A photograph of an orchard with trees in bloom under a clear blue sky. The trees are arranged in rows, and the ground is covered with green grass and some yellow wildflowers. The sky is a solid, clear blue. The text is overlaid on the top left of the image.

Integrating broad-scale landscape perspectives with bees, floral resources, and fruit crop yields

Rachel Mallinger

Hannah Gaines Day

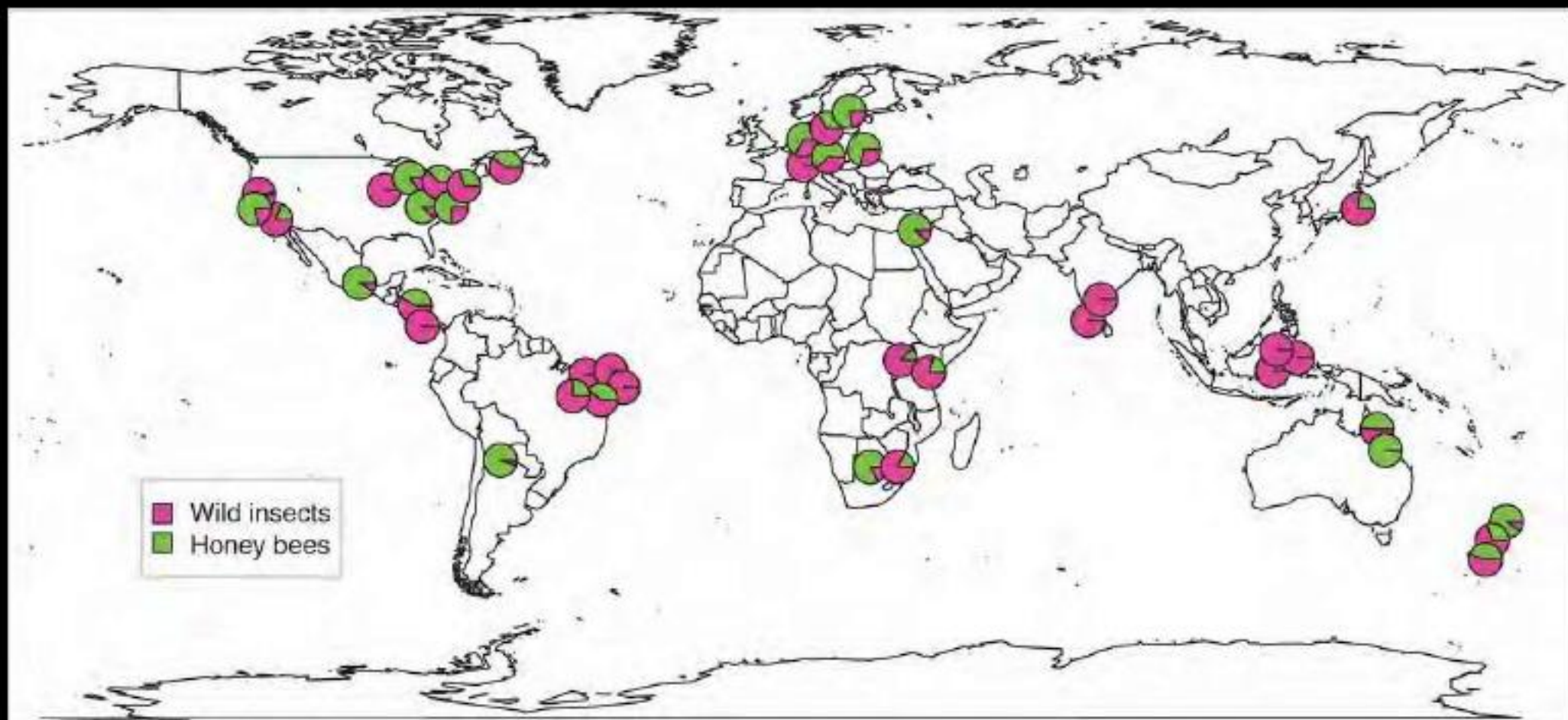
Claudio Gratton



Apple growers of WI
Cranberry growers of WI
Mike Arduser
Jason Gibbs
USDA SARE Grant
USDA Specialty Crop Block Grant
Hatch Grant
Gratton Lab



Wild bees and honey bees used for pollination of crops around the world



Garibaldi et al 2013



| TAXA | APRIL | MAY | JUNE | JULY | AUG | SEP | OCT |
|---------------------------------------|-------|-----|------|------|-----|-----|-----|
| <i>Colletes (inaequalis, validis)</i> | | | | | | | |
| <i>Andrena</i> | | | | | | | |
| <i>Augochlora pura</i> | | | | | | | |
| <i>Augochlorella striata</i> | | | | | | | |
| <i>Halictus (females)</i> | | | | | | | |
| <i>Lasioglossum (females)</i> | | | | | | | |
| <i>Osmia</i> | | | | | | | |
| <i>Bombus</i> | | | | | | | |



Landscape structure affects wild bees



- Natural habitat ↑ wild bees (Kennedy et al 2013)
- Intensive agriculture ↓ wild bees
- Context dependent
- Floral resources?
- Effects on crop yields?

Landscape structure affects honey bees



- Monocultures ↓ honey bees
- Non-crop habitats?
- Foraging behavior?
- Effects on crop yields?

1. Landscape structure →

wild bees →

apple fruit set

2. Landscape structure →

honey bees →

cranberry yield



1. Landscape structure → wild bees → apple fruit set

Apples are self-incompatible
Require cross-pollination



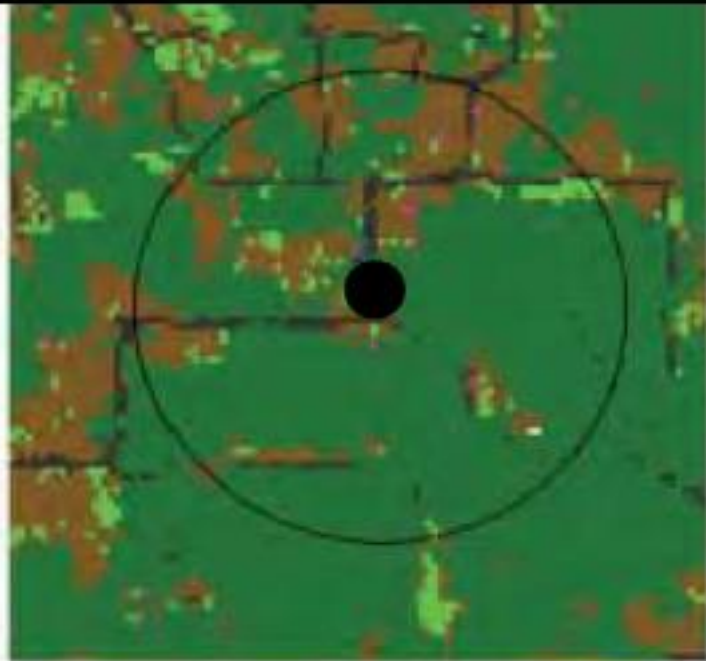
1. Landscape structure → wild bees → apple fruit set



