The Place of Ecological Silviculture: Now and in the Future

Fire-Dependent, Mixed-Species Pine Woodland in MN circa 1939

- Why, what, and where (on the landscape)
- Is the past still relevant?
- Is ecological silviculture also adaptation silviculture?

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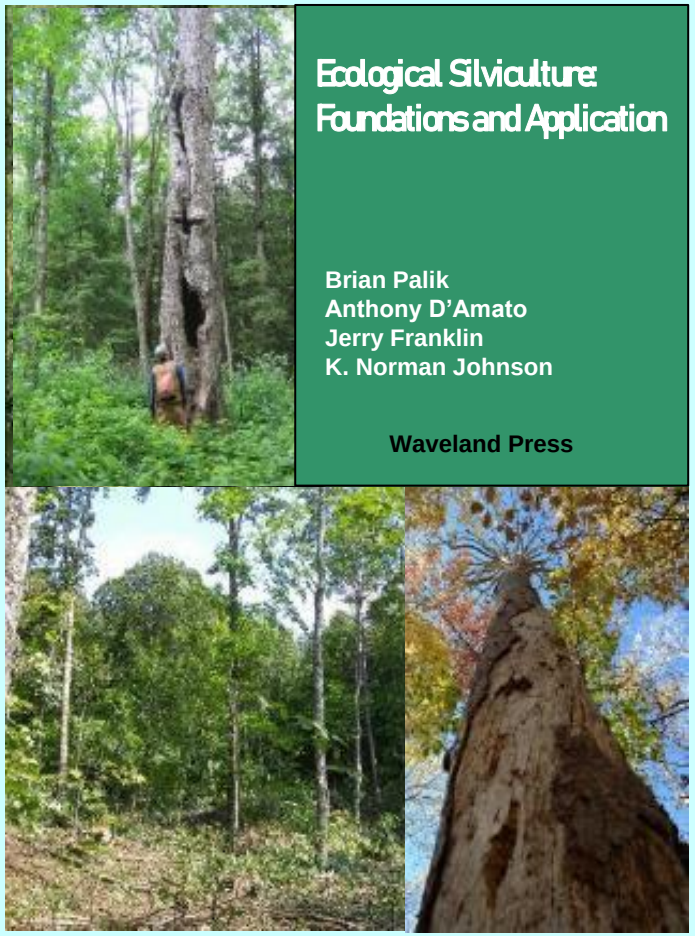
D'Amato & Palik. 2021. Building on the last "new" thing. Can. J. For. Res.
Palik et al. 2020. Ecological silviculture. Waveland Press.
Palik and D'Amato. 2023. Ecological silvicultural systems. Wiley Press.

Ecological Silviculture:

The toolbox to manage forest stands as ecosystems, based on emulation of natural models and that explicitly incorporates ecological principles

Objectives:

-native biodiversity
-ecosystem & watershed health
-habitat
-ecosystem adaptation
-aesthetics
-timber/fiber production



Why Ecological Silviculture

"To keep every cog and wheel is the first precaution of intelligent tinkering."
-Aldo Leopold, A Sand Country Almanac

Keeping the cogs & wheels is the first precaution of intelligent silviculture

This is what Ecological Silviculture does

"If your goal is to sustain the ecological services provided by natural forests, then management based on natural processes, including disturbance, is the appropriate model"
-Jerry Franklin, University of Washington

This is what Ecological Silviculture does

A comprehensive rethinking of silviculture is needed to achieve societal objectives for forestry; a tweaking of the traditional (agricultural) model is not sufficient.
-Klaus *Puettmann et al 2013: Managing forests as complex adaptive systems*

This is what Ecological Silviculture does

Sustaining economic output through management is critical for providing financial incentives to use ecological approaches

Forest Stewardship Council and others

This is what Ecological Silviculture does

Why: The Changing Drivers of Forest Management

The rise of non-traditional forest owners and stewards: e.g., TNC, Tribes, and others have different goals and objectives than timber-focused stakeholders

Leech Lake Band of Ojibwe (MN)	"Natural conifer stands often have gaps and openings. These openings are often the locations where other beneficial species of interest to Band members can grow."

Objectives of traditional forest stewards (e.g., National Forests) have evolved to be more inclusive of sustaining a broad array of ecosystem services using approaches that emulate natural models

USDA Forest Service 2012 Planning Rule:	"..plans are to reduce fire risks, improve tree health, and protect species and ecosystem functions."

Third-party certification, e.g., FSC, includes criteria and indicators reflective of natural models

FSC Criterion 6.3: Ecological functions…	Indicator 6.3.f: "… maintains, enhances, or restores habitat components and associated stand structures, in abundance and distribution that could be expected from naturally occurring processes."

Ecological silviculture is designed to respond to these drivers and needs

What: Foundational Principles

Continuity, Complexity, Timing, Context

Principle 1: *Continuity*

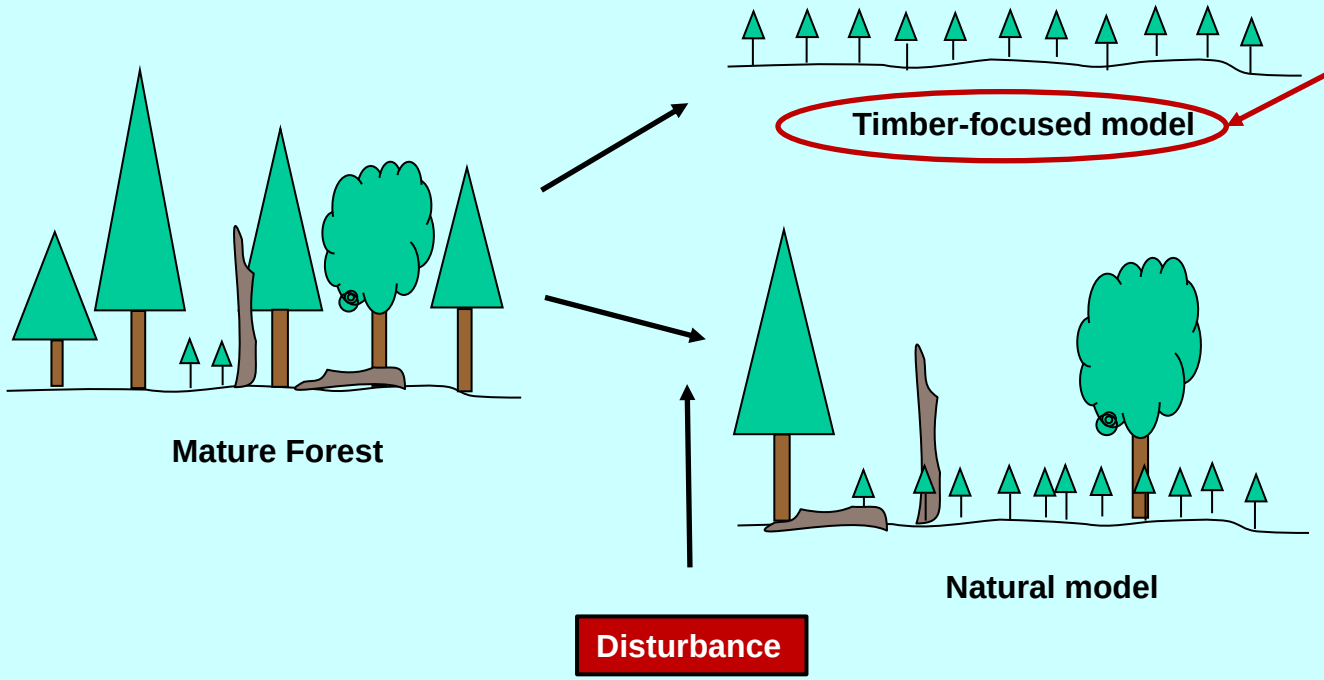
Continuity in forest structure, function, and biota between pre- and post-disturbance ecosystems (regeneration-scale event)….*biological legacies…ecological memory*

