Applying principles of ecological forestry to the management of pine-oak forests in the Lake States

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- **-Context**
- **-Ecological Foundations**
- **-Management Application**

Why Ecological Forestry?

If your primary goal is to sustain or restore the ecological services provided by natural forest ecosystems, then…

Ecological Forestry **is the appropriate model for your management**

Ecological objectives may have primacy, or they may have similar weight with managing for timber, wood products, and/or wildlife habitat

Context

Historically:

Stand-scale manipulations:

- **growth and yield, regeneration**
- **single-species, single-cohort focus**

Is this approach sufficient to:

- **Meet the needs of users?**
- **Provide a forest that best serves people and communities?**

- **The users of silviculture have expanded**
- **The needs of users have changed**
- **A global marketplace dictates a different approach**

Forest Management: Historically (post WWII)

Production forests

- -wood and fiber
- -watershed protection
- -wildlife (mostly game)
- -recreation

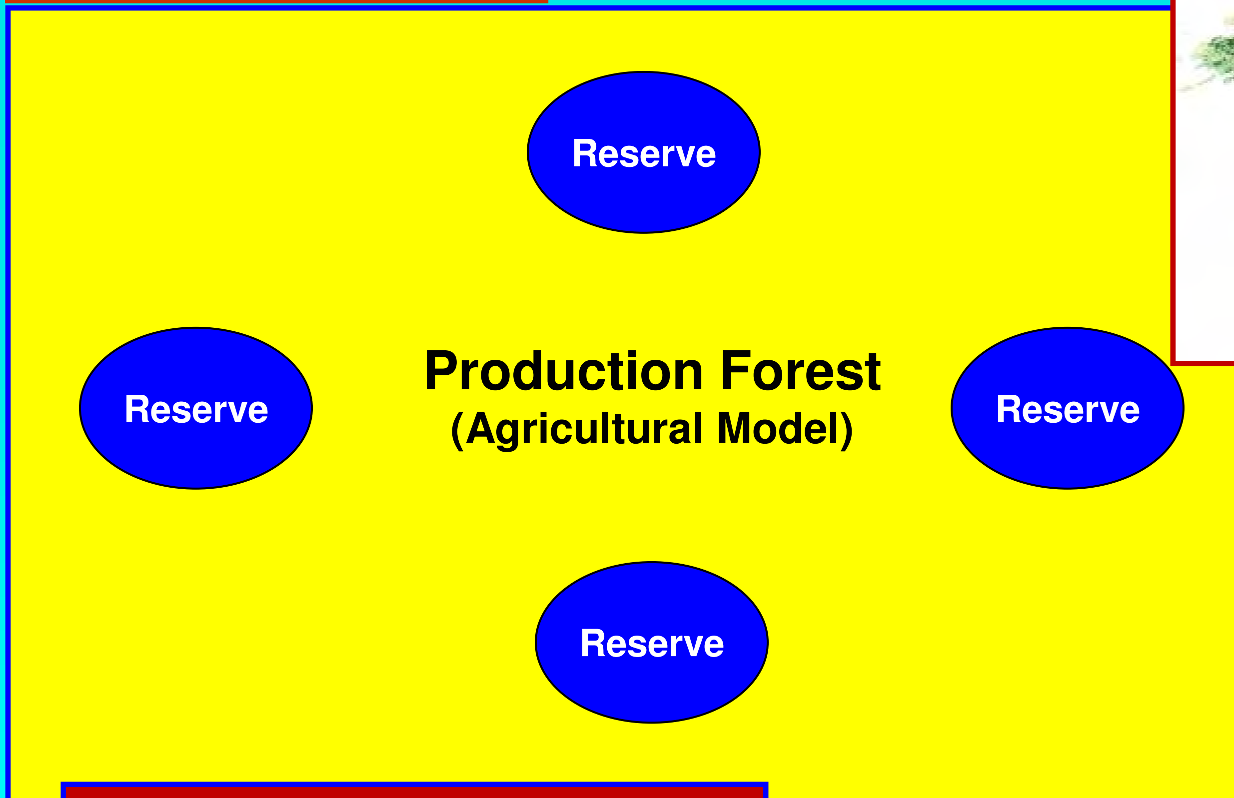
Agricultural Model: simple, homogeneous, energy subsidies

Conservation forests

- -habitat (coarse filter)
- -wildlife (more than game)

Reserves: national parks, wilderness areas, etc.

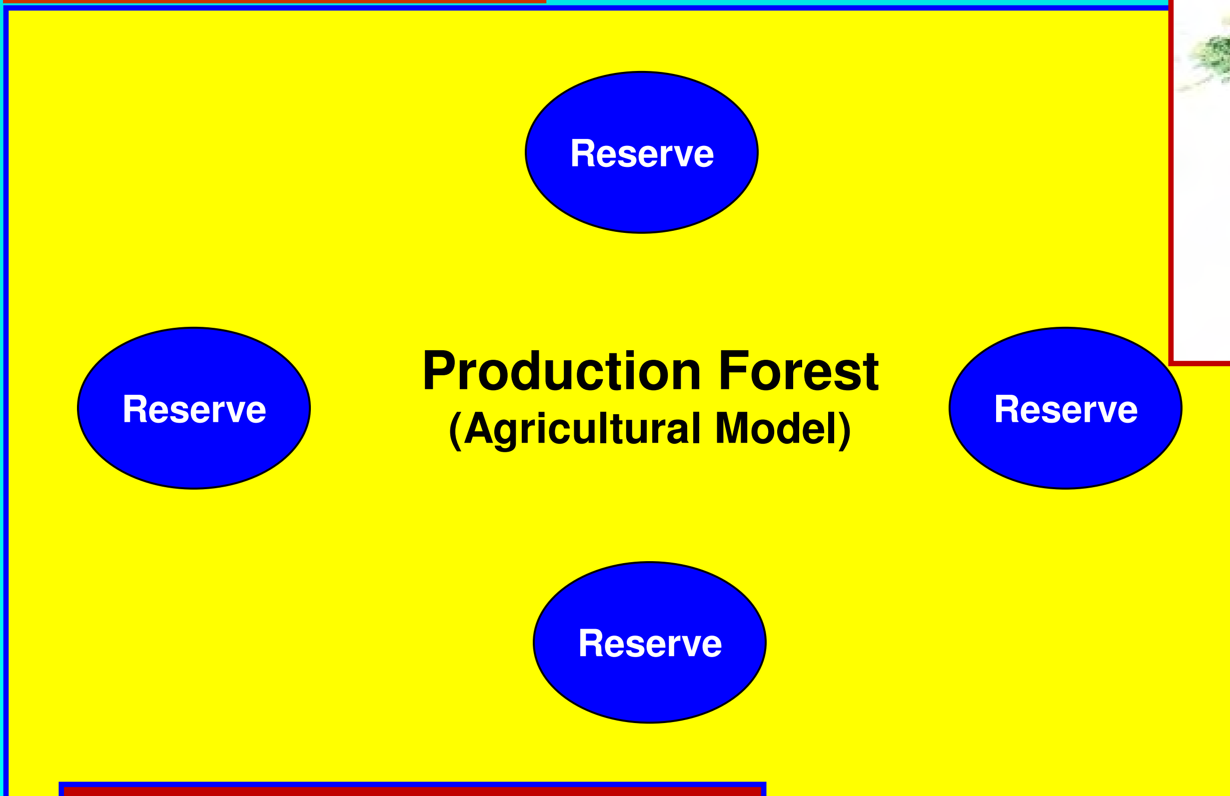
Landscape Allocation



Ecosystem science tells us that:

- **-This allocation is not sufficient to meet biodiversity and conservation objectives broadly**
- **-The condition of the "matrix" is important for sustaining many species (biodiversity)**
- **-Managing for biodiversity across more of the landscape is important for sustaining healthy forests and their services: e.g., *storing carbon, resisting invasive species, adapting to climate change, growing diverse wood products***

Landscape Allocation



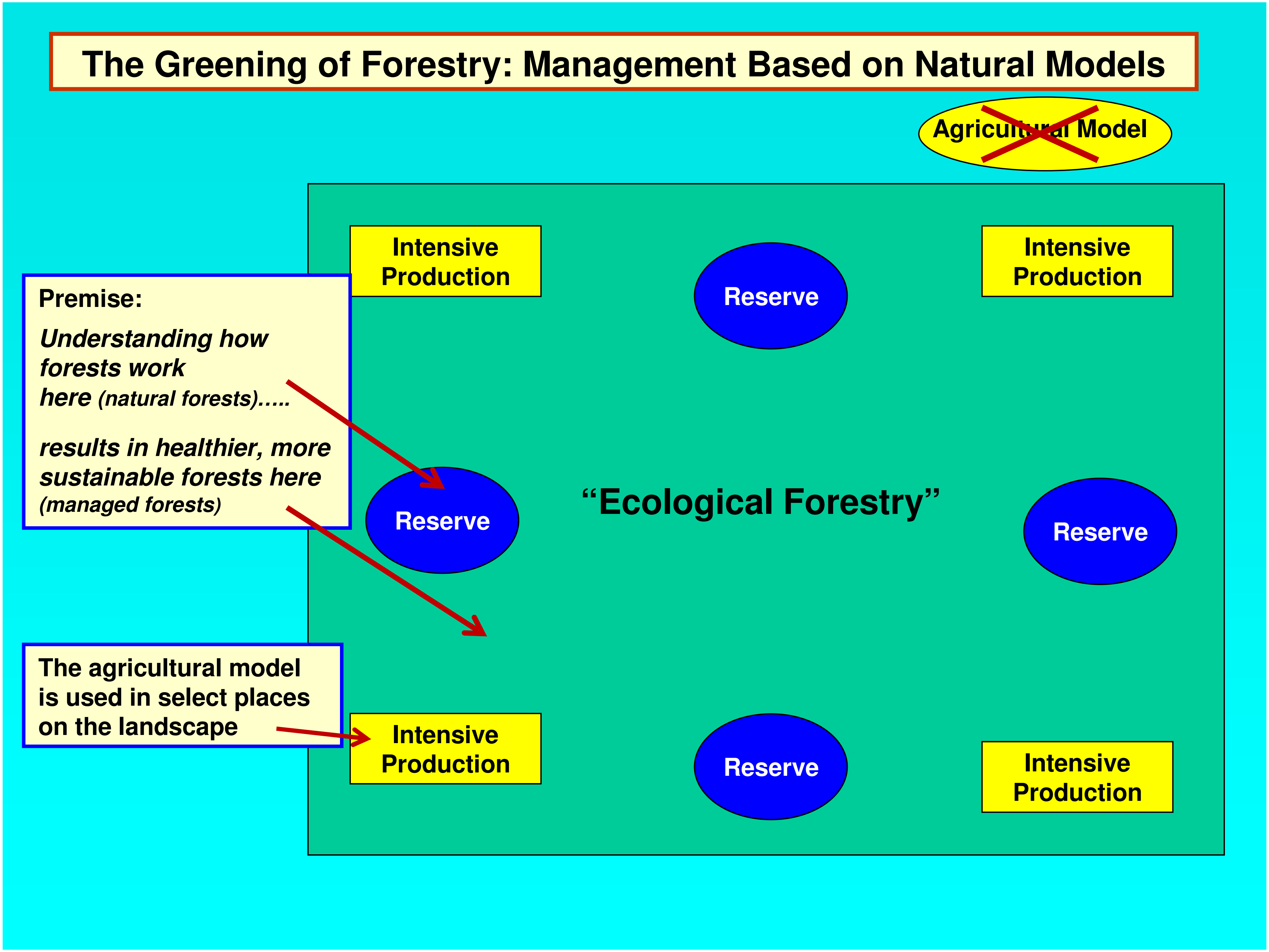
Ecosystem science tells us that:

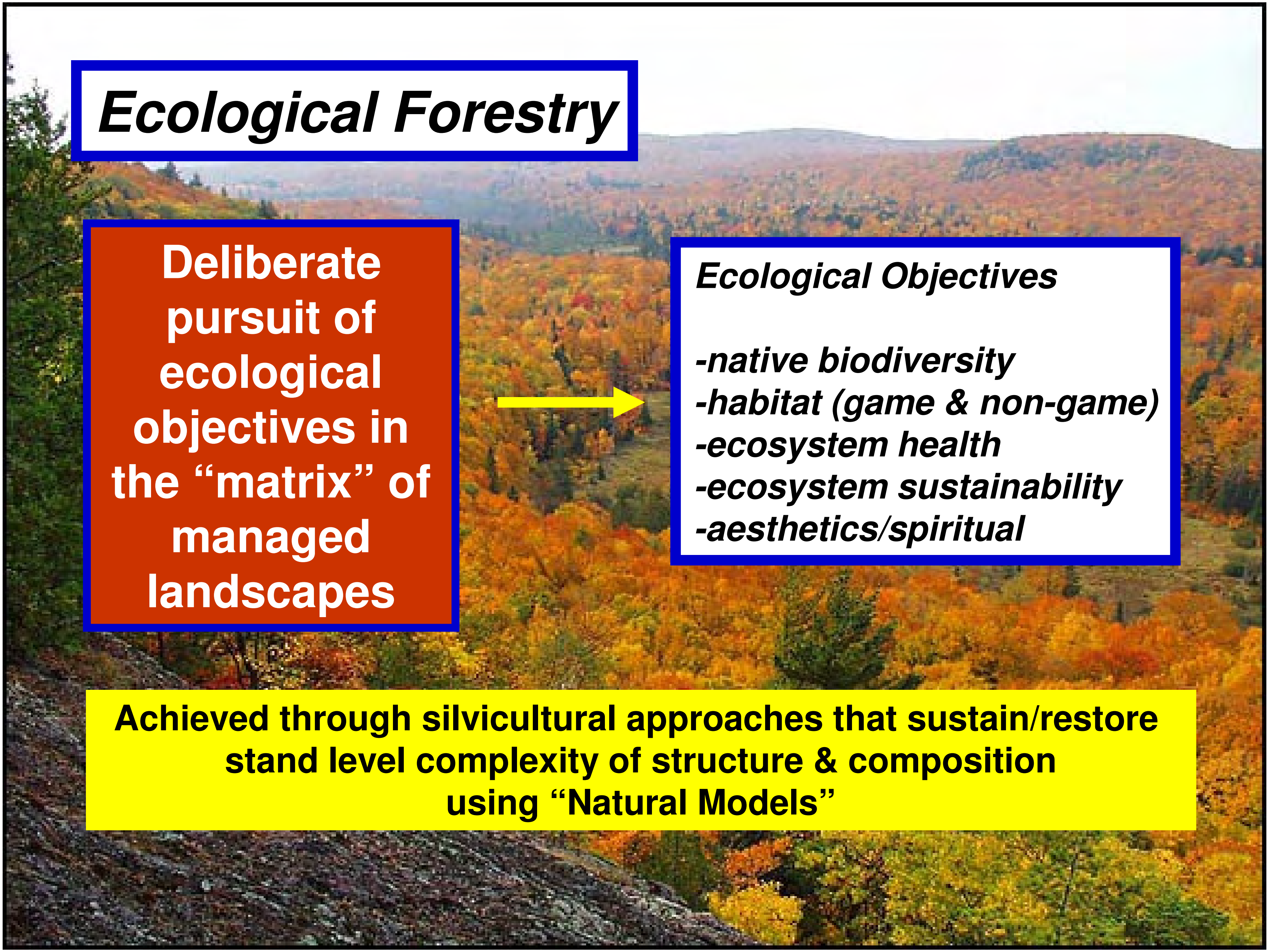
-This allocation is not sufficient to meet biodiversity and conservation objectives broadly

-The condition of the "matrix" is important for sustaining many species (biodiversity)

We need a new model if we are to sustain ecosystems and their services broadly!

adapting to climate change,
growing diverse wood products


The Greening of Forestry: Management Based on Natural Models
Agricultural Model
Premise:
Understanding how forests work here (natural forests).....
results in healthier, more sustainable forests here (managed forests)
The agricultural model is used in select places on the landscape
Intensive Production
Reserve
Intensive Production
Reserve
"Ecological Forestry"
Reserve
Intensive Production
Reserve
Intensive Production



