Long-term development of red pine forests in north central Minnesota

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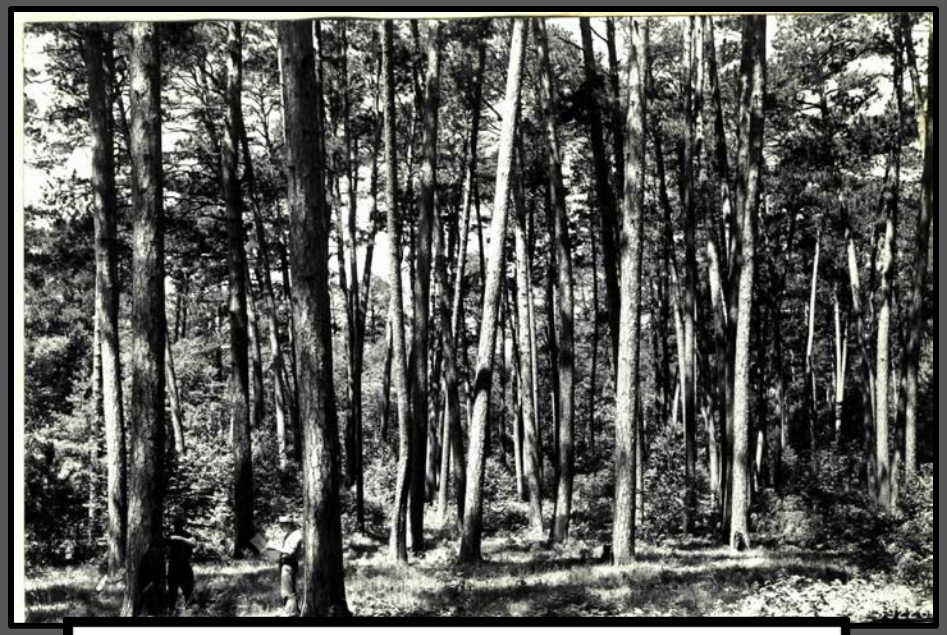
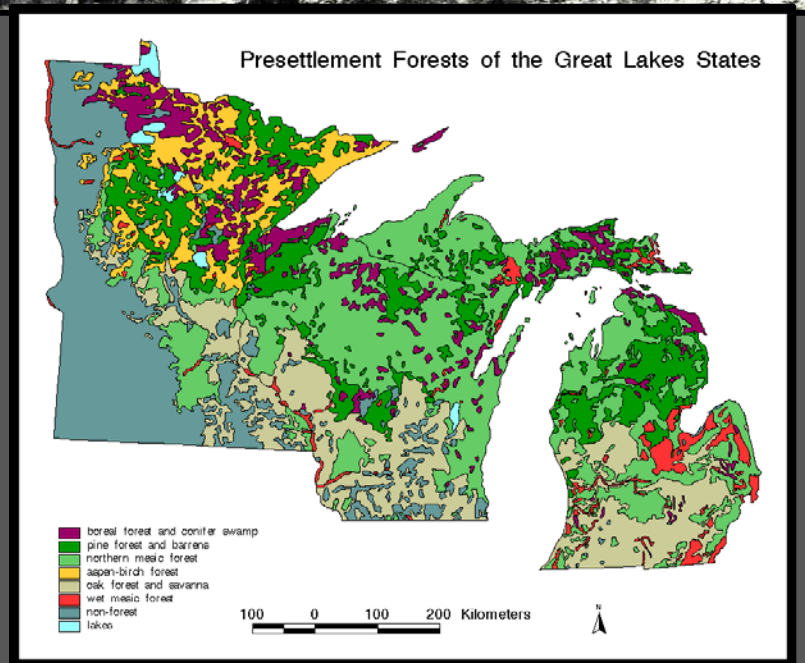
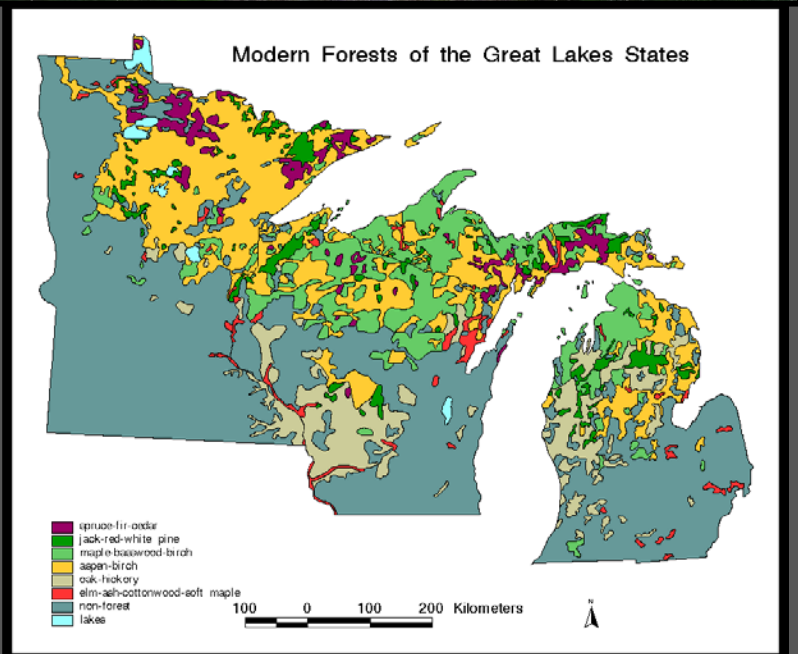
Background




Presettlement Forests of the Great Lakes States
boreal forest and conifer swamp
pine forest and barrens
northern mesic forest
aspen-birch forest
oak forest and savanna
wet mesic forest
non-forest
lakes
100 0 100 200 Kilometers
N


Modern Forests of the Great Lakes States
spruce-fir-cedar
jack-red-white pine
maple-basswood-birch
aspen-birch
oak-hickory
elm-ash-cottonwood-soft maple
non-forest
lakes
100 0 100 200 Kilometers
N

Objectives

- Quantify long-term patterns of development for fire-origin red pine systems under various management regimes
- Determine extent to which extended rotation systems can accelerate late successional structural and compositional conditions