Natural disturbance…biological legacies…live trees, deadwood, propagules, etc.

Implemented during regeneration harvesting in managed forests,

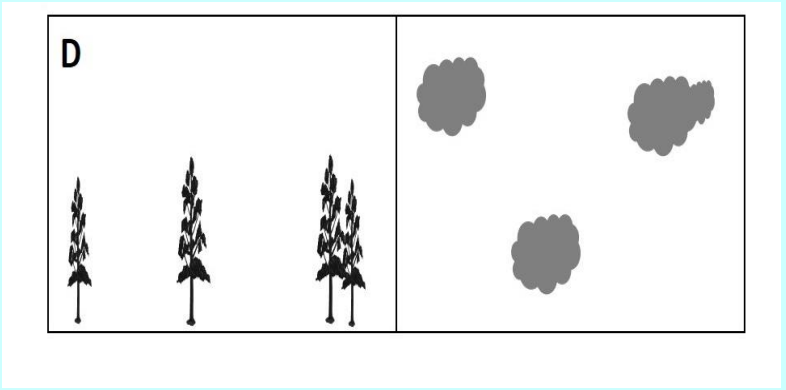
e.g., Variable Retention H

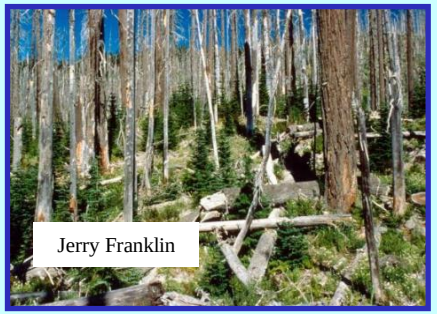
Silviculture with timber as the driving objective; Sometimes by design, but sometimes inadvertently



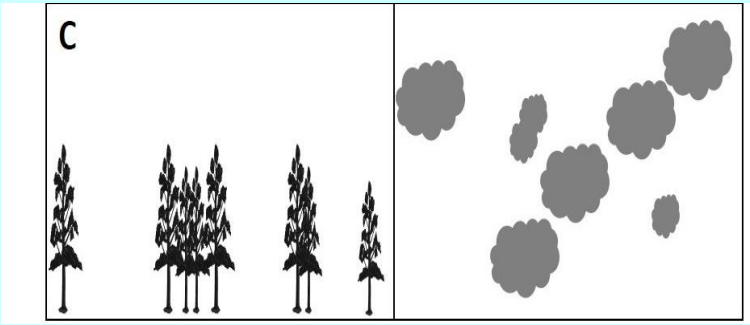
Continuity of structure with legacies occurs with all scales of regeneration disturbance

Stand Replacing Canopy Disturbance

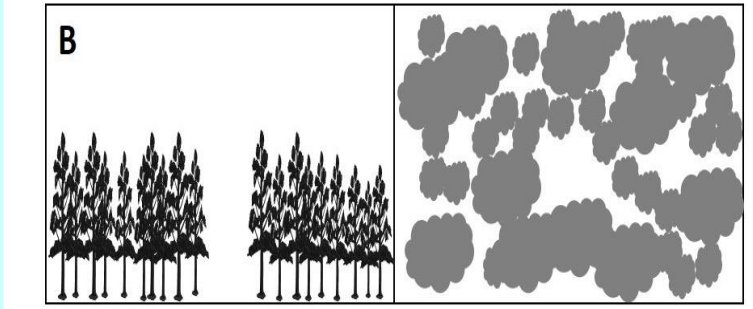




Heavy Partial Canopy Disturbance



Stand Maintaining (Gap) Canopy Disturbance

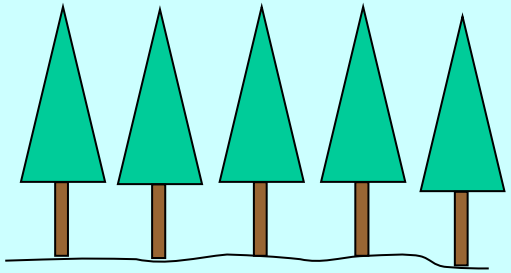


Principle 2: *Complexity/Diversity*

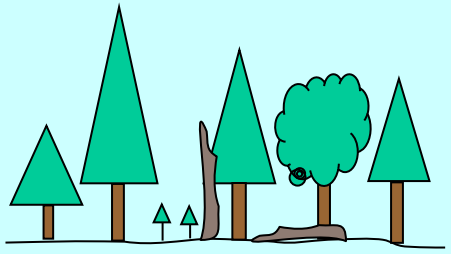
Development of structural complexity, heterogeneity, and species diversity in developing stands

Results from growth, decadence, mortality, small-scale disturbance, succession

Implemented in various ways: e.g., variable density thinning, decadence creation, enrichment planting



