# The role of taxonomic, functional, genetic, and landscape diversity in food-web responses to a changing environment

NSF/NASA Dimensions of Biodiversity

2013-2018

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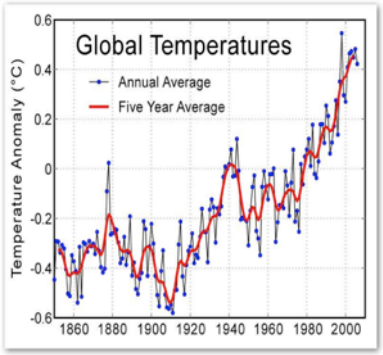
1. Overview of the grant
2. Frozen snow-free ground
3. Regional aphid dynamics

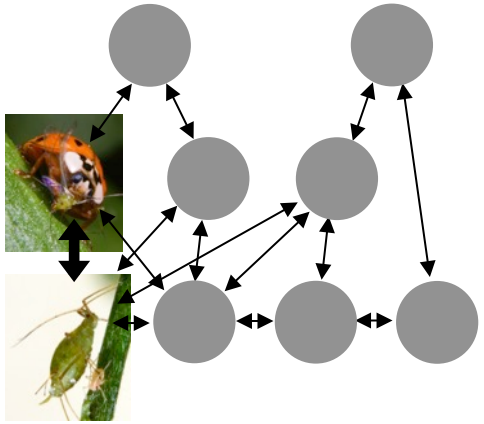



# Scale

individuals

organization

food webs



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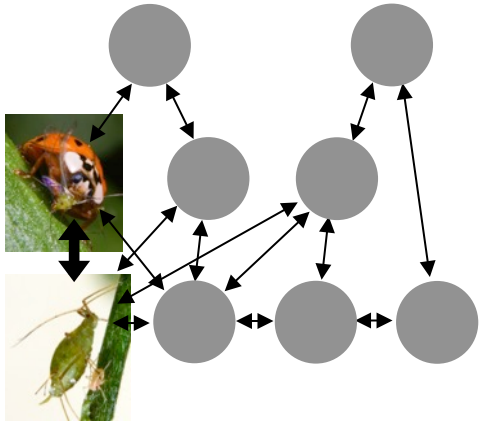
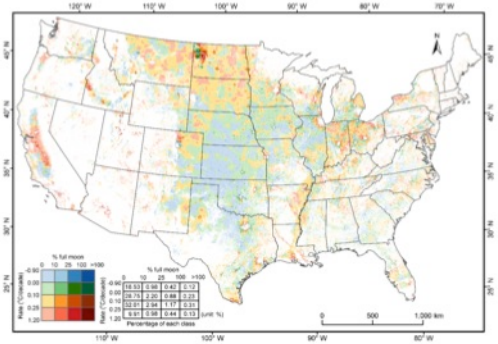


plants

space

continents



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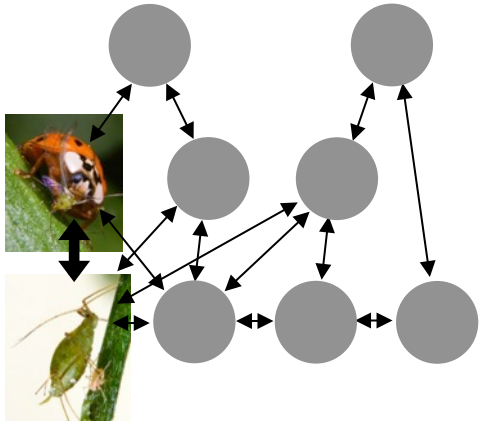

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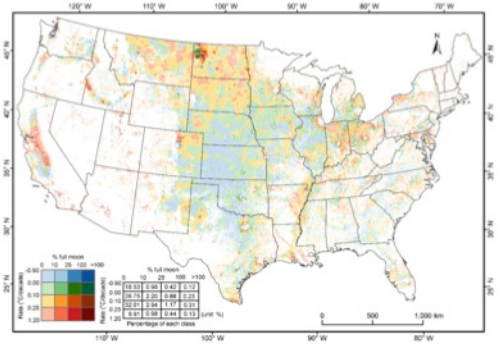
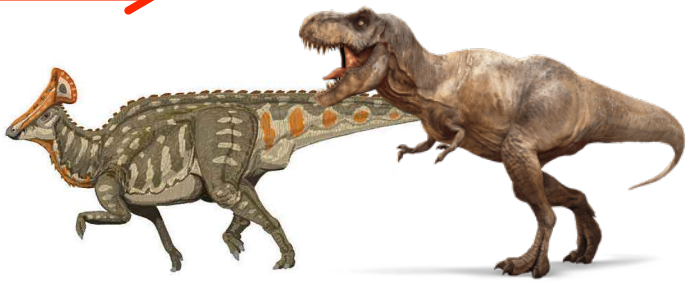


event

time

evolution



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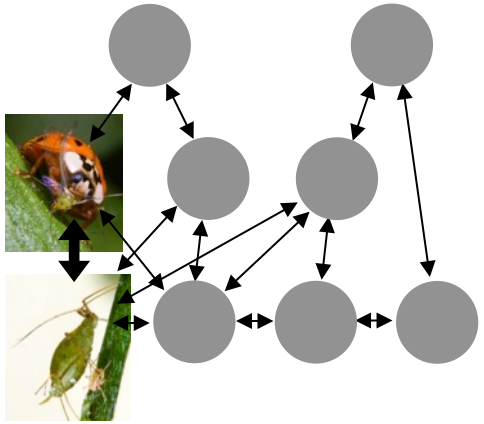
individuals

food webs



organization

plants

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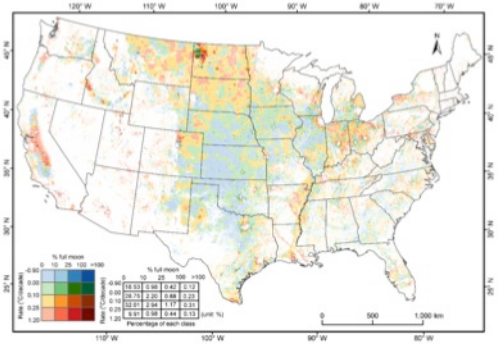


