Ecological silviculture in the Douglas-fir/western hemlock region

Klaus Puettmann

Oregon State University
College of Forestry

and a long list of students, colleagues, and cooperators, especially B. McComb, J. Tappeiner, and A. Mershell

Outline

Background

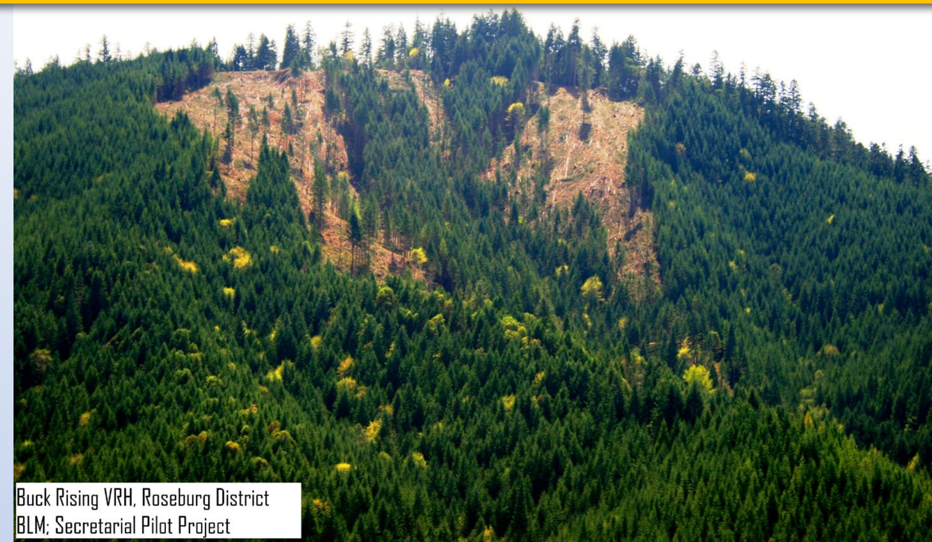
BLM – ecological forestry

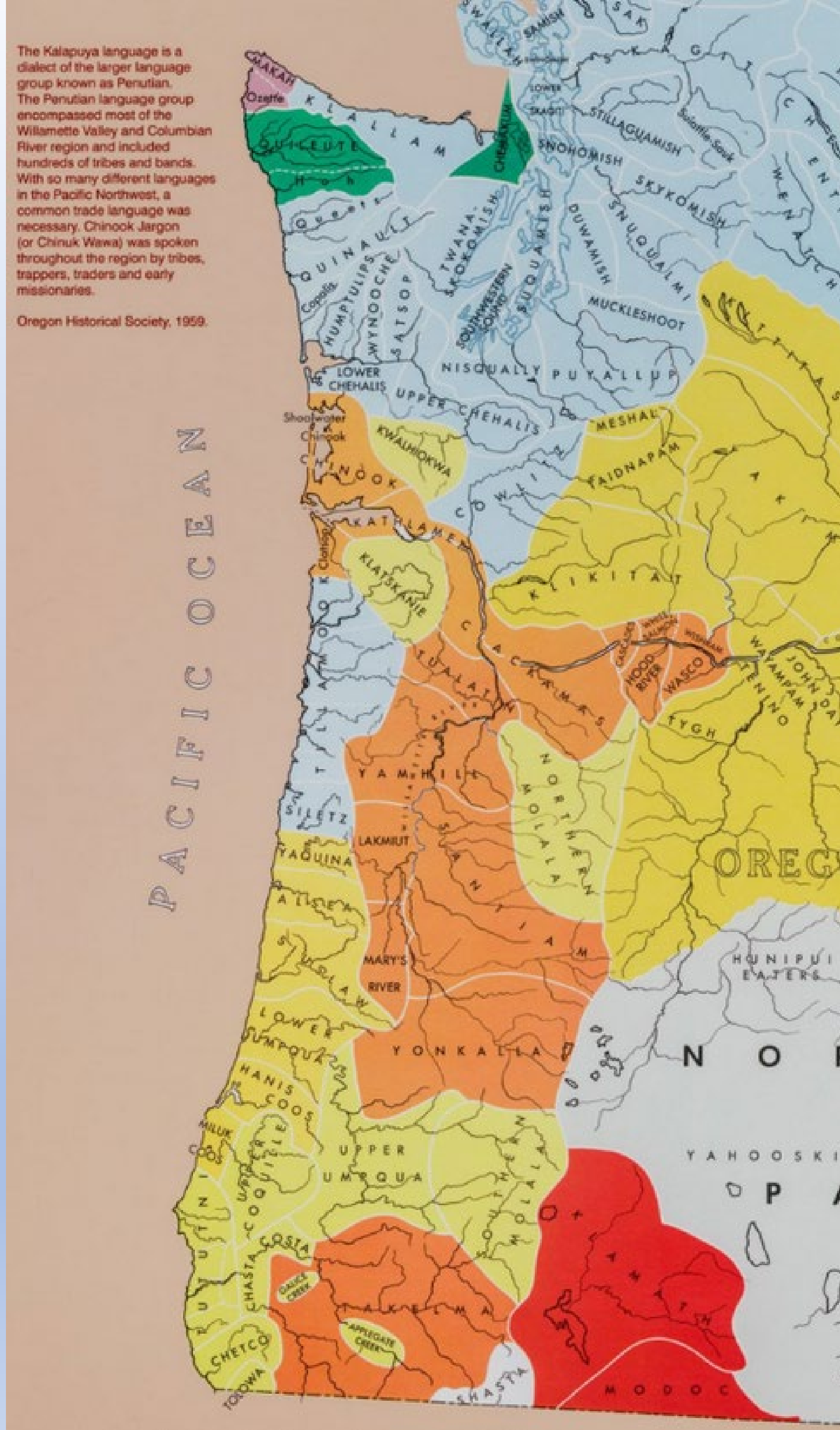
Stand development model

Management at
- Landscape
- Patch scales