Simple



Complex/Diverse

Complexity/Diversity

-Big trees
-Complex branch systems
-Buttressed roots

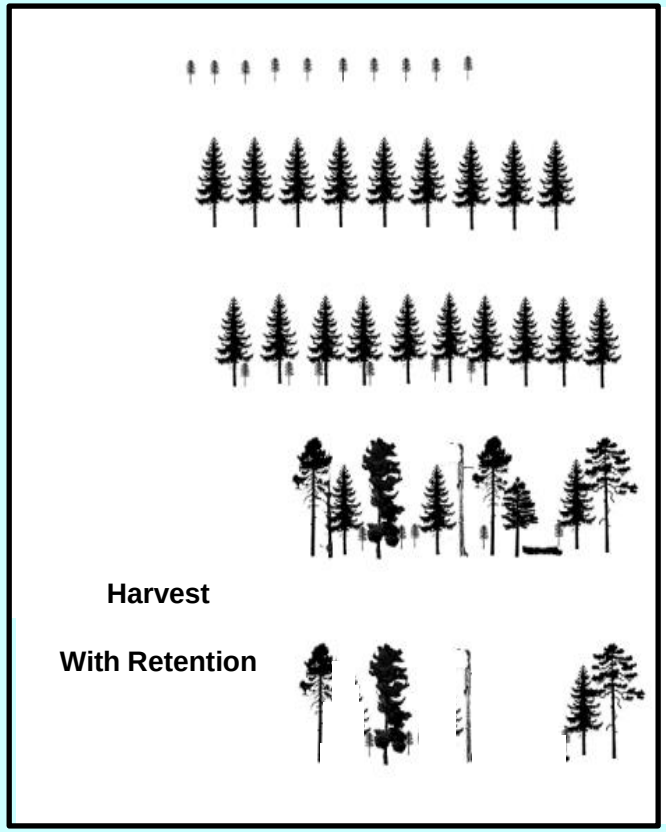
More than one tree species!

-Vertical and horizontal canopy heterogeneity
-Declining trees and deadwood
-Resource and microclimate variation
-Specialized habitat

Principle 3: Timing

Refers to the importance of appropriate time for specific structural elements and functional attributes to develop. e.g, a population of large trees

Implemented by allowing ecological appropriate time intervals between silvicultural interventions, especially regeneration harvests



-Related to rotation/cutting cycle, but not based just on growth (e.g. culmination of MAI)

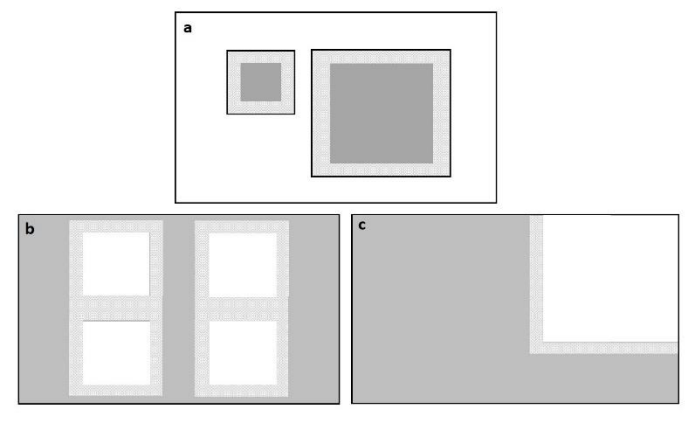
-Based on development of complex structure/composition

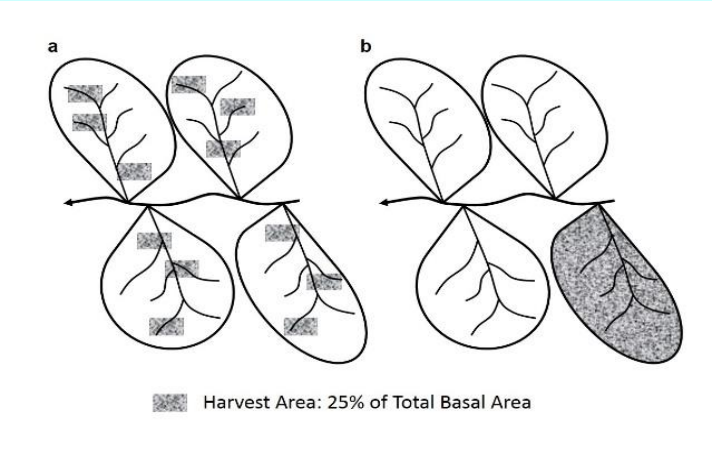
Timing: allowing at least some trees to live out their natural life-span

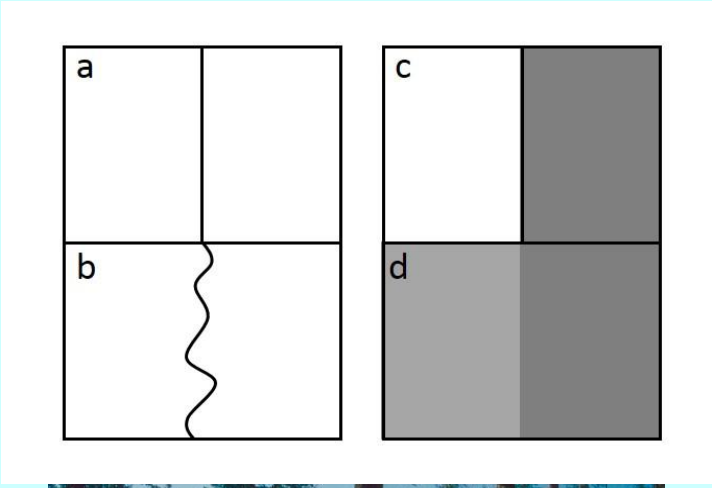
Principle 4: Landscape Context

Consider stand-scale actions in a landscape context:

Interactions, edge/patch structure, cumulative effects

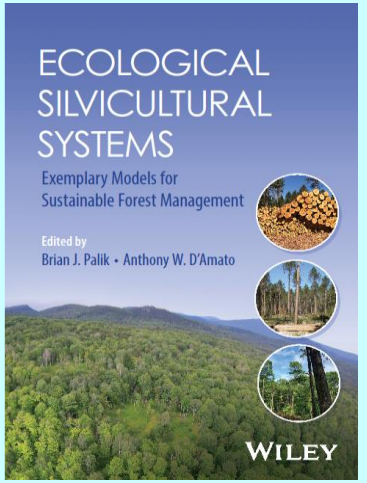






What to do with the foundational principles?

Ecological silvicultural systems: ***the long-term sequence of treatments for restoring and sustaining composition and complex structure of forests; informed by natural disturbance and development; incorporates foundational ecological principles, with a goal of reducing the disparity between natural and managed ecosystems***



-Systems named after the natural disturbance regime…we call these *disturbance archetypes*:

1) ***Infrequent severe***
2) ***Frequent low-severity***
3) ***Periodic gap-based***
4) ***Mixed-severity***

-There are more, but these are the most prevalent

-The specific silvicultural system reflects the *archetype and* the forest type (e.g., *gap disturbance in northern hardwoods; frequent low-severity fire in longleaf pine)*

You might ask, isn't classical silviculture based on understanding natural ecosystem dynamics?

