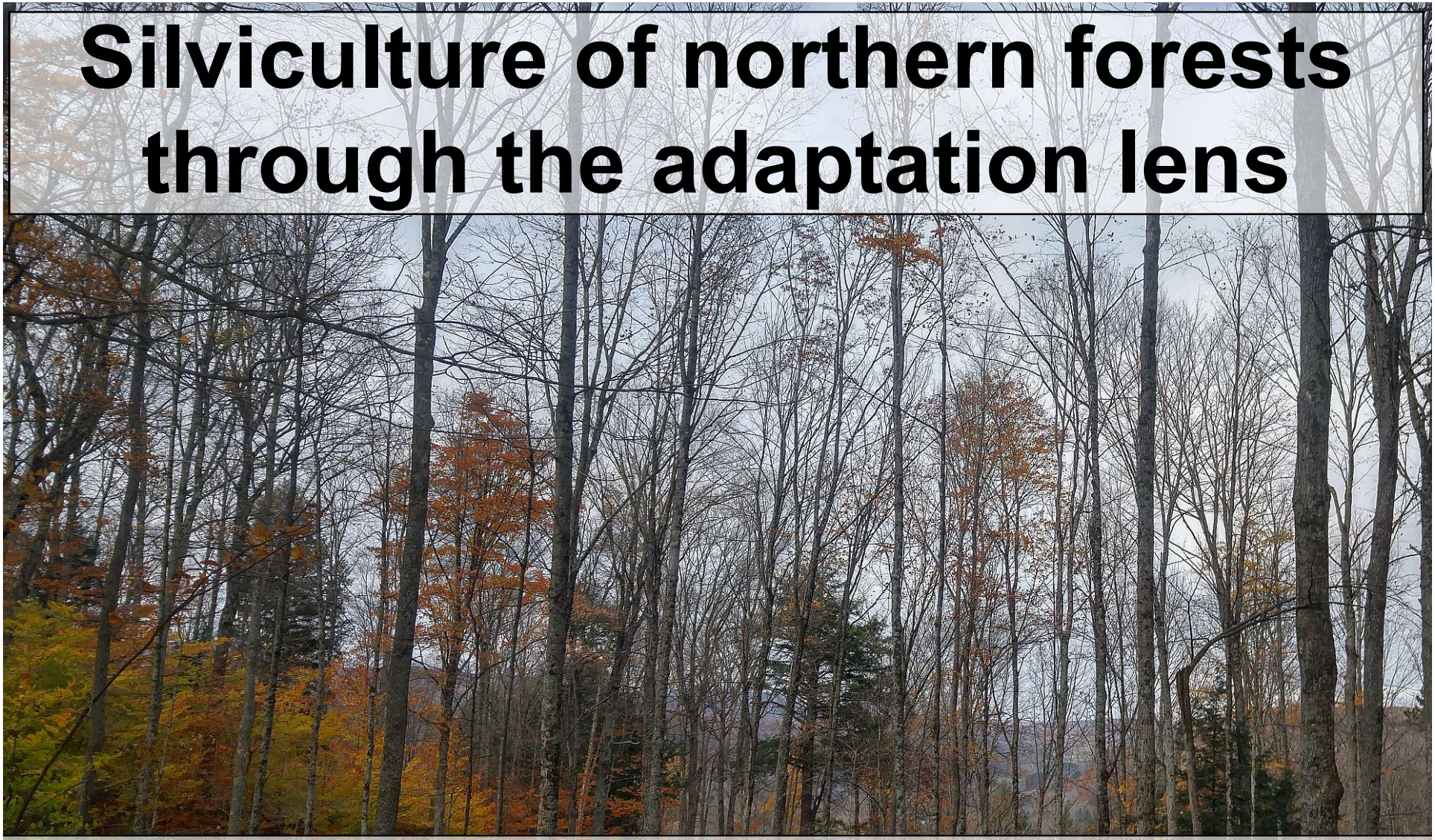
Silviculture of northern forests through the adaptation lens



THE UNIVERSITY OF VERMONT FORESTRY

Tony D'Amato
Rubenstein School
University of Vermont

NE CASC Northeast Climate Adaptation Science Center

Forest Adaptation Spectrum

Nagel et al. (2017)

Transition
To **facilitate change and encourage ecosystems to adaptively respond** to new or changing conditions

Resilience
Accommodate some change, but **encourage a return to prior or desired reference condition** following disturbance

Resistance
Improve forest defenses against predicted changes or disturbance to **maintain relatively unchanged conditions**

