Restoring a keystone tree species for the future:

American chestnut assisted migration plantings in adaptive silviculture

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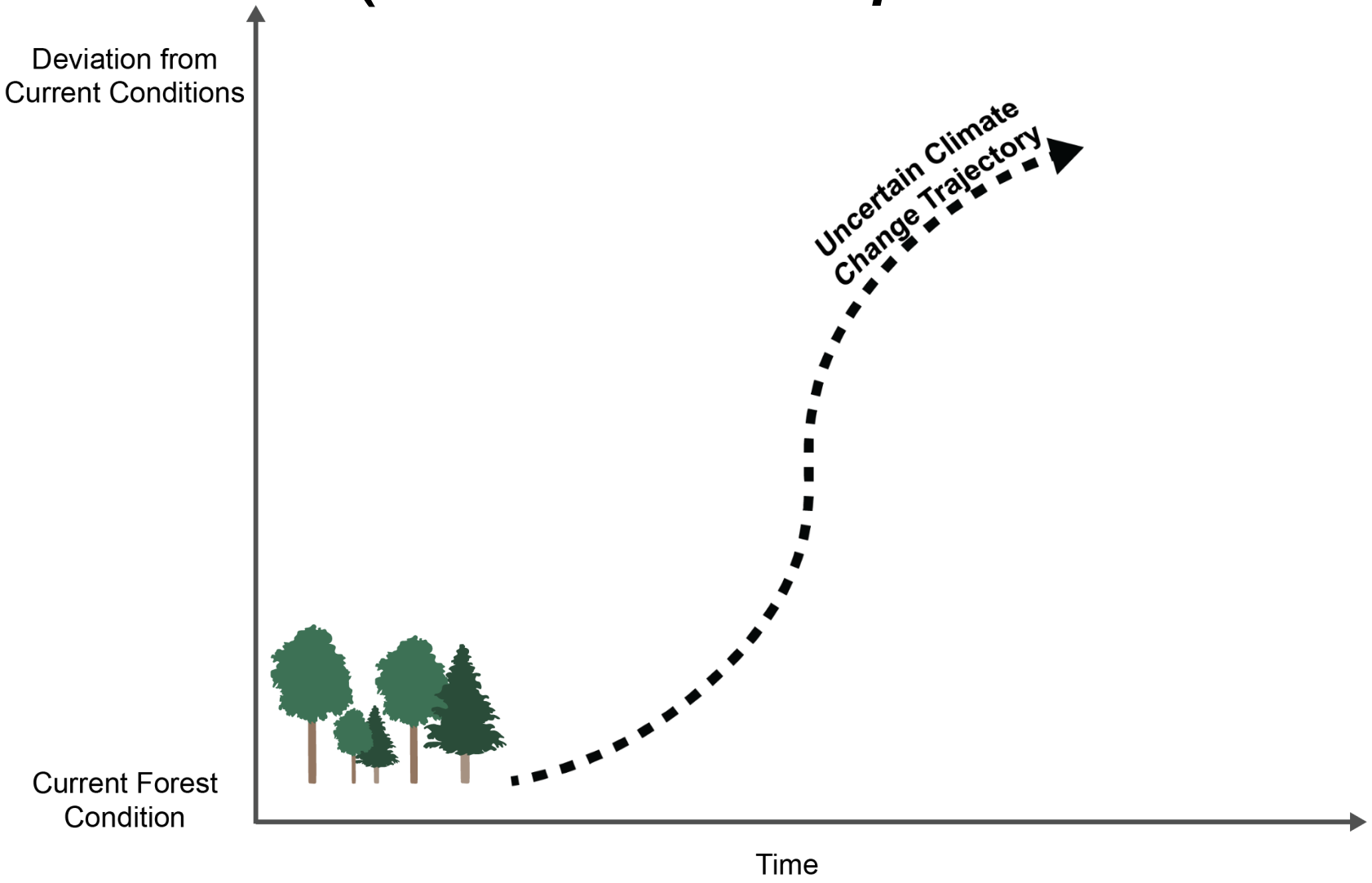
Collaborators: Tony D'Amato (UVM), Gary Hawley (UVM), Paul Schaberg (USFS), Kevin Evans (Dartmouth)

Evolving and shifting perspectives in forestry

- More challenges and complex than ever
- Managing for multiple-resources
- Ecological and “Climate-smart” forestry: diverse, carbon rich, and resilient to future changes

Climate adaptive forest management concepts (*the R-R-T spectrum of options*)



Nagel et al 2025

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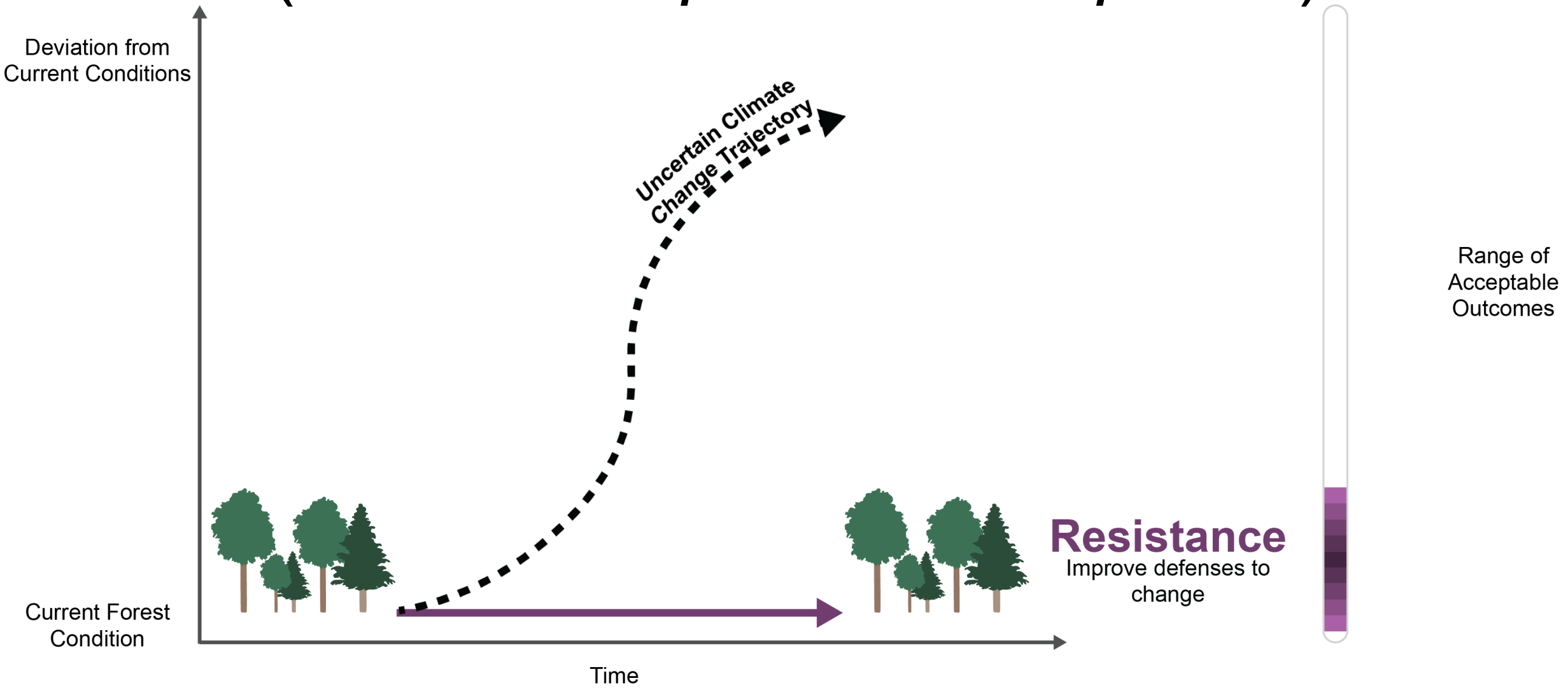

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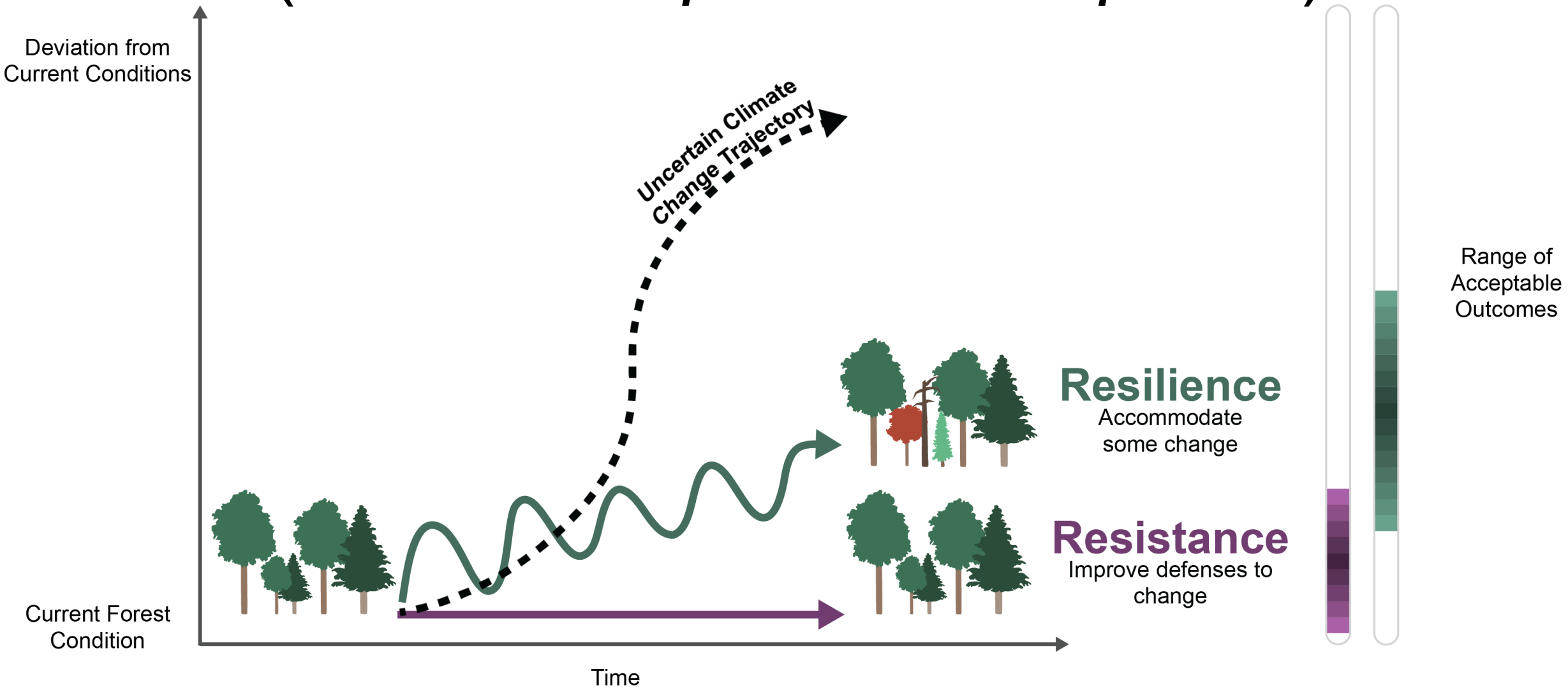

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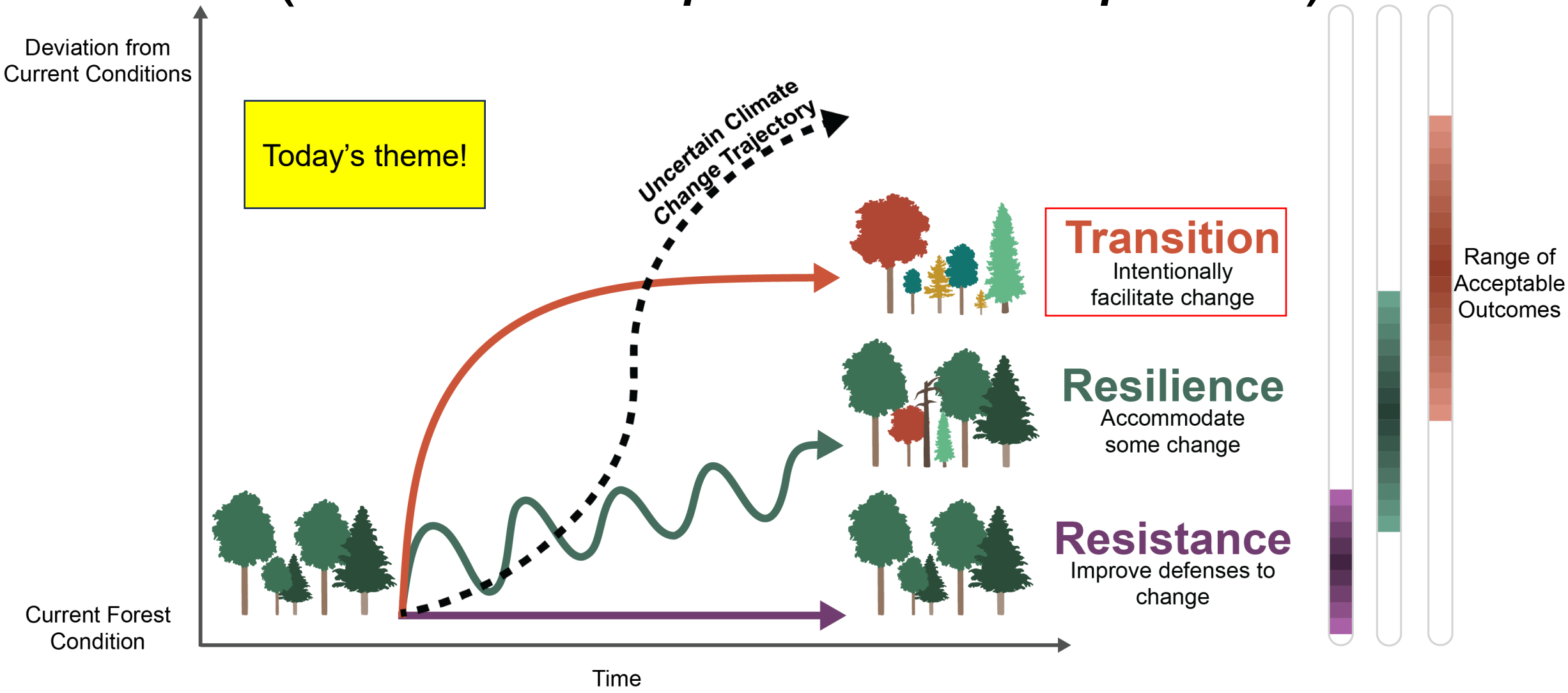
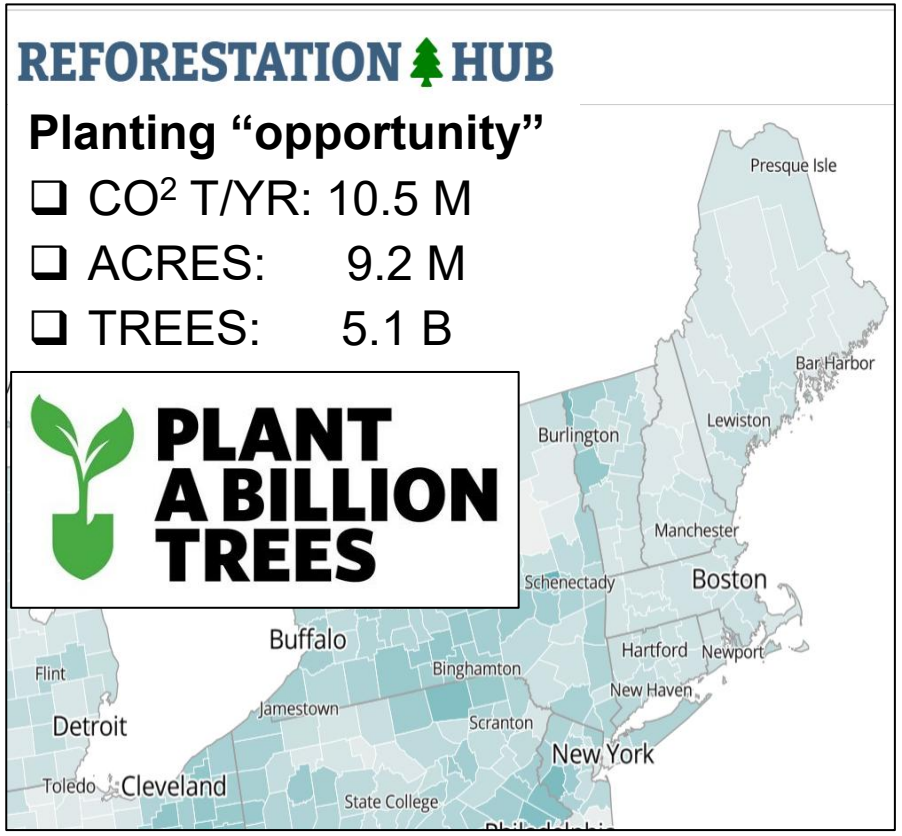