Approach

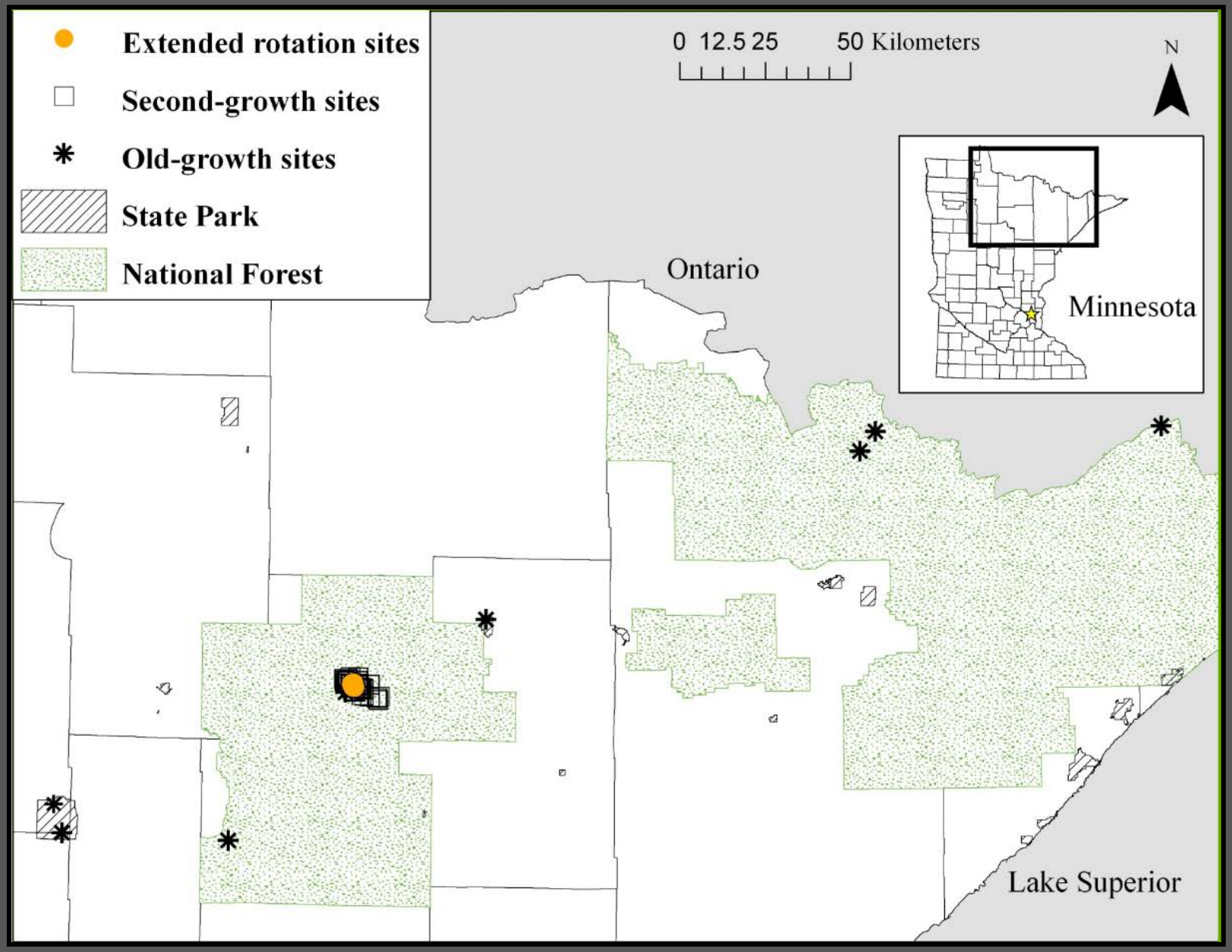
Capitalize on historic plots in north-central MN to characterize red pine development:

1. Allison plot (unmanaged, old-growth)
2. Growing Stock Levels Experiment (managed, second growth on extended rotation)
3. Red Pine Chronosequence (unmanaged, second-growth)
4. Fraver and Palik Old-growth Sites (unmanaged, old-growth)

How doe we get from here?

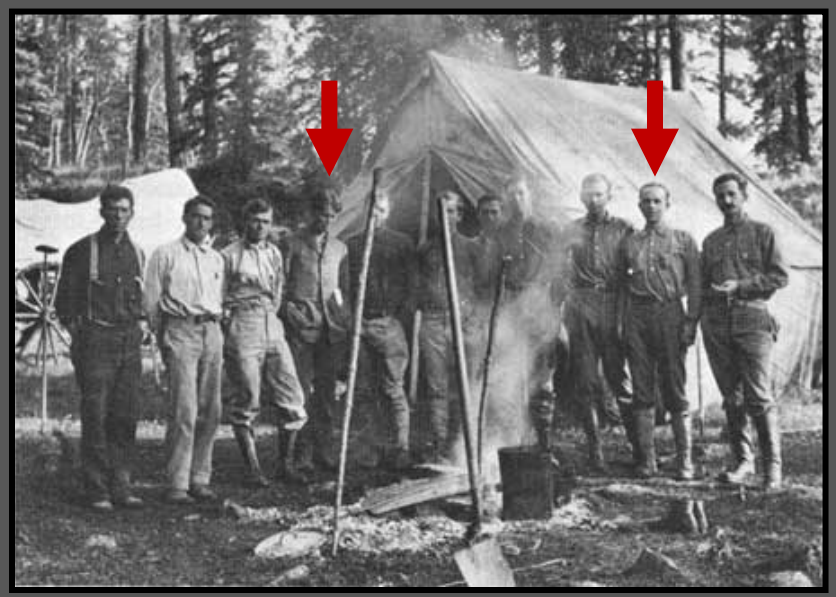
To here?

Study areas

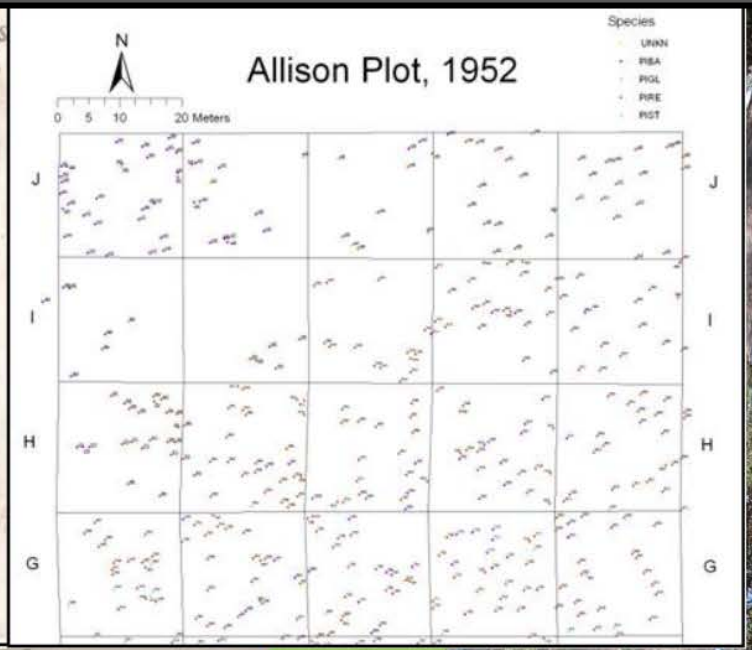

Extended rotation sites
Second-growth sites
Old-growth sites
State Park
National Forest
0 12.5 25 50 Kilometers
N
Ontario
Minnesota
Lake Superior

The Allison Plot

- Old-growth stand establishing following 1803 fire in Itasca SP
- Well-drained sandy loams derived from glacial outwash
- J.H. Allison established 2 hectare plot in 1923
  - All trees uniquely tagged and mapped
- 207 years-old at time of resampling in 2010



The Allison Plot



- Inventoried every five years from 1923-1963

Red Pine Growing Stock Levels

- Stand established following fire in 1864
- Well-drained sandy soils derived from glacial outwash
- 1949: Growing Stock Level experiment installed consisting of five levels of residual red pine growing stock (14, 18, 23, 28, and 32 m^2ha^{-1} basal area).
- Thinned every 5-10 years to maintain growing stock levels from 1949-present
- 85 years-old at time of initial sampling, 143 years at most recent sampling (traditional rotation age for red pine=80-120 yrs)

Red Pine Growing Stock Levels

14 m^2ha^{-1} (60 ft^2/ac); age 143

35 m^2ha^{-1} (140 ft^2/ac); age 143

Red Pine Chronosequence

- Six stands on the Chippewa NF established following fires in the 1840s-1870s
- Well-drained sandy soils derived from glacial outwash
- No history of active management (provide unmanaged comparison for endpoint of extended rotation site-RP GSL)
- 137-165 years-old at time of sampling