Uncertainty in management approaches

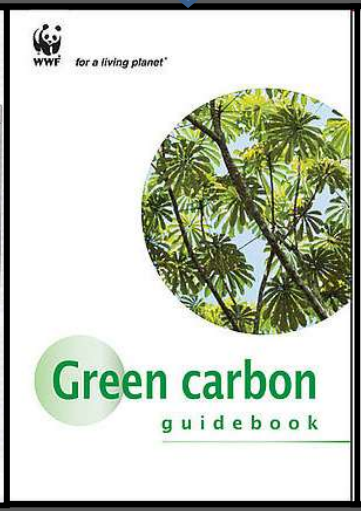
Promote Change

Maintain current conditions

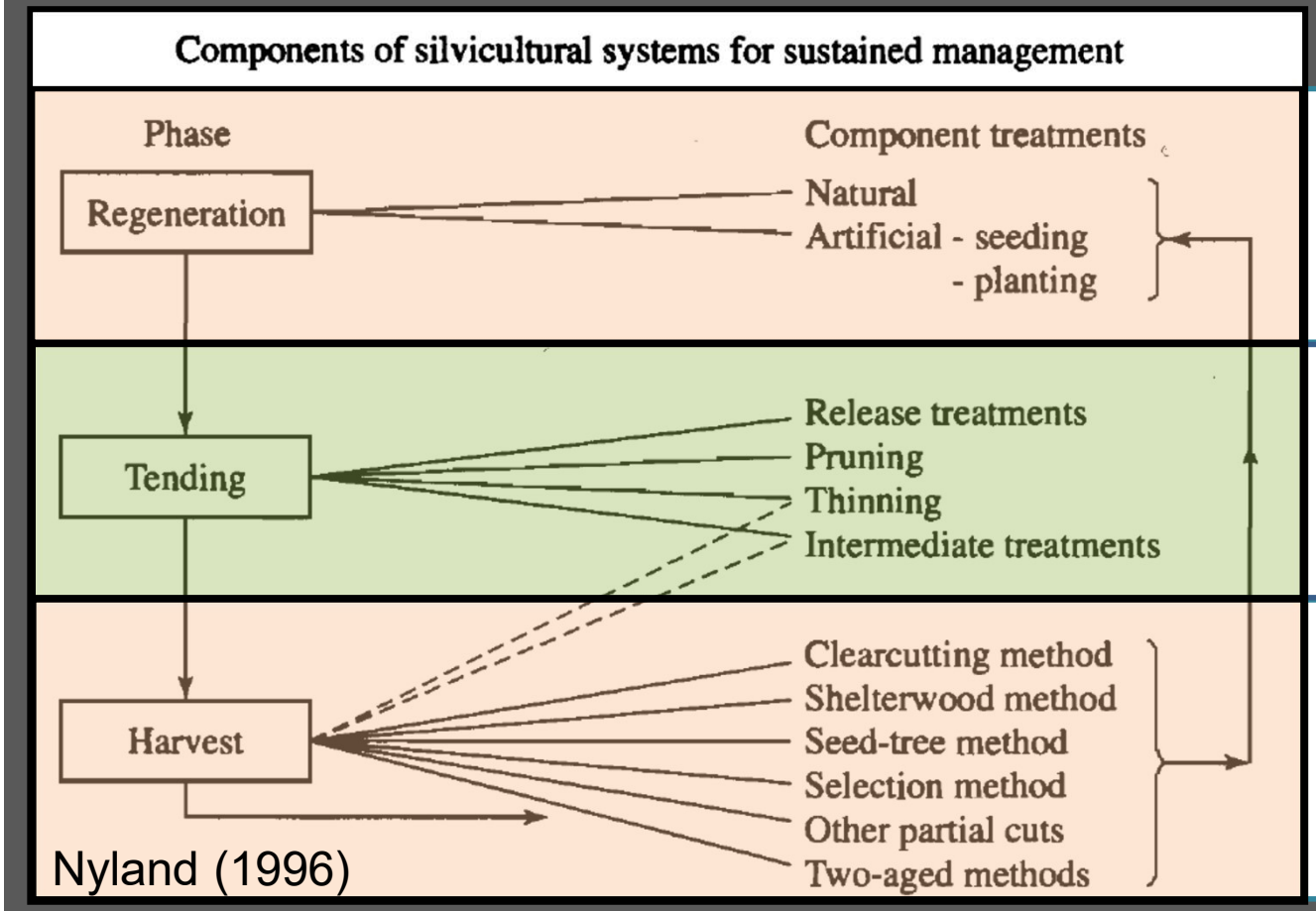
Reduce climate and forest health impacts

