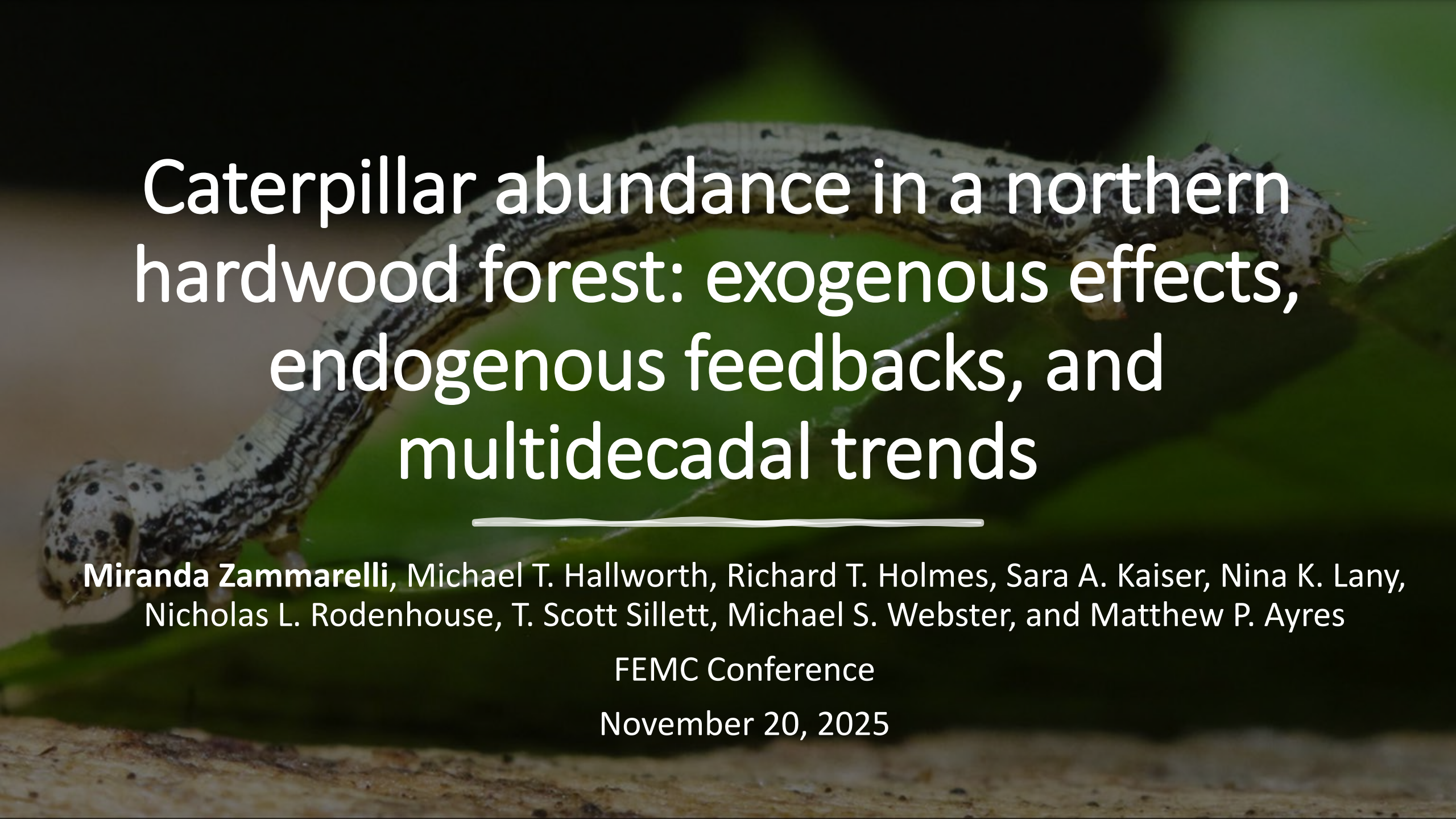


Caterpillar abundance in a northern hardwood forest: exogenous effects, endogenous feedbacks, and multidecadal trends

Miranda Zammarelli, Michael T. Hallworth, Richard T. Holmes, Sara A. Kaiser, Nina K. Lany, Nicholas L. Rodenhouse, T. Scott Sillett, Michael S. Webster, and Matthew P. Ayres

FEMC Conference

November 20, 2025

Introduction

- Herbivorous insects fluctuate in abundance
- These fluctuations can be concordant
- Why do these fluctuations matter?
  - Food for birds and bats
  - Defoliation

- What is driving these fluctuations in abundance?

What are the endogenous effects regulating caterpillar populations?

Density-dependence

Delayed density-dependence

What are the exogenous effects regulating caterpillar populations?

Weather

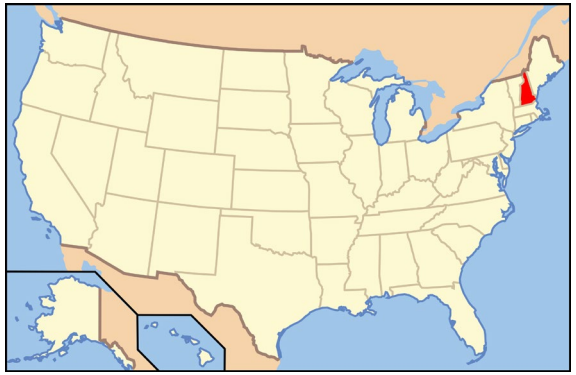
Host quality

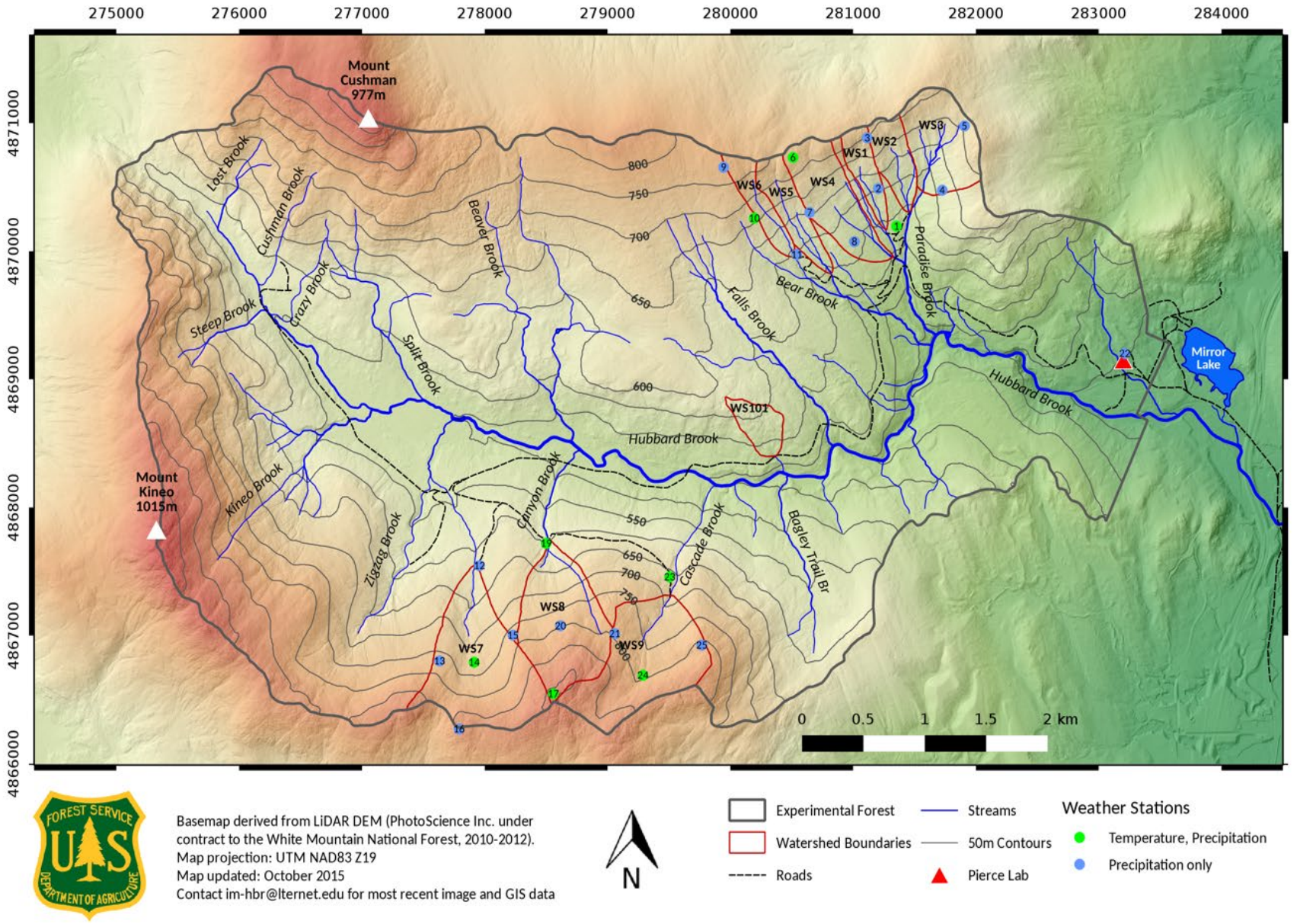
Natural enemies

Exogenous Effects

- Weather
  - Budburst in the spring
  - Average temperature during leaf expansion
  - **Thermal sum**
  - Minimum winter air temperature
  - Minimum winter air temperature without snow
  - **Total water-year precipitation**
  - **Summer precipitation**
  - Number of high rainfall events
- Host Quality
  - **Foliar Nitrogen of host plants**
- Natural Enemies
  - **Birds**
  - Parasitic Wasps