Habitat elements

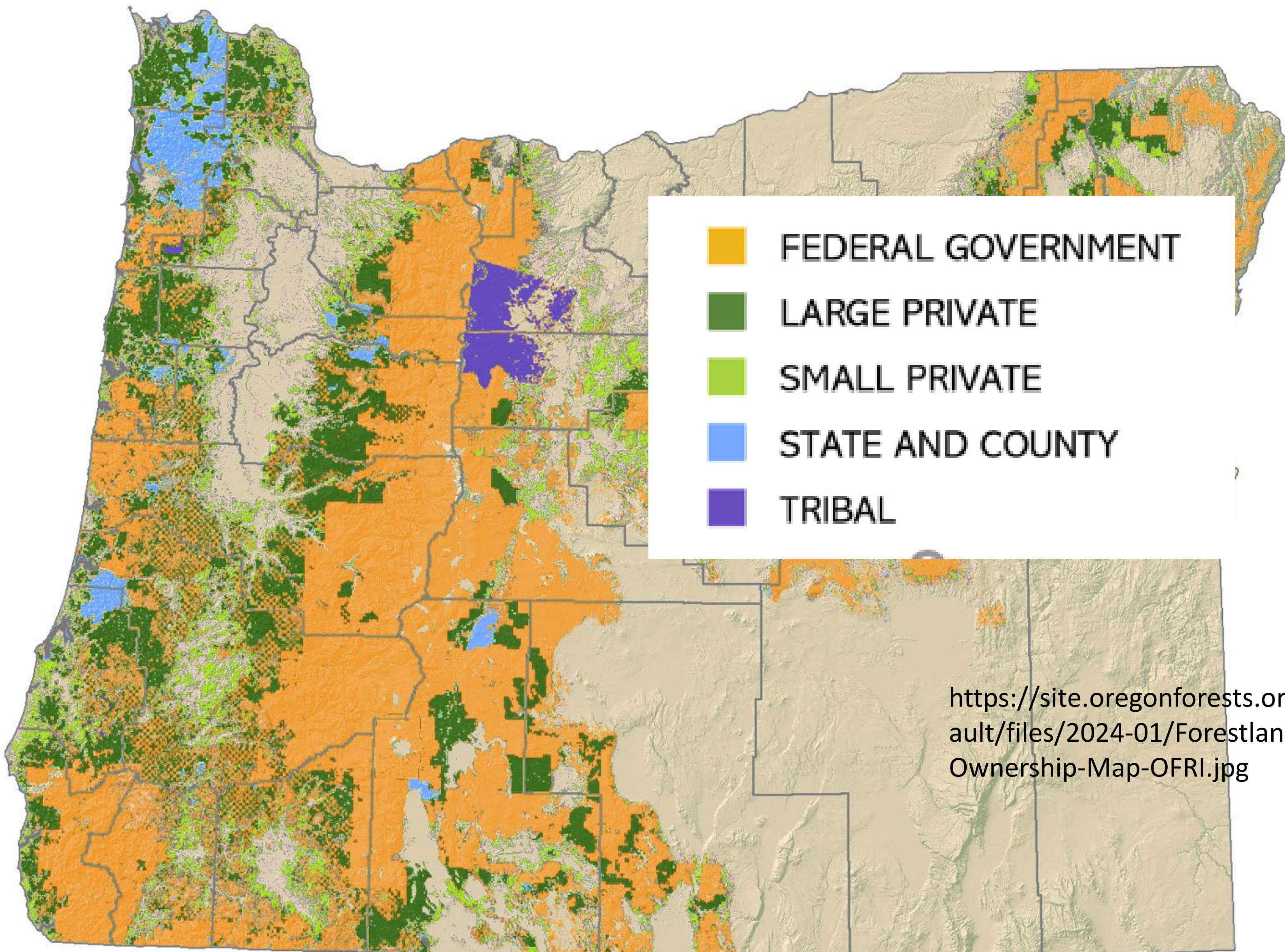
Assisted migration





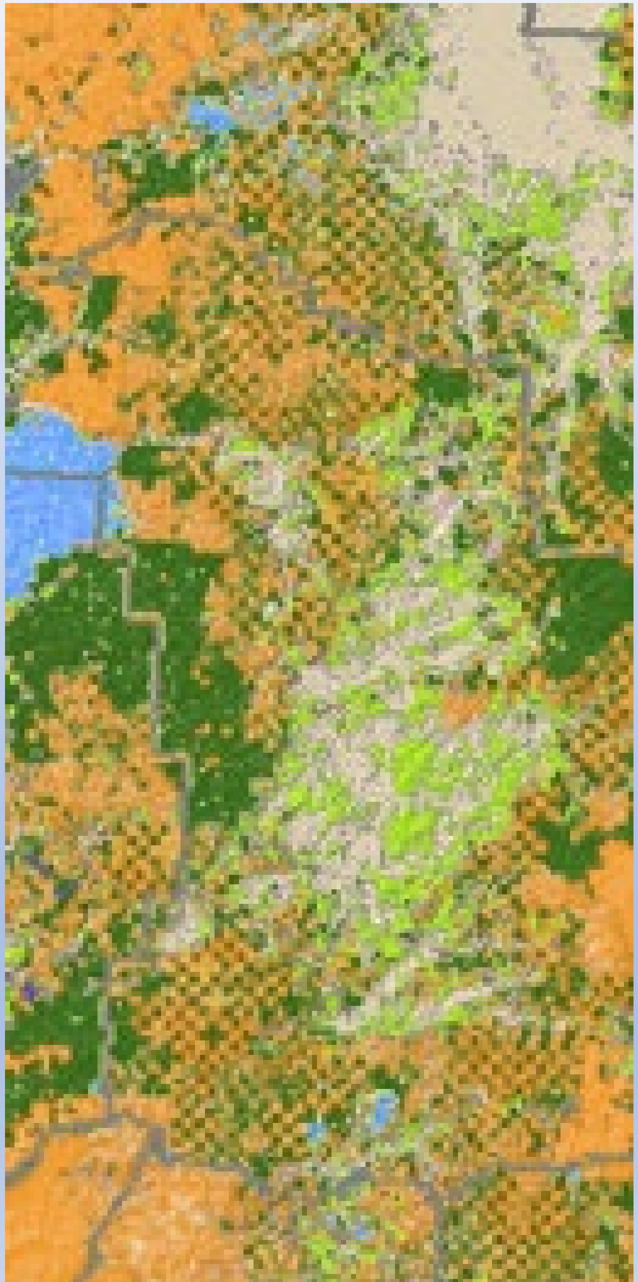
https://fiveoaksmuseum.org/this-is-kalapuyan-land-tribes-and-languages-map/

Background - Ownership



https://site.oregonforests.org/sites/default/files/2024-01/Forestland-Ownership-Map-OFRI.jpg

Background - Ownership



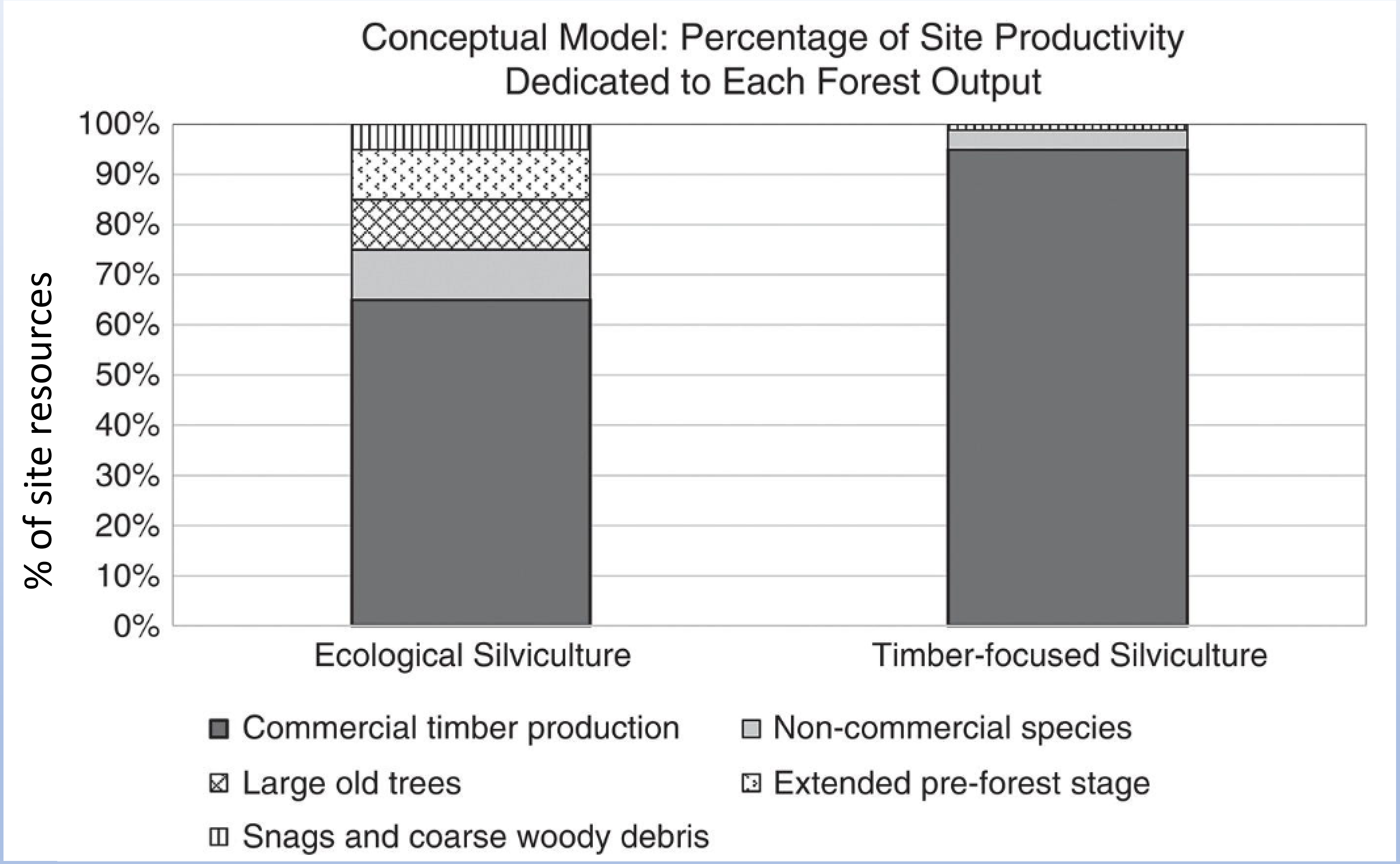
Railroad history – lands returned to federal ownership

