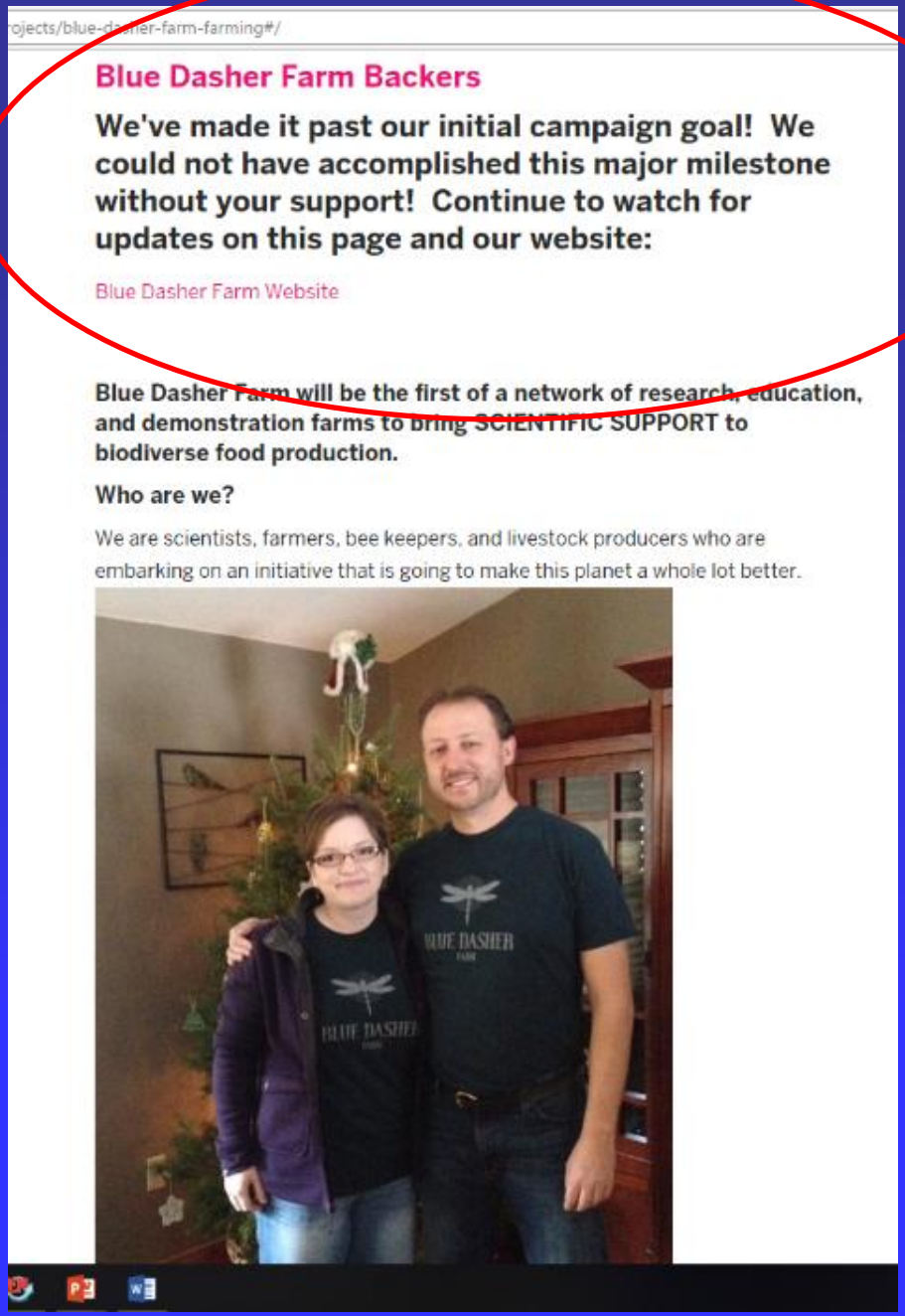
Diversity and Pest Management

Jonathan Lundgren
Ecdysis Foundation
Blue Dasher Farm

The Blue Dasher Farm Initiative

A national network of centers for excellence in Regenerative Agriculture



Research with No-strings Attached

Start up funds were provided by beekeepers, farmers, and supporters from all over the world

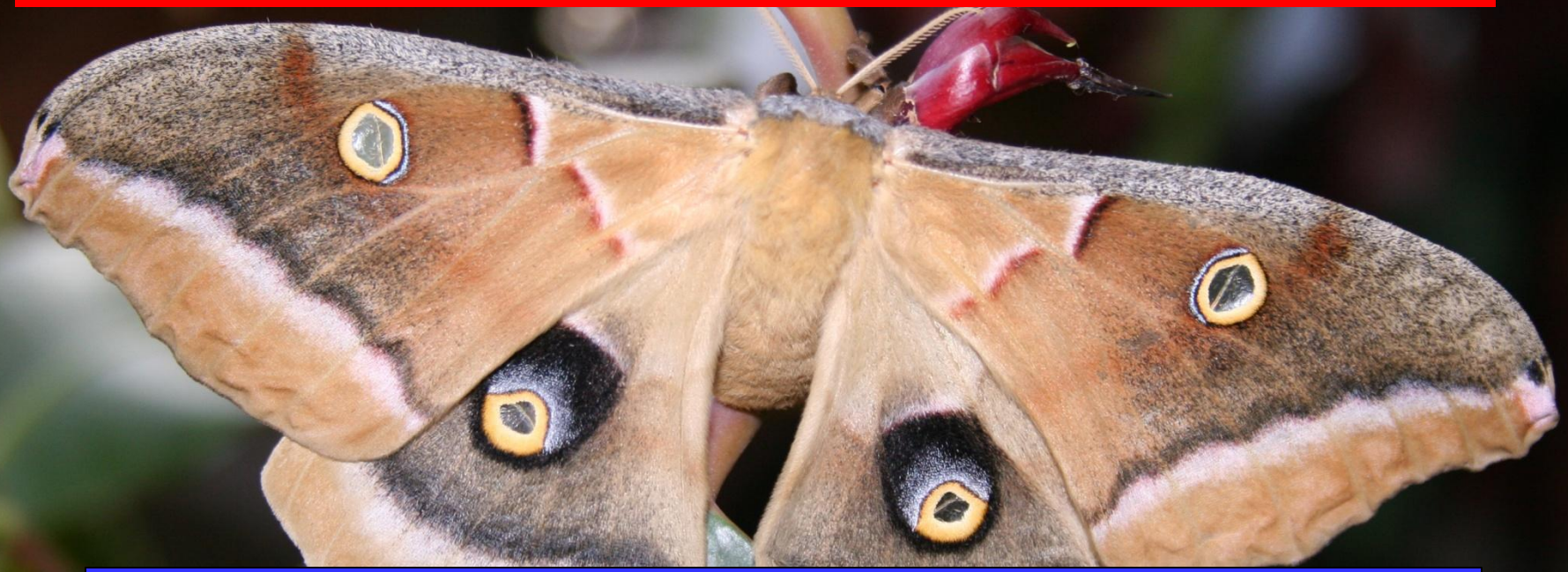
Goals

Scientific research to remove barriers for farmers

Education: training the next generation of scientists and farmers in regenerative principles

Demonstrating regenerative principles

Insect Diversity on Earth



Insects are the most diverse animals on the planet!