Site Location – Hubbard Brook Experimental Forest





Methods

- Four surveys
- May through July
- Count and measure caterpillars
- ID to family
- Calculate biomass

American Beech (*Fagus Grandifolia*)

Sugar Maple (*Acer saccharum*)

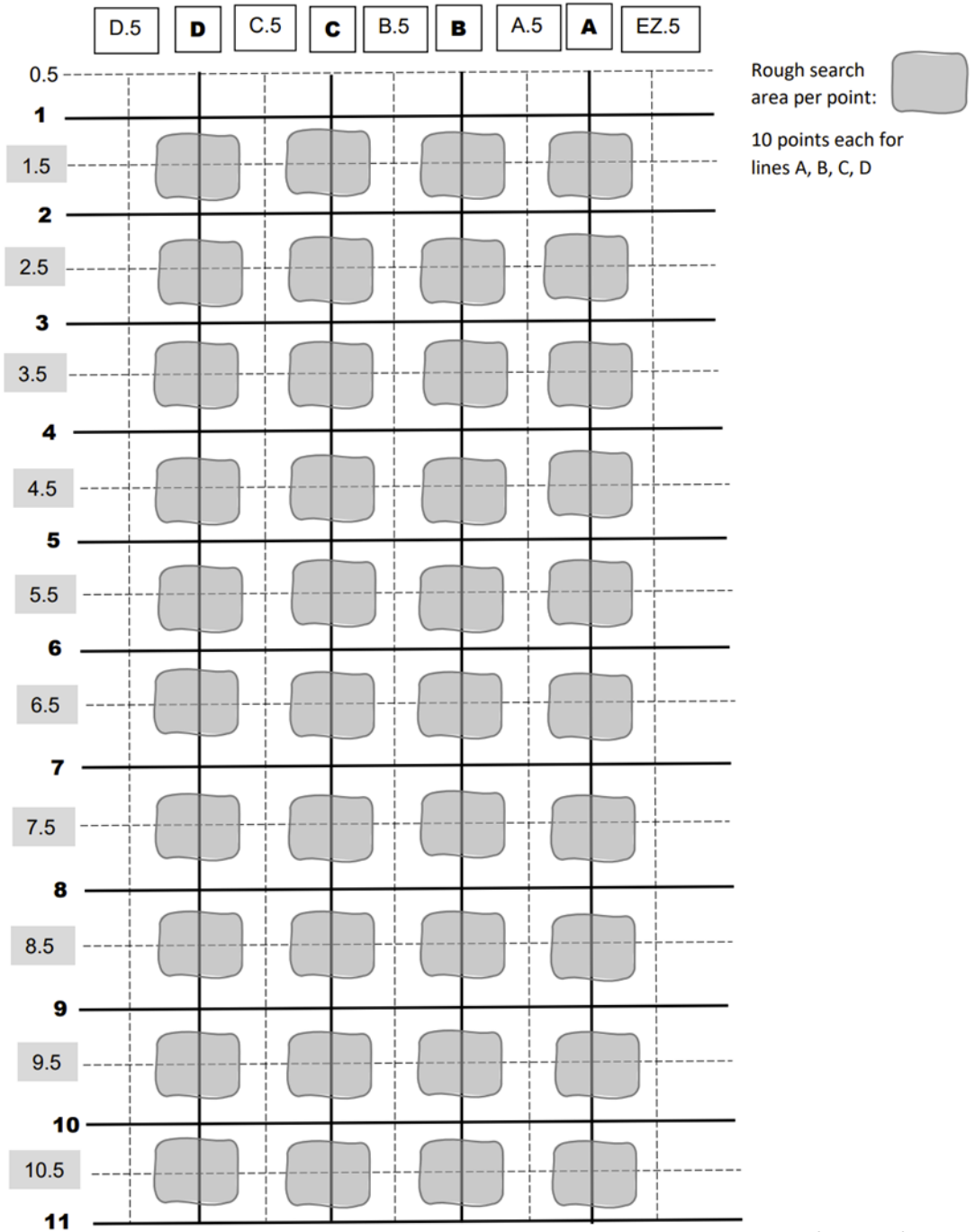
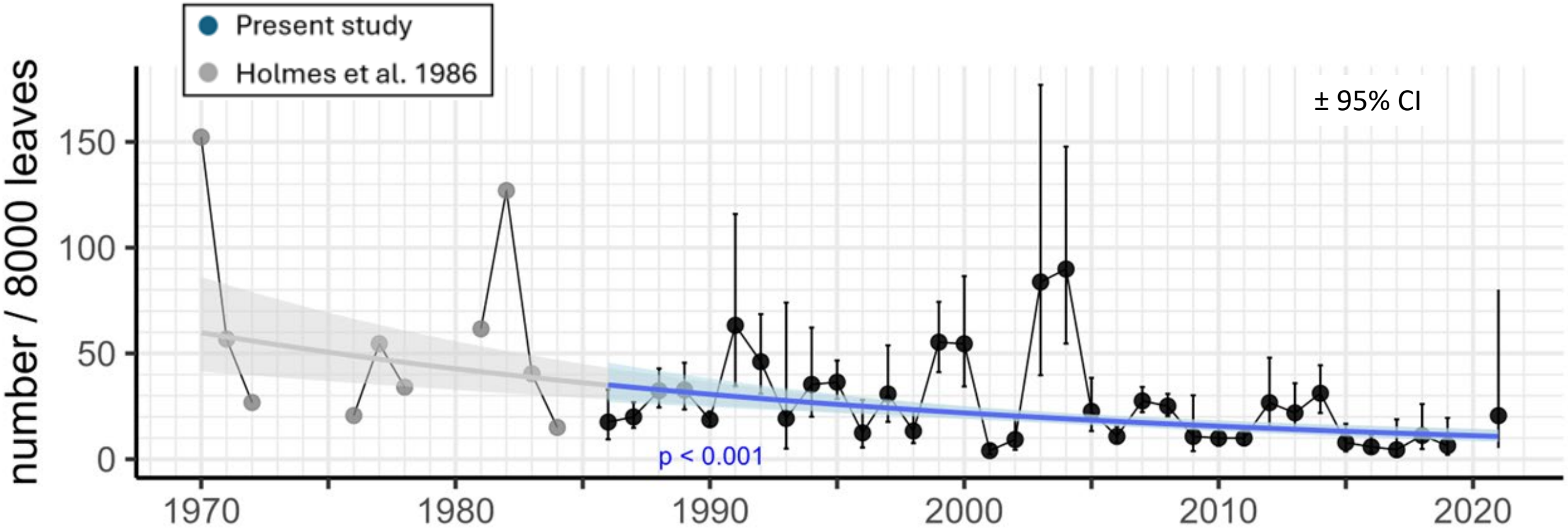