Federal lands

In checkerboard - Bureau of Land Management

In larger blocks – US Forest Service

Ecological Forestry: BLM



From Wheeler et al. 2023

Ecological Forestry: BLM

Treatment type	Eligible forest stage (stand ages)	Desired outcomes	Potential treatment design elements
Regeneration harvest; variable retention harvest	Young, mature, and old forest stage[a] (40–150+ years)	Timber harvest, complex early successional ecosystems, species diversity, habitat creation, culturally valuable species, regulation of water yield, rapid growth of retained trees, provide refugia	Structural and compositional variability, significant retention of preharvest basal area, retain large old trees, protect ecologically valuable areas, well-distributed arrangement of retention trees, variable introduction of fire, snag creation
Reforestation	Preforest stage (0–15 years)	Sustained timber yield, complex early successional ecosystems, influence species diversity, introduce valuable shade-intolerant plants, improve slope stability	Strategic mix of natural and artificial reforestation, variable-density planting, reforestation of conifers, hardwoods, and other desired species
Pre-commercial thinning	Preforest and Young forest stage (15–40 years)	Influence stand composition and density, prolong early successional conditions, reduce fire hazard	Variable-density thinning, favor-desired species and hardwoods, release ecologically and culturally important species, maintain openings
Commercial thinning, variable-density thinning	Young and mature stage (40–150 years)	Sustained timber harvest, forest health, habitat development, influence stand composition and density	Skips and gaps, develop future wildlife habitat trees, treat hazardous fuels, snag creation

From Wheeler et al. 2023

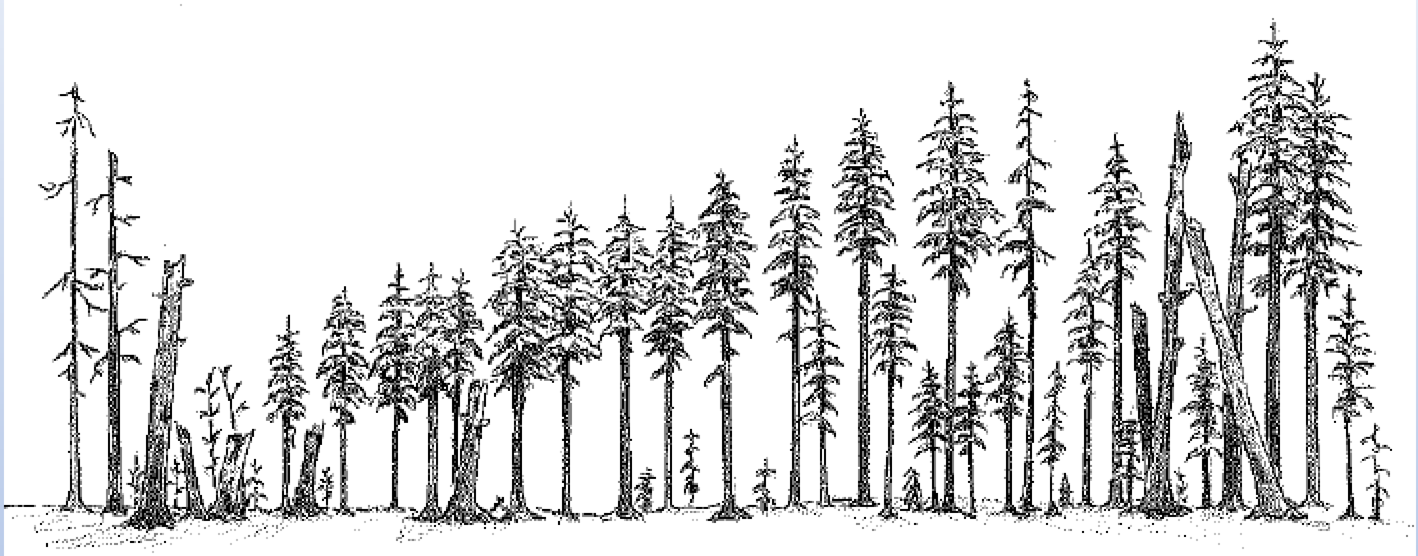
Ecological Forestry: BLM

Photocredit K. Ruzicka, BLM

Ecological Forestry: BLM

Photocredit K. Ruzicka, BLM

Stand development models



From Hanson and Zuckerman 2024 (PNW Handbook of Ecological Forestry)

Conventional model:

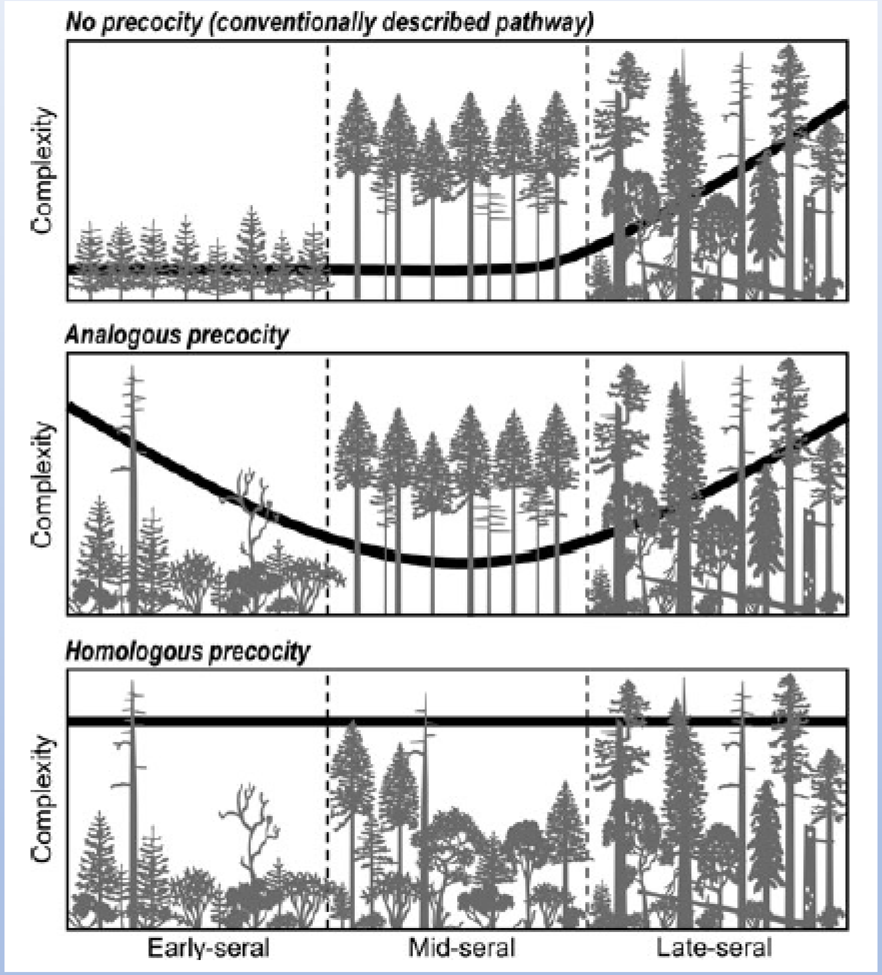
Stand development characterized by long periods between disturbances

