Using a functional trait approach to inform assisted migration for climate adaptation in the Northern Forest Region

Emily Anders e.anders@unh.edu

PI:

Heidi Asbjornsen, University of New Hampshire

Co-PIs:

John Butnor, USFS Northern Research Station

Martin Dovciak, SUNY-ESF

Matt Vadeboncoeur, University of New Hampshire

Jay Wason, University of Maine

Collaborators:

James Donahey, USFS Rochester and Middlebury Ranger Districts

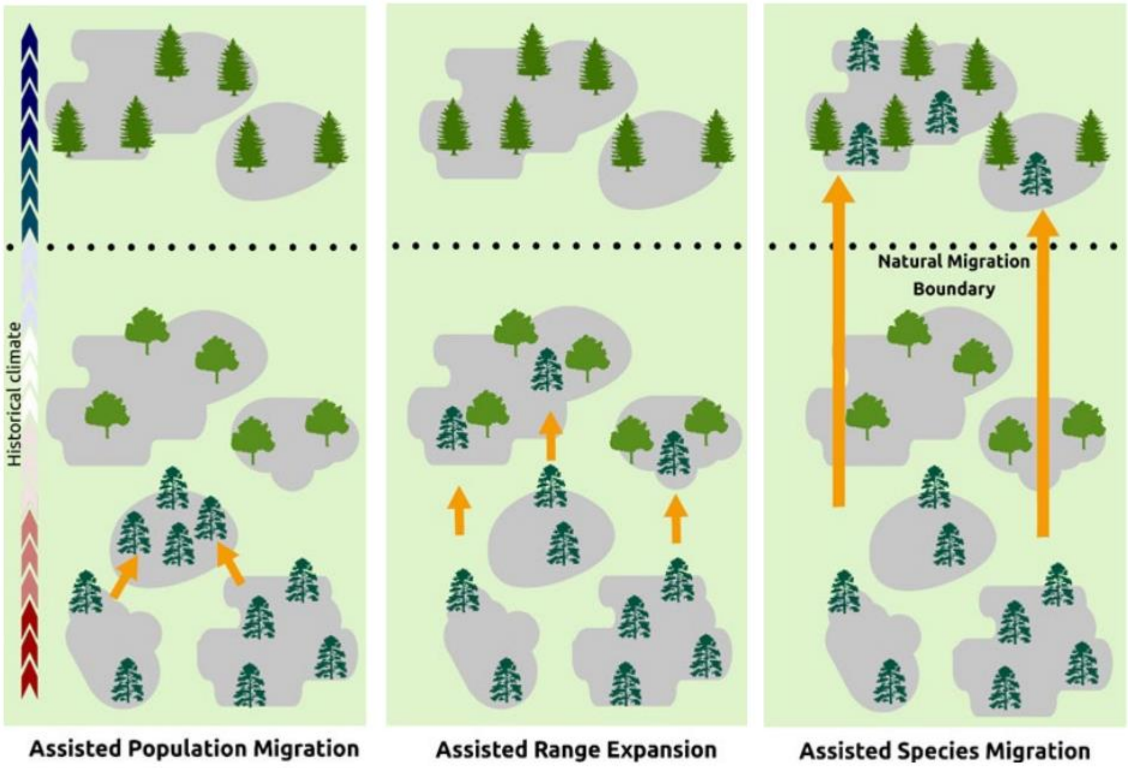
William Kunelius, Manager, New Hampshire State Forest Nursery

Assisted Migration **(AM)**

Human assisted movement of species to more **suitable habitats** in a response to **climate change**.

Primary Objectives

- Increase the **adaptive capacity, productivity** and **resilience** of forests.
- Protect ecosystem services: **biodiversity**, **carbon sequestration** and **forest-based products.**



USFS Superior National Forest Assisted Migration Plan

Limitations to AM in the NE

New Hampshire State Nursery

White Pine Natural Regeneration

- Historical reliance of silviculture in the NE on **natural regeneration** methods.
- Forest managers lack **clear guidelines** on selecting seed source populations.
- Limited supply **of climate-appropriate seedling diversity** in forest nurseries.

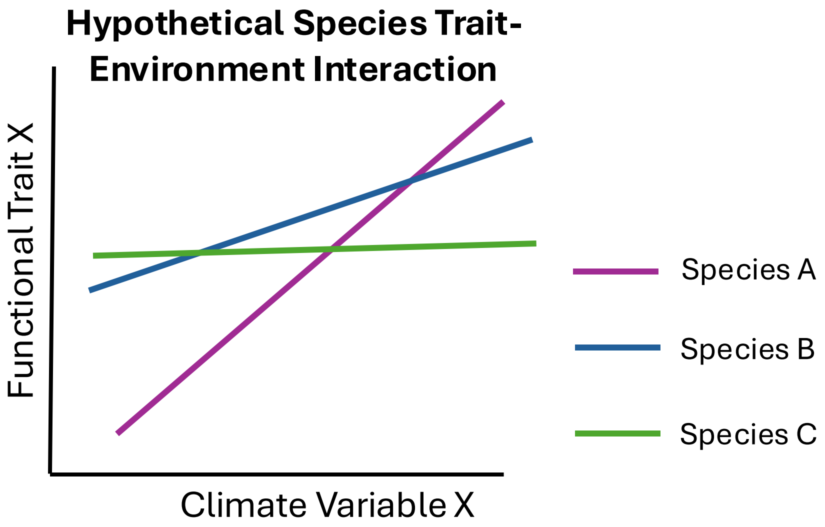
Functional Trait **(FT)** Based Approach for AM

Plant FTs

- **Morpho-physiological** or **phenological** characteristics that influence **productivity**, **stress response**, and **allocation of resources** (e.g., leaf size/shape).

- FTs link **performance** to the **environment.**

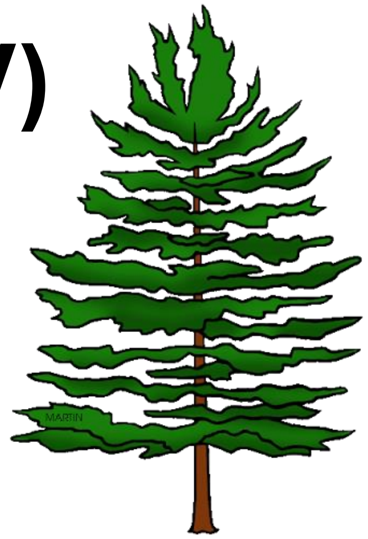
- Asses **trait-environment interactions** and **adaptive capacity.**



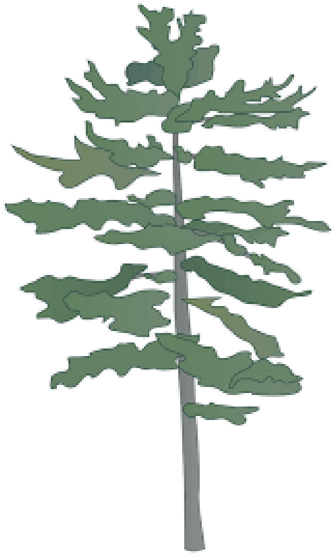
Intraspecific Trait Variation **(ITV)**

Ecotypes

- Populations with distinct genotypes, displaying different phenotypes due to **local adaptation.**