For every pest species, there are 1,700 species that are either beneficial or that we simply don't understand

The Benefits of Insects

The basis of complex food webs

Support wildlife

Pollination

A major component of human diets

Return nutrients to the soil (dung beetles, decomposers)

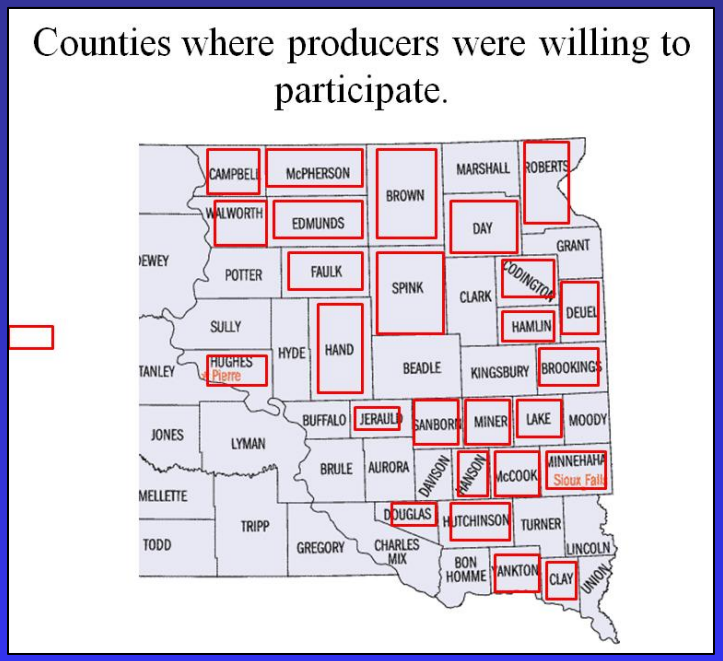
Regulate herbivores (predators, parasitoids)

Shape the dispersion and density of plant communities (herbivores, granivores)

Agroecosystems are an Important Source of Insect Diversity

2010-2011
Sampled 53 farms in Eastern SD

Lundgren et al. Journal of Applied Entomology, in press



More than 10 acres

Non-Bt corn

~~No insecticides~~

Err….minimal insecticides

South Dakota Corn Insect Survey

107 “insect” species found (just in the canopy)

7% were primary pests (none at economically damaging levels)

13% have some impact on corn

Natural Enemies

In SD field corn
2010
4.58 ± 0.39 predators per plant

2011
5.36 ± 0.60 predators per plant

137,000- 161,000 predators per acre in the corn canopy

If We Have All of These Predators, Then Why Are There Still Pests?

This is Not Enough Species!!!

What kind of diversity *used* to be in farmland?

Is There Reduced Biodiversity in Cropland?

Characterized the plant and insect communities in:

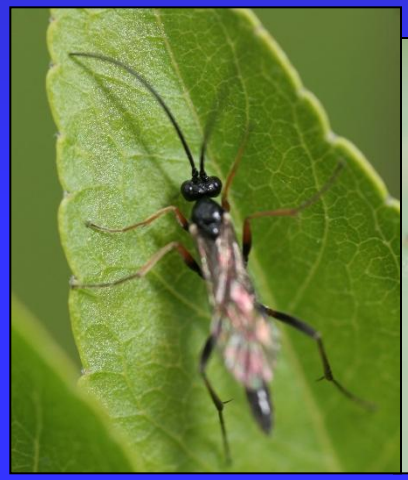
1) Prairies (n = 3)
2) Pastures (n = 3)
3) Cornfields (n = 3)

Ryan Schmid, MSc

Schmid, Lehman and Lundgren. Reductions in local biodiversity curtail gut microbial symbiont communities within a beneficial insect. Submitted to Annals of ESA

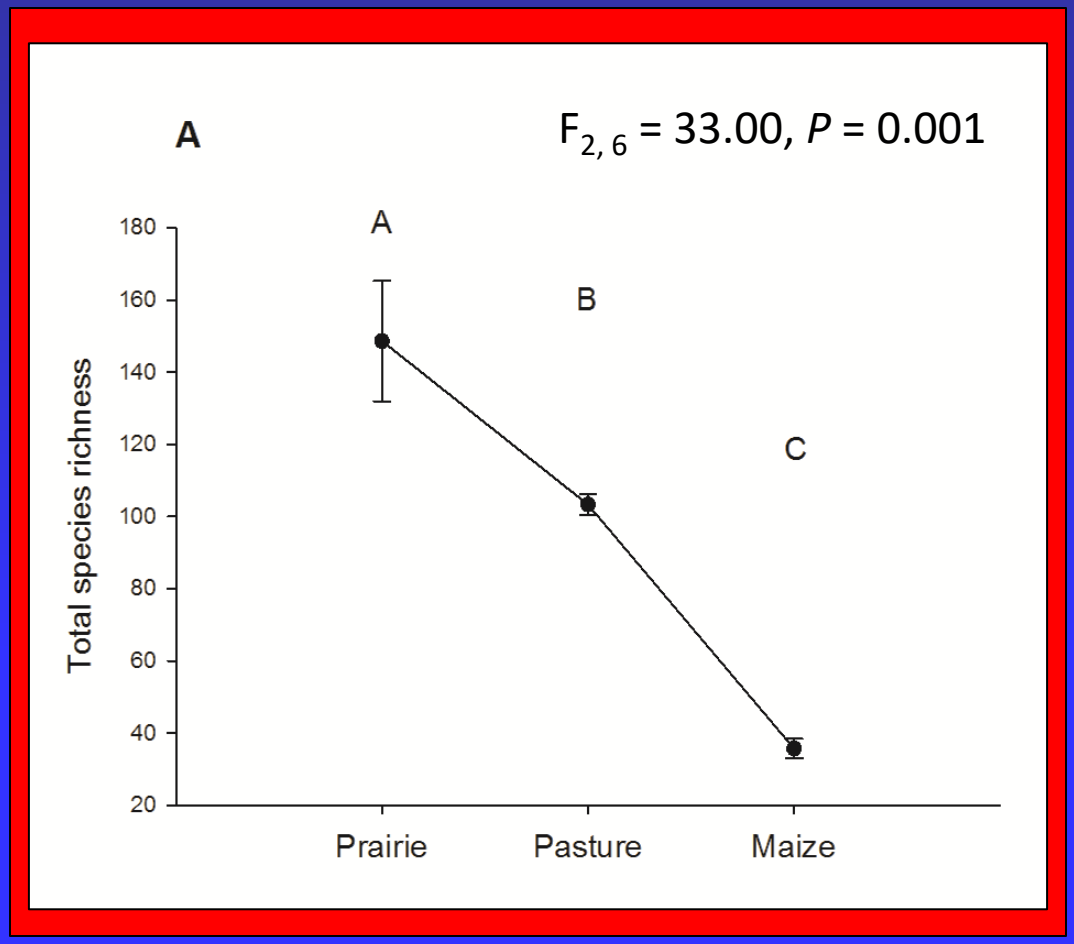
The Database

2,771 specimens representing 344 arthropod species were collected.