Stand development models

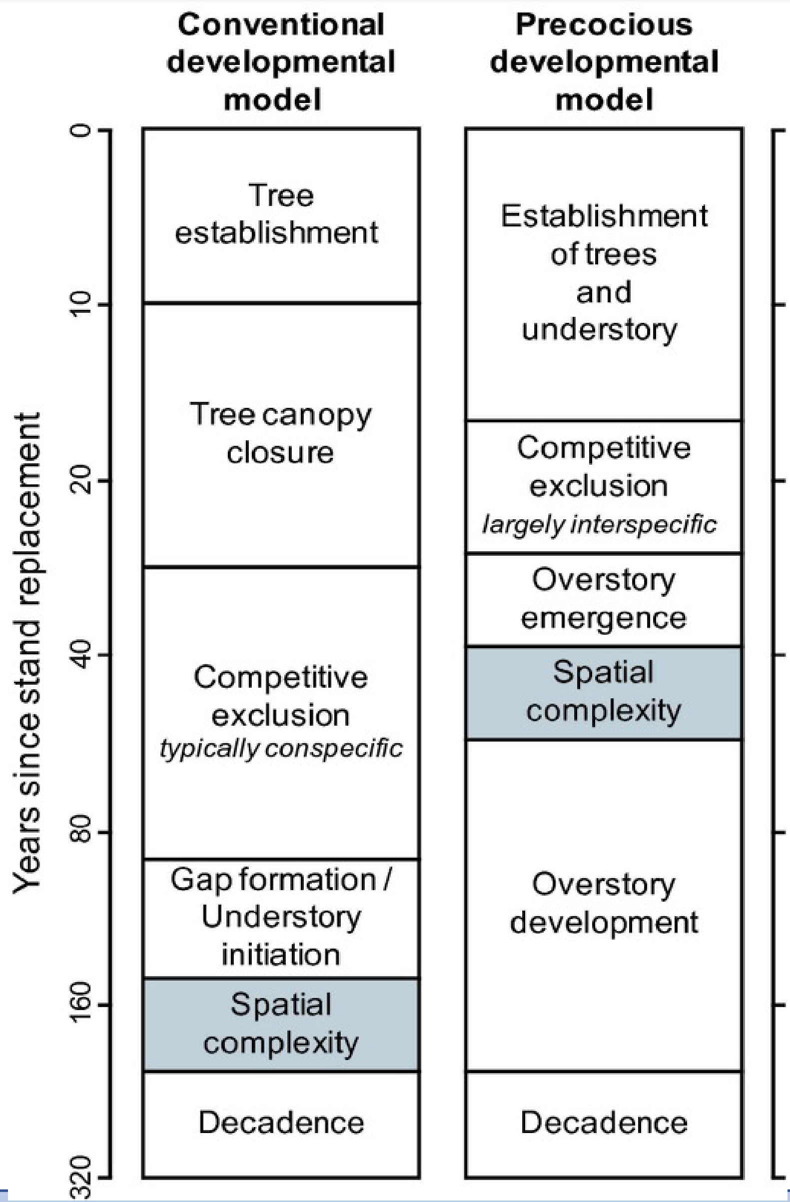
Typical stand age (years)	Classification: This article	Oliver and Larson (1990)	Spies and Franklin (1996)	Carey and Curtis (1996)	Bormann and Likens (1979)
	Disturbance and legacy creation				
0					
	Cohort establishment	Stand initiation	Establishment phase	Ecosystem initiative	Reorganization phase
20					
	Canopy closure				
30		Stem exclusion	Thinning phase	Competitive exclusion	Aggradation phase
	Biomass accumulation/ competitive exclusion				
80		Understory re-initiation		Understory re-initiation	
	Maturation		Mature phase		Transition phase
		Old-growth		Botanically diverse	
150					
	Vertical diversification		Transition phase (early)	Niche diversification	
					Steady-state
				Old-growth	
300					
	Horizontal diversification		Transition phase (late)		
800					
	Pioneer cohort loss				
1200			Shifting-gap phase		

Modified from Franklin et al. (2002)

Stand development models



Stand development models



Donato et al. 2012 J Vegetation Science, Volume: 23, Issue: 3, Pages: 576-584, First published: 11 November 2011, DOI: (10.1111/j.1654-1103.2011.01362.x)

Stand development models

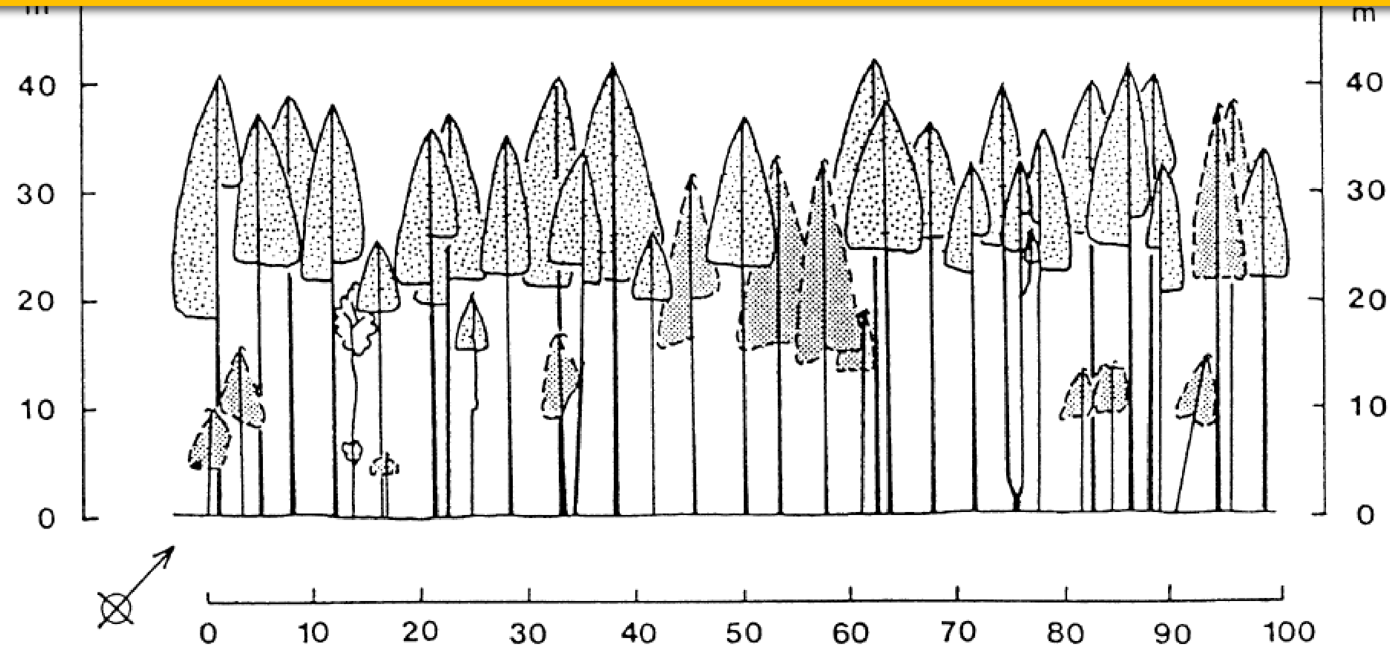
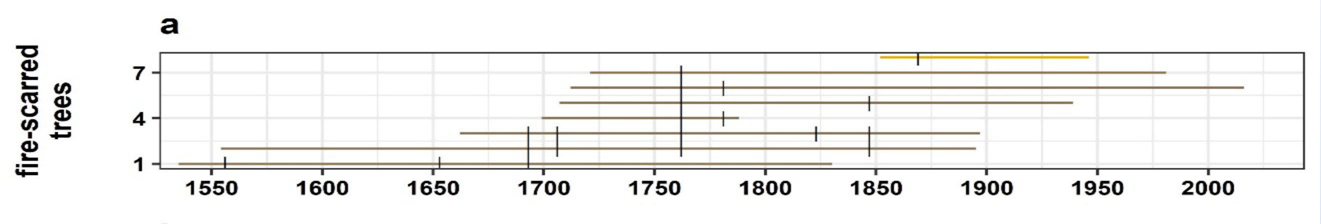


Fig. 4. Biomass accumulation/competitive exclusion stage of Douglas-fir stand development; 55-year-old stand near Humptulips River, Olympic Peninsula, Washington (redrawn by R. Van Pelt from Kuiper, 1994).