Southern Pinus strobus



Northern Pinus strobus

Phenotypic Plasticity

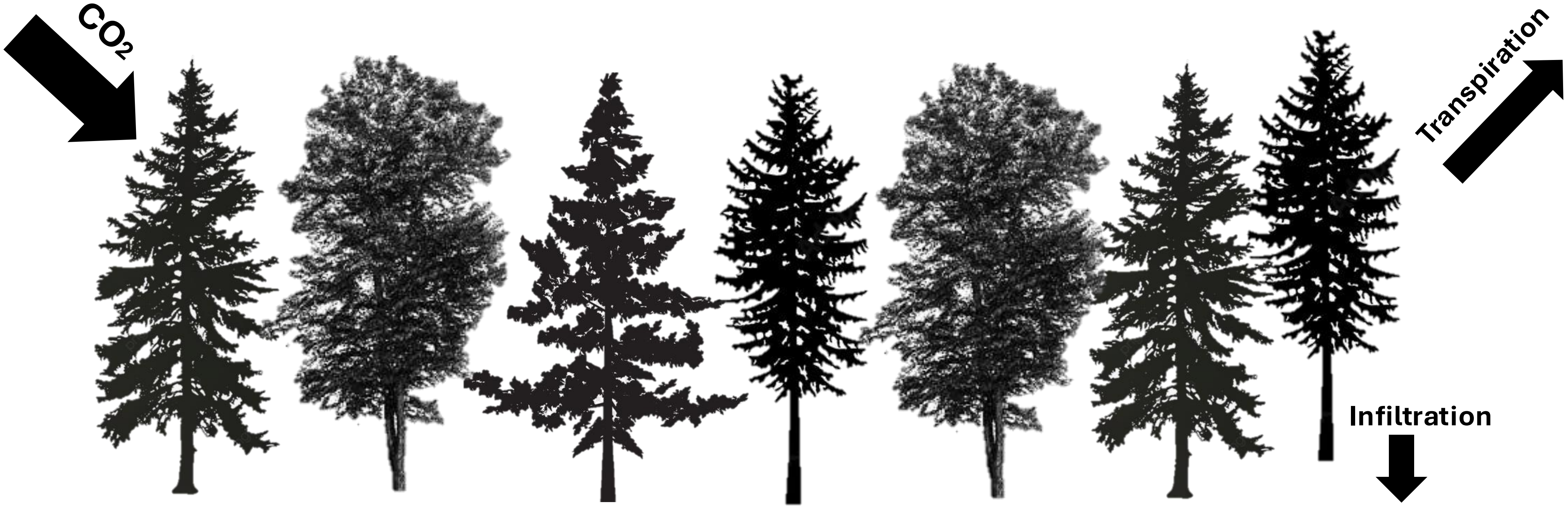
- The expression of multiple phenotypes from the same genotype in **response to environmental change**.

Lower SLA

Higher SLA

Applications of Trait-Based AM

- Match **seed sources** or **populations** to **local conditions** and the anticipated **future climate.**
- Increase forest **resilience**, **productivity, hydrologic regulation** and **carbon sequestration**.



Objectives

(1) Quantify **ITV** of potential seed source populations along elevational and latitudinal gradients to assess **trait-environment interactions** and **acclimation potential** to future climate.

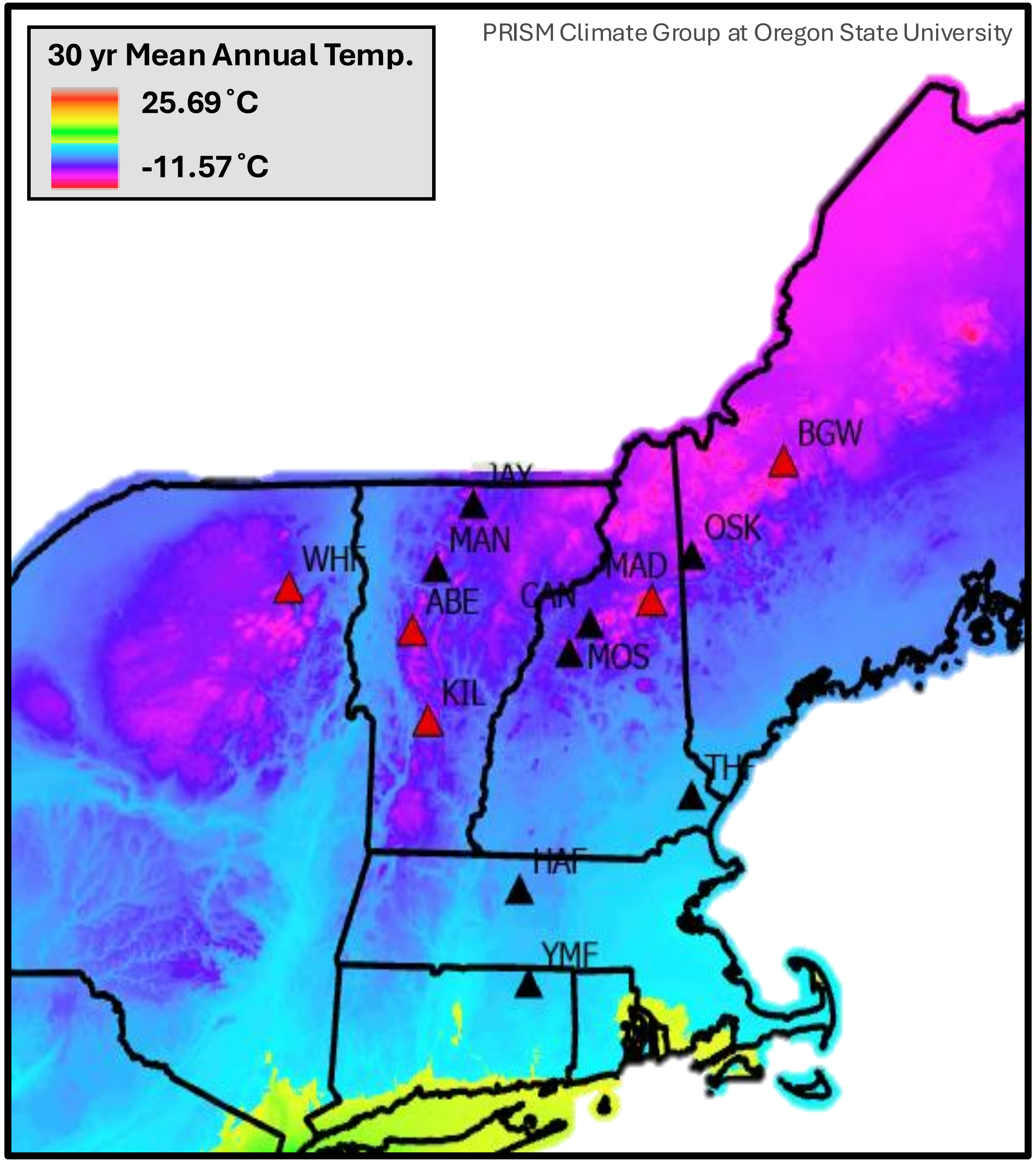
(2) Assess **germination success** and **seedling quality** from potential seed source populations and maintain healthy seedlings for a future **common garden experiment** to assist forest nurseries develop an ecological and **climate-appropriate inventory for AM.**

Site Selection

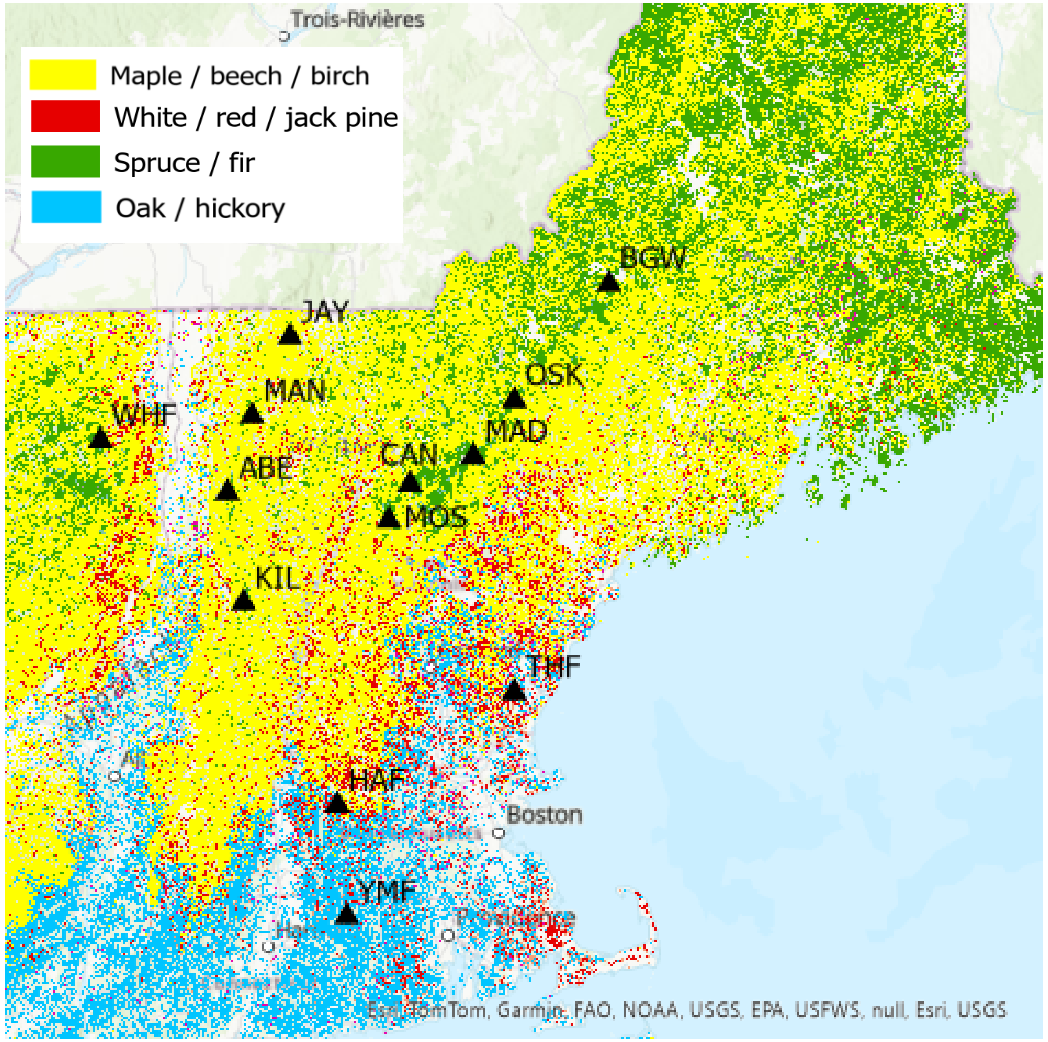
10 study mountains, 3 sites along an elevational gradient (500-1000 m) were established by **Tourville et al. (2022)** in 2013.