Ecological Forestry

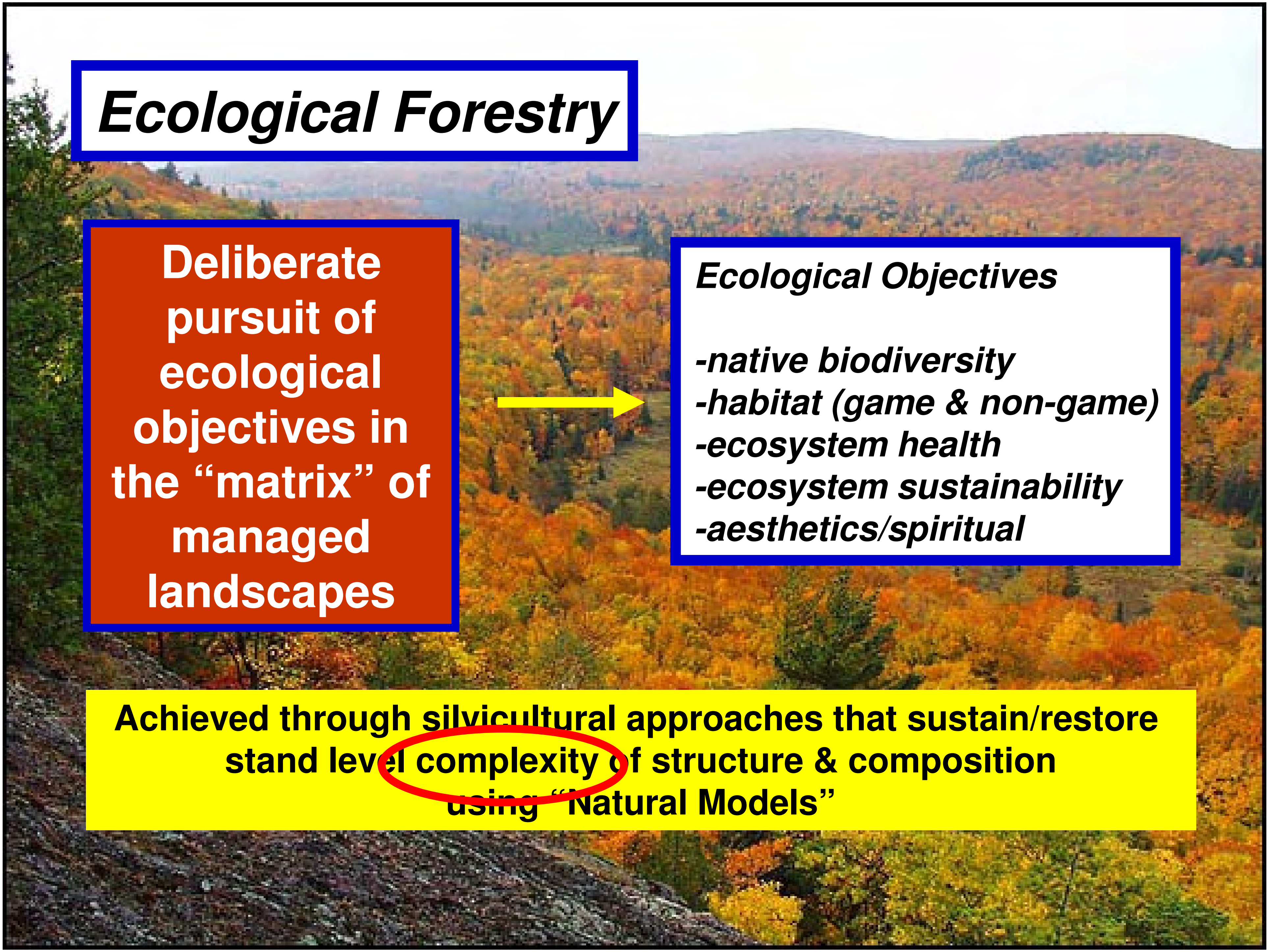
Deliberate pursuit of ecological objectives in the “matrix” of managed landscapes

→

Ecological Objectives

- ***-native biodiversity***
- ***-habitat (game & non-game)***
- ***-ecosystem health***
- ***-ecosystem sustainability***
- ***-aesthetics/spiritual***

Achieved through silvicultural approaches that sustain/restore stand level complexity of structure & composition using “Natural Models”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Ecological Foundations: Complexity

Nature Generates Complex Forest Stands,
Management Simplifies Them

Ecological Forestry: Sustains-Restores Complex Structure in Forests Managed for Wood

Elements of Complexity in the Context of Forest Stands?

-Tree Size Distributions
(range, variation, extremes)

Elements of Complexity

-Age Distributions
(range and variation)

-Cohort Structure
(size, distribution)

-Canopy Structure
(horizontal, vertical)

-Composition
(richness, evenness)

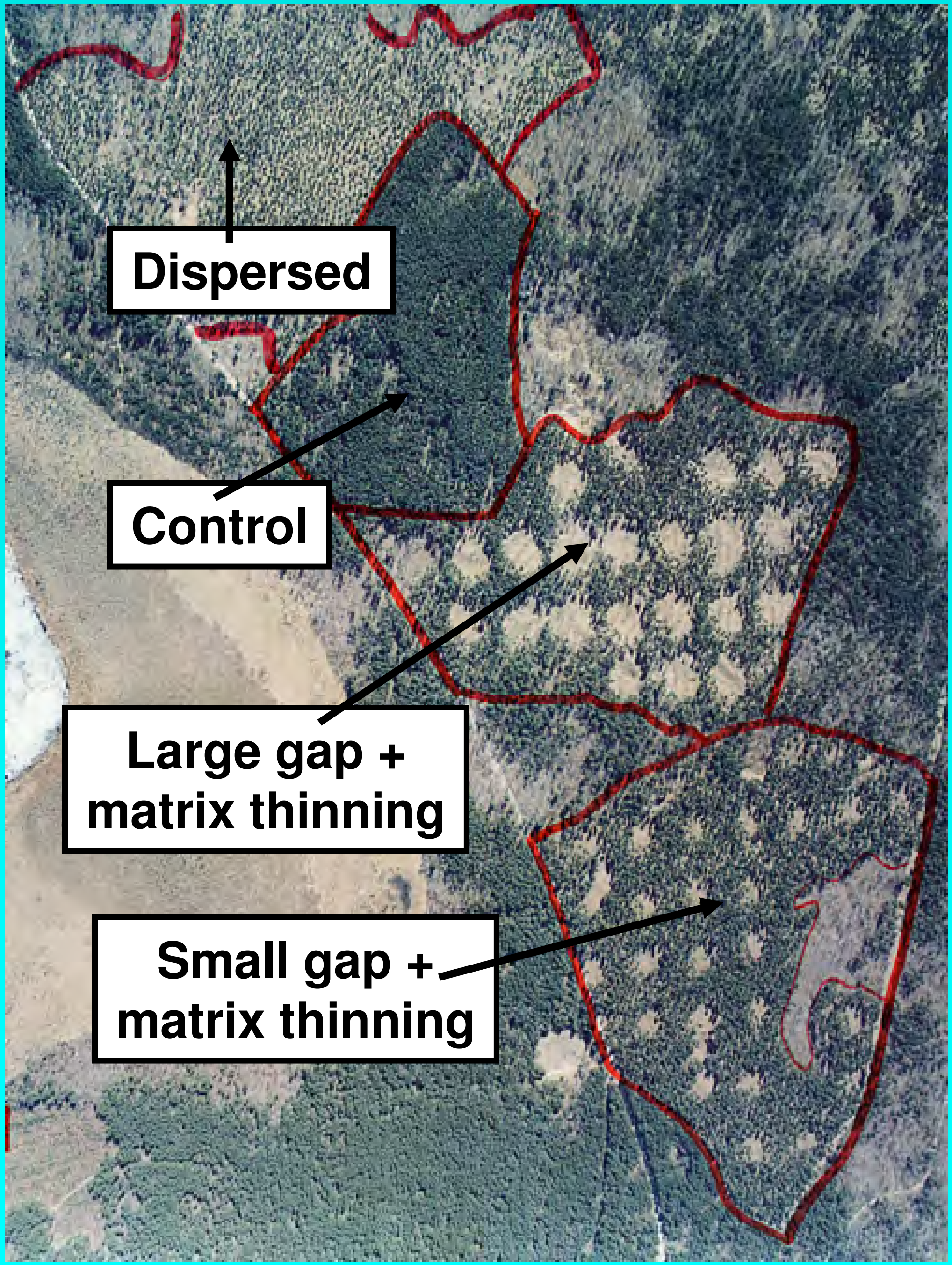
Elements of Complexity

-Dead Wood:
(amount, condition, type)

-Understory Structure
(amount, spatial pattern)

Examples of Complexity Elements

Non-merchantable Trees



Elements of Complexity

Spatial Pattern
(heterogeneity, variation)

- Canopy structure
- Cohort structure

Ecological Complexity in Forest Stands

Complex	Simple
Multiple species	Single species
Multiple age cohorts	Single cohort
Wider size and age ranges	Narrow ranges; young trees
Understory plant diversity	Few species
Seed and Seedling banks	Depleted
Abundant tree-derived structures (large wood; cavities trees)	Few
Spatial heterogeneity	Spatial homogeneity

What have we learned?

Unmanaged *Benchmark* Ecosystems:

-Complex and heterogeneous structure

-Compositionally diverse (relative)

Why is complexity important?

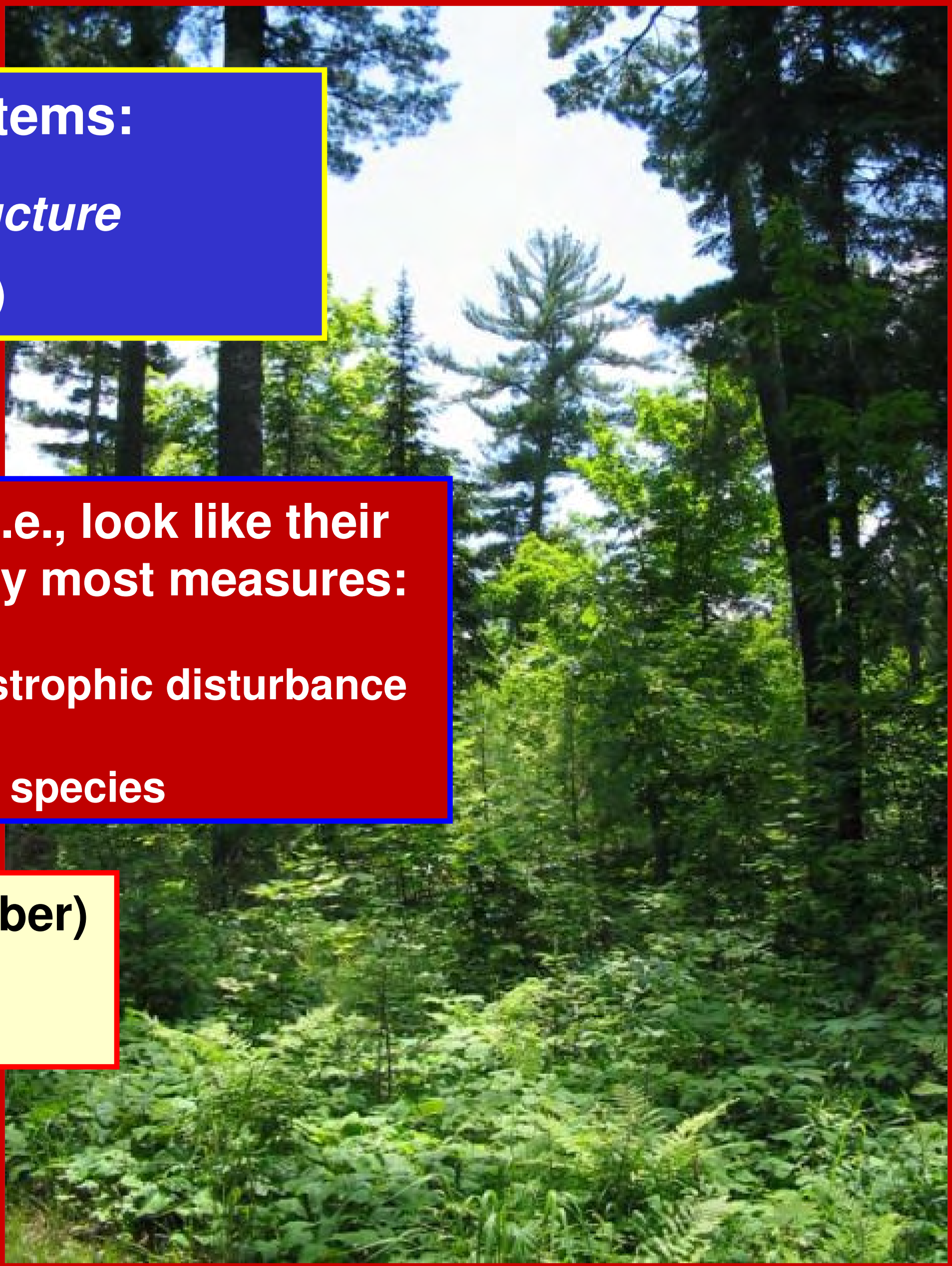
Forests that are naturally complex, i.e., look like their natural counterparts, are healthier by most measures:

-resistant to invasion and catastrophic disturbance
-store more carbon
-provide habitat for a variety of species

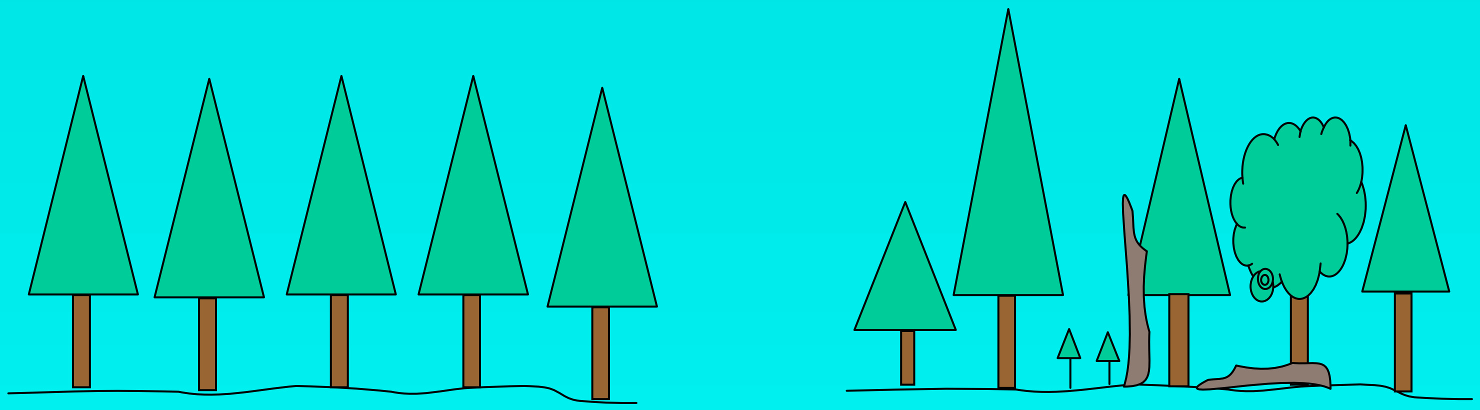
-Product diversity (timber & non timber)

-Maintaining options

Applies to all stand ages

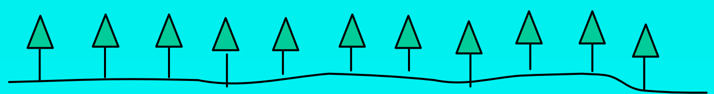


Mature Forest:

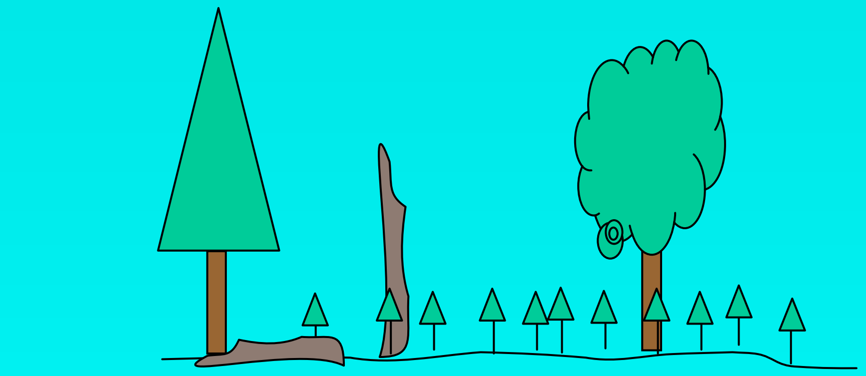


Simple → Complex

Also true for young forests



Simple



Complex

Ecological Foundations: How Complexity Develops

1) Natural disturbance

2) Stand development processes

3) Time

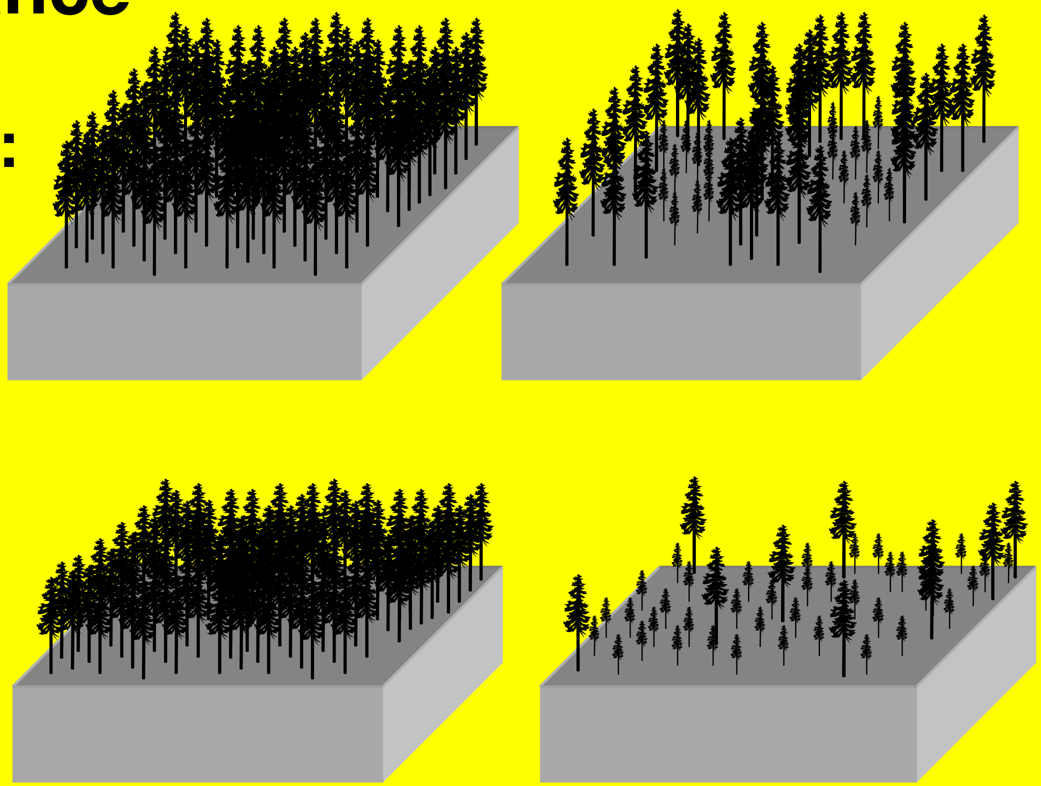
Management to restore complexity of forests and meet ecological objectives is based on "natural models".