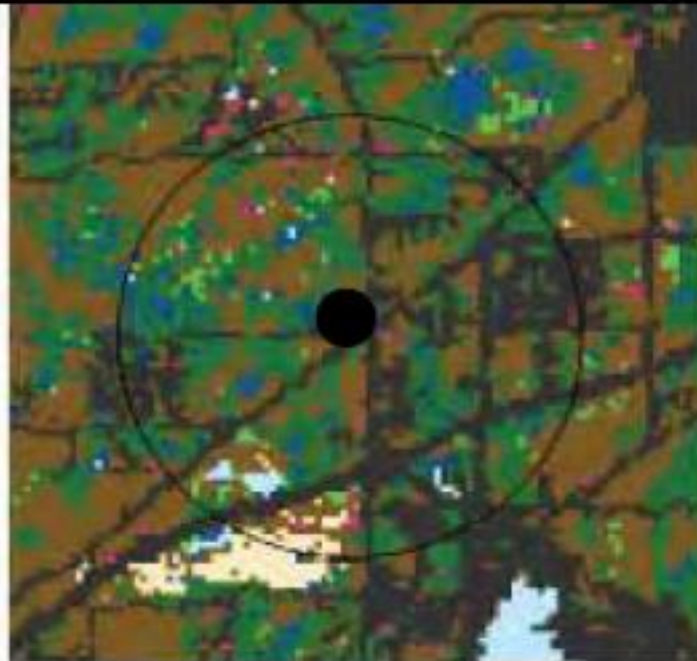
- Annual crops
- Pasture/ hay
- Natural grasslands
- Woodlands
- Developed
- Wetland

1. Landscape structure $\xrightarrow{\text{red arrow}}$ wild bees $\xrightarrow{\text{black arrow}}$ apple fruit set

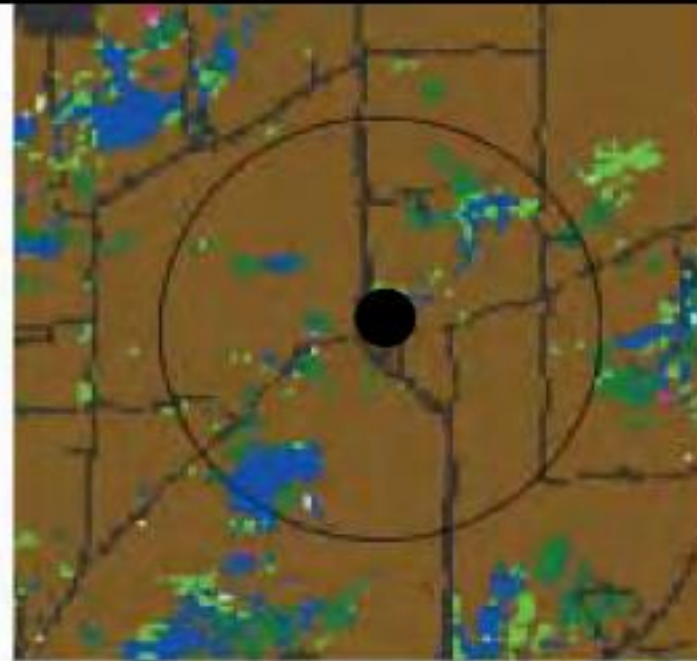
Sites selected on 2 gradients: high-low woodland (natural) and high-low landscape diversity at 1 km radius



High woodland



High diversity



High agriculture

1. Landscape structure $\xrightarrow{\text{red arrow}}$ wild bees $\xrightarrow{\text{black arrow}}$ apple fruit set



1. Landscape structure



wild bees



apple fruit set

80 species

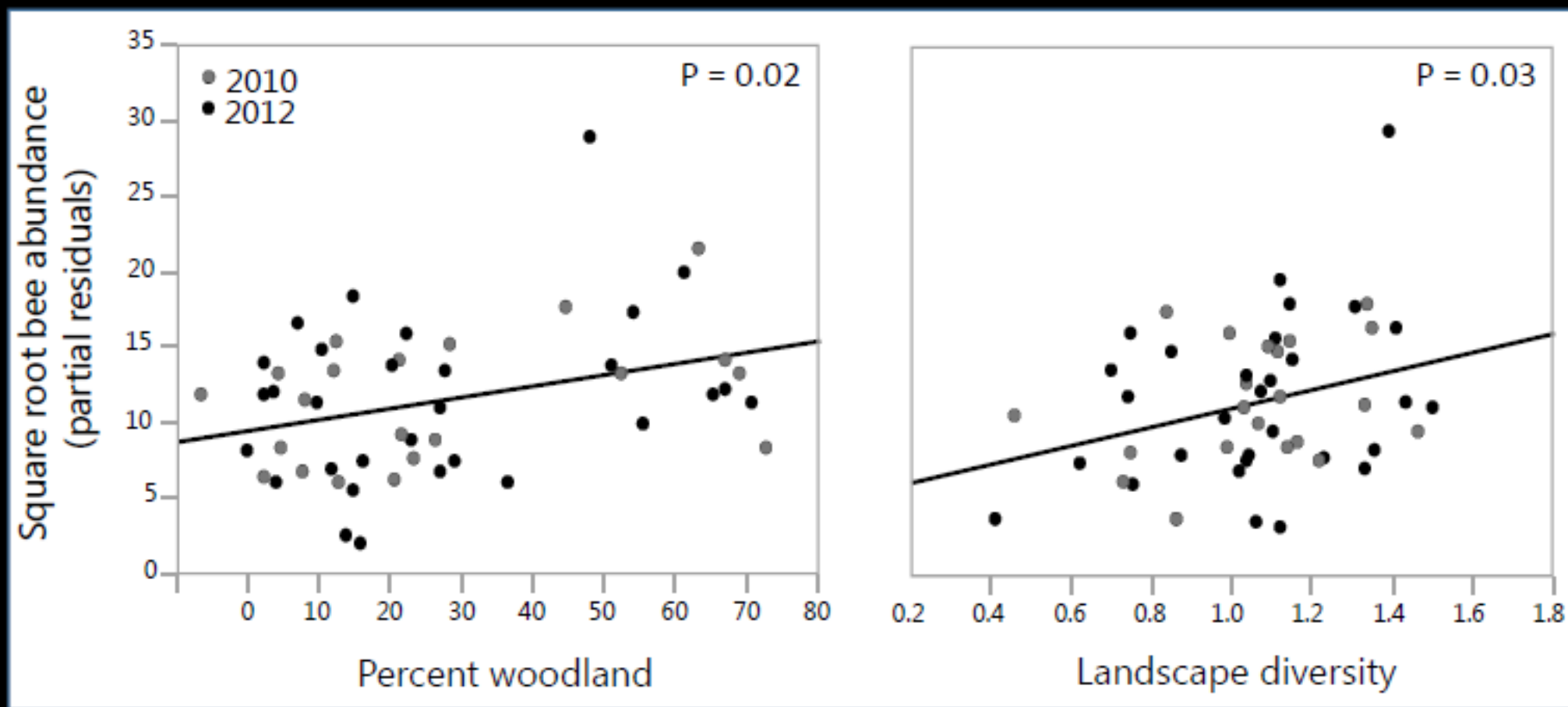
13 genera

- Andrena
- Lasioglossum
- Halictus
- Bombus
- Ceratina
- Green sweat bee genera
- Cuckoo bees
- Osmia
- Megachile
- Colletes



