Investigation of mechanisms for oak seedling success under pine in the Lake States Region

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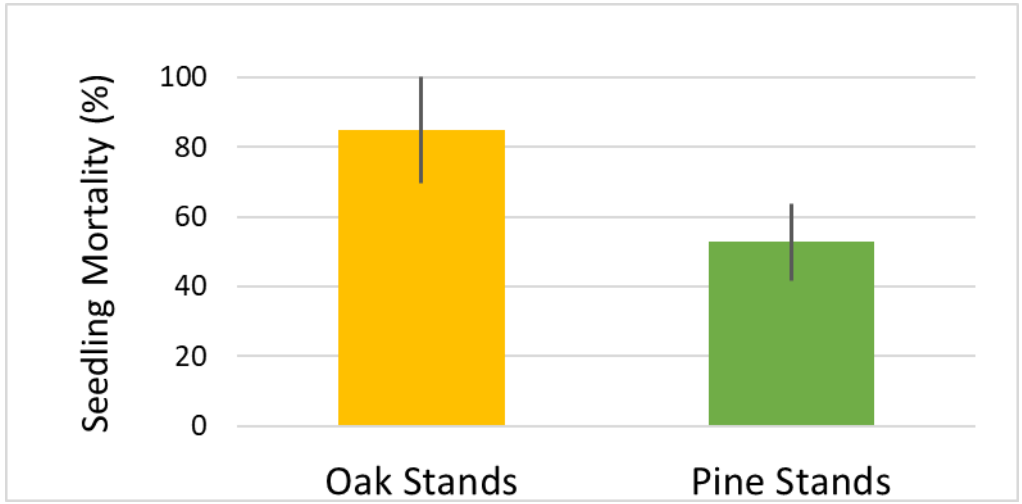
Oaks in the Lake States Region

- Important ecosystem component in the Lake States region
  - 96 wildlife species feed oak acorns in North America
  - Valuable hardwood products
- Oak dominance declining across the region
  - Poor regeneration
  - Poor seedling establishment

Successful Oak Regeneration under Red Pine

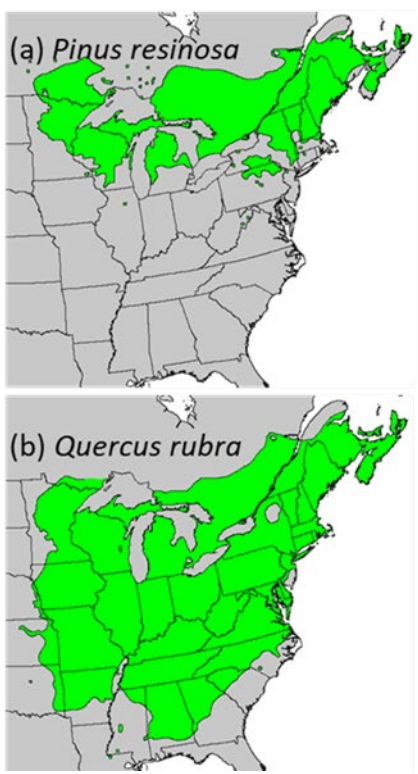


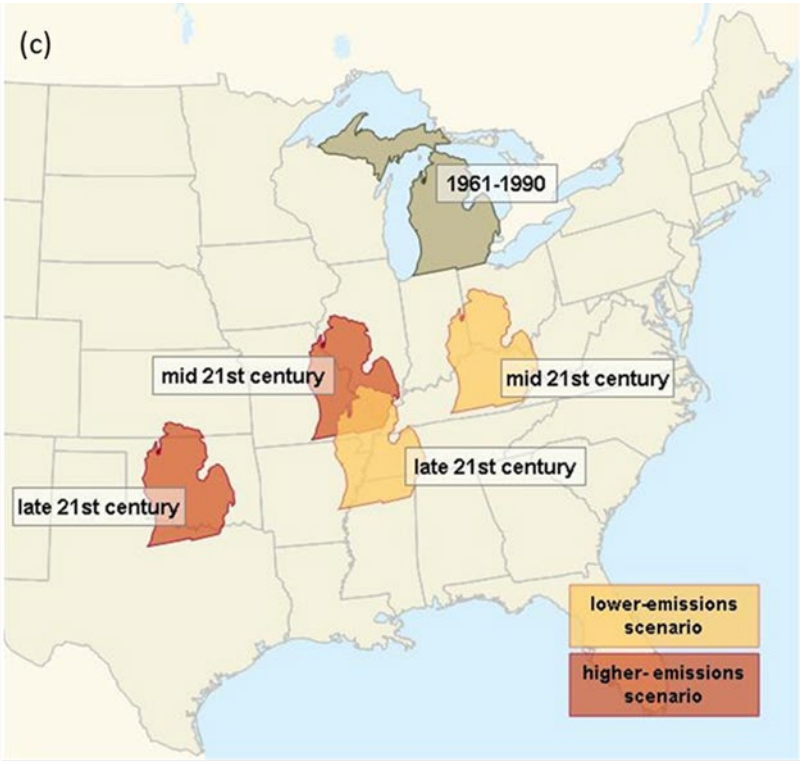
Granger et al. 2018. Forest Eco & Management. 429:467-479.