Harvard Forest (**HAF**), Yale-Myers Forests (**YMF**) and Thompson Farm (**THF**).

Intraspecific trait analysis by **Hecking et al. (2022)** (▲).



Study Species and Distribution in the NE

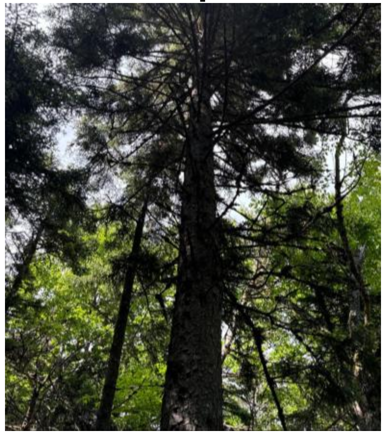


USFS Forest Inventory & Analysis plot data (2014-2018).

Yellow Birch

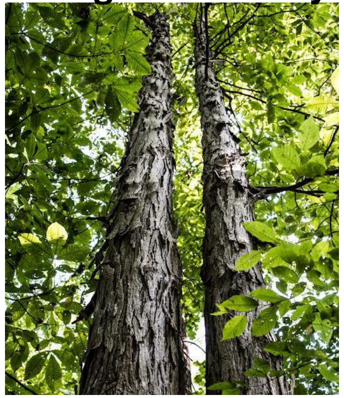
Sugar Maple

Red Spruce



Balsam Fir

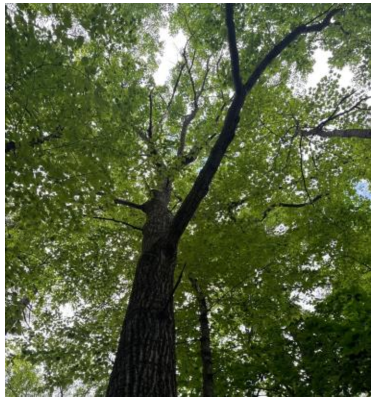
Shagbark Hickory



White Oak

White Pine

Red Oak



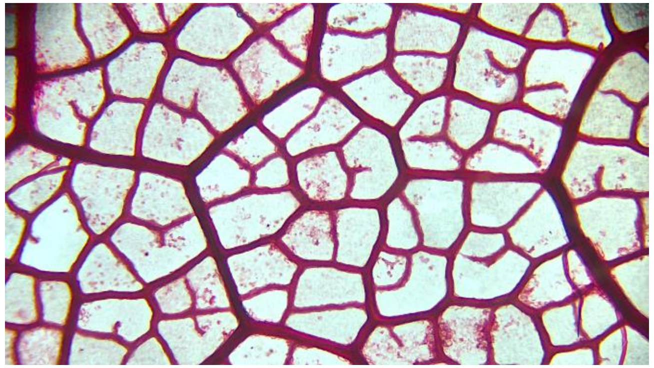
Methods

Hydraulic Traits
- Minor Leaf Vein Density
- Turgor Loss Point
- Stomatal Traits
- Water use efficiency (δ13C)

Photosynthetic Traits
- Short Increment Cores
- Leaf Nitrogen Content
- Specific Leaf Area

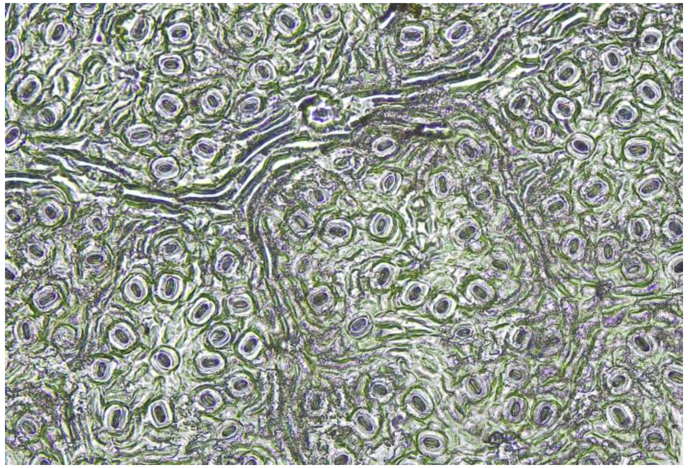
Germination
- Seed Weight
- Germination Success

Tolerance
- Bark Thickness
- Cold Tolerance



Minor Leaf Vein Density

Short Increment Cores



Stomatal Length and Density

Specific Leaf Area (SLA)

Prior Findings on Intraspecific Trait Variation (ITV)
Hecking et al. 2022

- ITV was generally **low** and related to **climate** and **light**.
- Traits related to **leaf chemistry, stem economics** and **branching architecture** had higher levels of ITV.

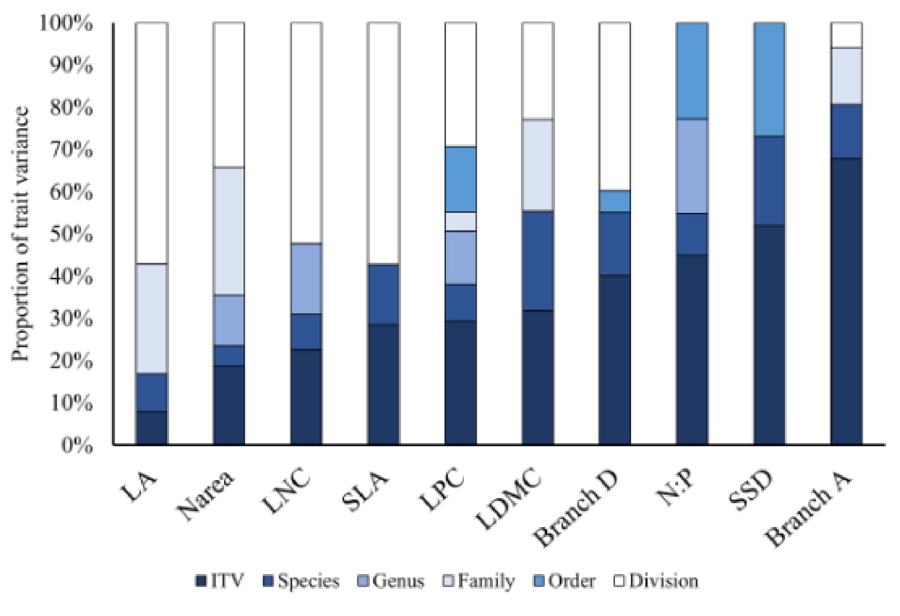


FIGURE 3 | Variance decomposition of measured leaf and stem economic traits across different taxonomic levels from communities spanning the temperate-boreal ecotone of the northeast United States.