Generators of Ecological Complexity

Natural Disturbance

-Stand maintaining:

-Stand replacing:



Structure is maintained after both types of disturbance


Stand Replacing
Canopy Disturbance
Photo courtesy of Jerry Franklin

Heavy Partial Canopy Disturbance

Stand Maintaining Canopy Disturbance


Also true for systems that are subtly complex

BIOLOGICAL LEGACIES:

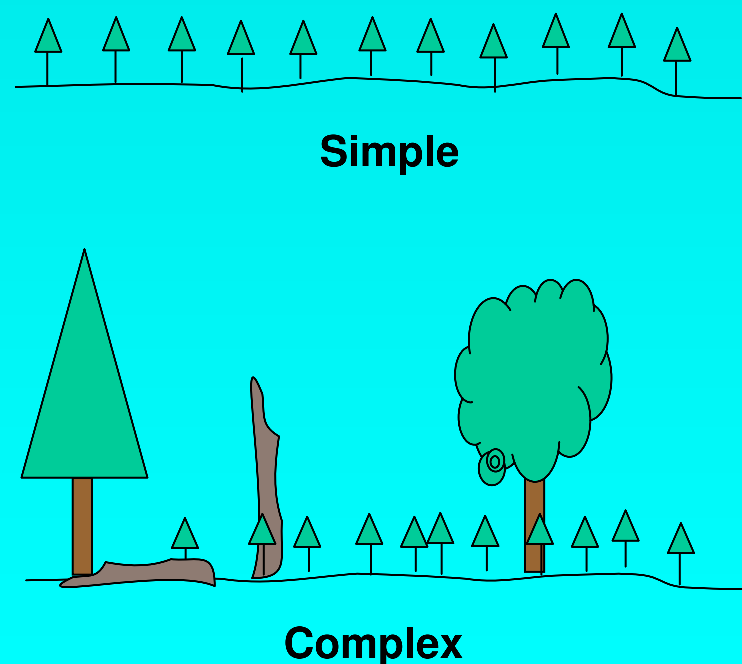
"….organisms, organic matter (including structures), and biologically-created patterns that persist from the pre-disturbance ecosystem….." (Franklin et al. 2003).

-Organisms :
trees, reproduction, seed banks, shrubs, herbs, animals

-Organic matter:
litter, forest floor

-Organically-derived structures:
CWD, root-wads

-Organically-derived patterns
patterns in soil properties
forest understory legacies



Ecological Foundations: how complexity develops

1) Natural disturbance

2) Stand development processes ★

3) Time

Management to restore complexity of forests and meet ecological objectives is based on "natural models".

Generators of Ecological Complexity

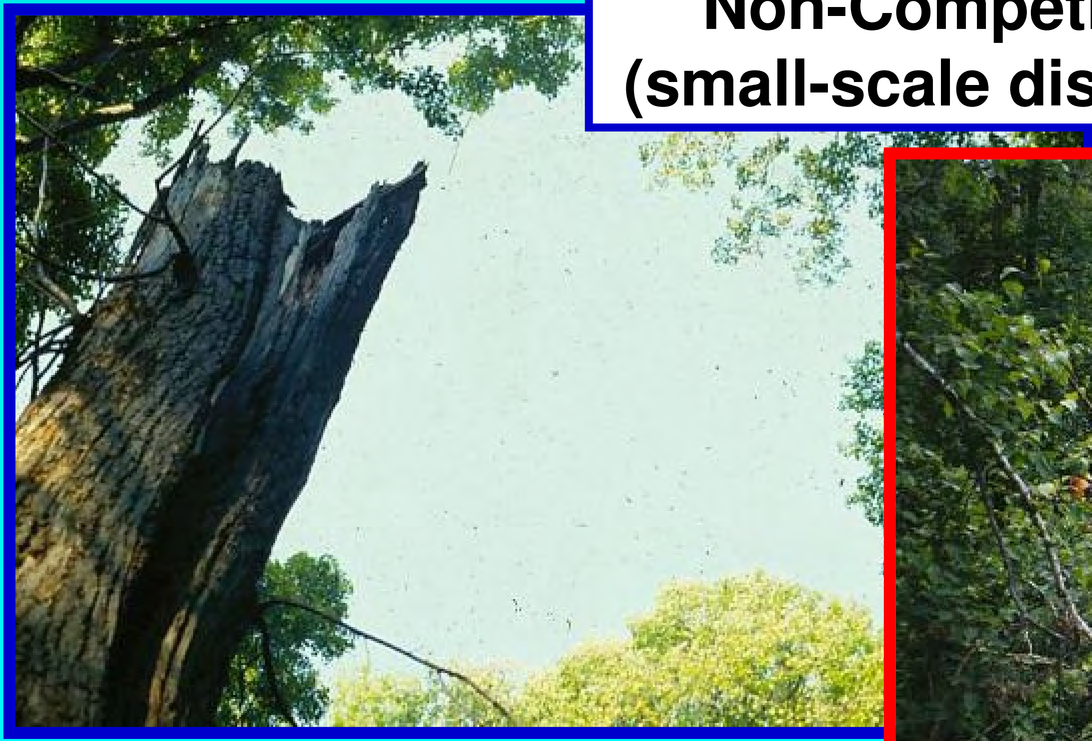
Stand Development Processes in Established Stands

-Non-competitive mortality

-Decay and decadence

Stand Development Processes

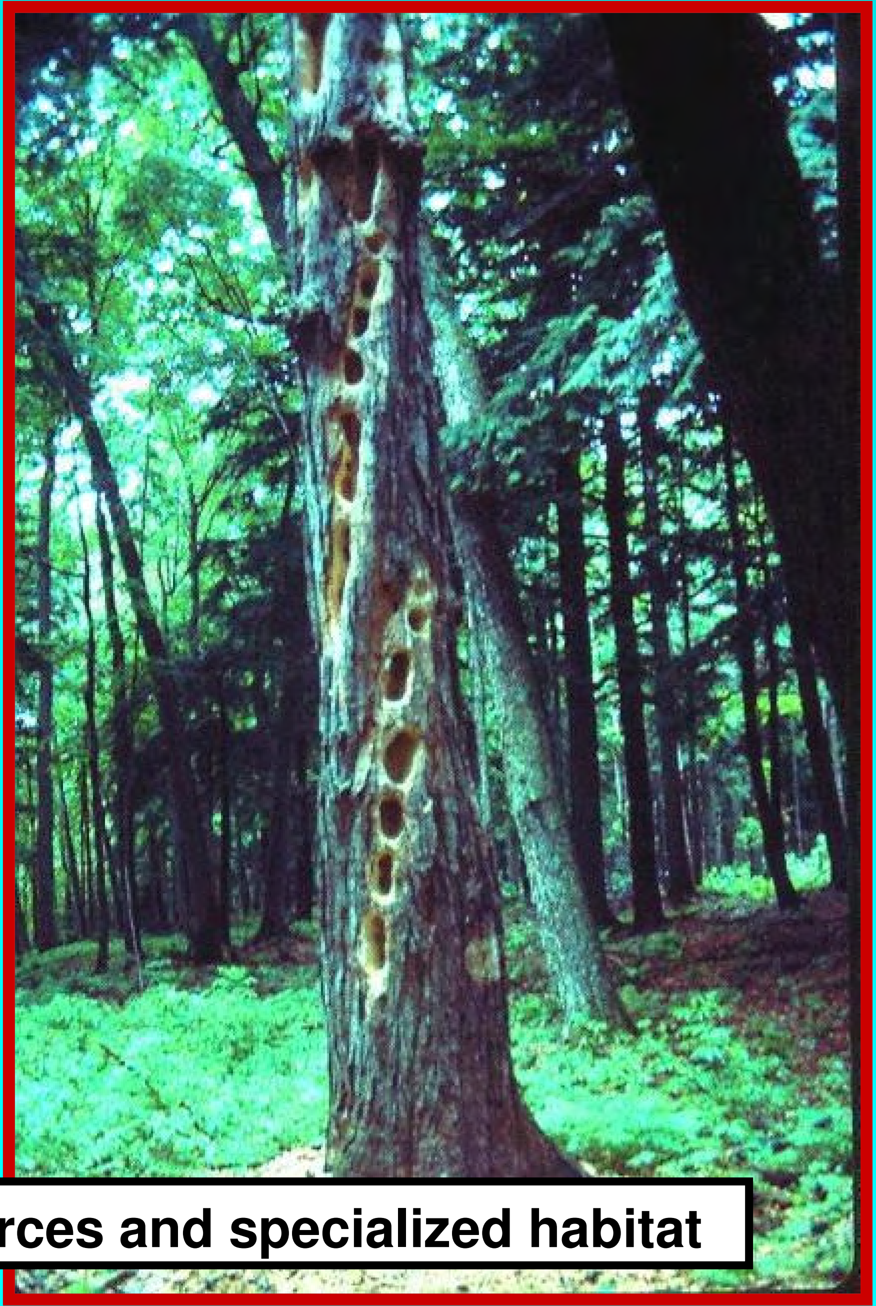
Non-Competitive Mortality (small-scale disturbance event)



- -Vertical and horizontal canopy heterogeneity
- -Resource and microclimate variation
- -Spatially variable habitat

Stand Development Processes

Decadence and Decline



Important source of resources and specialized habitat

Ecological Basis:

1) Natural disturbance

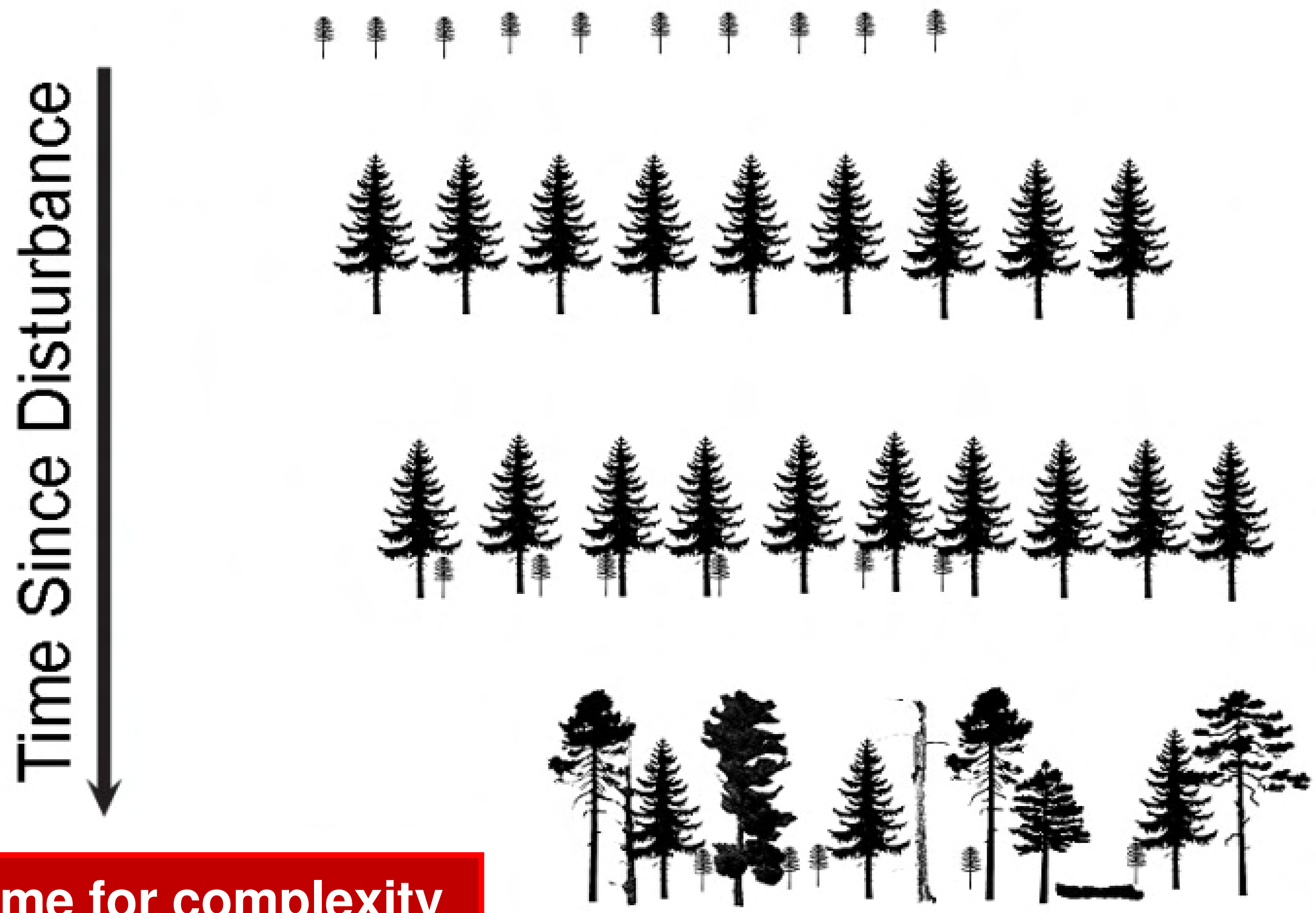
2) Stand development processes

3) Time ★

Management to restore complexity of forests and meet ecological objectives is based on "natural models".