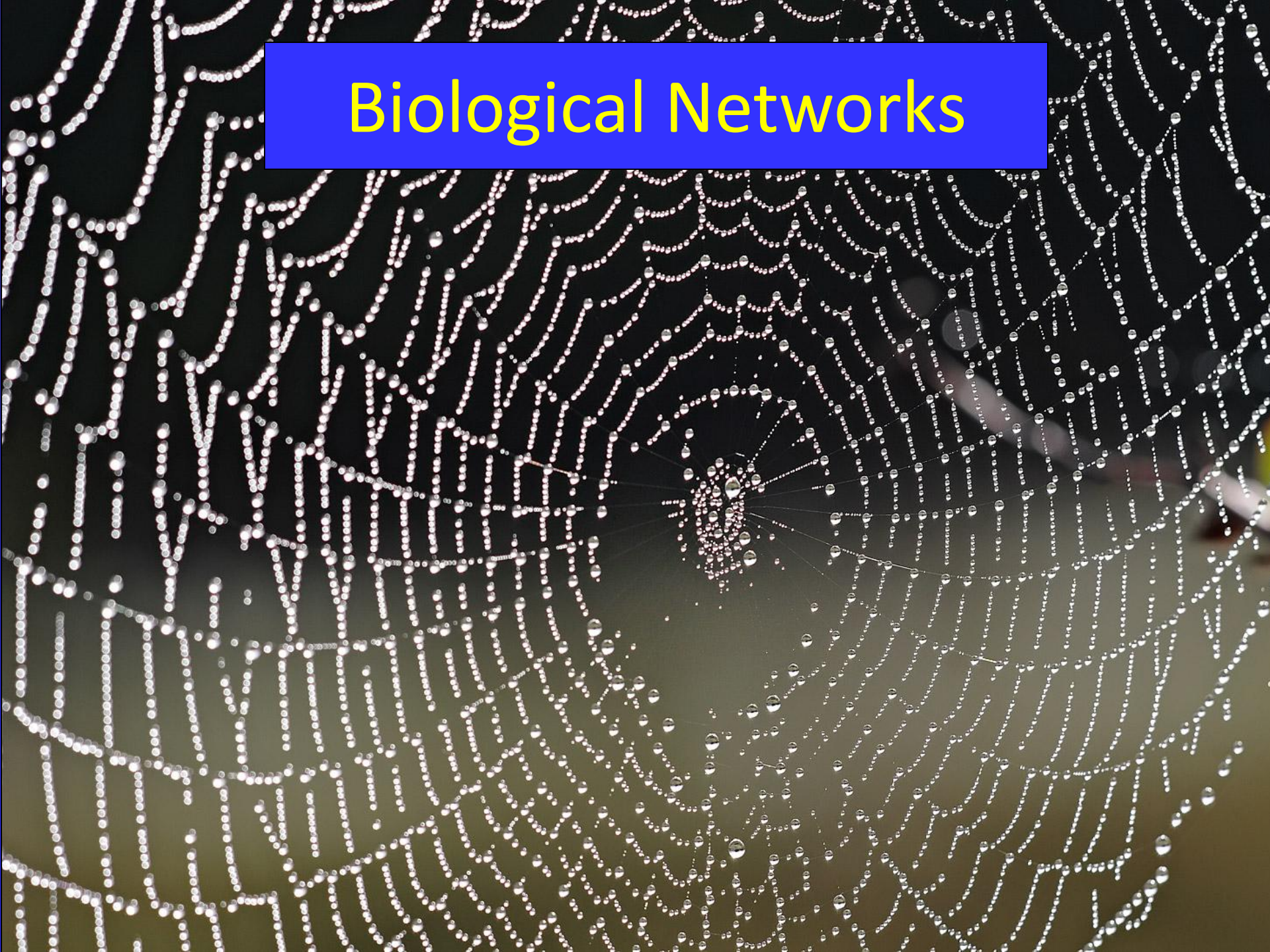


75 plant species

Corn has 24-34% of the biodiversity (plants and insects) found in more perennial habitats



Biological Networks



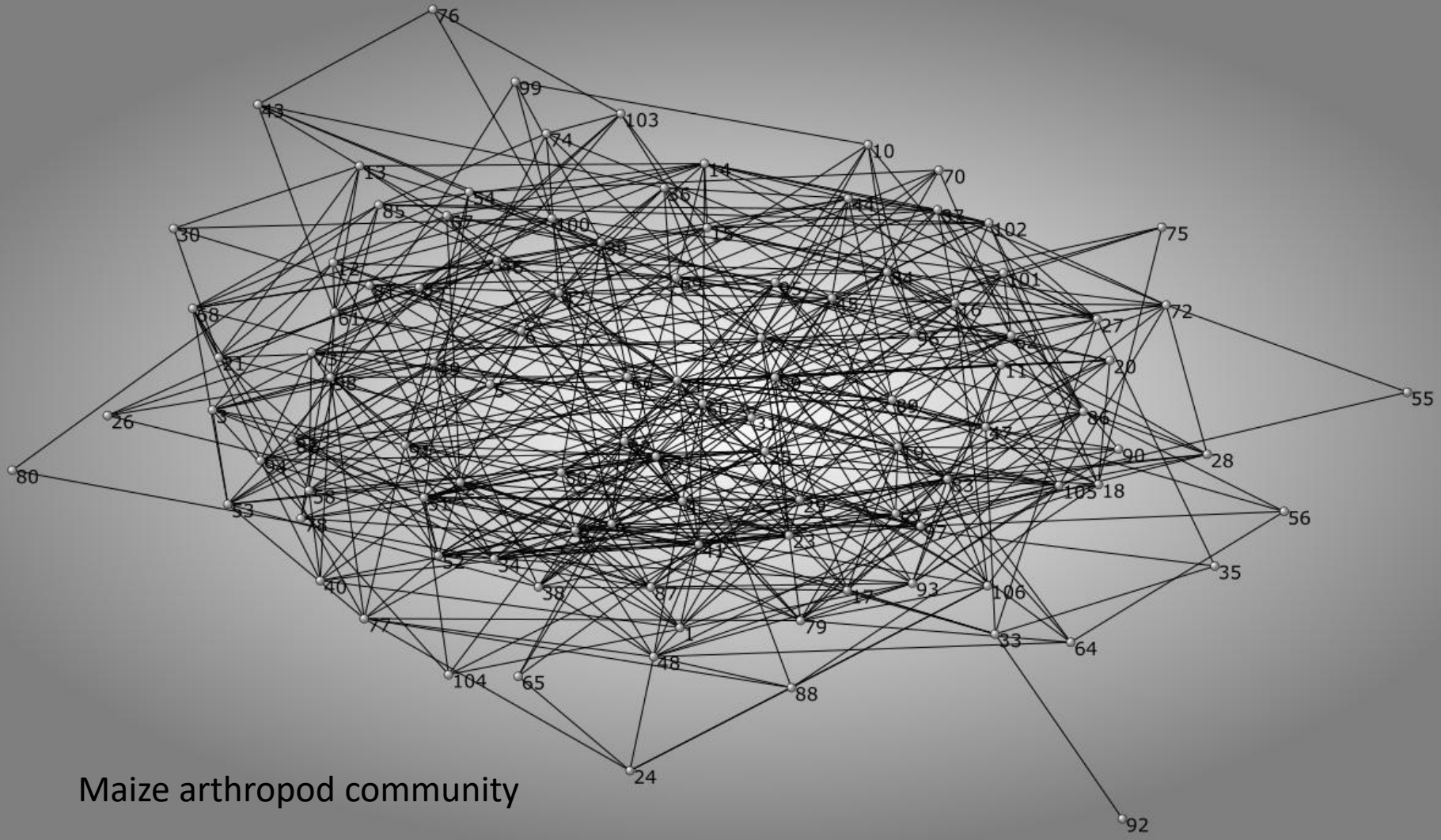
Perceptions of Biological Networks

Our understanding of species networks primarily comes from simplified systems

Crowder et al 2010. Nature 466: 109
Finke and Snyder 2008. Science 321: 1488
Tylianakis et al. 2010. Biol Conserv. 143: 2270