Montane Temperate-Boreal Forests Retain the Leaf Economic Spectrum Despite Intraspecific Variability (Hecking et al. 2022)

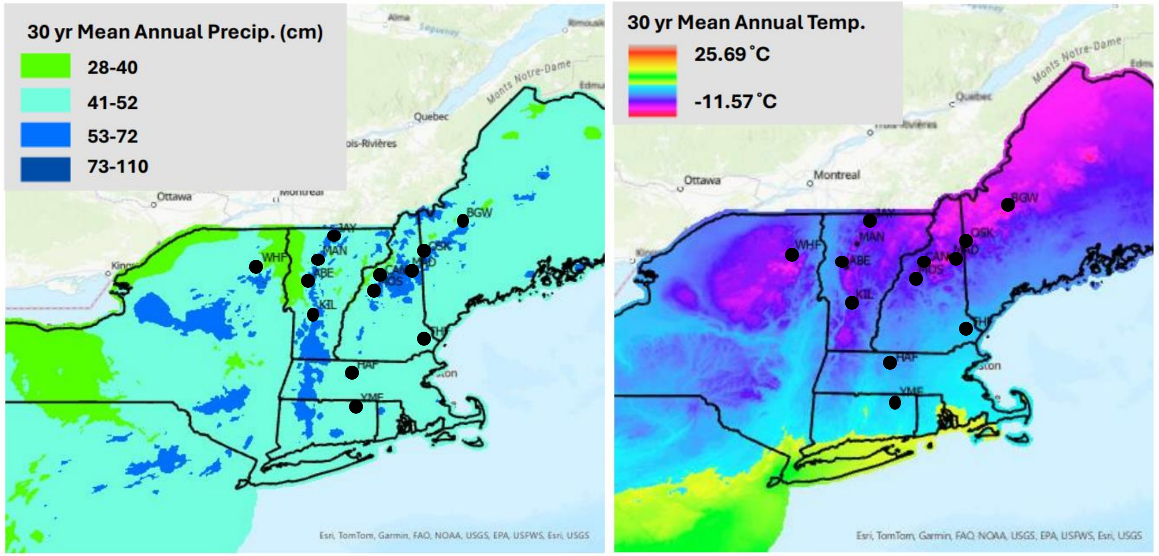
Expected Outcomes

Build off the work of **Hecking et al. (2022)** with a comprehensive examination of FTs across a **larger climatic gradient.**

Document diverse **seed sources** that can be used for targeted **AM enrichment planting** of managed lands across the NE.

Provide seedlings for **CGE** in NE to assist forest nurseries develop **climate-appropriate inventory** for AM.

PRISM Climate Group at Oregon State University



Climate Gradient Across Sites (Temp. and Precip.)

Climate adapted species planted in Transition Site (Second College Grant ASCC project)

Thank You

PhD Advisors:

Heidi Asbjornsen

Matt Vadeboncoeur

Undergraduate Assistance

- Nicolas Forestell
- Zachary Hooper
- Katie Johnstone
- Dakota Mako
- Aaron Saffian

University of New Hampshire

NH STATE FOREST NURSERY
QUALITY SEEDLINGS SINCE 1910

1865 THE UNIVERSITY OF MAINE

FOREST SERVICE U S DEPARTMENT OF AGRICULTURE

NSRC Northeastern States Research Cooperative

ESF COLLEGE OF ENVIRONMENTAL SCIENCE AND FORESTRY STATE UNIVERSITY OF NEW YORK 1911

Emily Anders
PhD Student at the University of New Hampshire
USFS Pathways Intern
e.anders@unh.edu

Assisted migration

a phenotypic evaluation of species, ecotypes, and drought responses

Sam Zuckerman | PhD candidate | Samuel.Zuckerman@unh.edu

Heidi Asbjornsen, Anthony D'Amato, Cameron McIntire, Jay Wason, Matthew Vadeboncoeur

University of New Hampshire
College of Life Sciences and Agriculture

NSRC
Northeastern States Research Cooperative

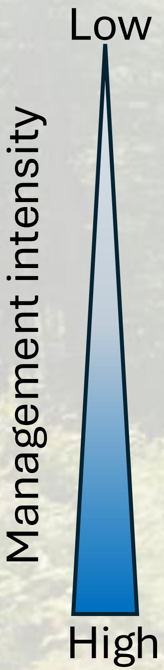
NH Agricultural Experiment Station

UMAINE

The University of Vermont

Forest Service U.S. Department of Agriculture

Adaptive Forest Management Strategies



- Resistance: improve forest defense a
- Resilience: forest returns to desirabl
- Transition: facilitate new forests that adapt to novel conditions

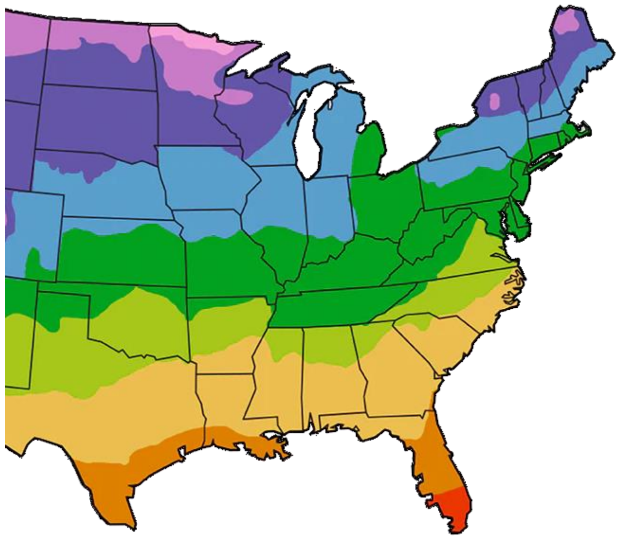
Forestry assisted migration: *Transplanting species or populations adapted to the future climate of a region with the goal of* ***maintaining forest health and productivity under climate change***

Nagel et al. 2017. Adaptive silviculture for climate change: A national experiment in manager-scientist partnerships to apply an adaptation framework
Pedlar et al. 2012. Placing forestry in the assisted migration debate.

Missing pieces

Which species?

From where?



Drought adapted?