- Oaks regenerate better under red pine than adjacent parent oak trees
- Research conducted in Michigan by Michigan Tech Univ & MI-DNR
- Mechanisms not clear, but:
  - Abiotic conditions (e.g., light, temperature, soil water content, protection from late spring frost)
  - Biotic conditions (e.g., soil pathogens accumulated in oak soils)

Red Pine to Oak Transition under Warming

- Vast red pine plantations across the Great Lakes Region
- Red pine has a narrow temperature range
- Red pine may not grow well under future warming
- Oaks (e.g., northern red oak) can be good trees to replace red pine plantations in the southern distribution



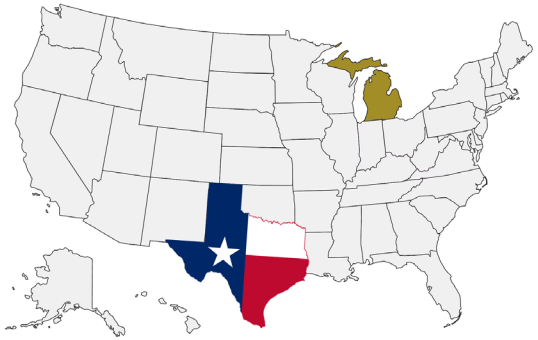


Hayhoe et al. (2010) J. of Great Lakes Research. 36:7-21.

Objectives: “Oak Success under Pine” Project

- Oak seedling growth & survival in red pine plantations and adjacent oak stands
- Soil legacy for nutrients and microbiome in a greenhouse
- Abiotic factors (e.g., light, soil moisture, and temperature) in the field
- To develop silvicultural guidelines to grow oak trees under red pine

Materials & Methods: Study Sites



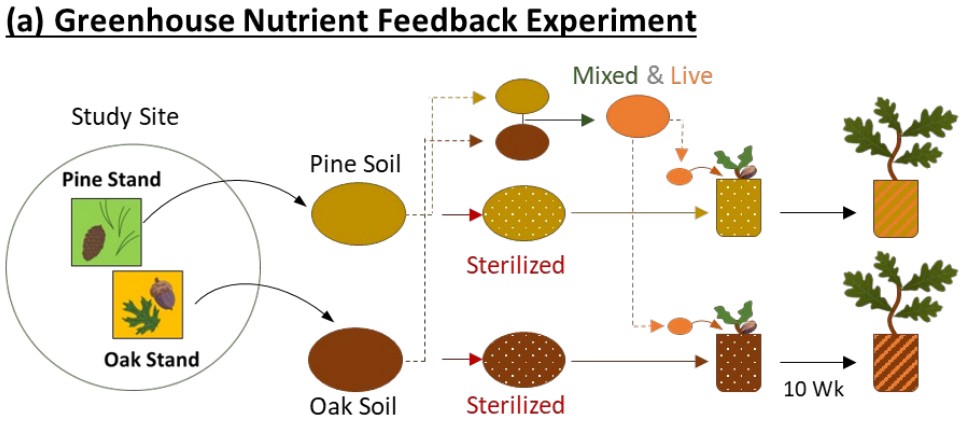
Four study sites in Michigan with paired red pine/oak stands (approx. 1 acre)