Fig. 4 and photo b) from Franklin et al. (2002)

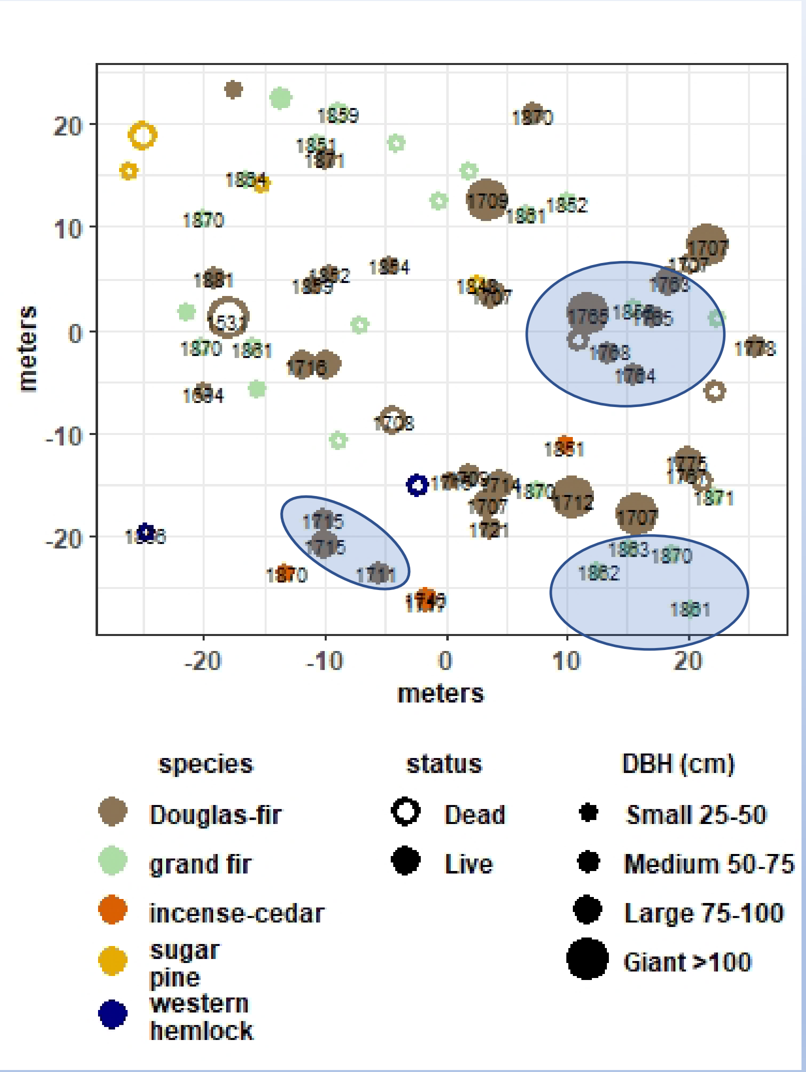
Stand development models



Fires

Courtesy of Andrew Mershell

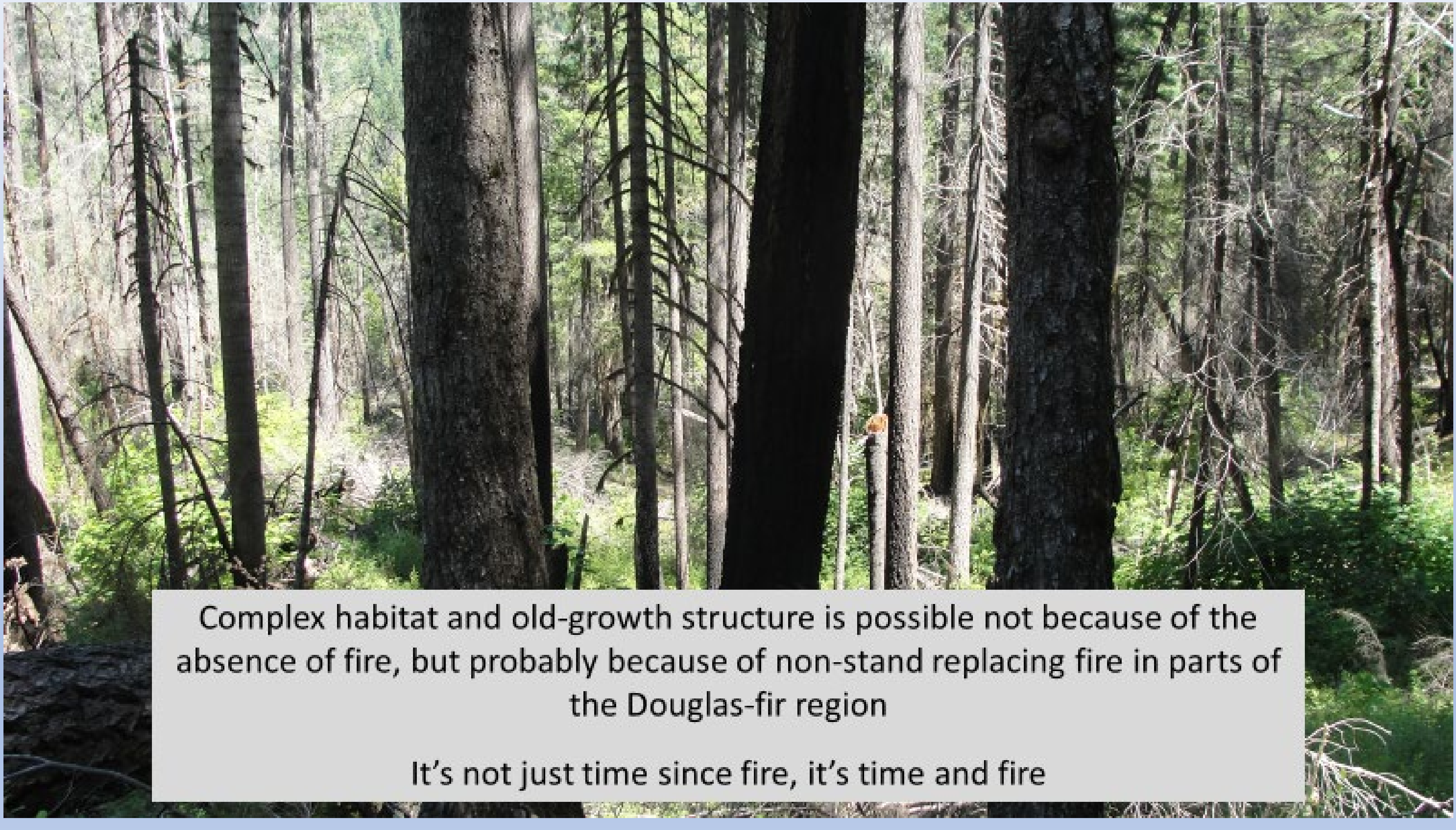
Stand development models



Old-growth stem map

Courtesy of Andrew Mershell

Stand development models



Complex habitat and old-growth structure is possible not because of the absence of fire, but probably because of non-stand replacing fire in parts of the Douglas-fir region

It's not just time since fire, it's time and fire

Courtesy of Andrew Mershell

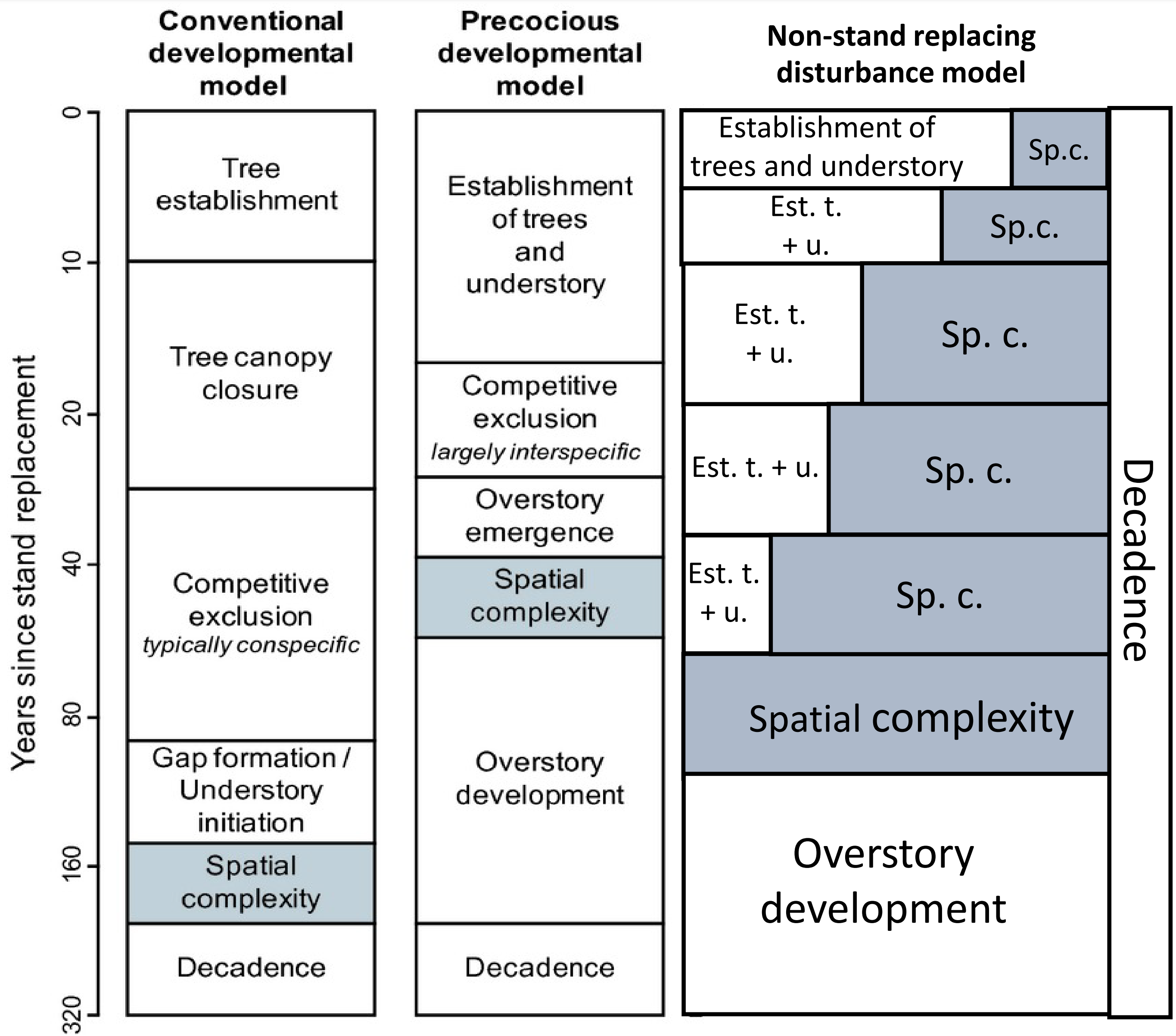
Stand development models: Crown structure