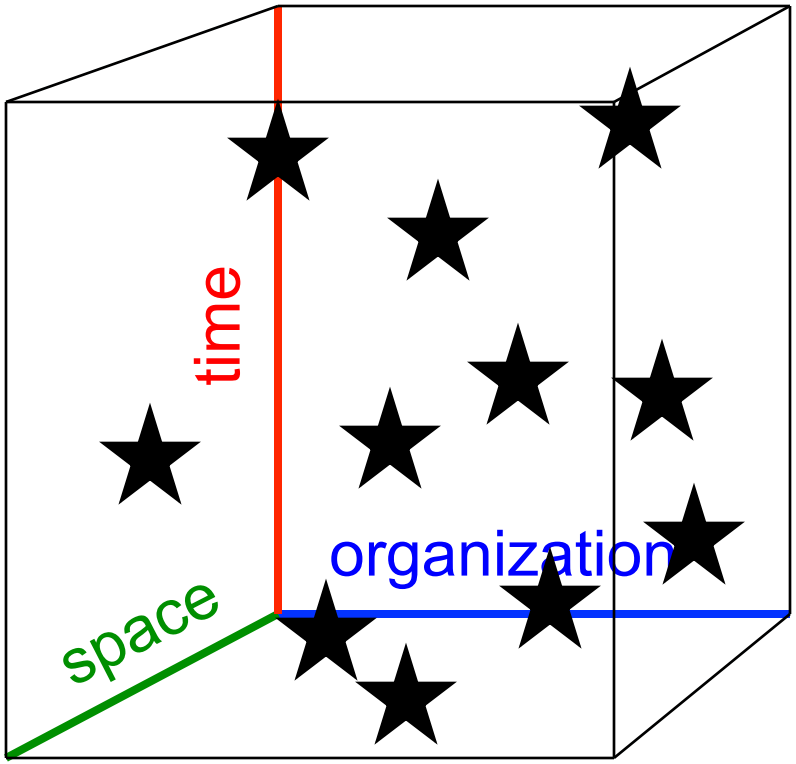
event

time

evolution


one reason to
study insects

# Grant components



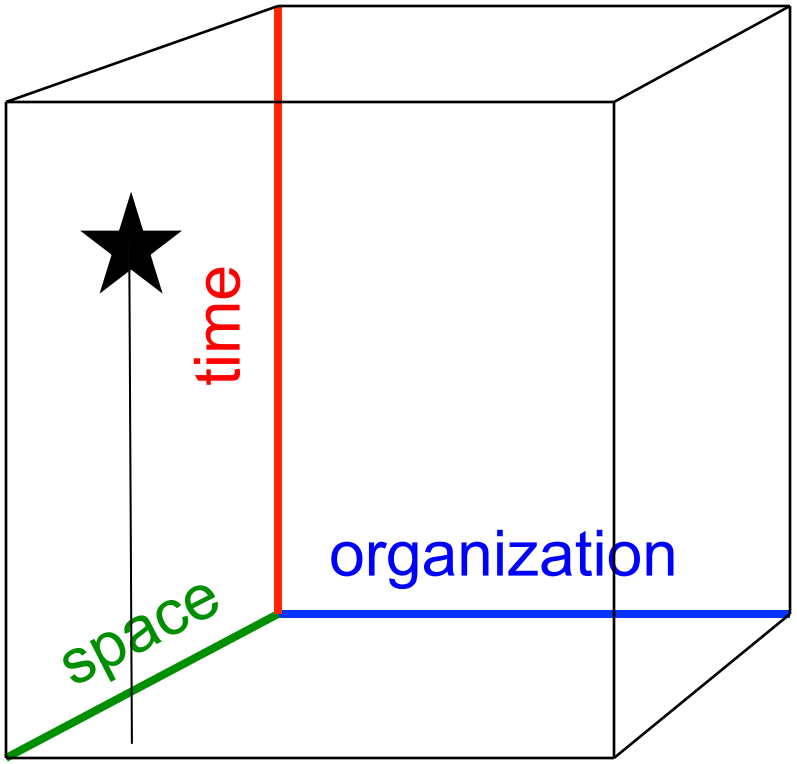

**1.** Co-evolution among insects and bacterial symbionts

**2.** Environmental effects on aphids and predators

**3.** Rapid evolution to environmental change

**4.** Interplay between ecological and evolutionary dynamics

# Grant components




**1.** Co-evolution among insects and bacterial symbionts

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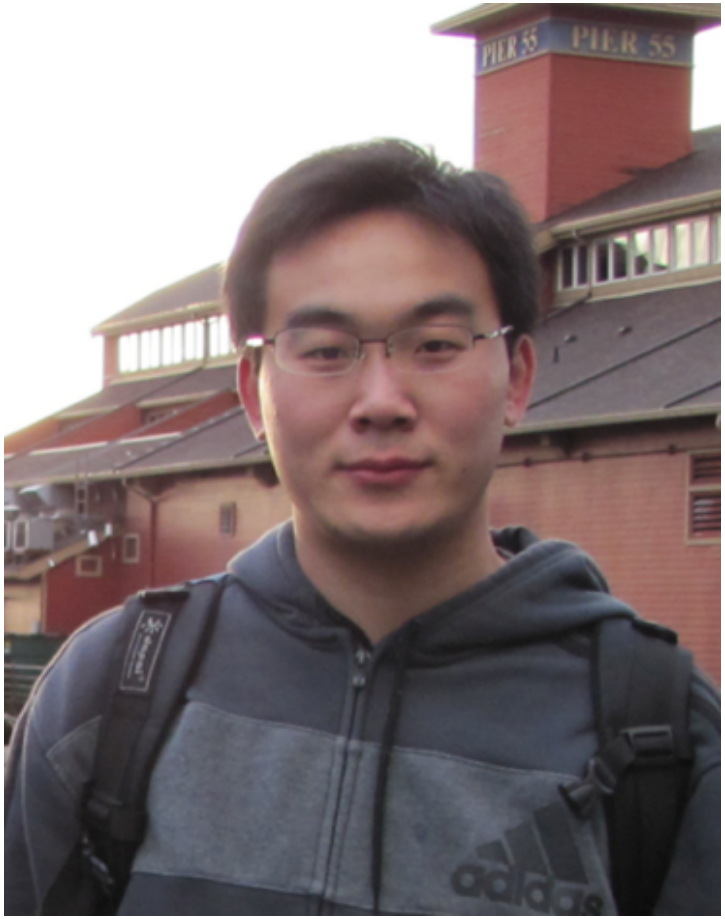
**4.** Interplay between ecological and evolutionary dynamics

**5.** Spin-offs

# Frozen, snow-free ground

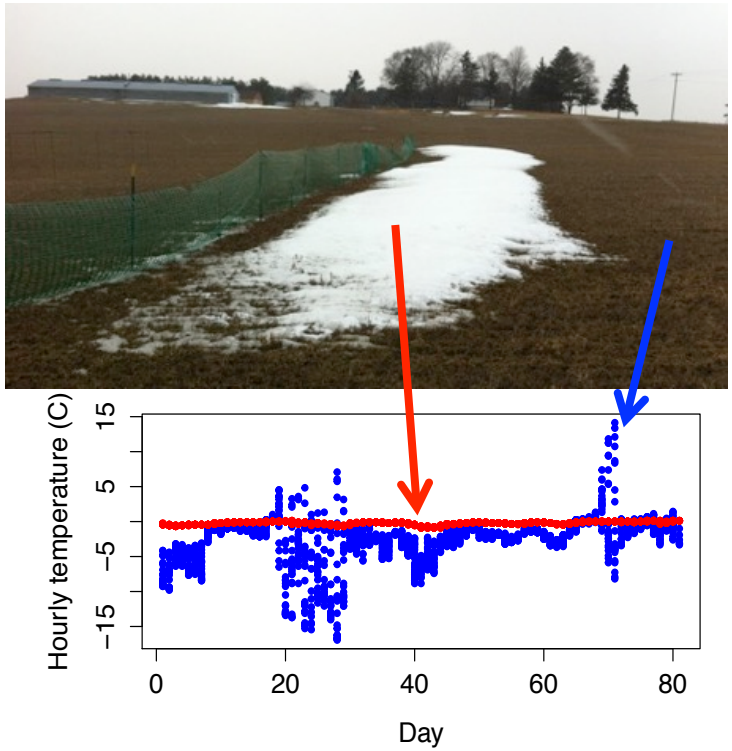



Likai Zhu

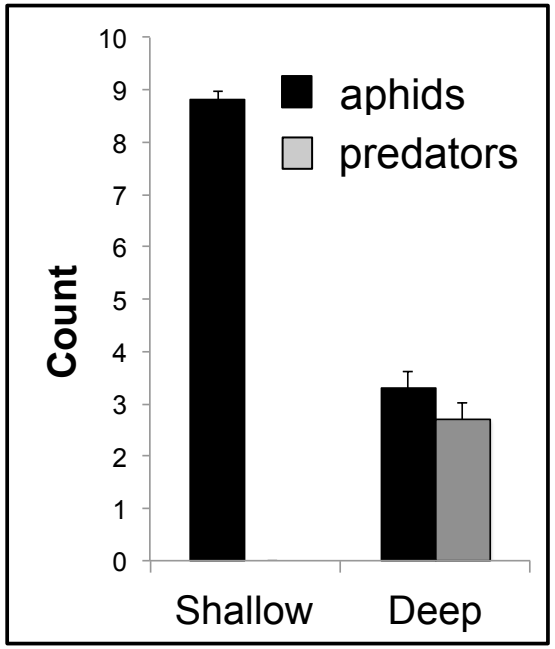
The environment depends on the organisms in question