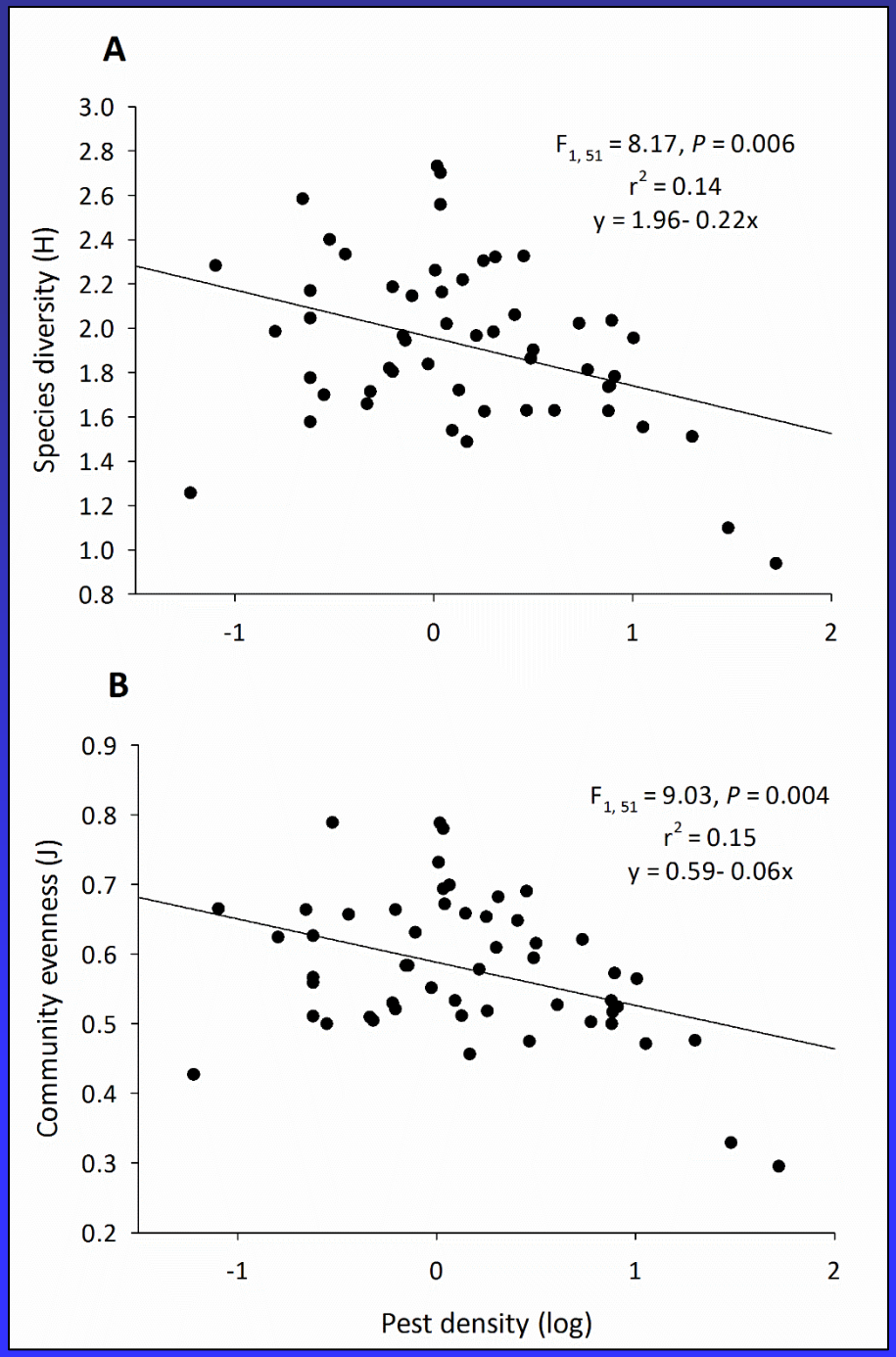
But simplified systems ignore the complexity of biological communities and their unforeseen interactions

Community Network in Agroecosystems



Maize arthropod community

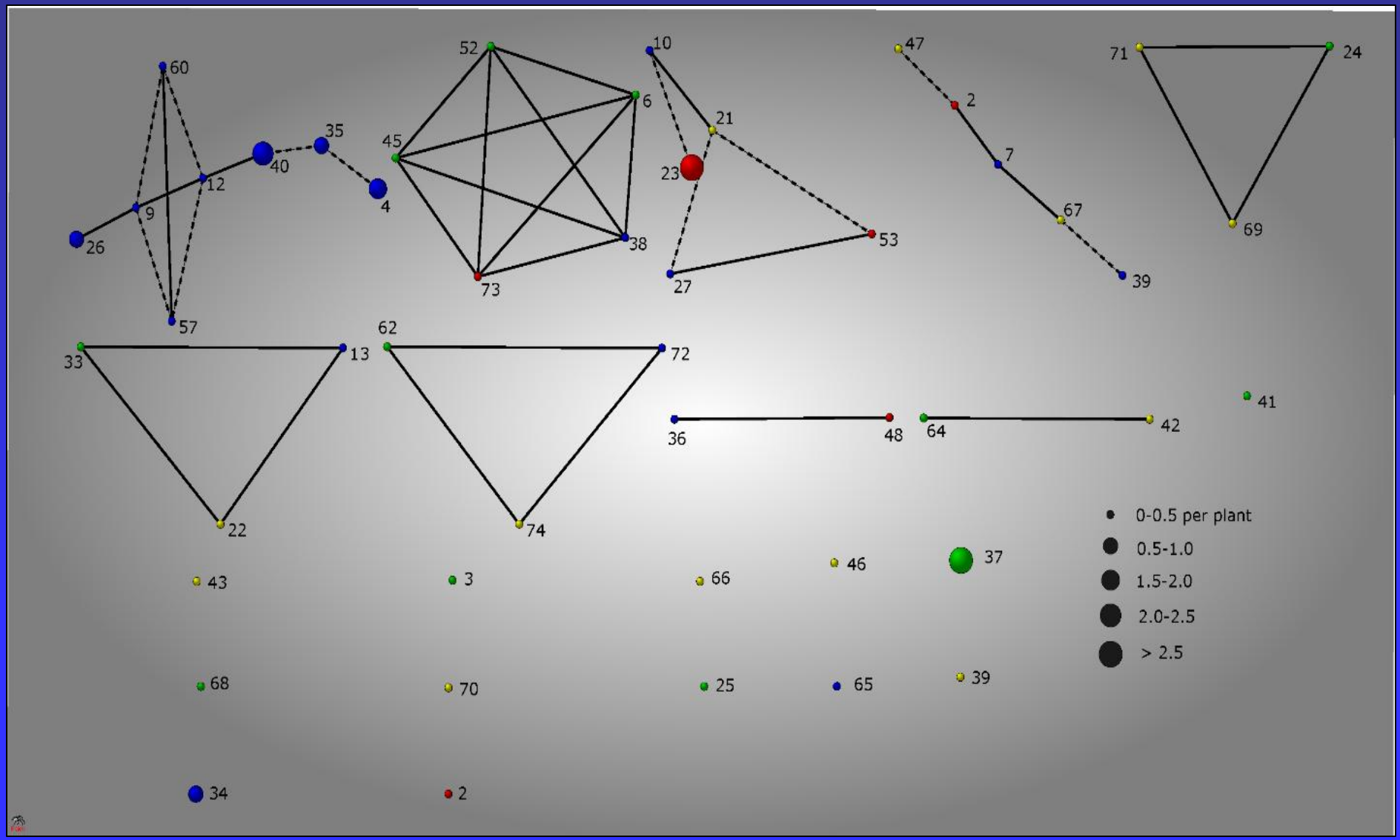
Biodiversity on Farms Reduce Pest Pressure in Corn



Lundgren and Fausti 2015. Science Advances 1: e1500558

Network Topology and Pest Abundance

High Pest Abundance



Community Structure and Pests

Biodiversity influences the magnitude of pest populations

The complexity of interactions within a community affects pest abundance

Lundgren and Fausti 2015. Science Advances 1: e1500558

How Does Biodiversity Work?

Biodiversity provides services and performs functions that can not be indefinitely replaced by technology

Predation

Predation and Managing a Pest

Corn Rootworm System

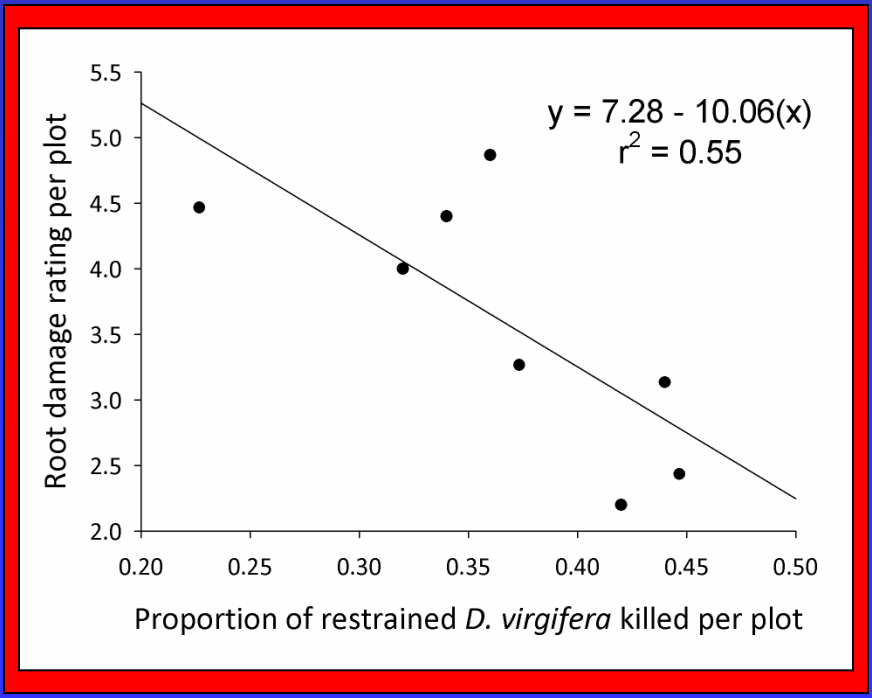
The most severe pest of corn…

- Recognized as a pest for 100 yrs
- Millions of research dollars have been spent on this pest
- When I began, I was assured that there are NO natural enemies of larval rootworms

Spencer et al. 2009. Agric For Entomol 11: 9-27
Vidal et al. 2005. Western Corn Rootworm: Ecology & Management. CABI Publishing.

