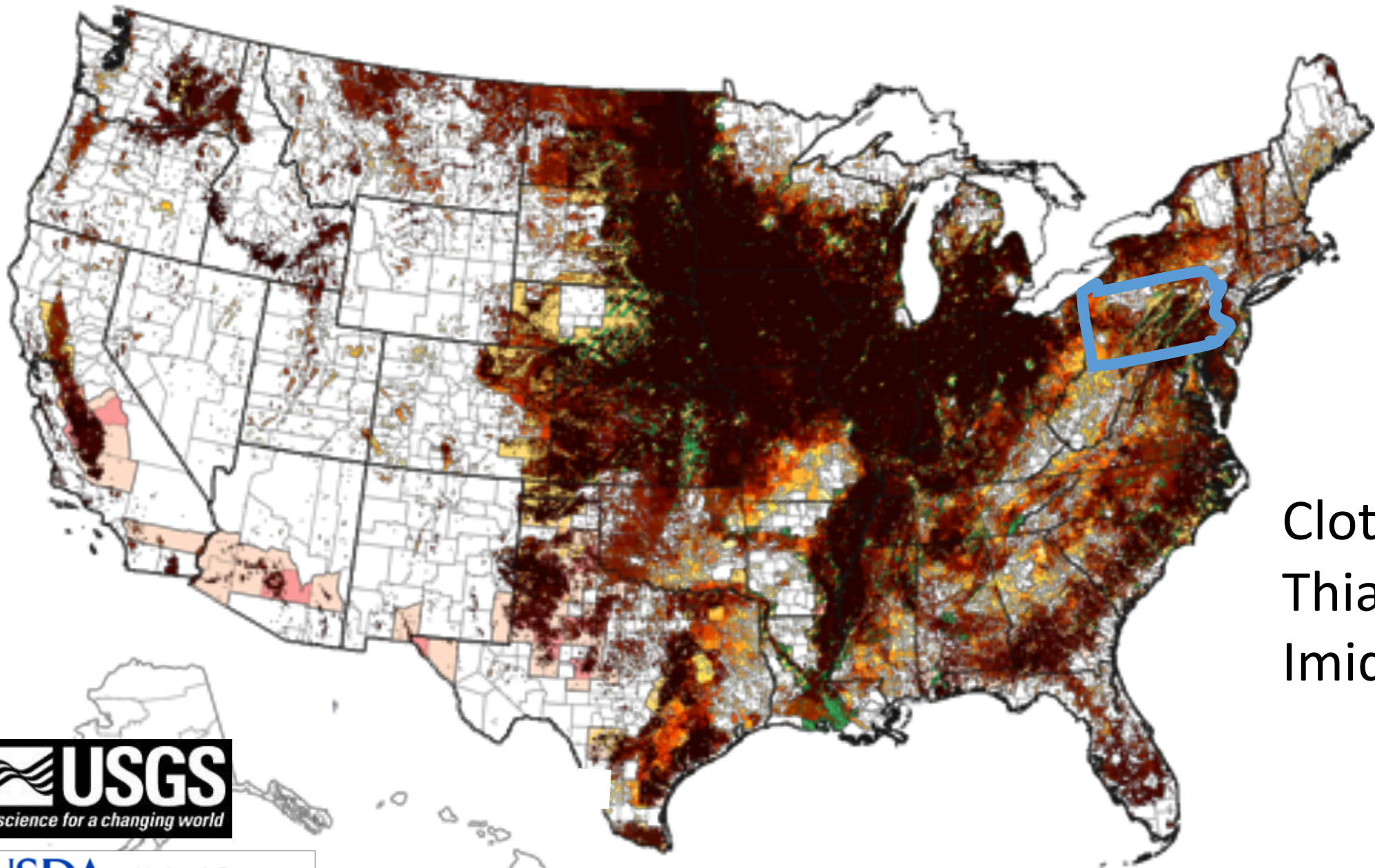
Predators

Biocontrol

Nutrient & Carbon
Cyclers

Residue Breakdown
Soil Fertility





Clothianidin
Thiamethoxam
Imidacloprid



Data from 2014

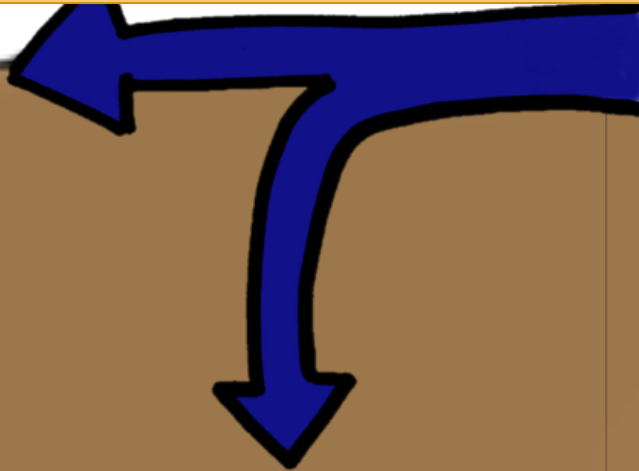
Where do neonicotinoids from seed coats end up?



Plant Uptake < 1.5%*

Run-Off/
Tile Drainage: 0.3%†

= high potential for epigeal invertebrate exposure



> 95% in the soil

Microbe breakdown
 $t_{1/2}$: days to years‡

Core Questions:

How do seed coats affect surface-active predator activity?



How do seed coats affect surface-active decomposer activity?



How do these effects compare to alternative insecticides?



Expectations:

How do seed coats affect surface-active predator activity?

Seed coats will reduce predator activity

(Douglas, Rohr, and Tooker, 2015)



How do seed coats affect surface-active decomposer activity?

Seed coats will reduce decomposer activity

(Zaller et al, 2016)



How do these effects compare to alternative insecticides?

These effects will be similar for alternative insecticides (e.g. pyrethroids)

(Douglas and Tooker, 2016)



3-year field experiment in a corn-soy rotation

Latin Square Design, 6 plots of each treatment:



Control

no insecticide



Seed Coat

neonicotinoid
+ fungicide mix



Pyrethroid

1x spray,
~ 1 month post-plant

Active Ingredient:

Imidacloprid on soy

Clothianidin on corn

Active Ingredient:

λ-cyhalothrin, 3 oz/acre

Trade name: Warrior®

Sampling Epigeal Invertebrate Activity and Diversity



Functional endpoints: predation and decomposition



Predators/Predation:

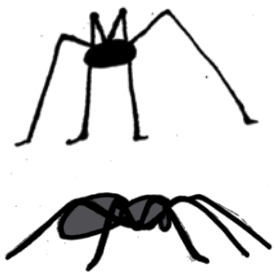
How do seed coats affect surface-active predator activity?



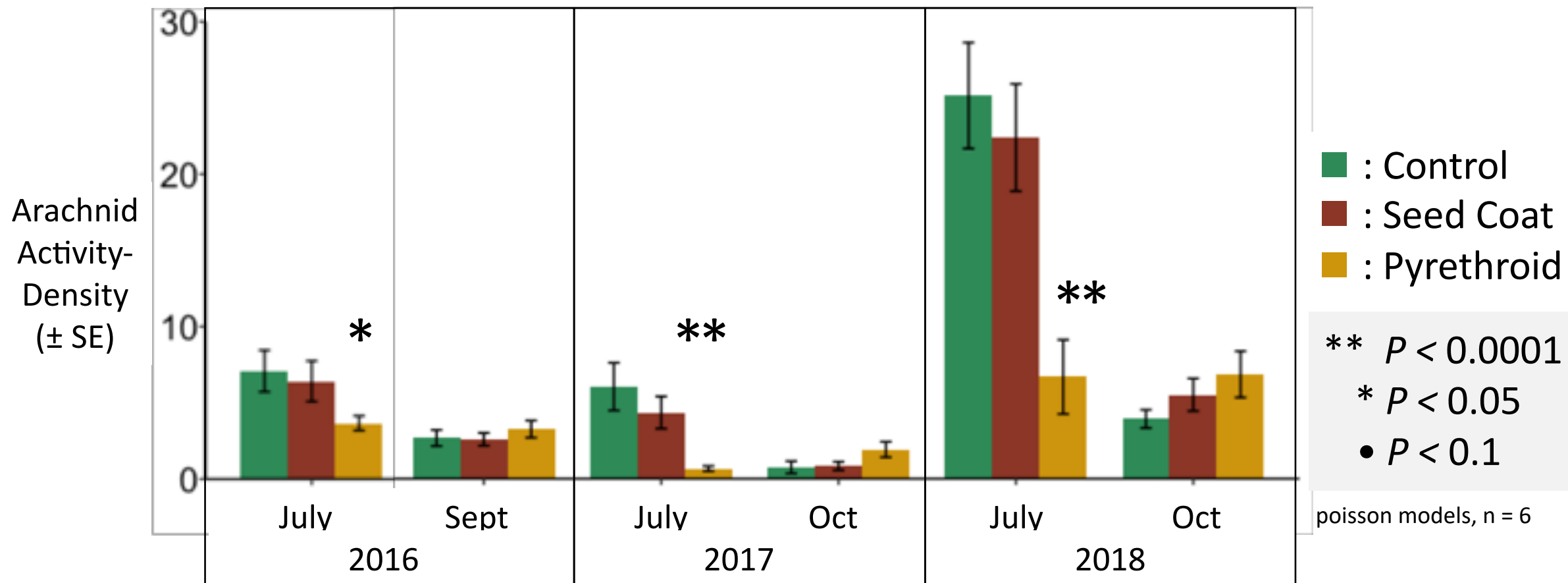
Captured arachnids (spiders and harvestmen), centipedes, carabid beetles, and rove beetles

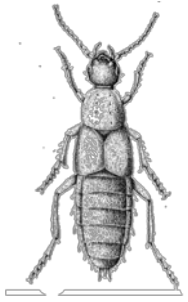
How do these effects compare to alternative insecticides?