Brandon Barton

# Snow cover protects predators and reduces aphids



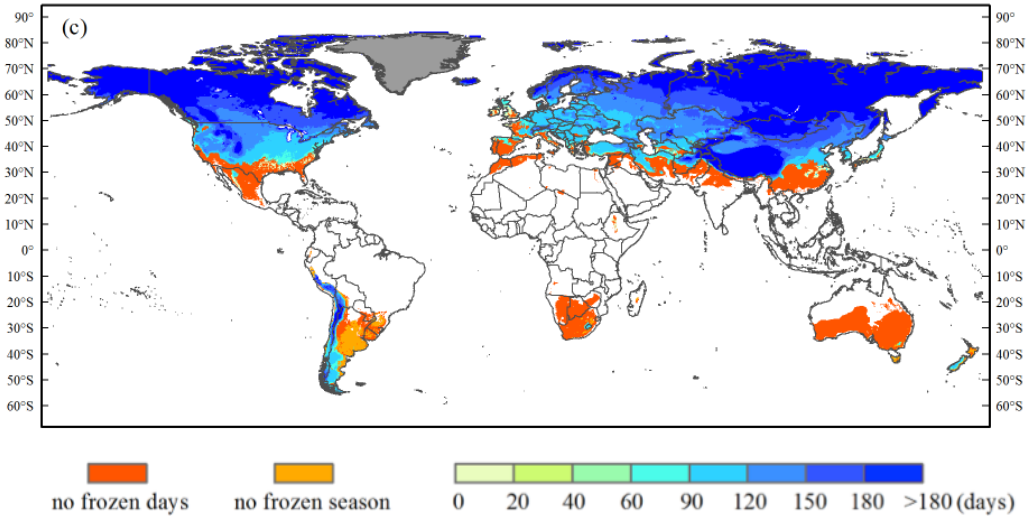

spring



# Has the protective cover of winter snow changed from 1982 to 2013?

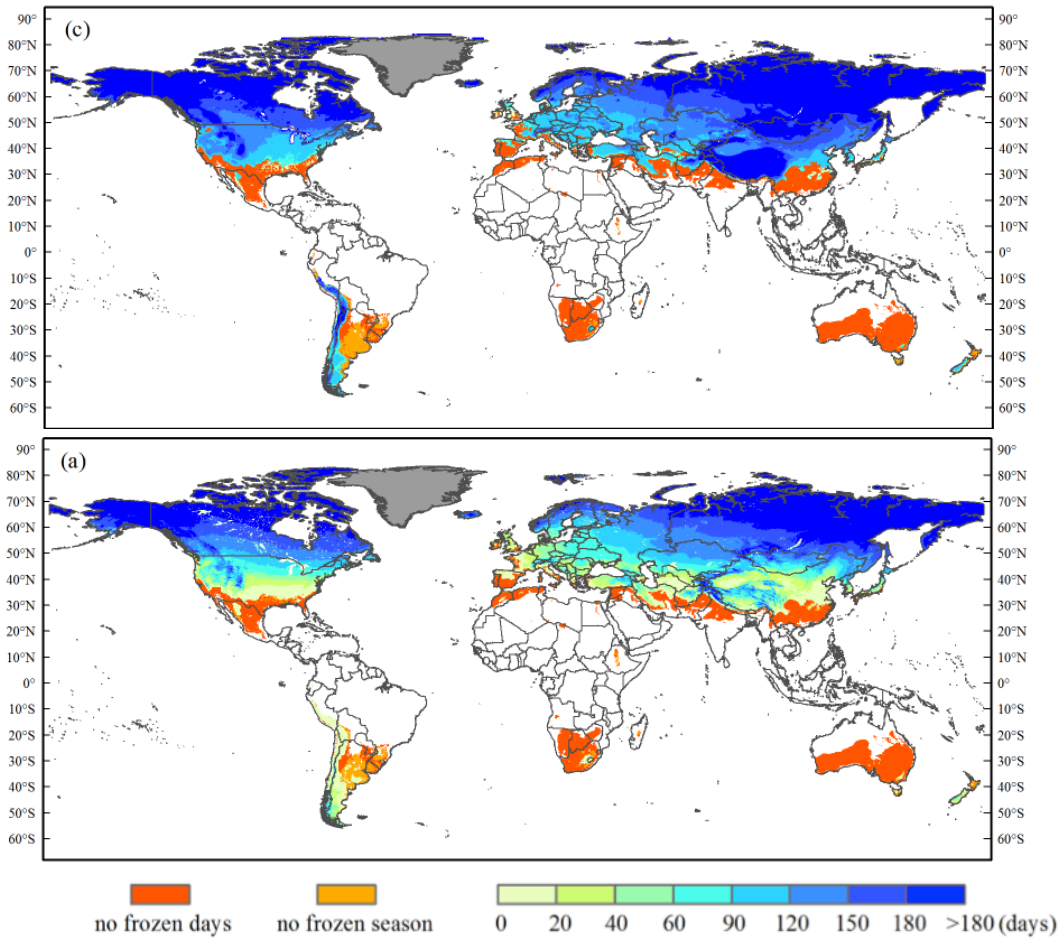

John Curtis
*Vegetation of Wisconsin* 1959

Subnivium
Credit: Kristin Link




# Length of frozen season

NASA MEaSUREs data from SSM/I and SSMIS




# Length of frozen season

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# Frozen days with snow

combined with JASMES data
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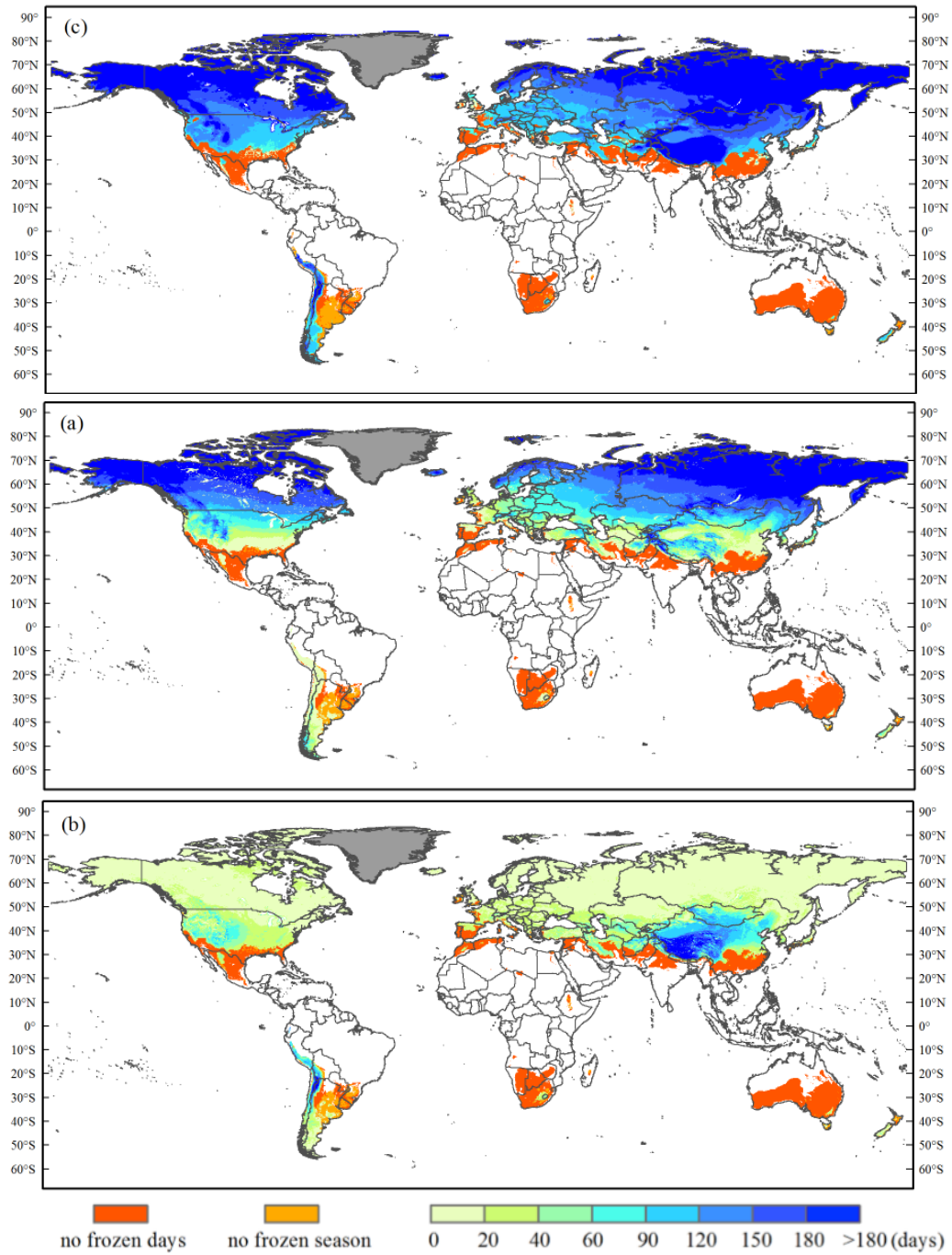


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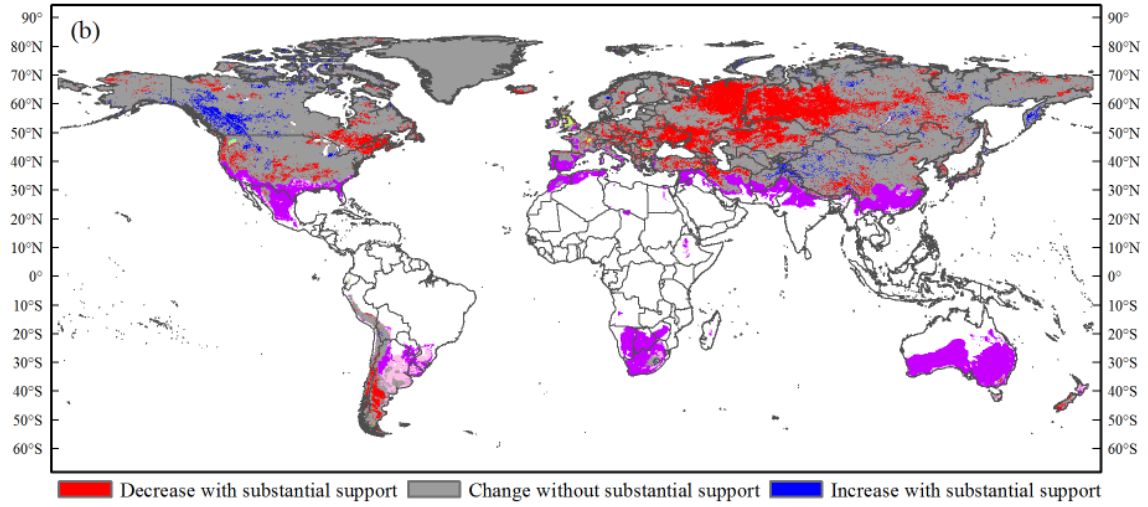
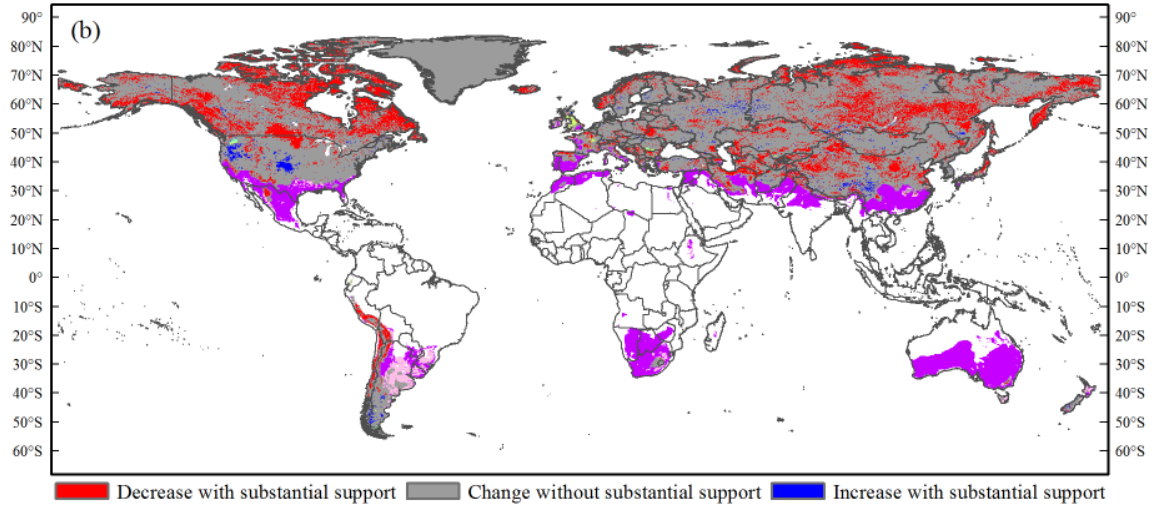
# Frozen days without snow