Red Pine Chronosequence

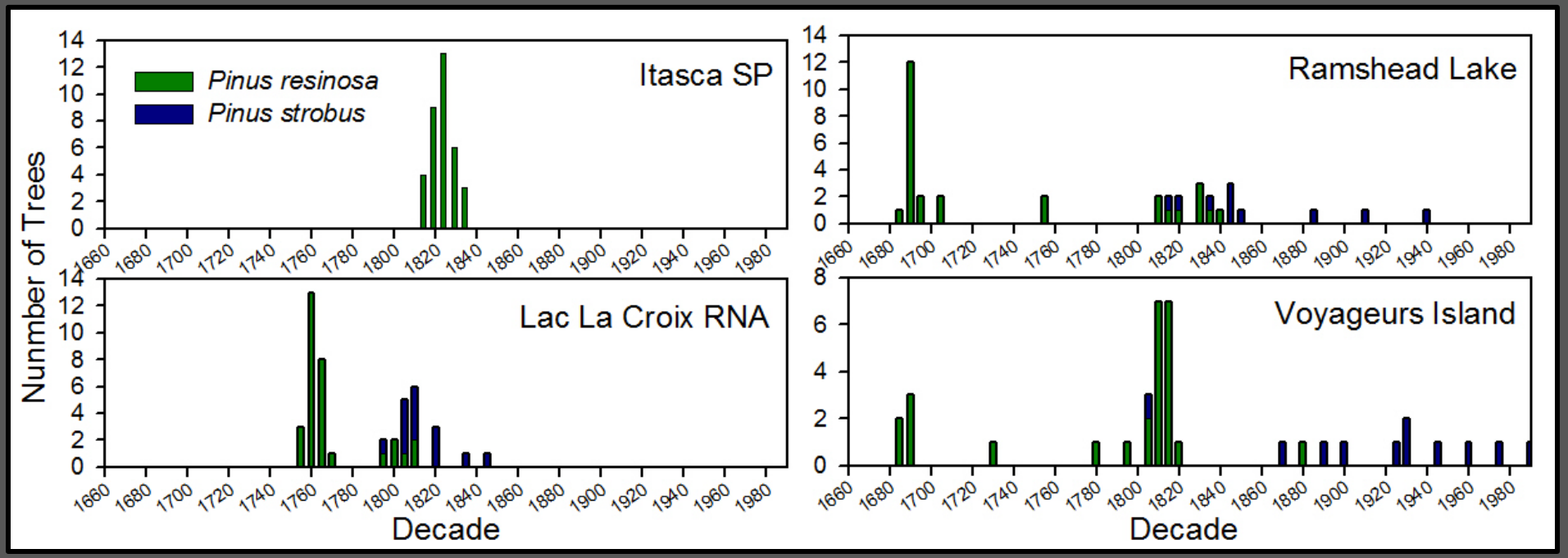
151 year-old stand

162 year-old stand

Fraver and Palik Old Growth

- Seven old-growth stands in north-central and northeastern MN (oldest living trees 201-317 years)
- Well-drained sandy soils primarily derived from outwash
- Range from single- to multi-cohort stands with varying disturbance history

Fraver and Palik (2012)



Fraver and Palik Old Growth

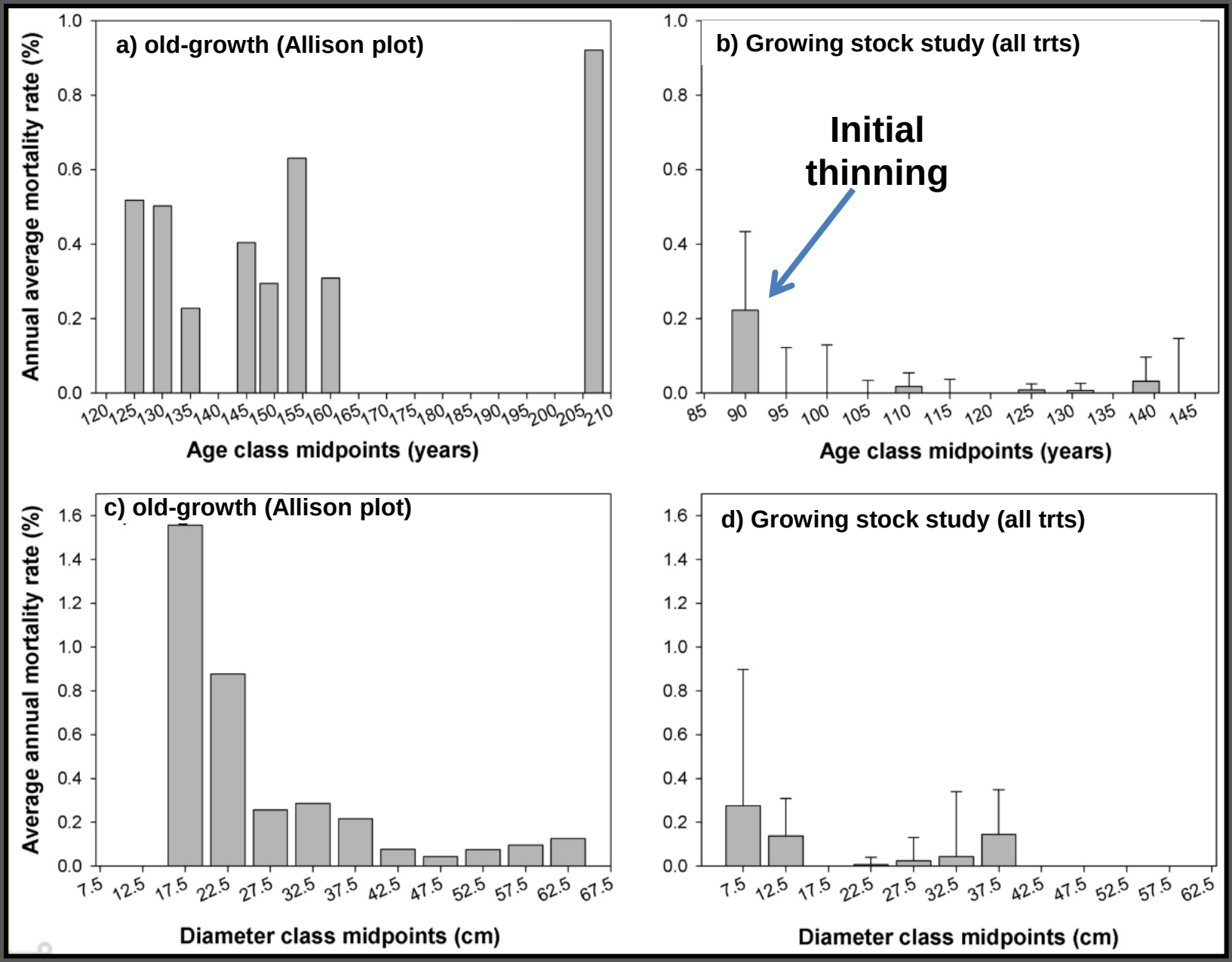
Lac La Croix RNA (270 years)

Voyageurs Island (317 years)

Mortality and spatial patterns

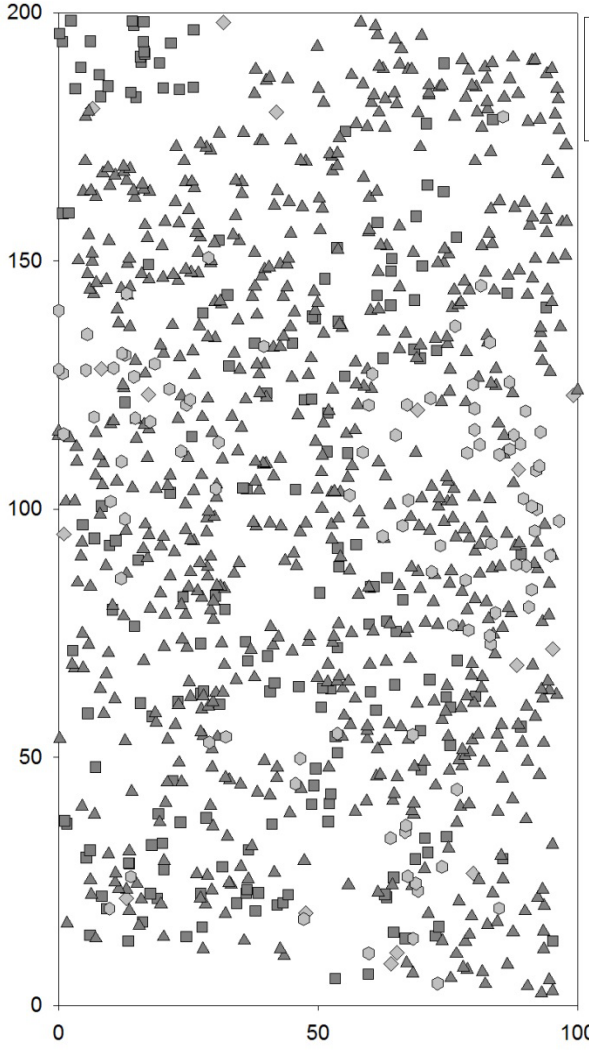
What are the natural patterns of mortality in old-growth red pine forests?