Facilitate adaptive responses

Repackaging silviculture



Repackaging silviculture

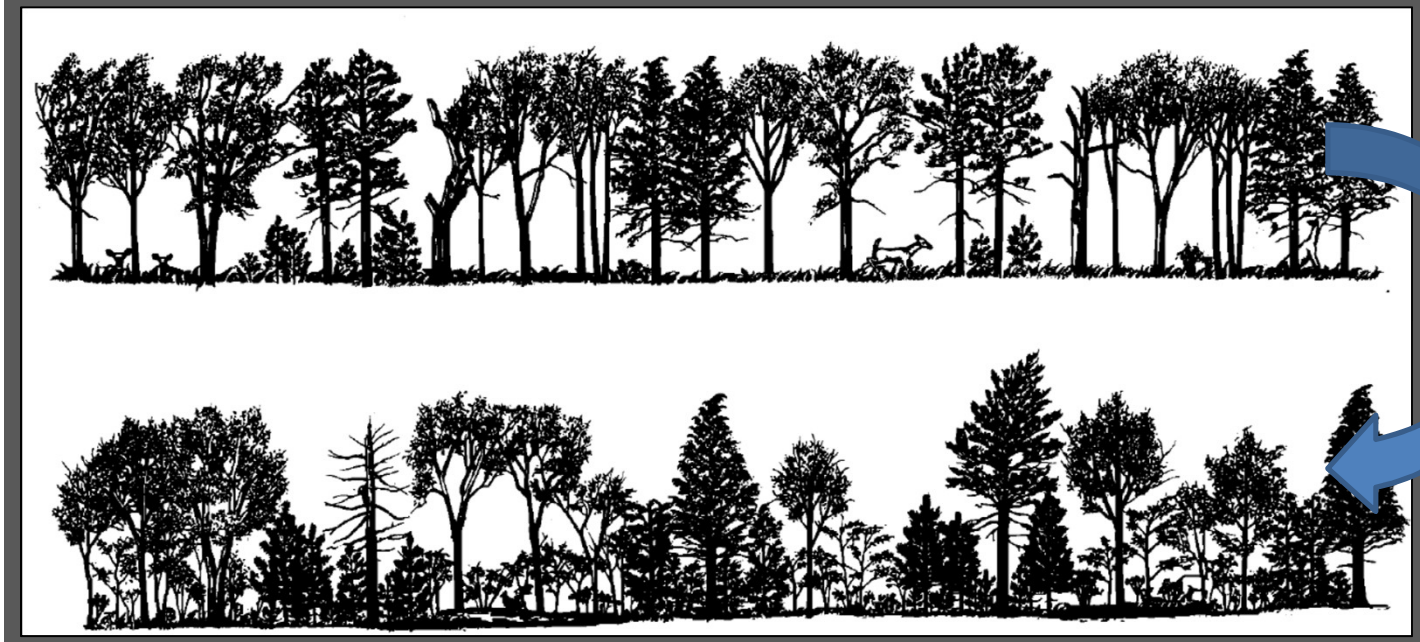


Resilience & Transition Strategies

Resistance Strategies

Resilience & Transition Strategies

Repackaging silviculture



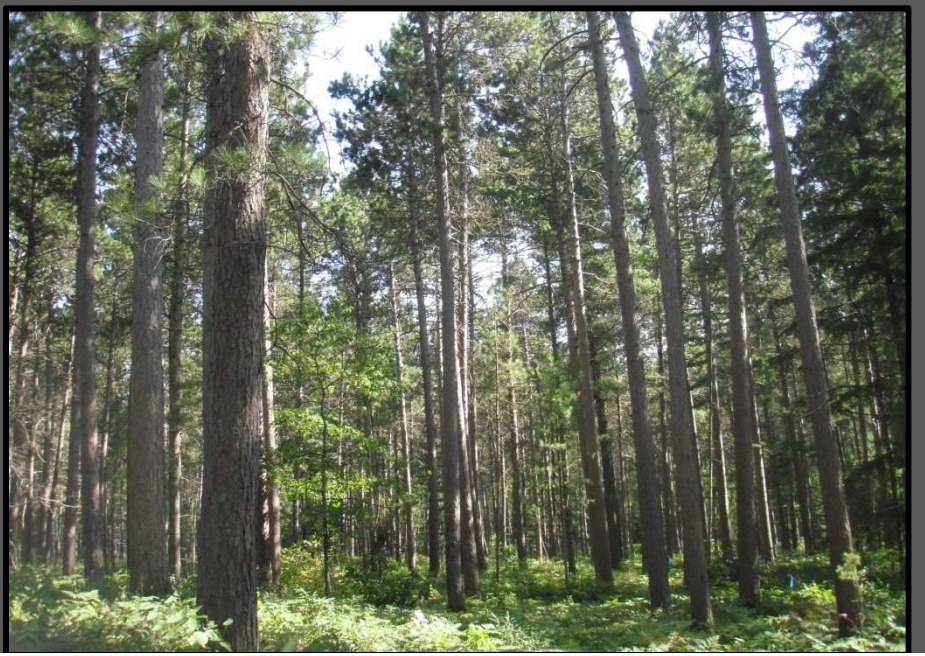
Barten et al. (1998)

Patch, irregular shelterwoods, and selection cuts to guide development of structurally diverse stands

"Optimal" watershed protection forest consists of three patch characteristics:

1. Regeneration for recovery following disturbance
2. Vigorous middle-aged trees and stands for nutrient uptake and biomass accumulation
3. Mature trees and stands for seed sources and amelioration of temp and moisture conditions

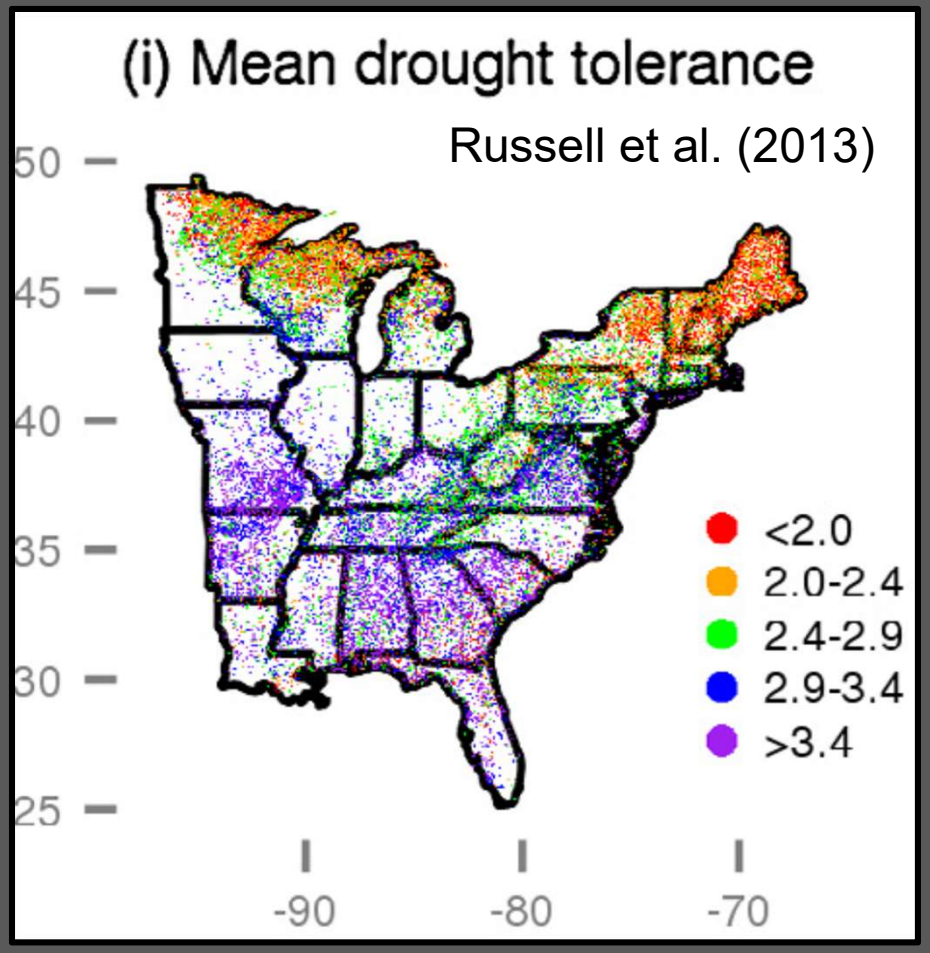
Applying the adaptation lens



Silvicultural outcomes and adaptation

1. Forest composition
   - Functional characteristics of species (drought tolerance, regeneration strategies, disturbance response)
2. Forest structural conditions
   - Resource levels and heterogeneity, size and cohort structures (disturbance and drought response)
3. Site conditions
   - Is adaptation a priority based on edaphic factors and disturbance vulnerability?