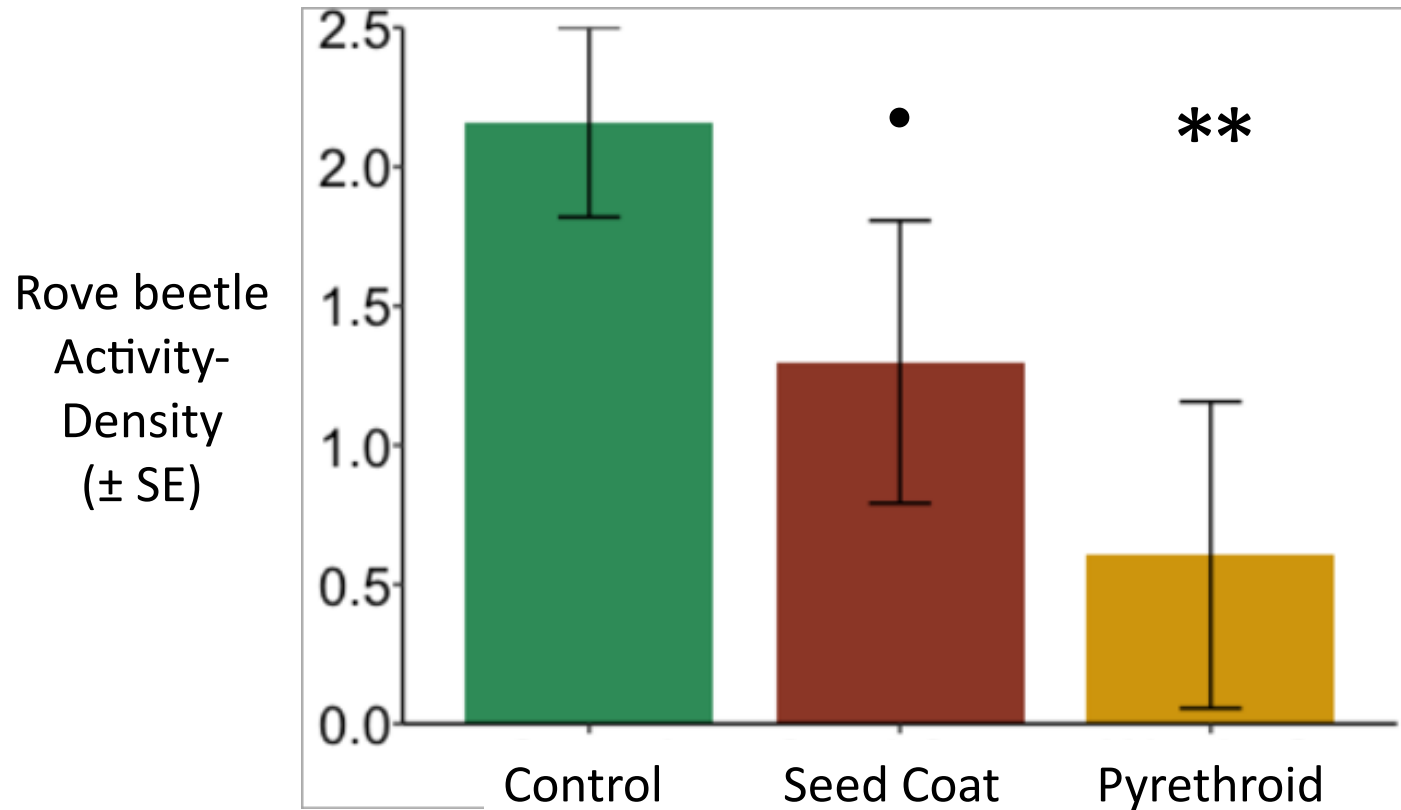


The pyrethroid decreases mid-season arachnid activity-densities





Rove beetle activity-densities decreased by pyrethroid, marginally by seed coats



$P = 0.090$

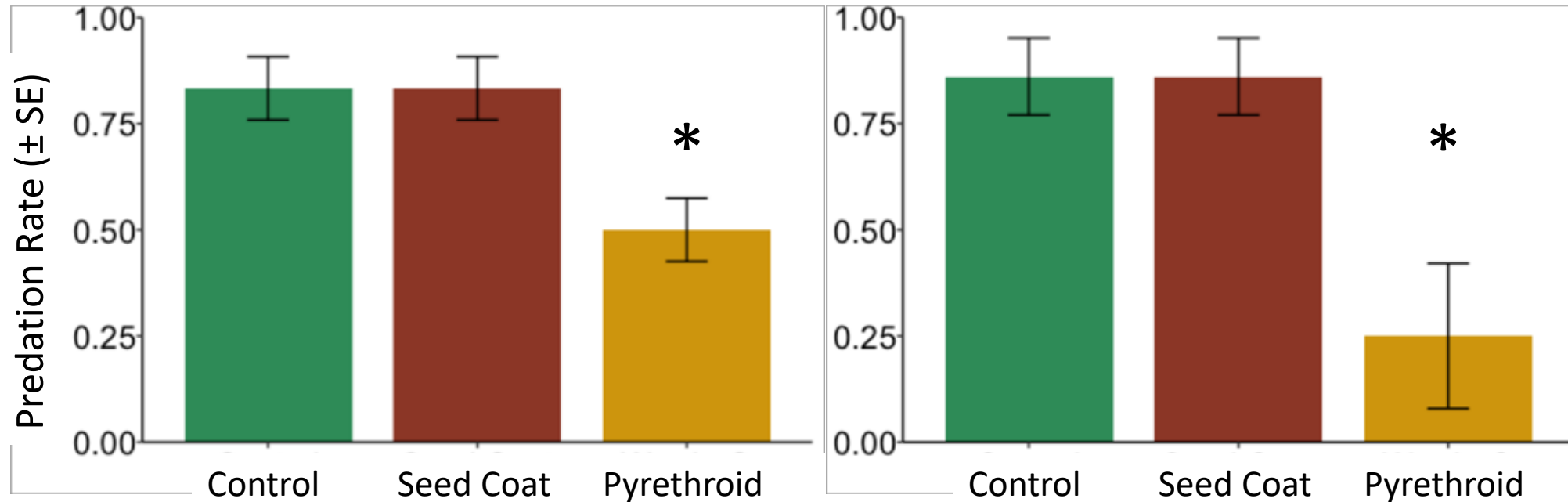
** $P < 0.0001$
* $P < 0.05$
• $P < 0.1$

negative binomial model,
n = 6

Pyrethroid decreases predation, seed coats no effect

July 2017

July 2018



** $P < 0.0001$

* $P < 0.05$

• $P < 0.1$

quasibinomial models,
n = 6

47 days post-plant
13 days post pyrethroid spray

25 days post-plant
2 days post pyrethroid spray

Predators / Predation:

How do seed coats affect surface-active predator activity?

Not much (a month after planting)



How do these effects compare to alternative insecticides?

The pyrethroid significantly reduces arachnid activity-densities

Reduces predation rate



Decomposers / Decomposition:



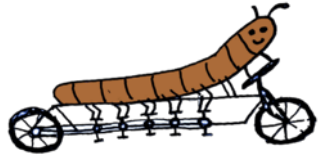
How do seed coats affect surface-active decomposer activity?



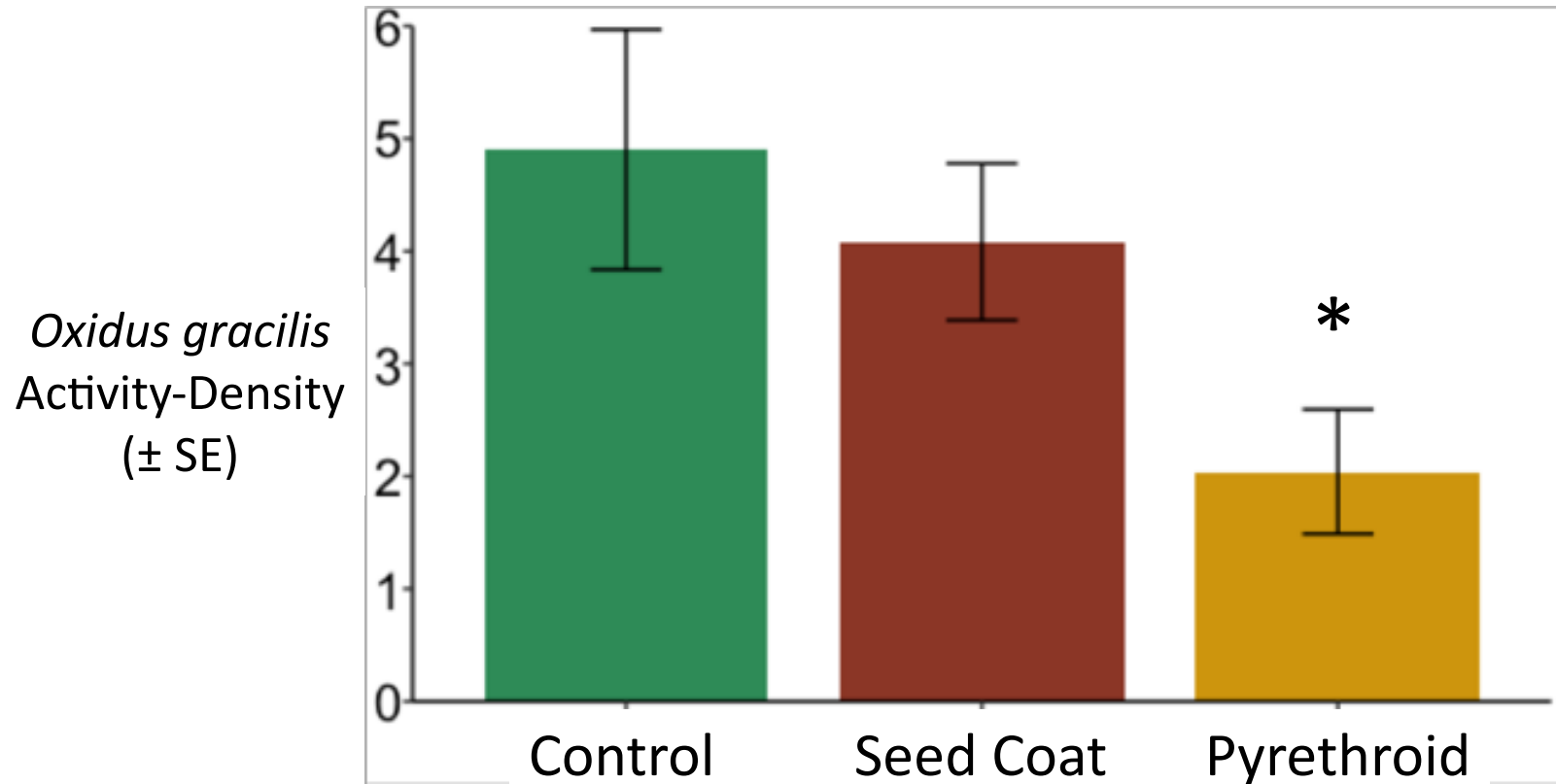
Focusing on millipedes, mites, and collembola

How do these effects compare to alternative insecticides?