# **Changes** 1982-2013




Frozen days with snow

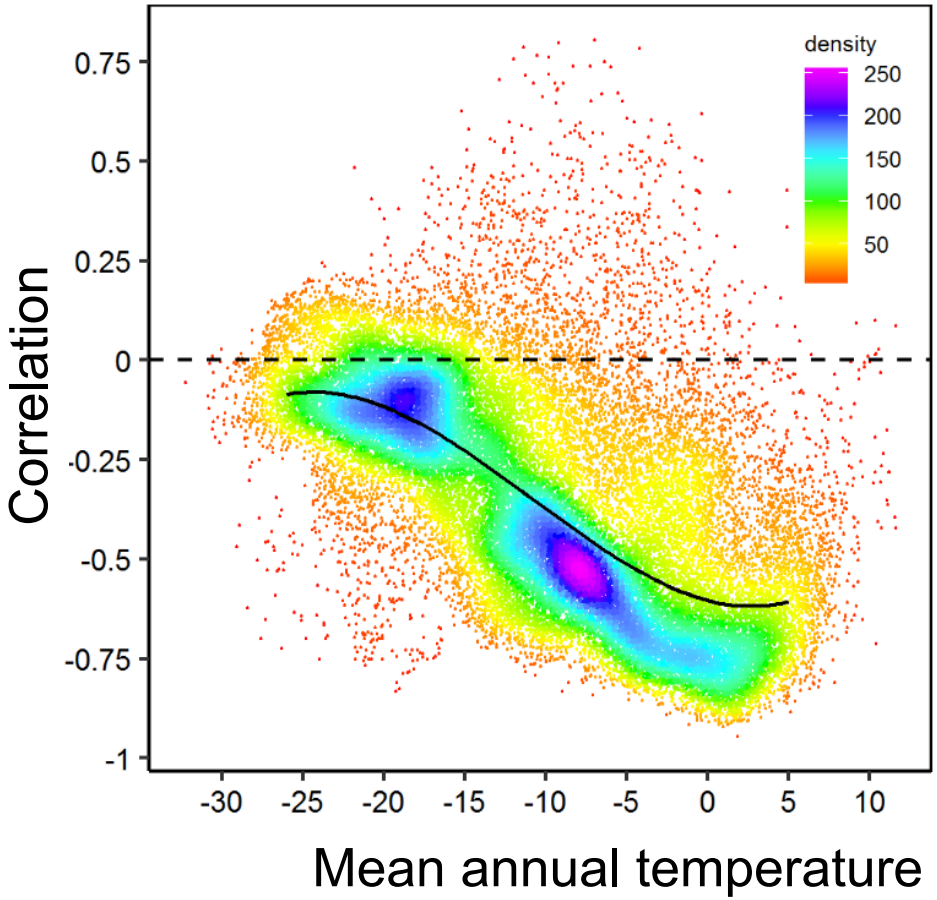



Frozen days without snow

In some (mountainous) places, global warming has made winter functionally colder

# Days with snow decrease with temperature in warmer regions

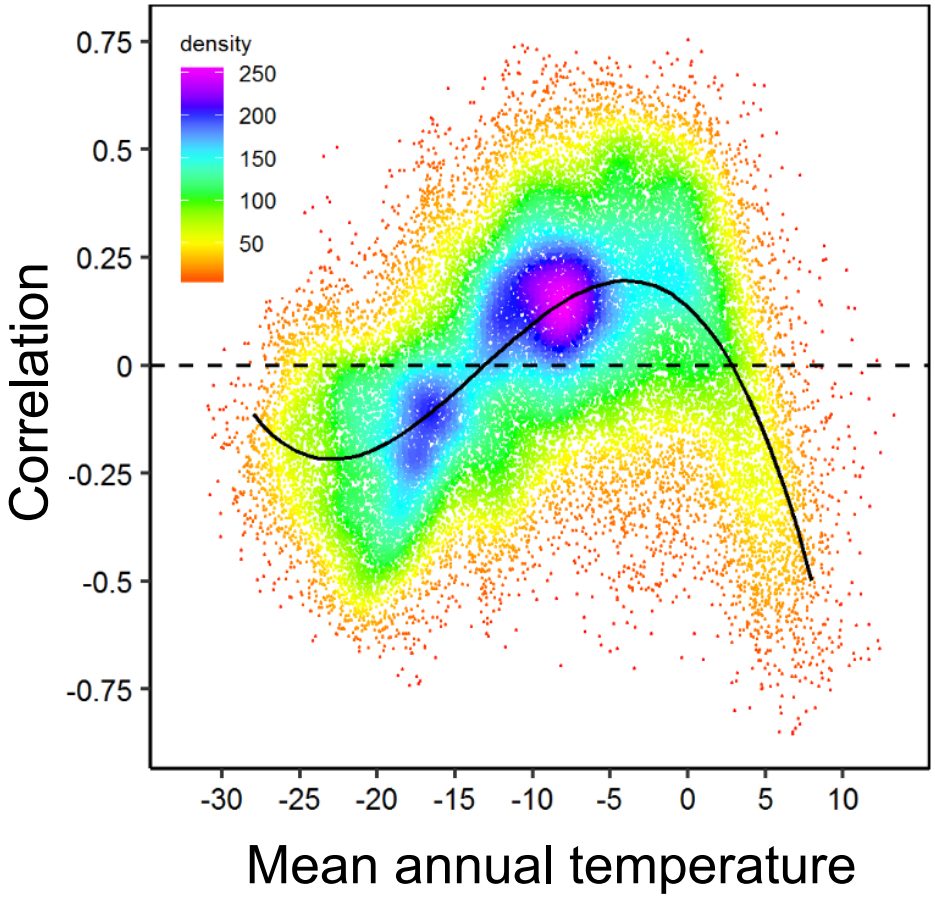
Correlations with snow-covered days




Changes in precipitation have small effects

# Frozen days without snow increase with temperature in warmer regions

Correlations with frozen days without snow



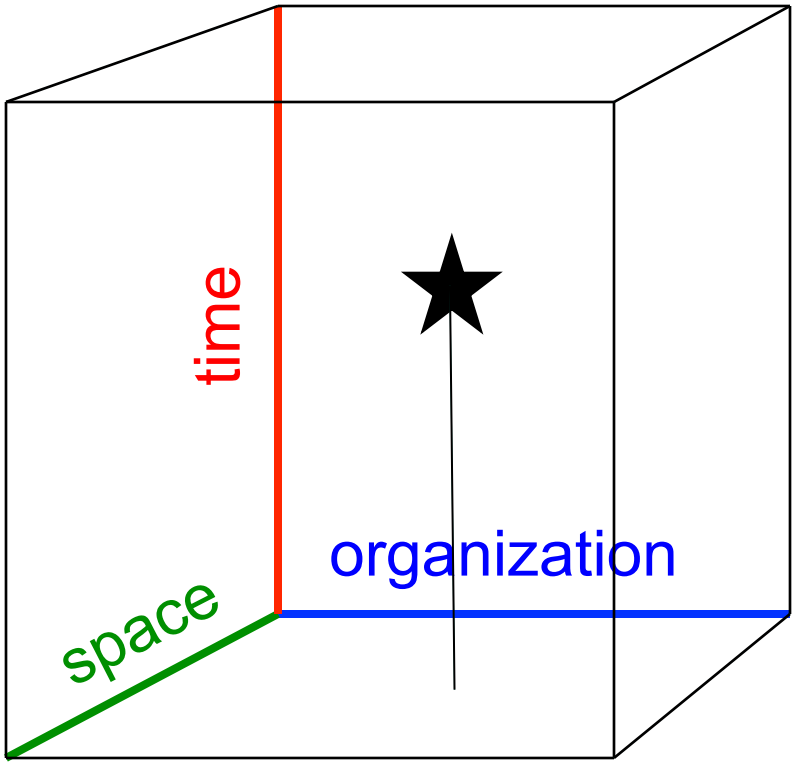
# Global warming might not make organisms warmer