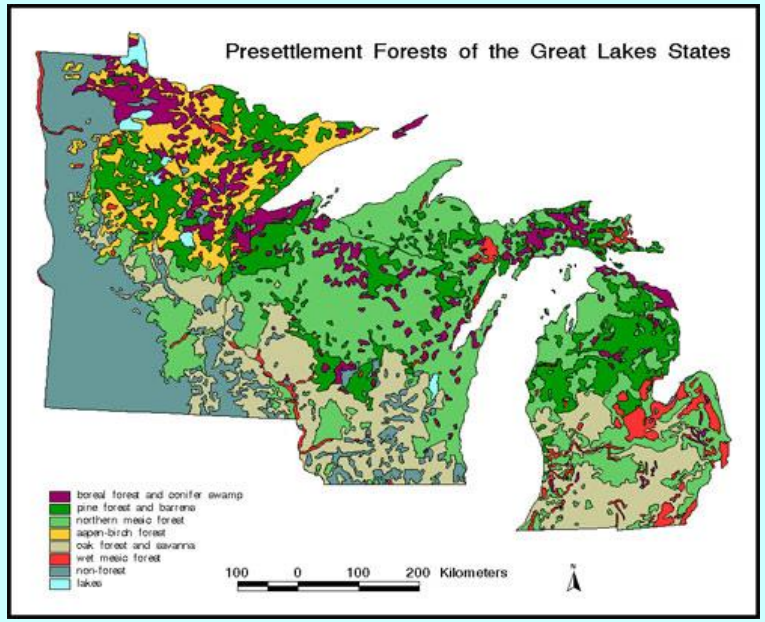
Timber-focused

Yes…but not really…
- **-no goal of reducing disparities**
- **-based on ecology of agricultural ecosystems**
- **-no explicit incorporation of ecological principles**

Laurentian-Acadian Northern Pine-(Oak) Woodlands….aka Red Pine

Ecological silvicultural system example

Archetype 4*: forests characterized by disturbances of varying severity, ranging from infrequent, near stand-replacing, to heavy, but less than stand-replacing*



-Sustained dominance by shade-intolerant Red Pine

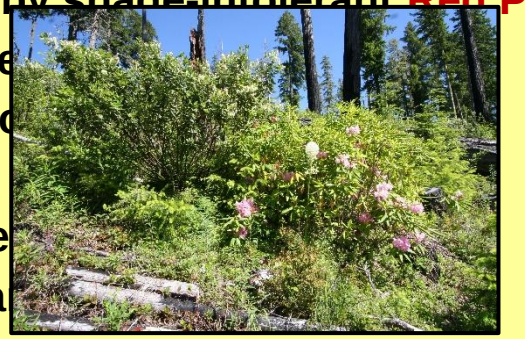
-Inclusions of other tree

-Extended pre-forest, yo

-Long-lived species

-Complex age structure

-Structurally complex a



-Frequent fire…6.6 year mean return interval in n. MN (low severity to higher severity)

Natural disturbance regime:
-Fires often not stand-replacing
-Overstory present during regeneration events
-Two-cohort, multi-cohort, broadly single-cohort

Evidence for complex age structures and less-than-stand replacing disturbance

(Bergman 1924, Shirely 1932, Eyre and Zehngraff 1948

Red pine forests in the Lake States Now

-Even-aged regeneration systems
-Spatially homogeneous in structure
-High density (favoring the A-line)
-Generally short rotations: 50-90 yrs
-Strongly red pine dominated
-Early full stocking of regeneration
-Mostly plantations (76% in MN,MI,WI)

Nothing wrong with this model, unless your objectives include more than timber as the priority

~300,000 cords harvested annually
-Sawtimber, utility poles, cabin logs

Timber-focused

Year	Activity
0	Clearcut harvest
1	Site preparation
2	Plant in spring
2-4	Browsing control
4-5	Competition control
30	First thinning
45	Potential second thinning
60	Potential third thinning
50-90	Final harvest

Ecological Silvicultural System: Great Lakes Mixed-Pine Ecosystem

Developmental Stage/Event	Duration (yrs)	Example Activities
Disturbance and Legacy Creation	0	Variable retention harvest; deadwood creation
Preforest	1 to 5+ (20+)	Site preparation including fire; competition control; regeneration
Young Forest (early)	5 to 30	Regeneration; browse control; release
Young Forest (later)	30 to 70	Variable density thinning (VDT))
Mature Forest	70 to 150	VDT; regeneration in VDT gaps; deadwood creation; competition control; Rx fire
		Variable retention harvest
Old Forest	+150	Decadence/deadwood creation; VDT; regeneration in openings; competition control-Rx fire; VRH?

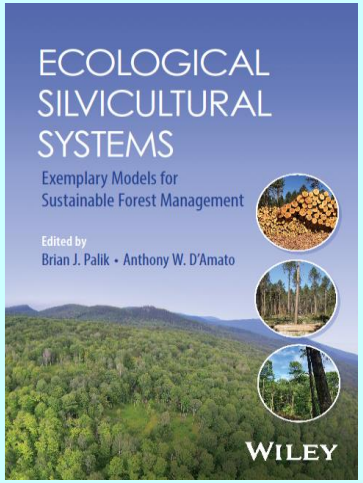
Continuity

Complexity/Diversity

Timing

Continuity

Timing



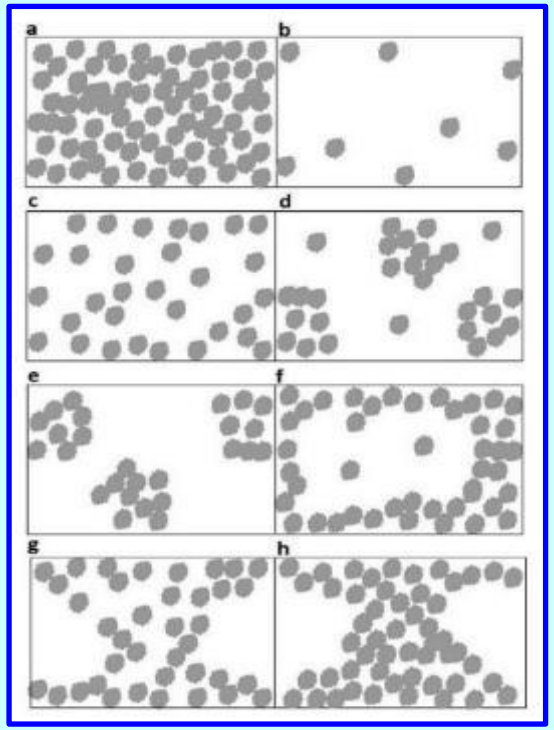
Many other examples

Stage	Yrs	Actions	Outcomes
Disturbance/ Legacy Creation	0	Variable retention harvest Deliberate creation and/or retention of dead wood	Continuity of structure; maintain functionality; increase growing space; initiate pre-forest stage