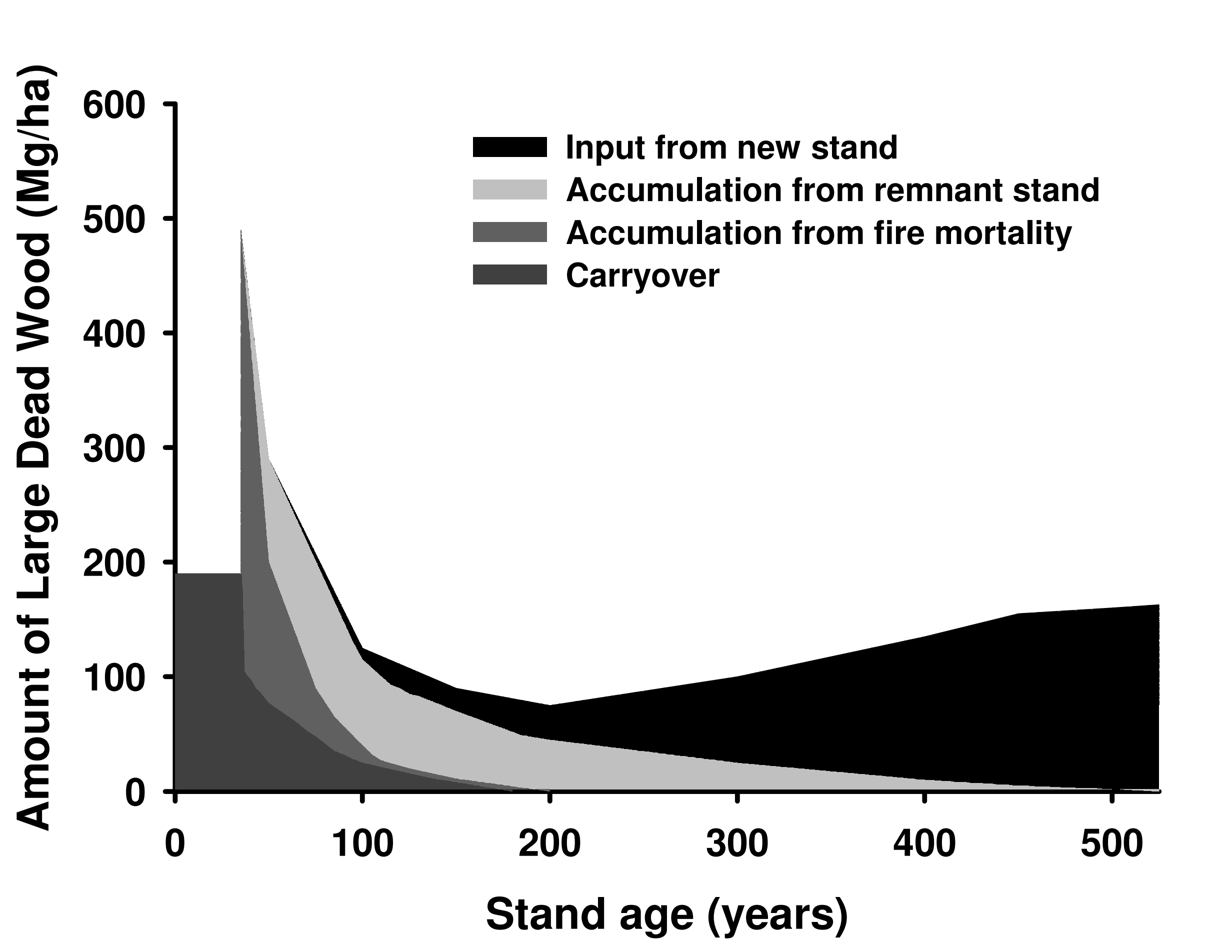
Generators of Ecological Complexity

Time



It takes time for complexity to develop!

Large Dead Wood: *Pseudotsuga menziesii* forest



Redrawn from Spies et al. 1988.

It takes over 200 years for large dead wood to begin to accumulate!

Time

Development of
old-growth structure

Development of a
tolerant understory
(enhancing species diversity)

Summary so far…

-Complexity (of forest stands) includes the type, size, and condition of structural features, as well as compositional diversity

-Greater stand complexity distinguishes unmanaged reference forests from managed counterparts (but it is all relative)

-The three primary drivers of complexity are natural disturbance, stand development process, and time

Translating ecological foundations into silvicultural principles!

Ecological Forestry: Application

Natural Models for Ecological Forestry

1) Legacy management at harvest

Legacies of disturbance

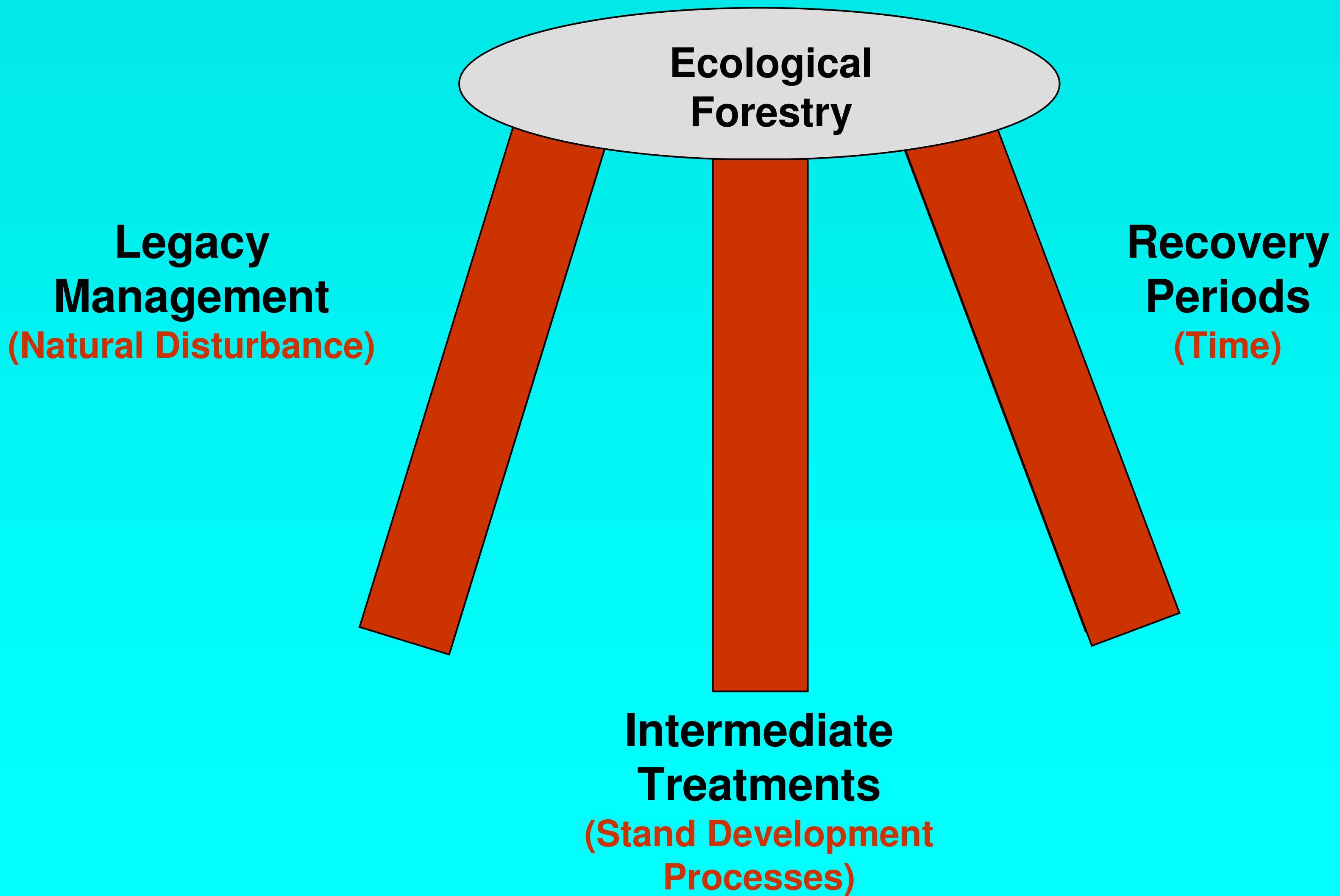
2) Intermediate treatments to create heterogeneity

Stand development processes

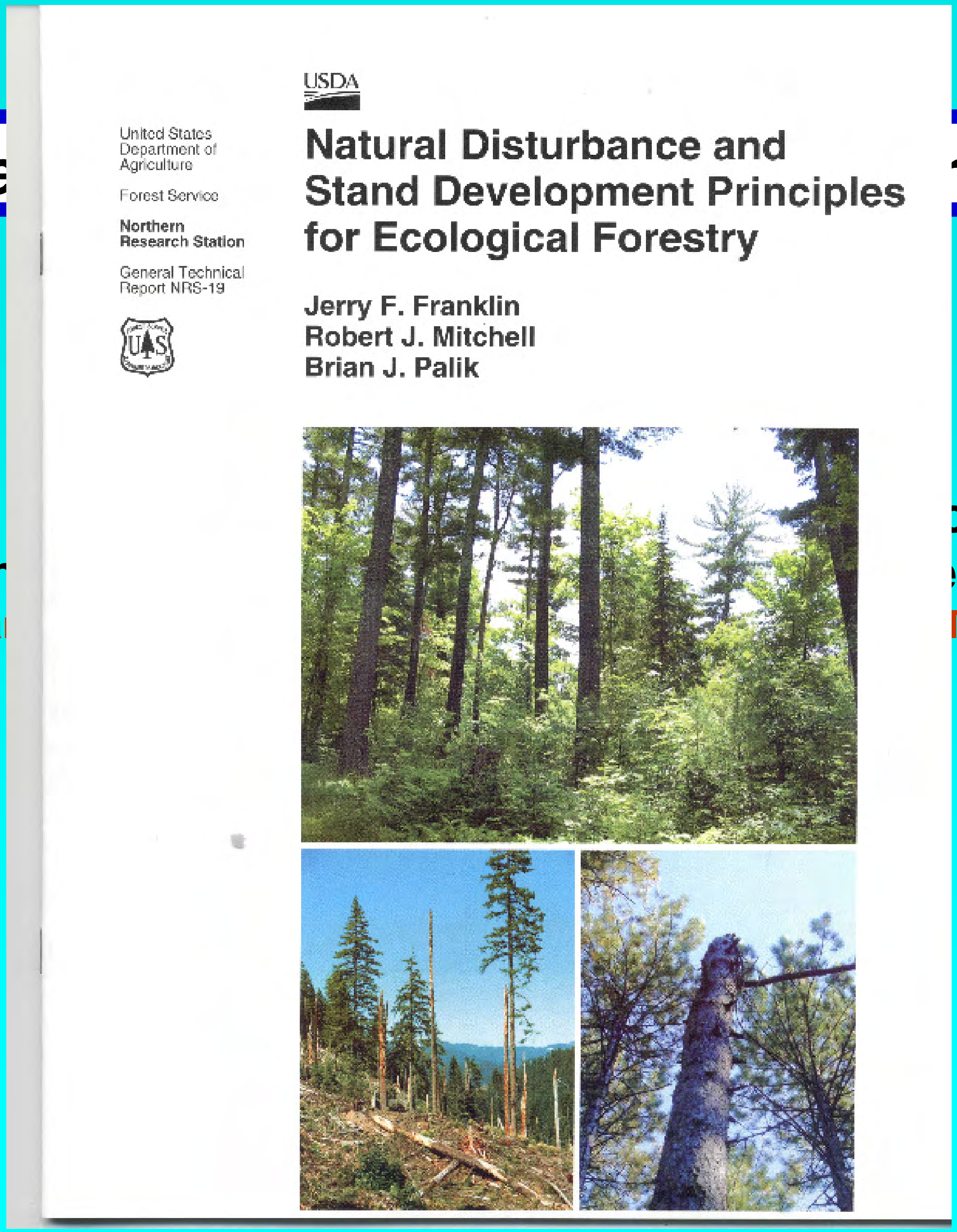
3) Appropriate recovery periods

Time

Three-Legged Stool of Ecological Forestry



Three ... estry


USDA

United States Department of Agriculture

Forest Service

Northern Research Station

General Technical Report NRS-19

Natural Disturbance and Stand Development Principles for Ecological Forestry

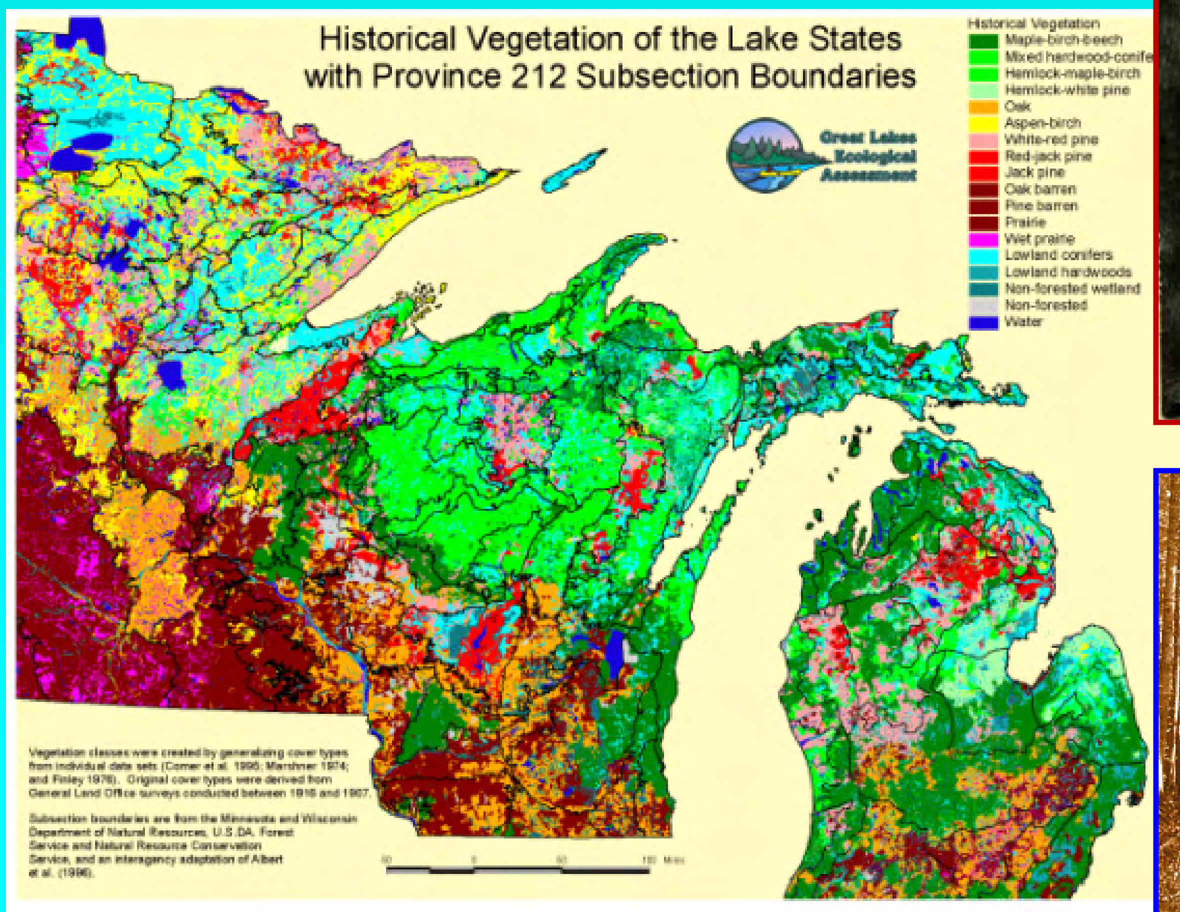
Jerry F. Franklin
Robert J. Mitchell
Brian J. Palik

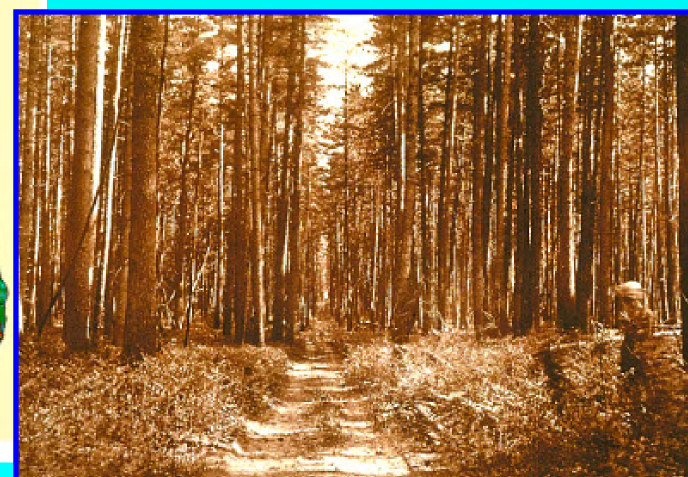
Legacy Managemen ... covery ... eriods

(Natural Disturba ... Time)

Application: Laurentian-Acadian Northern Pine (Oak) Forest

- -Historical Area: ~4 million ha
- -Contemporary Area: < 750,000 ha
- -Oak or aspen dominance; plantations





Natural Disturbance Regime: Classical Model

- Periodic surface fire: 5-20 (50) years frequency
- Infrequent crown fires (150-250 years)

Mature Forest: high needle fuels, large trees are fire resistant, limited vertical continuity w/ regular surface fire

Frequent surface fires: low severity, reduces understory competition, expose mineral seedbeds

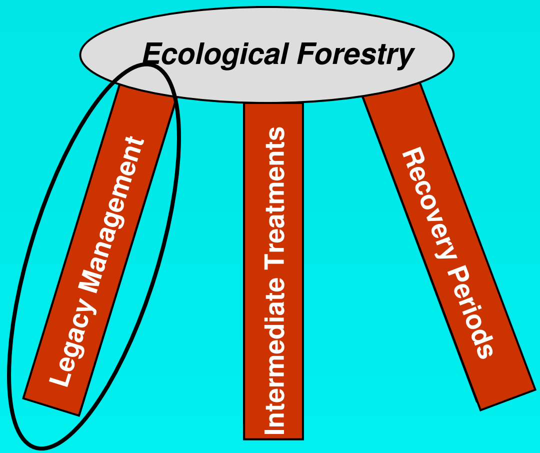
Regeneration from near-by and residual trees, even-aged (single cohort)

Infrequent stand replacement fires: high severity, high mortality of the overstory

Traditional Approach to Pine Silviculture:

Rotation age:	-50-90 years (100-150 years)
Regeneration method:	-clearcut (shelterwood)
Intermediate treatment:	-vegetation control (prescribed fire?) -thinning ~ 10 year intervals
Stand structure:	-single-cohort, usually no obvious activities directed at establishing multi-species

Simple Structure and Low Diversity



What does science tell us about application of the three-legged stool (natural models) to the pine(oak) forest?