## The environment depends on the organisms in question


John Curtis
*Vegetation of Wisconsin* 1959

Subnivium
Credit: Kristin Link

# Grant components

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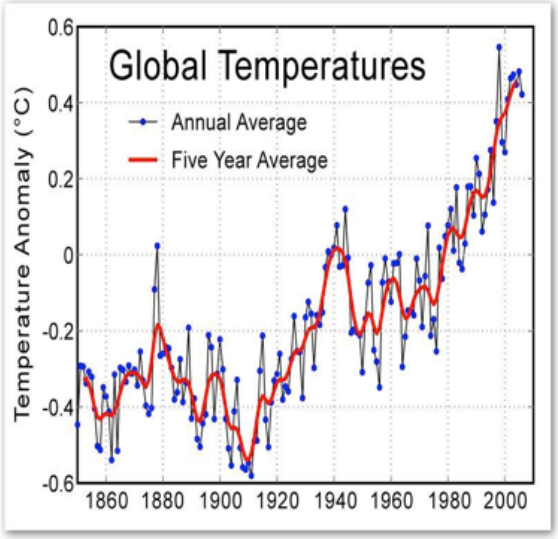
# Regional aphid dynamics



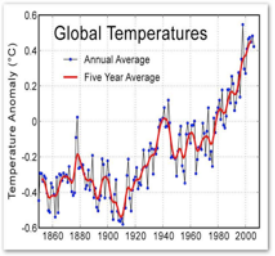

parasitoid attacking an aphid

# Facts

1. Pea aphid populations are controlled locally by predators

2. Aphid dispersal is a measure of local abundance

3. Dispersing aphids are synchronized regionally




## Puzzle

Since predators control pea aphids locally, what could synchronize the regional abundance of aphids?

# 1. Pea aphid populations are controlled by predators

Ladybeetles follow local abundance of aphids

Parasitoid dynamics are tightly coupled to pea aphids

If remove predators, pea aphid abundance reaches 1000x natural abundance

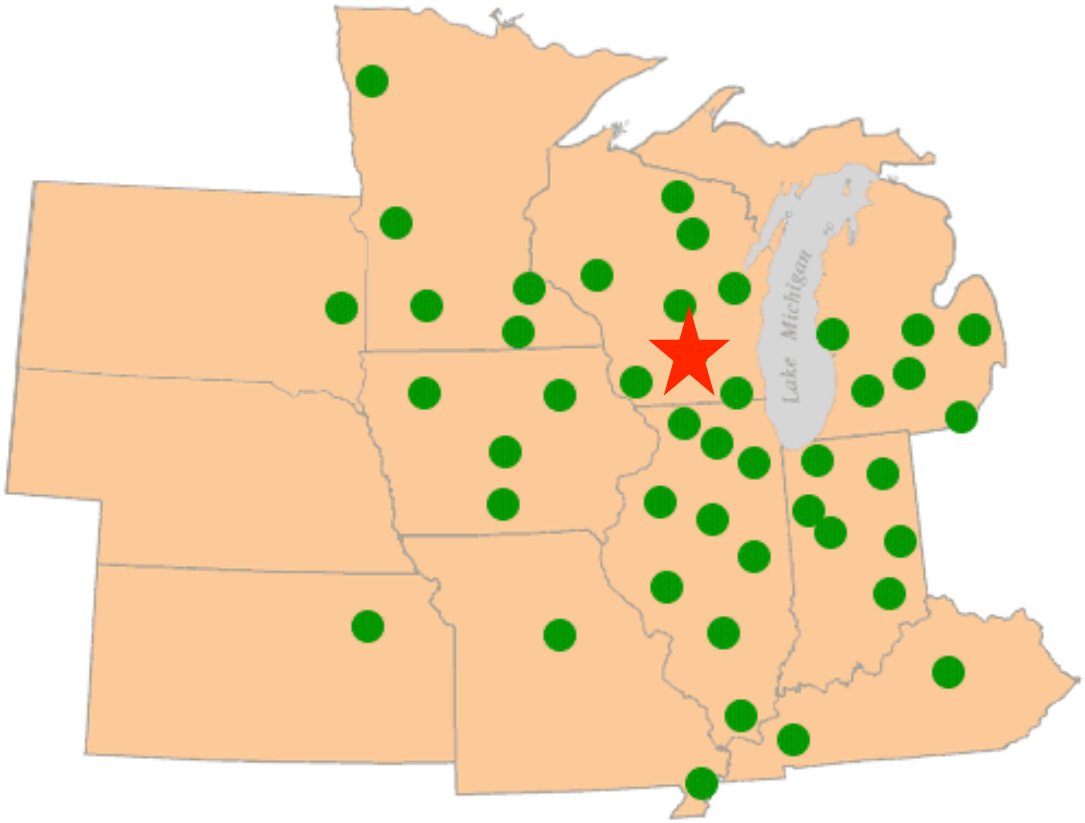
# 2. Aphids produce wings when densities are high

Mothers decide their offspring should have wings when densities are high and plant quality low