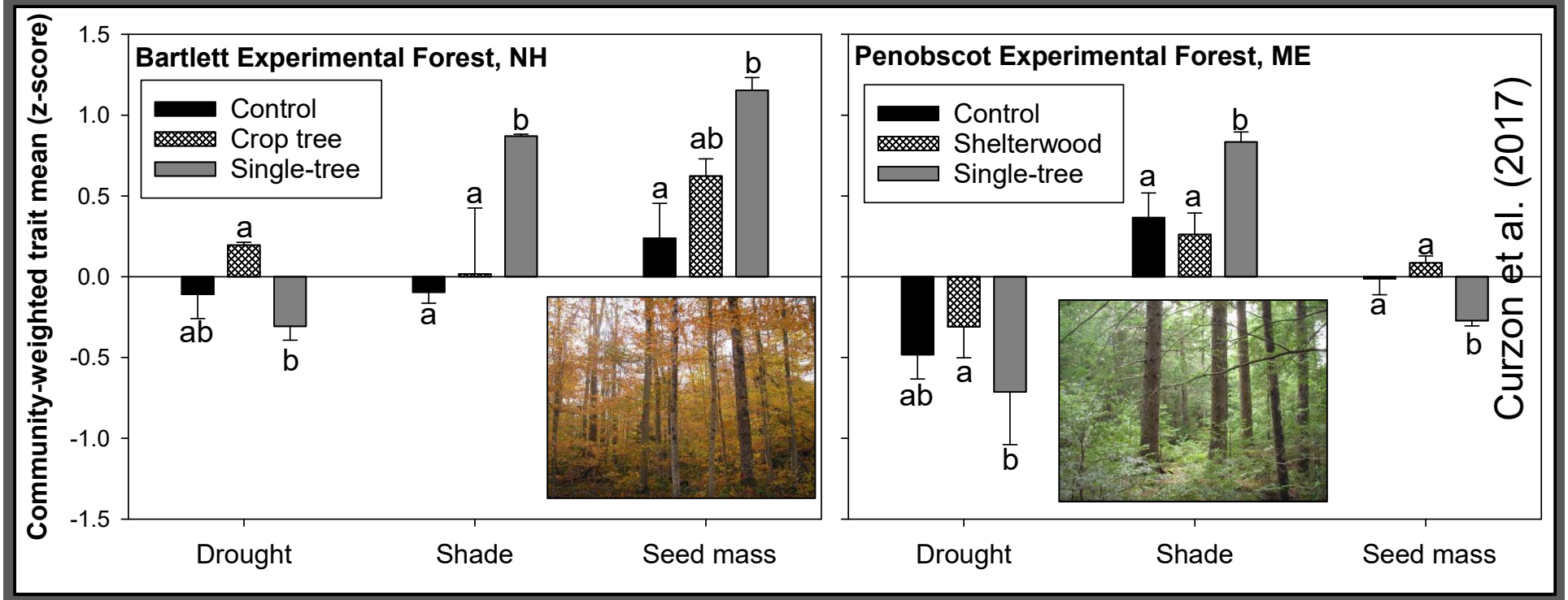
Compositional considerations



Shade tolerance is common lens we use to evaluate stands
-general inverse relationship with drought tolerance

Compositional considerations

Long-term silvicultural impacts on stand drought tolerance

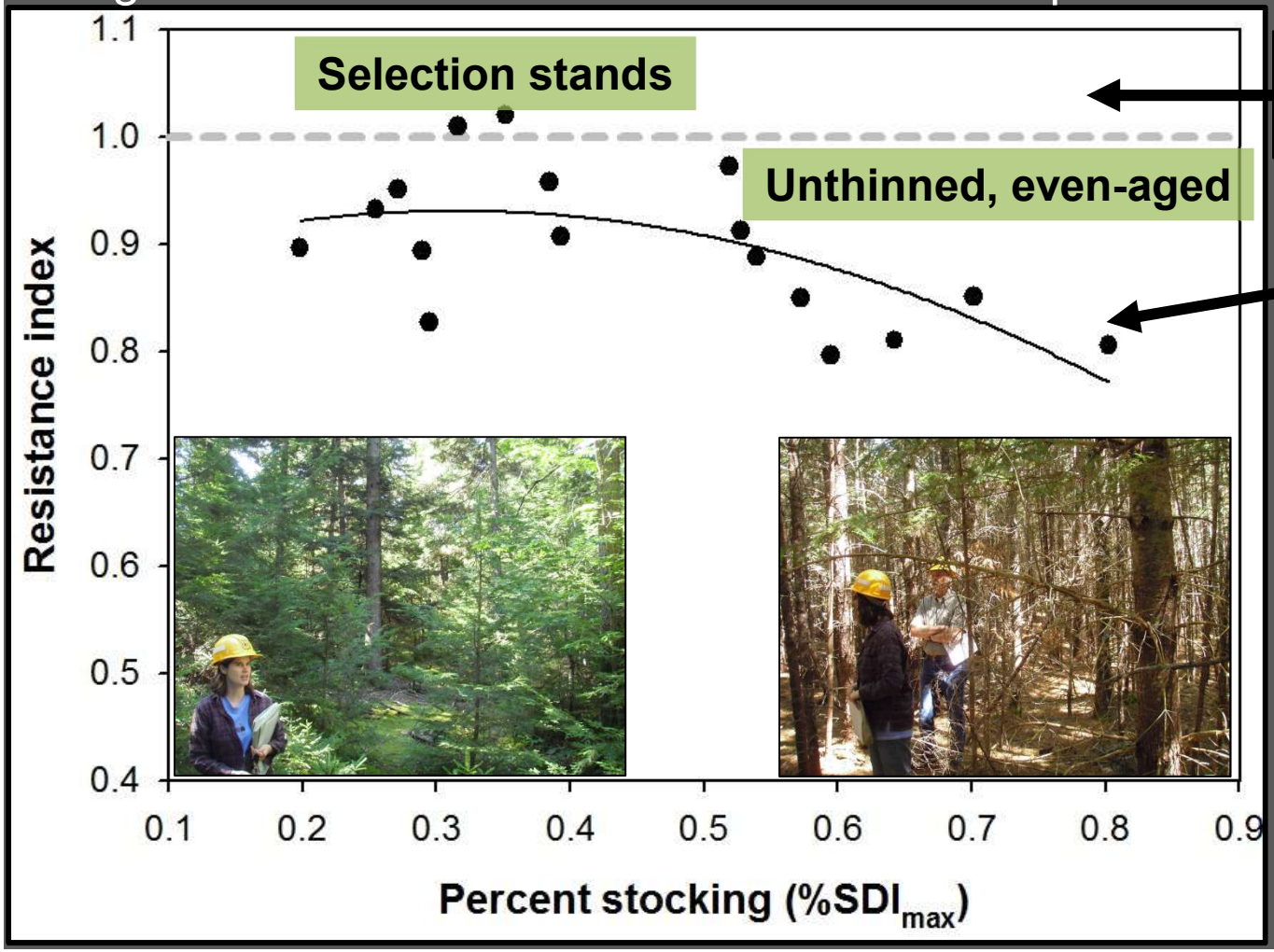


- Reduced drought tolerance under single-tree selection (opposite shade tolerance)
- Greater seed mass reflective of beech dominance in selection plots at BEF; decline at PEF due to increasing hemlock
- Homogenization towards vulnerable condition relative to projected changes in climate

Structural considerations

- Past vulnerability of managed and unthinned stands to known drought events (e.g., 2001)