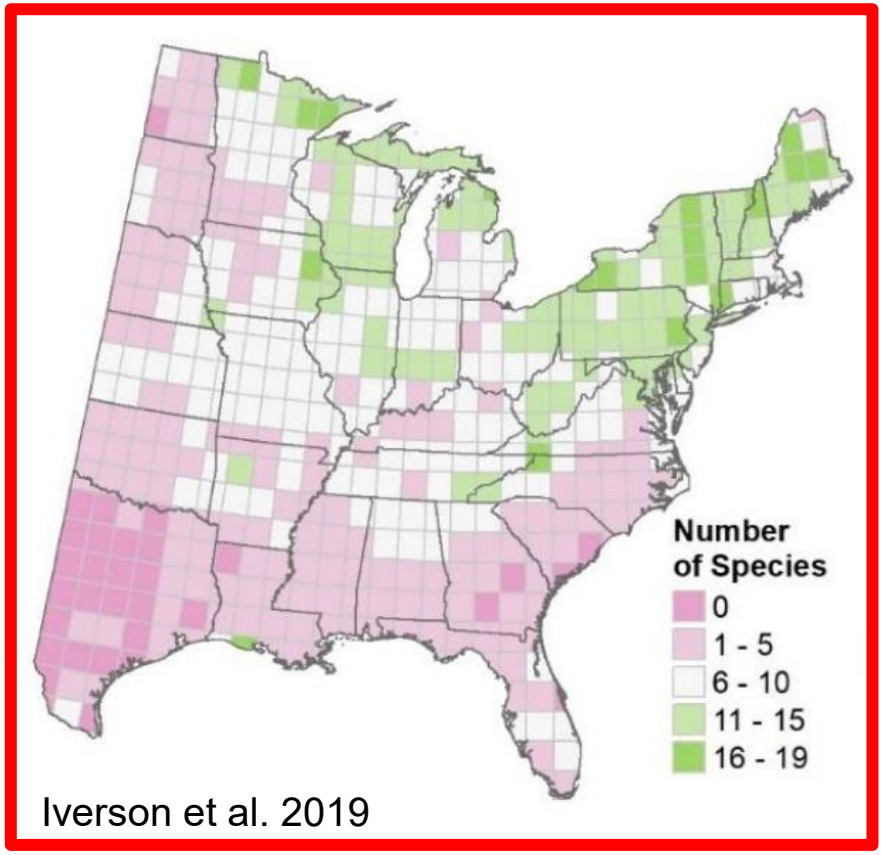
Nagel et al 2025

A need for tree planting for adaptation in the Northeastern US?

Carbon Mitigation

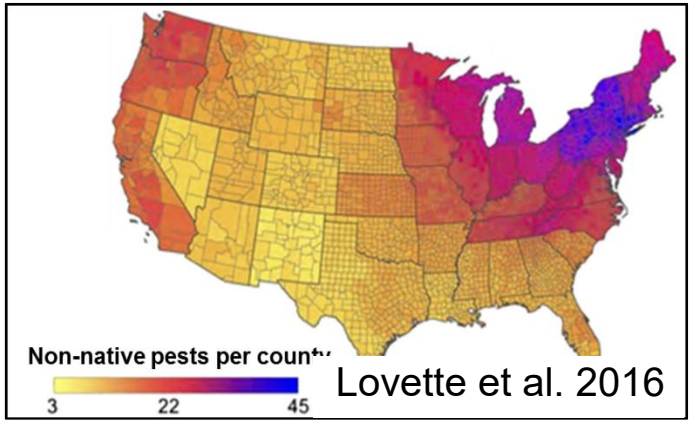


Assisted Migration



Iverson et al. 2019

Restoration & "Replacement"



Lovette et al. 2016

Basis for Assisted Migration

Plant dispersal rates ≠ pace of climate change

Historical dispersal of tree species:
~0.1-0.3 miles/year

Post-glaciation forest communities

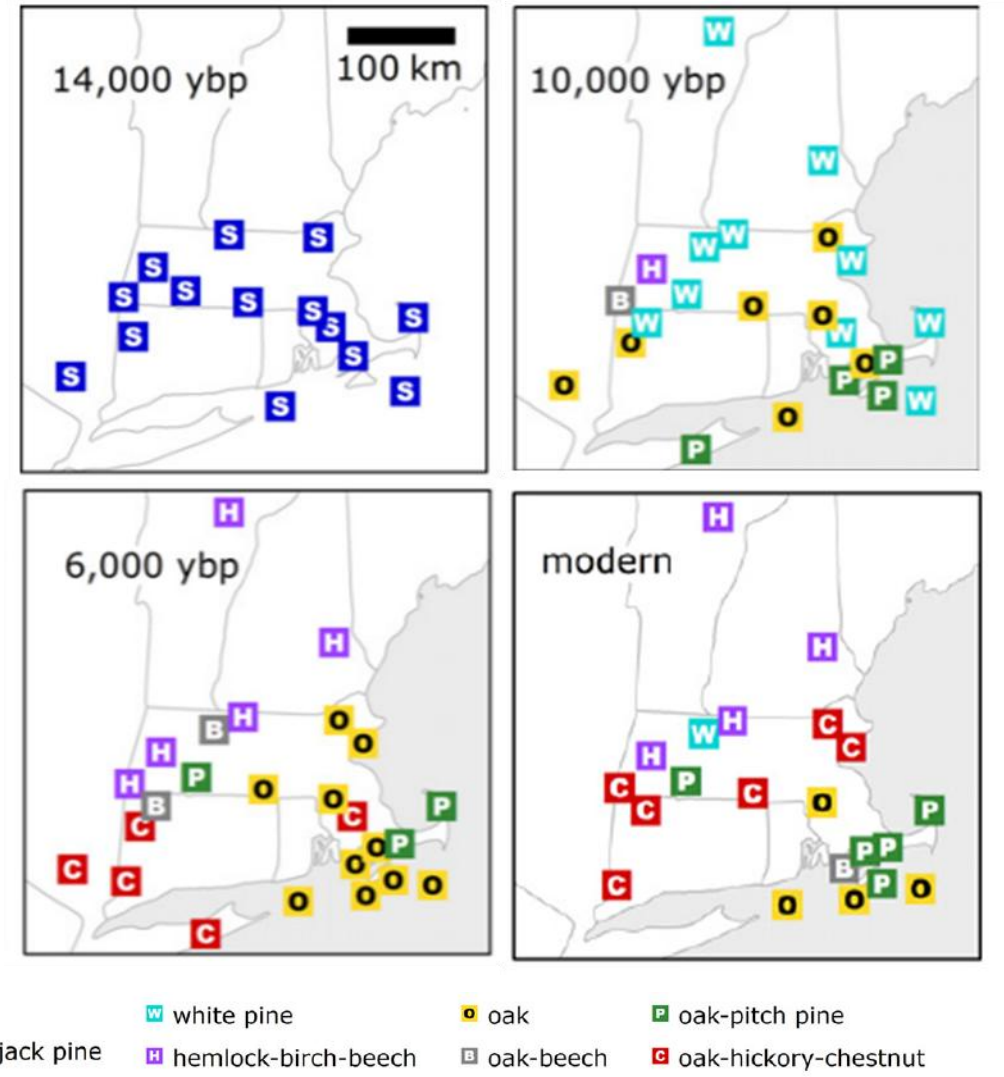


FIGURE 4 Results of cluster analysis of pollen percentage data from New England lake-sediment pollen records; cluster assignments mapped at 1,000-year intervals

Basis for Assisted Migration

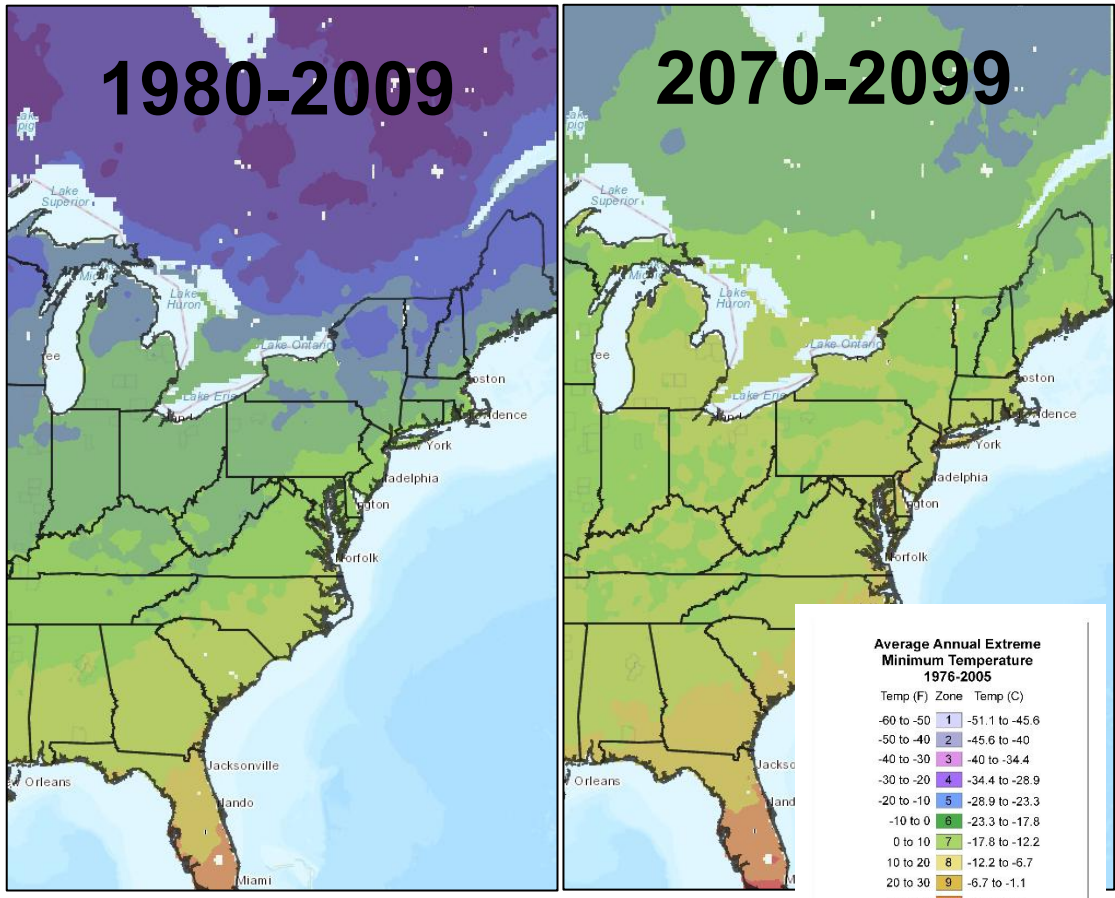
Plant dispersal rates ≠ pace of climate change

Historical dispersal of tree species:
~0.1-0.3 miles/year

Climate change currently shifting:
~4.0-6.0 miles/year

Climate change <u>far</u> exceeds natural plant migration rates

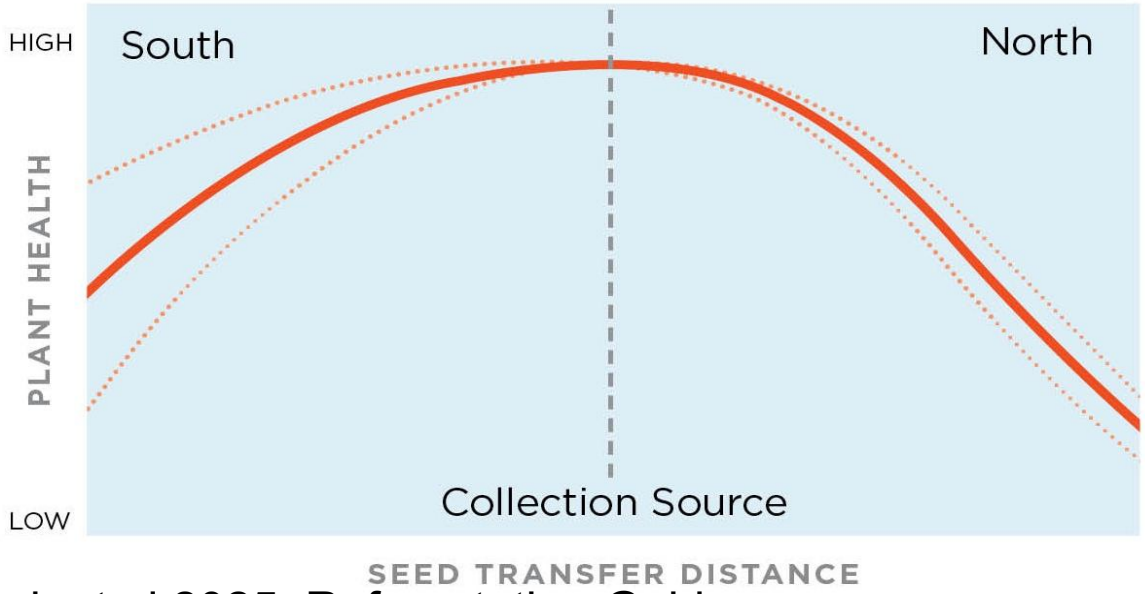
Expected changes in plant hardiness zones



Implication of climate-maladapted forests

- Local species/genotypes not adapted to future conditions
- Weakened, more vulnerable canopy trees
- Regeneration failure (seedlings are sensitive!)

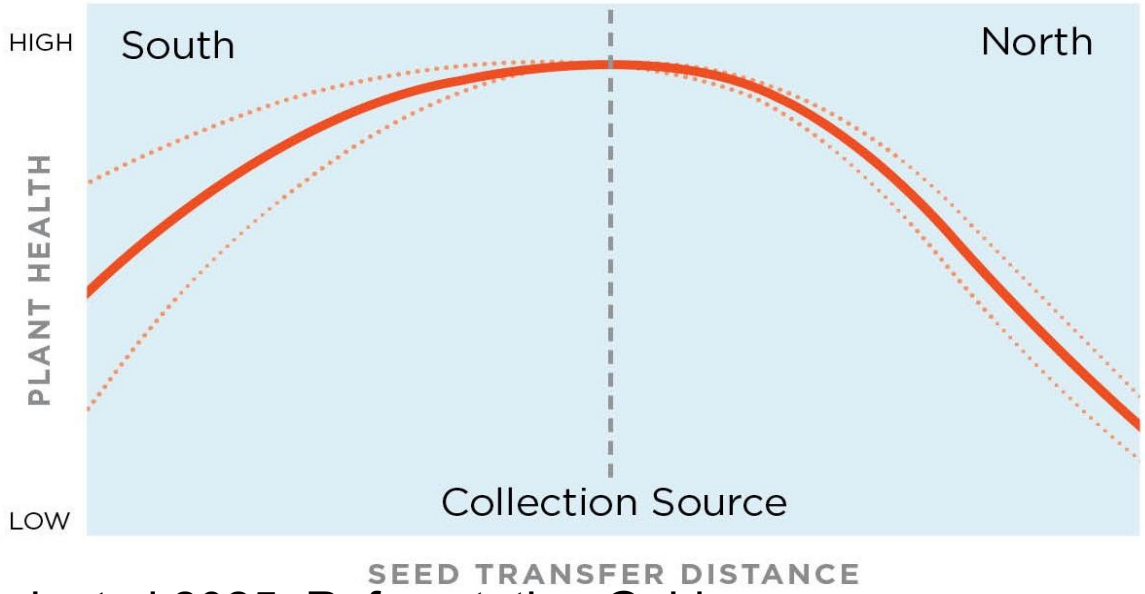
Seed sourcing under a warming climate



- Historically, “local is best” but may need to source from warmer collection zones
- Most tree species can tolerate some degree of seed transfer
- So, what seed source is best for the future?