Hotter with more consecutive dry days

Guiding questions

For potential assisted migration species in the Northeast…

1. Are ecotypes distinguishable from one another?
   - In growth rate, physiology, or anatomy?

2. Does drought exposure amplify these differences?

3. How important is ecotype selection compared to species selection?

Greenhouse common garden: Durham, NH

Experimental design

Seedling selection

Species

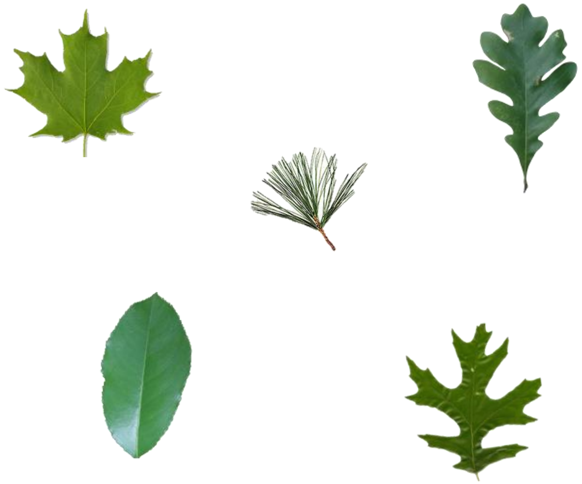
Sugar maple

Eastern white pine

Black cherry

White oak

Northern red oak

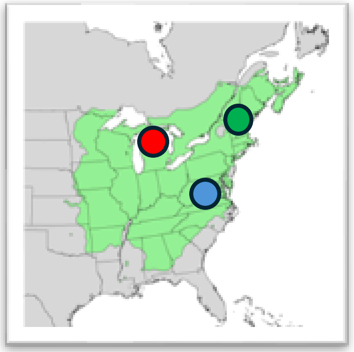


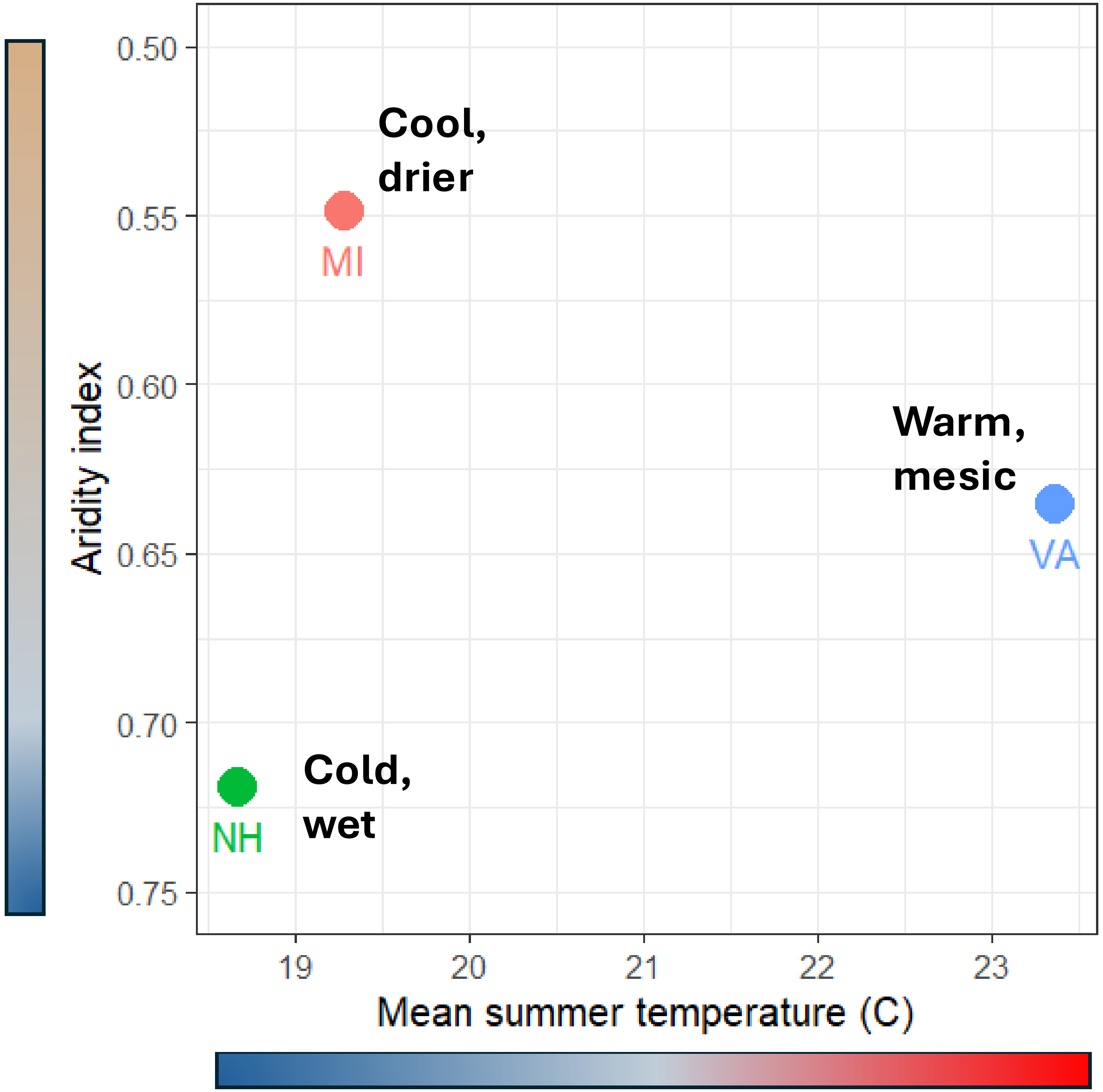
Sources

MI: Cold Stream nursery, MI

VA: State nursery

NH: State nursery





Drought treatments

Year 1

Drought
3 weeks no water

Control
maintain field capacity

Year 2

Moderate drought
3 weeks 5% VWC → rewatered

Severe drought
Water withheld indefinitely

Control
maintain field capacity

n = 10 per species-ecotype-treatment combination

Growth

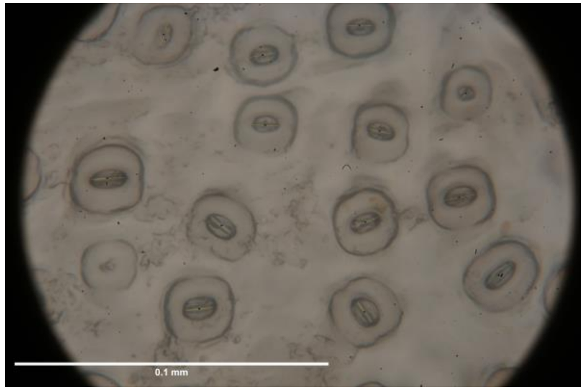
Height and diameter

Physiology

Stomatal conductance, photosynthesis

Anatomy

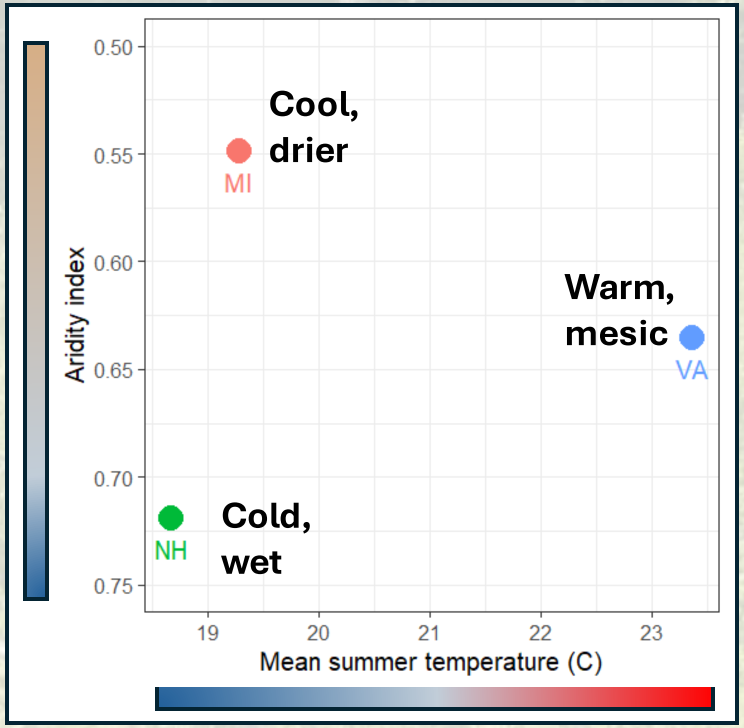
Specific leaf area, stomatal traits



Hypotheses

H1: Trees from **warmer** climates will grow ***faster*** and have ***higher rates of gas exchange***

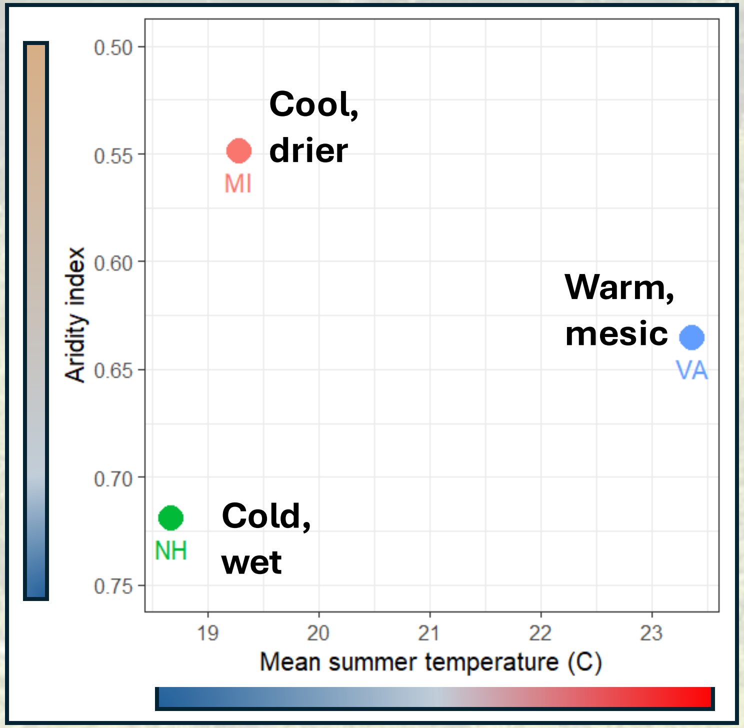
H2: When exposed to drought, trees from **arid** environments will be ***least impacted***



Hypotheses

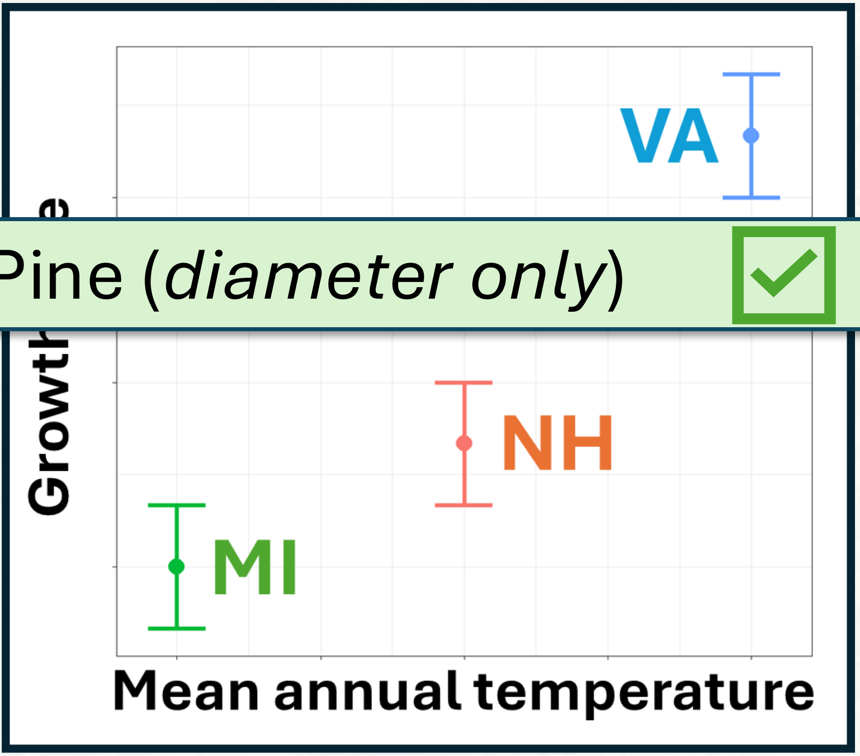
H1: Trees from **warmer** climates will grow ***faster*** and have ***higher rates of gas exchange***