Long-term silviculture studies at Penobscot Experimental Forest, ME

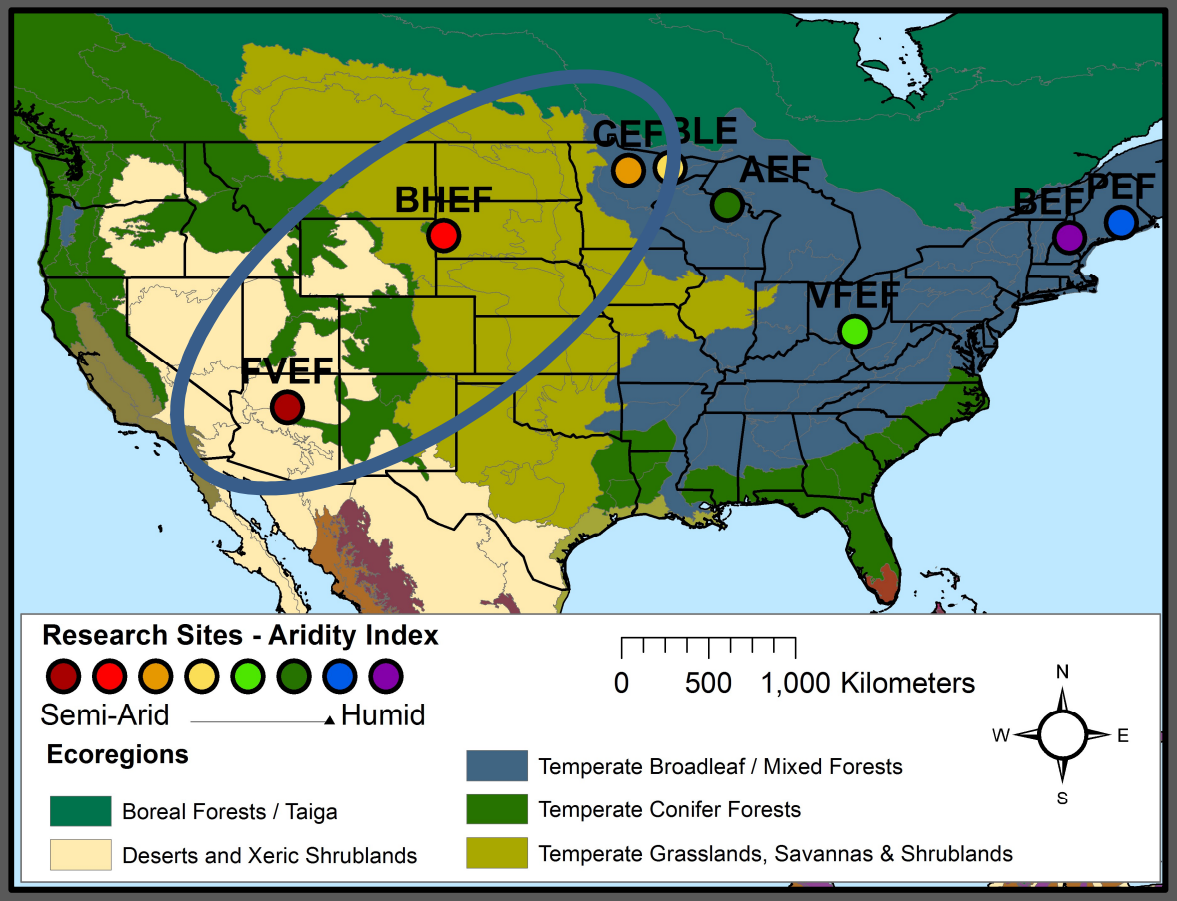


No effect of drought on stand-level growth

Stand-level growth reduced during drought

Density management and drought

- Examining drought response across arid and temperate *Pinus*



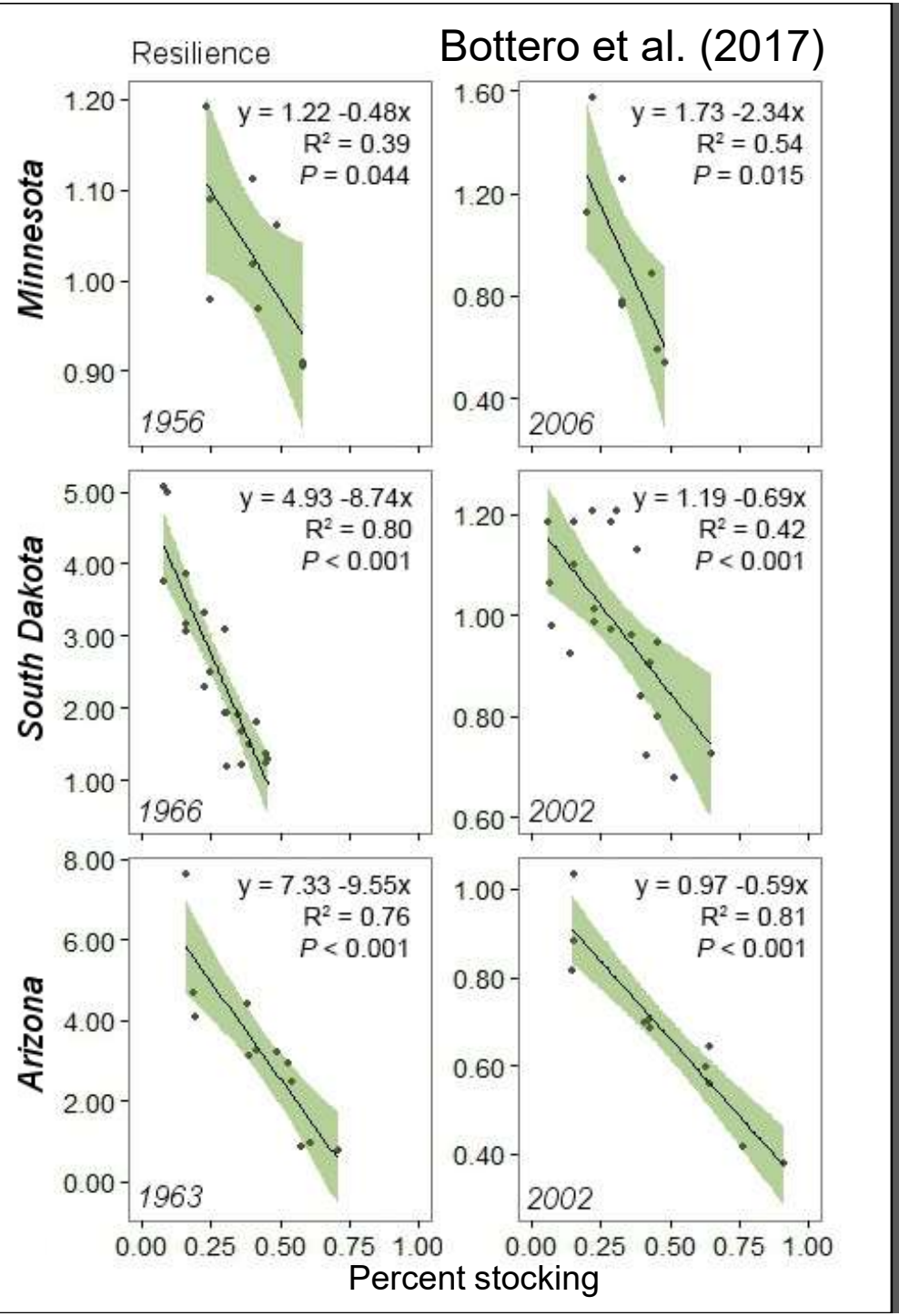
MN