Clark et al 2025, Reforestation Guide

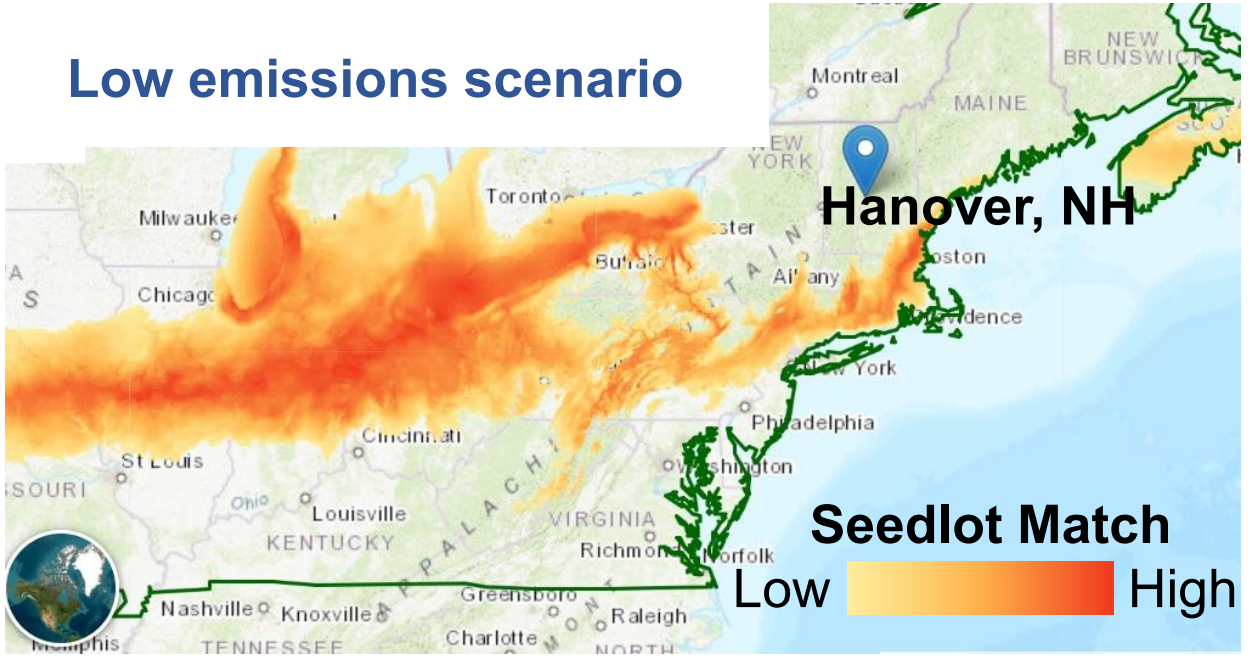
Seed sourcing under a warming climate



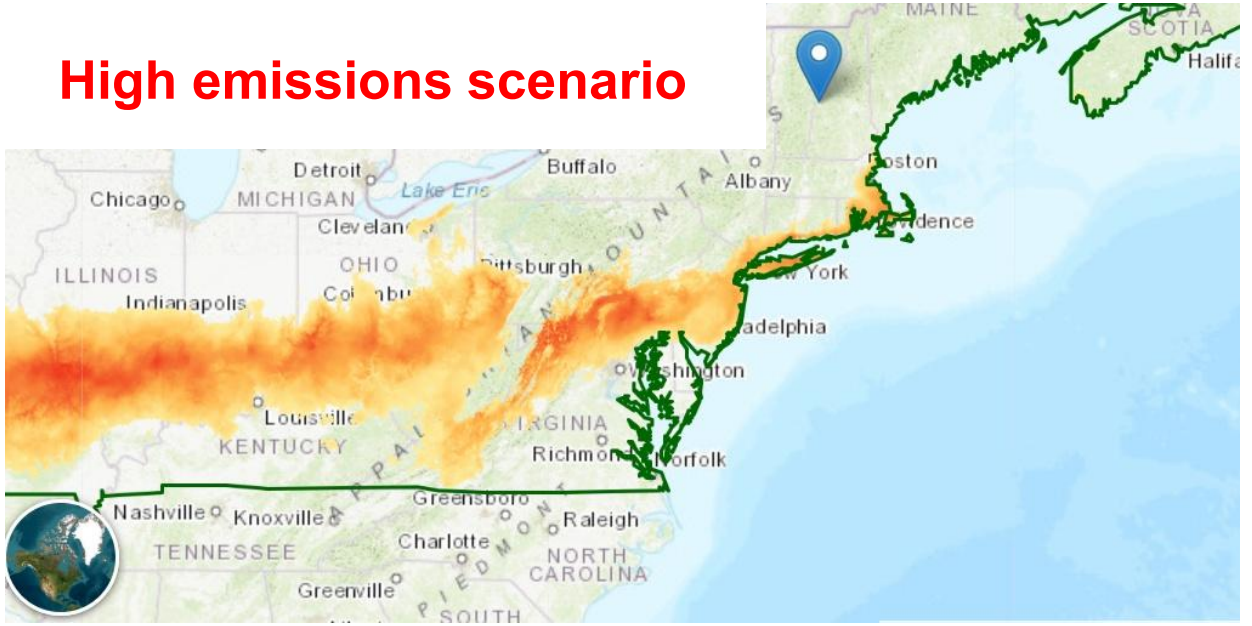
Clark et al 2025, Reforestation Guide

Modelled seed collection zones 2071-2100

Low emissions scenario



High emissions scenario



Species are expected to shift too

For instance, in Vermont:

Red oak

White pine

Increase

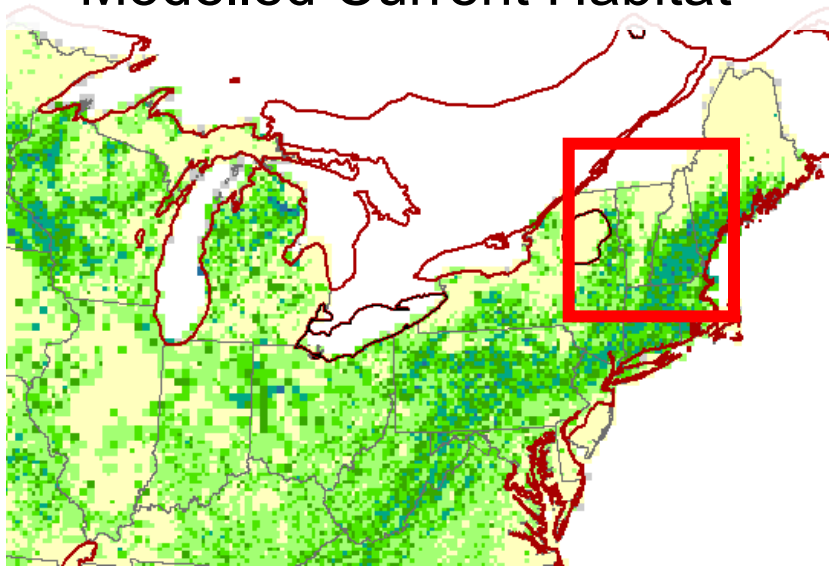
Sugar maple

Red spruce

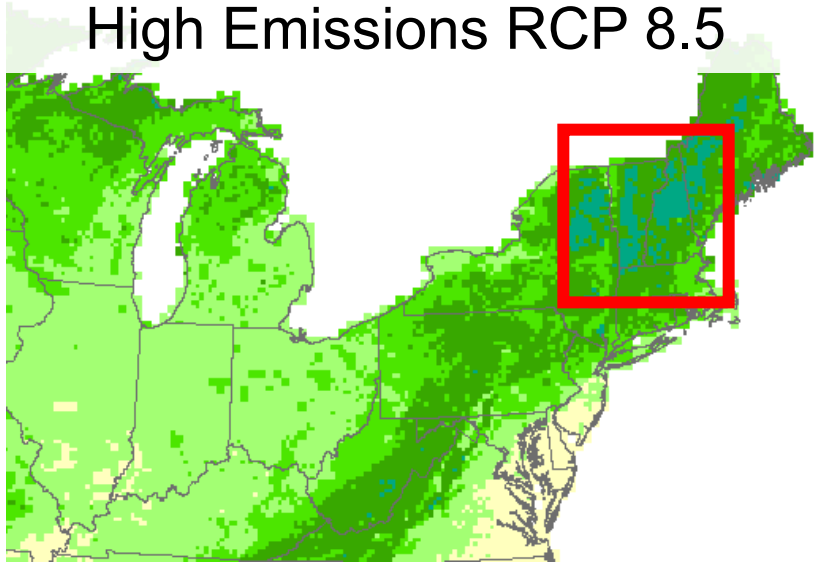
Decrease

Red Oak

Modelled Current Habitat



High Emissions RCP 8.5



USDA Tree Atlas

Species are expected to shift too

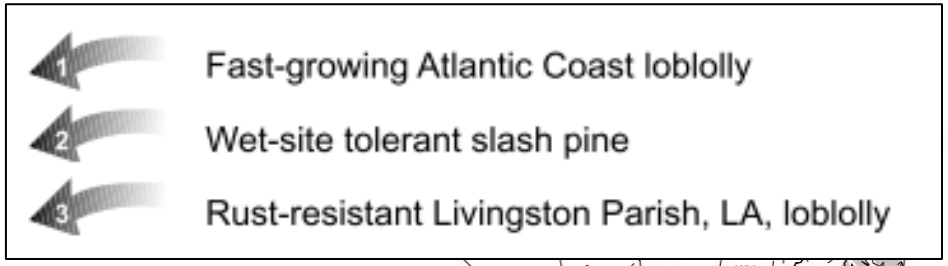
American Chestnut

Models are unreliable due to absence, but we can make inferences

USDA Tree Atlas

Assisted Migration in Forestry: **Population Migration**

Species currently found on-site or located within its historical range, but **sourcing more southern or lower elevation seed sources** expected to be better adapted to future climatic conditions.



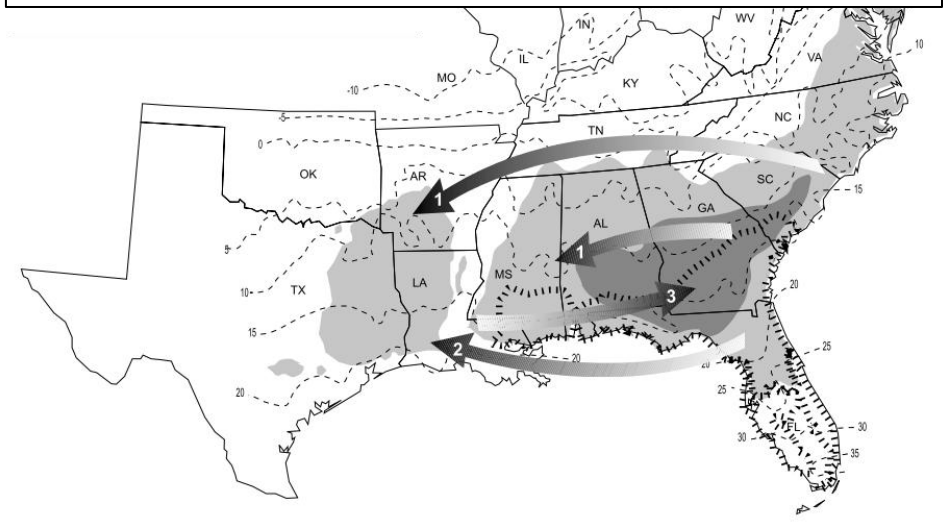
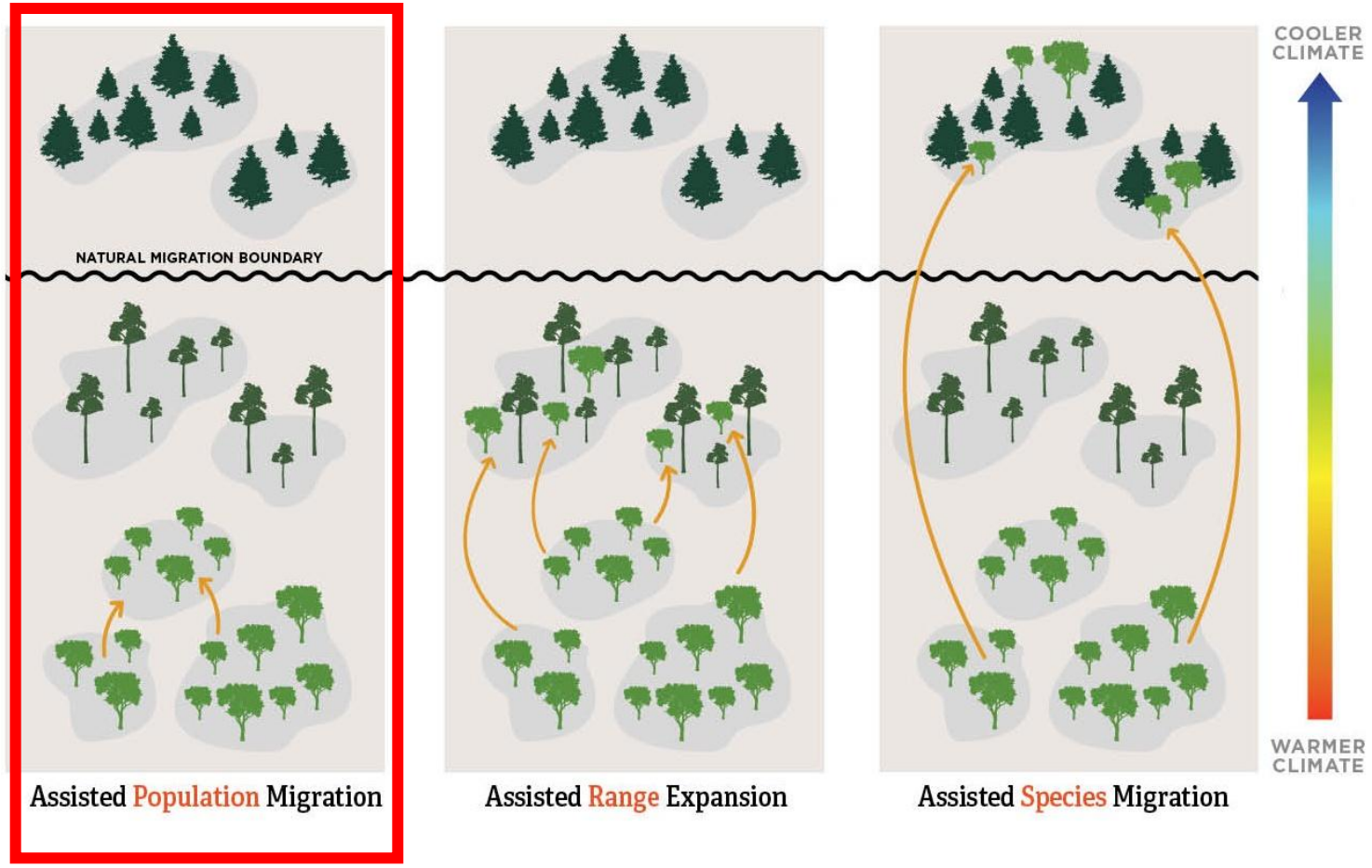


Figure 1—Major seed movement of southern pines since the Great Depression. Natural distributions of species adapted from Critchfield and Little (1966);