Background on Rootworm Predator Communities

Root damage decreases as predation on rootworms increases



Dozens of predators have been identified using gut analysis

Lundgren et al. 2009. Biocontrol Science and Technology 19(3): 327-333
Lundgren et al. 2009. Ecological Applications 19(8): 2157-2166
Lundgren and Fergen 2010. Environmental Entomology 39(6): 1816-1828
Lundgren and Fergen 2011. Applied Soil Ecology 51: 9-16

Field Study to Examine Predator Diversity and Rootworm Consumption

2 years; 8 fields annually

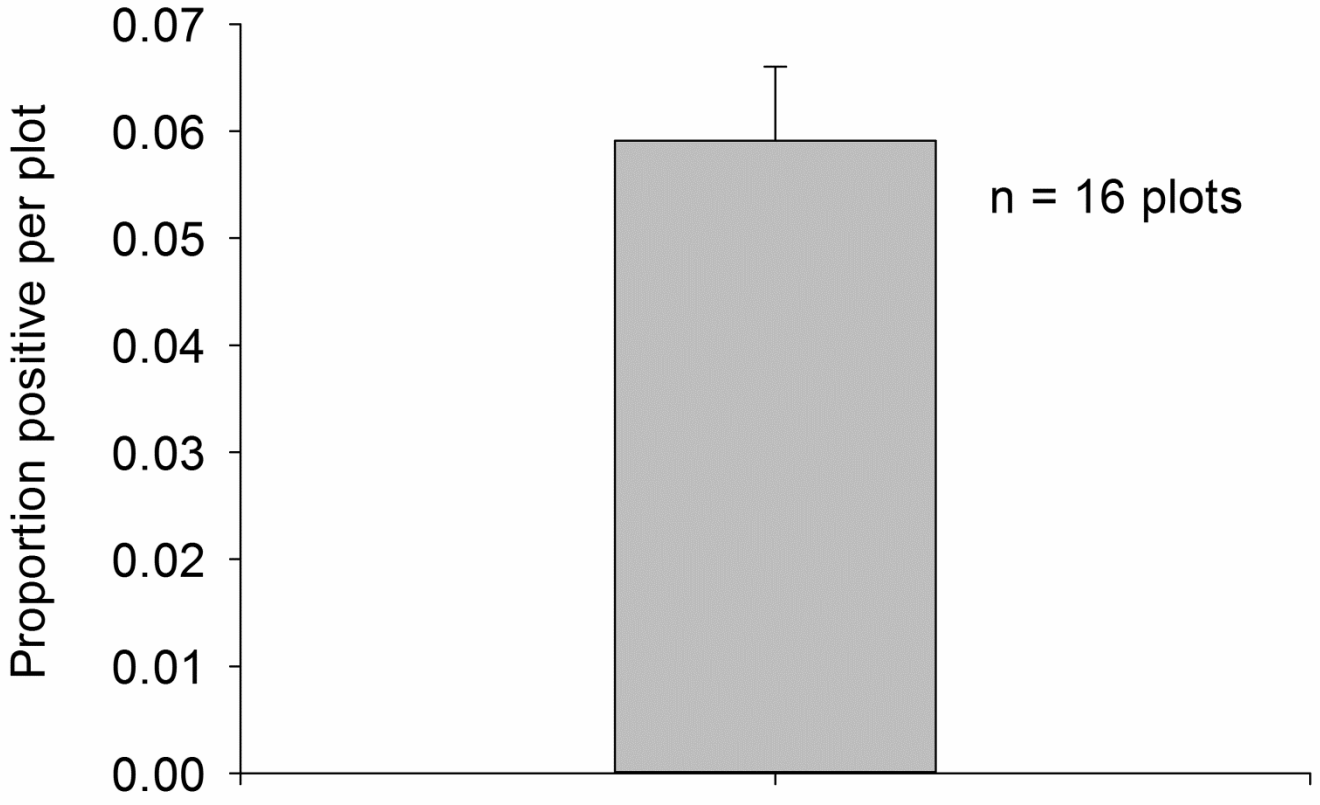
Three patches of rootworms placed in each plot

Soil cores to collect pest larvae and soil communities

Analyzed 1,980 predators using qPCR

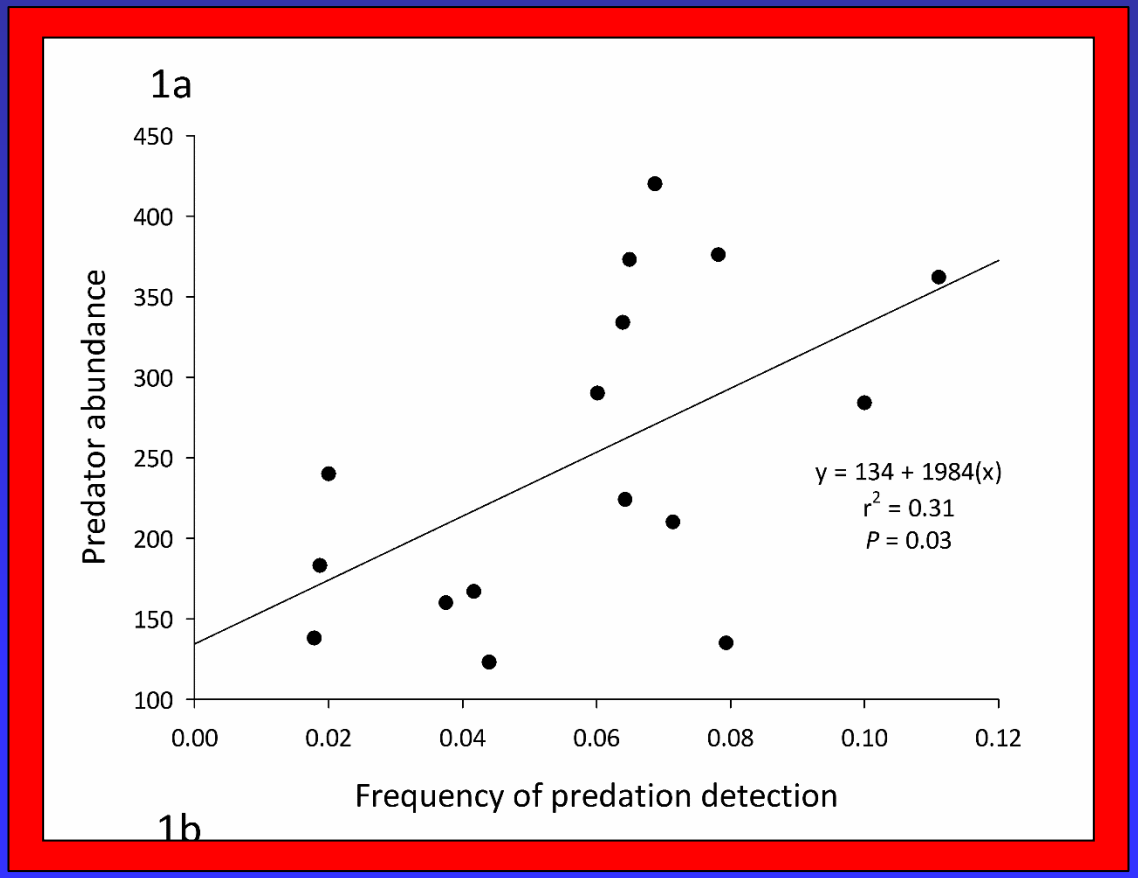
Lundgren and Fergen. 2014. Predator community structure and trophic linkage strength to a focal prey. ***Molecular Ecology 23: 3790***

What we need to know for pest management:
How does the community as a whole function?