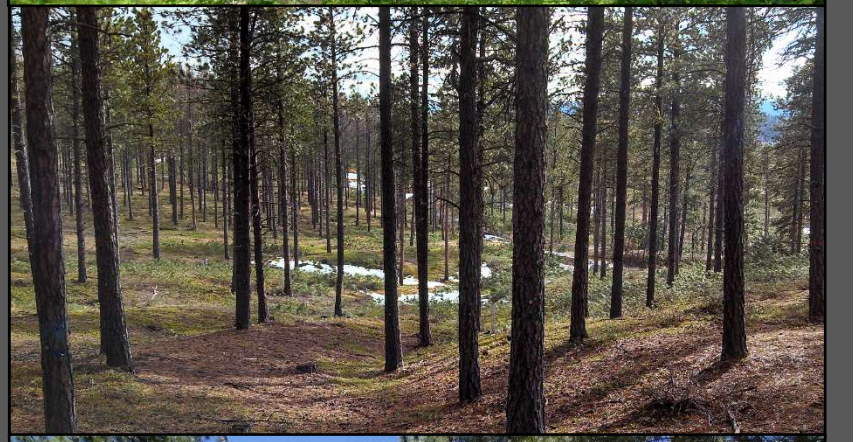
SD

AZ

- Fort Valley EF, AZ; Black Hills EF, SD; Cutfoot EF, MN

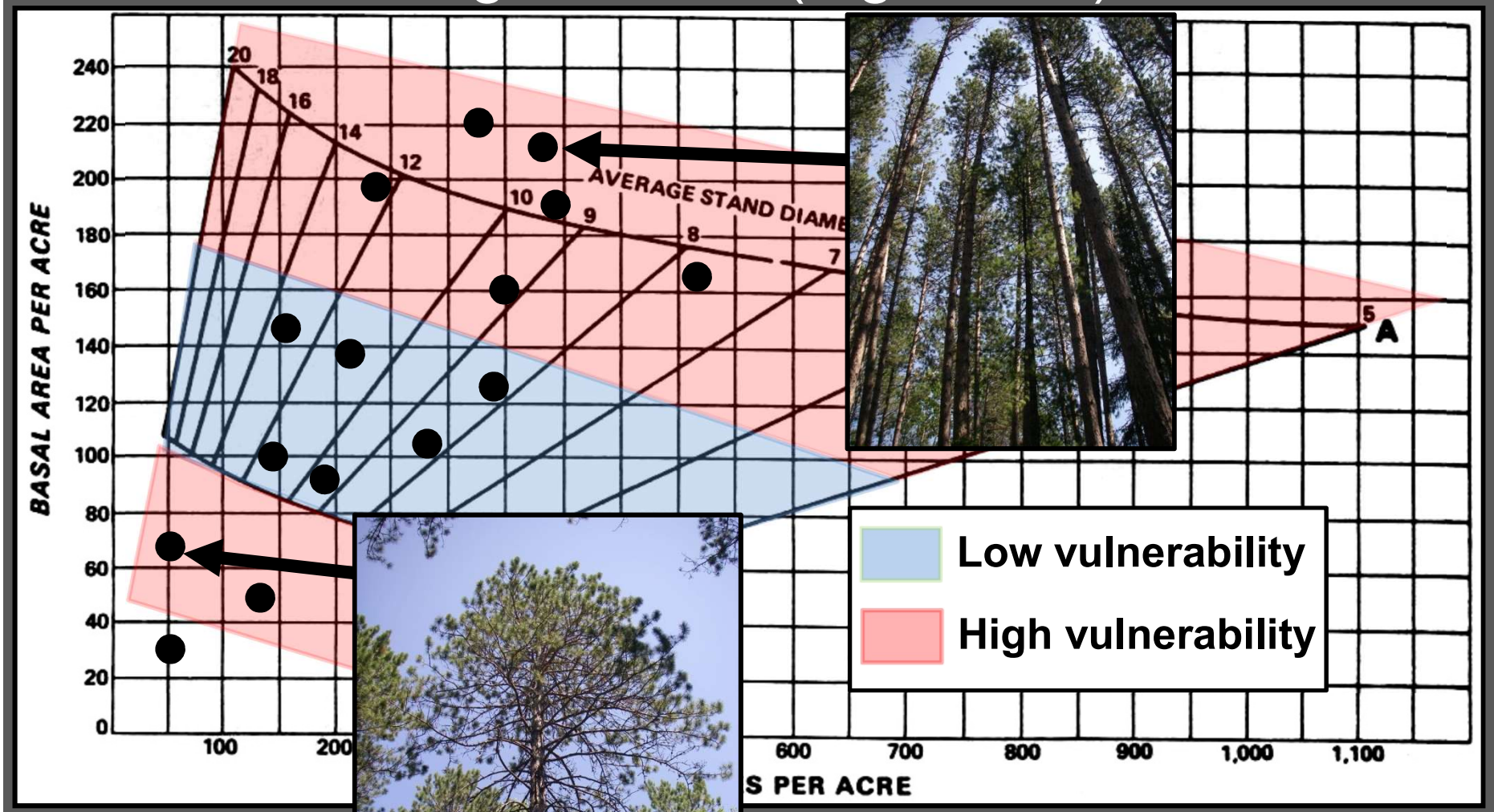
Bottero et al. (2017)





Structural considerations

- Past vulnerability of thinned and unthinned stands to known drought events (e.g., 1988)



Thinned and unth Lake, MN

Clark et al. (2016)