Mortality and spatial patterns



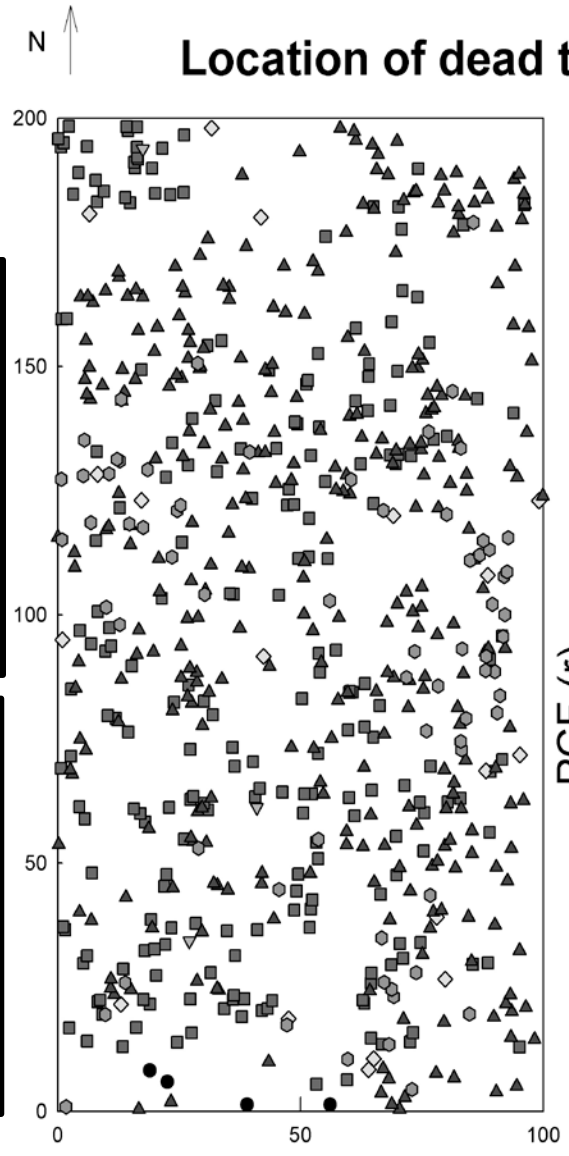
Mortality and spatial patterns

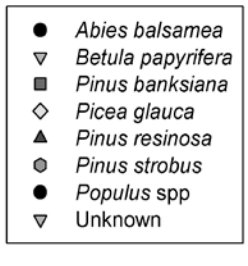
Location of live+dead trees in 1923

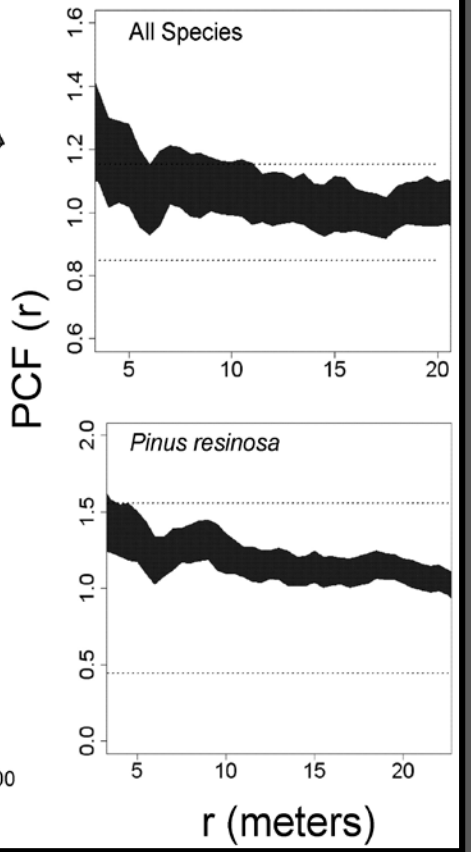


Stand age 120

Location of dead trees in 2010

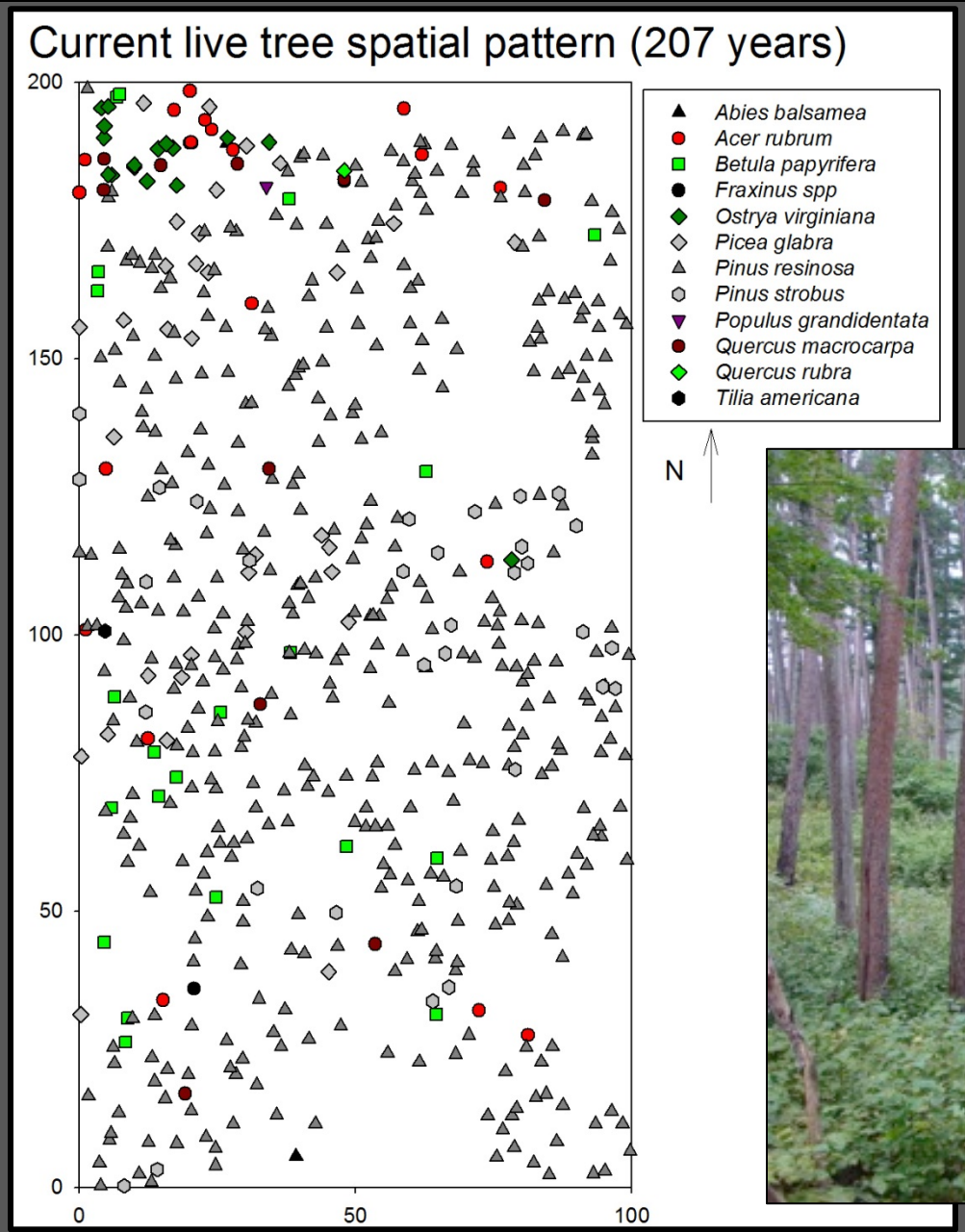






Stand age 207

Mortality and spatial patterns



Mortality and spatial patterns

- Mortality patterns generally random in space over time
- Loss of jack pine cohort generated patchy conditions in 1923 (stand age 120)
  - Recent disturbance agents affecting stand may increase level of aggregation in mortality (*Armillaria*, 2012 windstorm)