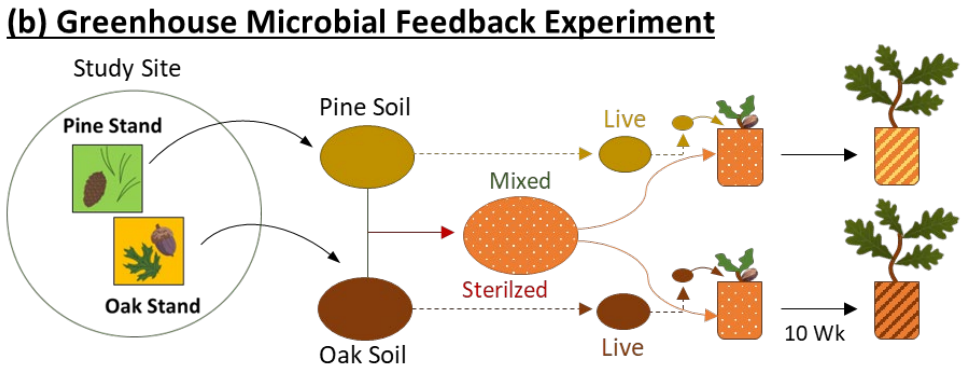
- Kellogg Forest (KF)
- Roscommon (RO)
- Kalkaska (KA)
- Atlanta (AT)

- Thinning to 25% canopy coverage (winter 2020)