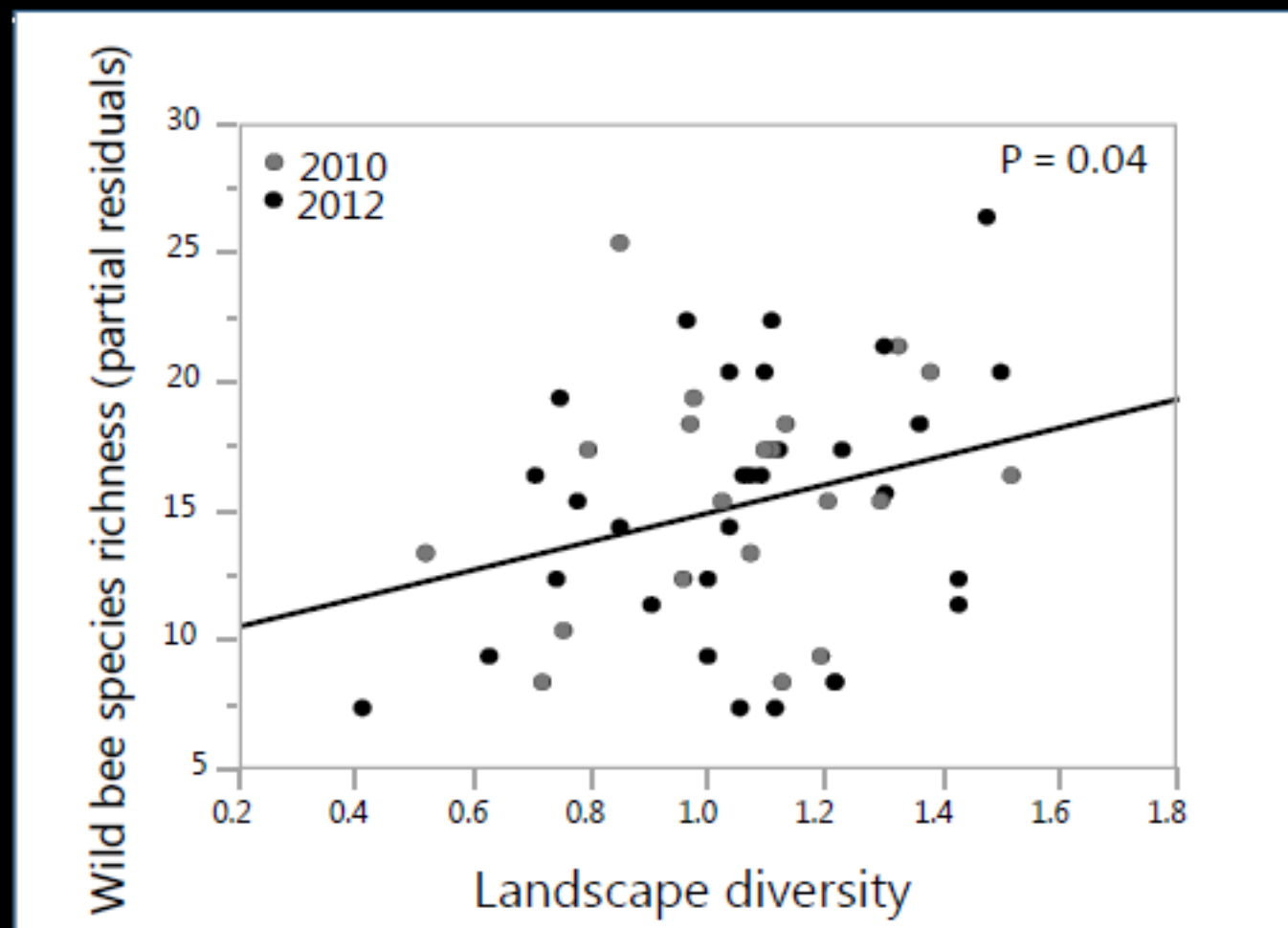
1. Landscape structure $\xrightarrow{\text{red arrow}}$ wild bees $\xrightarrow{\text{black arrow}}$ apple fruit set