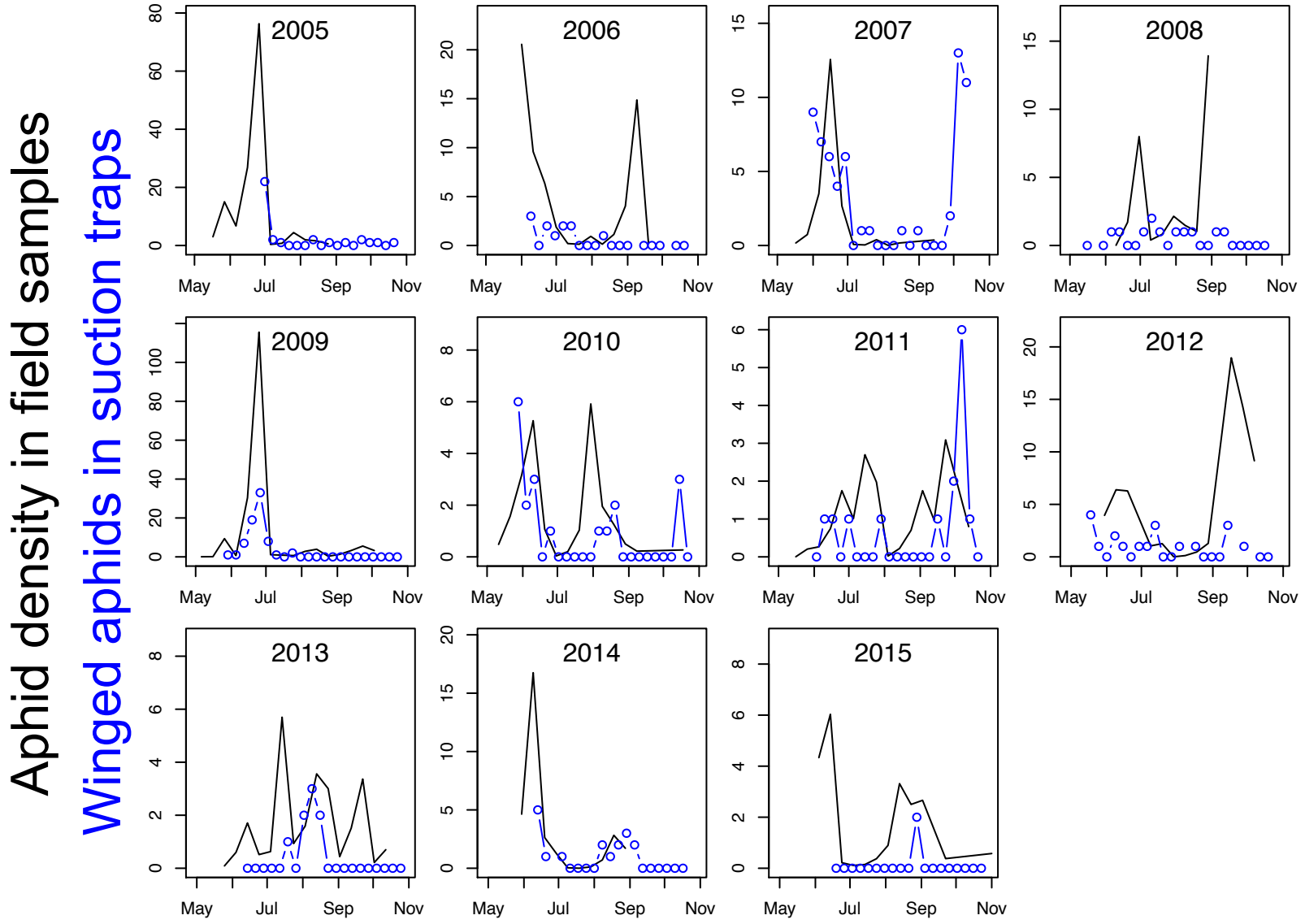
North Central IPM Center

# Regional Soybean Aphid Suction Trap Network

CSREES

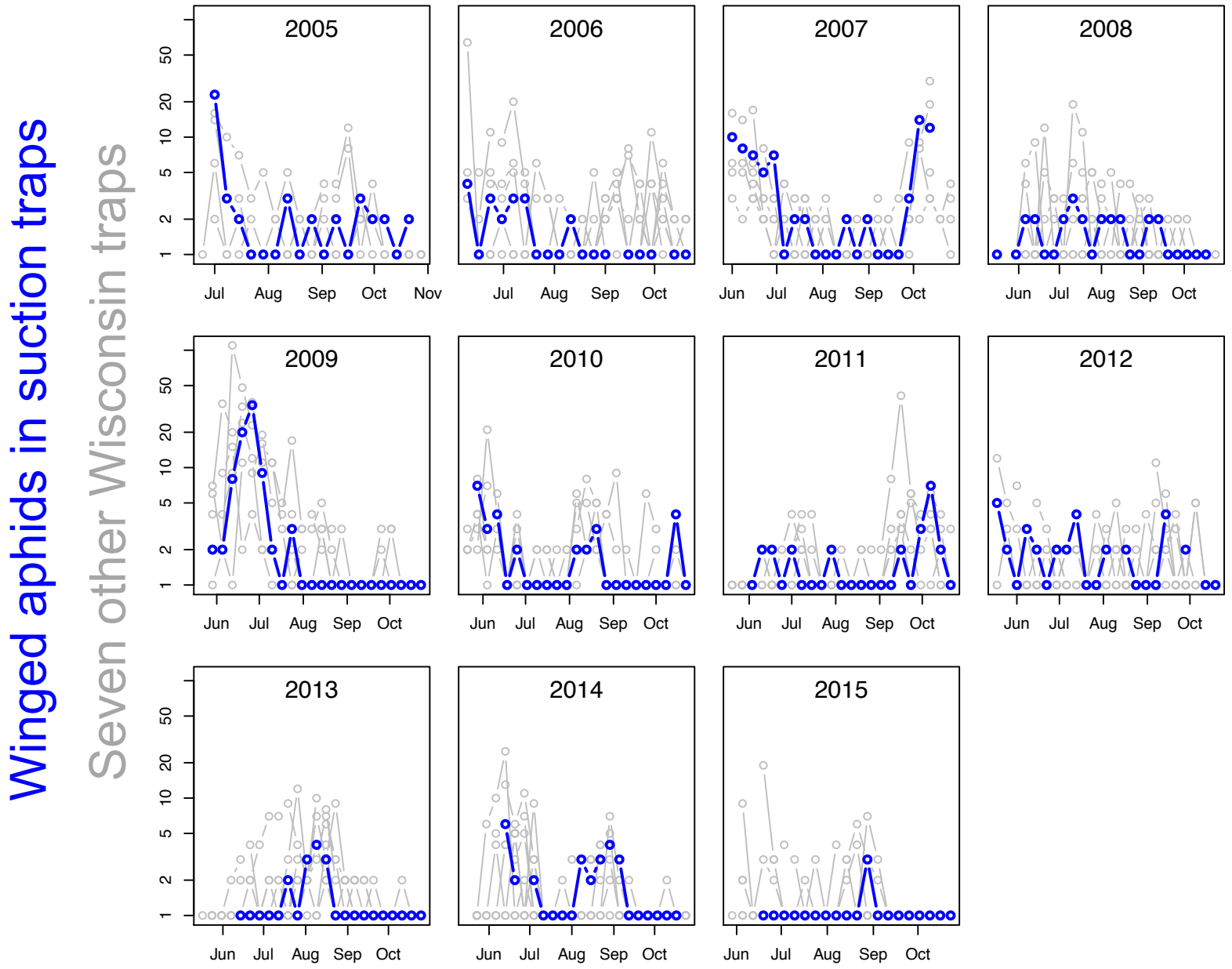



★ our field site




Production of aphids with wings is correlated with local abundance

# 3. Dispersing aphids are synchronized regionally



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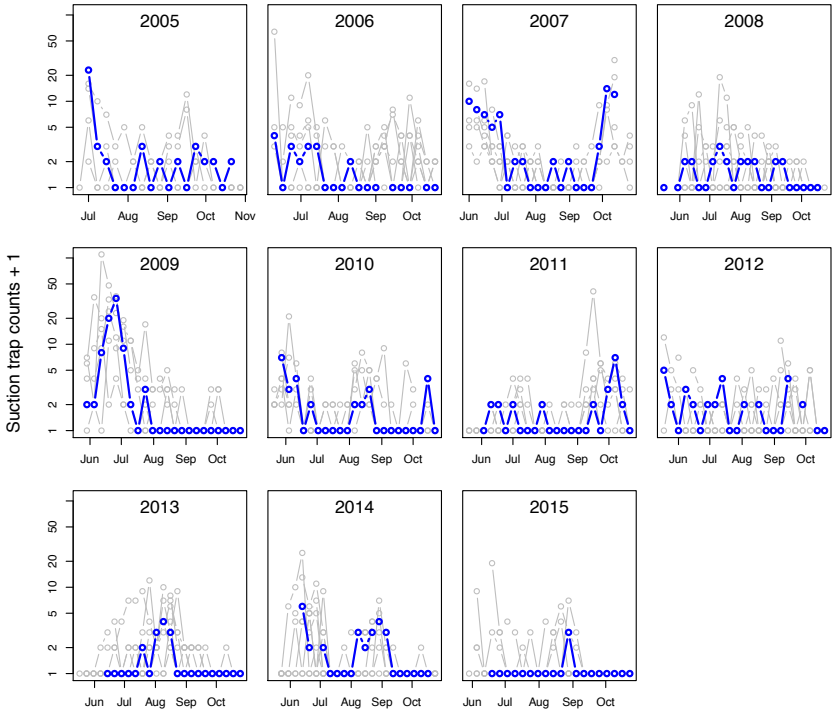


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Since predators control pea aphids locally, what could synchronize the regional abundance of aphids?

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i. Aphid dispersal

ii. Predator dispersal

iii. Climatic forcing

iv. Harvesting patterns

Since predators control pea aphids locally, what could synchronize the regional abundance of aphids?

i. Aphid dispersal

<1/1000 aphids have wings

ii. Predator dispersal

iii. Climatic forcing

iv. Harvesting patterns

Since predators control pea aphids locally, what could synchronize the regional abundance of aphids?

i. Aphid dispersal

ii. Predator dispersal

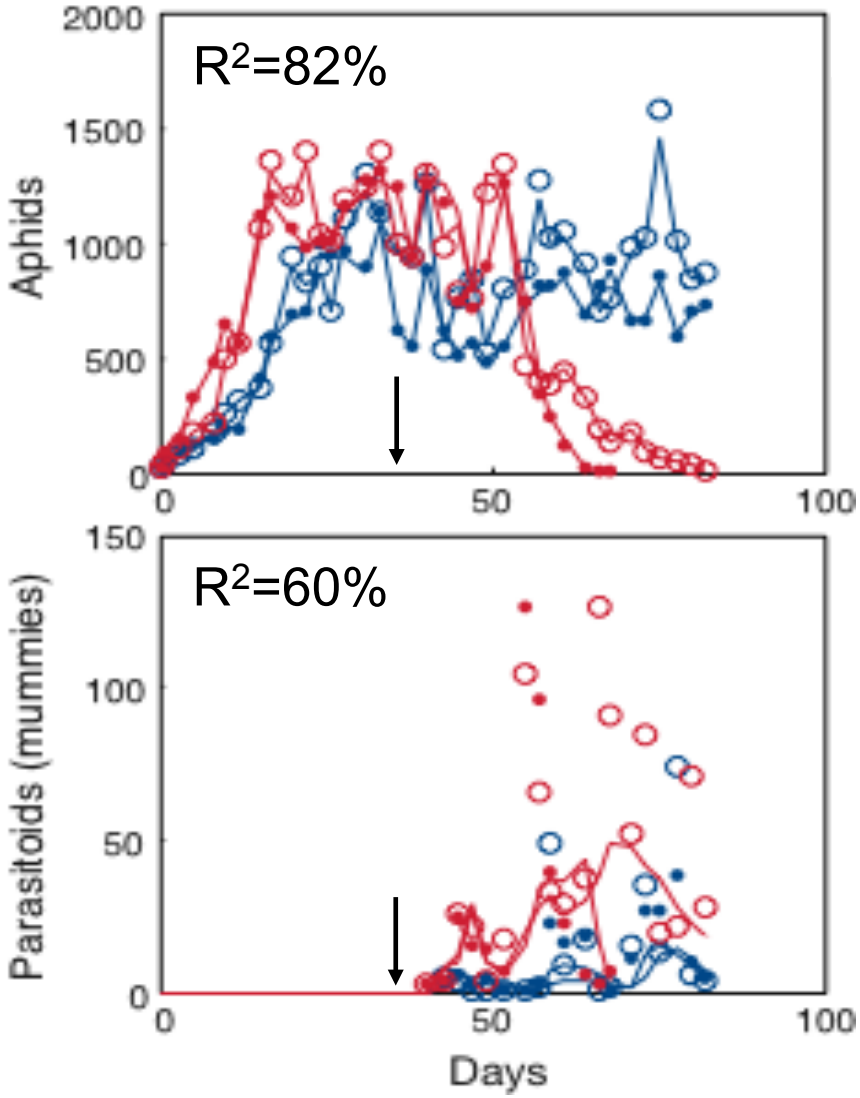
predators don't move far

iii. Climatic forcing

iv. Harvesting patterns

# iii. Climatic forcing

## Parasitism increases with temperature




$R^2$s from process-based model

cool

hot

parasitoid introduction

Lab cages (and field data) show that parasitism is higher at higher temperatures

Since predators control pea aphids locally, what could synchronize the regional abundance of aphids?