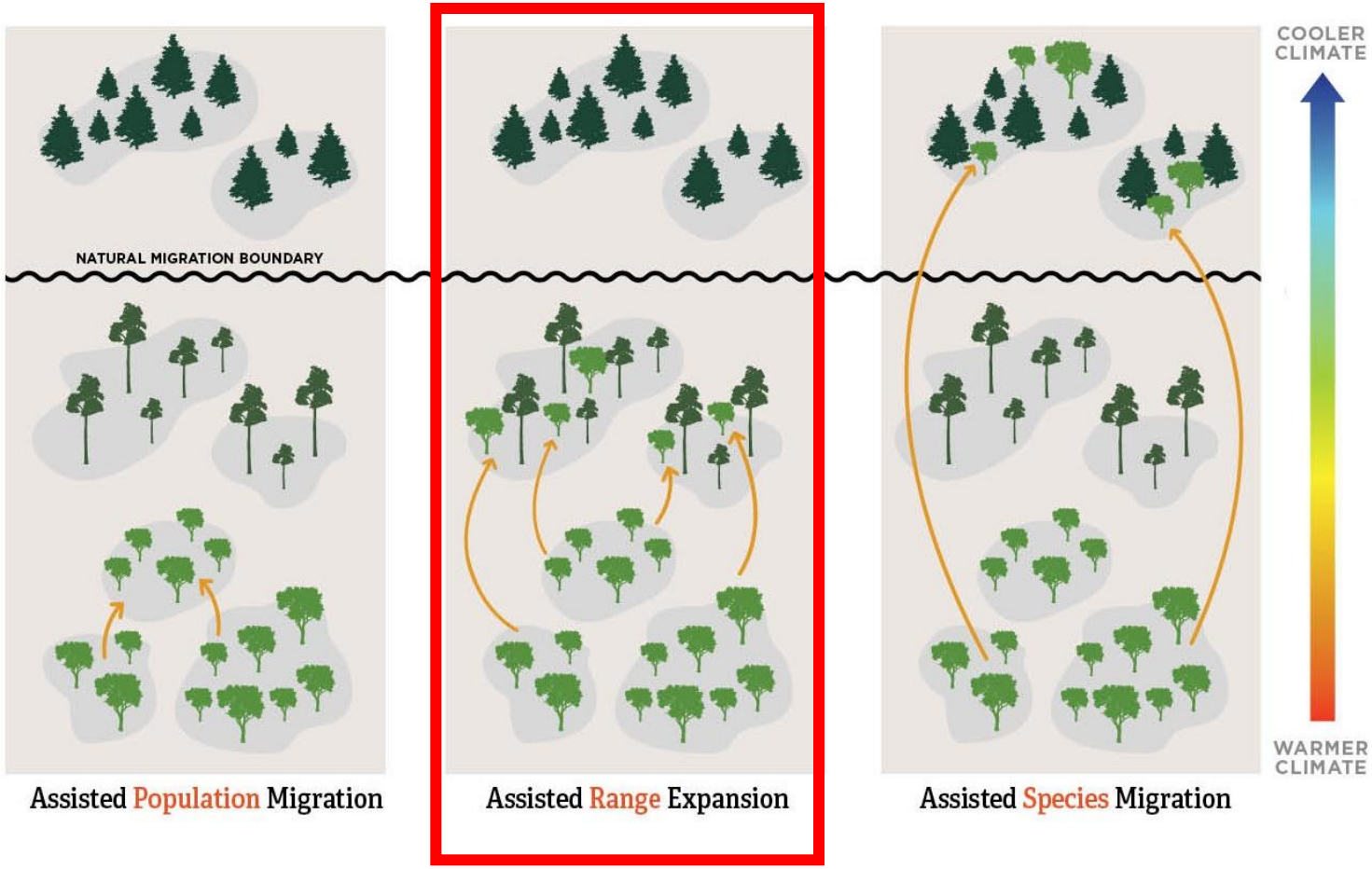
Clark et al 2025. Reforestation Guide, recreated from Williams and Dumroese 2013

Assisted Migration in Forestry: **Range Expansion**

Moving species beyond its historical range into nearby or adjacent areas in anticipation of increased habitat suitability… where the species could realistically establish via natural dispersal over long timescales without a natural migration barrier

Native Americans as active and passive promoters of mast and fruit trees in the eastern USA

Marc D. Abrams[1]* and Gregory J. Nowacki[2]

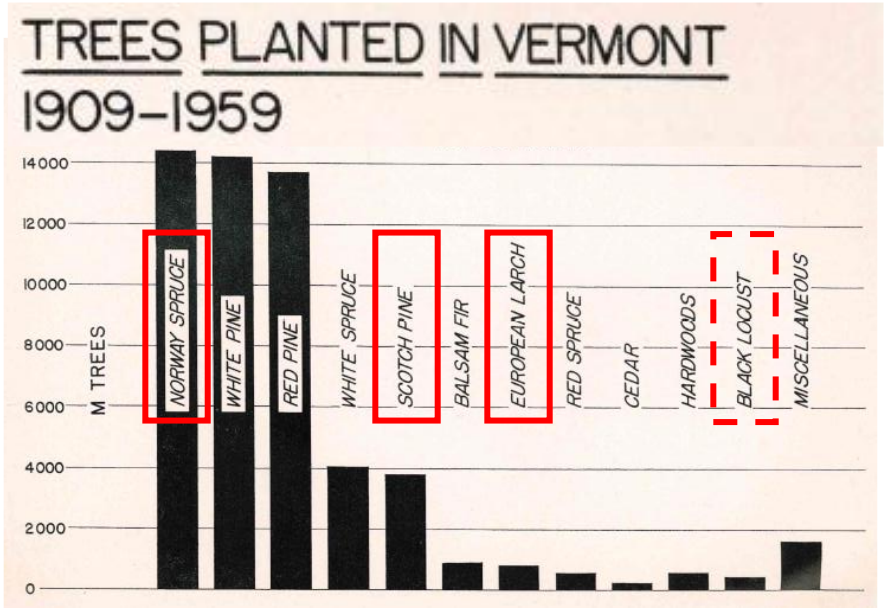


Clark et al 2025. Reforestation Guide, recreated from Williams and Dumroese 2013

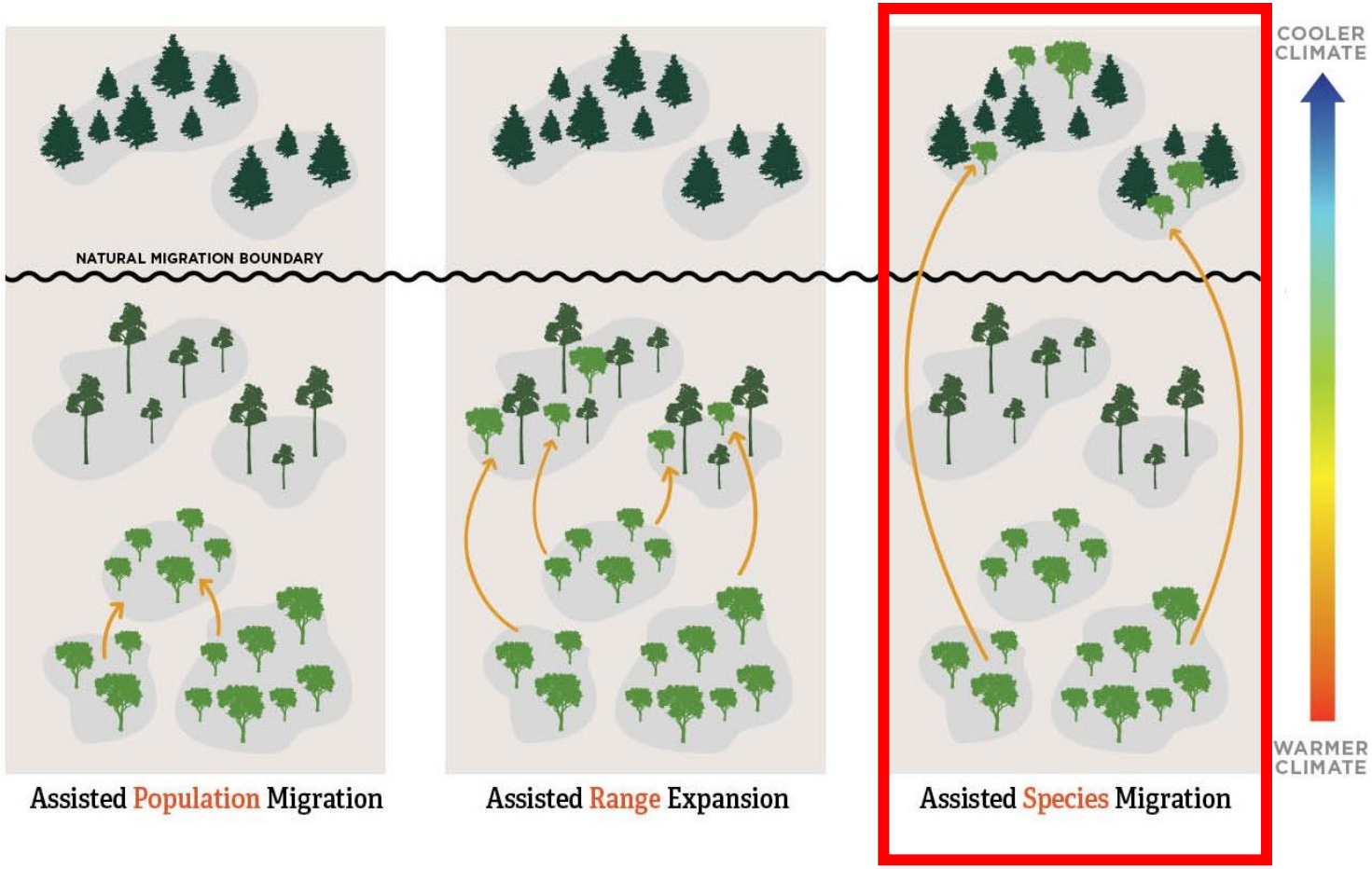
Assisted Migration in Forestry: **Species Migration**

Long distance (trans continental) relocation to areas ever inaccessible by natural dispersal.

Highest risk, **generally not advised**



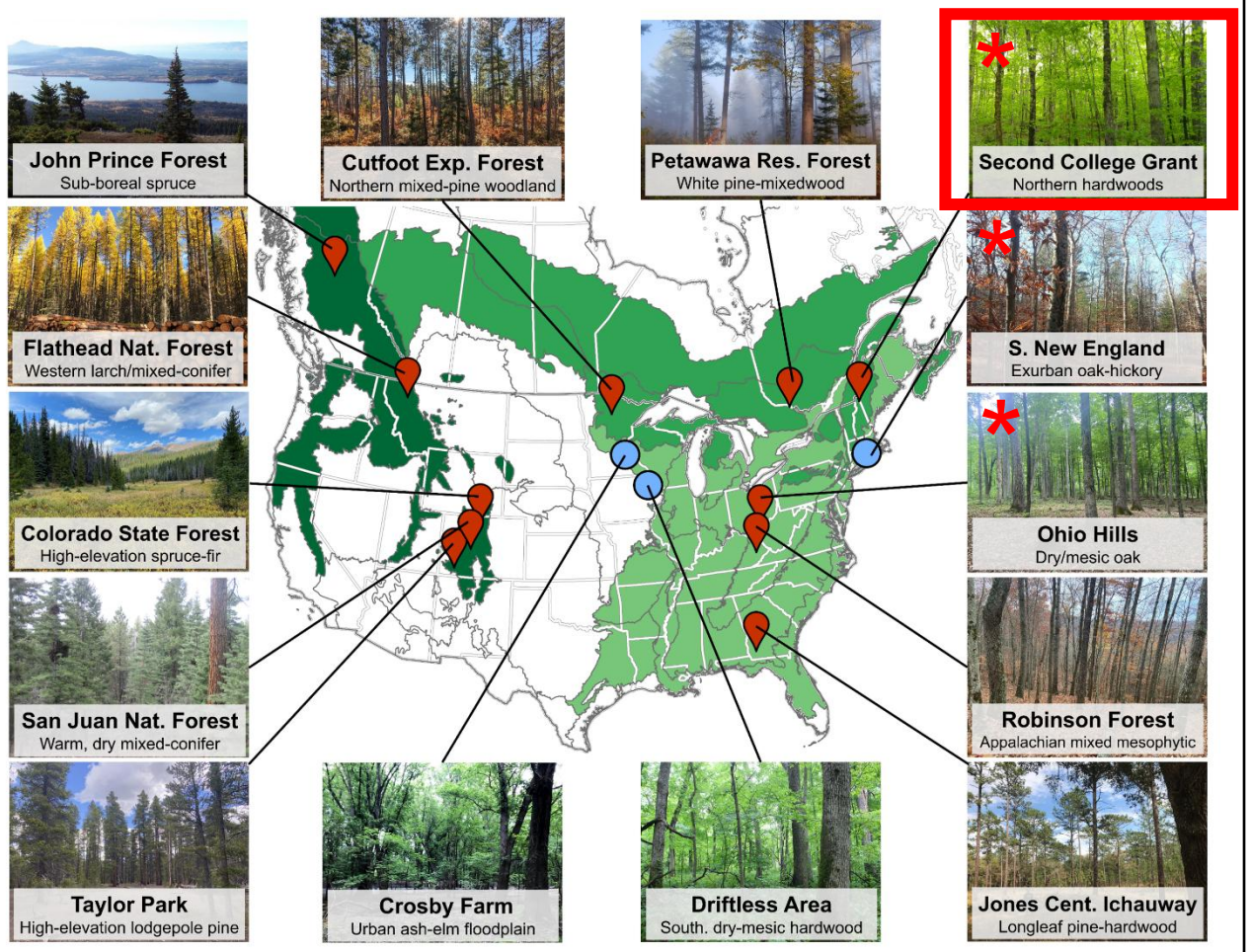
Merrill (1959)



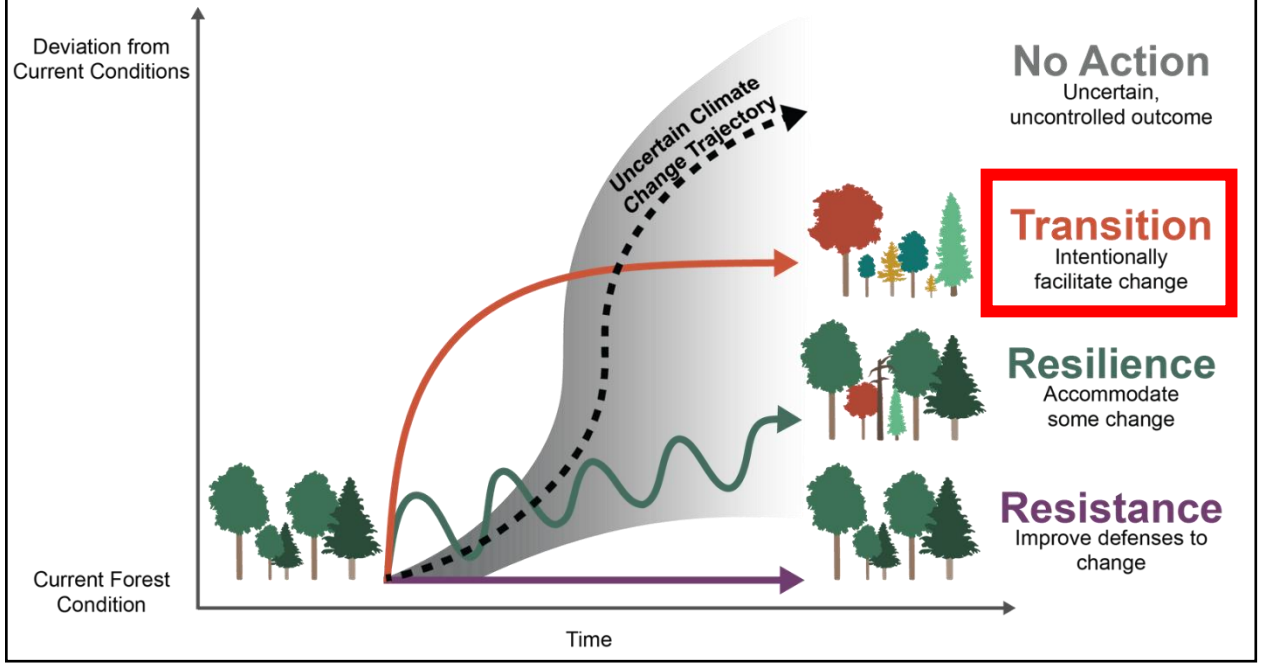
Clark et al 2025. Reforestation Guide, recreated from Williams and Dumroese 2013

Adaptive Silviculture for Climate Change (ASCC):

an international experiment in manager-scientist partnerships to apply an adaptation framework