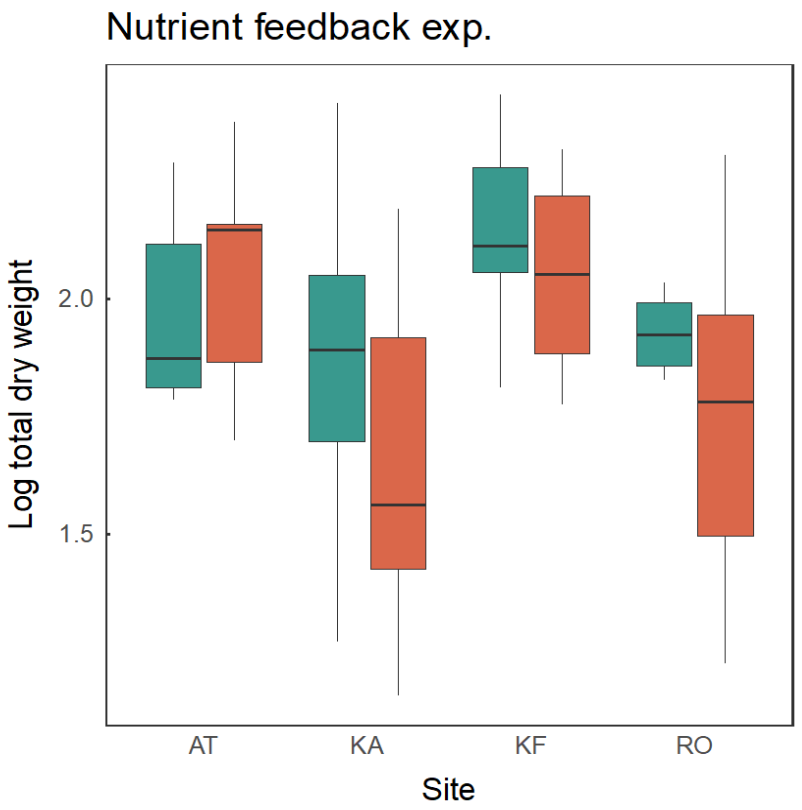
Soil Nutrient and Microbial Legacy

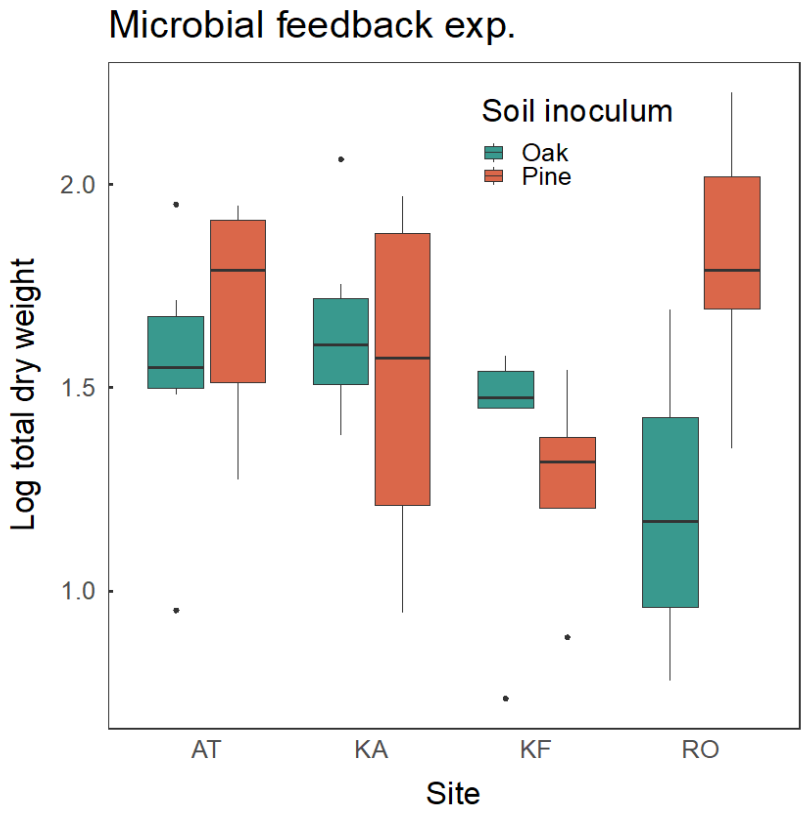
- Soils collected from pine/oak stands from the four sites
- Northern red oak seedling growth in a greenhouse
- Nutrient legacy
  - Soil sterilized with γ radiation
- Microbial legacy
  - Sterilized mixed soils inoculated with live soils from plots