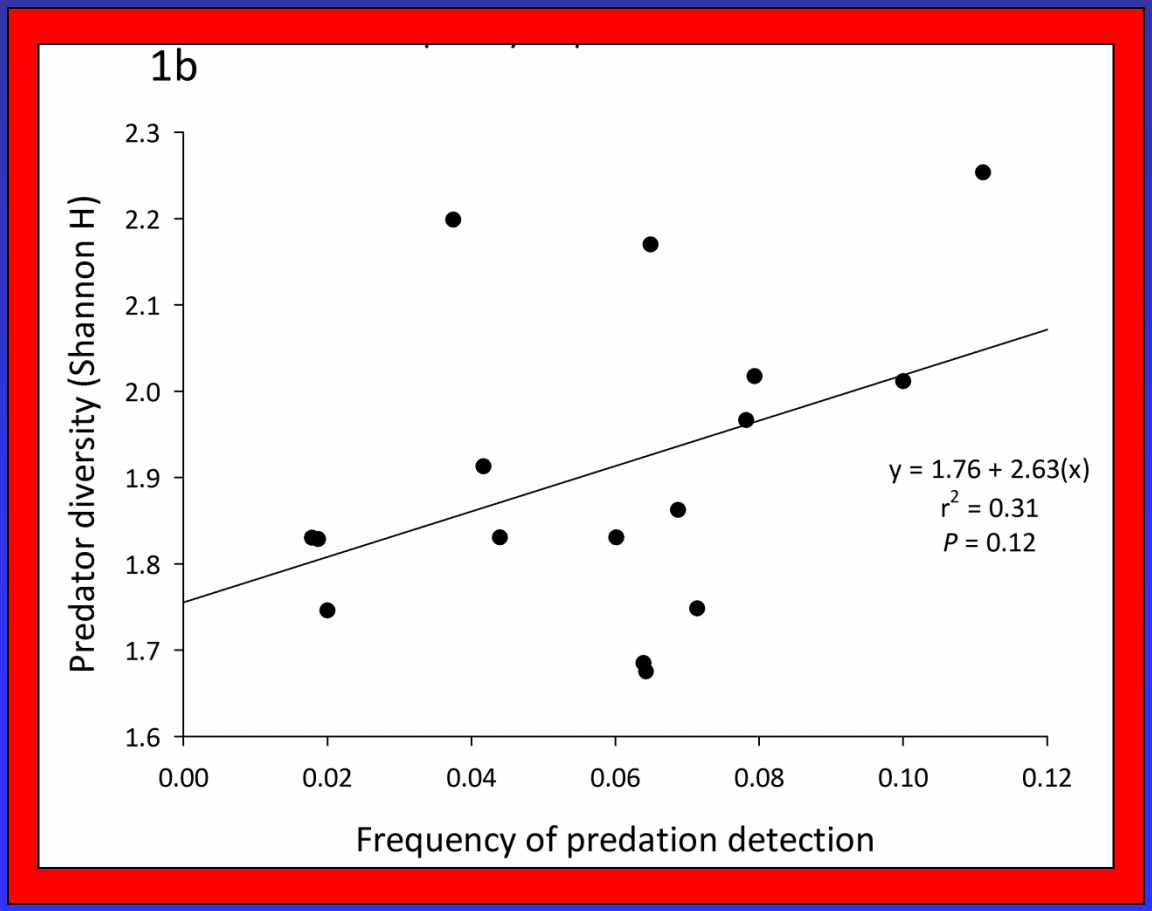


Predator Abundance and Predation on Rootworms

As total predators became more abundant, they consumed rootworms more frequently



Predator Diversity and Predation on Rootworms



As the predator community became more diverse, they fed on rootworms more frequently

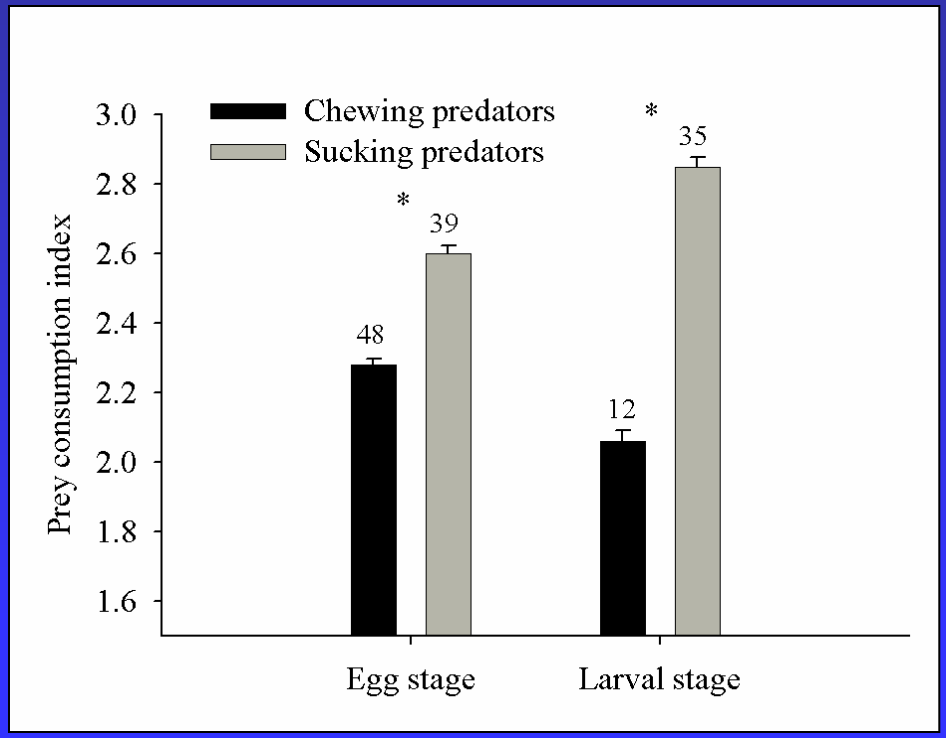
Why Do More Diverse and More Abundant Predator Communities Eat Rootworms More Frequently?

As predators become more abundant and more diverse, easy prey are the first to go.

Lundgren et al. 2009. Biocontrol Sci Tech 19: 871-880
Lundgren, Toepfer, Haye, & Kuhlmann. 2010. J. Appl. Entomol. 134: 439-448

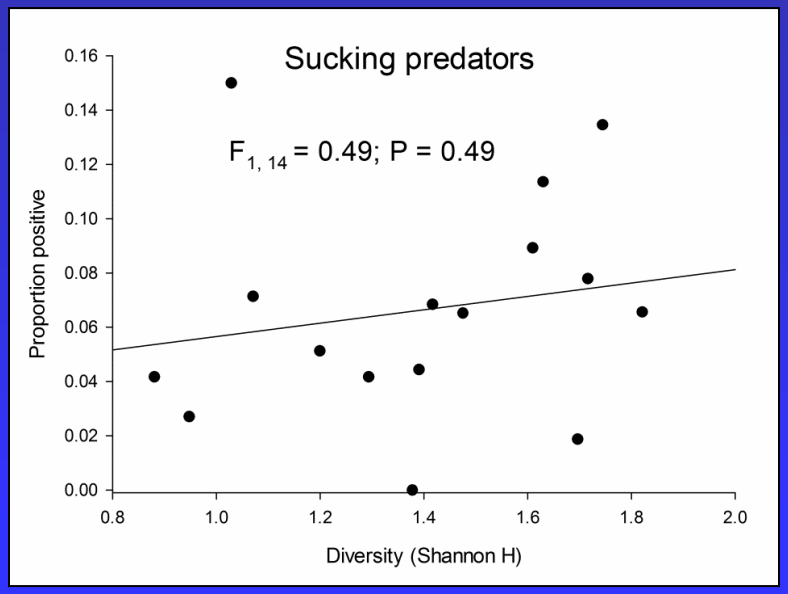
Corn Rootworms Have an Anti-predator Hemolymph Defense