National Park Service

https://digitalmedia.fws.gov/digital/collection/natdiglib/id/12328/

Seidel et al. 2016

Stand development models



Modified from Donato et al. 2012 J Vegetation Science, Volume: 23, Issue: 3, Pages: 576-584, DOI: (10.1111/j.1654-1103.2011.01362.x)

Ecological Forestry: Stand development models

Treatment type	Eligible forest stage (stand ages)	Desired outcomes	Potential treatment design elements
Regeneration harvest; variable retention harvest	Young, mature, and old forest stage[a] (40–150+ years)	Timber harvest, complex early successional ecosystems, species diversity, habitat creation, culturally valuable species, regulation of water yield, rapid growth of retained trees, provide refugia	Structural and compositional variability, significant retention of preharvest basal area, retain large old trees, protect ecologically valuable areas, well-distributed arrangement of retention trees, variable introduction of fire, snag creation
Reforestation	Preforest stage (0–15 years)	Sustained timber yield, complex early successional ecosystems, influence species diversity, introduce valuable shade-intolerant plants, improve slope stability	Strategic mix of natural and artificial reforestation, variable-density planting, reforestation of conifers, hardwoods, and other desired species
Pre-commercial thinning	Preforest and Young forest stage (15–40 years)	Influence stand composition and density, prolong early successional conditions, reduce fire hazard	Variable-density thinning, favor-desired species and hardwoods, release ecologically and culturally important species, create and maintain opening Reforestation, cultural burning
Commercial thinning, variable-density thinning	Young and mature stage (40–150 years)	Sustained timber harvest, forest health, habitat development, influence stand composition and density	Skips and gaps, develop future wildlife habitat trees, treat hazardous fuels, snag creation

Modified from Wheeler et al. 2023

Ecological Forestry: Stand development models

If structures/composition of pre-European settlement Douglas-fir/western hemlock forests is viewed as guide:

- Stewarded by indigenous people
- Natural disturbances played out
- Development phases included a combination of
    - Conventional
    - Precocious
    - Non-stand replacing disturbance patterns

What is the need for or role of management in young stands to achieve late successional structures?

- to accelerate selected structures
- necessary for selected structures
    - in absence of disturbances (fire control)
    - when starting conditions are outside of natural range (plantations)

Natural adaptation mechanisms

Organiza-tional level	Measurable property	Modification potential
Biota	Species composition	Migration, extinction, speciation
	Food web structure	Different routes and rates of energy movement (matter?)
Population	Number of organisms	Flexibility in reproduction rates, social structures and relationships
	Spatial location of organisms	Social plasticity, movement
Organism	Number of organs, relative position of organisms	Developmental plasticity (e.g., muscle, leaf area, size
		Physiological plasticity Behavioral plastiicty
Genome	DNA sequence	Gene pool diversity,

Modified from Conrad 1983

Ecological Forestry: Stand development models

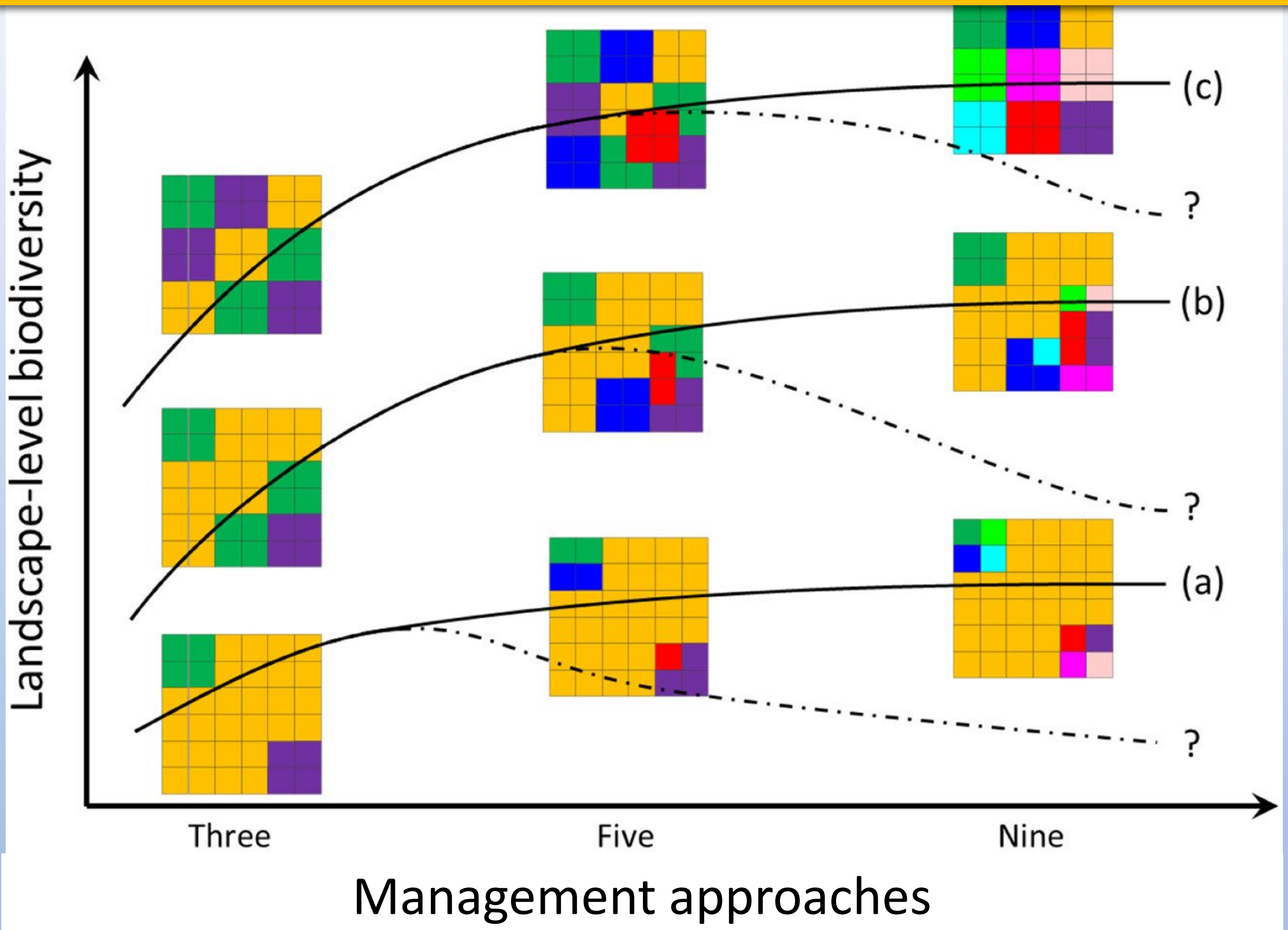
Create the diversity of wildlife habitat

Landscape level - a combination of management approaches

Patch level - focus on specific habitat components

Habitat diversity at landscape scale

Habitat diversity at landscape scale



~ Developmental models

Duflot, R., Fahrig, L., & Mönkkönen, M. (2022). Management diversity begets biodiversity in production forest landscapes. *Biological Conservation*, *268*, 109514.