* = include chestnut research



Second College Grant, NH

University of Vermont

https://adaptivesilviculture.org

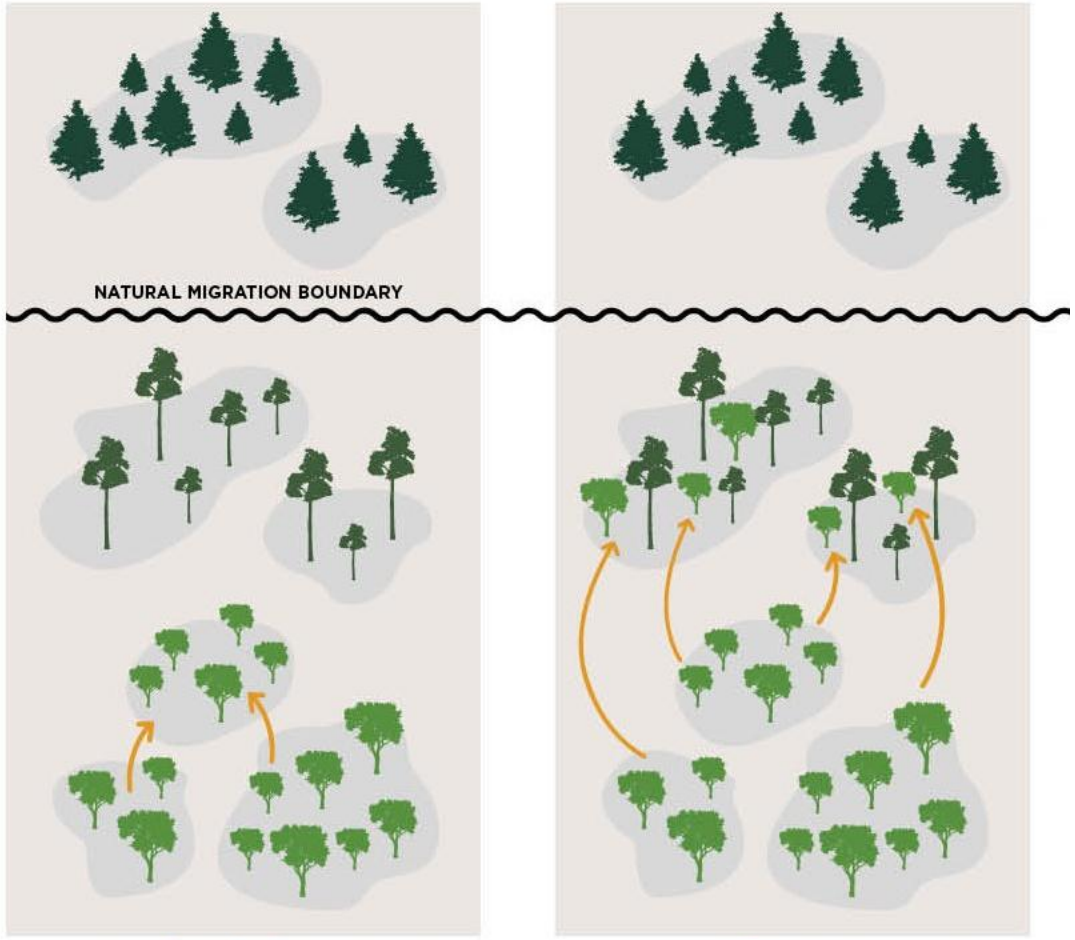
Key Desired Future Conditions of “Transition” treatments at SCG-ASCC

- Shift pure northern hardwood forest (maple-beech-birch) toward more “**future-adapted**” species composition
- Still, maintain key ecosystem functions, through “**functional reinforcement**” or “**functional replacement**”

5,000 planted seedlings

SPECIES
B. Aspen
B. Cherry
E. Hemlock
R. Oak
R. Spruce
W. Pine
B. Hickory
B. Birch
A. Chestnut B3F3

SPECIES	MIGRATION
B. Aspen	Pop. Migration
B. Cherry	Pop. Migration
E. Hemlock	Pop. Migration
R. Oak	Pop. Migration
R. Spruce	Pop. Migration
W. Pine	Pop. Migration
B. Hickory	Range Expansion
B. Birch	Range Expansion
A. Chestnut B3F3	Range Expansion



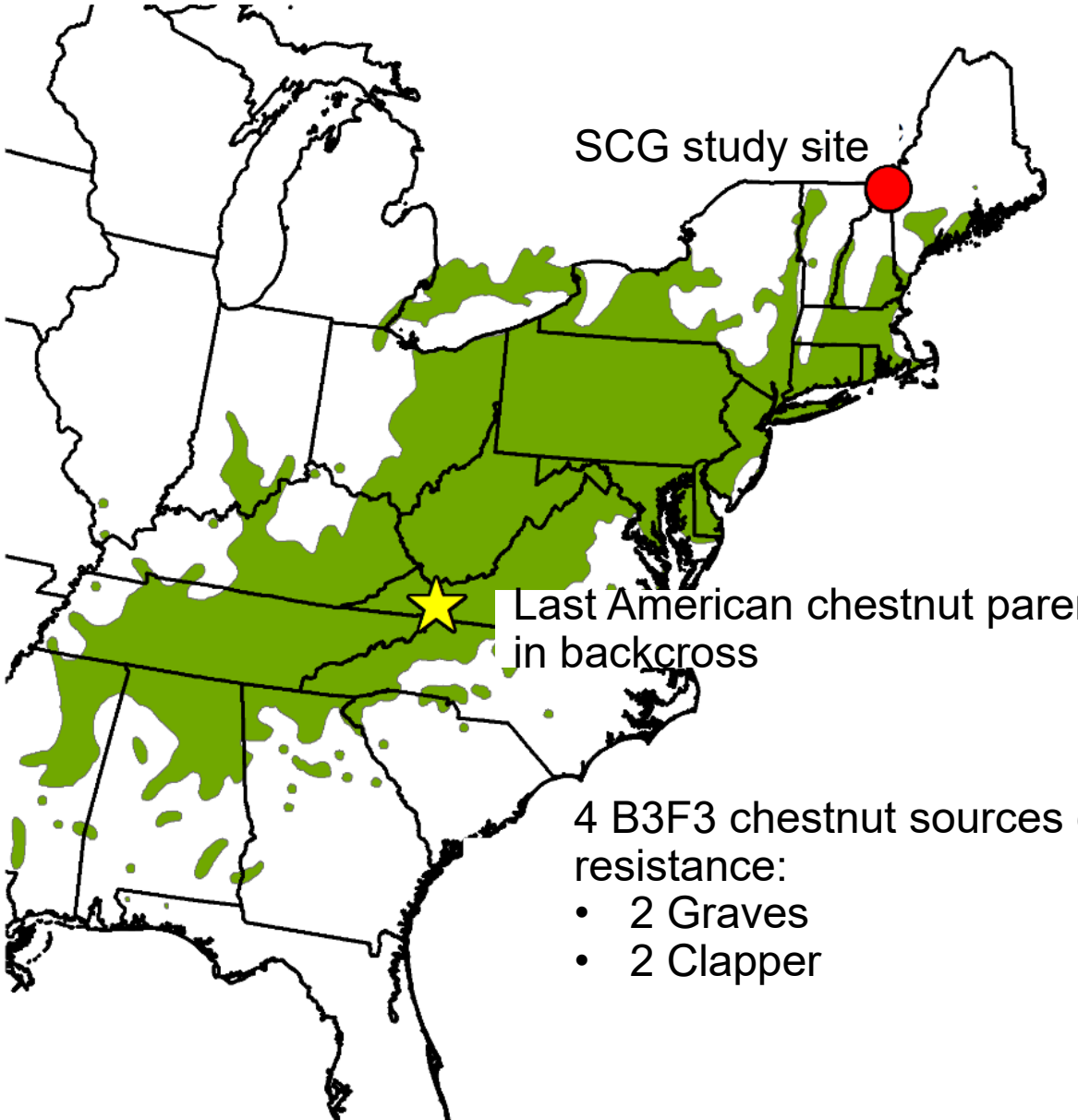
Assisted pop. migration

Assisted range expansion

Trait diversity and redundancy

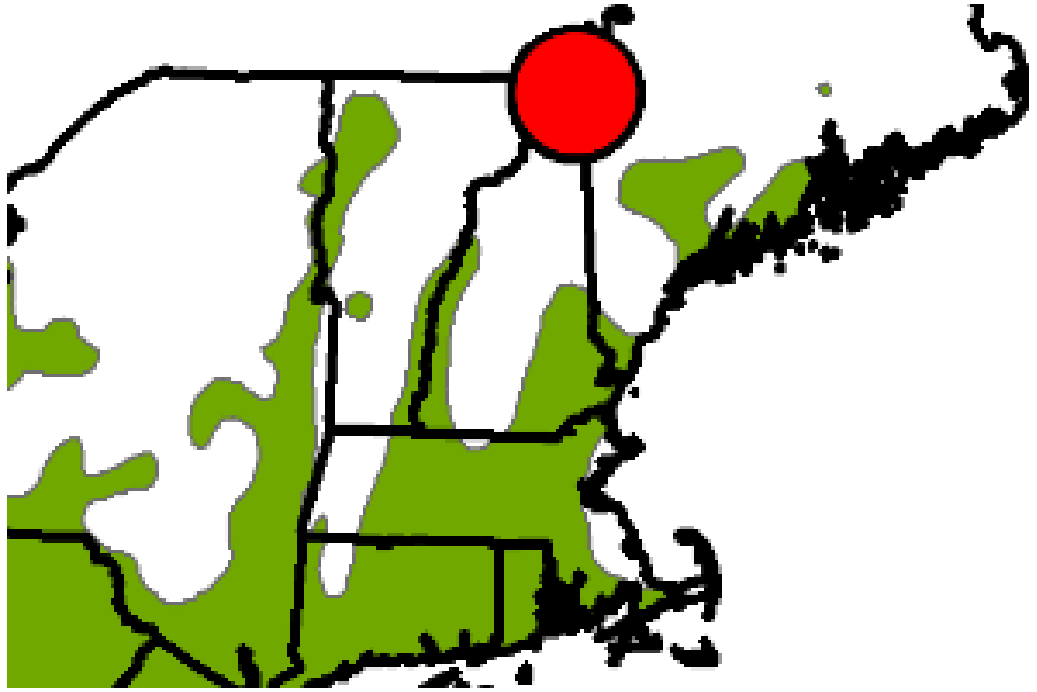
SPECIES
B. Aspen
B. Cherry
E. Hemlock
R. Oak
R. Spruce
W. Pine
B. Hickory
B. Birch
A. Chestnut B3F3

Chestnut Migration to SCG

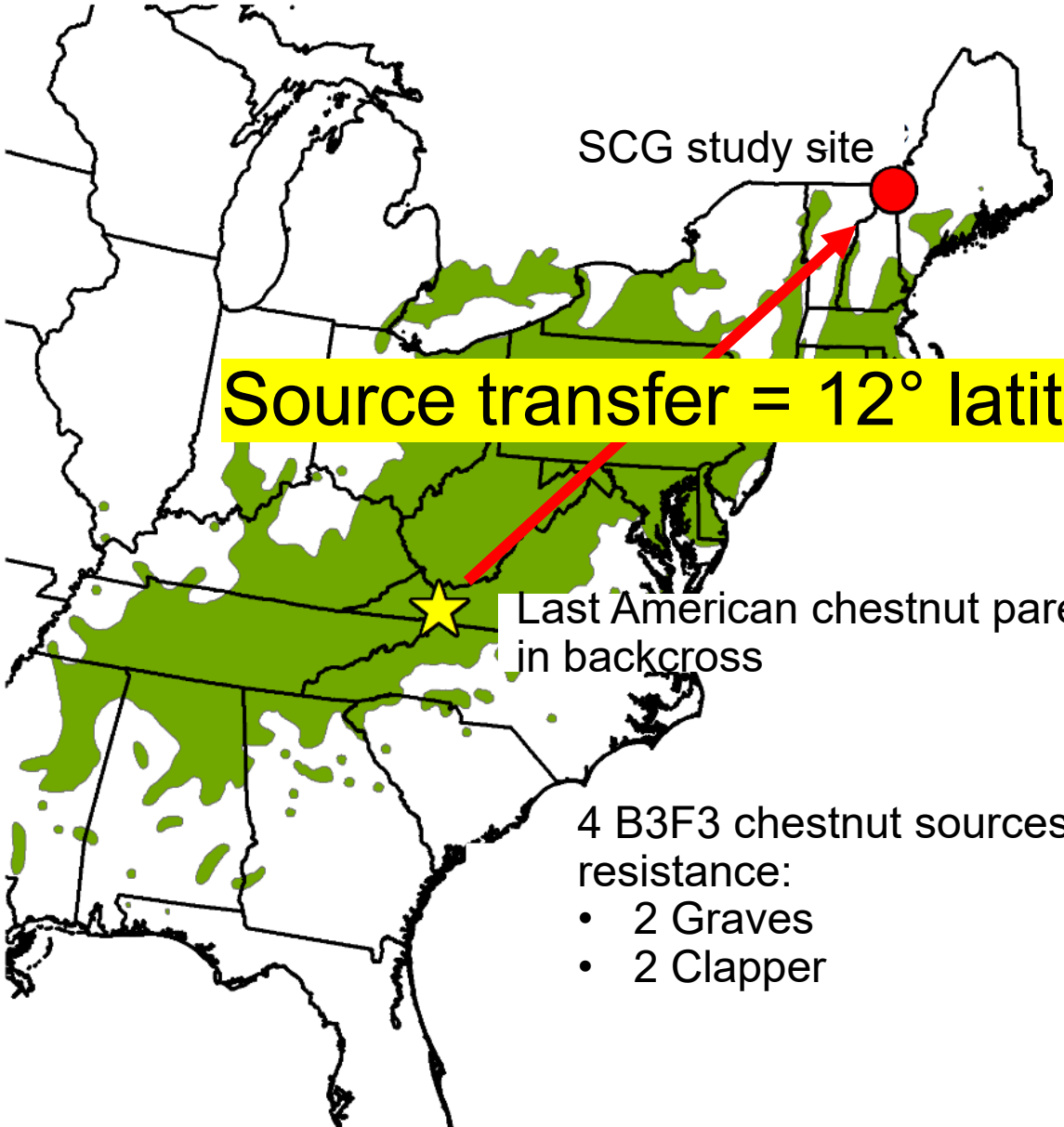


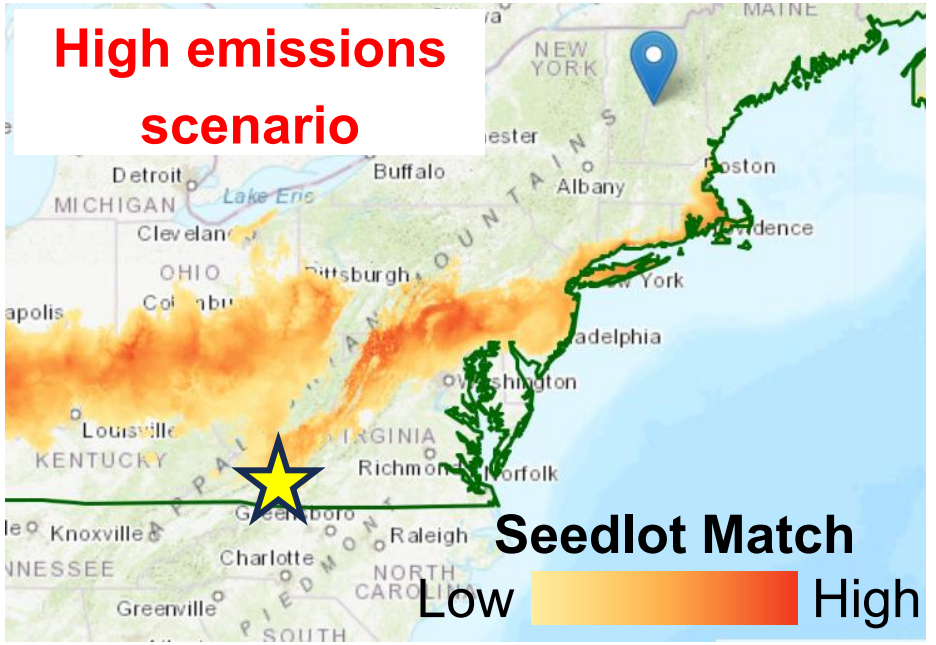
4 B3F3 chestnut sources of resistance:

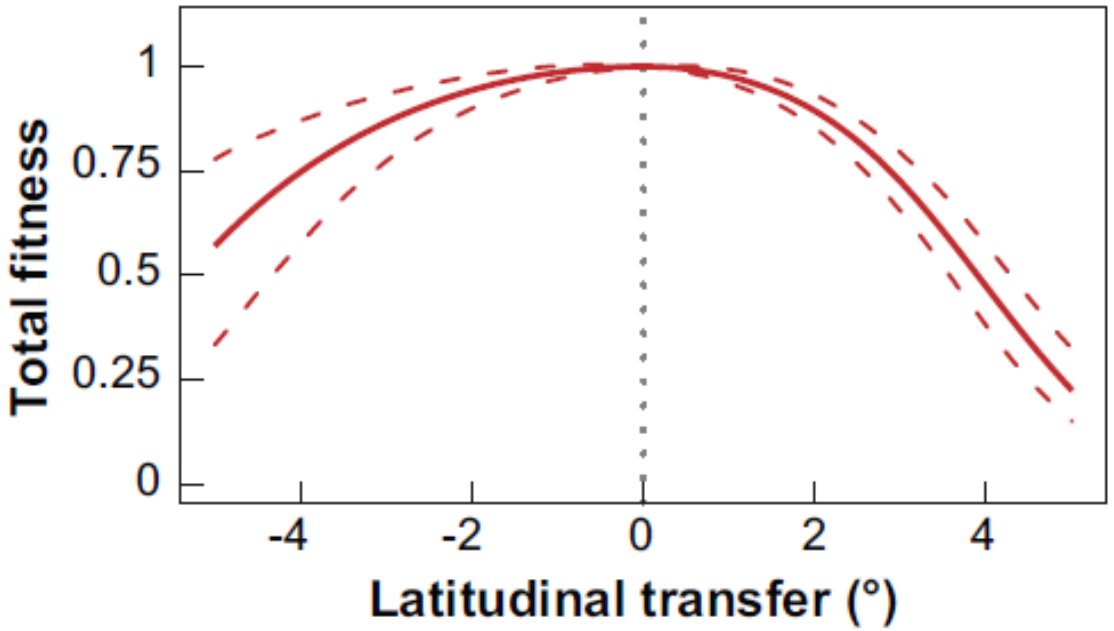
- 2 Graves
- 2 Clapper



Chestnut Migration to SCG







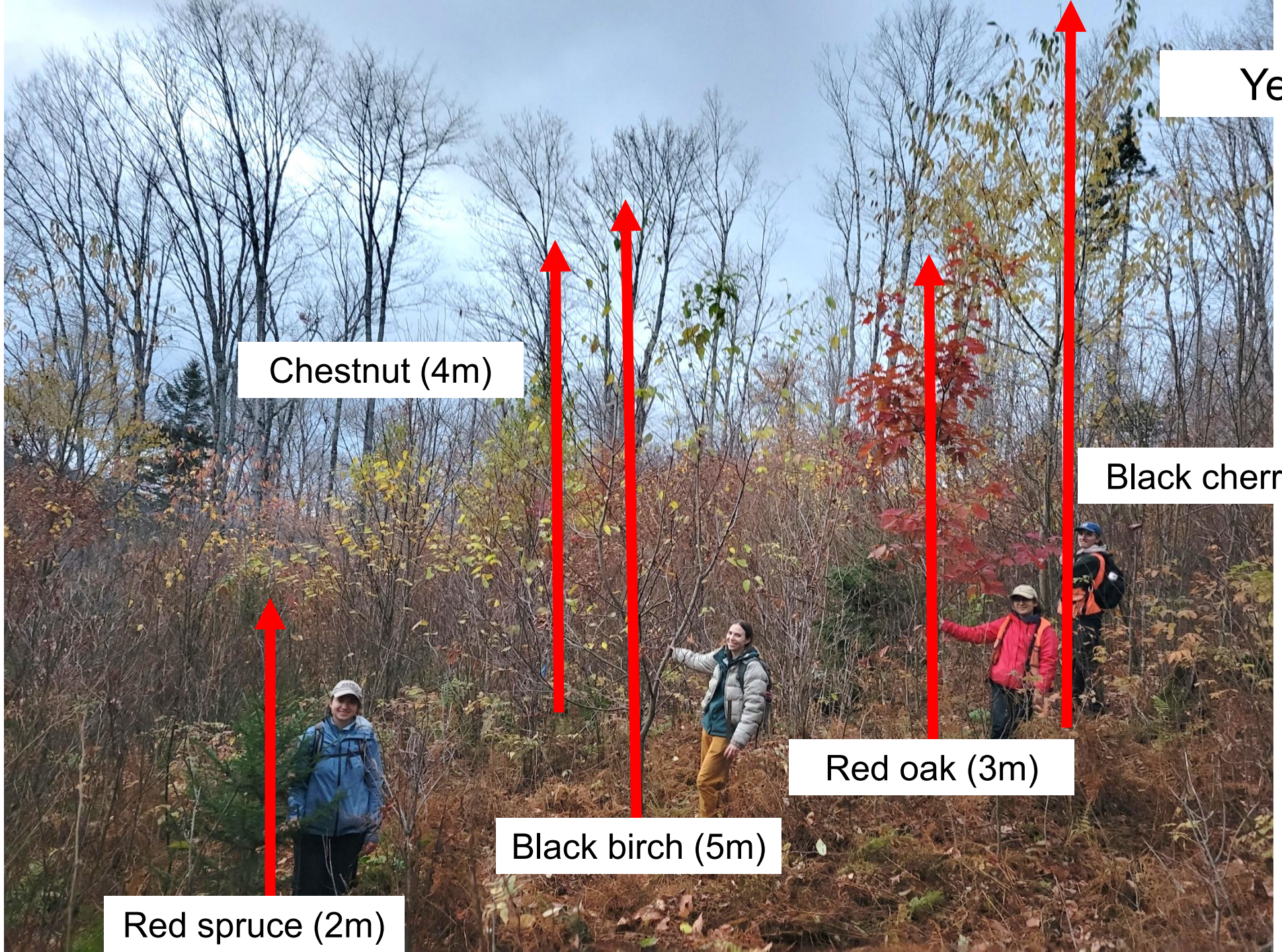

Year 2


Year 3


Year 4


Year 4
Black birch
Chestnut
White pine


Year 8
Red oak
Chestnut
White pine


Year 8
Chestnut (4m)
Black cherry (6m)
Red oak (3m)
Black birch (5m)
Red spruce (2m)

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journal homepage: www.elsevier.com/locate/foreco

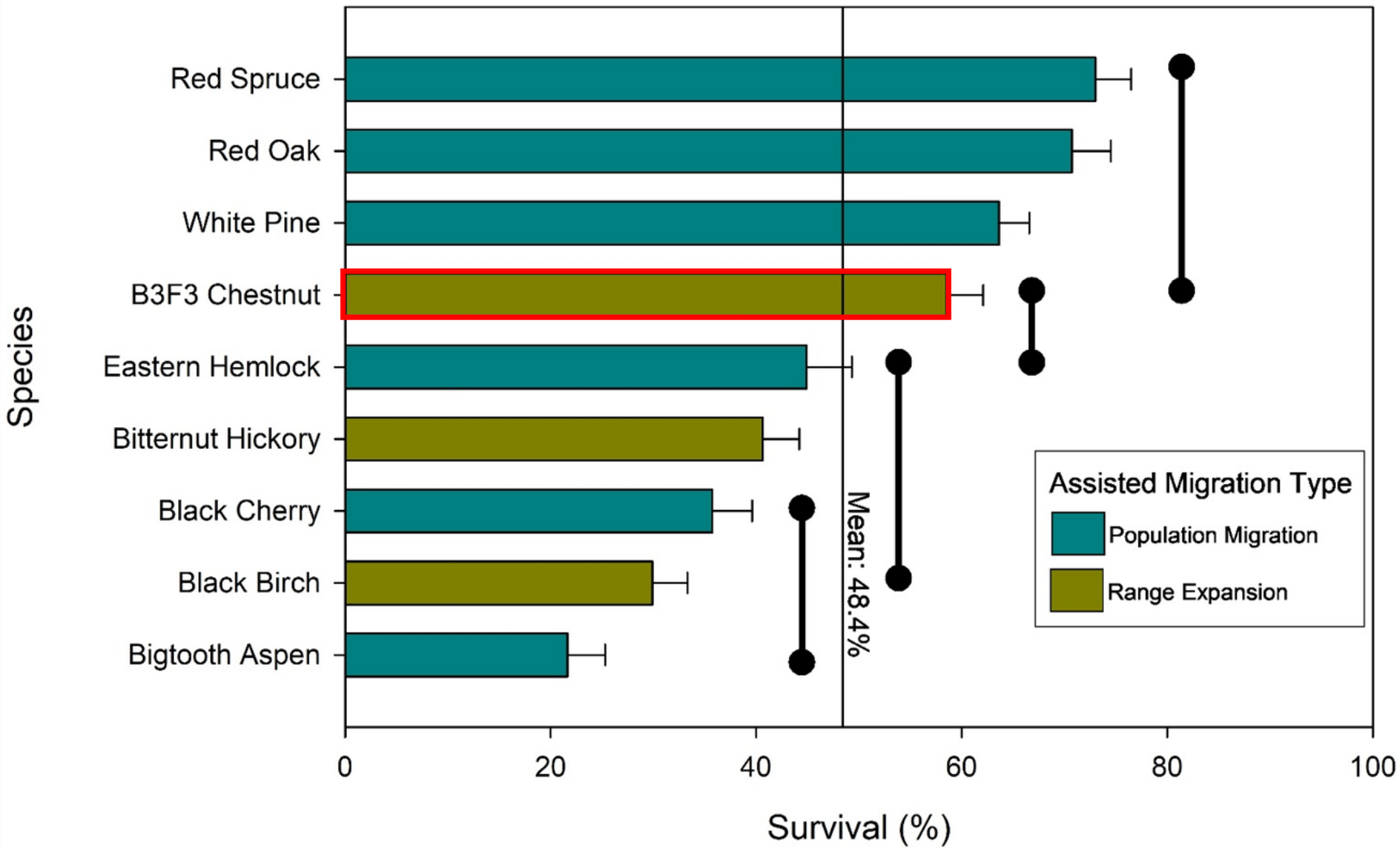
Restoring a keystone tree species for the future: American chestnut assisted migration plantings in an adaptive silviculture experiment

Peter W. Clark [a,*], Alissa J. Freeman [a], Anthony W. D'Amato [a], Paul G. Schaberg [b], Gary J. Hawley [a], Kevin S. Evans [c], Christopher W. Woodall [d]

[a] *Rubenstein School of Environment and Natural Resources, University of Vermont, Burlington, VT, United States*
[b] *US Department of Agriculture, Forest Service, Northern Research Station, Burlington, VT, United States*
[c] *Dartmouth College Woodlands, Milan, NH 03588, Italy*
[d] *USDA Forest Service, Northern Research Station, Durham, NH 03824, UK*

2022

Eight-year outcomes: survival

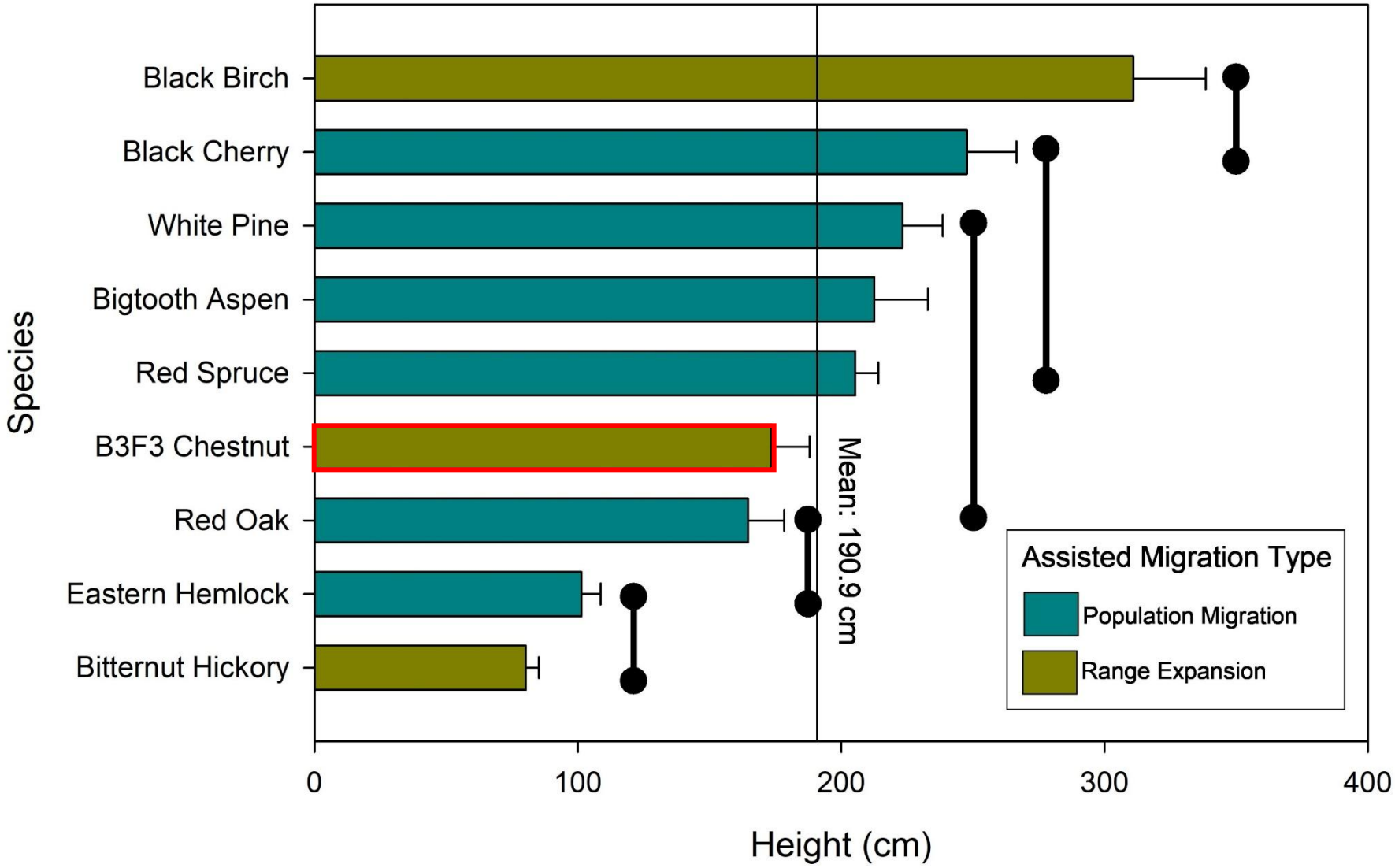


Chestnut takeaway:

- 59% survival (corrected for non-germination failure)
- No source difference

- Among top performers!

Eight year outcomes: growth (height)



Chestnut takeaway:

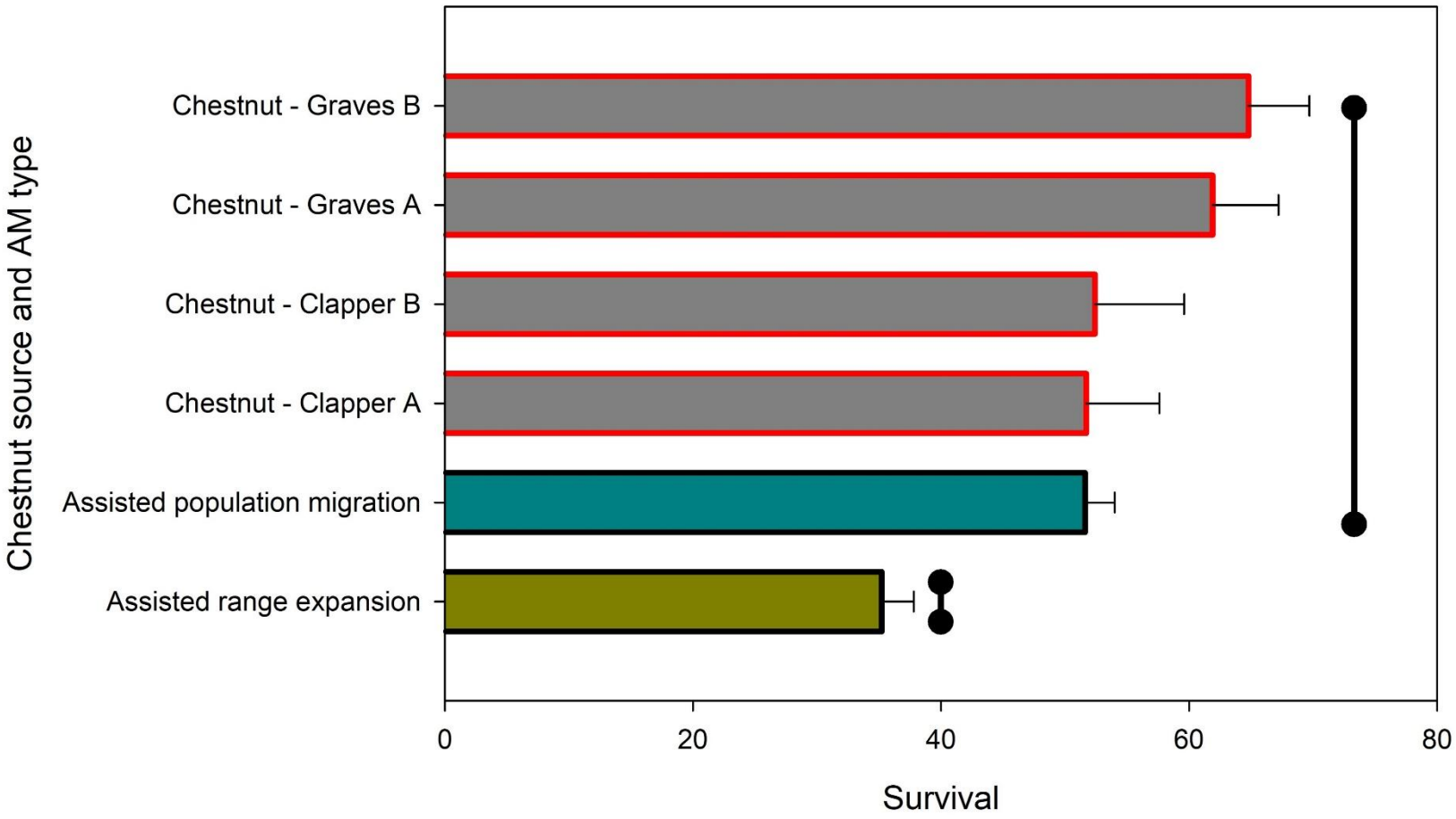
- Mean: 1.7m tall
- Max: 5m tall!
- No source difference