Fluid feeding predators are less affected by this defense than chewing predators

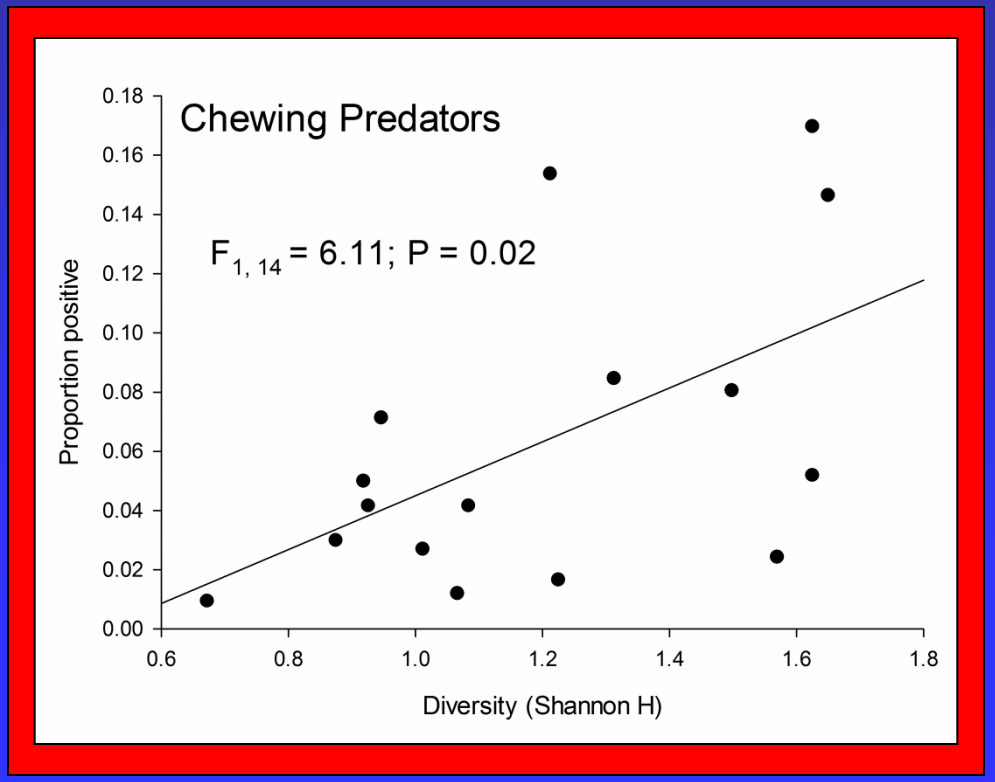


Lundgren et al. 2009. Ecological Applications 19(8): 2157-2166

Are Defense-Susceptible Predators more Affected by Predator Communities?



Sucking predators



Chewing predators

Conclusions

We need to saturate predator communities to force them to eat nasty-tasting pests

How Do We Get More Predators in Cropland?

Reduce disturbance

Increase diversity

Reduce Disturbance

We are creating an ideal environment for pests to outbreak

Increasing Diversity on Farms

Crop rotation

Intercropping

Smaller plots, more crops

Field margins

Cover crops

Weeds

Conservation strips

Letourneau et al. 2011. Does plant diversity benefit agroecosystems: a synthetic review. Ecological Applications: 21: 9-21

Cover Crops as a Pest Management Tool

Compared no-till cornfields planted with cover crops (slender wheatgrass) to those with bare soil

Pest Populations

Root ratings

Lundgren and Fergen 2010. Environmental Entomology 39(6): 1816-1828
Lundgren and Fergen 2011. Applied Soil Ecology 51: 9-16