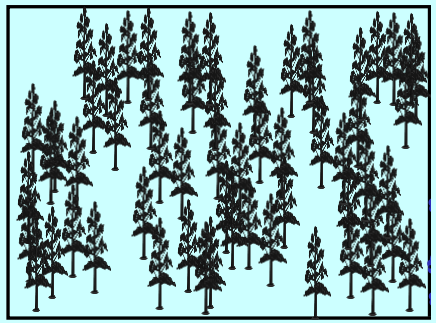
Palik & D'Amato 2019. Ecological Processes

VRH: Variable in Practice:

Large group to irregular shelterwood

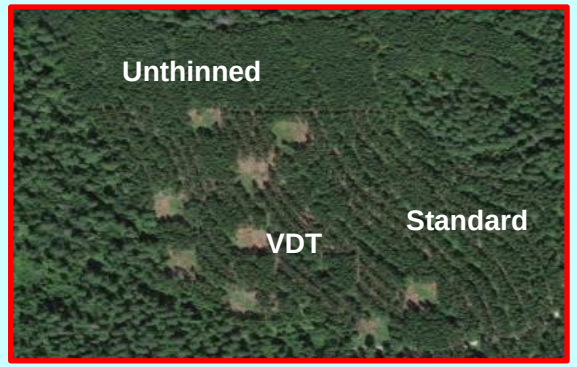


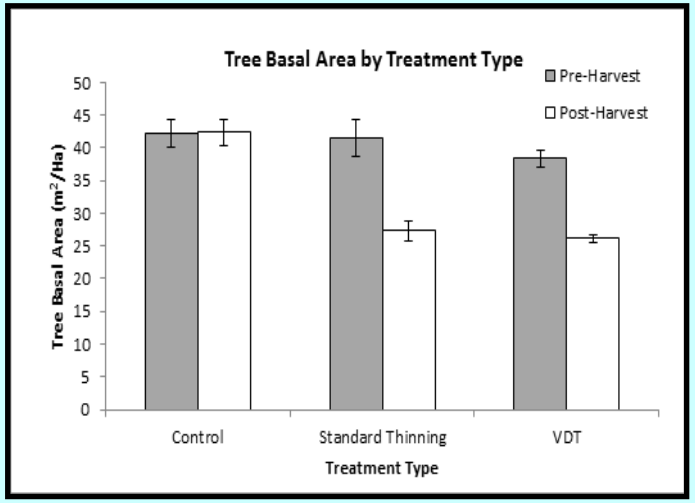
Stage	Duration (yrs)	Actions	Outcomes
Young Forest	30-70	Variable density thinning (VDT)	Increase growth of trees; enhance complexity/heterogeneity; enrich tree species
		VDT gaps: site preparation, competition control, regeneration	

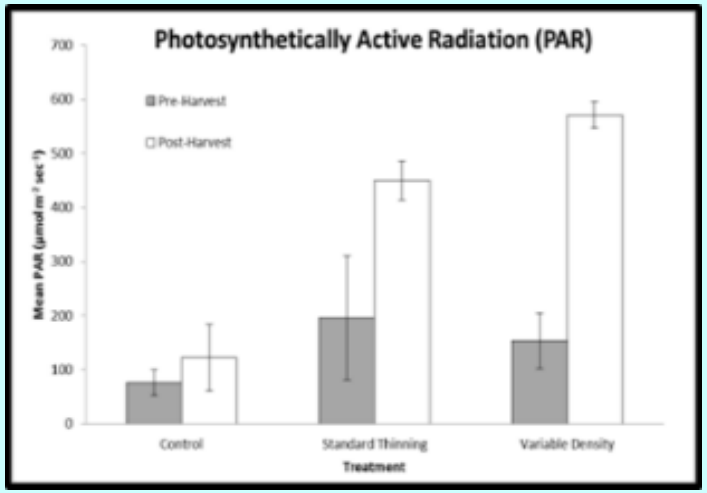


Variable Density Thinning:

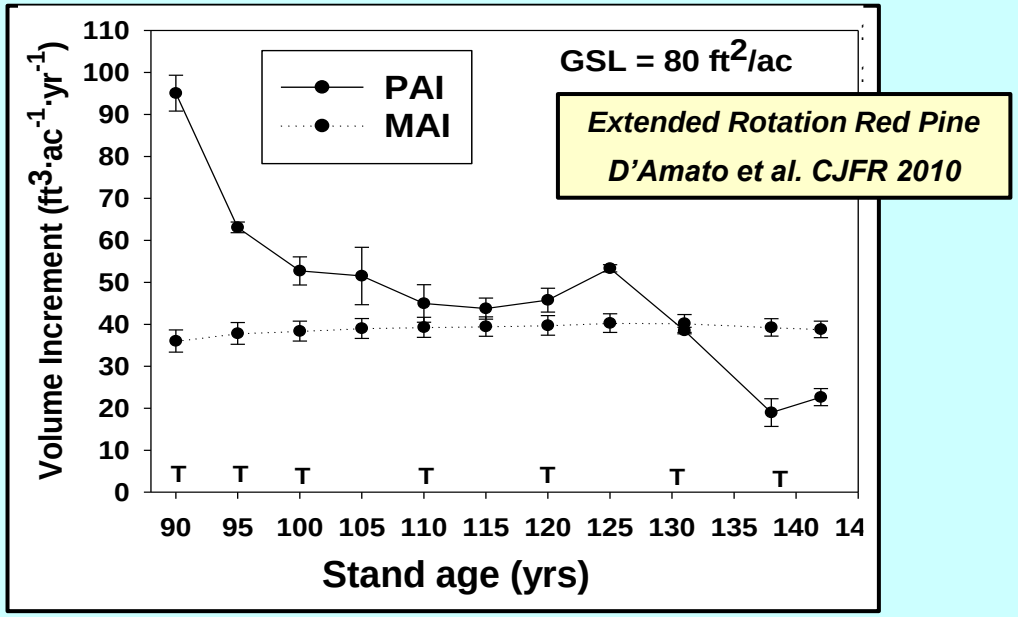
1) Accelerates the development of spatial heterogeneity
2) Shortens time required to reach complexity characteristic of mature forest







Stage	Yrs	Actions	Outcomes
Mature Forest	70-150	VDT or crop tree release VDT gaps: site preparation, competition control; regeneration	Increase growth of trees; accelerate development of complex structures



-Thinned red pine stands reach peak MAI at ages well beyond those ascribed in normal yield tables

-Stand-level production is responsive to thinning treatments, even at advanced ages

-MAI remains relatively constant, justifying rotation length based on metrics other than max MAI

Stage	Duration (yrs)	Actions	Outcomes
Old Forest	150+	Do nothing?	Enhance complexity and heterogeneity, enrich species, restore structure
		Decadence/deadwood creation	
		Rx fire or surrogate to reduce aggressive shrubs and fire-sensitive hardwoods	
		VDT in dense stands	