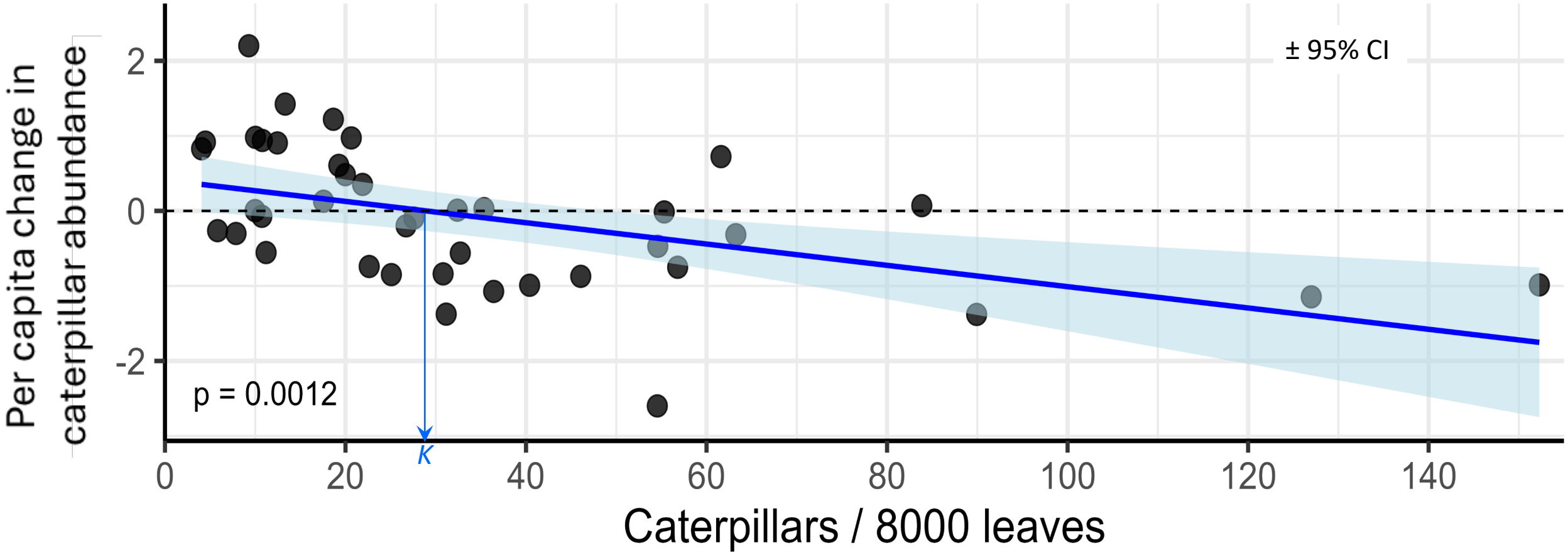
Diagram: Sophie Rabinowicz

Endogenous Feedbacks

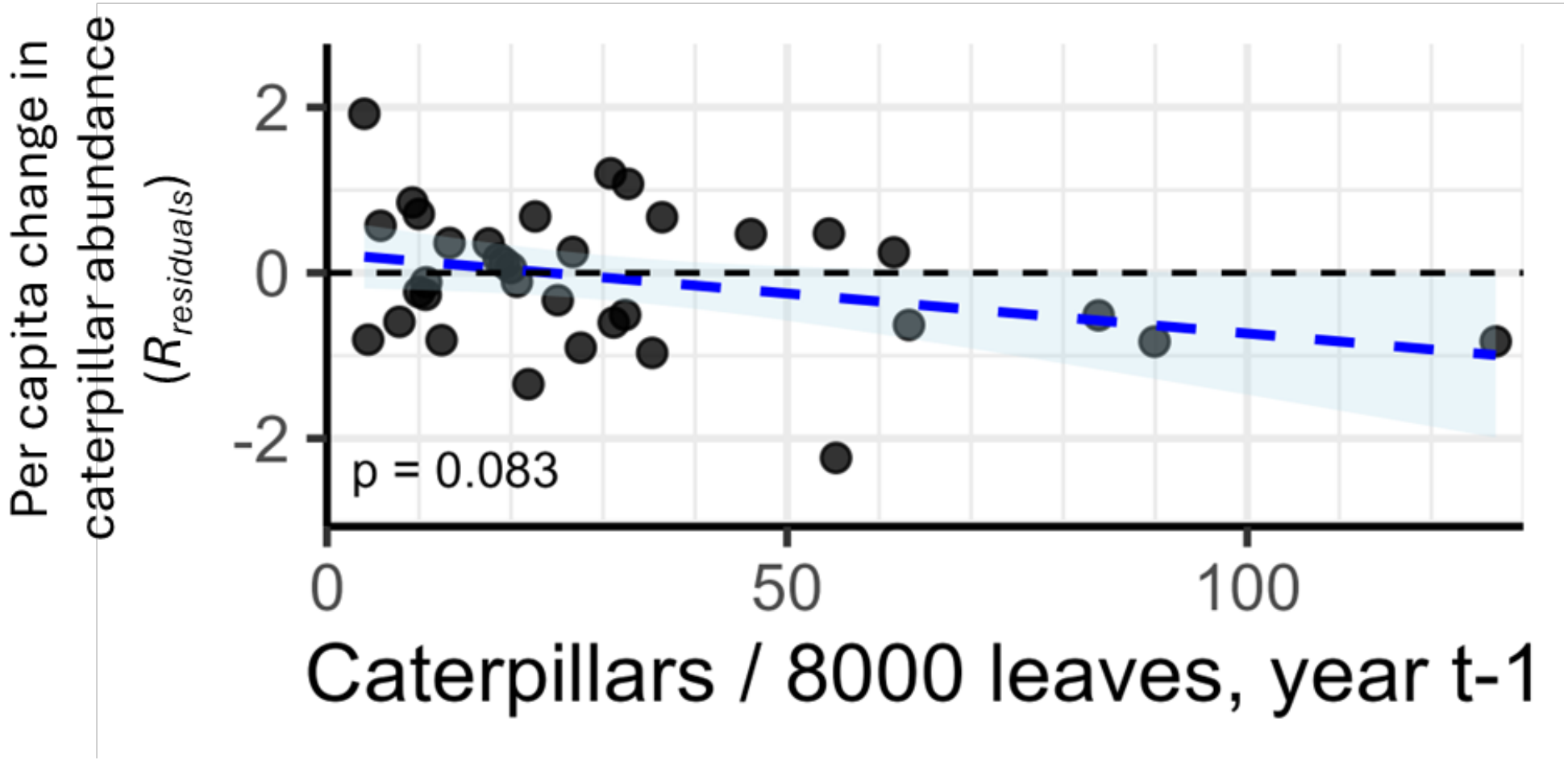
Fluctuations in Caterpillar Abundance



Negative Density-dependence

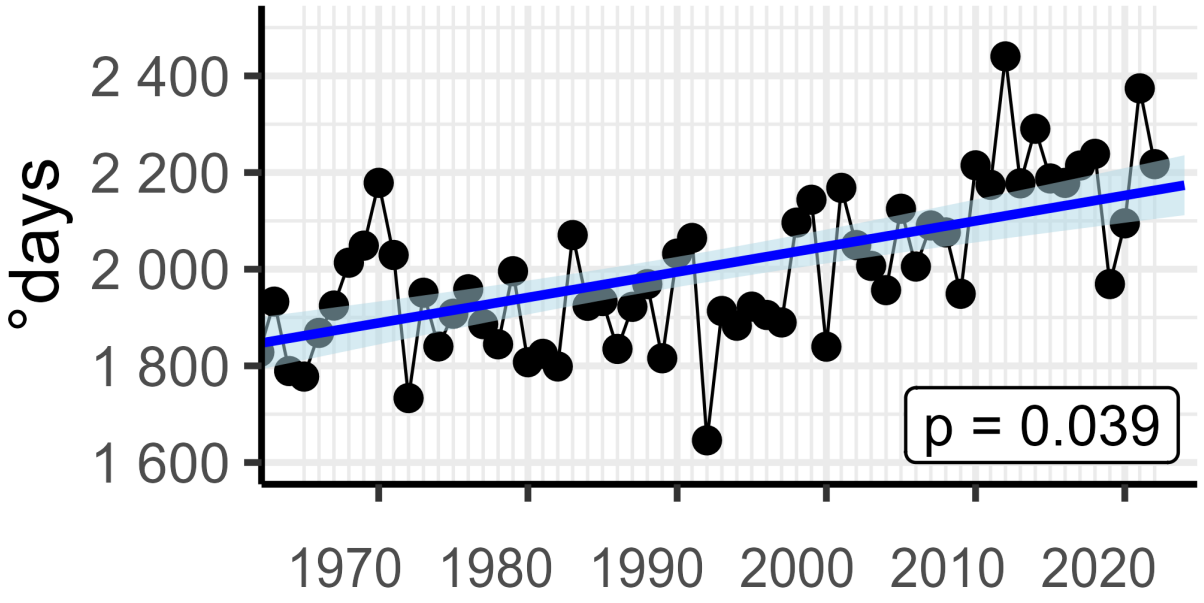


No Delayed Density-dependence