Bee abundance increases with natural habitat and with landscape diversity

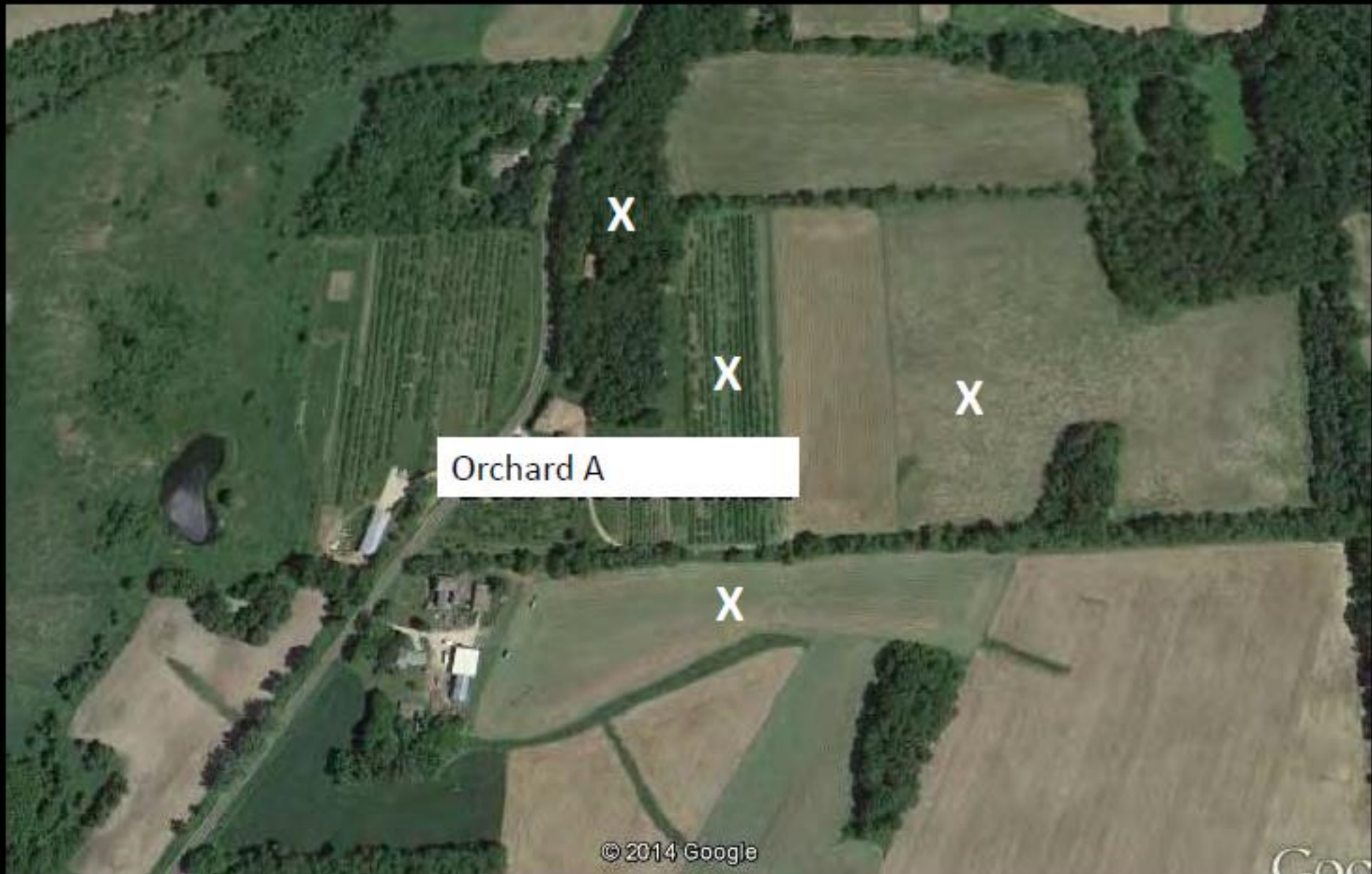


1. Landscape structure $\xrightarrow{\text{red arrow}}$ wild bees $\xrightarrow{\text{black arrow}}$ apple fruit set

Bee species richness increases with landscape diversity



1. Landscape structure  wild bees  apple fruit set





Orchard



Open grassland

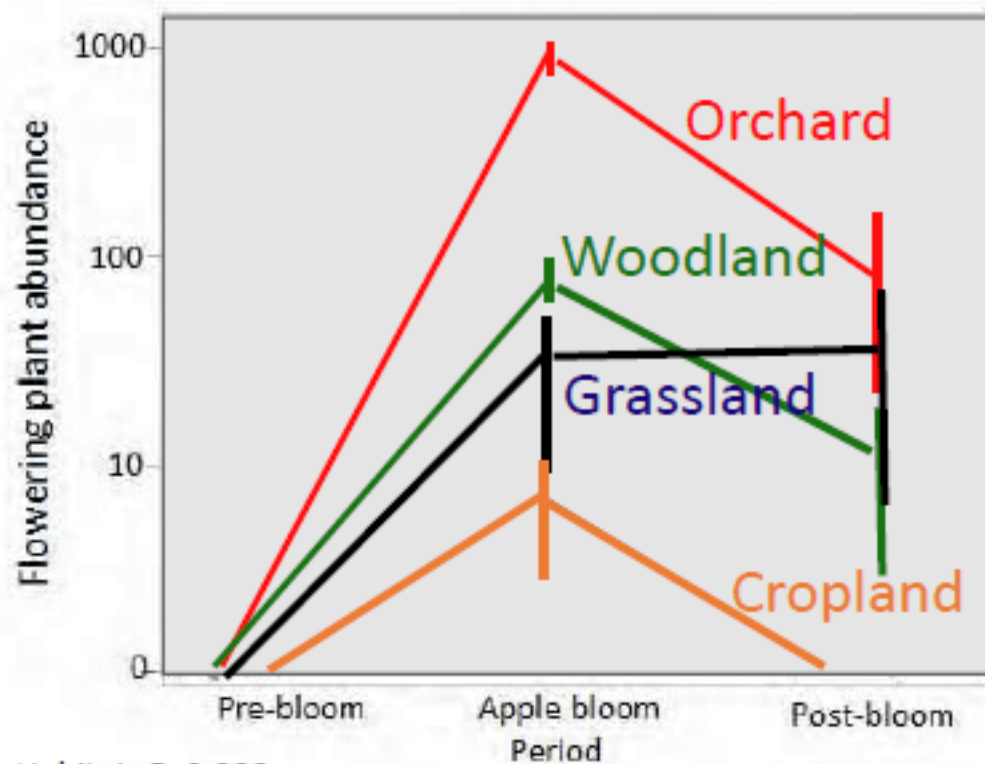


Woodland



1. Landscape structure $\xrightarrow{\text{wild bees}}$ apple fruit set

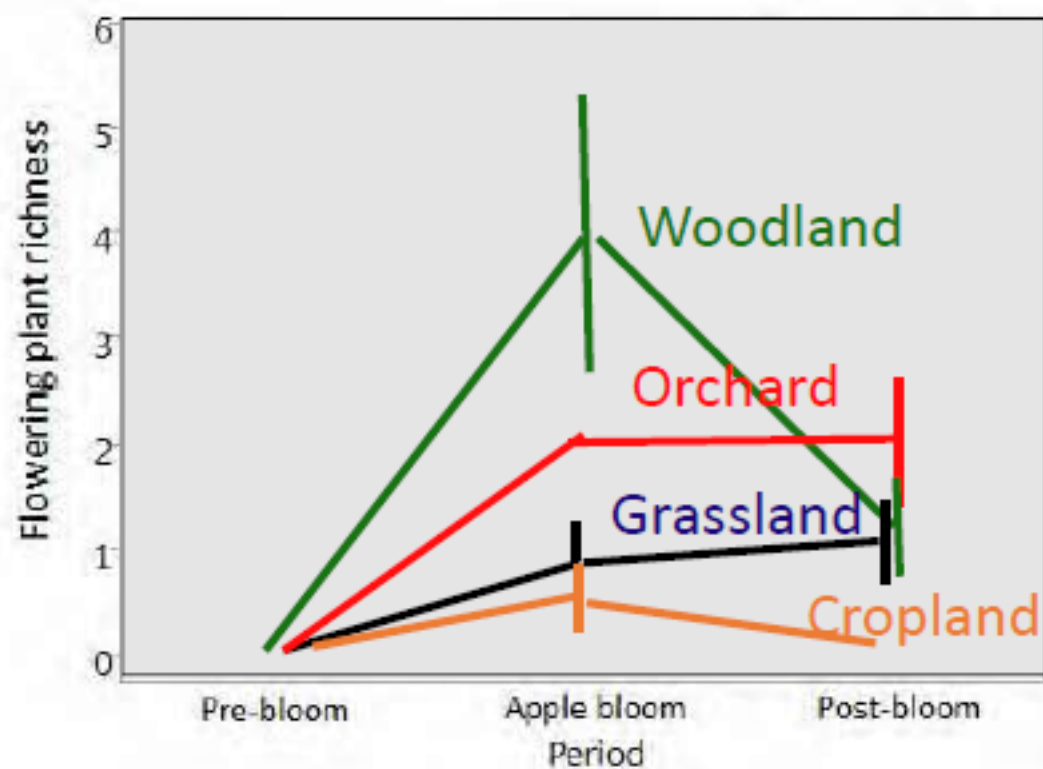
Different habitat types provide floral resources at different times