Ecological forestry: Patch level

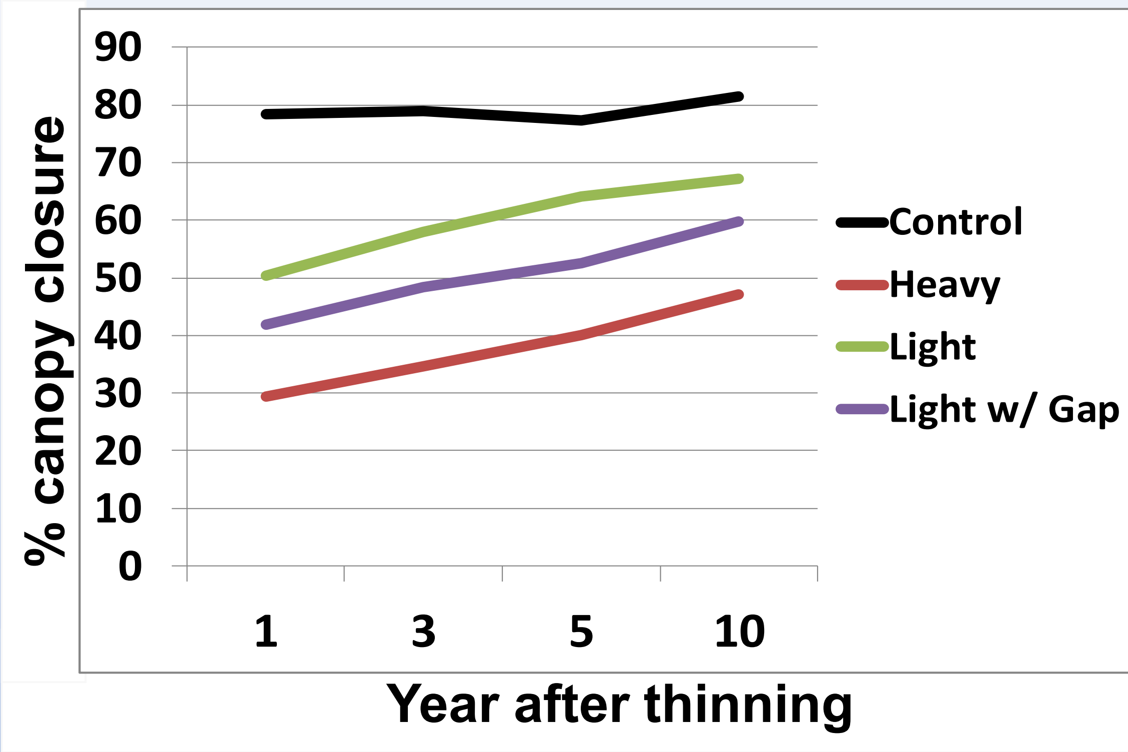
Habitat Elements

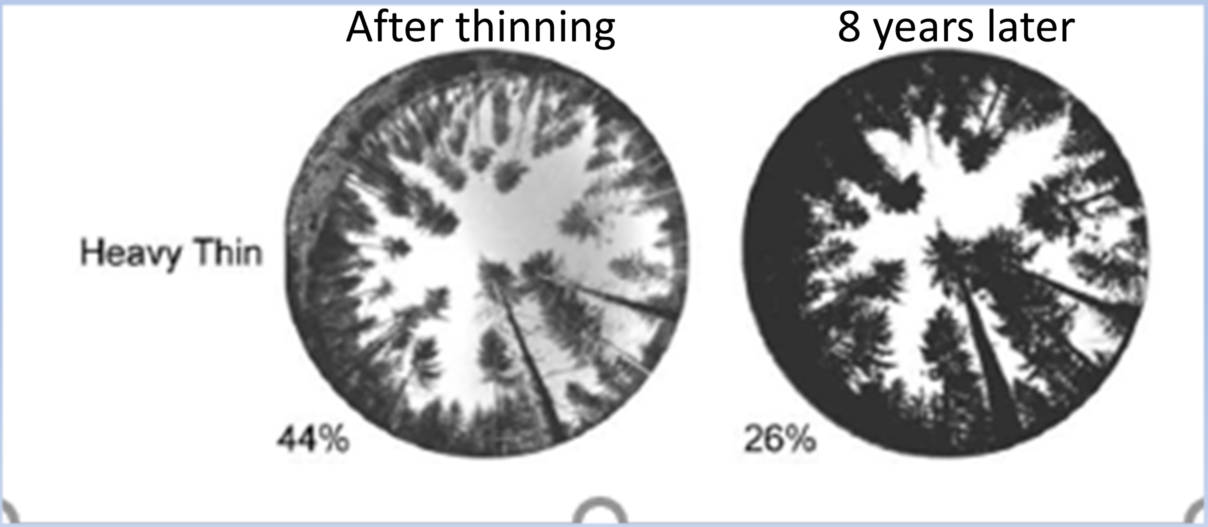
- Tree species (fruit, browse, bark structure)
- Tree sizes (dbh and height)
- Canopy cover and tree density
- Shrub, grass, forb cover
- Vertical complexity
- Dead wood (limbs, snags, logs)
- Tree cavities (size, density)
- Litter depth
- Others