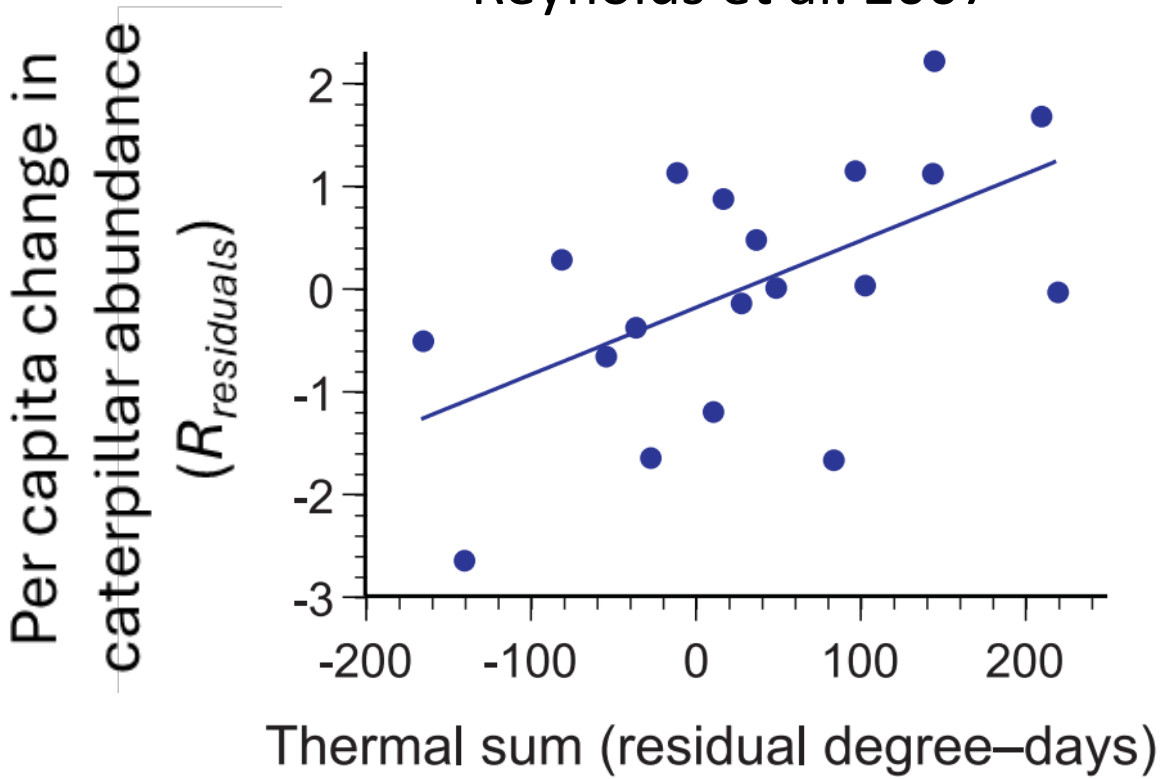


Exogenous Effects

Weather: Thermal Sums

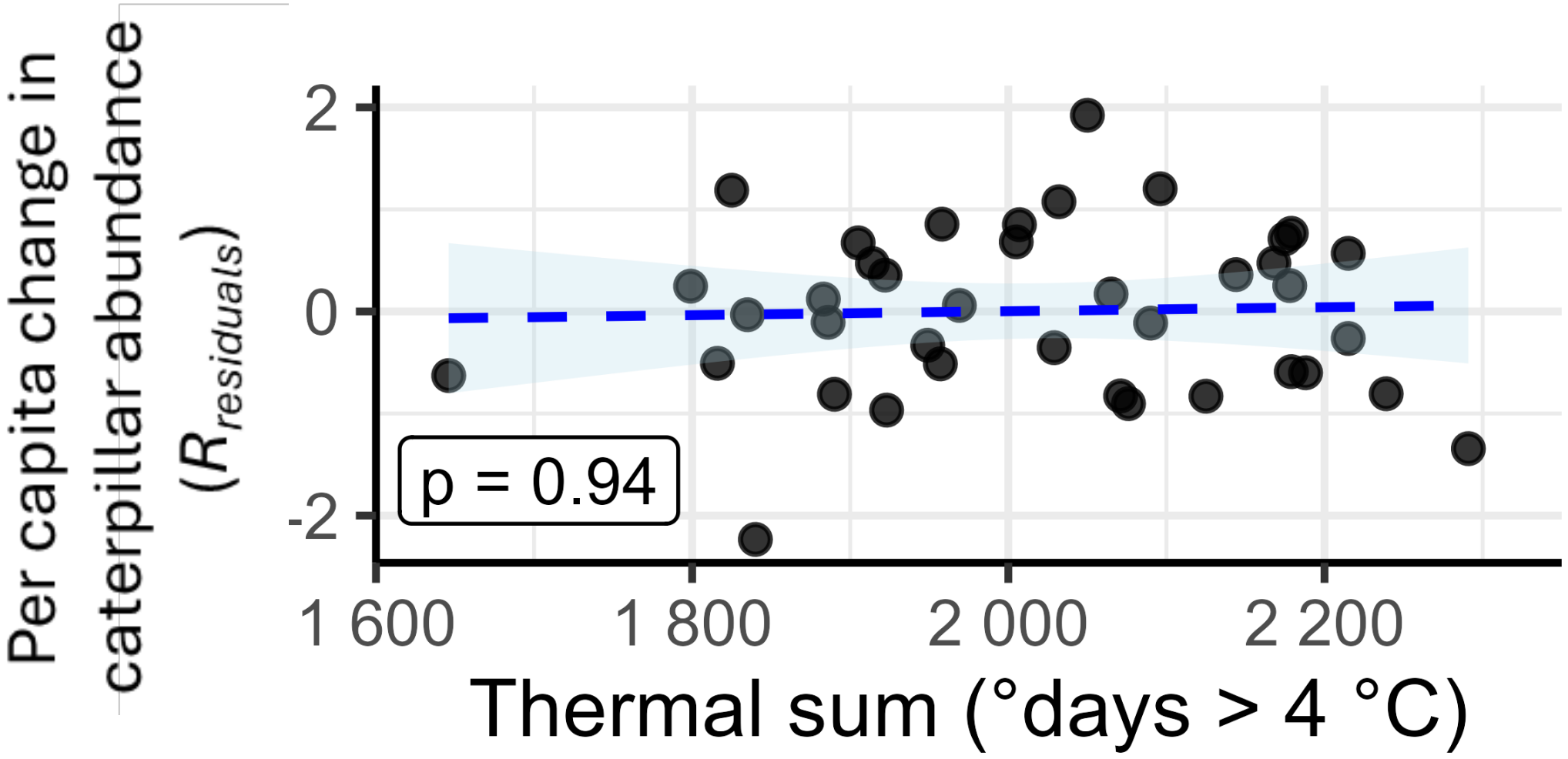


Reynolds et al. 2007

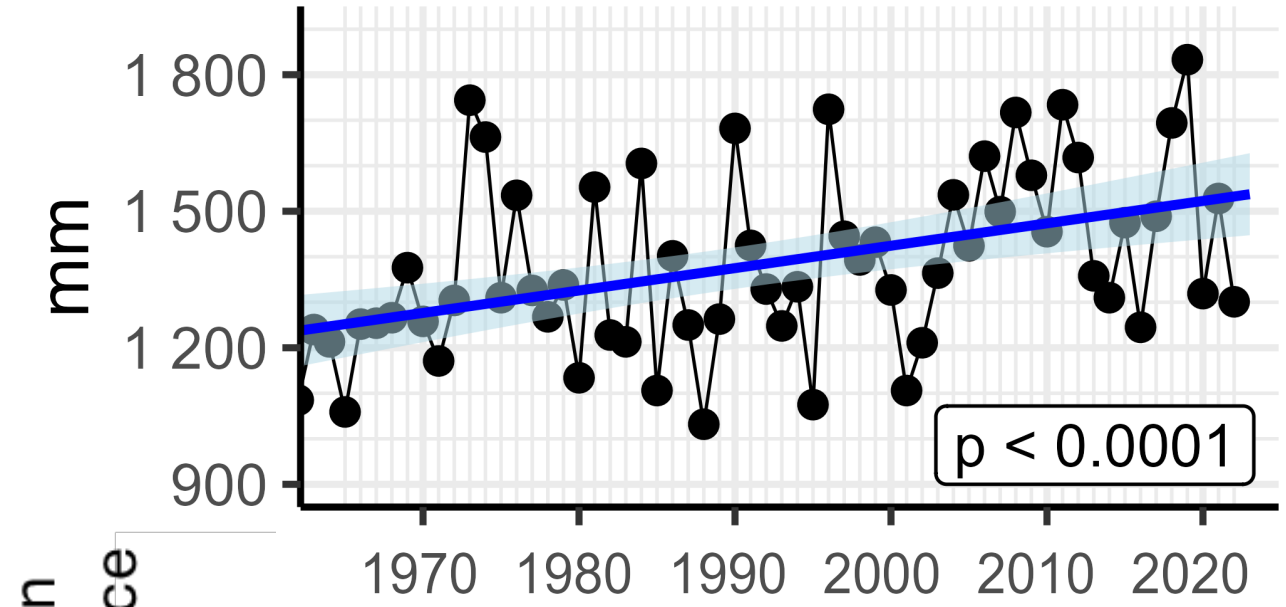


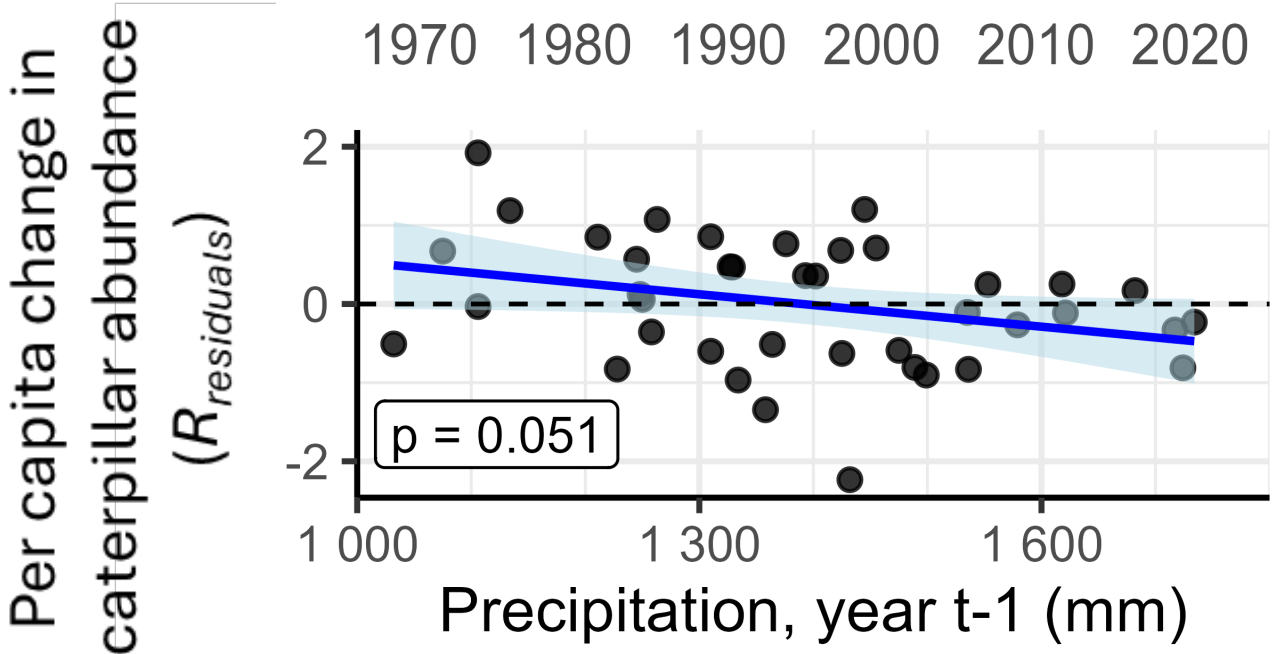
Thermal Sum - cumulative degree days above a 4 ˚C base from March 15 to October 15