Pyrethroid reduces millipede activity-density

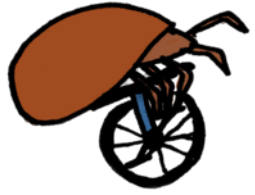


** $P < 0.0001$

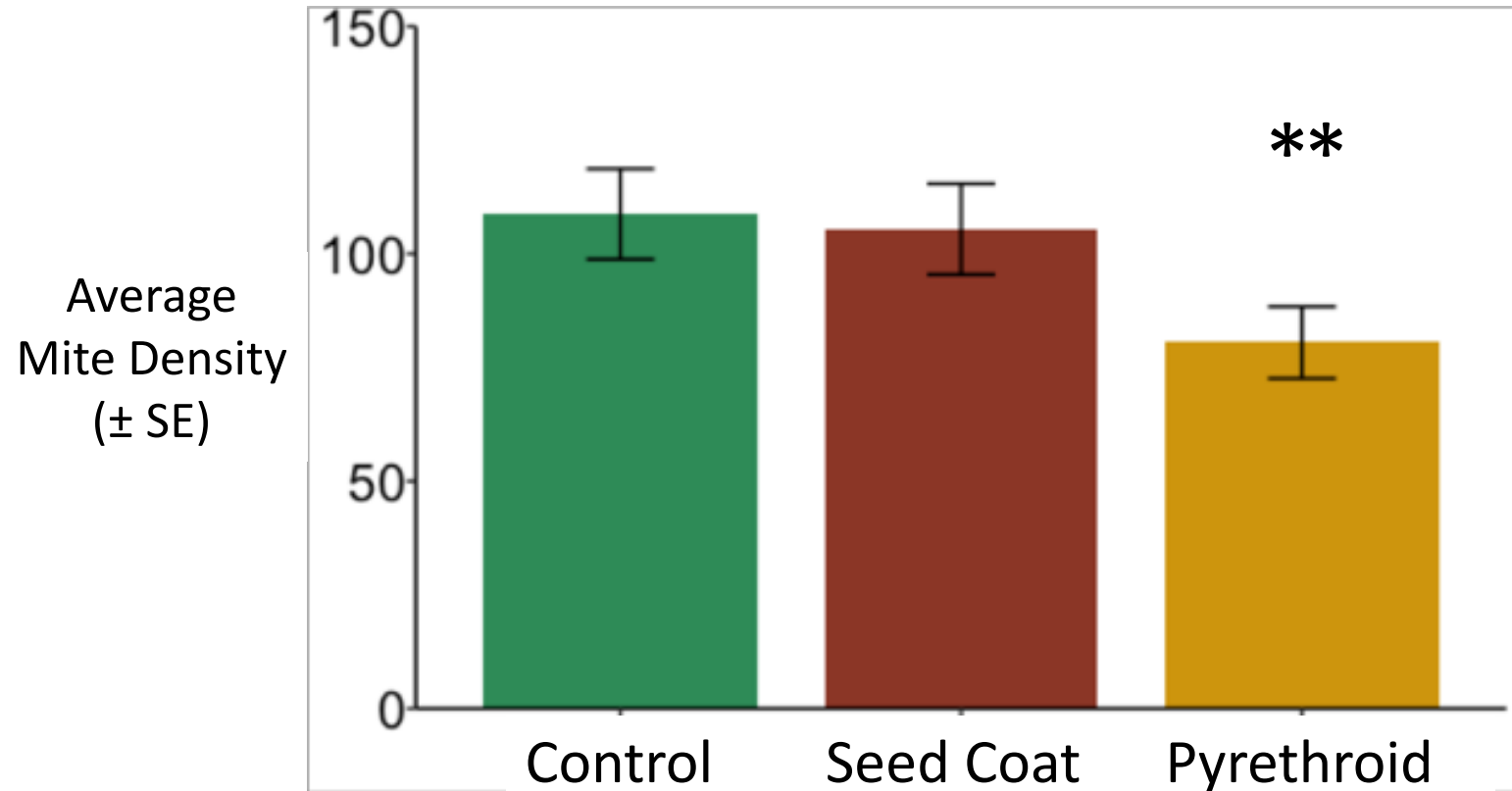
* $P < 0.05$

• $P < 0.1$

negative binomial model,
 $n = 24$



Pyrethroid reduces mite densities

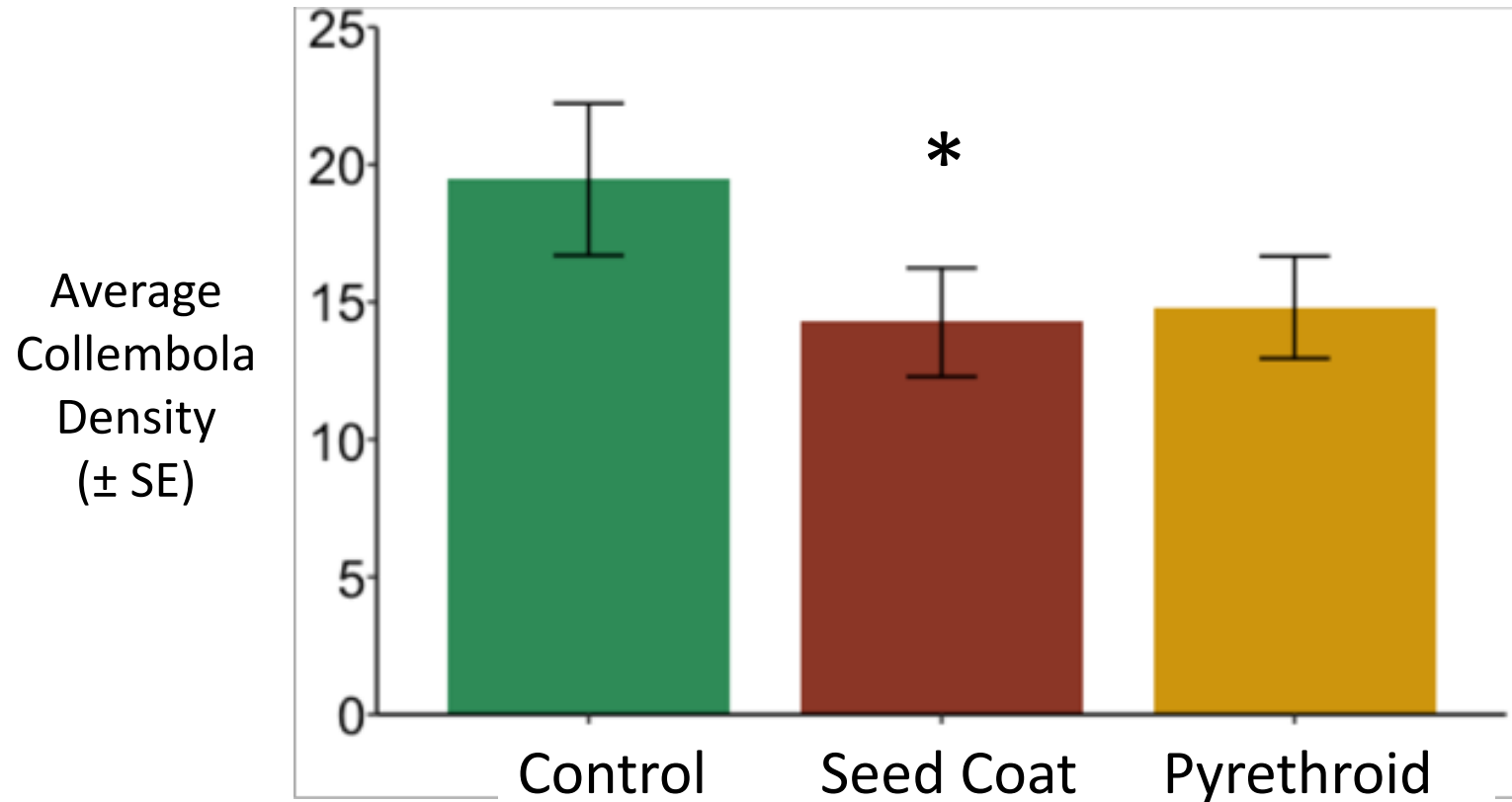


** $P < 0.0001$
* $P < 0.05$
• $P < 0.1$

negative binomial model,
Treatment * collection time
N = 320



Seed coats reduces collembolan densities



$P = 0.148$

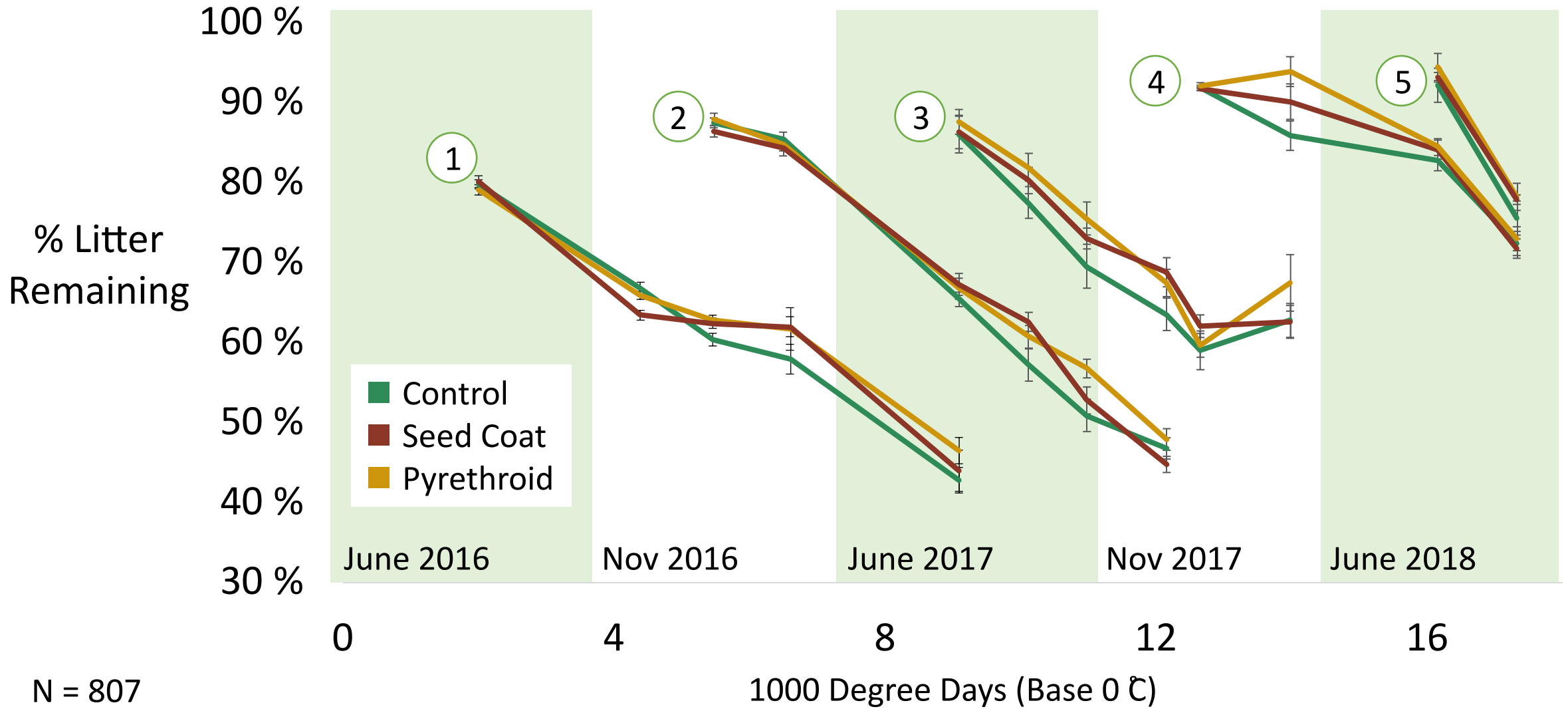
** $P < 0.0001$

* $P < 0.05$

• $P < 0.1$

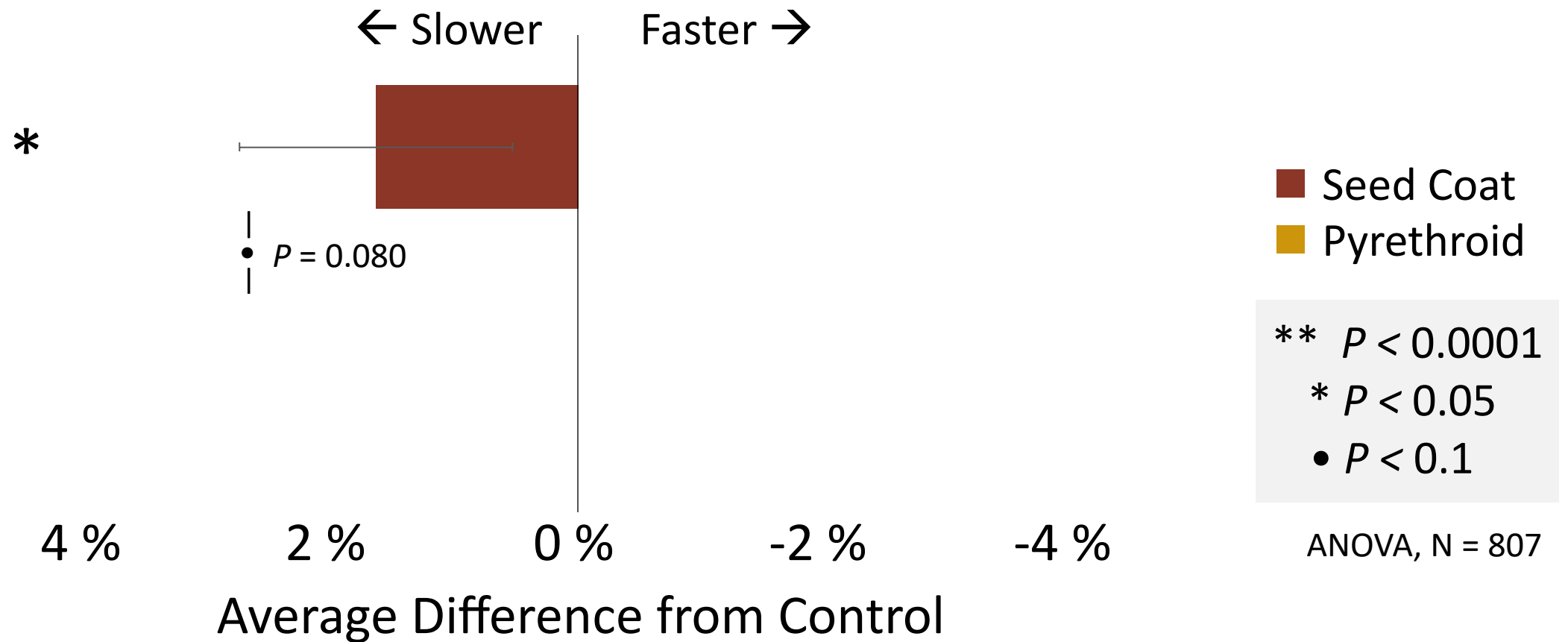
negative binomial model,