i. Aphid dispersal

ii. Predator dispersal

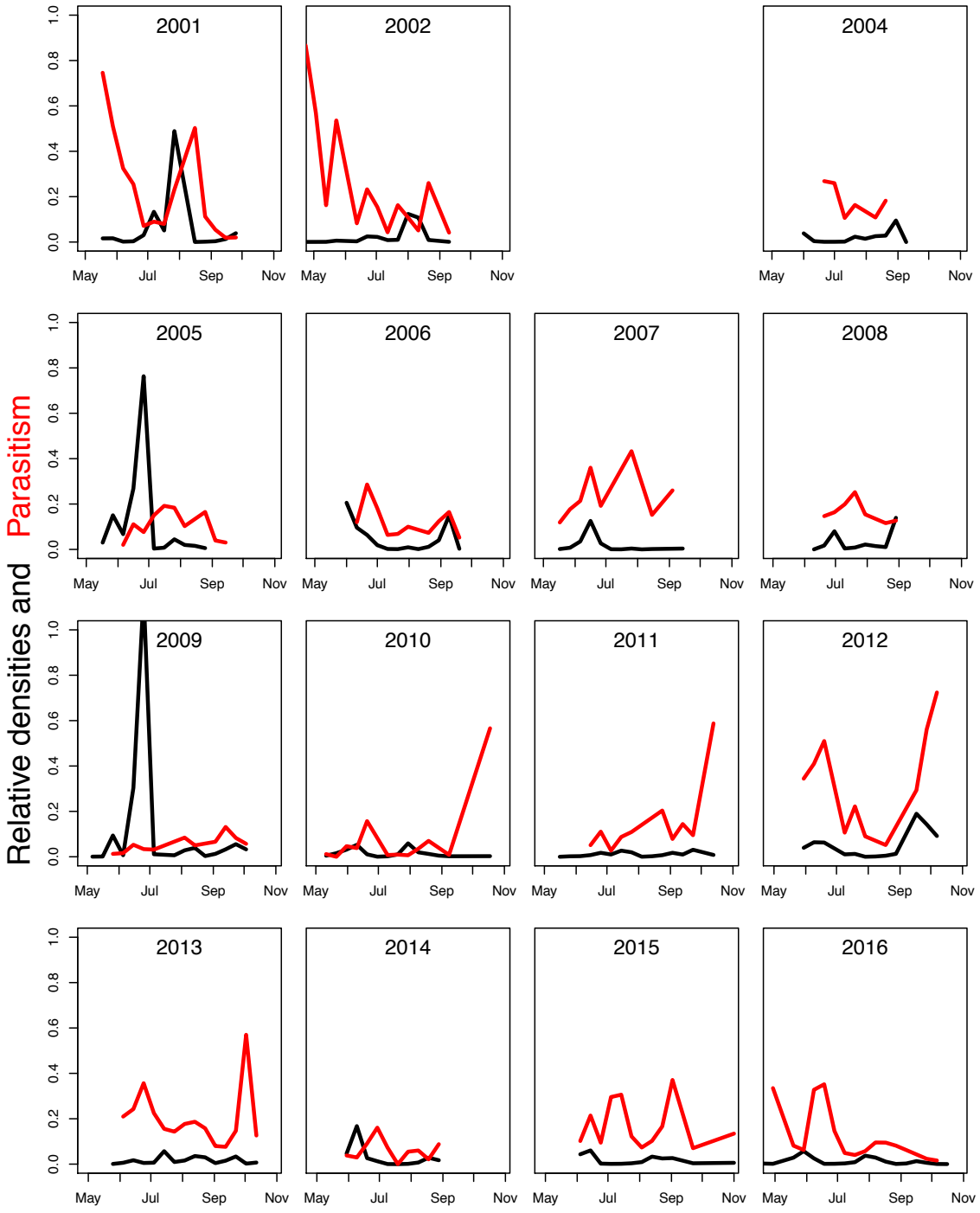
iii. Climatic forcing

iv. Harvesting patterns

# iv. Harvesting patterns

Harvesting fields at different times generally favors predators

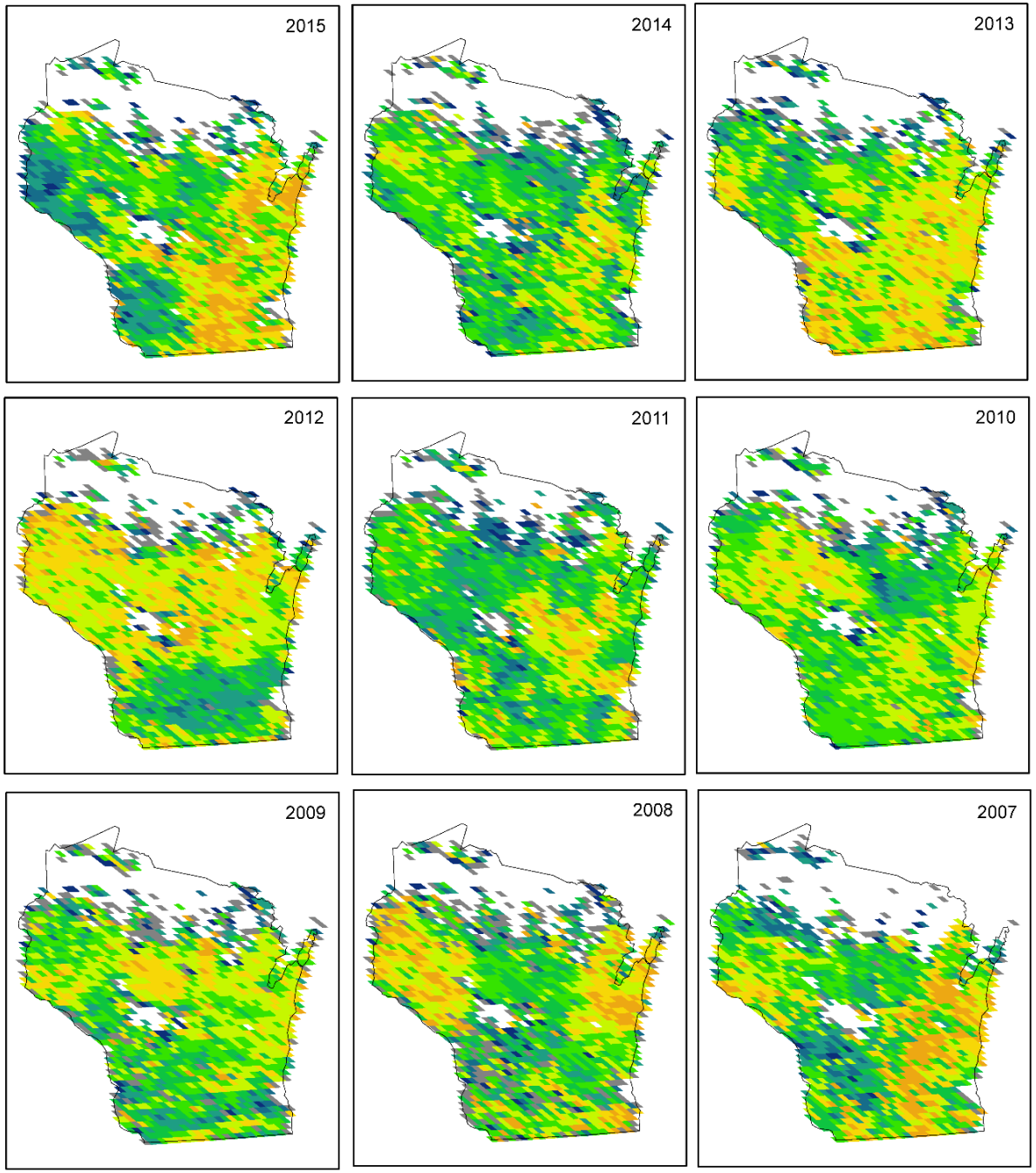
Shown by theory and large-scale experiments




# iv. Harvesting patterns

Peak annual aphid densities are negatively correlated with peak parasitism ($p$ = 0.03)

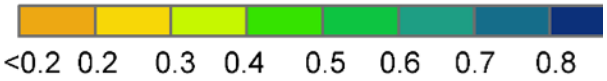
Are these related to harvesting?