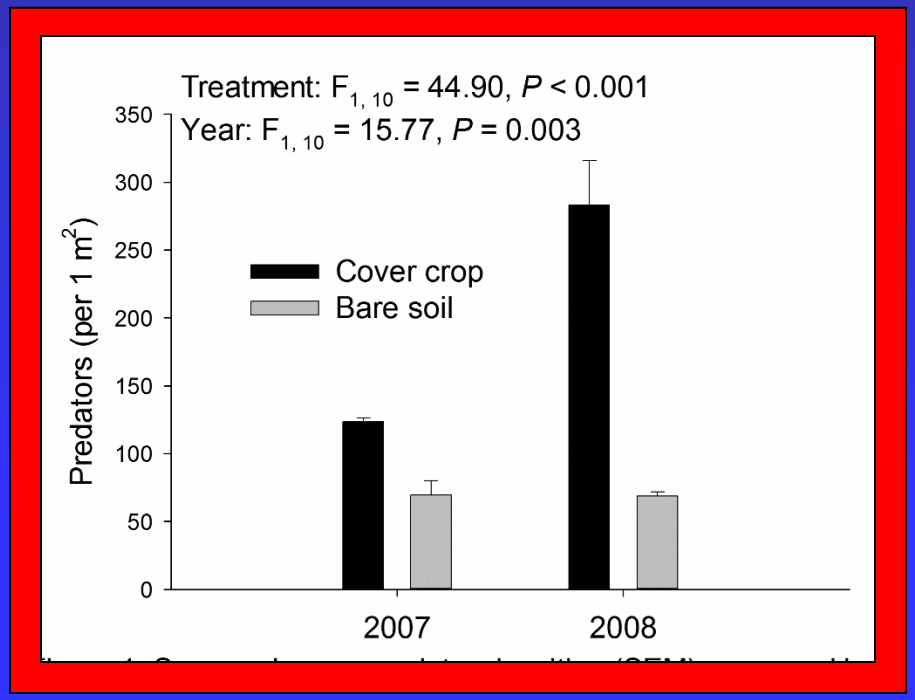
Sampling

Quadrats

Sentinel larvae

Effects on Predators

Significantly more predators in cover-cropped cornfields

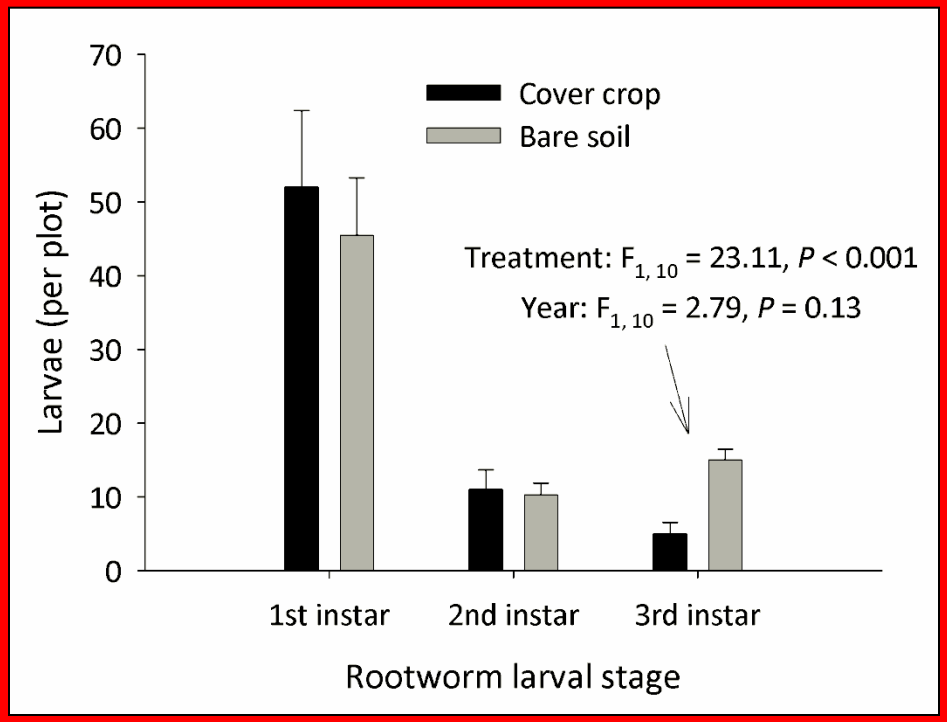


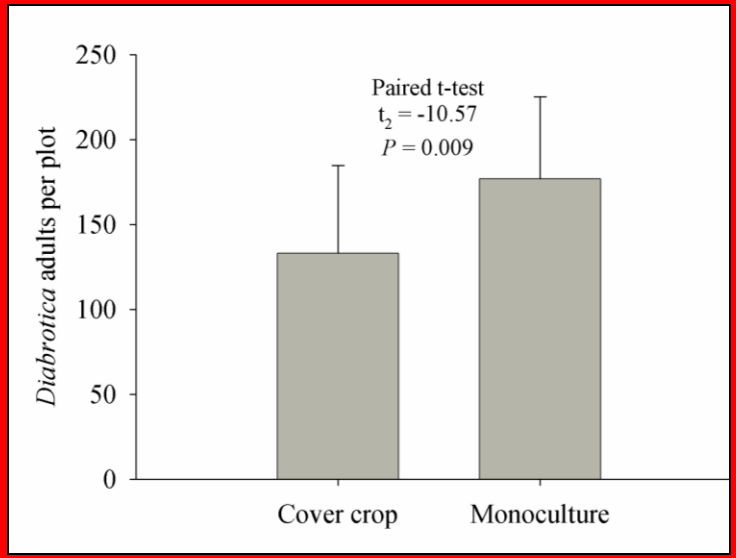
Lundgren and Fergen 2010. Environmental Entomology 39(6): 1816-1828
Lundgren and Fergen 2011. Applied Soil Ecology 51: 9-16

Effects on Rootworms

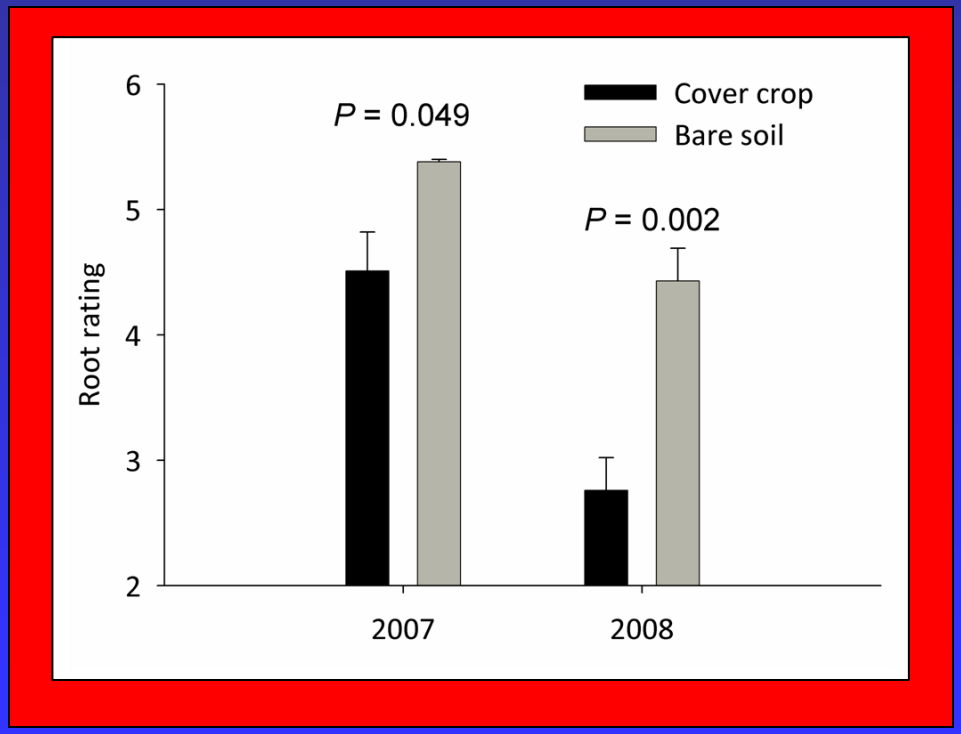
Cover-cropped cornfields had lower 3rd instar rootworm survival

…and lower adult emergence





Effects on Crop Damage



Cover-cropped fields experienced less damage

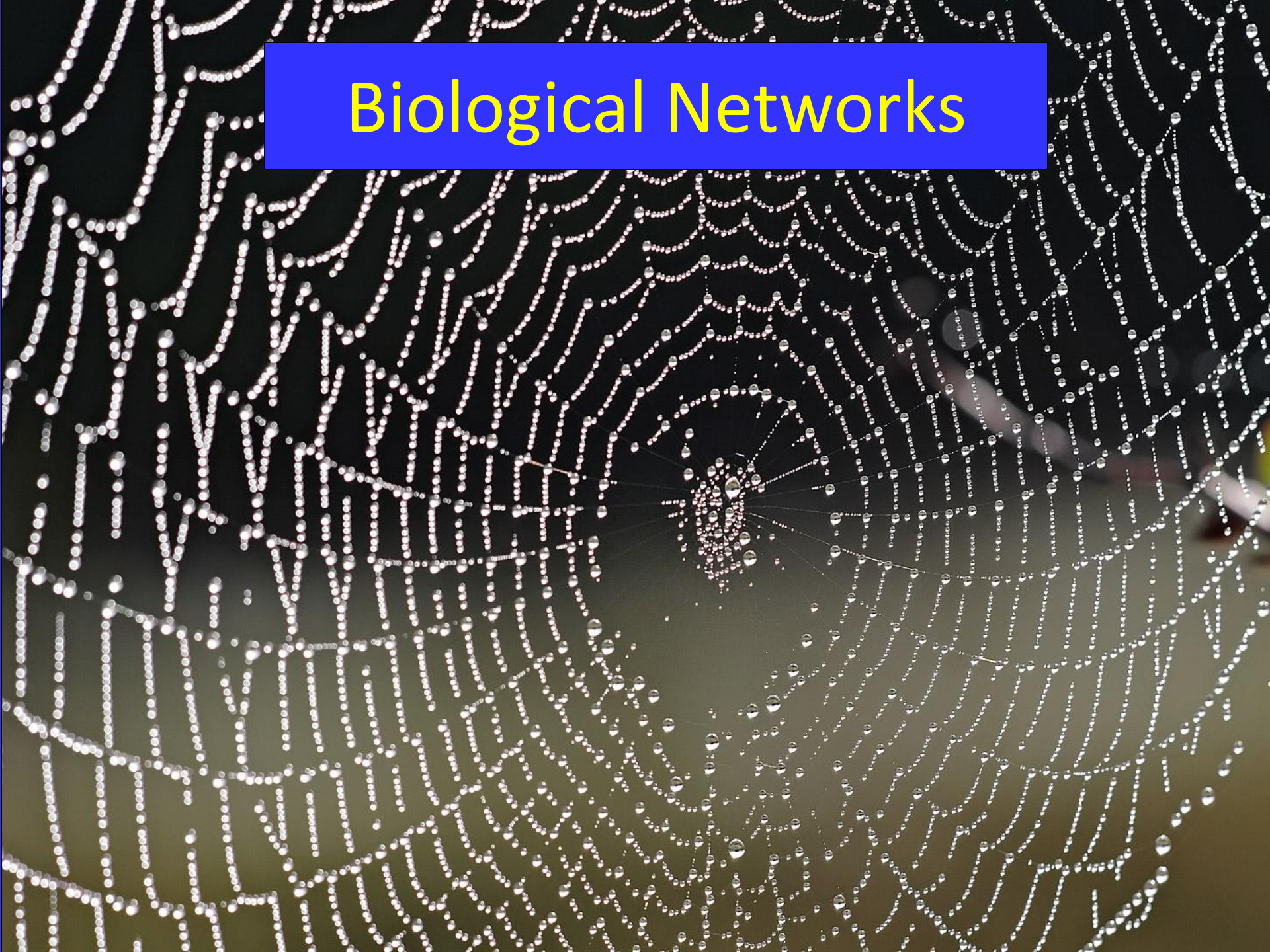
Conclusions

Diverse predator communities reside within farmland

Our decisions influence how much they contribute to reducing pest levels

Two key factors in promoting biological control:
-Habitat disturbance
-Biodiversity

Biological Networks



A Humbler Approach to Pest Management

Learn how insect communities function in natural systems.

Replace key processes back into agroecosystems to improve the health and productivity of cropland long-term.

Thanks!

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