Treatment * collection time
N = 320

Decomposition: 5 batches of litterbags



N = 807

Overall, seed coats slow decomposition,
the pyrethroid more so



Decomposers / Decomposition:



How do seed coats affect surface-active decomposer activity?



Seed coats reduce collembolan densities and slows decomposition

How do these effects compare to alternative insecticides?



Pyrethroids significantly reduce millipede & mite densities, further slows decomposition

The Epigeal

(Surface-active)

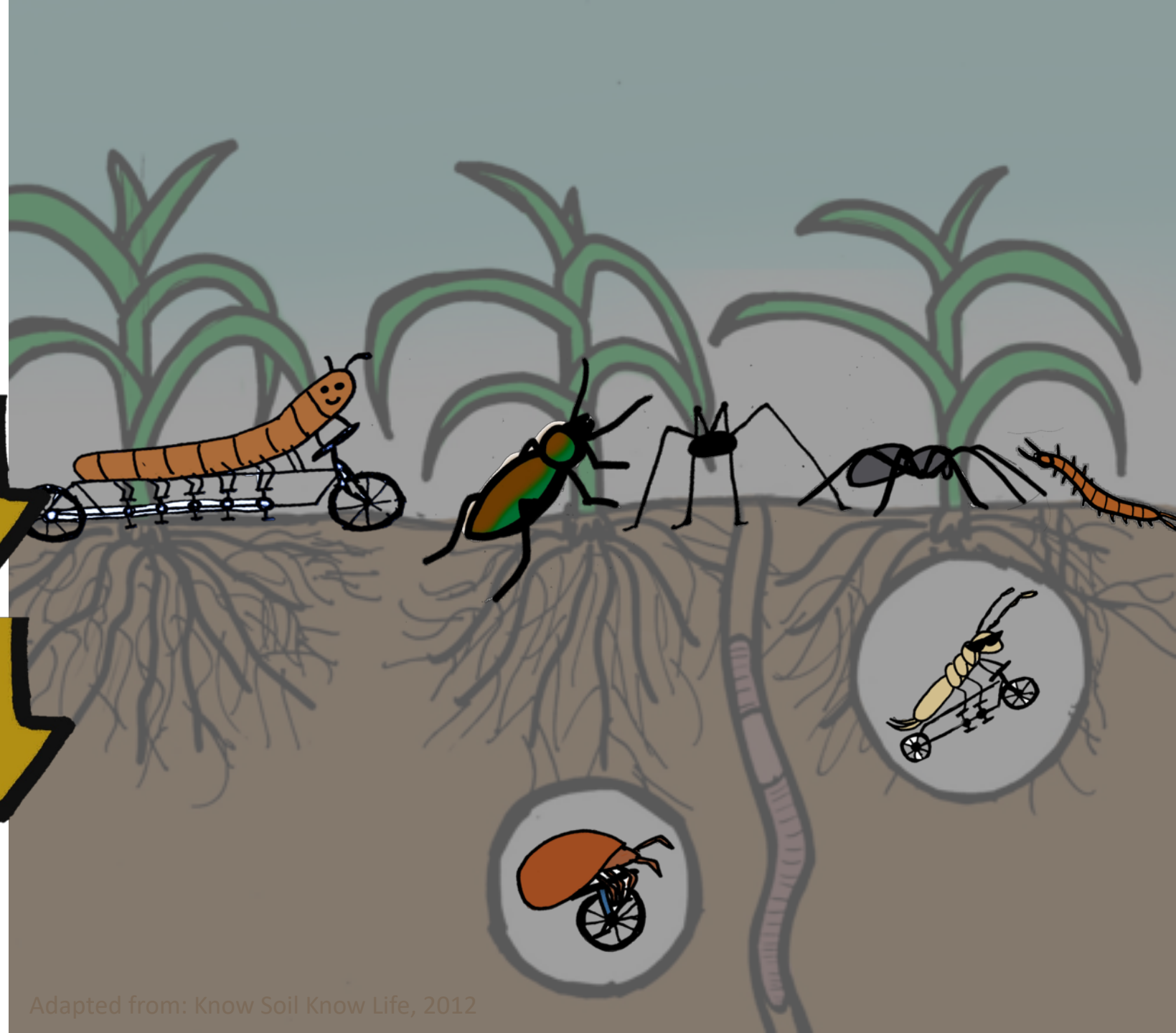
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Soil Fertility