H2: When exposed to drought, trees from **arid** environments will be ***least impacted***

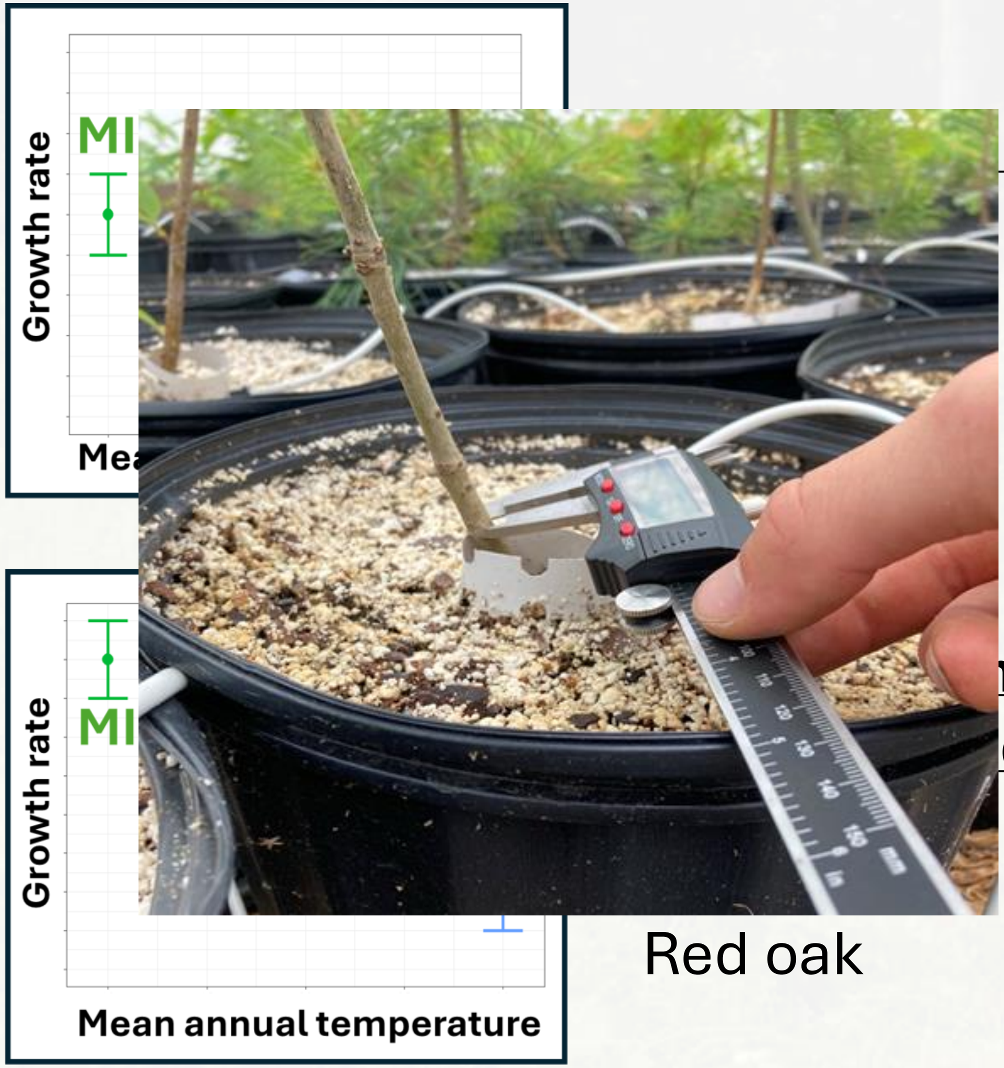


Growth

Expected



Pine (*diameter only*)