Restoration of old-forest stage stands

Principle 4: Landscape Context:

-little old or mature pine woodland

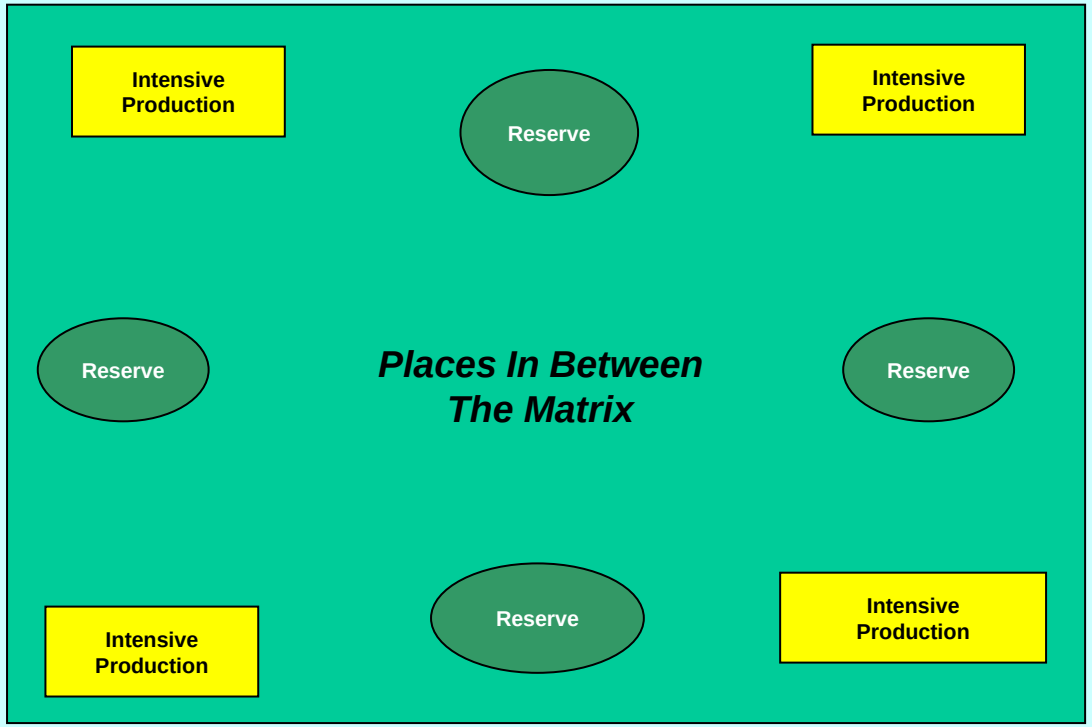
-76% in plantations

Where, Ecological Silviculture? **Almost everywhere, outside of intensively managed plantations?**

Global Forest (4 billion ha)

Intensive Production (plantations)……..……The places in between……..……..Reserves

0.30 billion ha **3.05 billion ha** **0.65 billion ha**



Family Forest Owners
-beauty/scenery
-habitat, biodiversity

Conservation Stewards
-restoring ecosystems
-sustaining ecosystem services

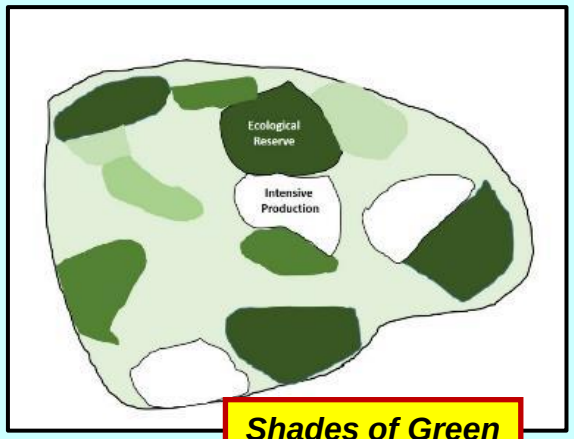
Tribal Forests
-ecosystem services
-culturally important species

Federal Forests
-multiple use
-sustainable ecosystems

State Trust Forests
-certification?
-best management practices

Certified Industrial Forests
-sustainability standards

Still, not everyone will apply the principles the same way…not all the same shade of green



Shades of Green

Triad Model

Himes et al. 2022. Thirty years of triad forestry. *Forest ecology and management* 510: 120103

Example: Northern Hardwood Silviculture

Intensive Production

Plantation on a hardwood site

Protected

Intensive w/ legacies

Intensive Production

Protected

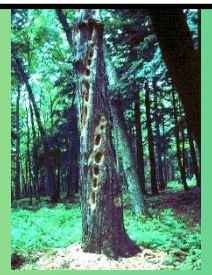
Landscape Forest

Gradient Model

Even-aged sugar maple stand

Protected

Extended rotation sugar maple stand w/legacies



Intensive Production

Multi-cohort, mixed species stand w/ old residuals

Protected

Old-forest stage northern hardwood stand

Intensive Prod

Greener (more like the natural model) …but…

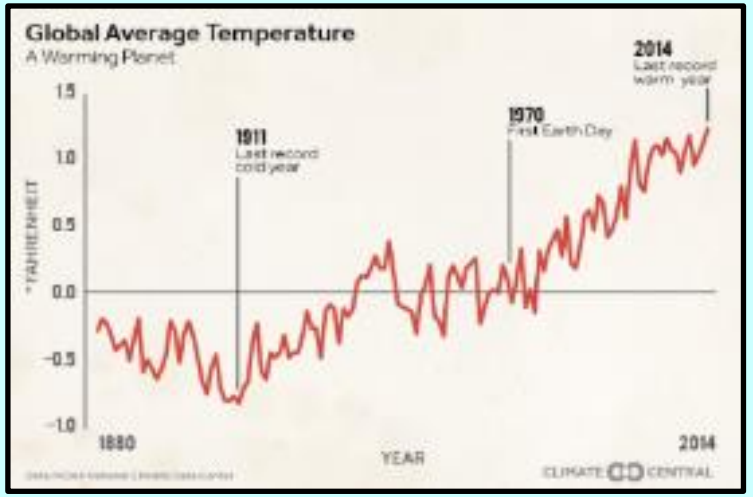
Does ecological silviculture look too much to the past…to conditions that are no longer relevant?

Evolving Drivers of Forest Management

-Invasive species

-Risk of catastrophic wildfire

-Climate change



Ecological silviculture is designed to respond to these drivers

Ecological Silviculture can be Adaptation Silviculture…..