Varying within stand densities to
of adap

Single trees (thinned matrix)

- Distributed mature habitat
- Lower drought sensitivity
- Lower fire vulnerability
- Higher vulnerability to wind

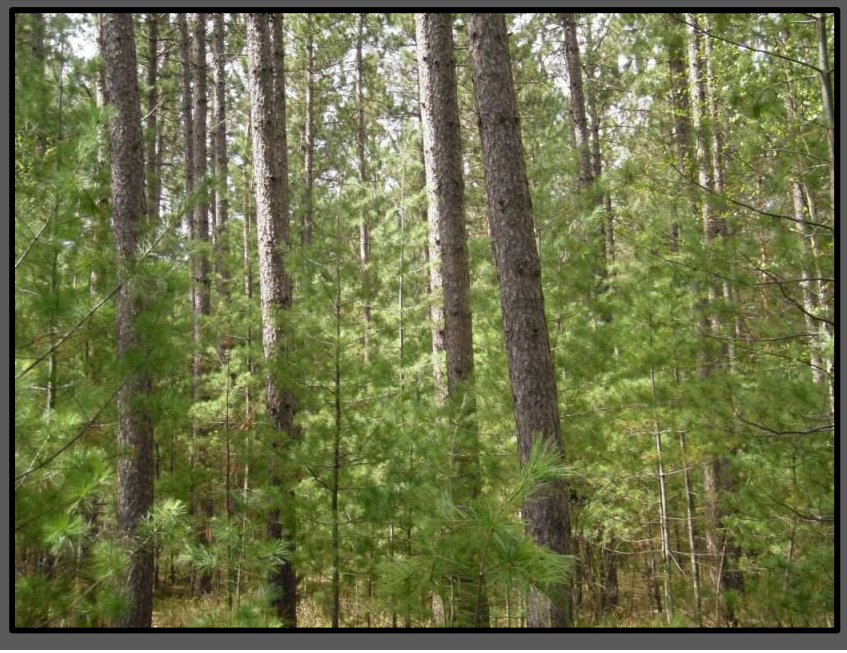
Clumps

- Potential refugia
- Greater drought sensitivity
- Lower wind vulnerability
- Greater selection pressure

Openings

- Increased vegetation cover
- Adaptation opportunities via natural and artificial regen

Regeneration considerations



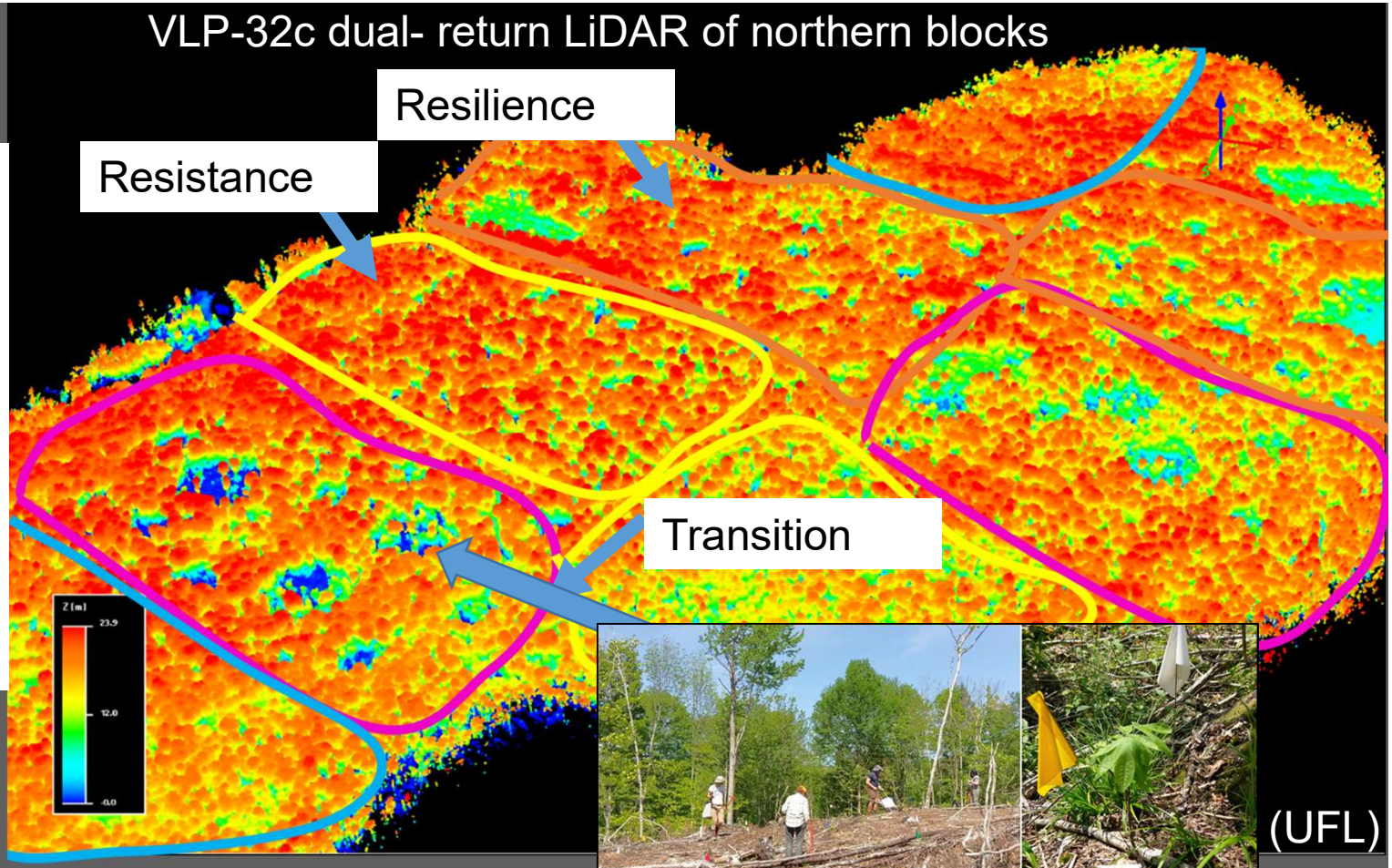
Regeneration considerations

Projected changes in suitable habitat by 2100 (Tree Atlas Mid-Atlantic-wide summary, Butler-Leopold et al. 2018)