Weather: Thermal Sums

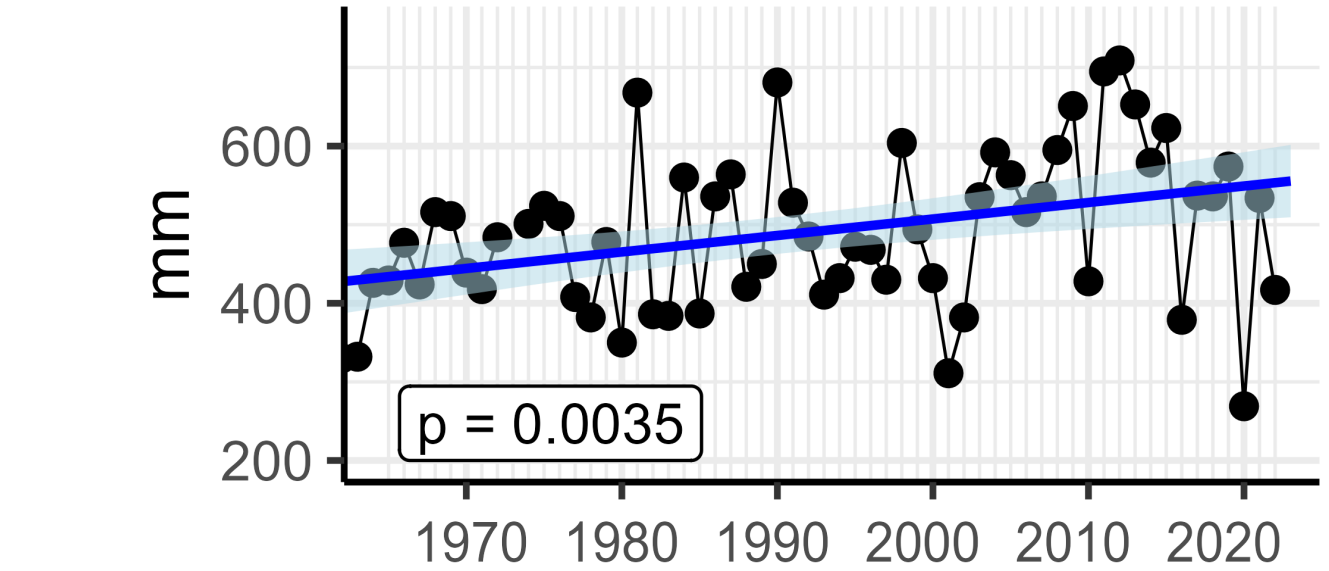


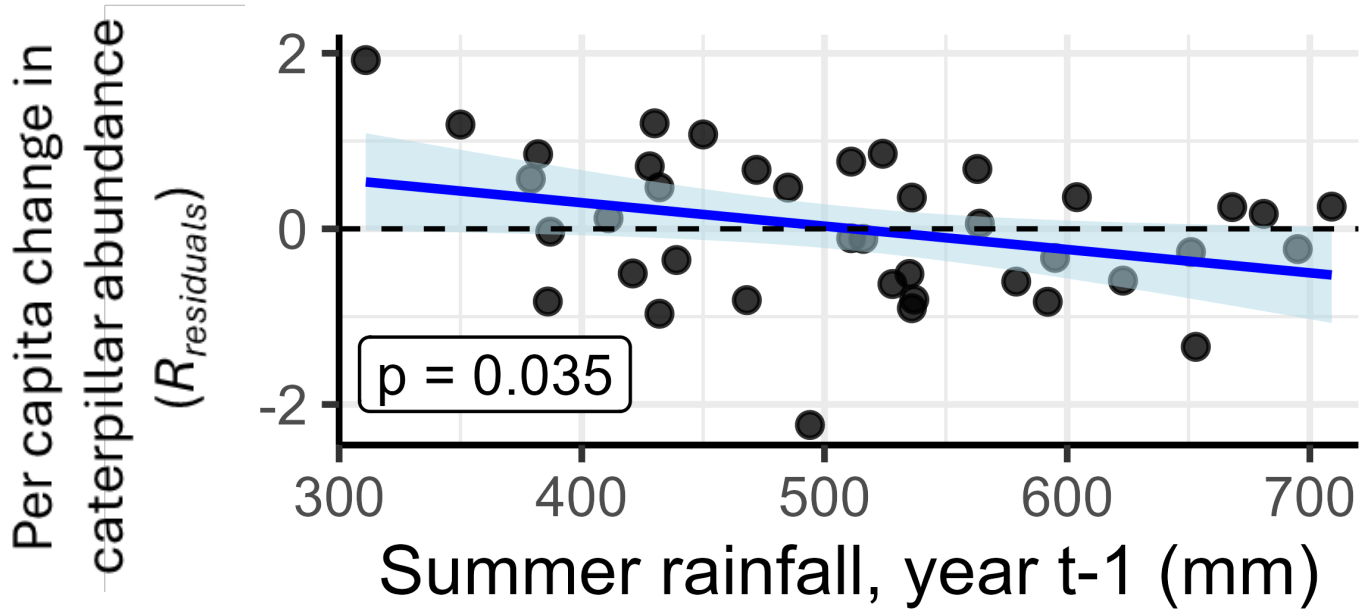
Weather: Water-Year Precipitation



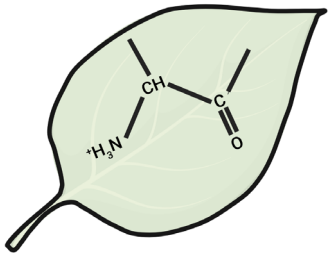


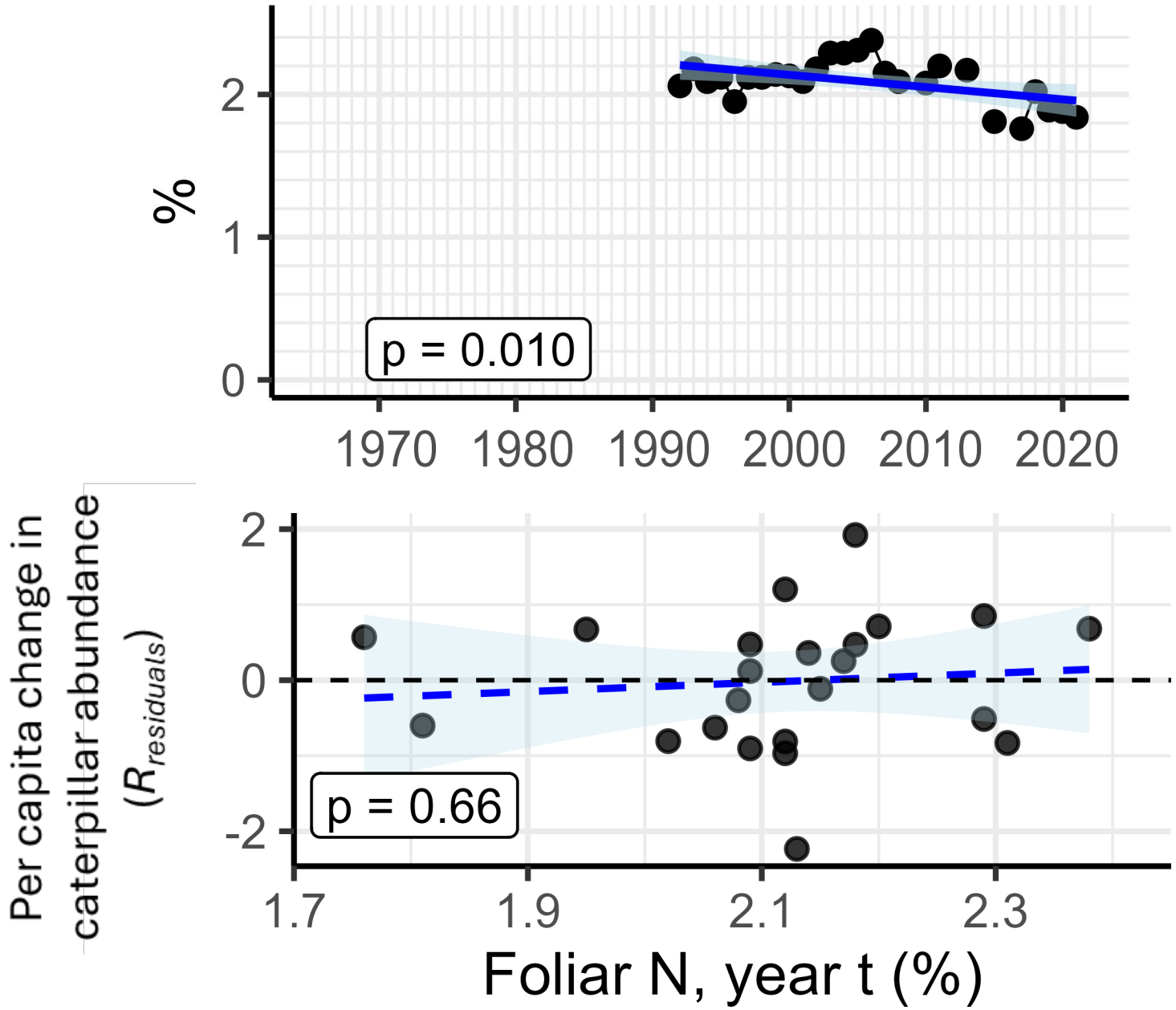
Weather: Summer Precipitation



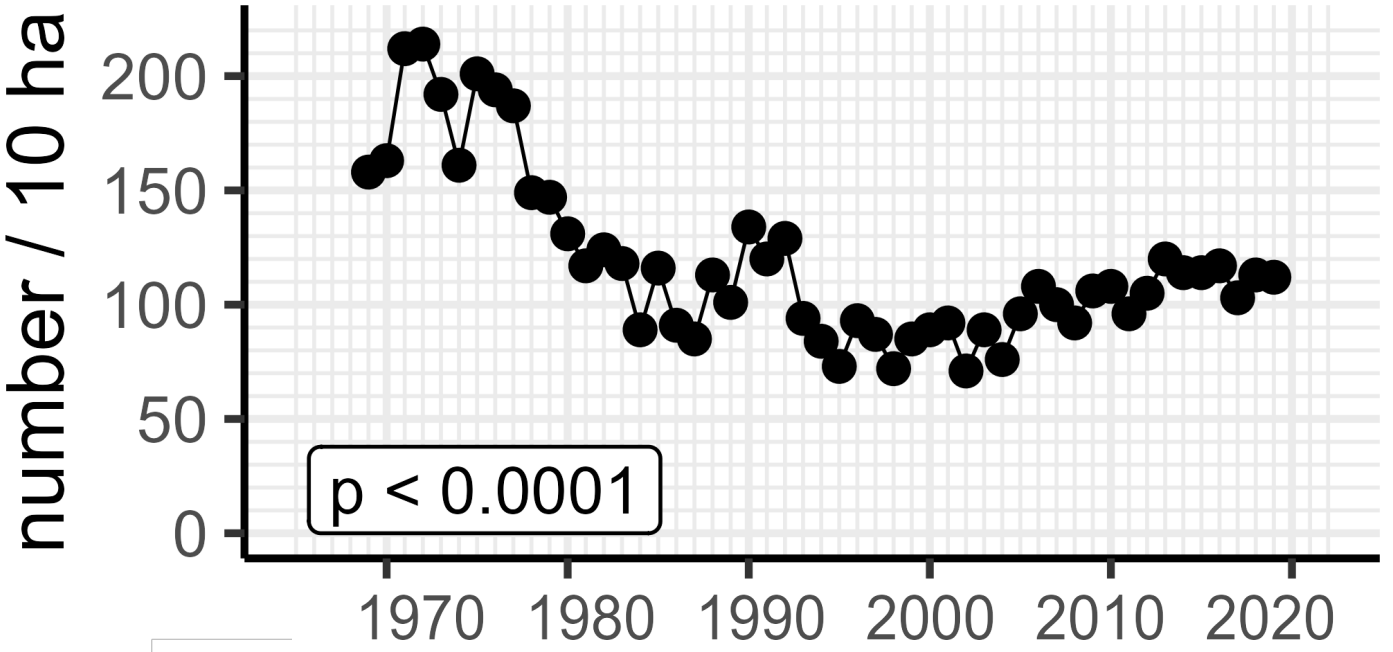


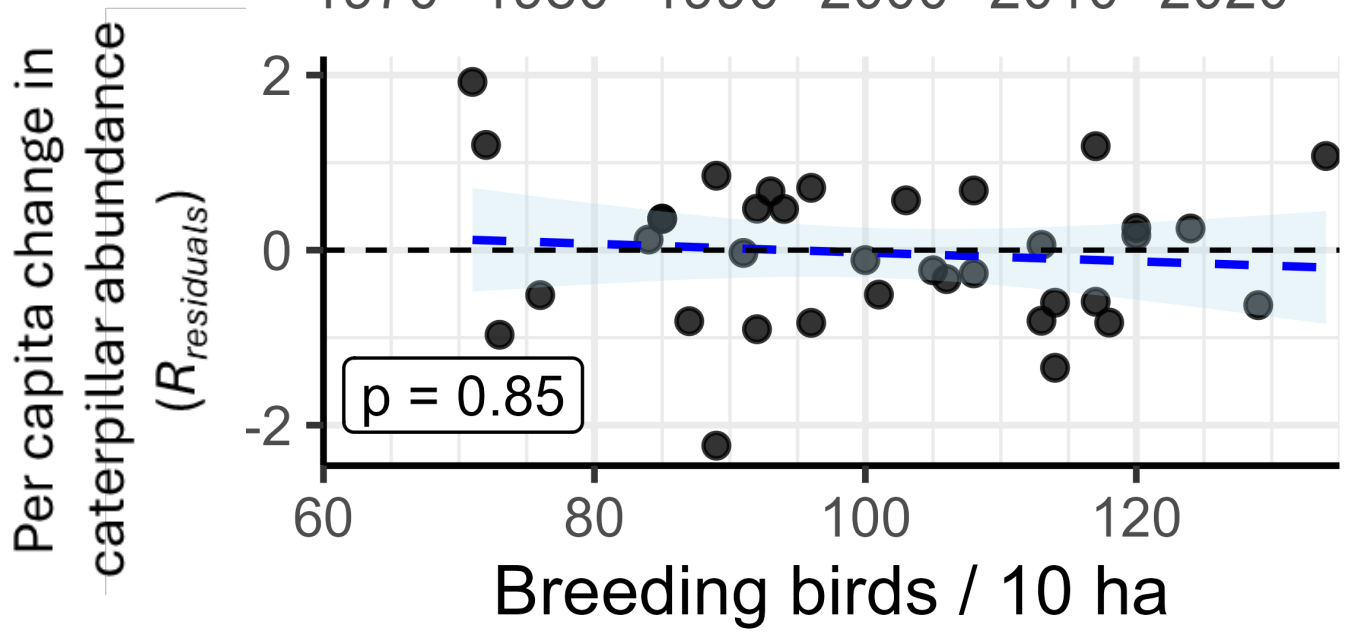
Host Quality: Foliar Nitrogen





Natural Enemies: Birds





Exogenous Effects

- Weather
  - ~~Budburst in the spring~~
  - ~~Average temperature during leaf expansion~~
  - ~~**Thermal sum**~~
  - ~~Minimum winter air temperature~~
  - ~~Minimum winter air temperature without snow~~
  - **Total water-year precipitation**
  - **Summer precipitation**
  - ~~Number of high rainfall events~~
- Host Quality
  - ~~**Foliar Nitrogen of host plants**~~
- Natural Enemies
  - ~~**Birds**~~
  - ~~Parasitic Wasps~~

Mechanism for precipitation causing decreases in caterpillar growth rate

- Fungal Pathogens: *Entomphaga*
- Increased infection rates with high moisture

- Years with high rain → high caterpillar infection rates → higher spore abundance → decrease in caterpillar abundance

Are insects declining in the White Mountains region?

- High precipitation favoring fungal entomopathogens is consistent with:
  - Fluctuations in caterpillar abundance
  - Multidecadal decrease in abundance
- Ecosystems with increase precipitation may also experience increased entomopathogens
- Globally, precipitation patterns vary

Acknowledgements

Coauthors

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Thank you to all the technicians who have counted caterpillars!