Habitat: $P=0.002$

Period: $P<0.0001$

Habitat X period: $P=0.0003$



Habitat: $P=0.03$

Period: $P<0.0001$

Habitat X period: $P=0.002$

Floral resource continuity and diversity



Landscape diversity increases wild bee abundance and richness

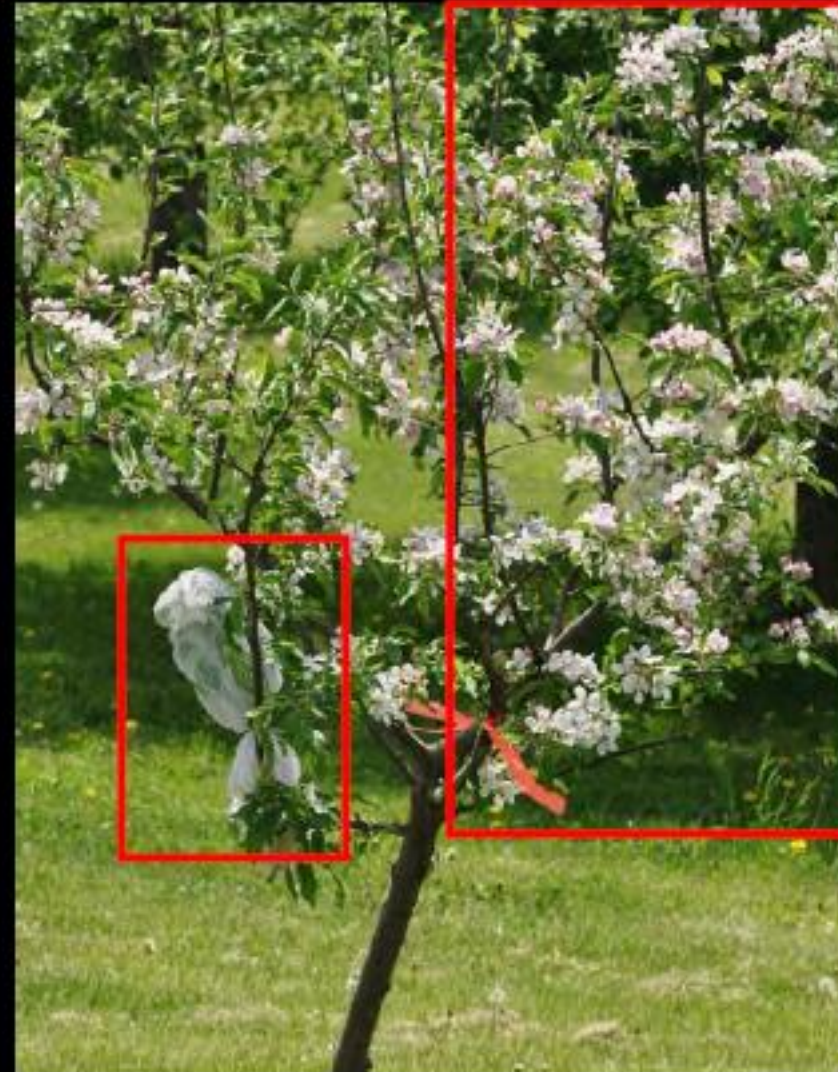
- Potentially through unique and complementary floral resources in different habitat types