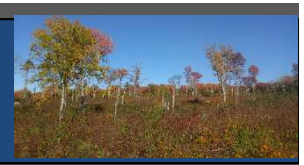
Decreasing	Increasing	New
American beech	bitternut hickory	black hickory
bigtooth aspen	black oak	longleaf pine
black cherry	black walnut	overcup oak
eastern hemlock	cherrybark oak	Shumard oak
eastern white pine	hackberry	slash pine
sugar maple	mockernut hickory	Sugarberry
sweet birch	northern red oak	Turkey oak
yellow birch	pignut hickory	
	Scarlet oak	
	shortleaf pine	

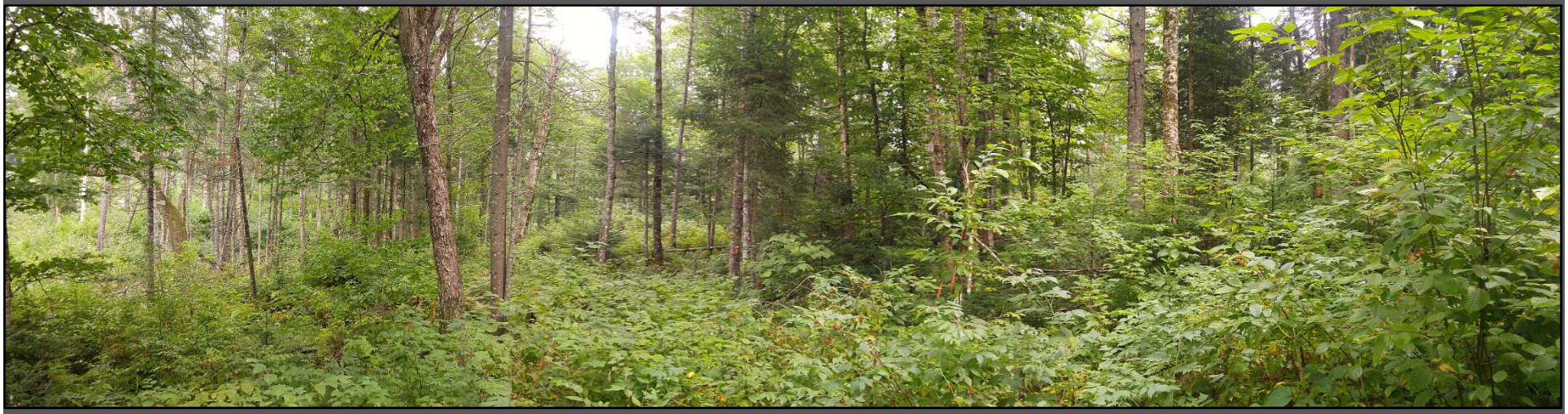
Primarily intolerant and midtolerant species

New England Adaptive Silviculture for Climate Change Dartmouth Second College Grant, NH



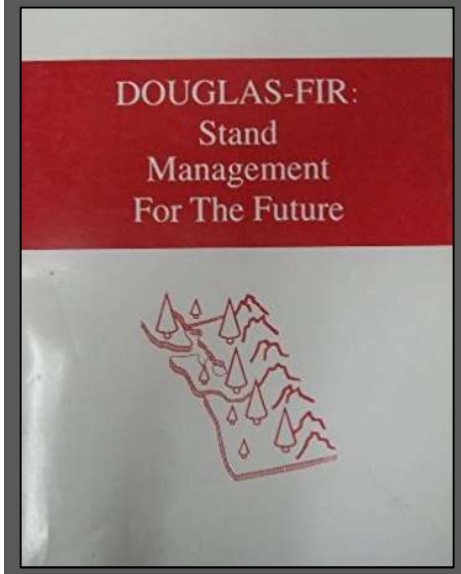
Moving forward with adaptation





Building on the Era of Complexity

"There are even fewer absolutes in ecology than in forestry, but an emerging operating maxim is *Simplification is rarely beneficial*." (Franklin et al. 1986)



MODIFYING DOUGLAS-FIR MANAGEMENT REGIMES FOR NONTIMBER OBJECTIVES

Jerry F. Franklin, Thomas Spies, David Perry, Mark Harmon, and Arthur McKee

Building on the Era of Complexity

Revisiting two of several principles guiding our previous silvicultural "revolution"

1. **Continuity** - provision for continuity in forest structure, function, and biota between pre- and post-harvest (legacies, system "memory")
2. **Complexity** - create and maintain structural and compositional complexity and biological diversity through silvicultural treatments

(From Seymour and Hunter 1999, Franklin et al. 2007)

Building on the Era of Complexity

Ecological silviculture principles

Principle	Linkages with Uncertainty and Adaptation

Continuity	• Long-term options for regeneration and structure in face of uncertainty
	• Amelioration of harsh environmental conditions
	  • Regeneration safe sites (shaded understory, well-decomposed dead wood)
	  • Micro-refugia for sensitive taxa
	• Conservation of genetic diversity **Palik et al. (in press)**




Building on the Era of Complexity

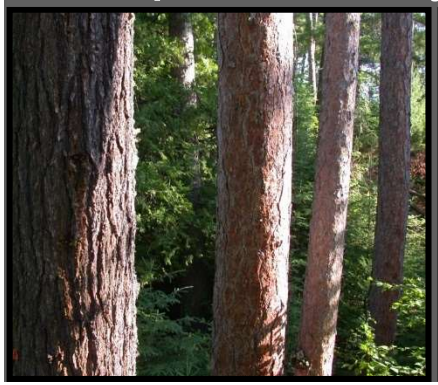
Ecological silviculture principles

Principle	Linkages with Uncertainty and Adaptation

Complexity	• Reduced vulnerability to disturbance
	  • Spatial variability in fuels
	  • Heterogeneity in: 1) wind risk, 2) potential host species abundance, 3) within-species stress tolerance (tree size/age), 4) resource availability
	• Multiple recovery/developmental pathways
	  • Diversity of seed sources and reproductive mechanisms
	  • Heterogeneity in microsites for new species

Conclusions

- In many circumstances, adaptation will entail repackaging of silvicultural strategies with an eye towards increasing and maintain ecosystem heterogeneity
- Despite future change, understanding of past drivers and dynamics can still inform transition methods
  - Use of regeneration methods that maintain overstory trees during regeneration phase to keep options on site and ameliorate extremes
  - Build on decades of experience managing these systems, particularly with recent ecological approaches

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Northern Research Station, USDA Forest Service

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NIACS Northern Institute of Applied Climate Science

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