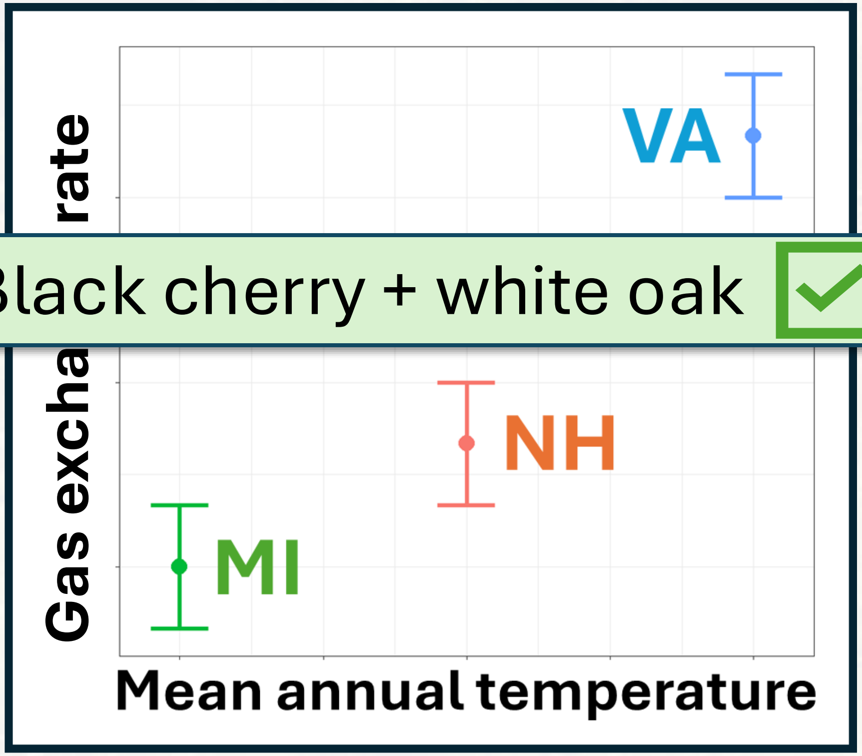


direction

Red oak

Gas exchange

Expected



Black cherry + white oak ✓

fference

maple

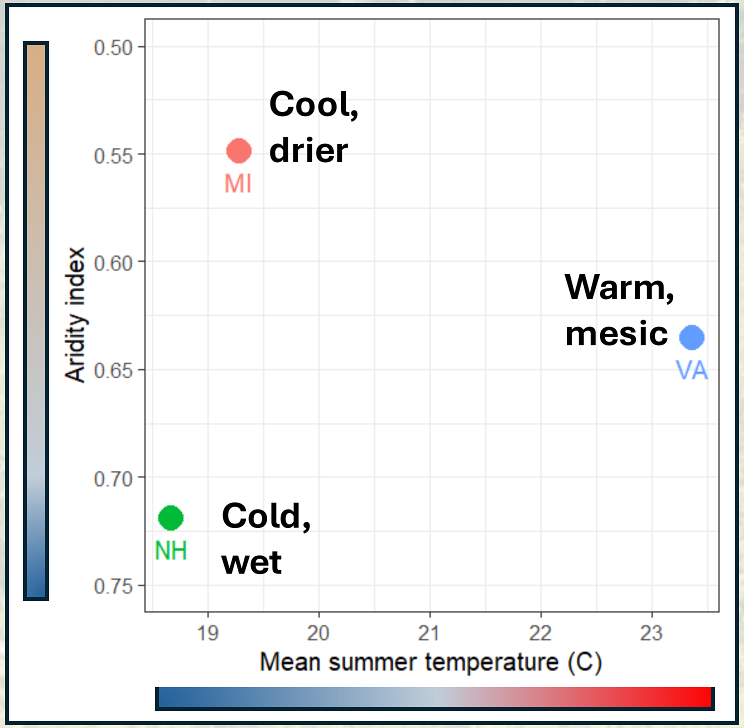
te pine

oak

Hypotheses

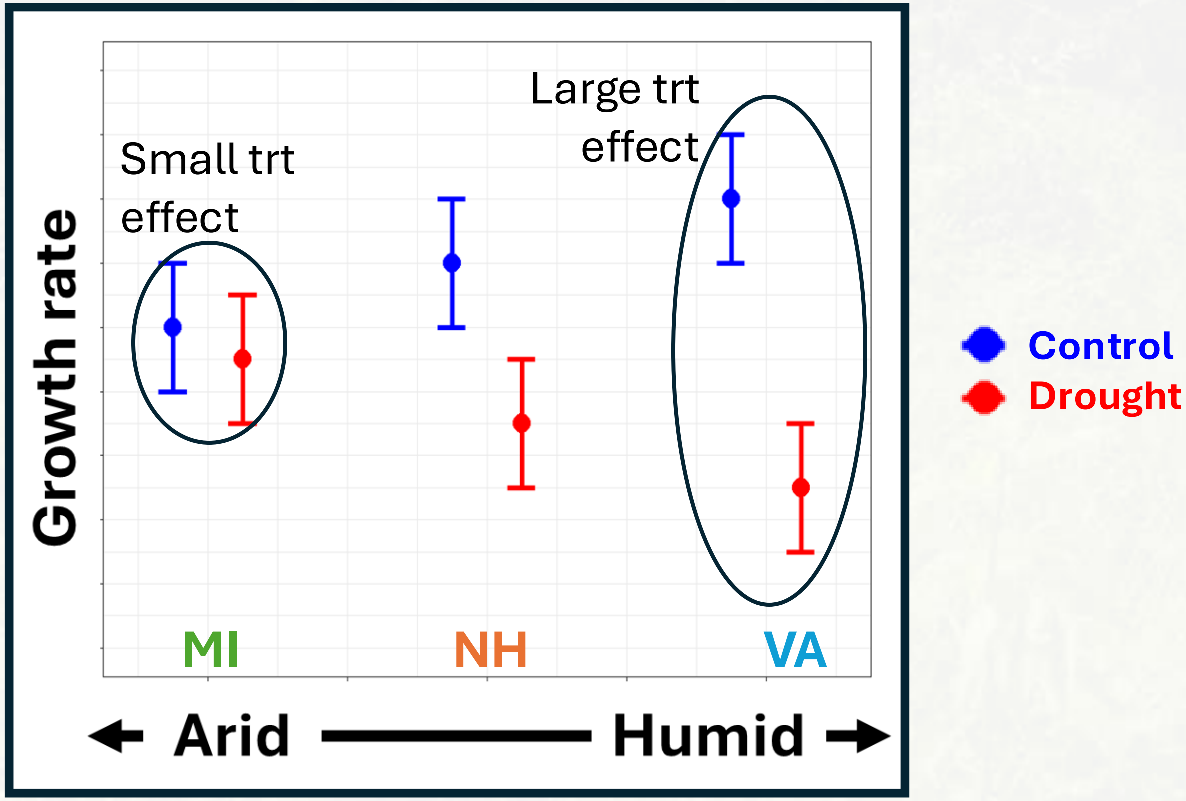
H1: Trees from **warmer** climates will grow ***faster*** and have ***higher rates of gas exchange***

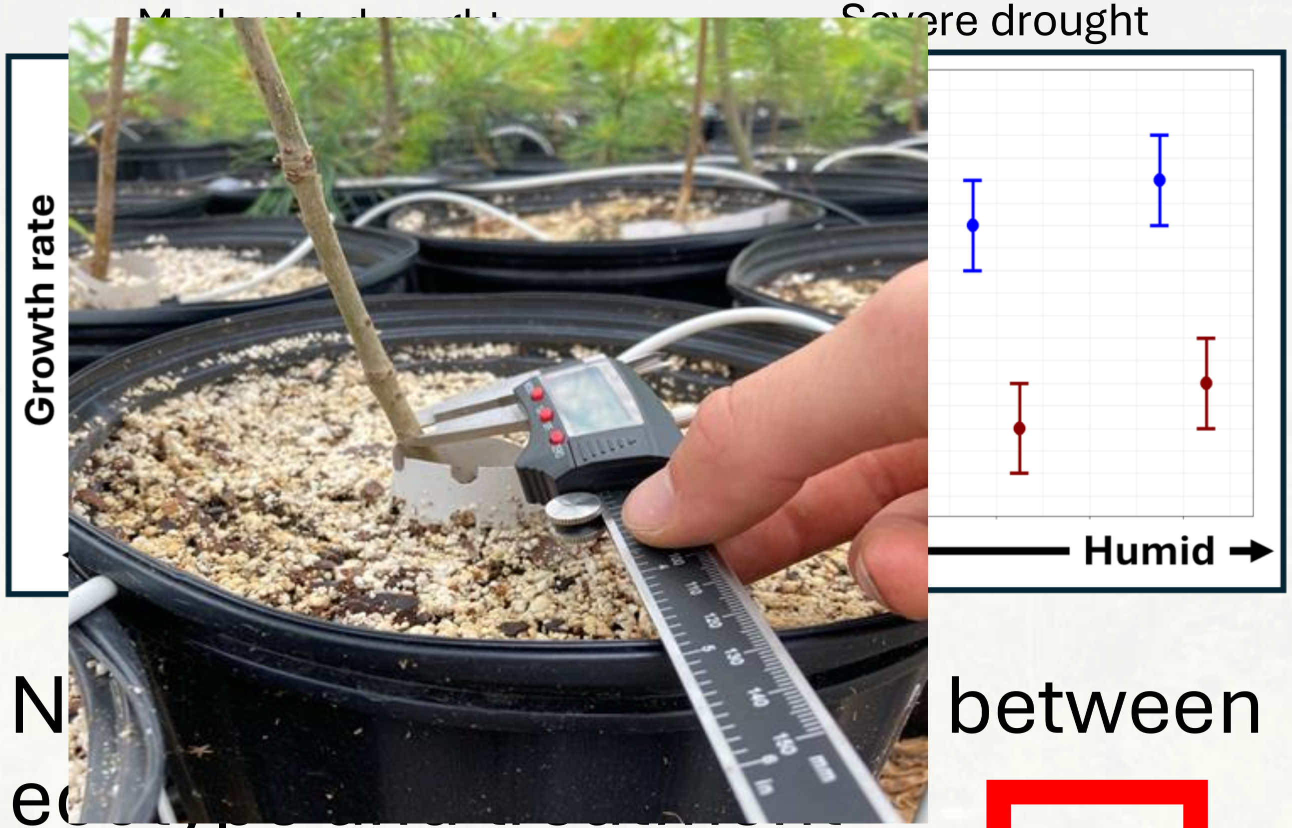
H2: When exposed to drought, trees from **arid** environments will be ***least impacted***