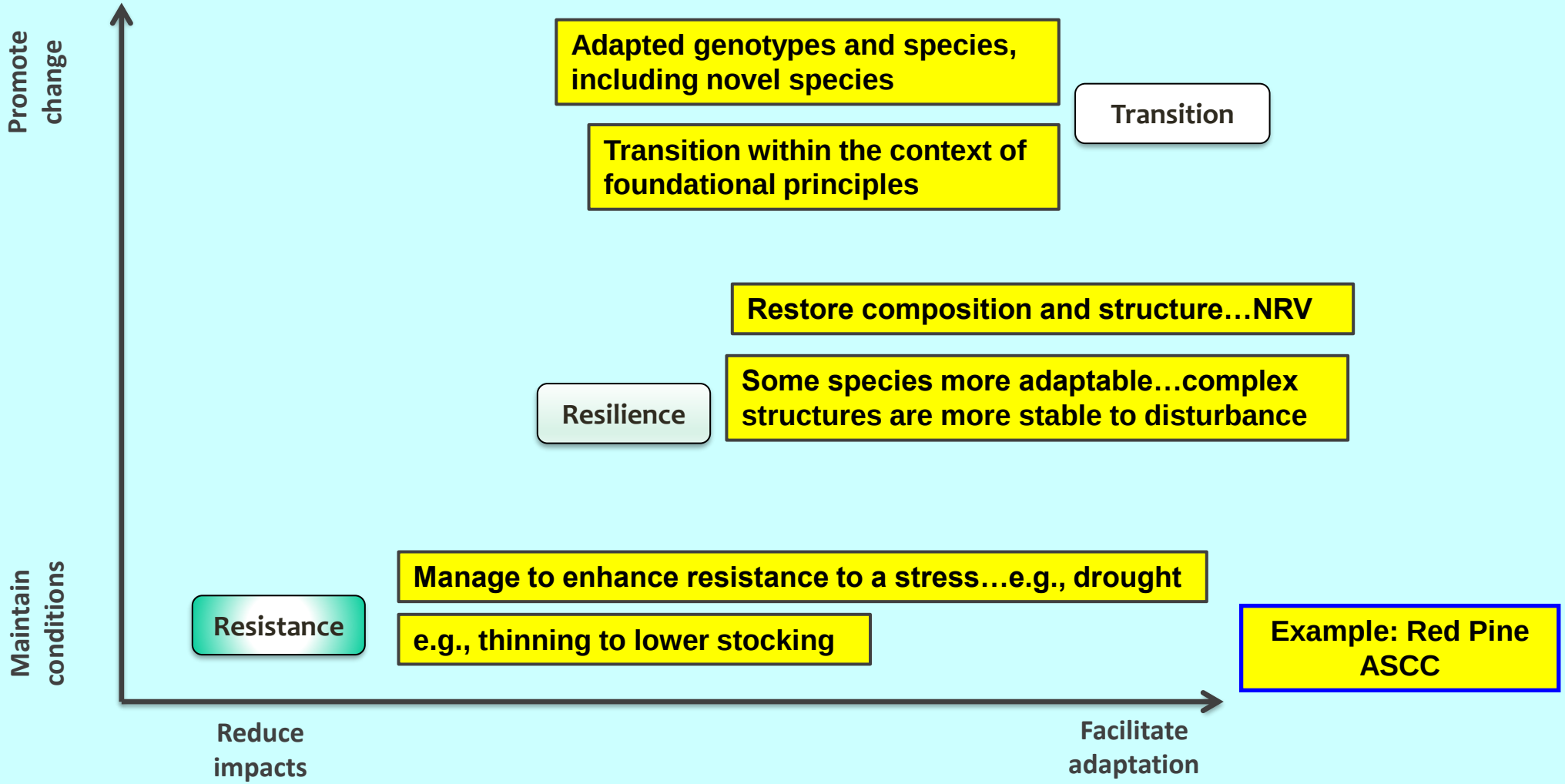
Timber-Focused	*Ecological*
-Reduction in tree species richness -Simplified age and size structure -Higher stocking (density, BA) ***Limits options in the face of uncertainty***	-Sustain/restore tree species richness -Allow/treat for development of complex age and size structure -Ecosystem-appropriate stocking and timing ***Enhanced adaptive capacity & options***
Continuity: -regeneration options in the face of uncertainty -amelioration of harsh conditions -conservation of genetic diversity	**Complexity/Diversity:** -reduced vulnerability to disturbance (complex size structures; spatially variable fuels; heterogeneous host availability -multiple recovery/development pathways
Timing: -long-term maintenance of adaption options -long-term amelioration of extreme conditions -large accumulation of carbon pools -reduced potential to compound harvesting and other disturbances	**Context:** -reduced risk from landscape-scale stressors…drought -enhance options at broad scales -conservation of genetic diversity

Ecological silviculture within a Climate adaptation framework

Resistance-Resilience-Transition
Nagel et al. Journal of Forestry 2017

ASCC
Adaptive Silviculture for Climate Change

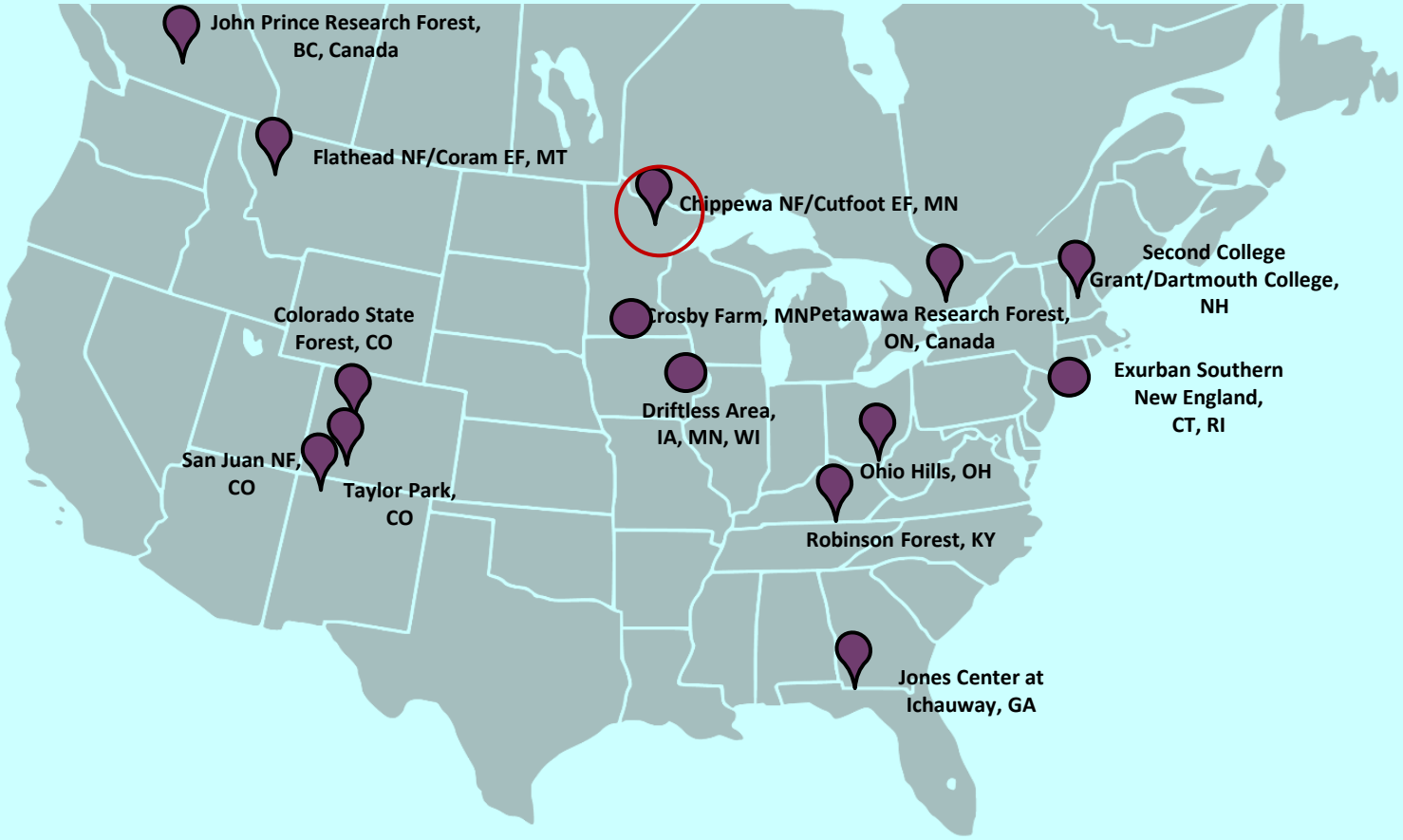
Adaptive Silviculture for Climate Change
www.adaptivesilviculture.org