- Lack of conifer regeneration reflecting shift towards hardwood species over time

Current structural conditions

What is the range in structural conditions across mature and old-growth red pine systems?

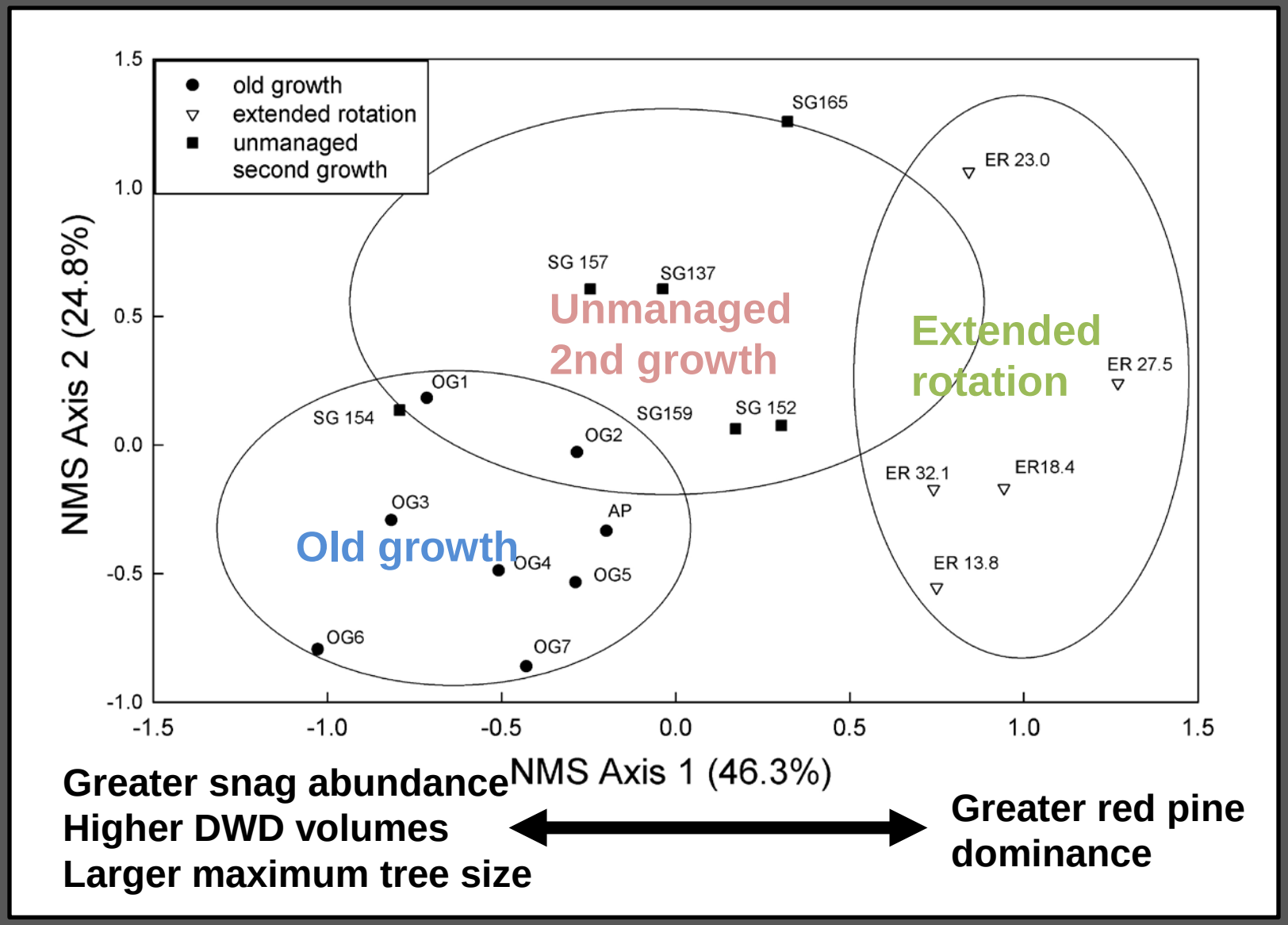
Current structural conditions

Downed coarse woody debris and snags

Structural attribute	Old growth (n = 8)	Second growth (n = 6)	Extended rotation (n = 15)
Downed CWD volume (m^3/ha)	70.7 ± 8.8^a	11.5 ± 3.5^b	4.7± 1.6^b
Snag basal area (m^2/ha)	6.9 ± 1.2^a	2.9 ± 1.8^b	0.5 ± 0.3^b
Snag density (no./ha)	84.2 ± 6.9^a	75.0 ± 27.5^a	10.8 ± 0.5^b

- Pronounced differences between stand types in terms of abundance of coarse woody debris reflecting differences in disturbance/management histories