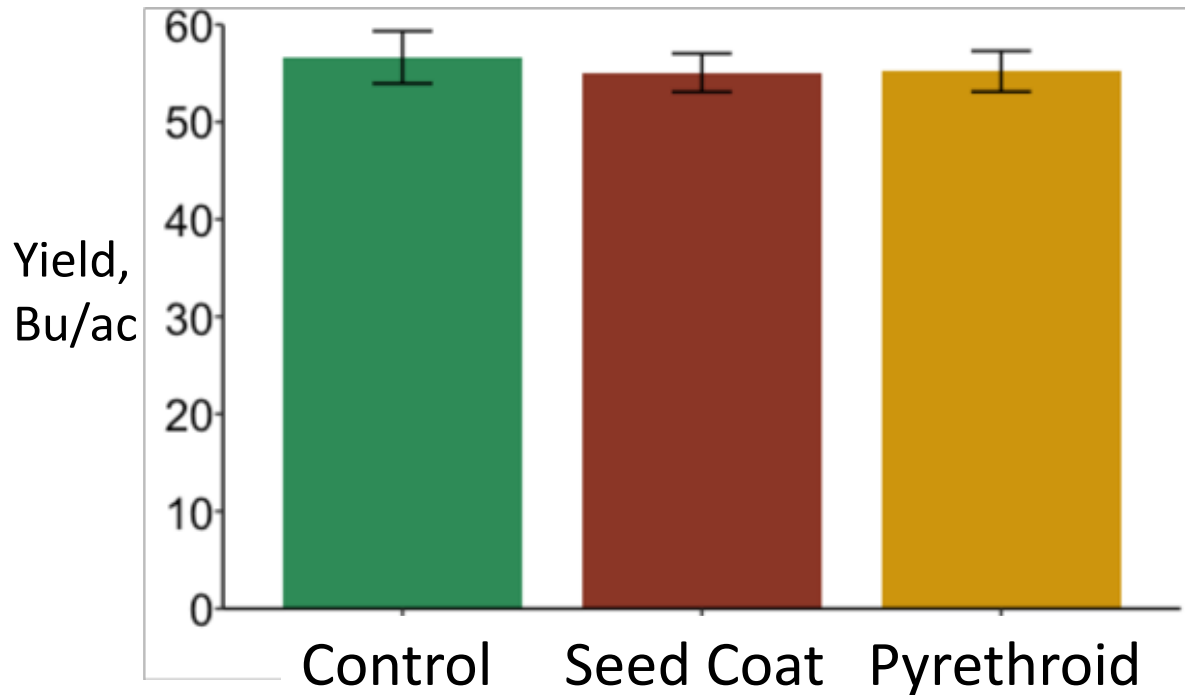
Alternatives may have more negative effects than neonicotinoid seed coats

So neonicotinoids may be a better choice when chemical control is warranted

However ...

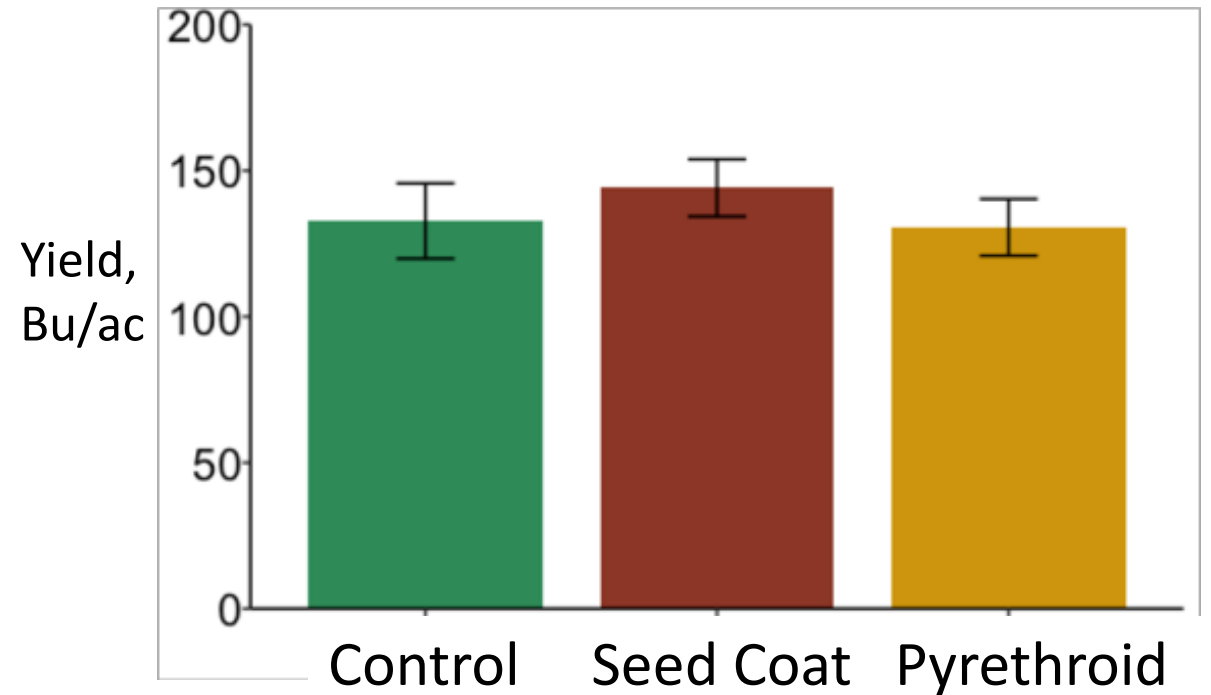
No yield advantage to either insecticide in Pennsylvania field crops

Soy Yield, 2016



$P = 0.863$
N = 18

Corn Grain Yield, 2017



$P = 0.651$
N = 18

Further concern about the over-use of neonicotinoid seed coats in North America

Little to no benefit in soybeans
Benefit in maize depends on region

(EPA Memo, 2014; North, 2018; Alford and Krupke, 2018)

Seed coats can miss critical pest control windows

(Alford and Krupke, 2017; Krupke et al, 2017)

Up to 30% of farmers may be unaware of insecticides in their seed coats

(Hurly and Mitchell, 2014)

Challenging to get untreated corn seed
(US)

Can we fit neonicotinoid seed coats into field crop Integrated Pest Management?

Recognize neonicotinoids as a valuable tool

Determine where/when any insecticide is warranted

Make it easier to get neonic-free seeds

Determine where/when seed coats are the best option

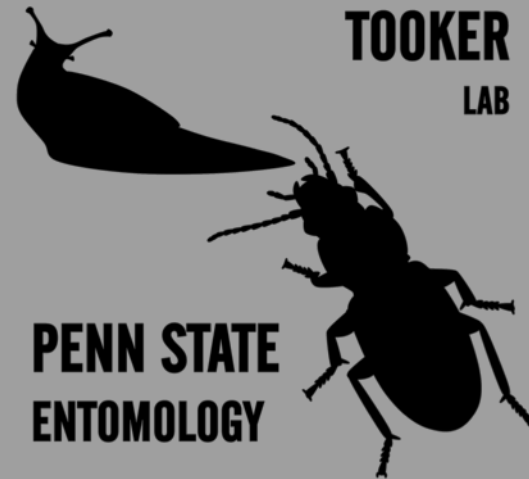
Thank you!



Corey Dillon,
Hort Farm Manager
PSU



Austin Kirt,
Ento Farm Manager
PSU



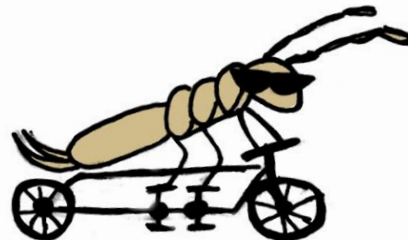
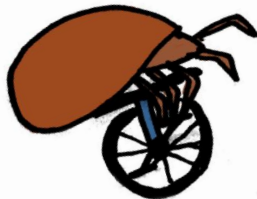
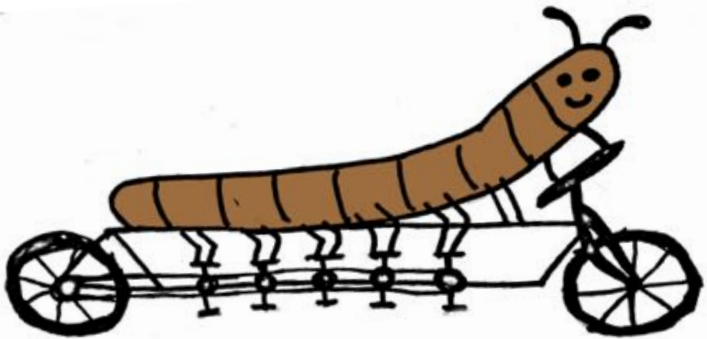
PennState
Entomology

Undergrad Interns (Tookerlings):