Red Pine ASCC:

ASCC
Adaptive Silviculture for Climate Change

www.adaptivesilviculture.org



Red Pine

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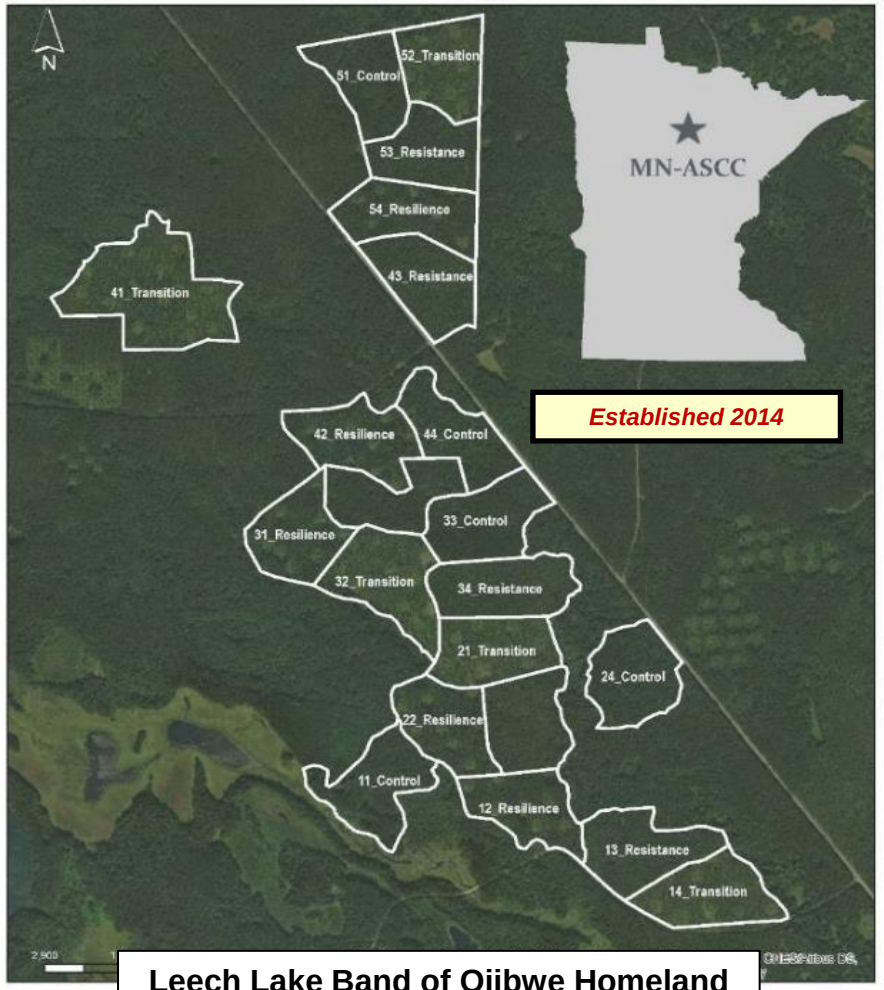

Leech Lake Band of Ojibwe Homeland
Chippewa National Forest
Cutfoot Experimental Forest

- Overly red pine-dominated
- Long fire excluded
- 180-200 ft^2/ac (41-45 m^2/ha), overstocked
- Dense shrub layer

Climate Change Vulnerable

-Thinning to woodland density

-Enhances drought resistance

Bottero et al. J. Appl. Eco. 2017

-Extended rotation

-No targeted regeneration

-Harvesting to woodland density and spatial structure (variable density thinning)

-Retention in gaps

-Two -cohort age structure

-Planting native adapted species

-Local and southern seed sources

-Irregular shelterwood

-Indefinite retention of some trees

-Multi-cohort age structure

-Planting adapted native and novel species (bitternut hickory, white oak)

-Resistance: thinning to a woodland structure..or lower stocking.. is ecological and adaptive

-Resilience: maintaining diverse native tree species and complex age structure is ecological and adaptive

-Transition: moving seed source that should be present already is ecological and adaptive….and still incorporating foundational principles is ecological and adaptive

Ecological Silviculture: same stuff, new terms?

Isn't classical silviculture based on understanding natural ecosystems?... Yes…but not really..

-Ecological Silviculture is Responsive to Changing Global Forces

By emphasizing diversity and complexity, ES is more responsive to the evolving needs of stewards and stakeholders than timber-focused silviculture

-Ecological Silviculture is Based on Natural Models

An explicit goal of ES is to reduce the disparity between the managed and natural stands; classic silviculture may conceptually share this goal, but the reality is that it tends to perpetuate the disparity

-Ecological Silviculture is Grounded in Ecological Principles

Classical silviculture is based as much on the ecology of agricultural ecosystems as natural models

-Ecological Silviculture is Ecosystem Centric

In classical silviculture the response of timber species is the framework upon which other ecosystem components are addressed….tail waging the dog silviculture

-Ecological Silviculture is Adaptation Silviculture….

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