1. **Legacies of Disturbance** (legacy management)

   -Stand replacing and heavy partial canopy disturbance (fire)

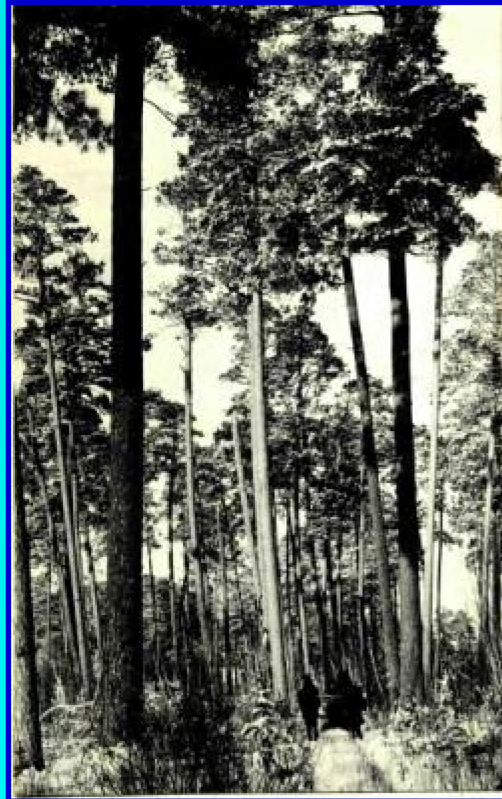
   -Even-aged (single cohort) and multi-cohort structure

Recall: classical model
Single-cohort structure?

However:

There has always been evidence that more complex (age structure) stands occurred naturally (Bergman 1924, Shirely 1932, Eyre and Zehngraff 1948), as a result of *less-than-stand-replacement fire*

FIGURE 1.—Typical virgin Norway pine stand, with young Norway reproduction in the openings. These saplings are about 18 years old and 4 to 5 feet high

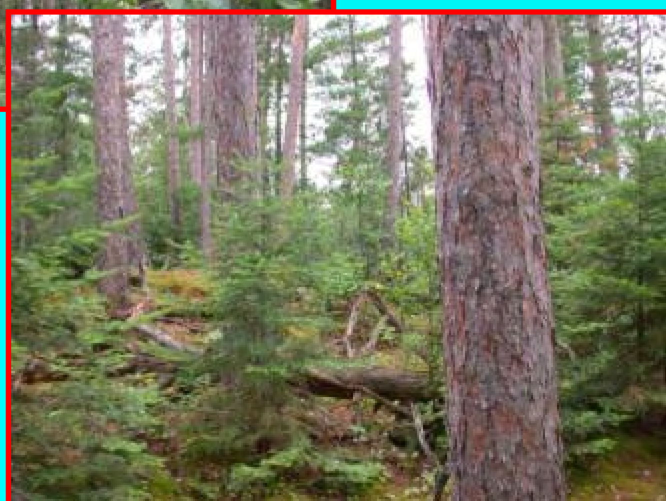


"Typical virgin Norway pine stand with young Norway reproduction in openings"

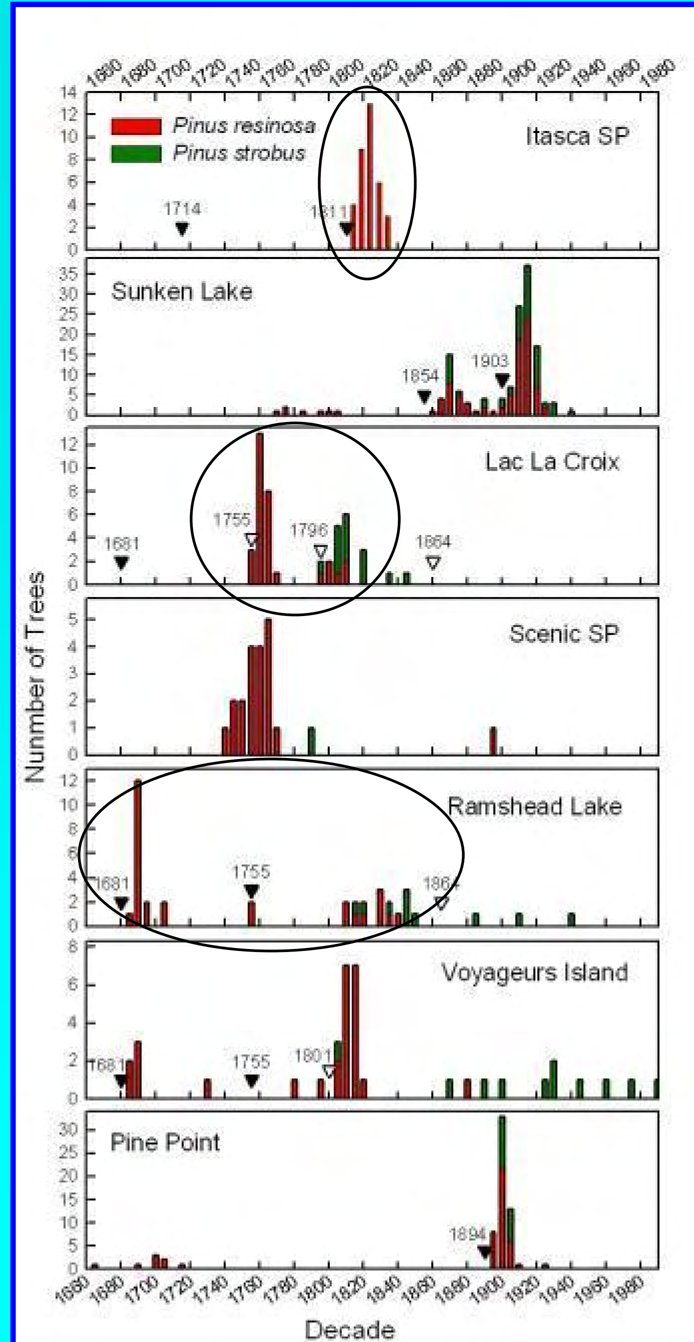
Cohort Structure in Extant Old-Growth

Shawn Fraver and Brian Palik

- -Single-cohort stands
- -Two- and three-cohort stands



Photos: Shawn Fraver



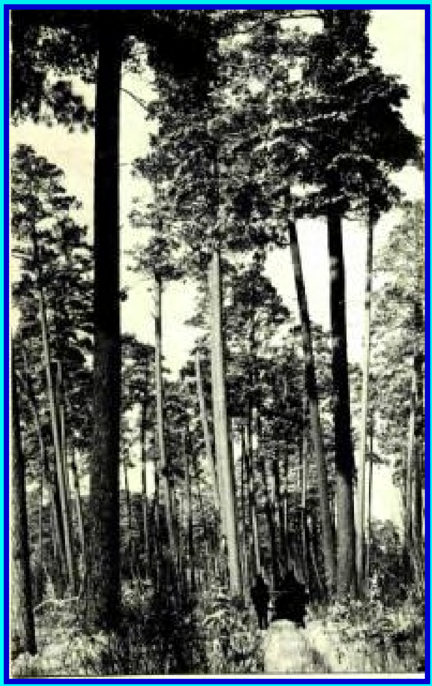
Legacy Characteristics in Pine-Oak Ecosystems

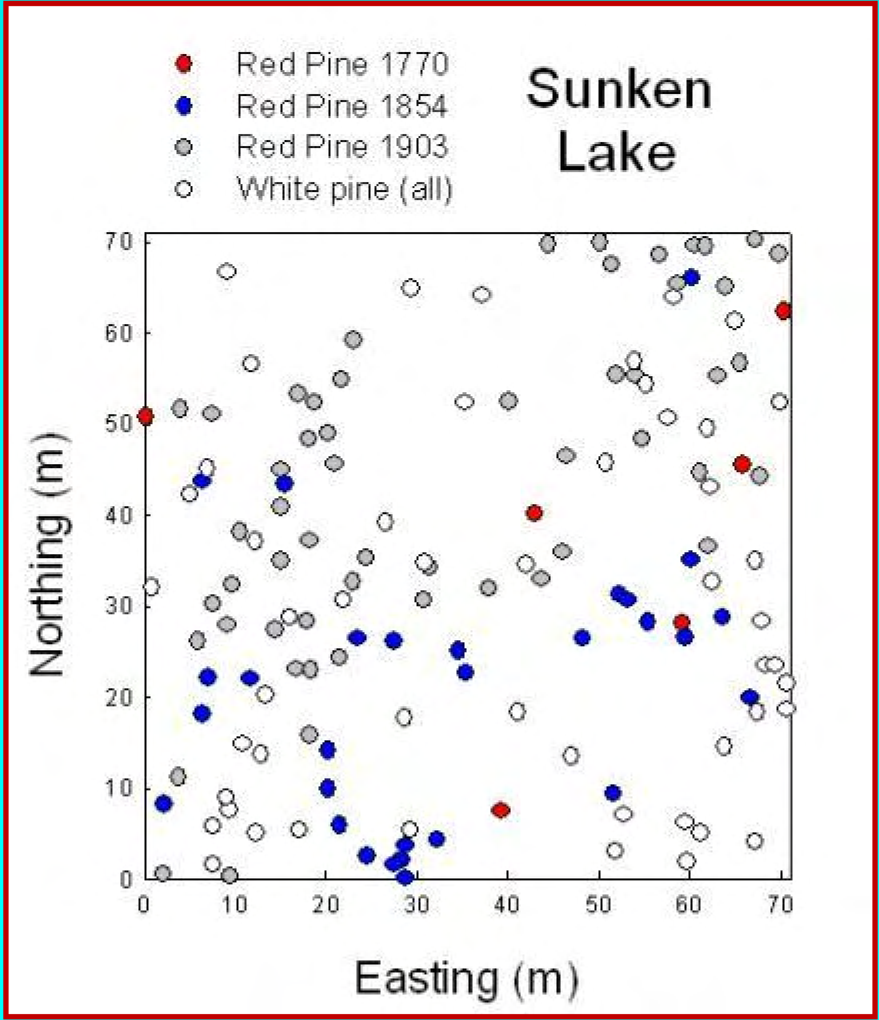
-Heavy partial canopy disturbance

-Regeneration in openings

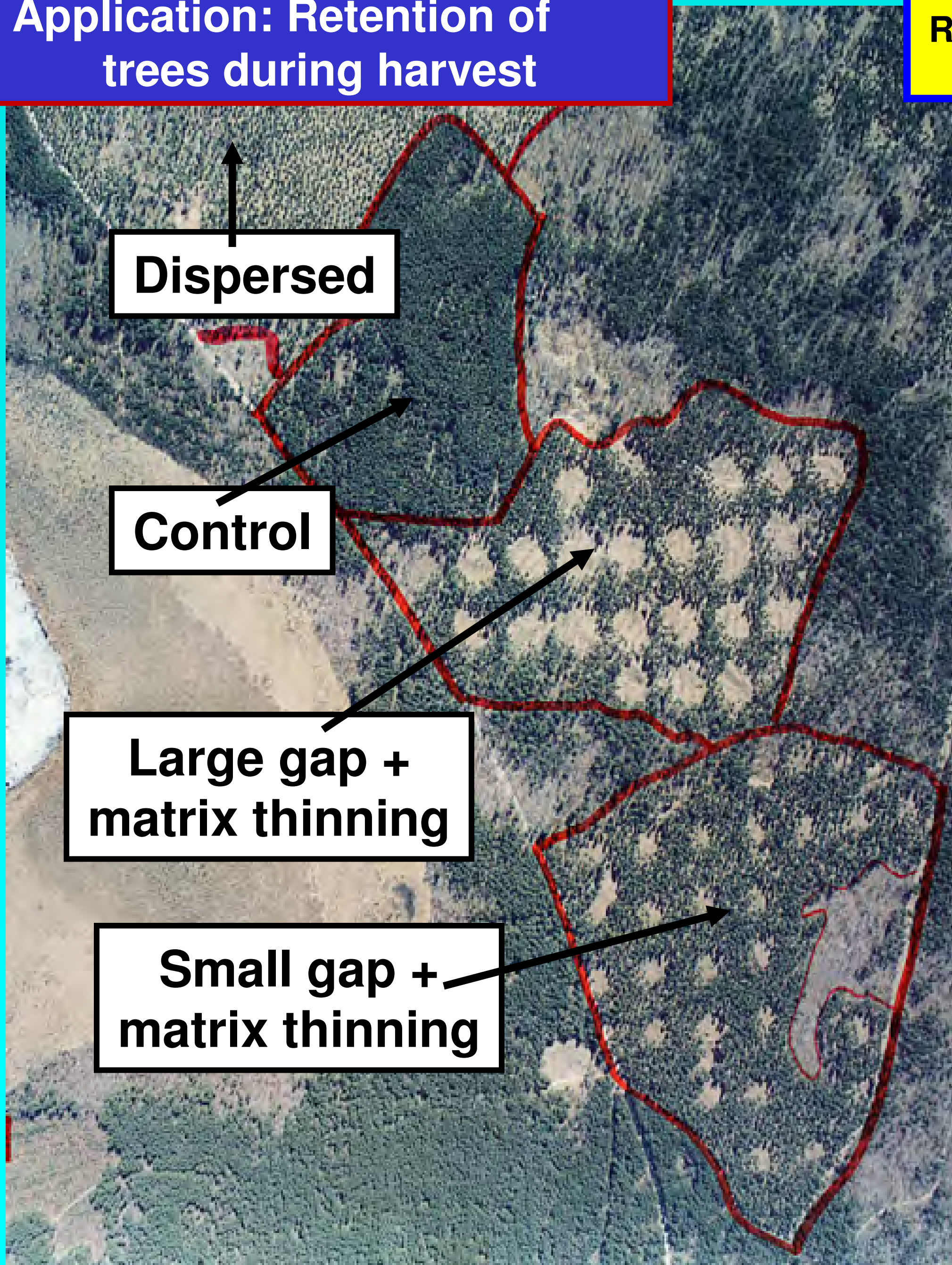
-Structural complexity

Less than stand replacing fire!