Hayden Bock
Jen Halterman
Kyra Hoerr
Ken Kim
Sonia Klein

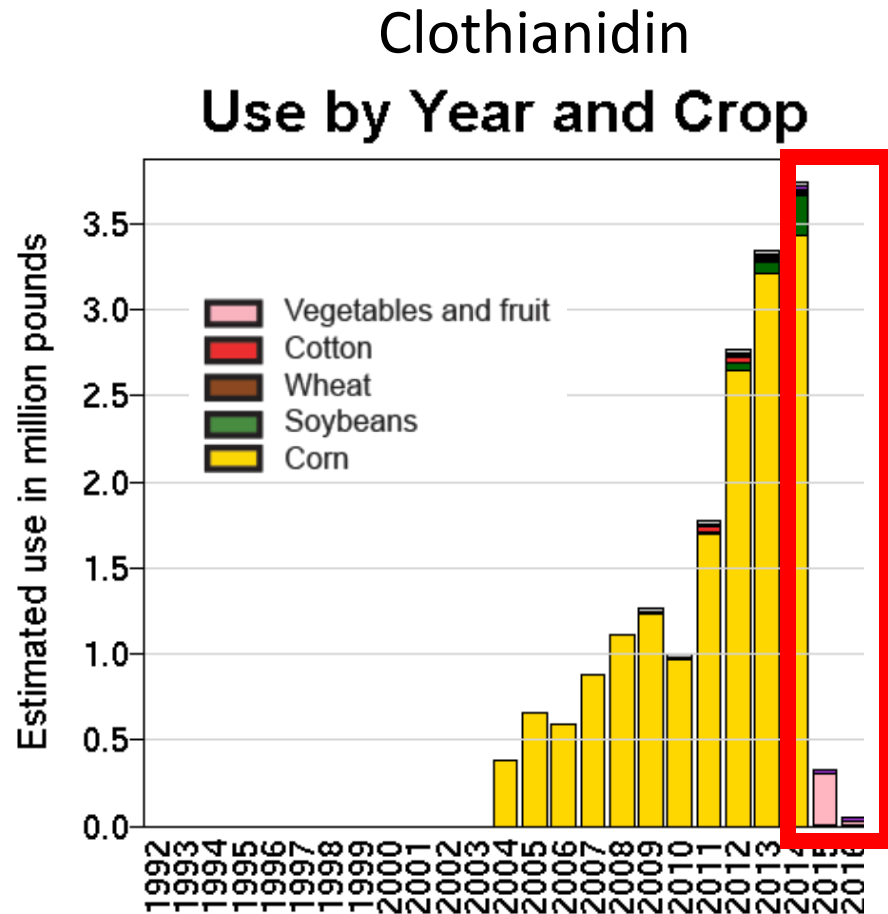
Ken Koepplinger
Garett Reiter
Amanda Seow
Dan Wisniewski

Any Questions?



“nutrient cycling”

We don't know how much AI is applied as seed treatments in North America



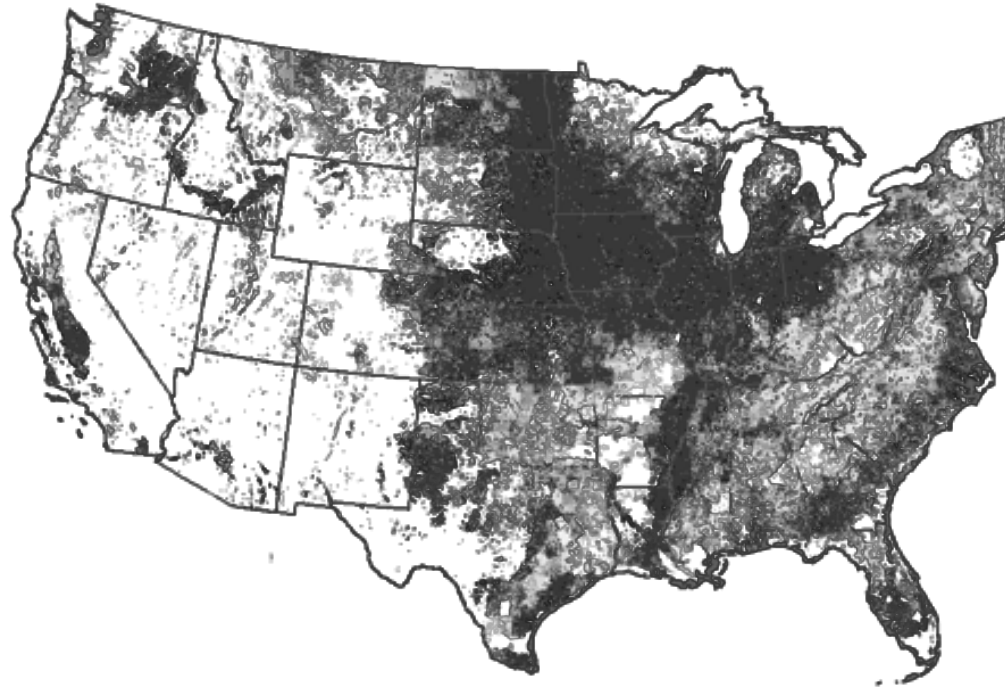
“...discontinued making estimates for seed treatment application of pesticides because of complexity and uncertainty.”

– Pesticide National Synthesis Project, USGS

“Pesticide use reporting in Canada is currently considered confidential...”

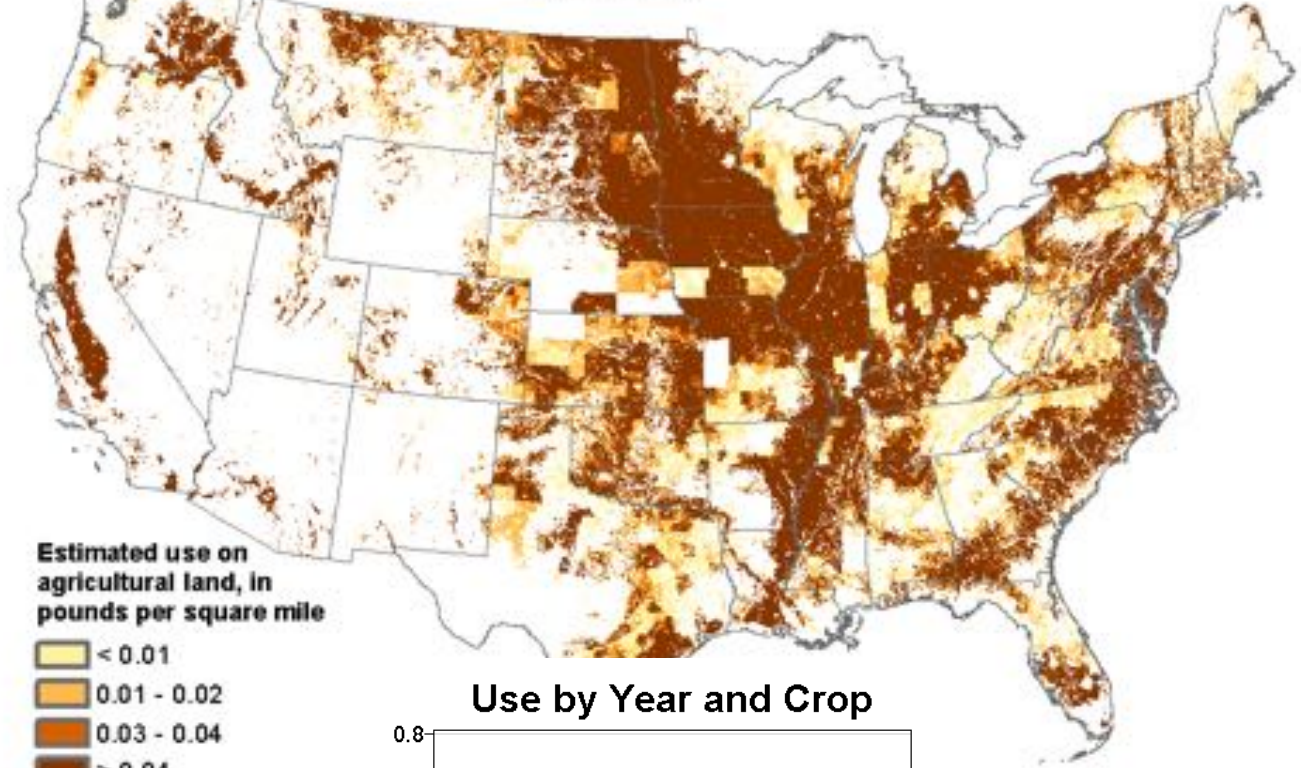
– Main et al. 2014

Neonicotinoids

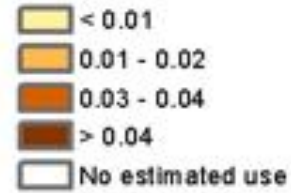


Estimated Agricultural Use for Cyhalothrin-Lambda, 2014 (Preliminary)

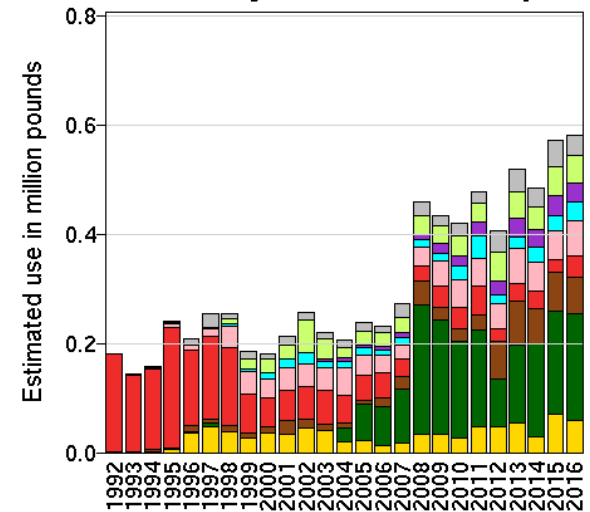
EPest-Low



Estimated use on agricultural land, in pounds per square mile



Use by Year and Crop



Validity of Litterbag Tests

Criteria:

60% mass loss in control ✓

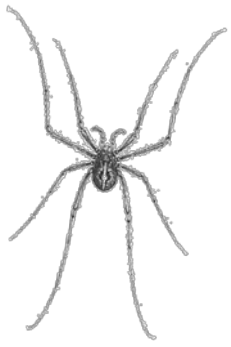
all below/nearing 60% loss

Differences of $\geq 10\%$ indicate concern ✗

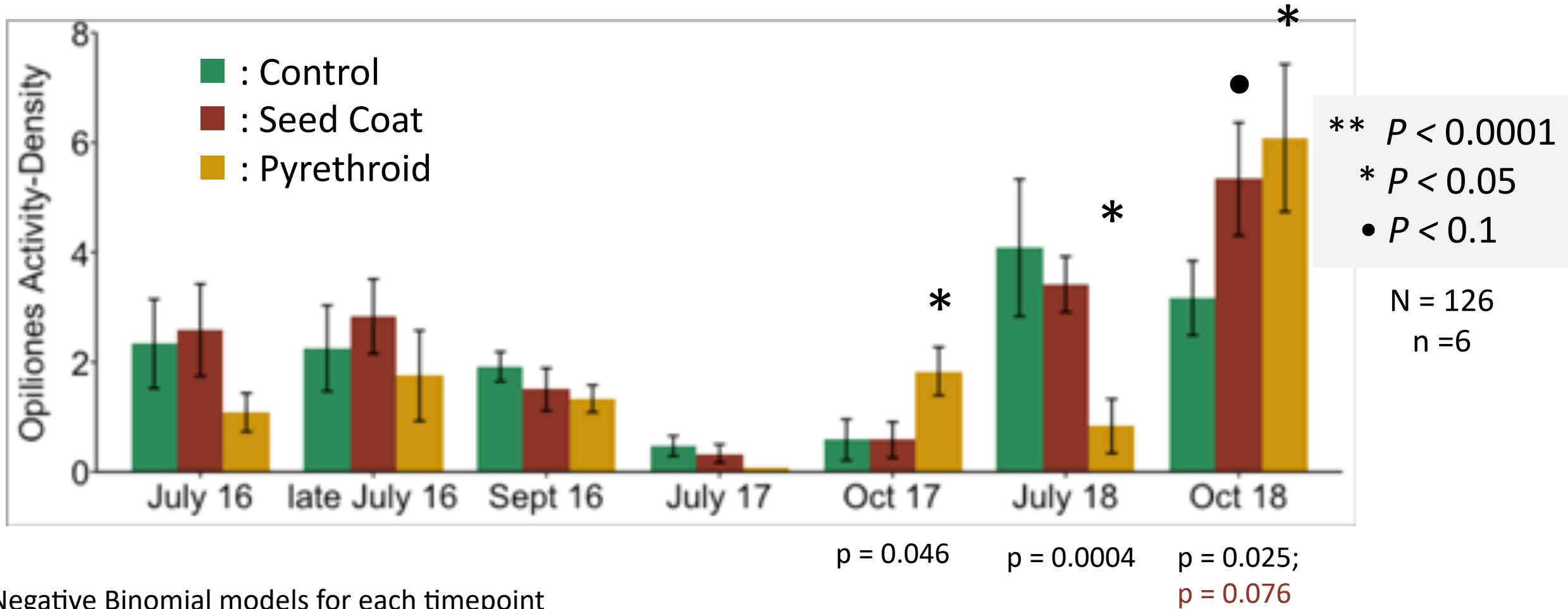
differences $< 3\%$

Recovery indicates acceptable risk ✓

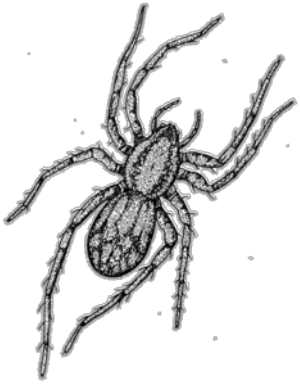
treatments converge



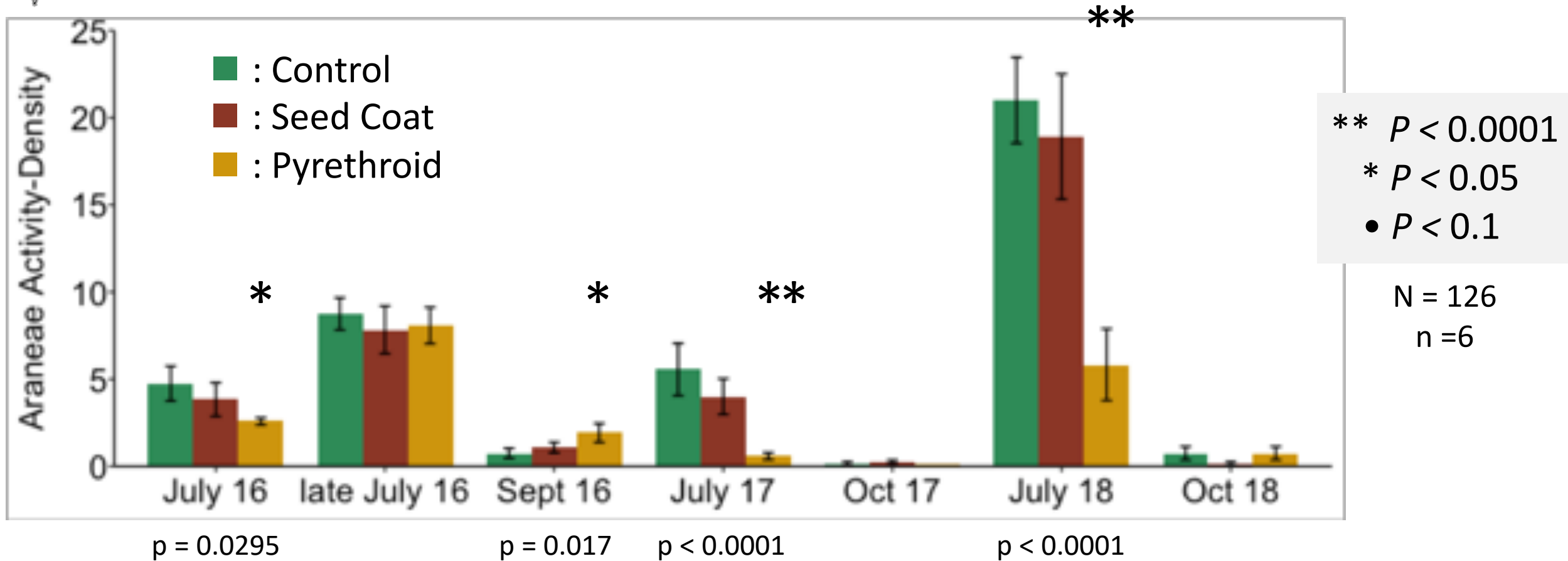
Pyrethroid decreases harvestmen activity-densities in July, but increases in October



Negative Binomial models for each timepoint



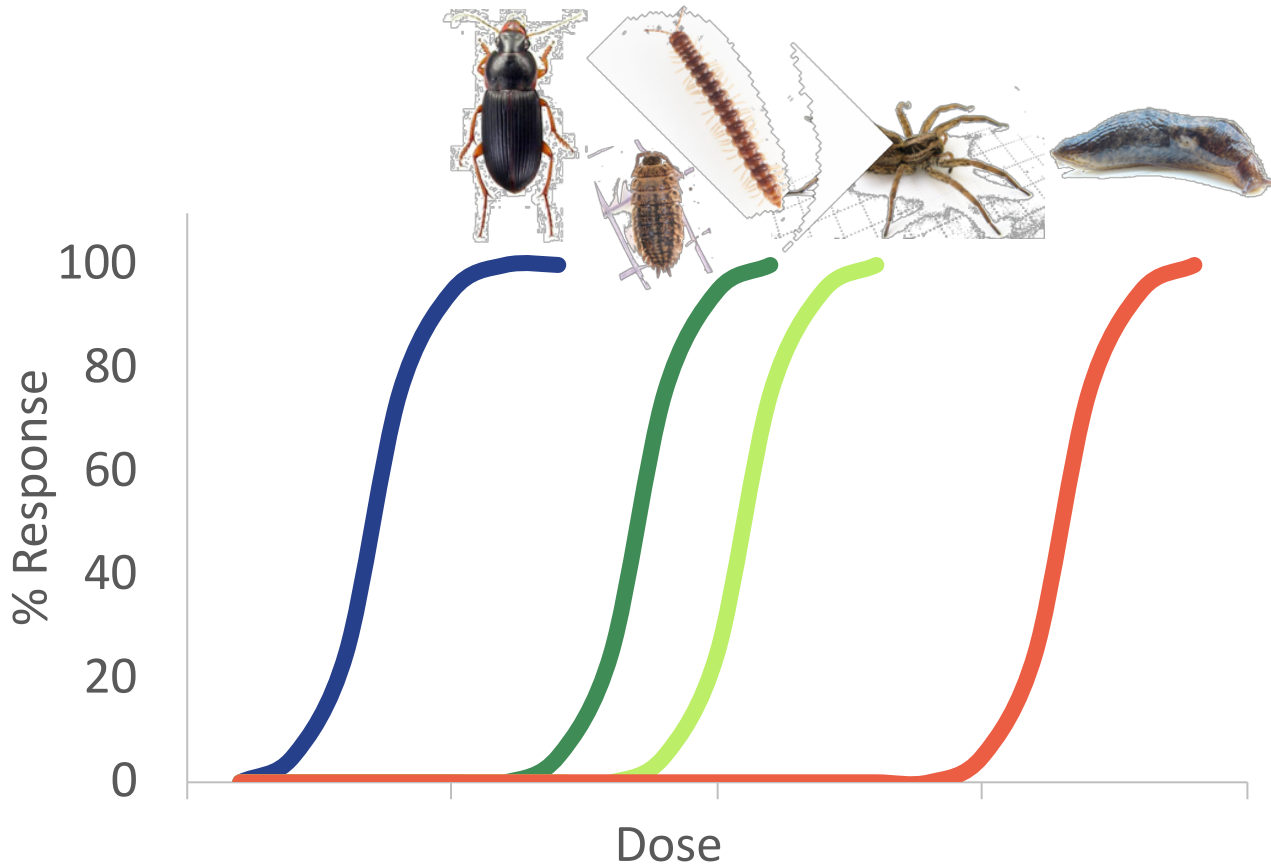
Similar trend with spider activity-densities