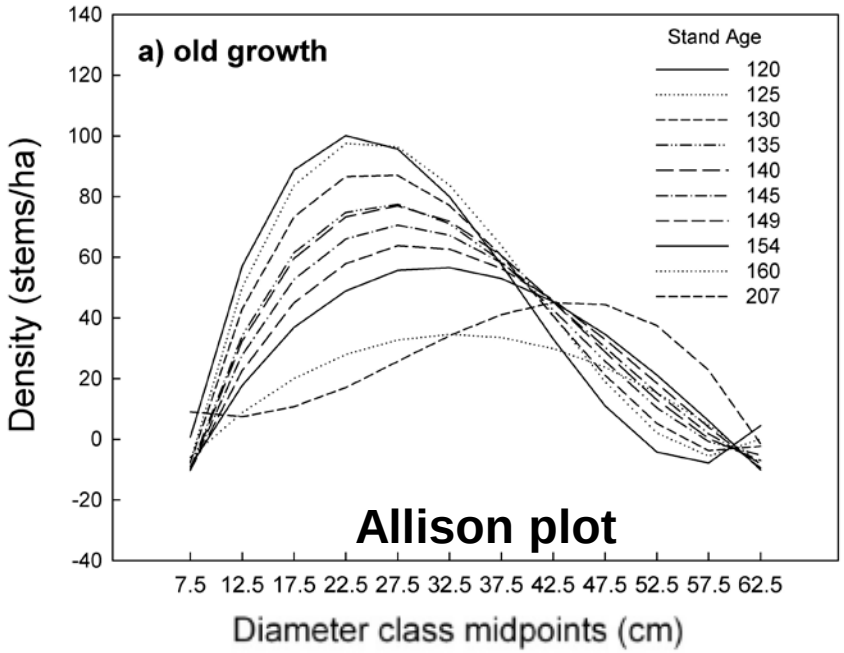
Current structural conditions

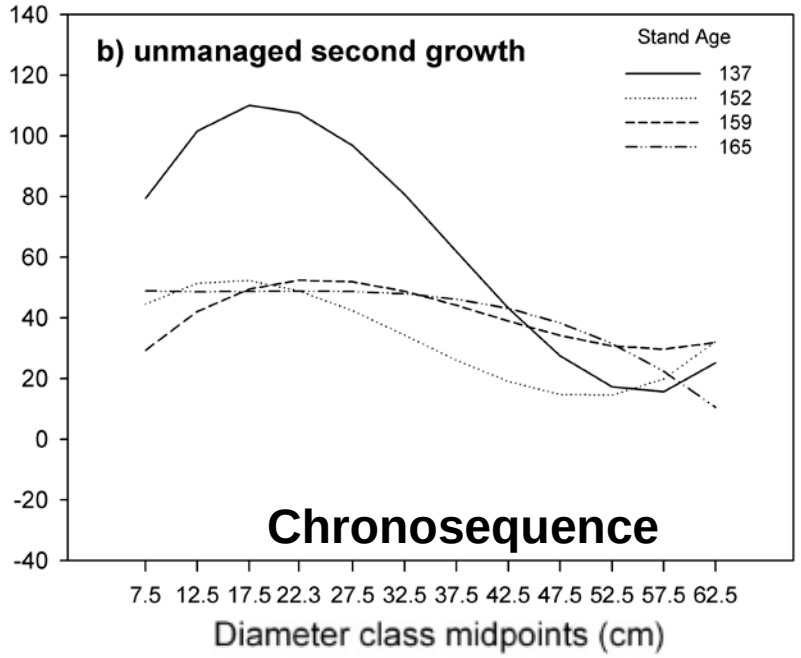


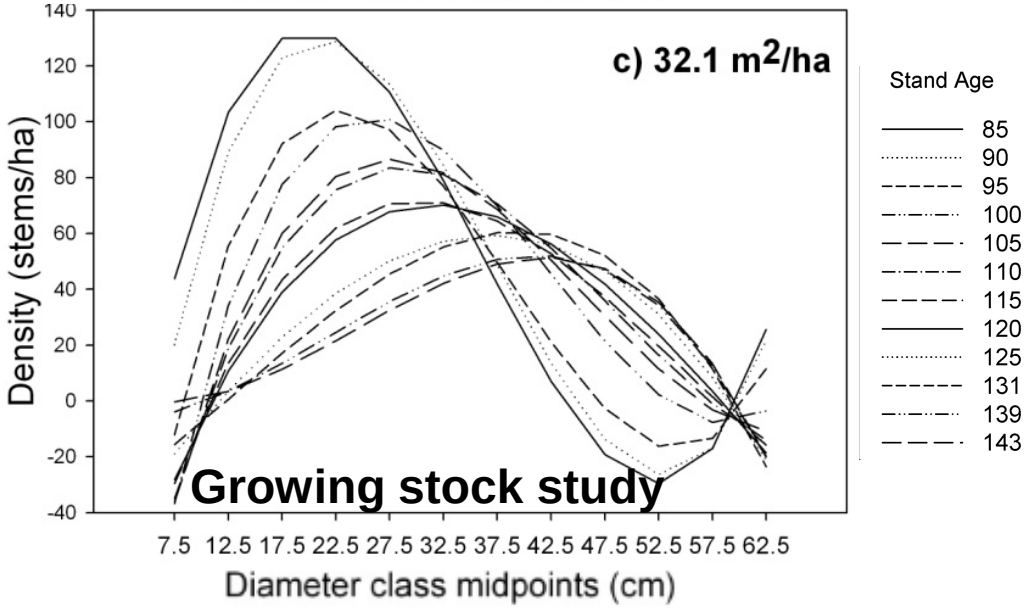
Structural & compositional development

Can active management accelerate the development of old-growth red pine structural and compositional conditions in managed stands?

Structural & compositional development





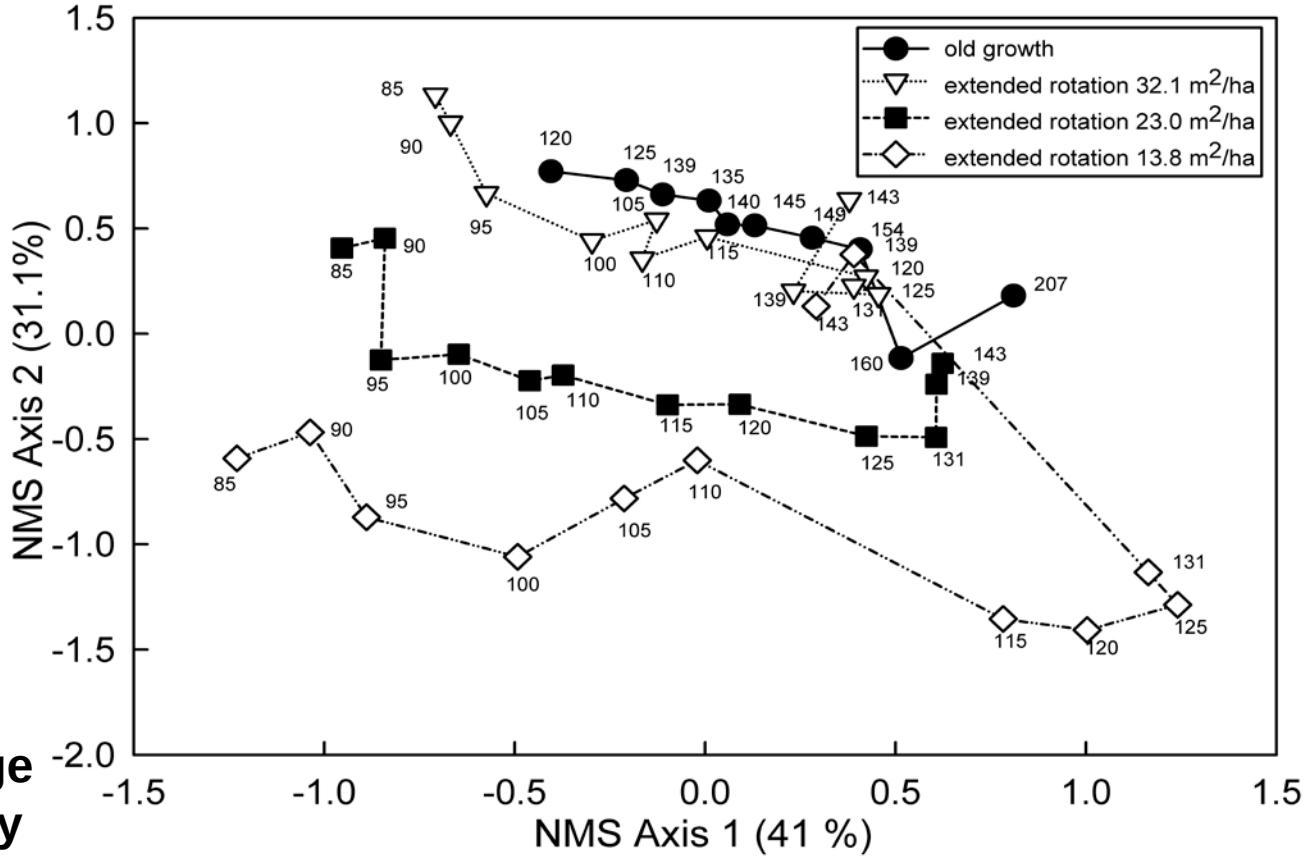


Long-term structural development

Silver et al. (2013)