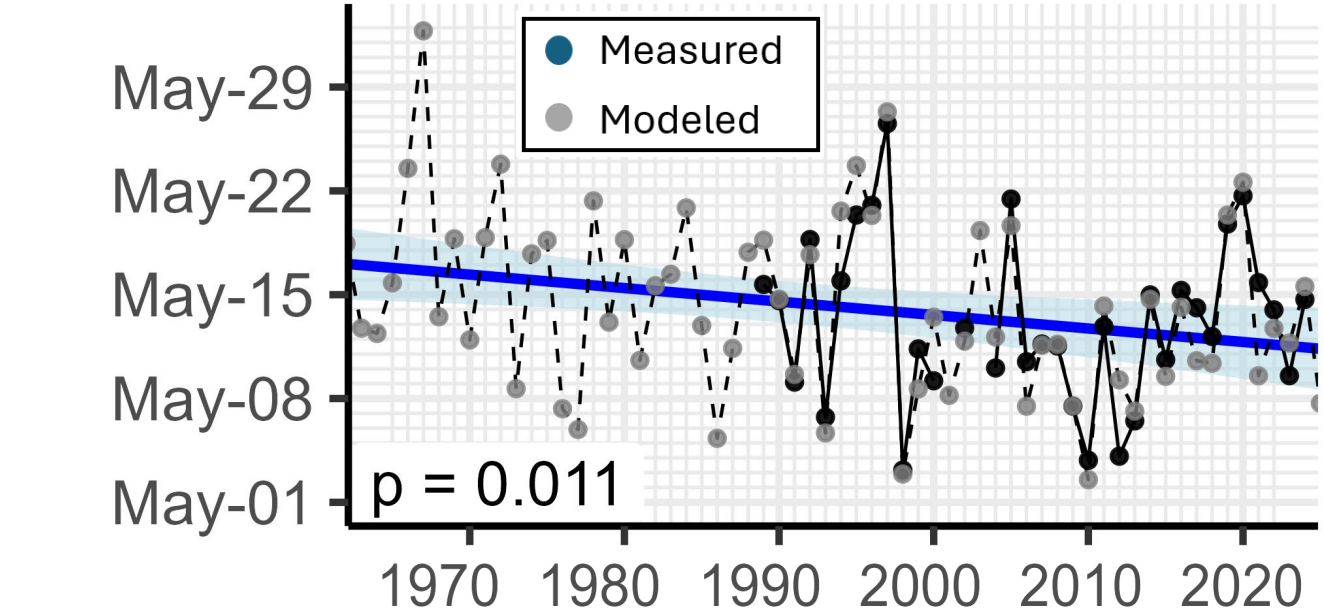
Figures created in Biorender

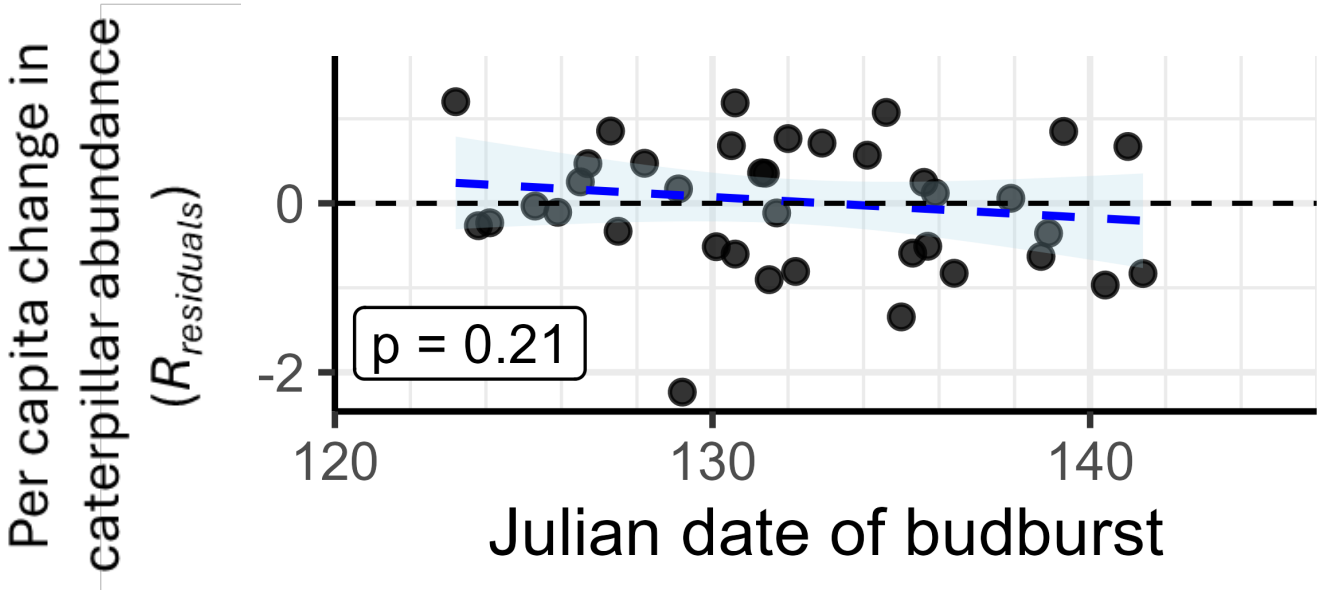
Raisa Kochmaruk for her caterpillar art

HUBBARD BROOK
ECOSYSTEM STUDY

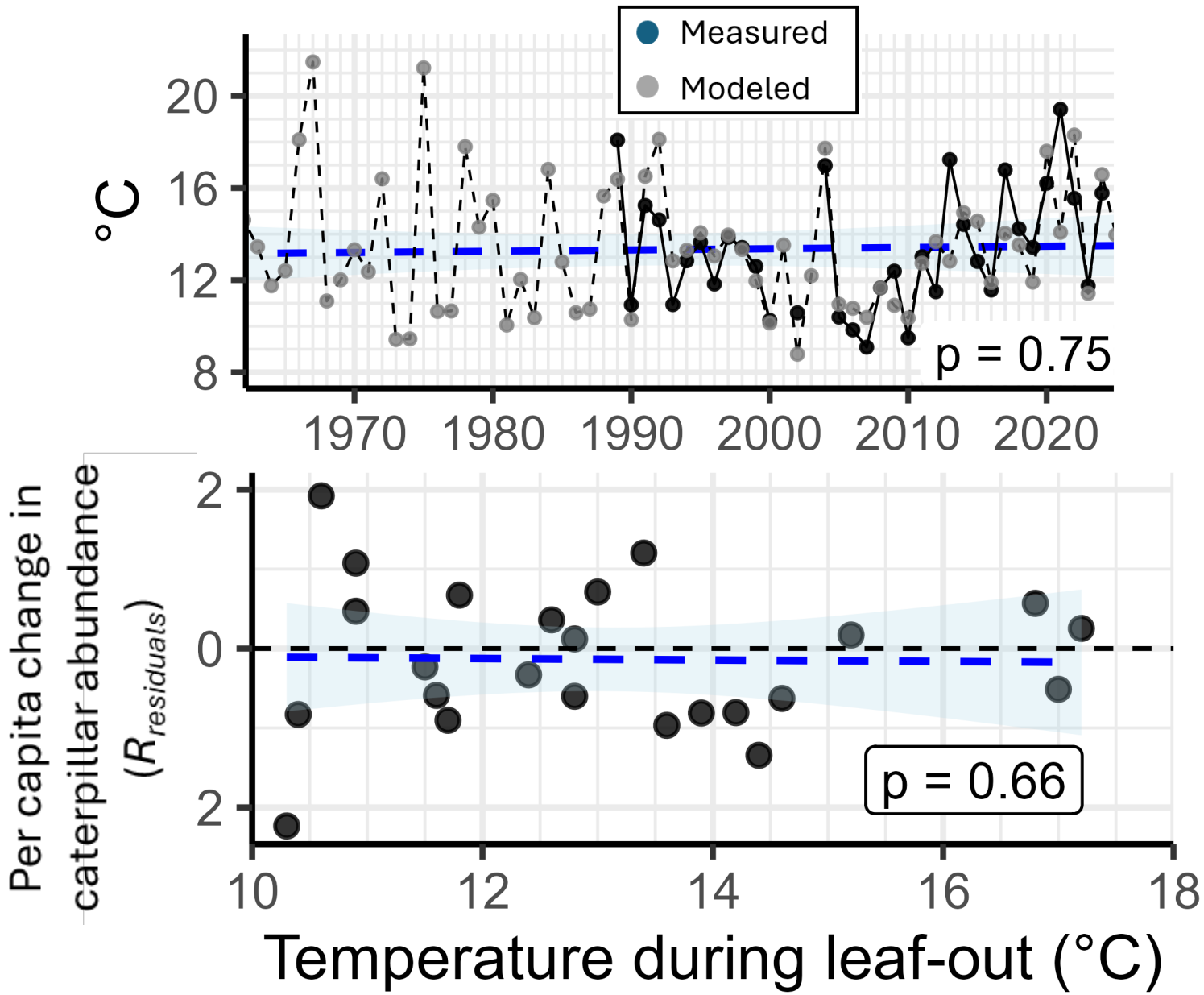