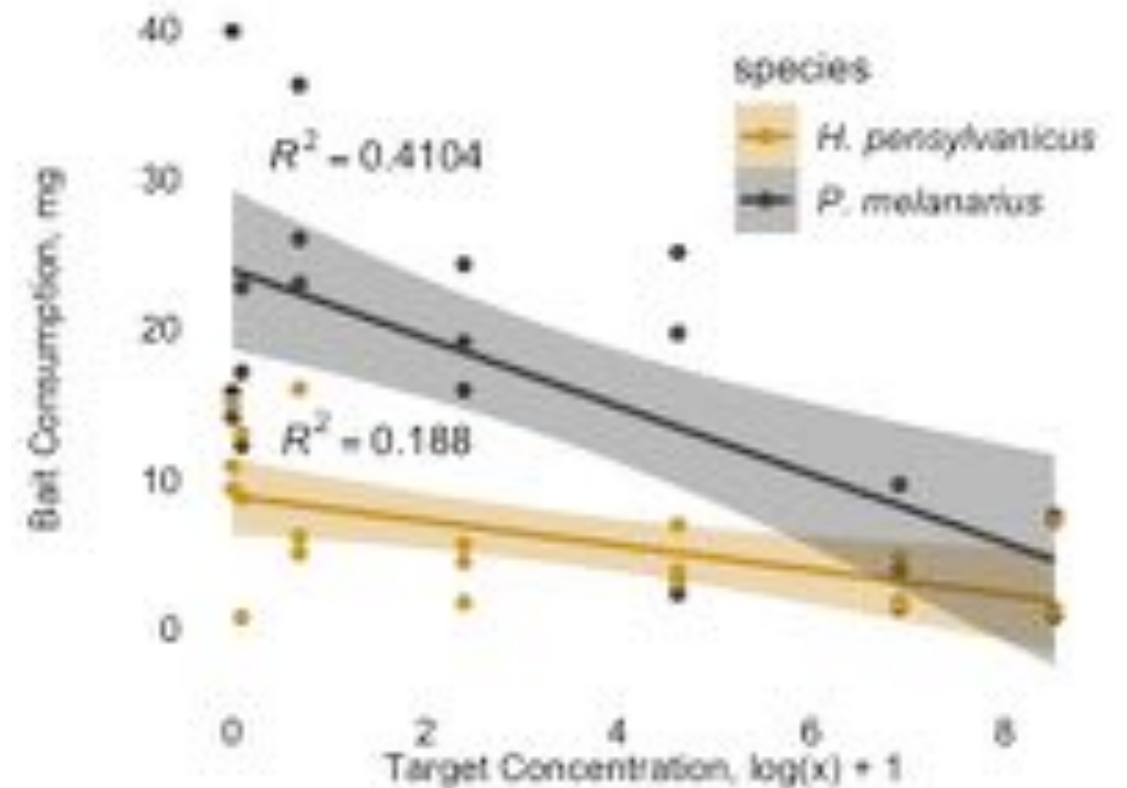
Negative Binomial models for each timepoint

Continued Work – Toxicity assays

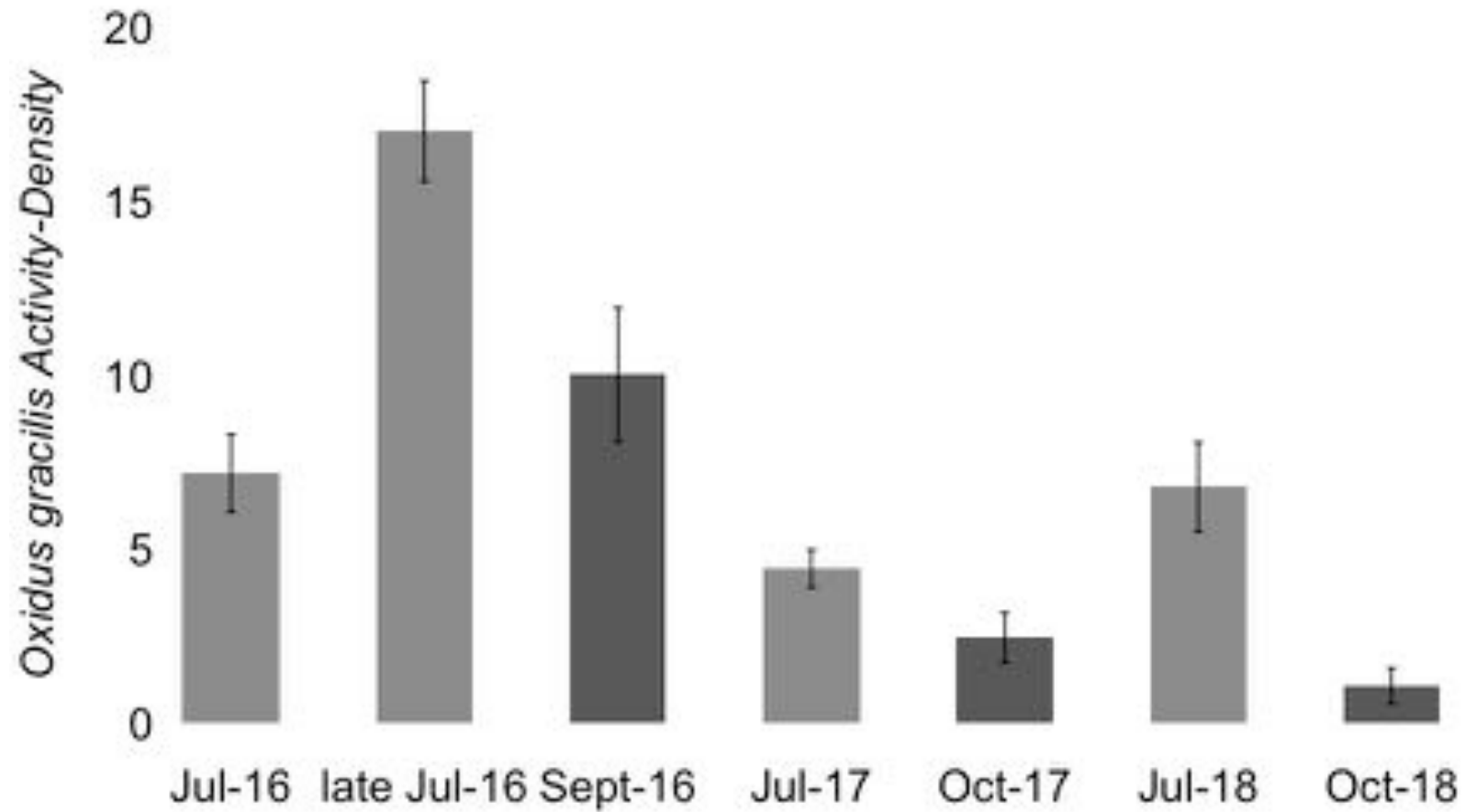
Predicted Neonic Dose Response



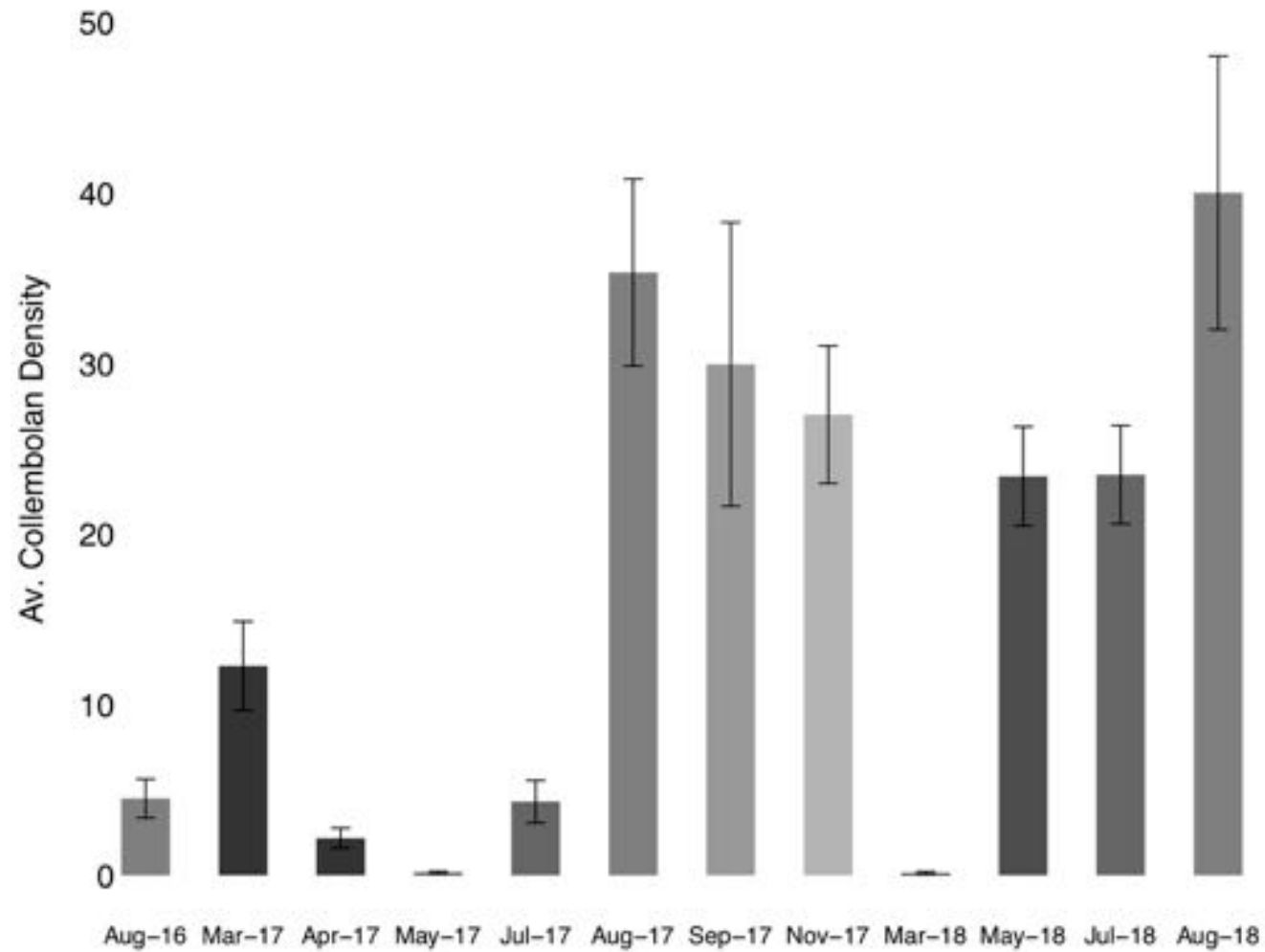
Clothianidin decreases carabid feeding



Millipedes over time



Collembola over time



Mites over time