Higher density

Greater average & max DBH Higher large tree density

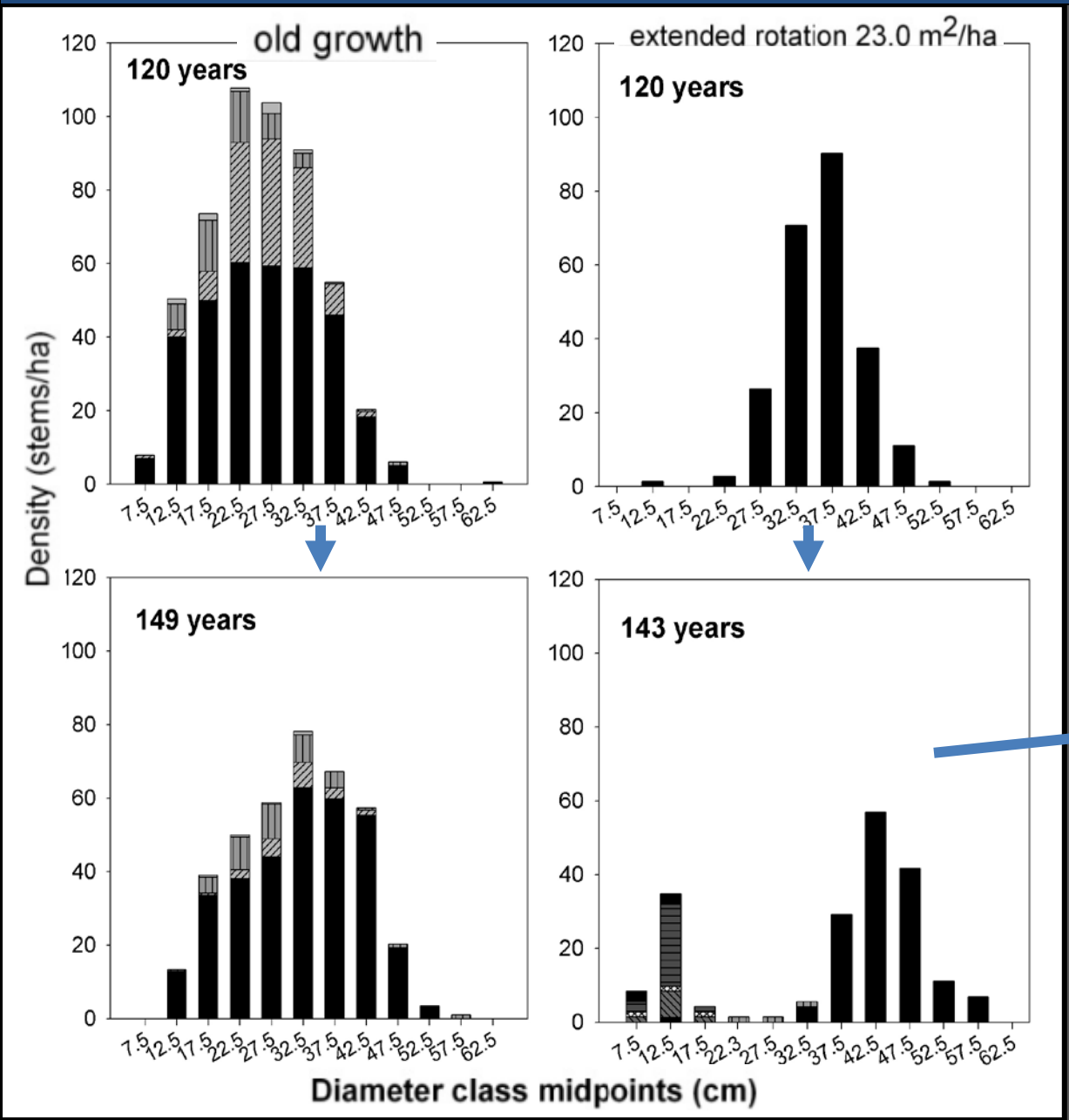


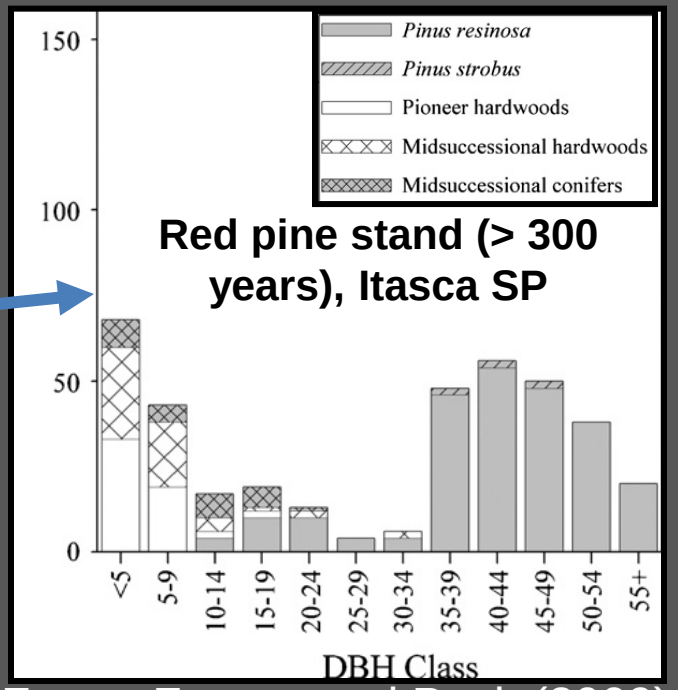
Smaller min. DBH

Greater red pine dominance Greater size inequality

- Thinning on extended rotations accelerated live tree conditions towards those found in a 207-year-old stand, by age 143