Some amount of natural (woodland) habitat increases bee abundance

1. Landscape structure → wild bees → apple fruit set

Measuring fruit set

Closed
branch

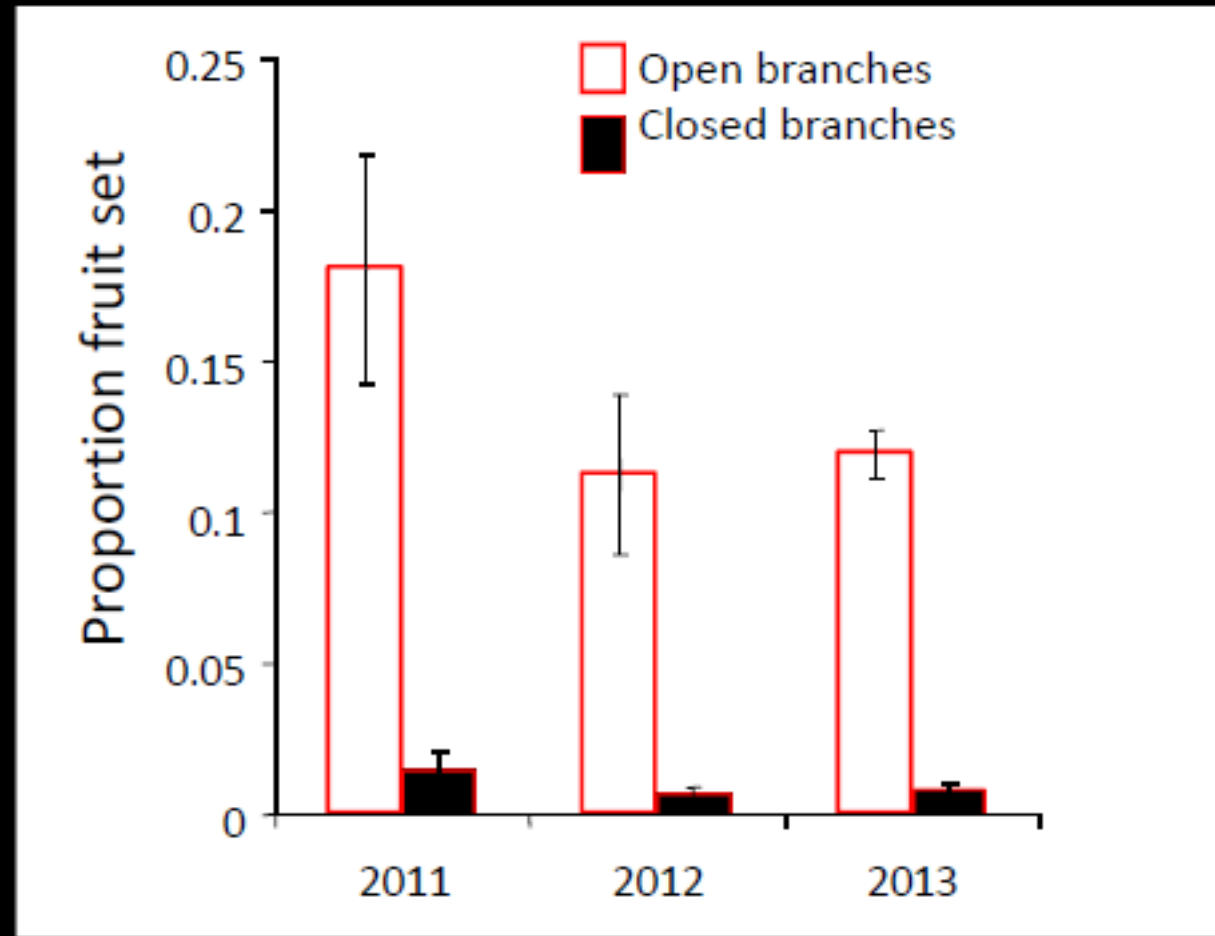


Open branch



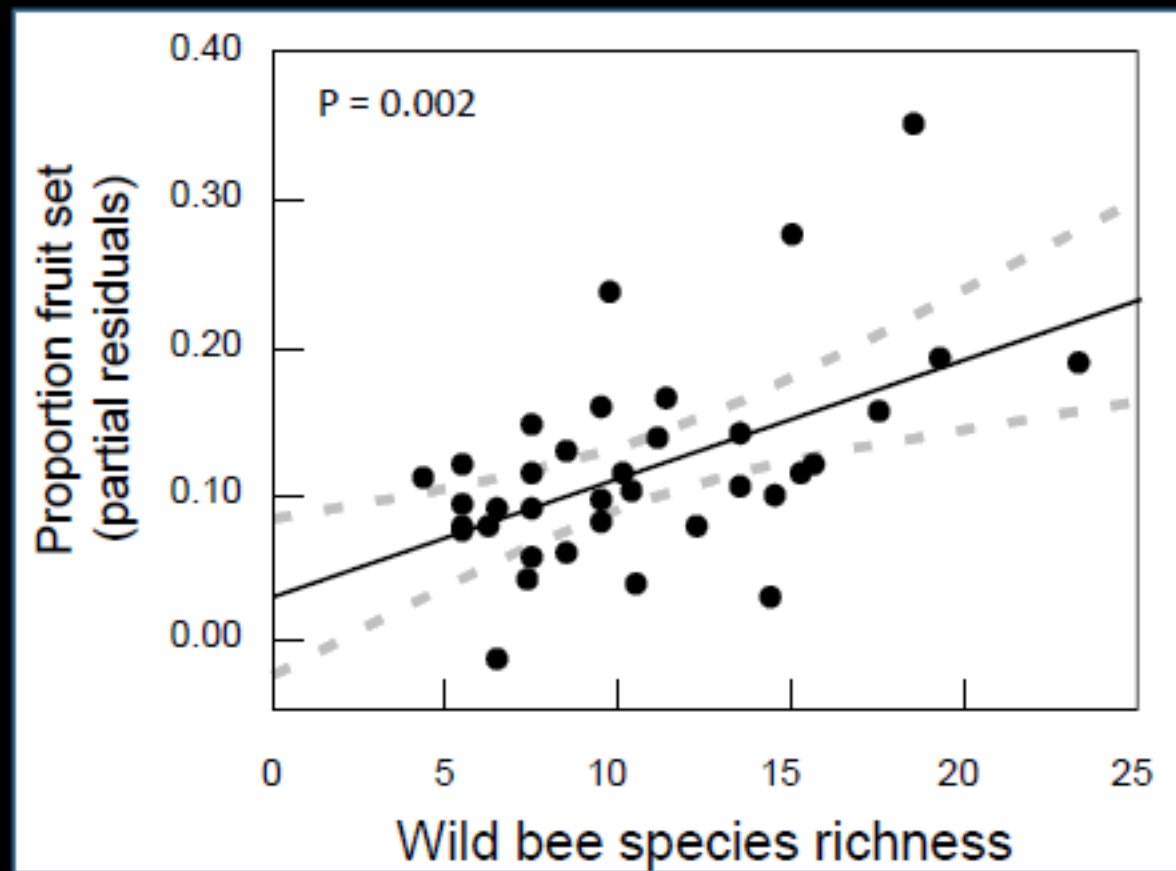
1. Landscape structure \longrightarrow wild bees \longrightarrow apple fruit set