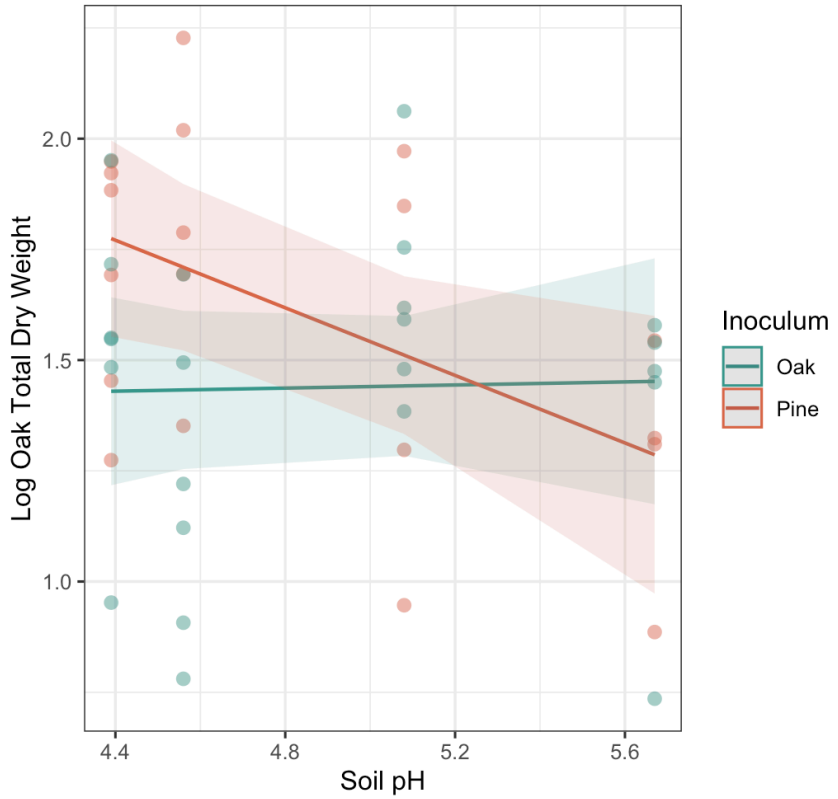


Results: Soil Nutrient & Microbial Legacy





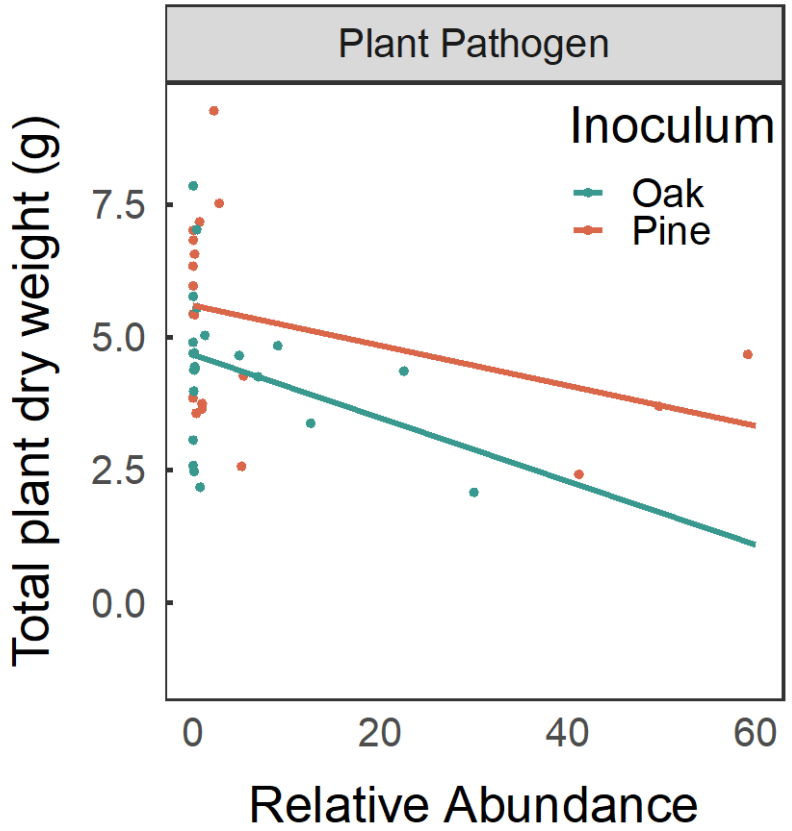
Soil Microbial Legacy for Oak Seedling Growth



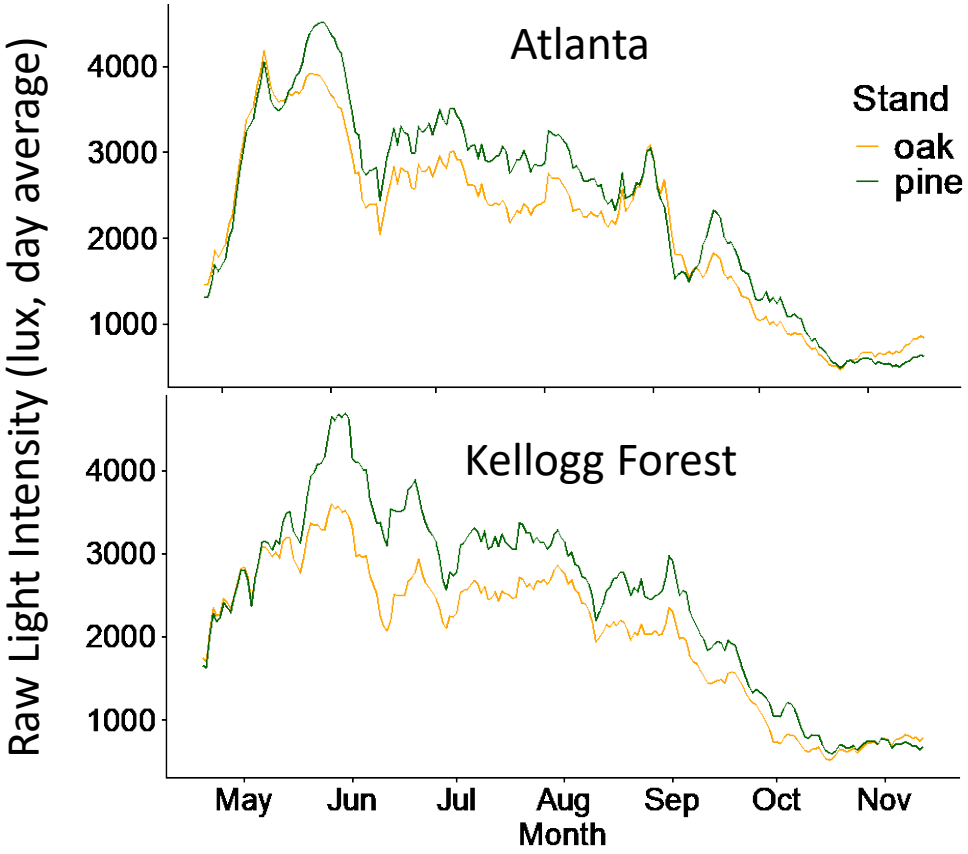
- Oak seedling growth depended on soil pH
- Pine > oak soil with soil pH < 5
- Pine ≈ oak soil with soil pH > 5
- In low pH soils, oak seedlings grow better due to soil microbiome