Structural & compositional development

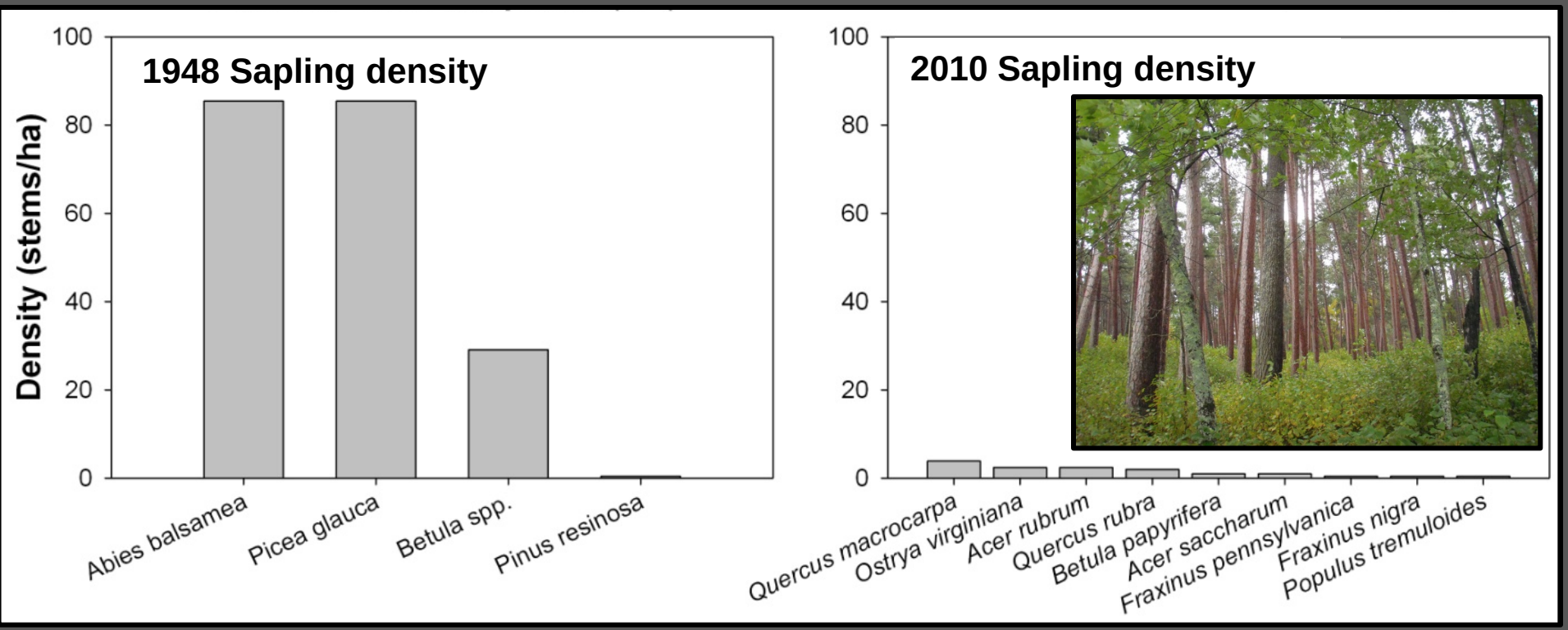




From : Zenner and Peck (2009)

Structural & compositional development

Successional trajectory at Allison plot



- Prescribed fires applied to plot in 1998, 2000, and 2003, in conjunction with herbivory, have reduced sapling densities and shifted understory dominance to hardwoods (and hazel)

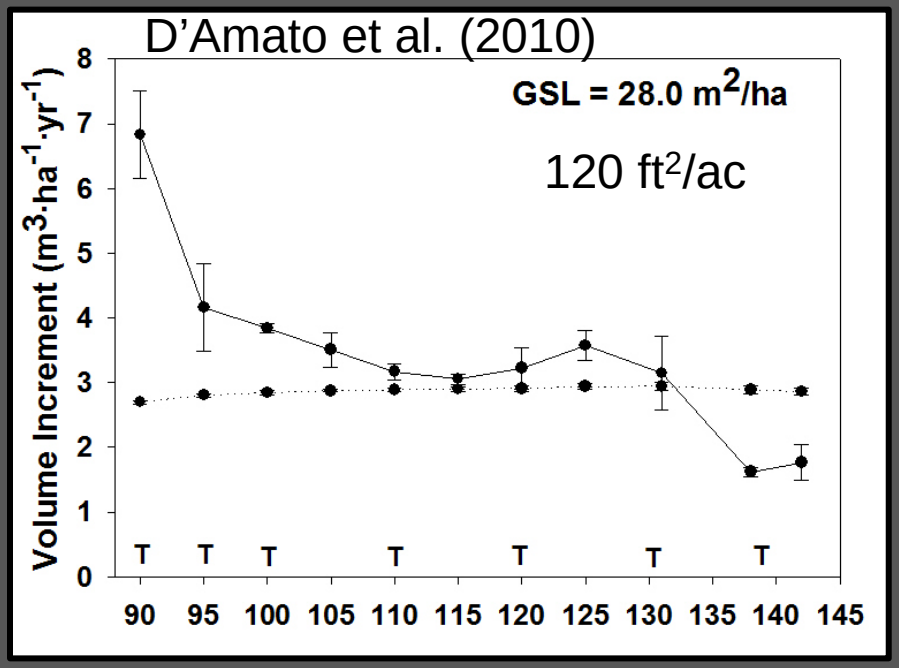
Structural & compositional development

Conclusions & management implications

- Natural patterns of mortality for red pine are spatially random
  - Demographic transition from mixed jack pine community and fire historically left patchy conditions
- Background mortality rates are generally higher in old-growth stands with important structural outcomes
  - Deadwood levels far exceeded extended rotation or unmanaged second-growth
- Extended rotation harvest systems with long-term thinning provide opportunity to accelerate development of old-growth structure (reduced pathways by 60 years)

Conclusions & management implications

- Extended rotations in red pine consistent with productivity goals
- Historic spatial patterns and lack of recruitment and coarse woody debris argue for use of variable density thinning regimes if objectives include accelerating late-successional structure in managed stands

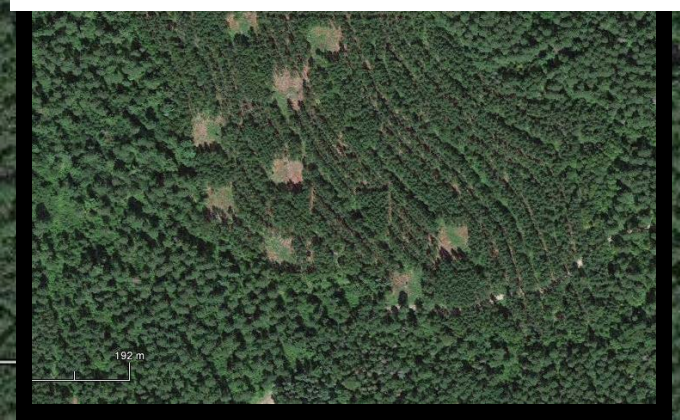


Variable density thinning and retention

Variable density thinning and retention

Single trees (thinned matrix)

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



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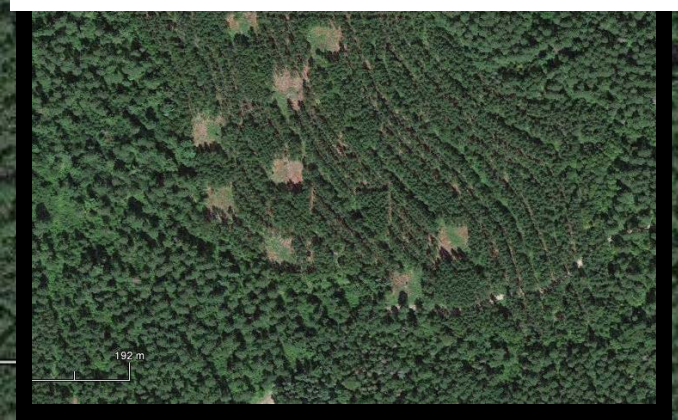
Clumps (“skips”)

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



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Clumps (“skips”)

- Potential refugia
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Openings (“gaps”)

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

Acknowledgements

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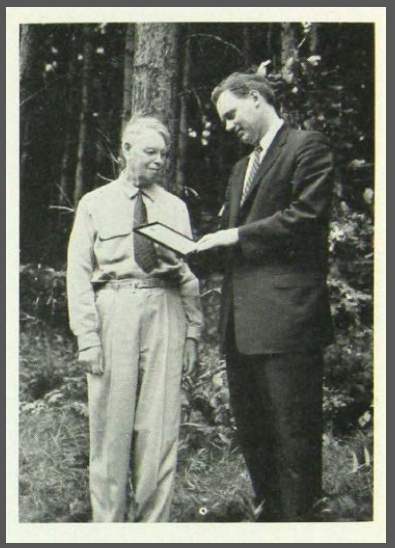


Thanks!

Next Webinar:

LSFSC 2014 Intern Projects

December 18, 2014 at 2:00 PM Eastern (1:00 PM Central)

Restoring barrens and northern dry forests in northeastern Wisconsin

Brian Sturtevant, Deahn Donner, Christel Kern, and Claire Hillmeyer

Characterizing the Spring Dip Using Foliar Moisture Content of Red and Jack Pine

Ron Masters, John Hintz, and Jonathan Steigerwaldt