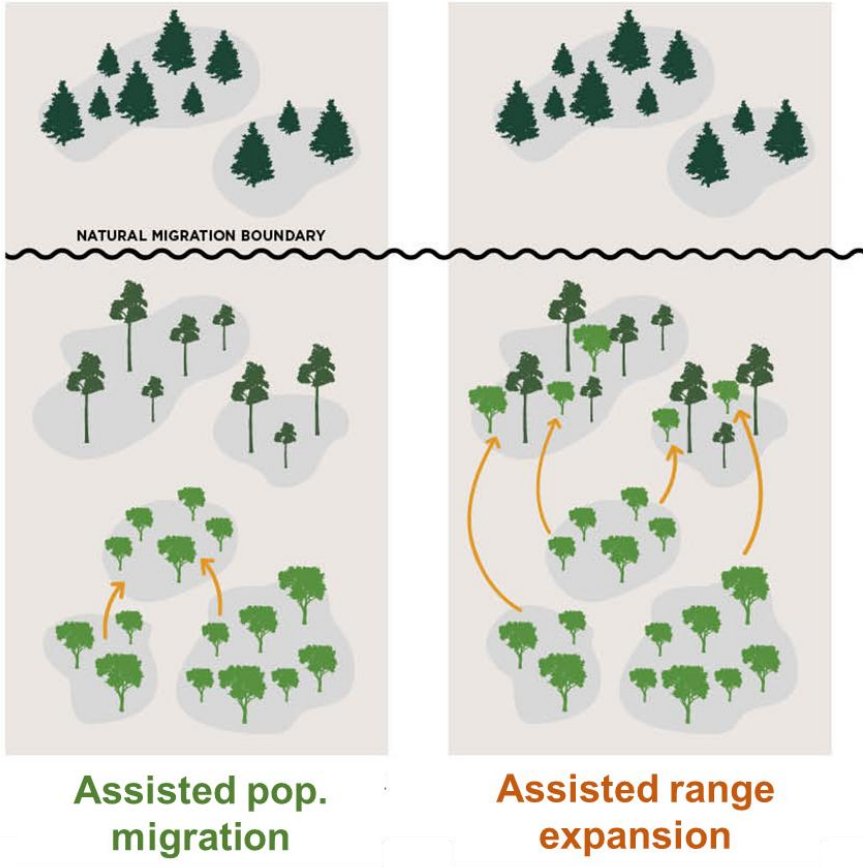
- Middle of the pack

Chestnuts in an assisted migration context

Chestnut takeaway:

- More tolerant of being planted outside of their “current” range than other species
- Bodes well for restoration and assisted migration of chestnuts



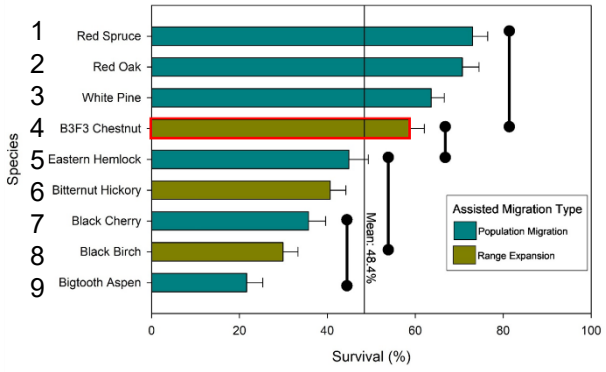


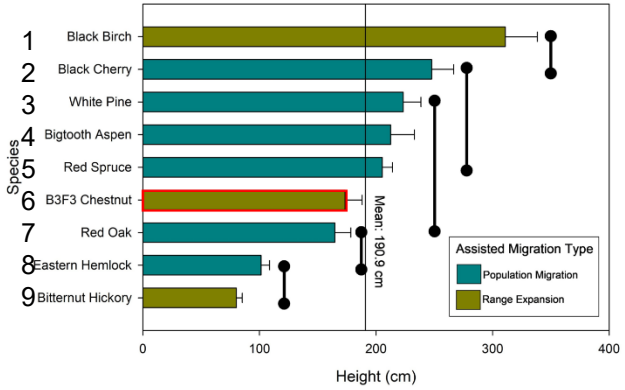
Combined ranked performance

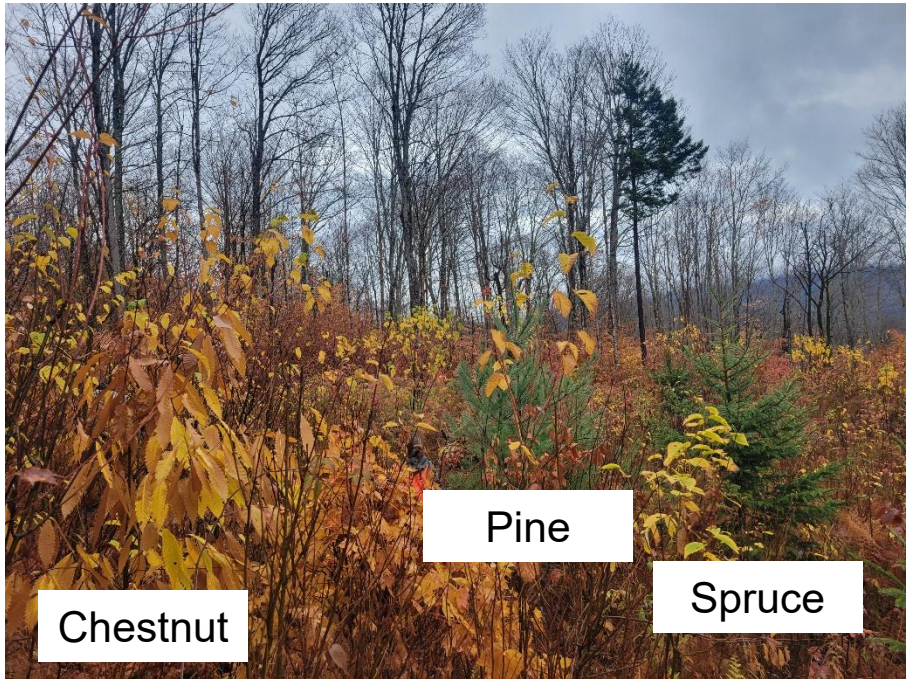
RANKED PERFORMANCE

Rank 1: R. spruce
Rank 2: W. pine
Rank 3: **AC Graves** & R. oak
Rank 4: B. birch & B. cherry
Rank 5: **AC Clapper** & B. aspen
Rank 6: E. hemlock
Rank 7: B. hickory

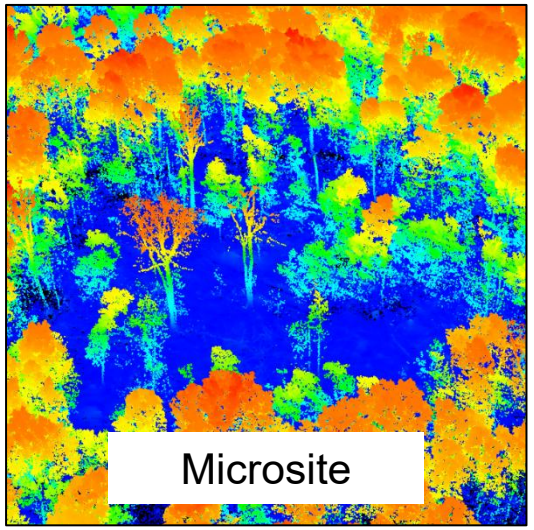
Survival + Growth







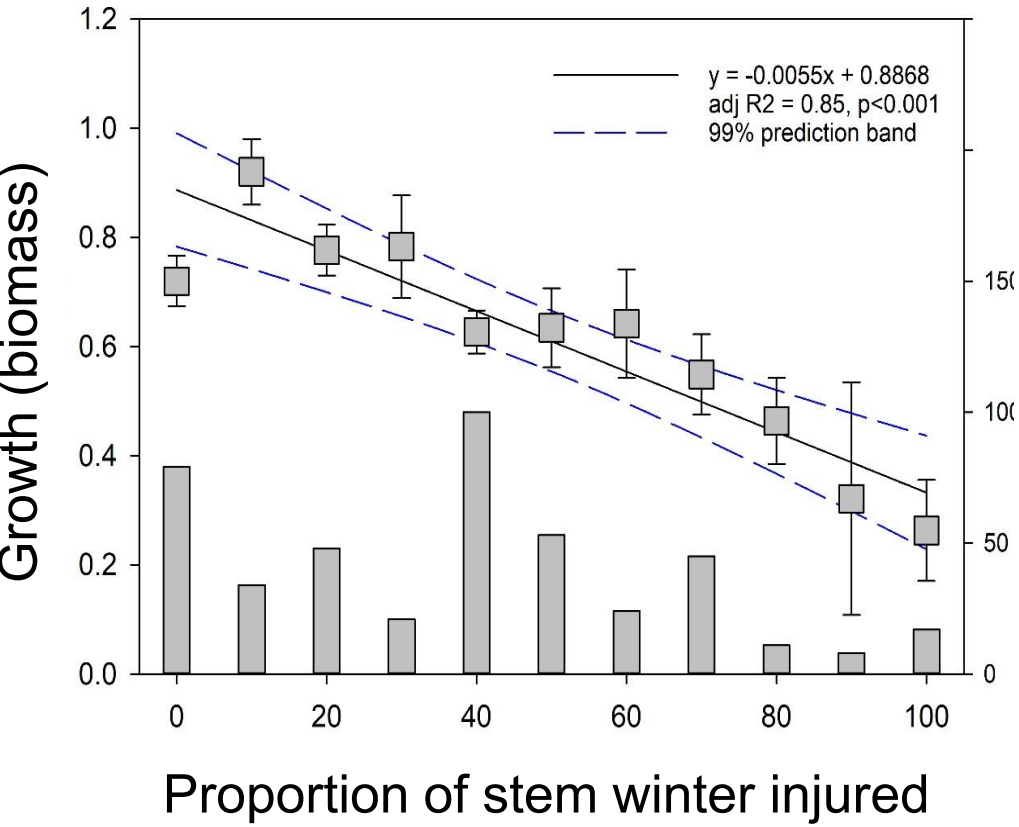
Some drivers of success

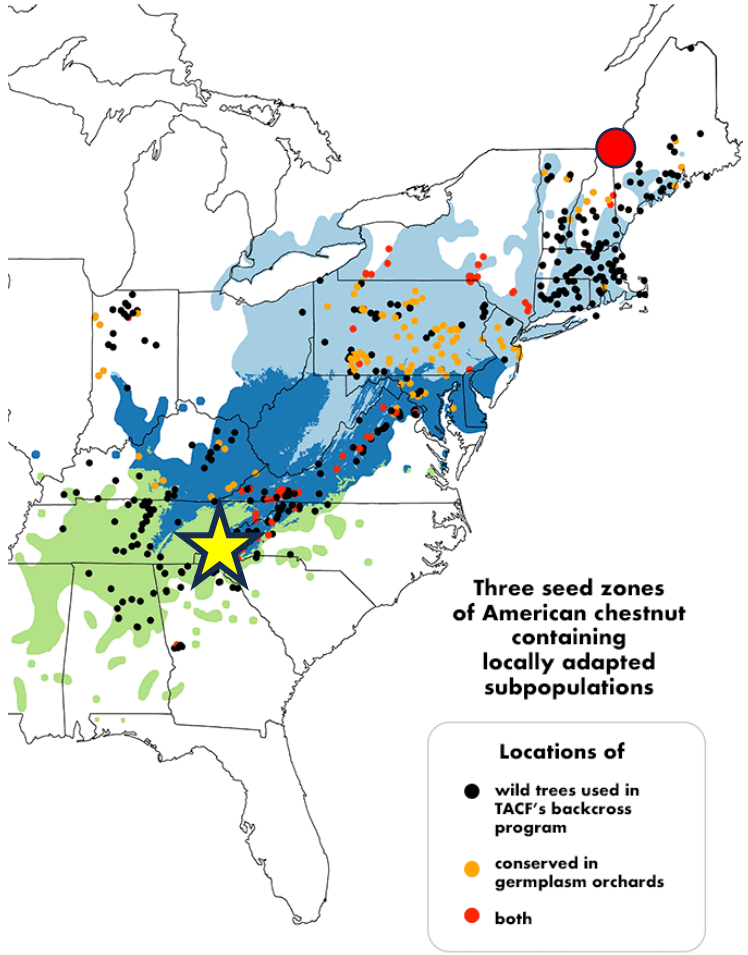


Site Maladaptation

Takeaway:

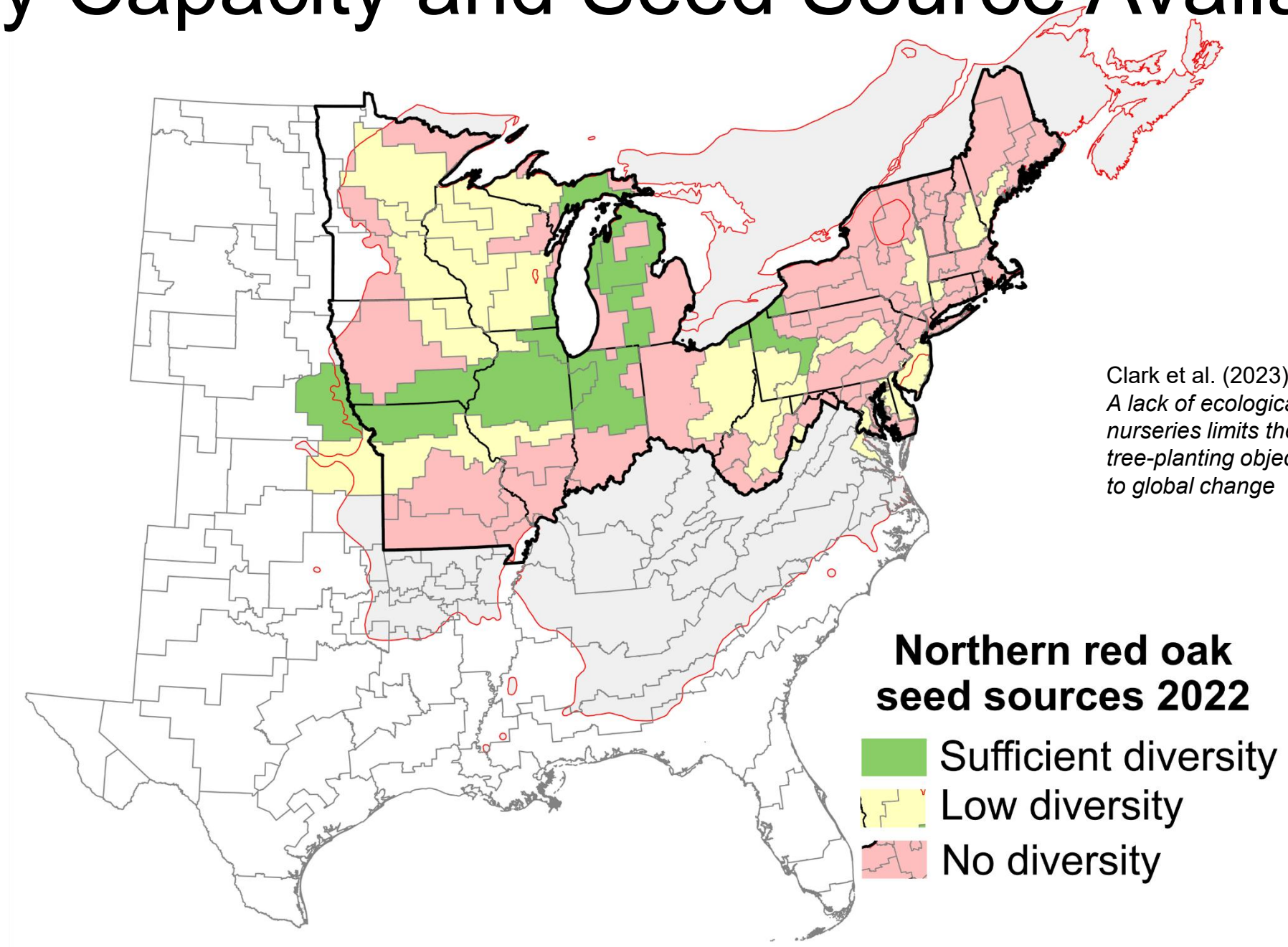
- Chestnut growth constrained by frost damage from extreme winter temps
- Improved by better matching seed source?