Oak Seedling Growth & Root Microbiome

- Root fungal microbiome assessed via Illumina amplicon sequencing
- Negative correlation between relative abundances of plant pathogens in roots and oak seedling biomass
- Soil pH and root pathogen load determine oak seedling growth



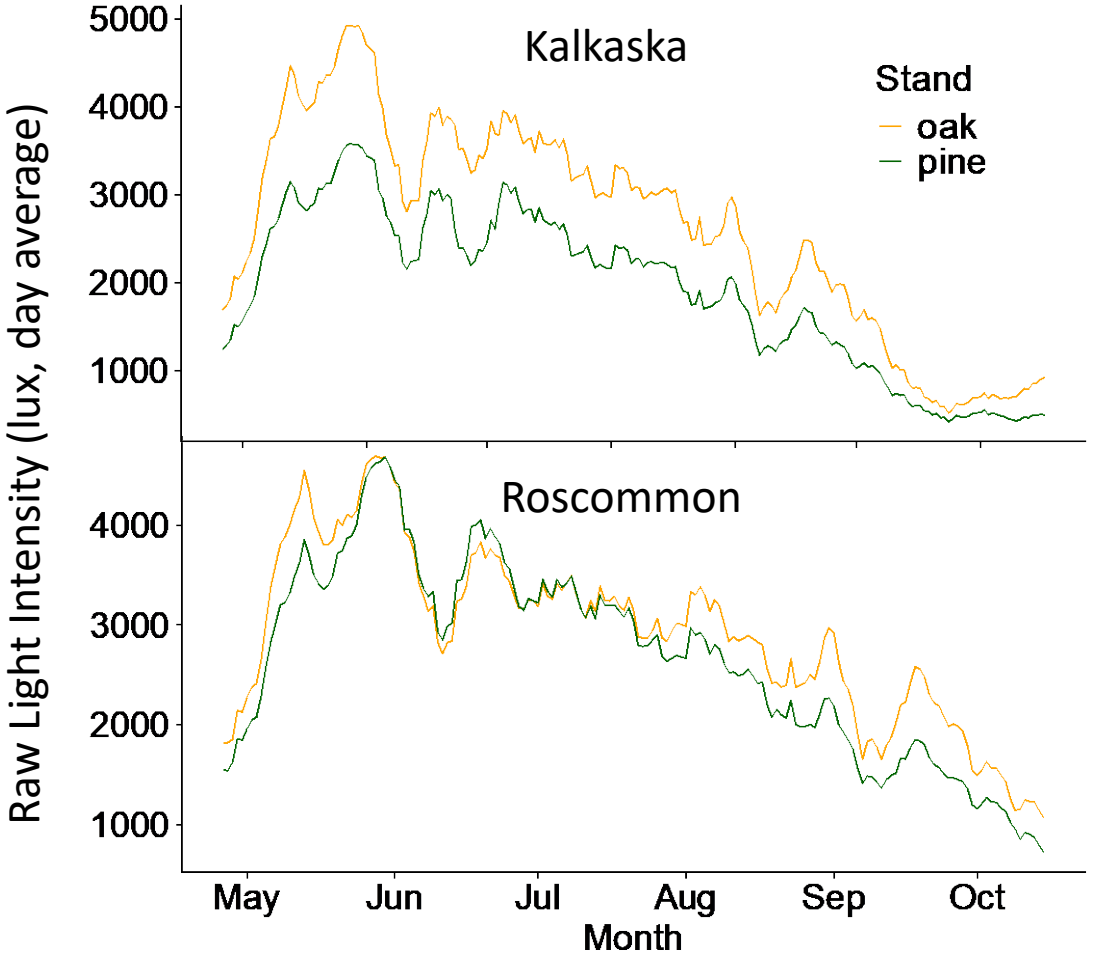
Field Abiotic Factors: Light Environment