Apples are dependent on pollinators



1. Landscape structure → wild bees → apple fruit set

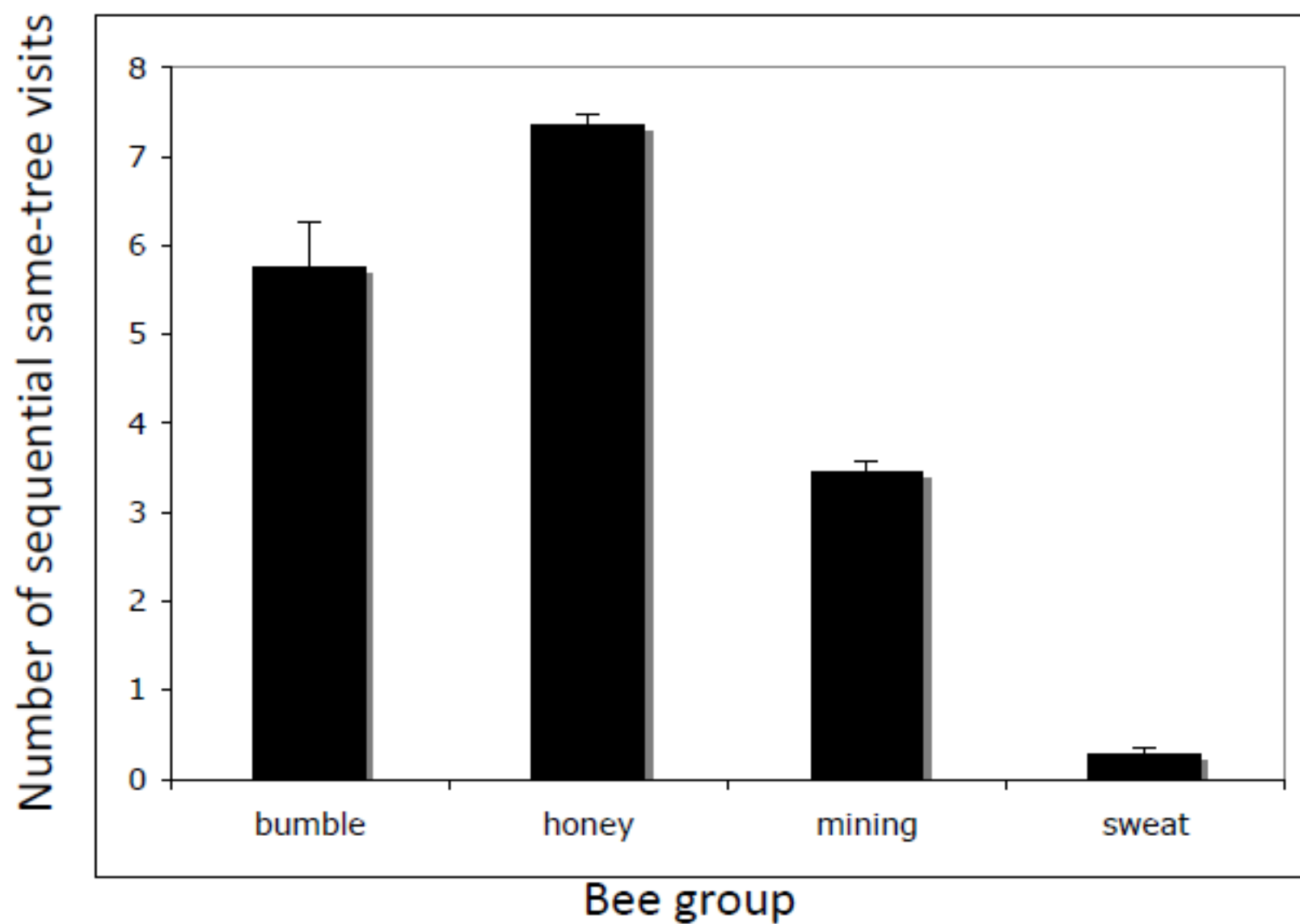
Wild bee richness increases fruit set



No effect of honey bees
No effect of overall bee abundance

Mallinger and Gratton. 2014. in press.
Journal of Applied Ecology

1. Landscape structure $\xrightarrow{\text{grey arrow}}$ wild bees $\xrightarrow{\text{red arrow}}$ apple fruit set



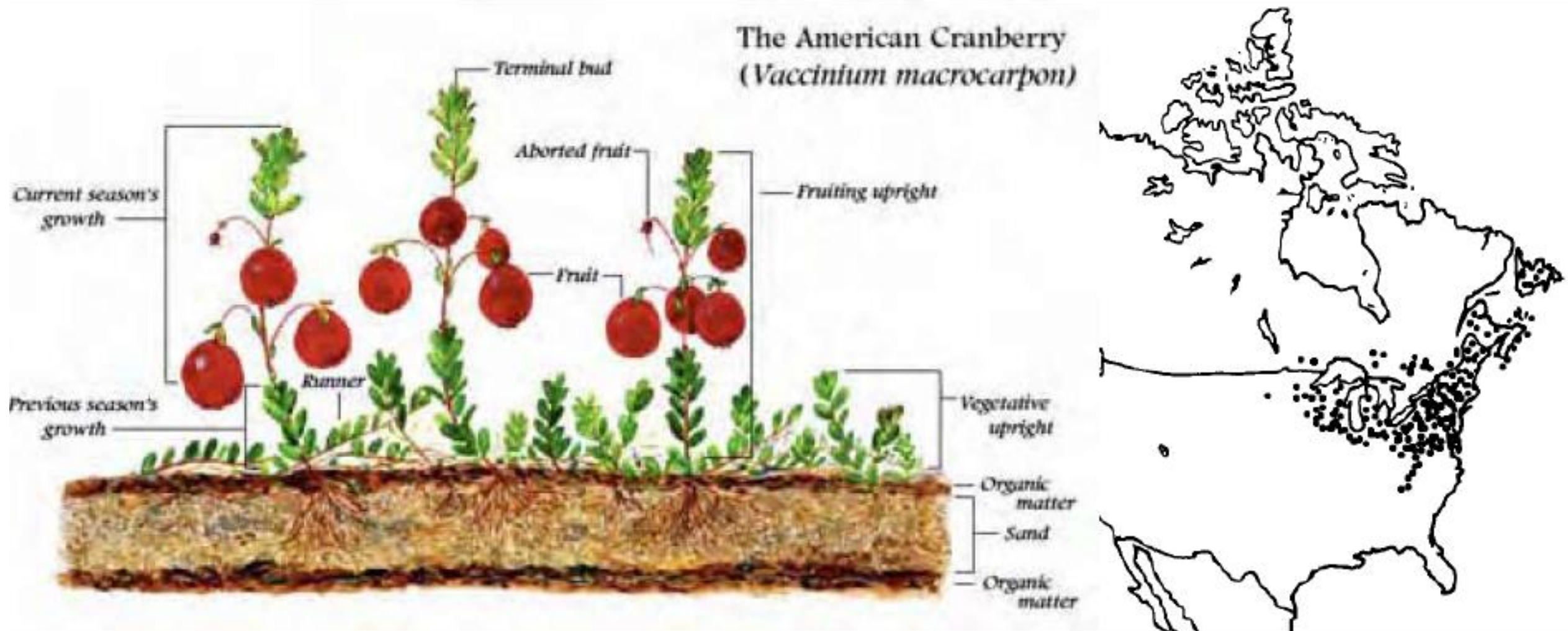
Floral resource continuity and diversity



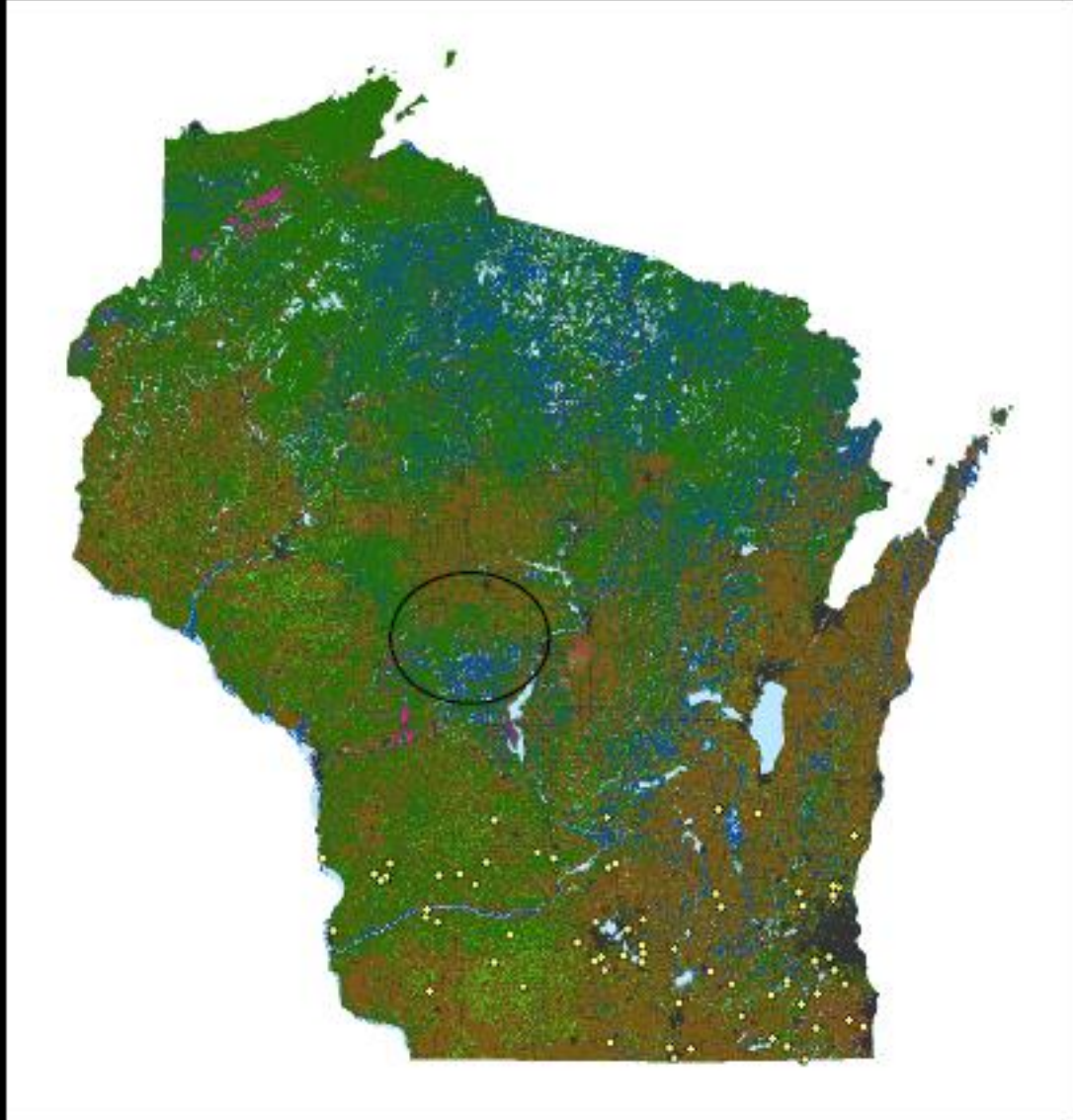
1. Landscape diversity $\xrightarrow{+}$ wild bee species richness $\xrightarrow{+}$ apple fruit set

2. Landscape structure → honey bees → cranberry yield

How does landscape structure affect honey bees and their role in pollination?