Chestnut with winter-injured stems, spring frost leaf damage, and browse damage

Nursery Capacity and Seed Source Availability

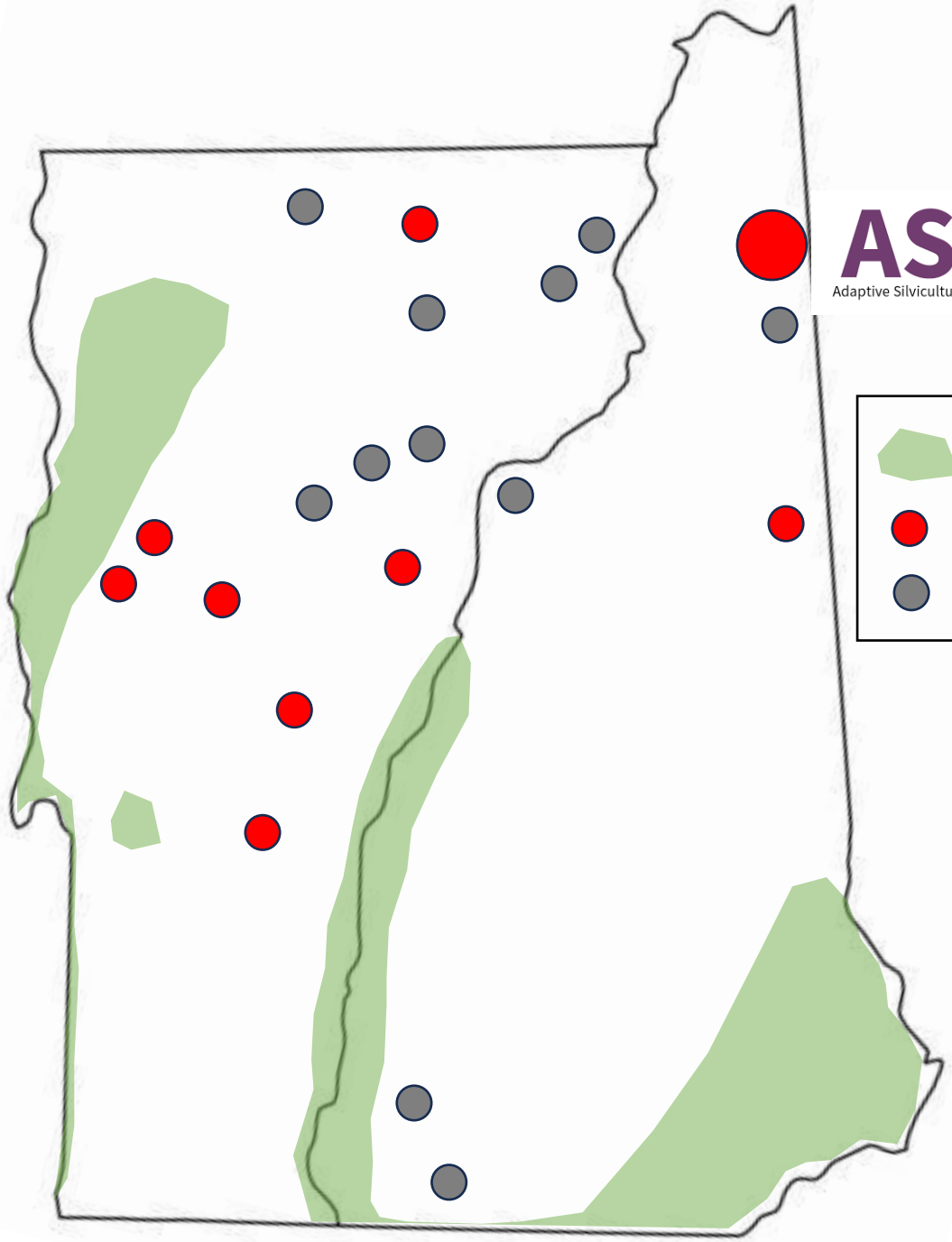


Clark et al. (2023), BioScience
A lack of ecological diversity in forest nurseries limits the achievement of tree-planting objectives in response to global change

Regional affiliate planting research

Site details

- >20 “operational-scale” and co-developed research sites; 10 with chestnuts
- >80,000 total seedlings planted experimentally
- ~5,000 chestnuts planted, 100% monitored

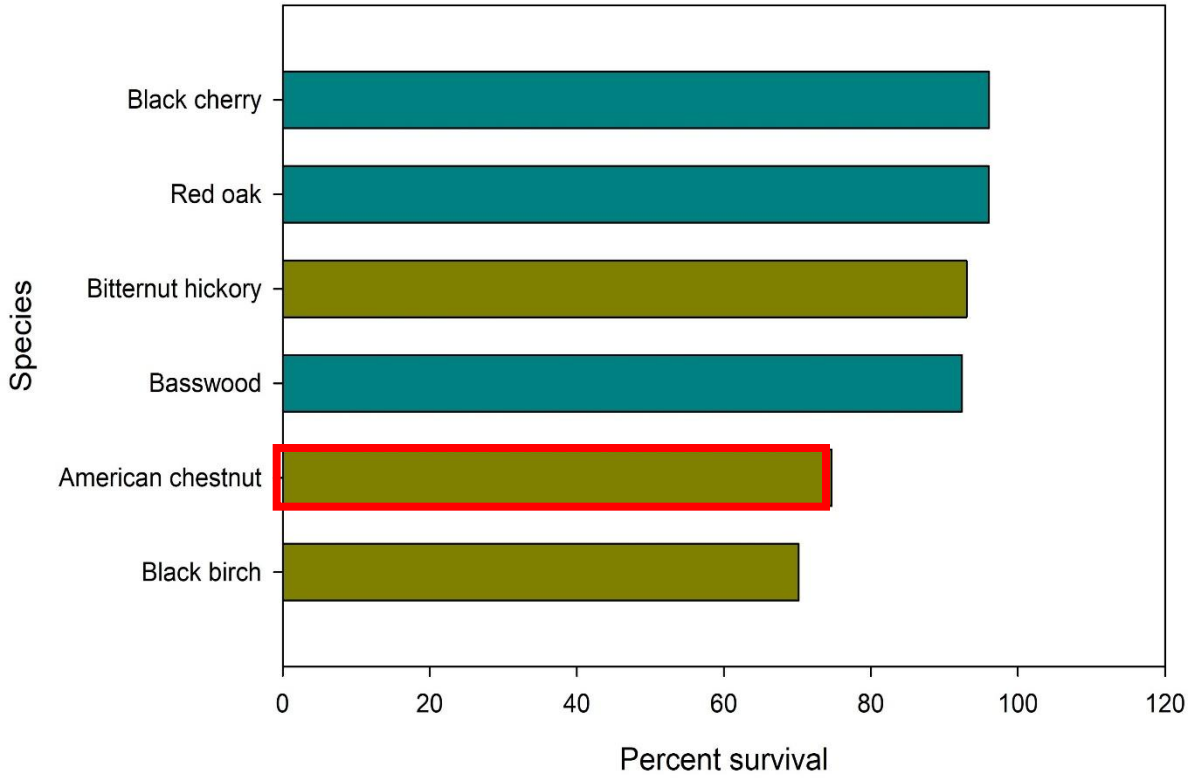


ASCC
Adaptive Silviculture for Climate Change

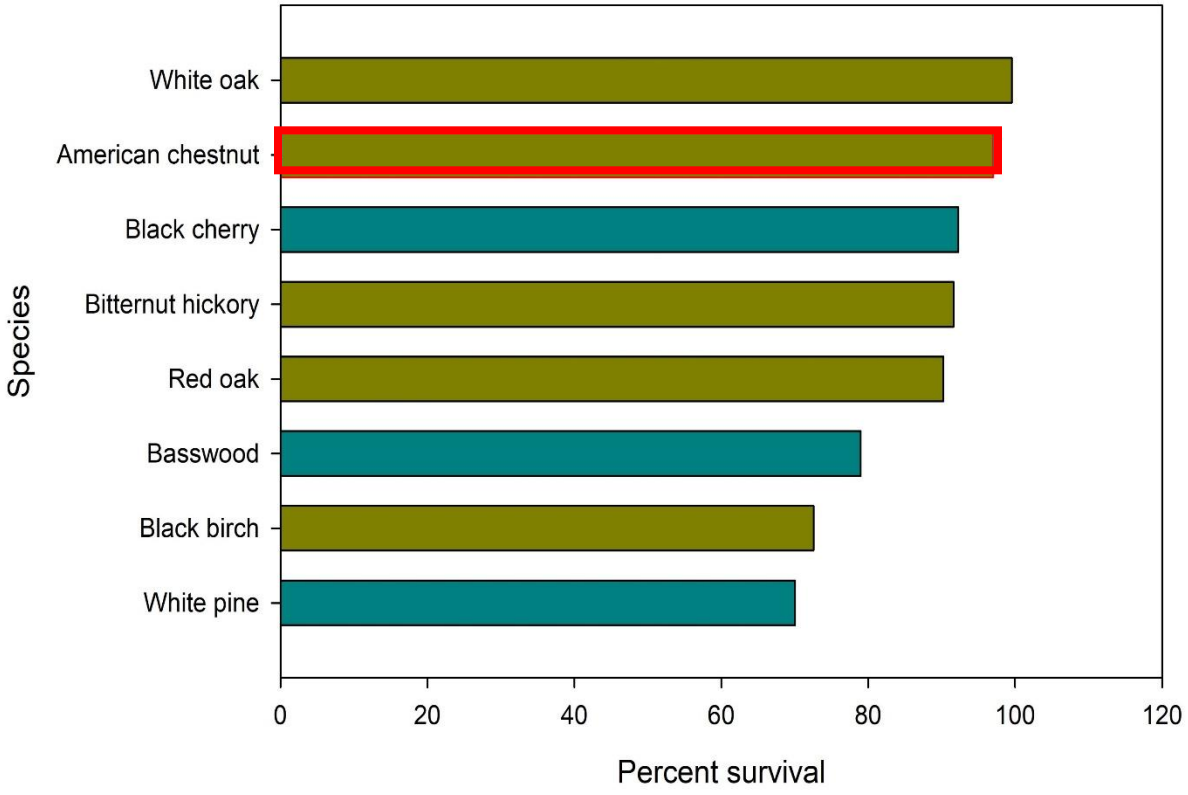
TNC
Vermont Land Trust
CATAMOUNT OUTDOOR FAMILY CENTER
chartered 1762 Hinesburg VERMONT
FORESTS, PARKS & RECREATION VERMONT
AGENCY OF NATURAL RESOURCES

Early results from other sites

Corinth, VT 3- year survival
Central VT, rich northern hardwoods



Greensboro, VT 2-year survival
Northern VT, northern hardwoods-boreal mix

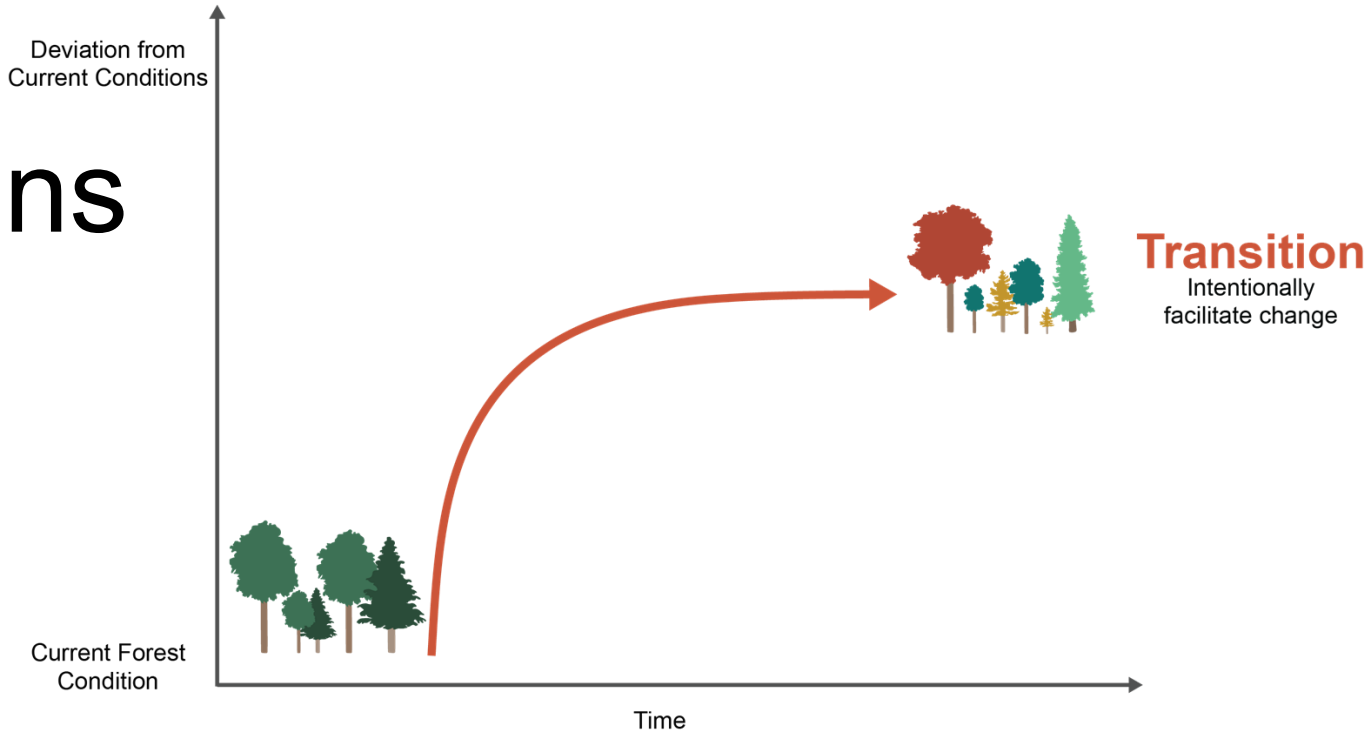


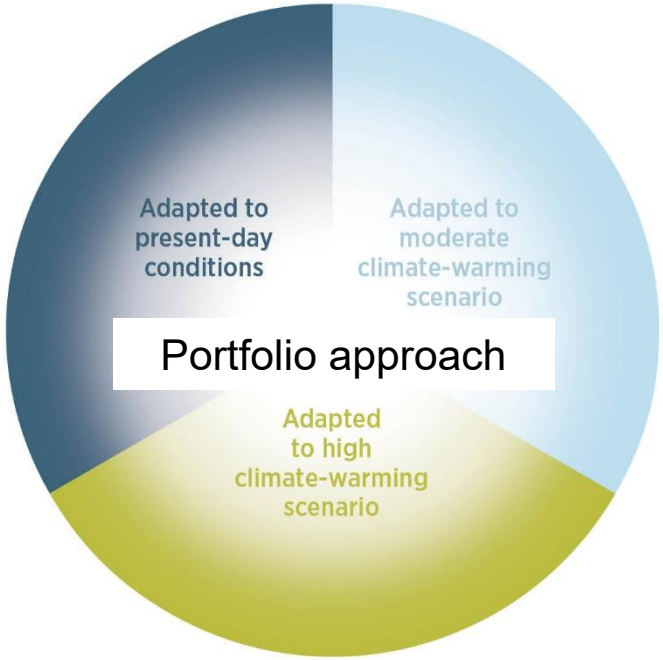
Broad Implications and Takeaways

- Chestnut restoration x assisted migration show promise in Northeast
  - Maladapted to extreme cold
  - Improved with seed selection
- Sustain important functions
  - Culturally & ecologically important
  - High growth = carbon mitigation potential
- “Can’t plant your way out”
  - Tending and monitoring still important

Broader Interpretations

- “Transition” of ecosystem remains a challenge
- “Portfolio approach”: Plant in mixes
- Even if a few survive to regenerate, that is one measure of success!





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