Application: Retention of trees during harvest



Red Pine Structural Retention Experiment
Chippewa National Forest, MN, USA

Northern Research Station

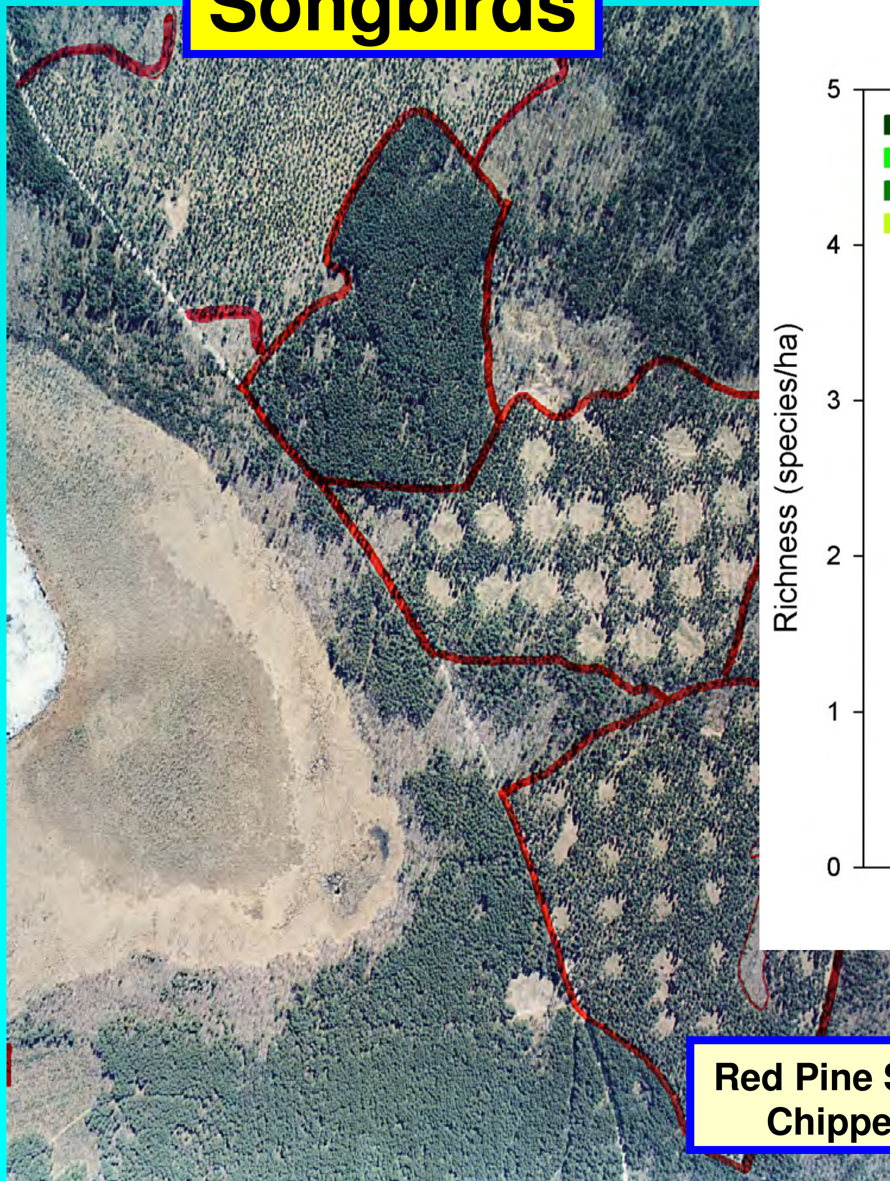
Rebecca Montgomery & Peter Reich
University of Minnesota

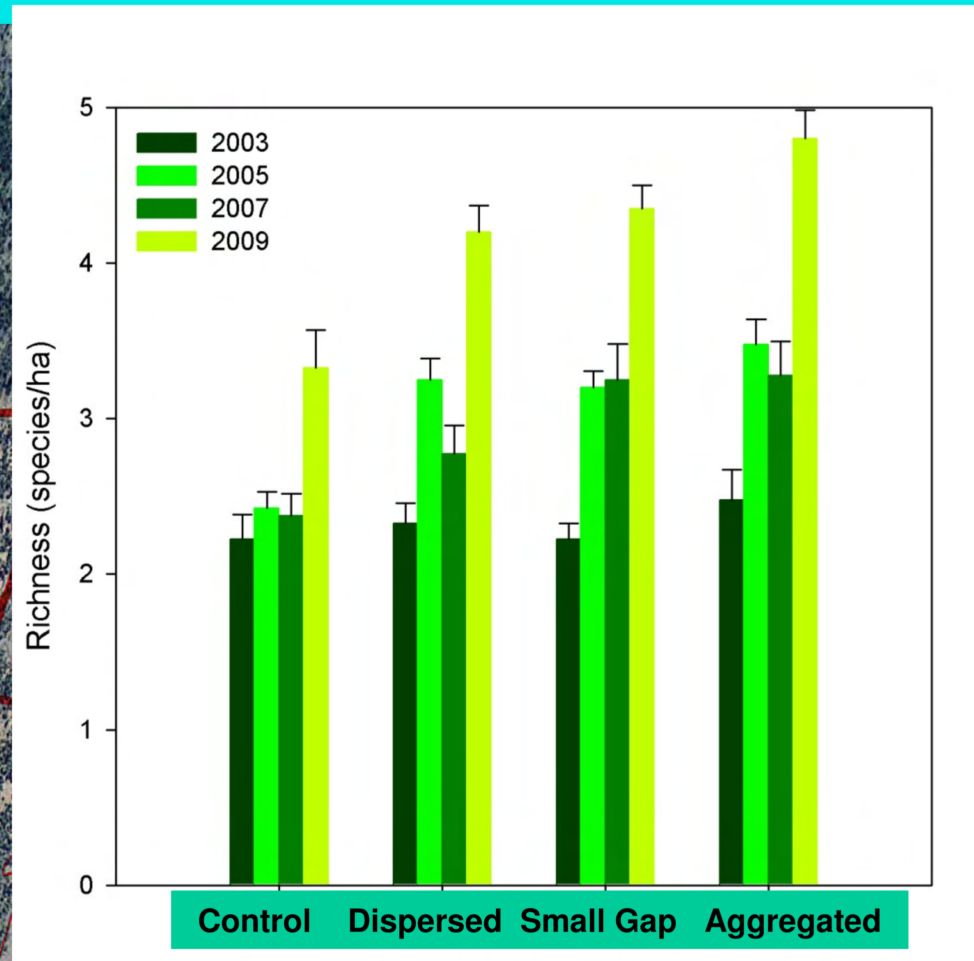
Suzie Boyden
Clarion College

Heavy partial "regeneration" disturbance:

- -Retain canopy trees
- -Emulates a mixed severity fire regime
- -Patchy, aggregated retention
- -Many things being monitored

Songbirds





Red Pine Structural Retention Experiment
Chippewa National Forest, MN, USA

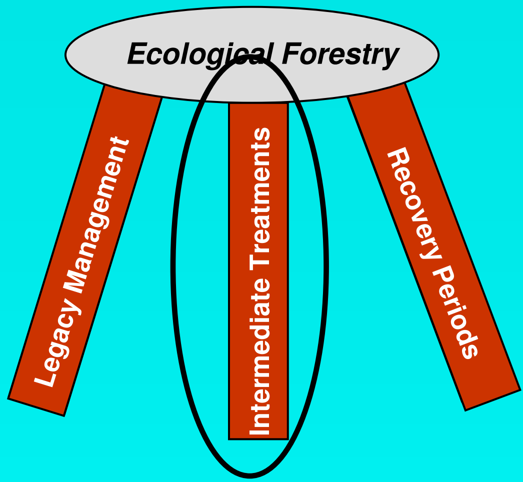
Northern
RESEARCH STATION
USDA Forest Service

Legacy Management: not just trees

Also snags, downed wood, understory plants, etc.

In general, consider retention of structures and conditions that take a long time to develop

What does science tell us about application of the three-legged stool (natural models) to the pine(oak) forest?



2. Stand Development Processes (Intermediate treatments)

- -Stand-maintaining disturbance (surface fire)
- -Non-competitive mortality/decadence and decline
- -Mixed-species stands

What do we know about process in established stands?

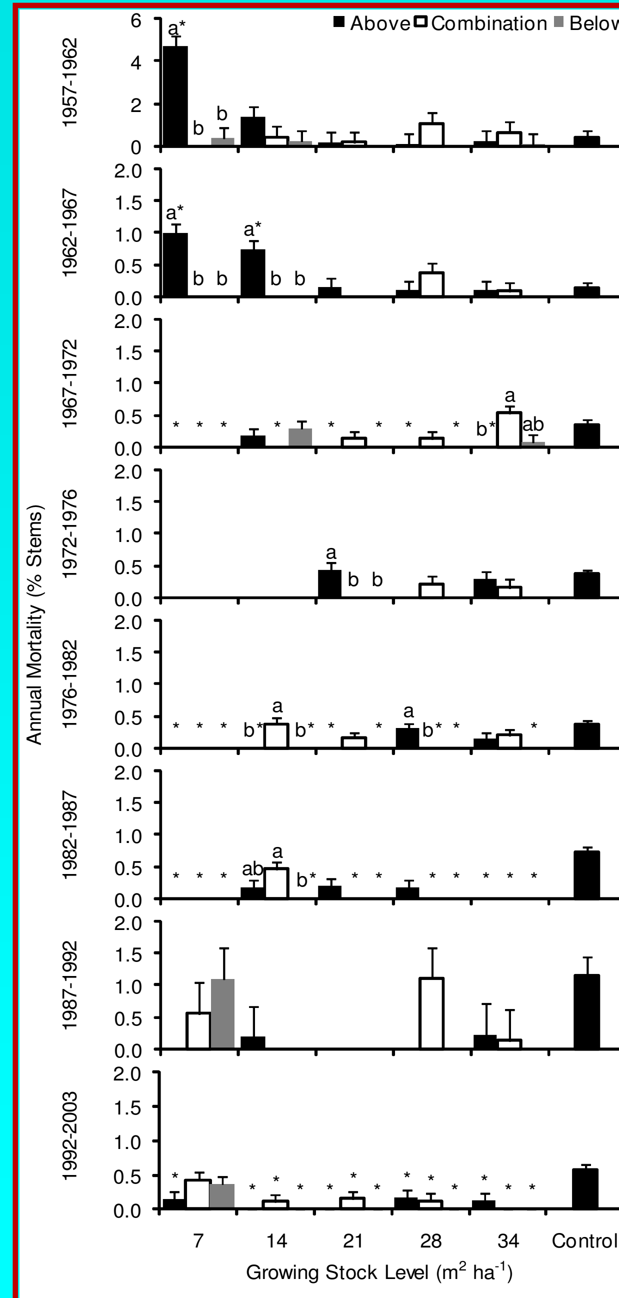
~Frequent surface fires occurred in established stands

Historical evidence suggests this could occur

We know what can happen without fire

We also know…that trees die for various reasons and their death results in heterogeneous structure

Annual Mortality in Red Pine Stands

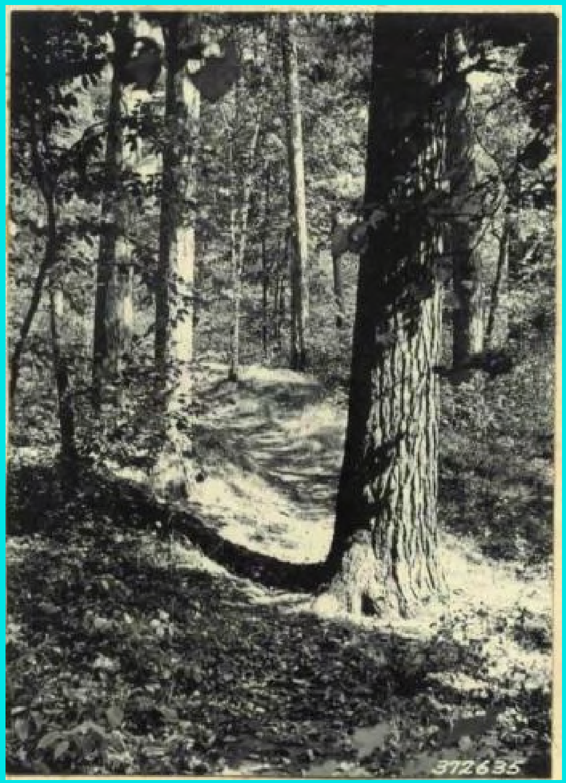


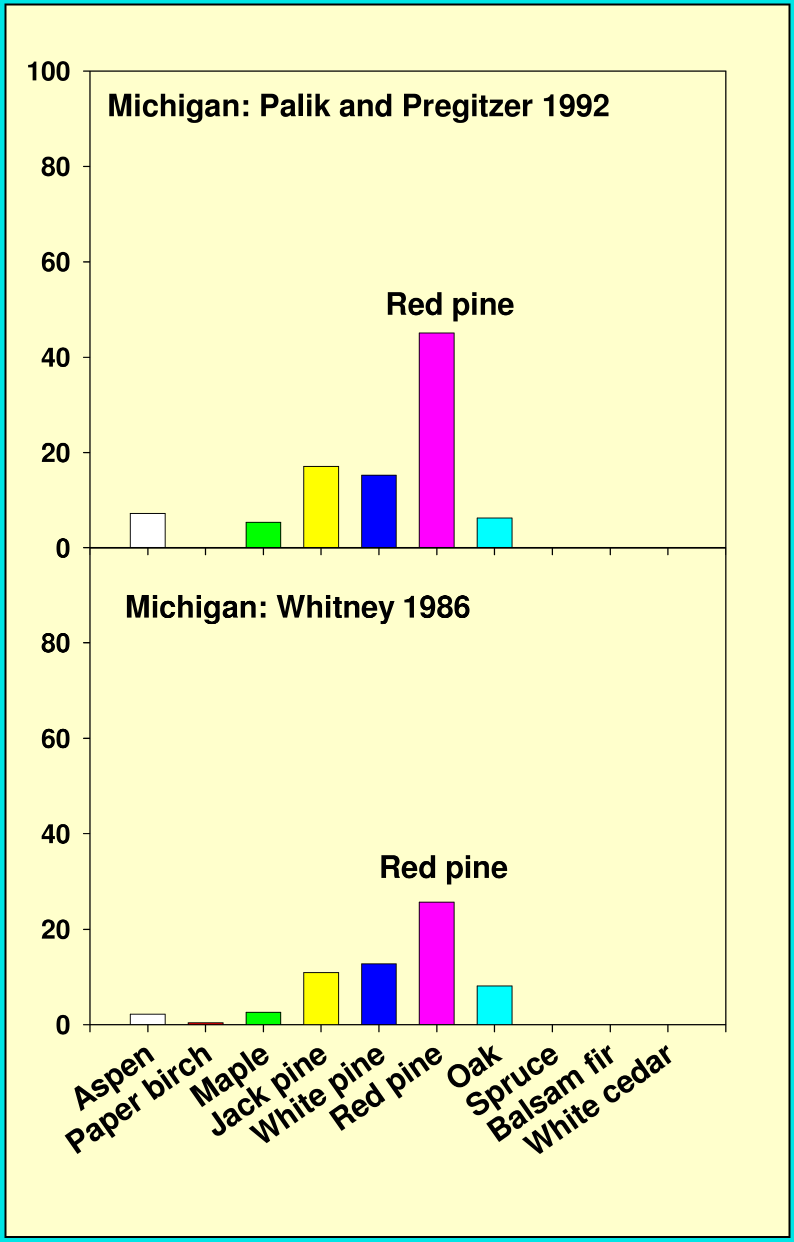
Powers et al. 2011. Forest Ecology and Management

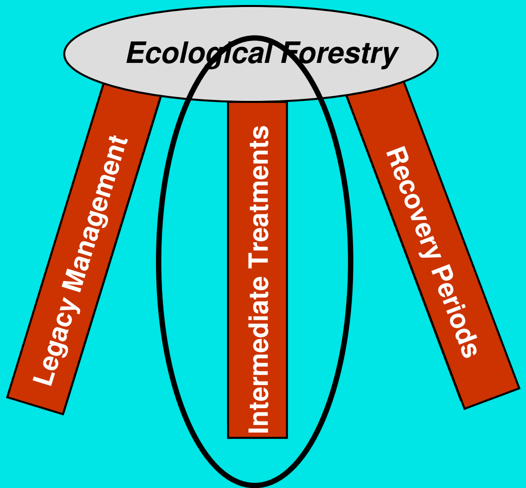
We also know that other species were important in pine stands historically

Development of Mixed-Species Stands

This suggests that surface fires were patchy and, along with non-competitive mortality from various causes, resulted in more heterogeneous structure and diverse stands that we create with management





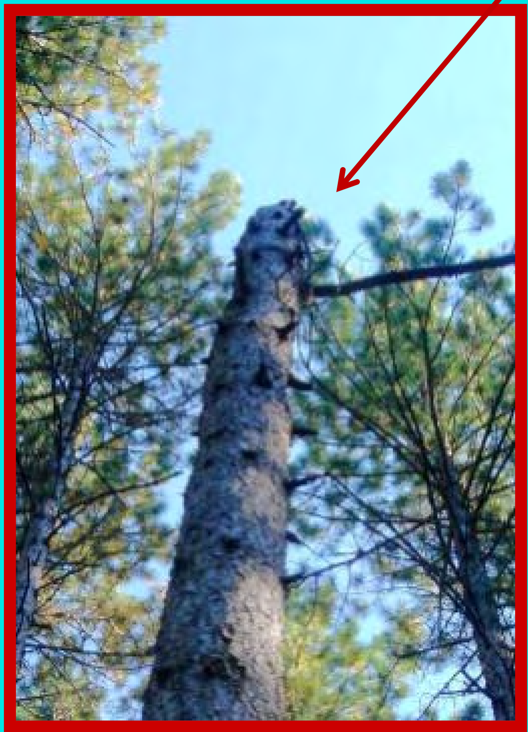


2. Intermediate treatments in established stands

-Decadence creation

-Prescribed fire

-Variable density thinning

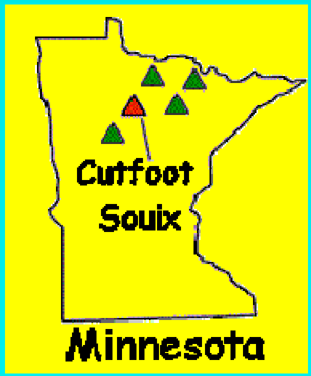


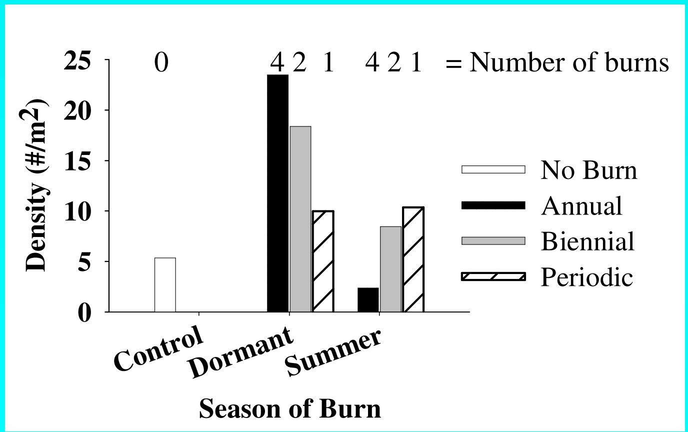
Goals:

-Manipulate stands to direct development to desired condition

-Create heterogeneity in simplified stands

Prescribed Fire

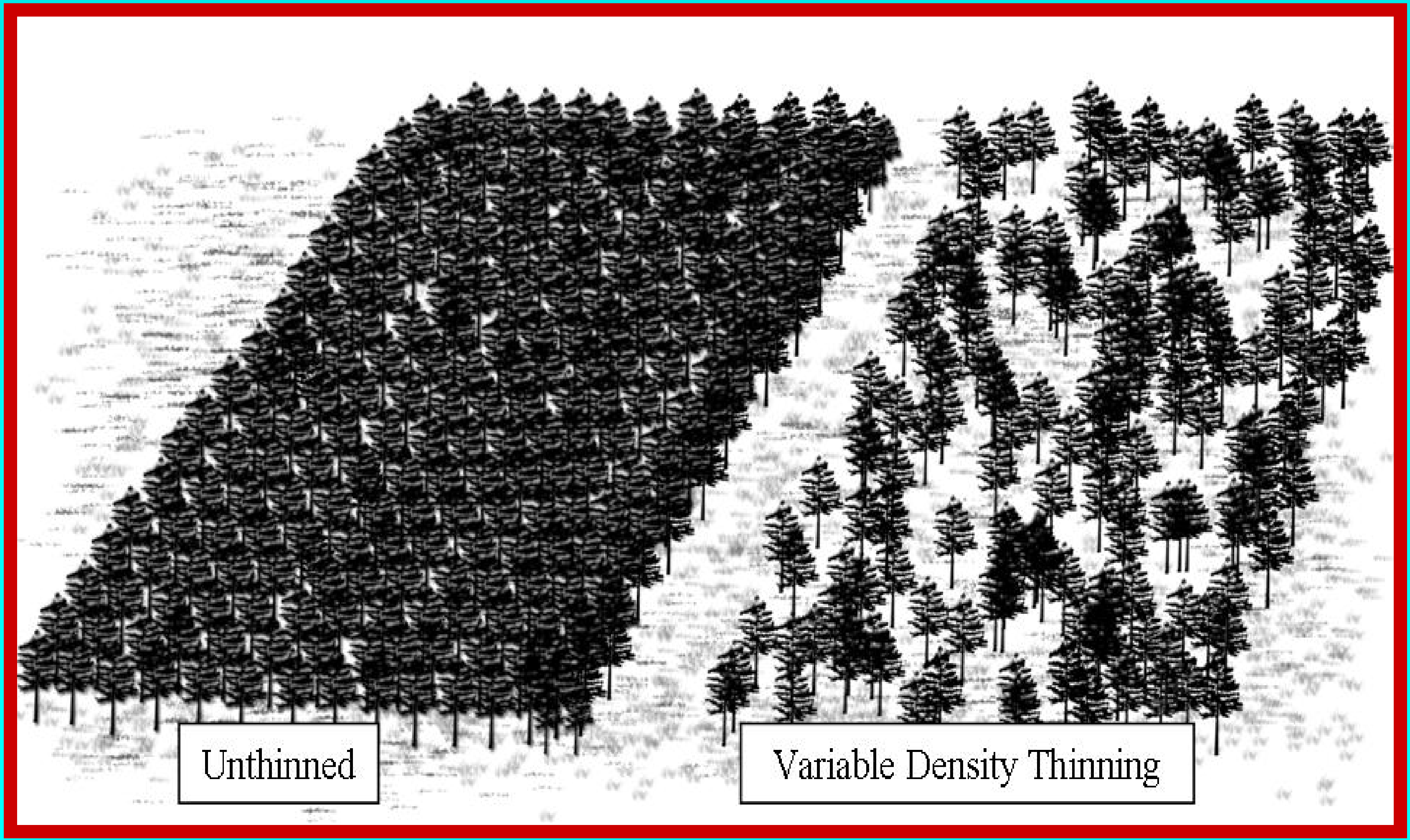




Corylus sp. density among fire treatments at Red Pine Burning Study.

Variable density thinning

- -Accelerating development of heterogeneity
- -Provides opportunities for other tree species to establish



Variable density thinning

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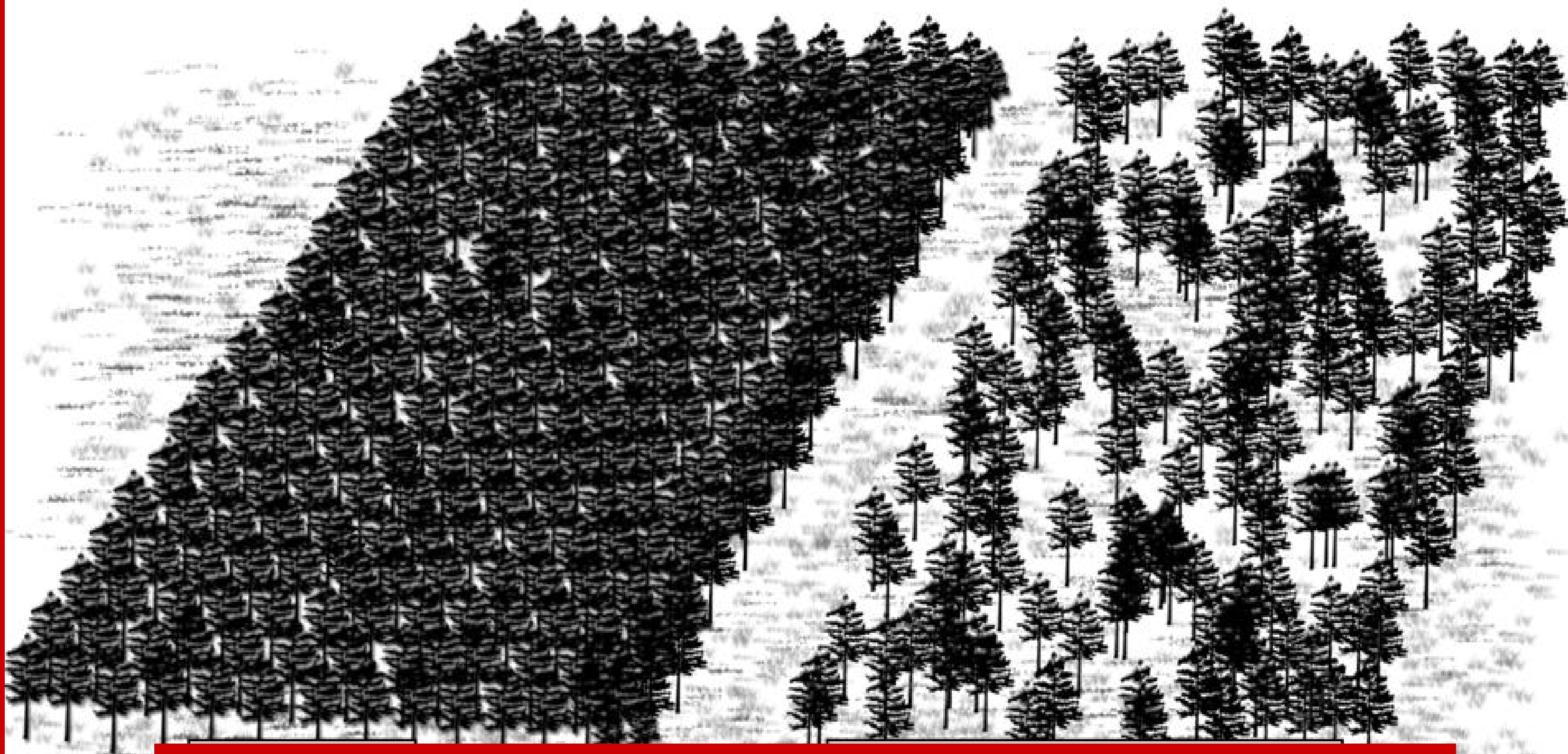
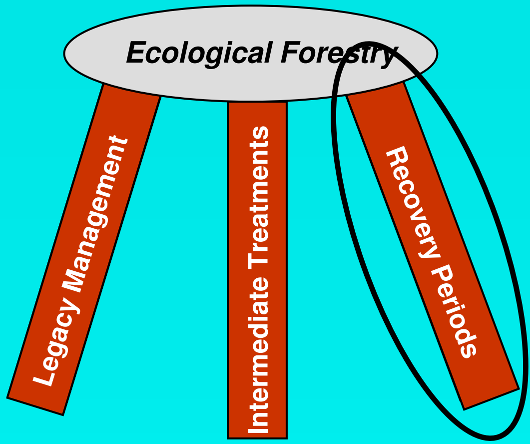


Spatial heterogeneity versus homogeneity!

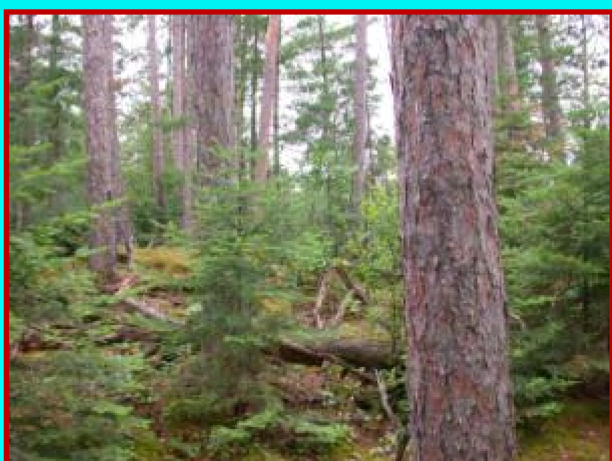


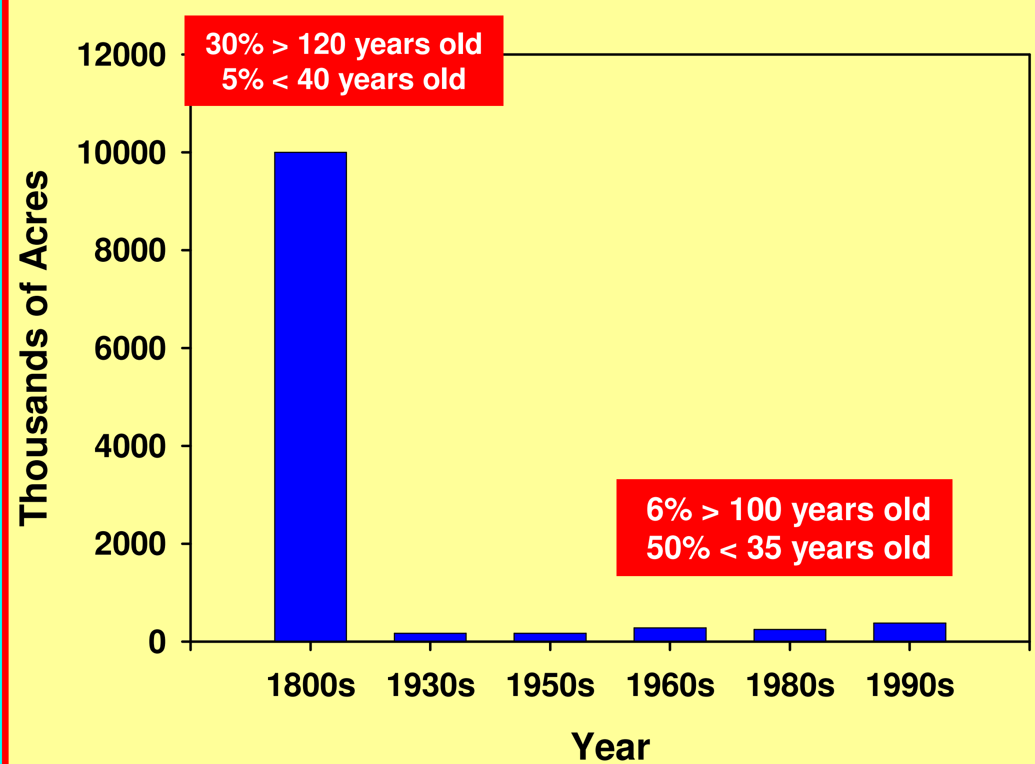
What does science tell us about application of the three-legged stool (natural models) to the pine(oak) forest?

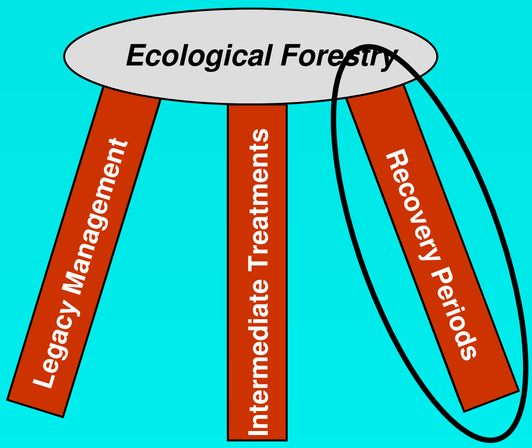
3. Time (Appropriate recovery periods)

-Old stands were common historically

-Old stands have a lot of structure







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3. Time (Appropriate recovery periods)

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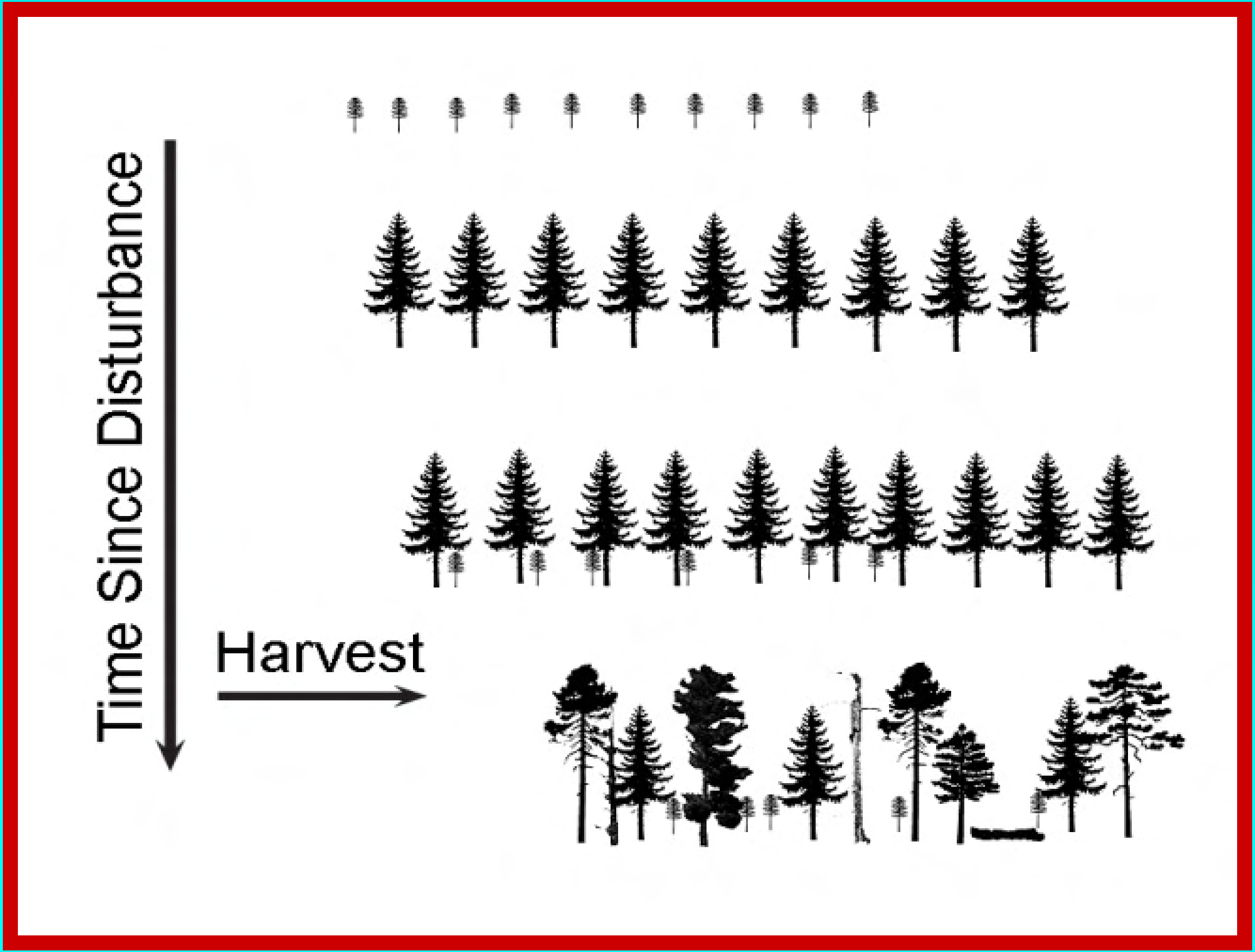
- **-Old stands have a lot of structure**