Thank you!

Weather: Budburst

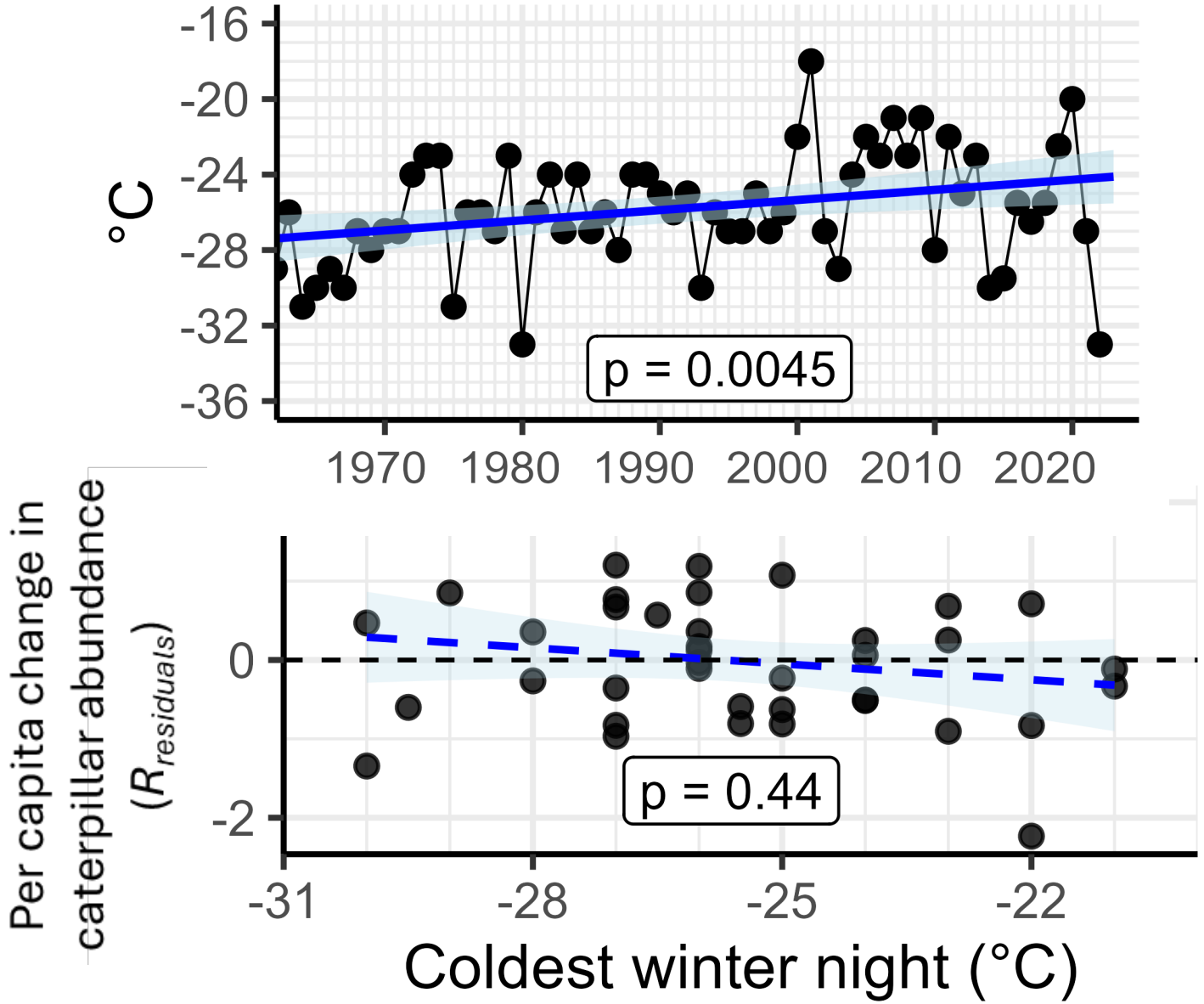




Weather: Temperature during Leaf-out



Weather: Coldest Night of the Winter



Natural Enemies: Hymenoptera Abundance