2. Landscape structure → honey bees → cranberry yield



2. Landscape structure → honey bees → cranberry yield



2. Landscape structure → honey bees → cranberry yield

Methods

Cranberry grower surveys

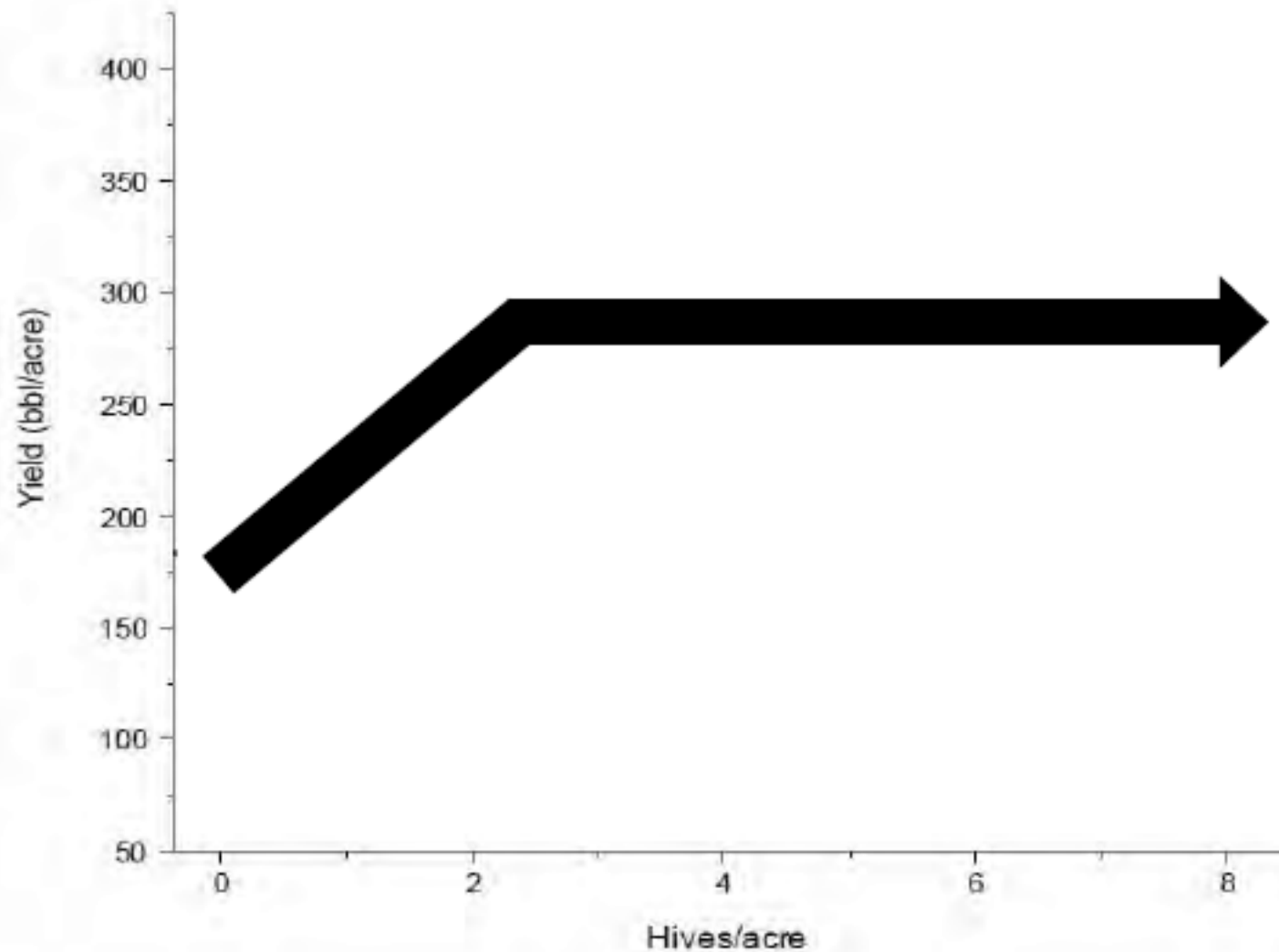
- # of honey bee hives
- Yield
- Multi-year

Land-cover maps (NCDL)

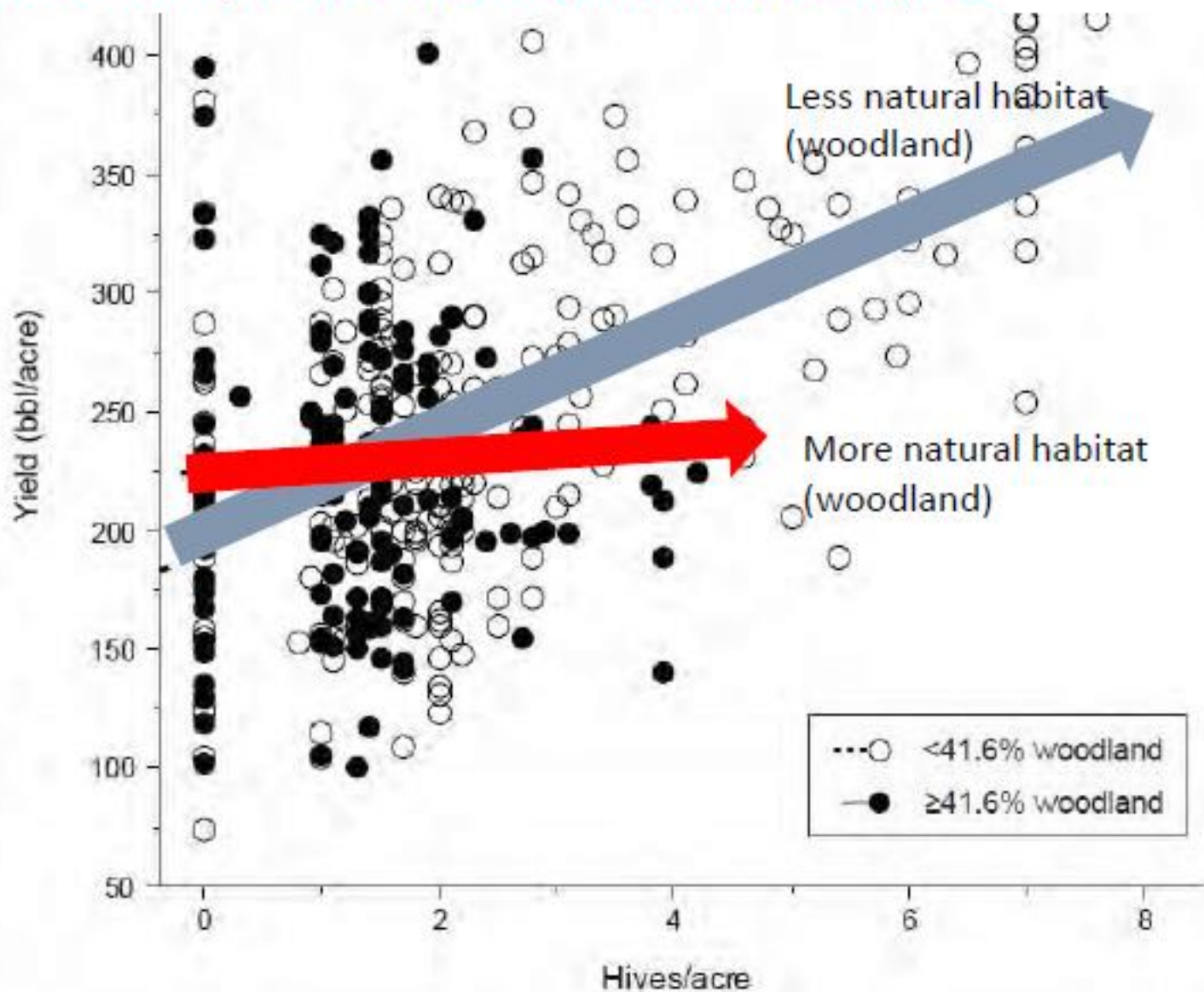


2. Landscape structure → honey bees → cranberry yield

EXPECTED RESULTS



More honey bees = more berries
BUT only in low woodland landscapes



2. Landscape structure → honey bees → cranberry yield

The effectiveness of honey bees for cranberry pollination varies with surrounding landscape.

- Honey bees foraging elsewhere?

Yield not zero without managed honey bees

- Contribution of native, wild pollinators
- Self or wind pollination

1. Landscape diversity $\xrightarrow{+}$ wild bee richness $\xrightarrow{+}$ apple fruit set

2. % woodland $\xrightarrow{-}$ honey bee foraging/efficacy $\xrightarrow{0}$ cranberry yield