- Forest stands were thinned to 25% canopy coverage in 2020
- Pine (evergreen) vs oak (deciduous)
- Light Intensity during the growing season
- Pine > oak in Atlanta and Kellogg Forest during growing season (2023)

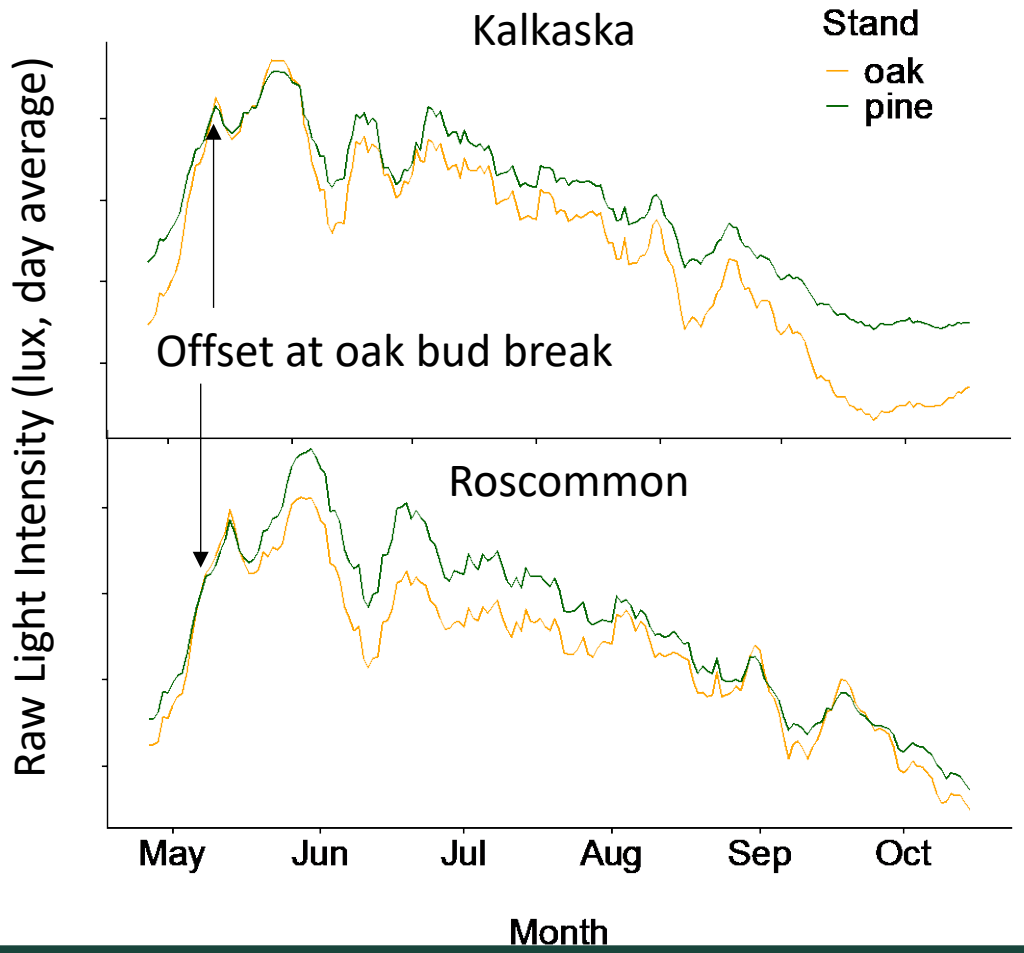
Field Abiotic Factors: Light Environment

- Oak > pine in Kalkaska
- Oak ≈ pine in Roscommon
- Some oak trees killed due to Spongy moth infestation and early summer drought in 2021



Field Abiotic Factors: Light Environment

- When light intensity values were offset at the oak bud break in May 2023
- Pine > oak during the growing season
- Favorable light environment for oak seedlings under pine than oak



Ongoing “Oak Success under Pine” Project

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- Northern red oak and white oak seedling growth and mortality rates in the field
- Other abiotic factors, including soil moisture, air and soil temperature, and light
- Ectomycorrhizal fungal associations in oak roots
- What are the important factors?

Thank you!

Acknowledgments

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- Midwest Climate Adaptation Science Center (MW CASC)