Growth

Expected



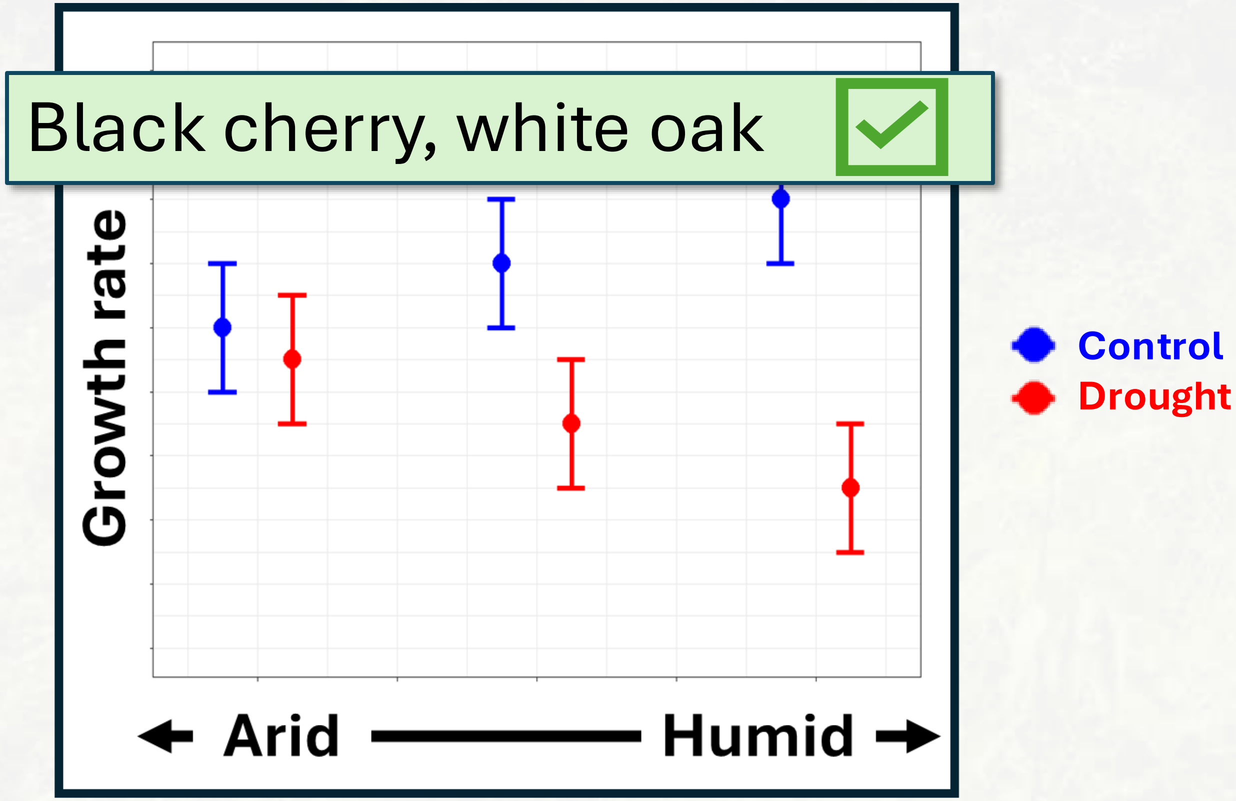


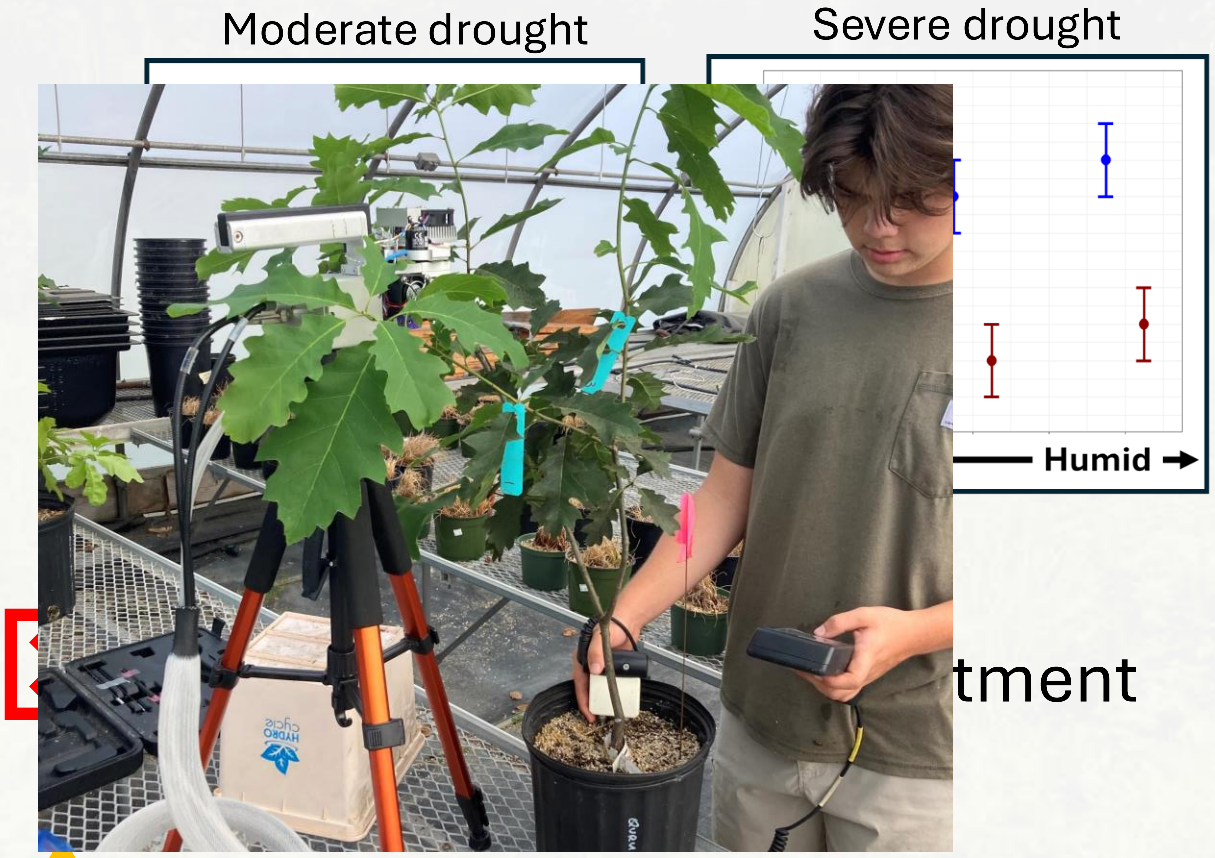
N between

ec

Gas exchange

Expected



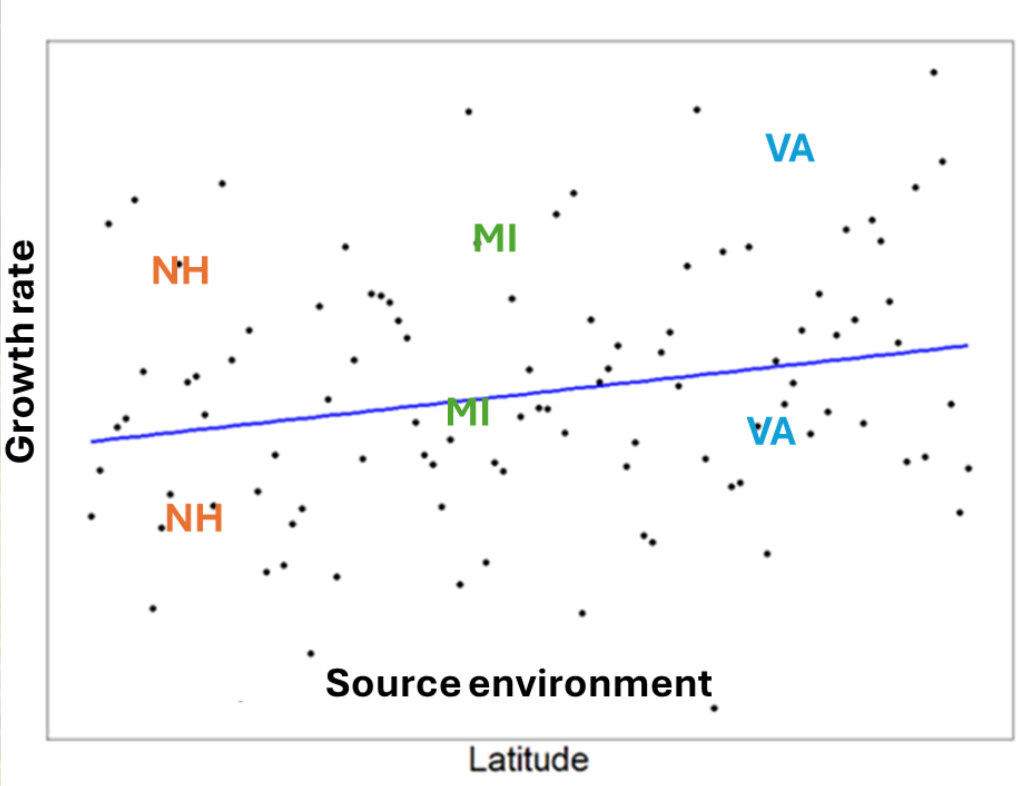


H2 partially supported (N. red oak)

Key takeaways

- ➢Ecotypes more easily distinguished by physiology than growth
- ➢Inconsistent patterns
  (warmer/arid sources not always better)
- ➢Limited selection of nursery stock from diverse provenances

*Conceptual figure



Variability in ecotype performance may contribute to uncertainty in provenance selection

Acknowledgements

Heidi Asbjornsen--UNH

Cameron McIntire--USFS

Jay Wason--UMaine

Tony D'Amato--UVM

Matthew Vadeboncoeur--UNH

Jackson Ehmett

Katie Johnstone

Zach Hooper

Dakota Mako

Nicholas Forestell

Aileen Auclair

Matthew Rozinski

Jack Hastings

Jason Demers

Jess Gersony/PLACE lab

Emma Flaherty

David Moore

Tanner Frost

Emily Anders

Matt Biondi

Luke Hydock

University of New Hampshire
College of Life Sciences and Agriculture

NH Agricultural Experiment Station

NSRC Northeastern States Research Cooperative

UMAINE

The University of Vermont

Forest Service U.S. Department of Agriculture

Email me at:
Samuel.Zuckerman@unh.edu