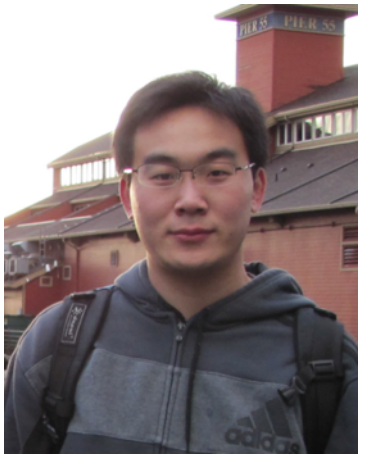



# iv. Harvesting patterns

From MODIS (MDO09Q1), correlations in 8-day NDVI among alfalfa fields within a 10km grid

average correlations



# iv. Harvesting patterns

## Hypothesis

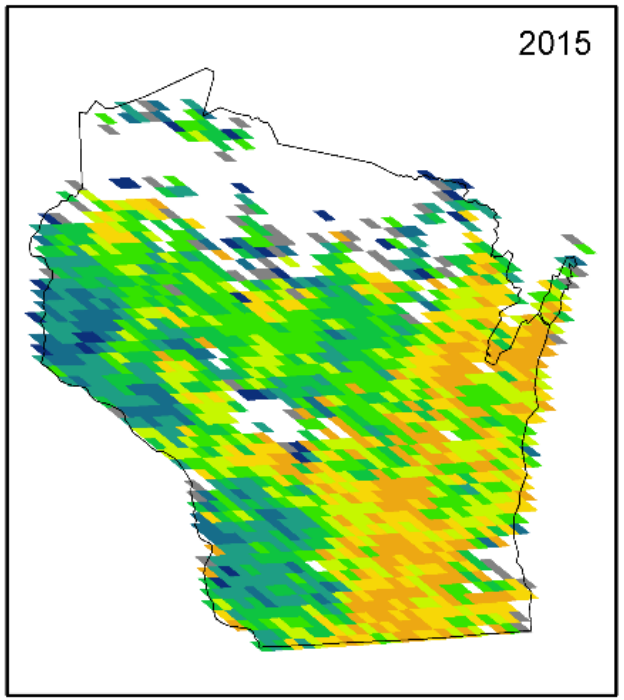
Asynchronous harvesting favors predators and leads to aphid suppression

Therefore, years with broad-scale asynchrony have lower aphid abundances throughout Wisconsin

# Take-homes

1. Remote sensing of the environment can be tailored to different organisms

2. Remote sensing at scales impossible by other means



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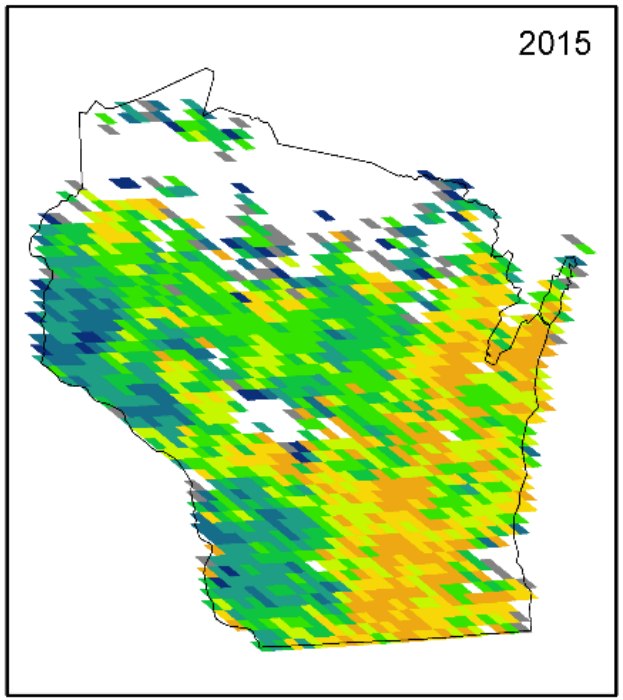
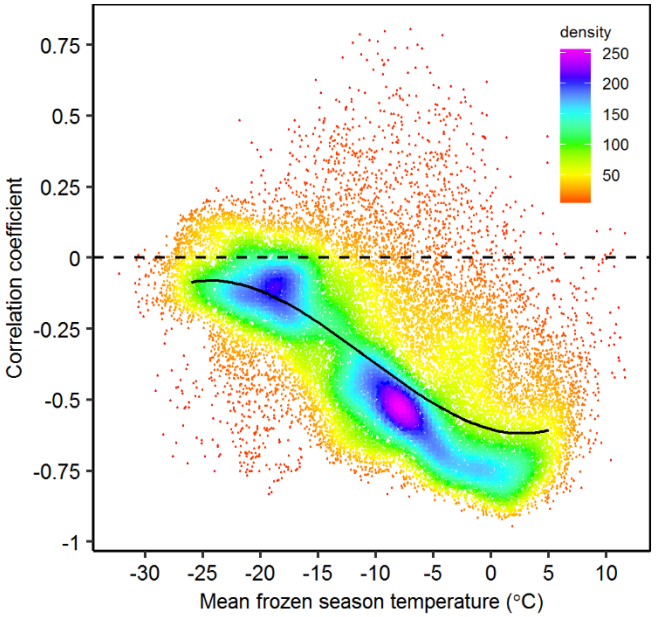



The story of my career: the solution always seems to be at the next-higher scale.

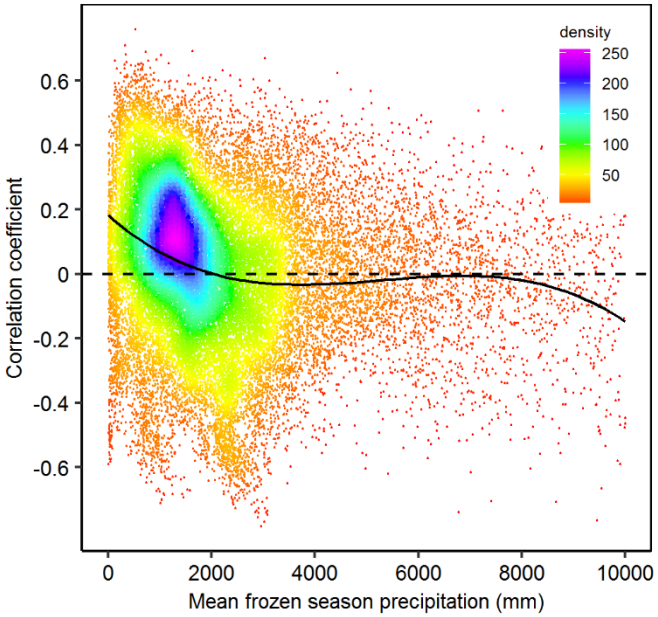
# The changes are mainly due to temperature

## Correlations with snow-covered days

### Temperature




### Precipitation

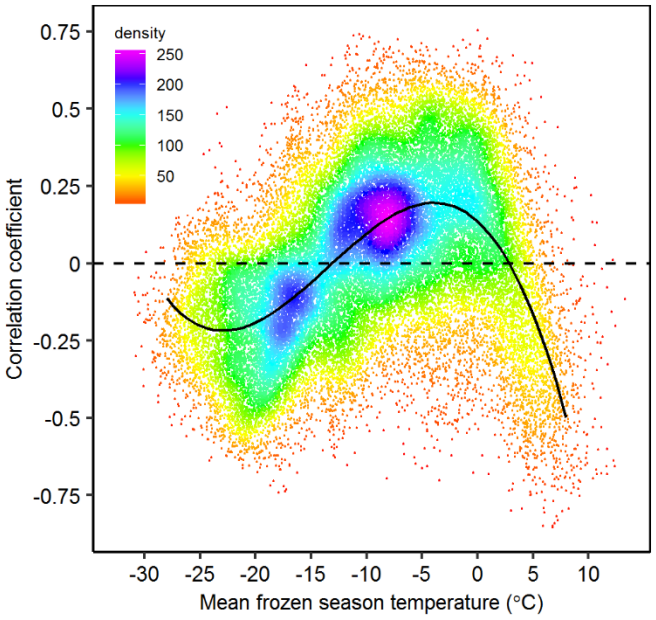



Snow-covered days decrease most with temperature in warmer regions

# The changes are mainly due to temperature

## Correlations with frozen snow-free days

### Temperature

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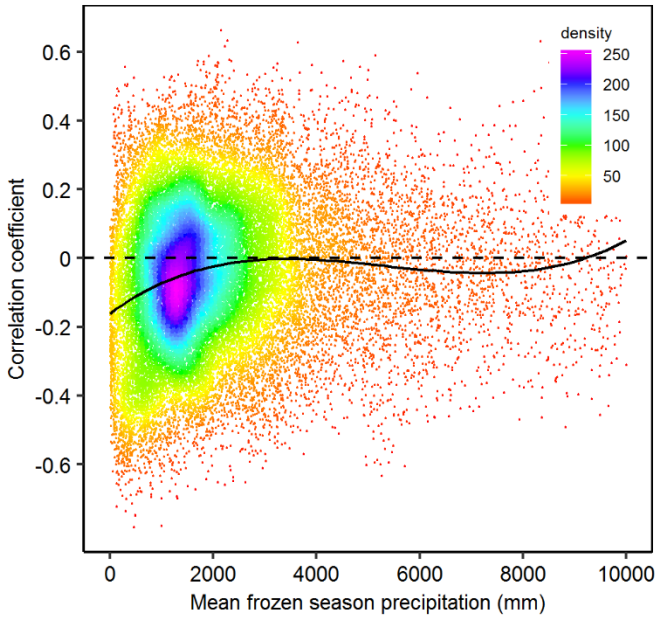


Frozen snow-free days increase most with temperature in warmer regions

# 1. Pea aphid populations are controlled by predators

(data from 10 fields aggregated)

aphids

ladybeetles

parasitism