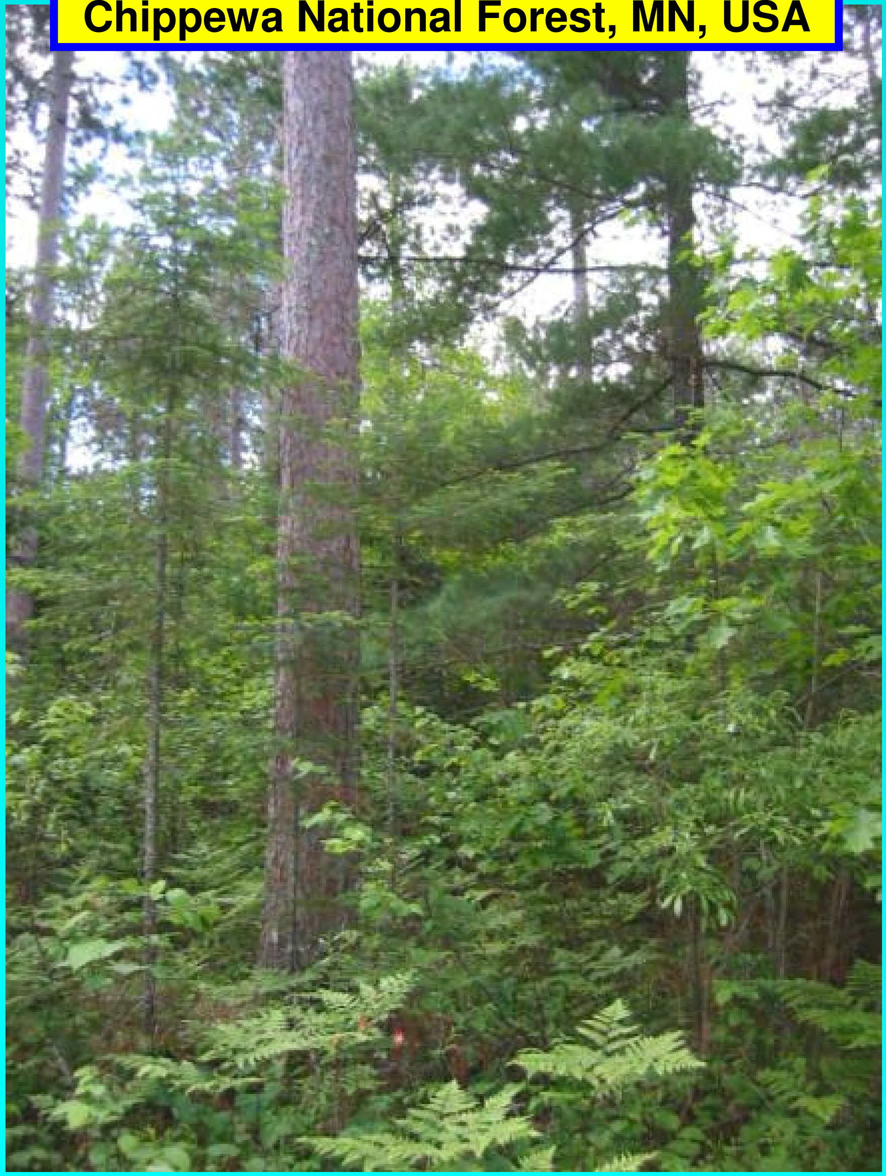
Site	Trees >40 cm dbh/ha	Snags >40 cm dbh/ha	Uprootings No./ha	DWD Vol./ha
Itasca State Park	130	10	24	61.6
Sunken Lake	104	2	15	74.5
Lac La Croix	112	24	16	127.6
Scenic State Park	92	6	30	82.4
Ramshead Lake	114	22	2	120.4
Voyageurs Island	80	54	24	157.8
Pine Point	62	20	22	75.5

It take a long time for complexity to develop



Application: Longer recovery periods between regeneration harvests

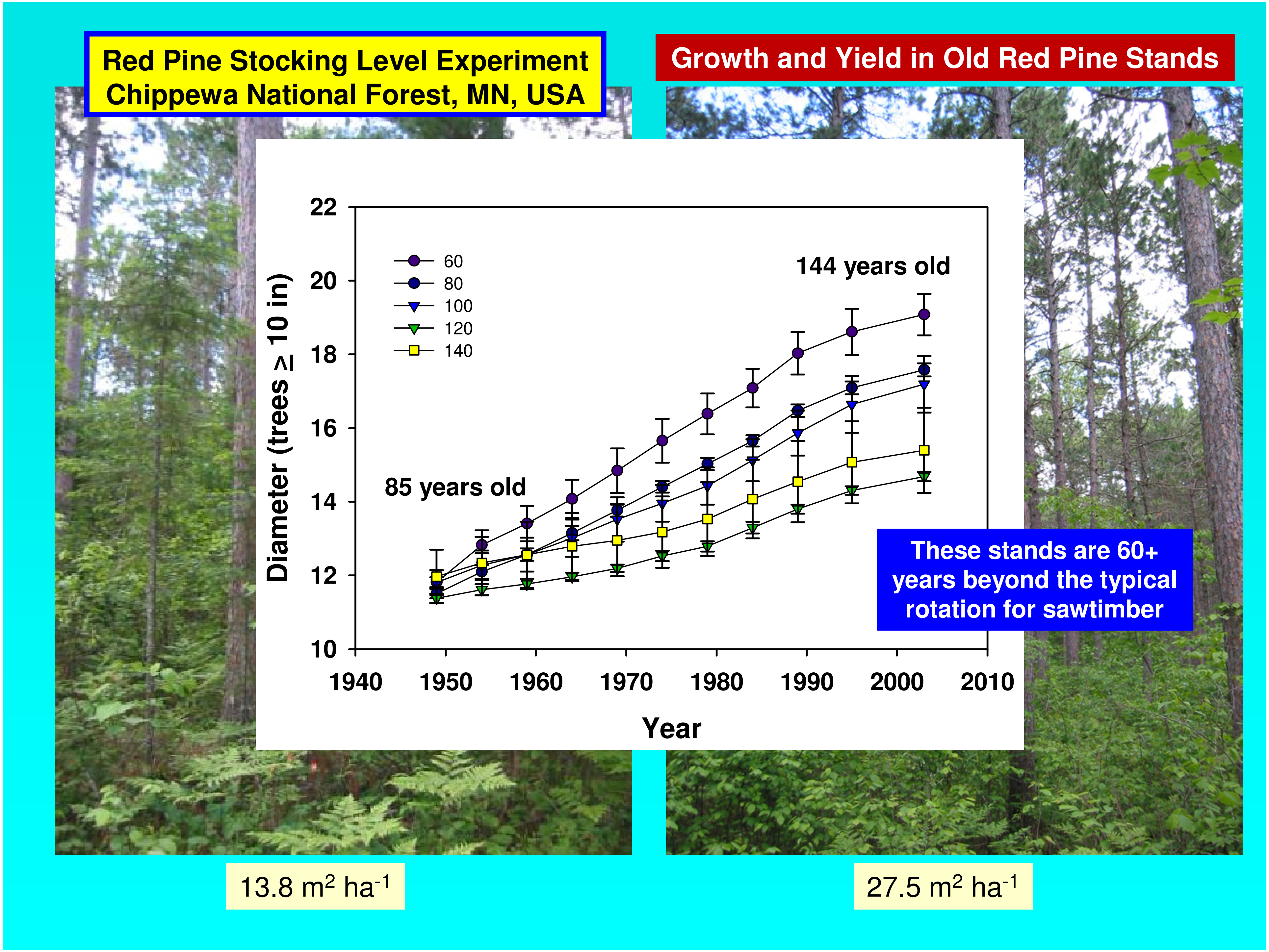
Red Pine Stocking Level Experiment
Chippewa National Forest, MN, USA



13.8 $m^2\ ha^{-1}$

Growth and Yield in Old Red Pine Stands

27.5 $m^2\ ha^{-1}$


Red Pine Stocking Level Experiment
Chippewa National Forest, MN, USA
Growth and Yield in Old Red Pine Stands
Diameter (trees ≥ 10 in)
Year
60
80
100
120
140
144 years old
85 years old
These stands are 60+ years beyond the typical rotation for sawtimber
22
20
18
16
14
12
10
1940
1950
1960
1970
1980
1990
2000
2010
13.8 m² ha⁻¹
27.5 m² ha⁻¹

Red Pine Stocking Level Experiment
Chippewa National Forest, MN, USA

13.8 m^2 ha^{-1}

Growth and Yield in Old Red Pine Stands

27.5 m^2 ha^{-1}

Low stocking stands in particular are structurally complex and have high quality, large trees

Application:

Why organizations and agencies are adopting ecological approaches?

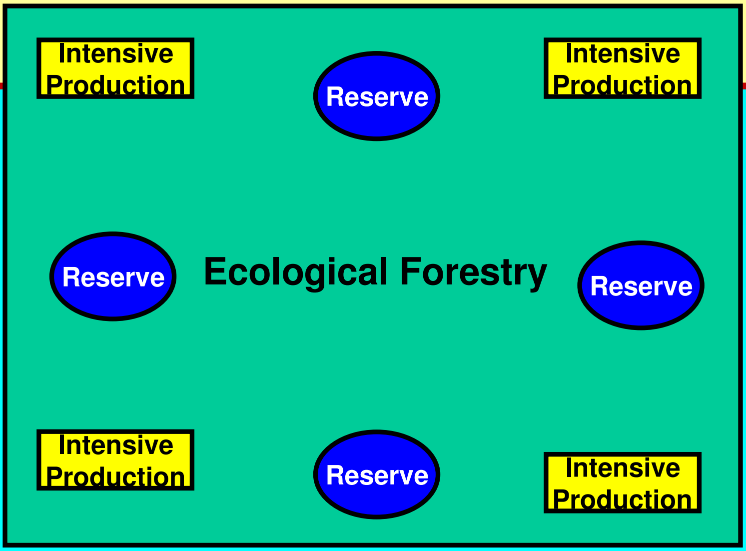
Increasingly part of comprehensive (sometimes) strategies to:

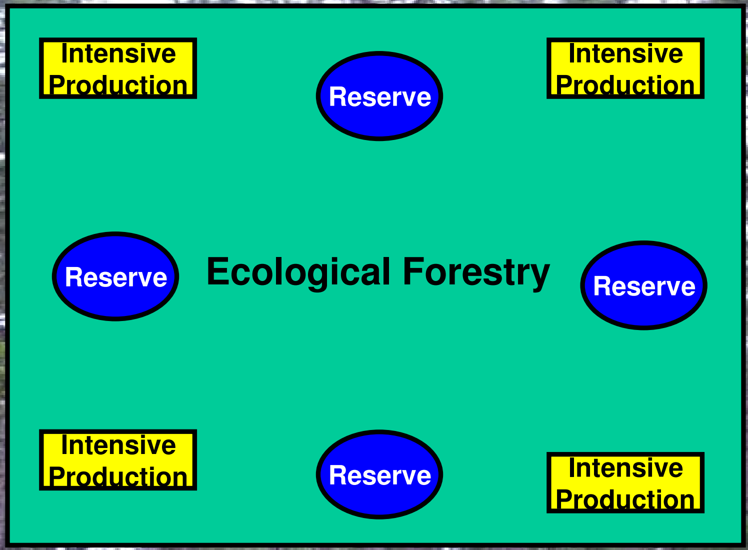
- *Sustain biodiversity and ecological services*
- *Restore native ecosystems*

Mandated by public interests on public lands

National Forest Management Plans: some of the next generation speak to restoring and managing based on elements of natural models

- Helps m*eet requirements of forest certification (especially FSC)* An important driver on many ownerships





Ecological Forestry: needs to be flexible

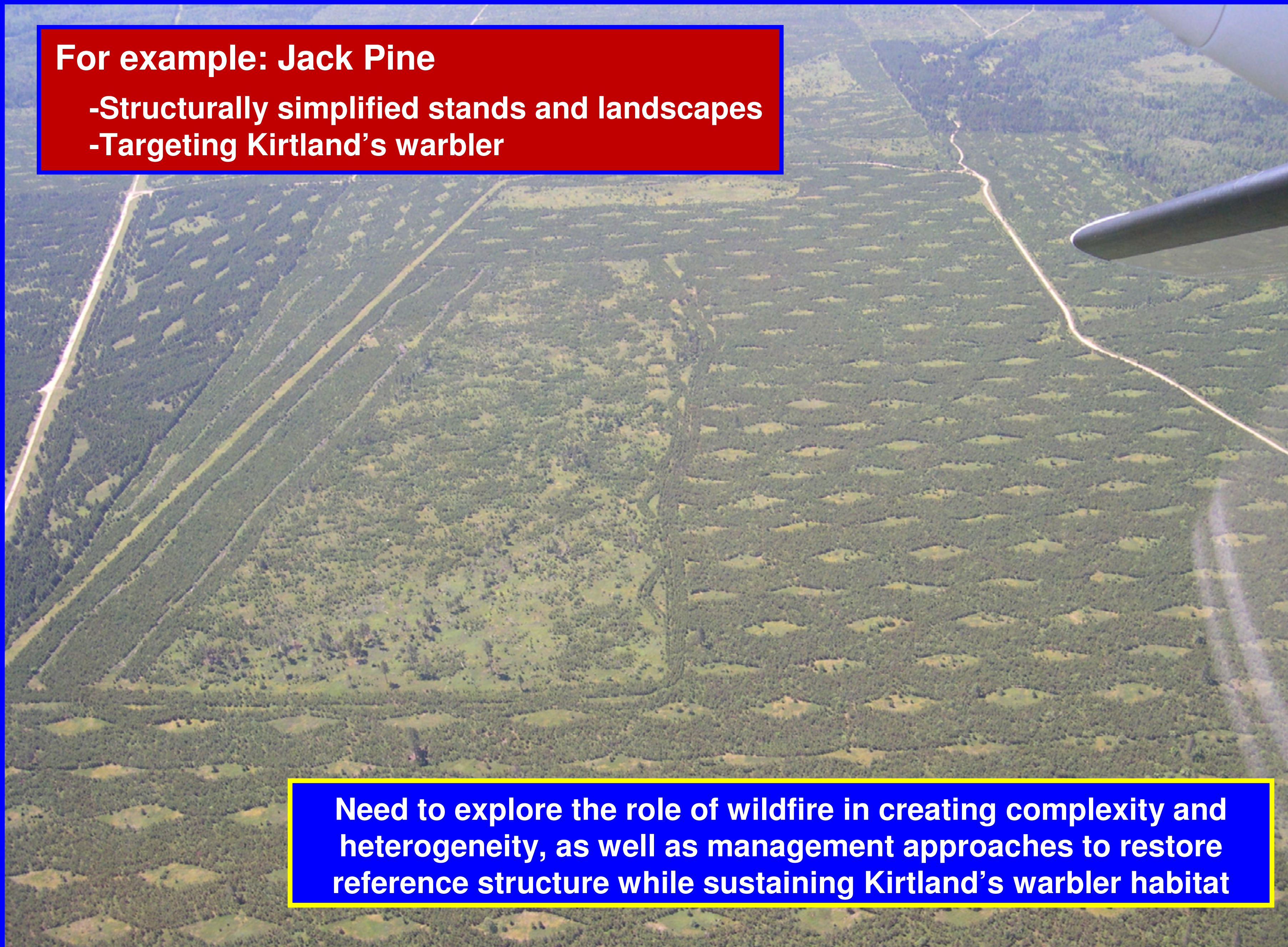
1) Balancing economic and ecological objectives

2) A continuum of approaches

3) Applicable to a wide range of fire-dependent forests in our region

For example: Jack Pine

- -Structurally simplified stands and landscapes
- -Targeting Kirtland’s warbler



Need to explore the role of wildfire in creating complexity and heterogeneity, as well as management approaches to restore reference structure while sustaining Kirtland’s warbler habitat

For example: Fire-dependent oak

- -Commercial important
- -Key wildlife habitat
- -At risk regionally

Ecological management: the role of fire and fire-surrogates in sustaining/restoring structure and composition

Lake States Fire Science Consortium

In summary:

Traditional (agricultural model) forest management results in greatly simplified structure and composition

There is ample evidence that most forest ecosystems were more complex and heterogeneous than their managed counterparts

Simplified forests have reduced biodiversity, are less healthy by many measures, and provide fewer options for the future

Forests managed using natural models sustain biodiversity, provide more options for services, and are more adaptable to uncertain futures

Forestry based on natural models has wide applicability to the bulk of our forest estate; e.g. mixed pine-oak, but other systems as well!

Ecological forestry needs to be flexible; there is a continuum of approaches to consider