“Stolen” from Brenda McComb’s presentation

Habitat: Canopy closure

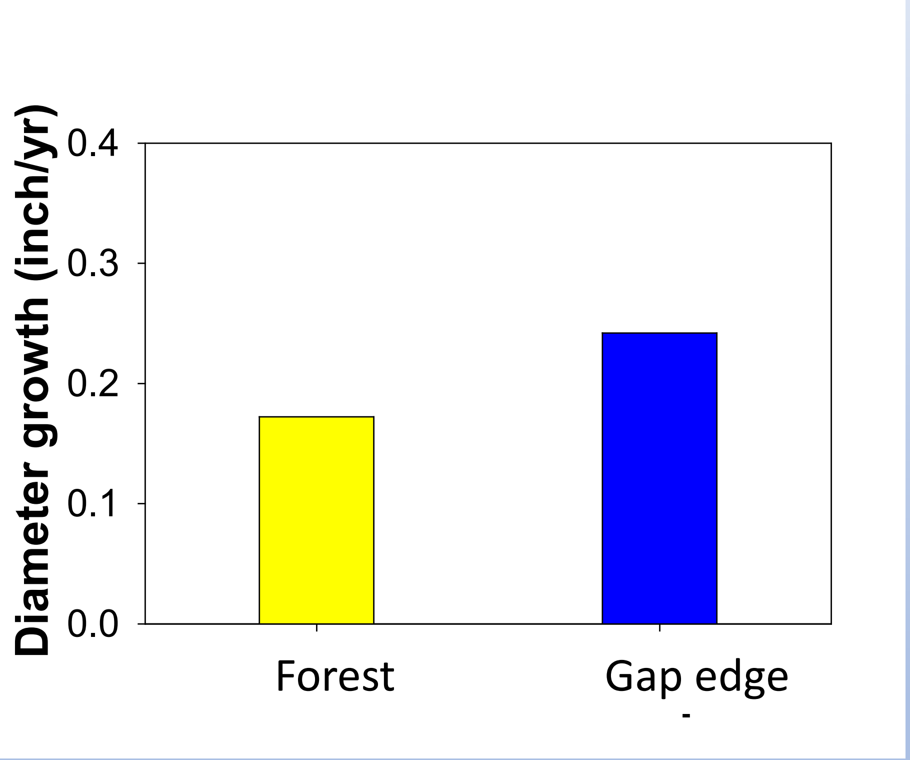
Davis et al. 2007





Chan et al. 2006

Habitat: Tree growth

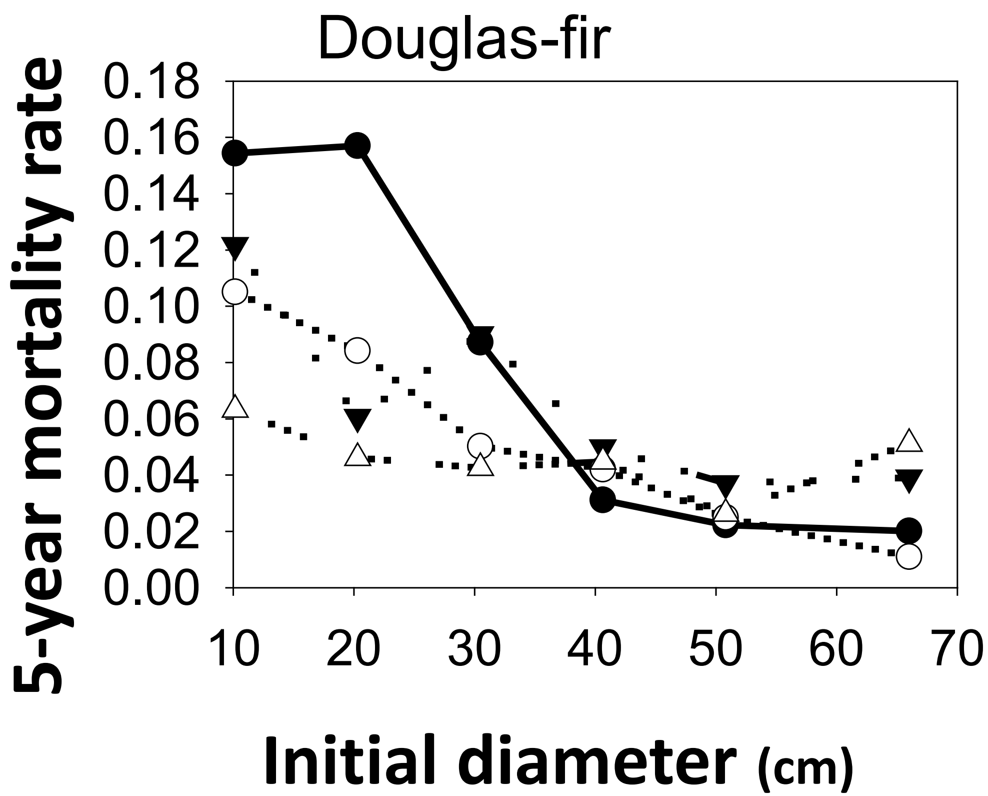


Dodson et al. 2014

Habitat: Crown structure

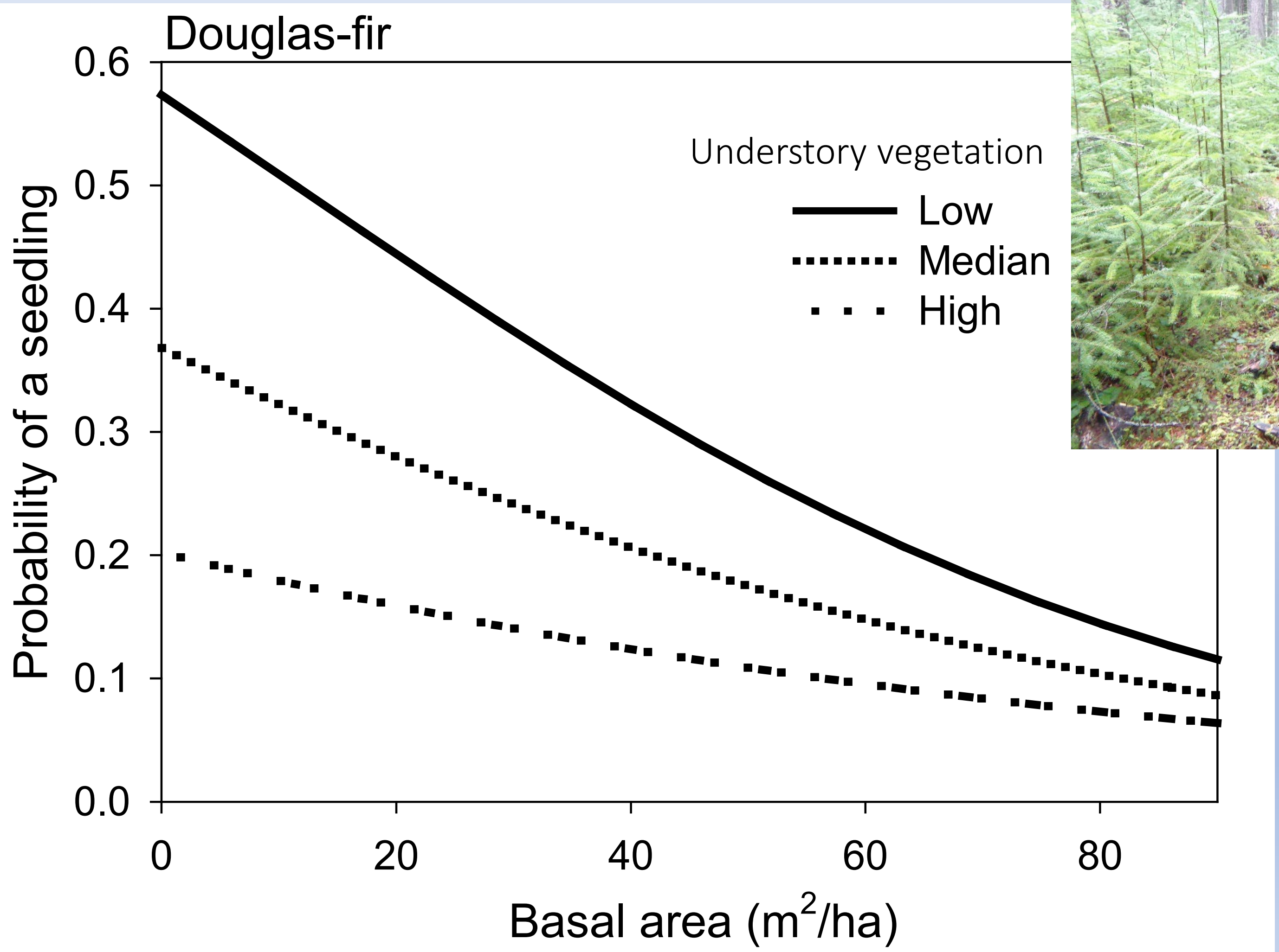
Seidel et al. 2016

Habitat: Snags/Downed wood



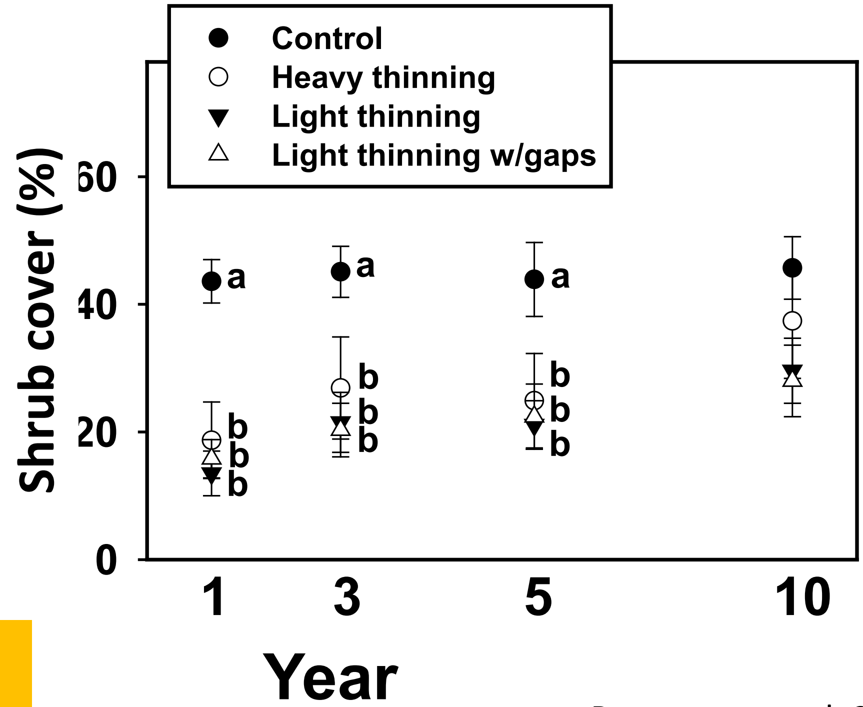
Dodson et al. 2012

Habitat: Tree regeneration



Dodson et al. 2014

Habitat: Understory vegetation



Puettmann et al. 2013

Initial shrub cover

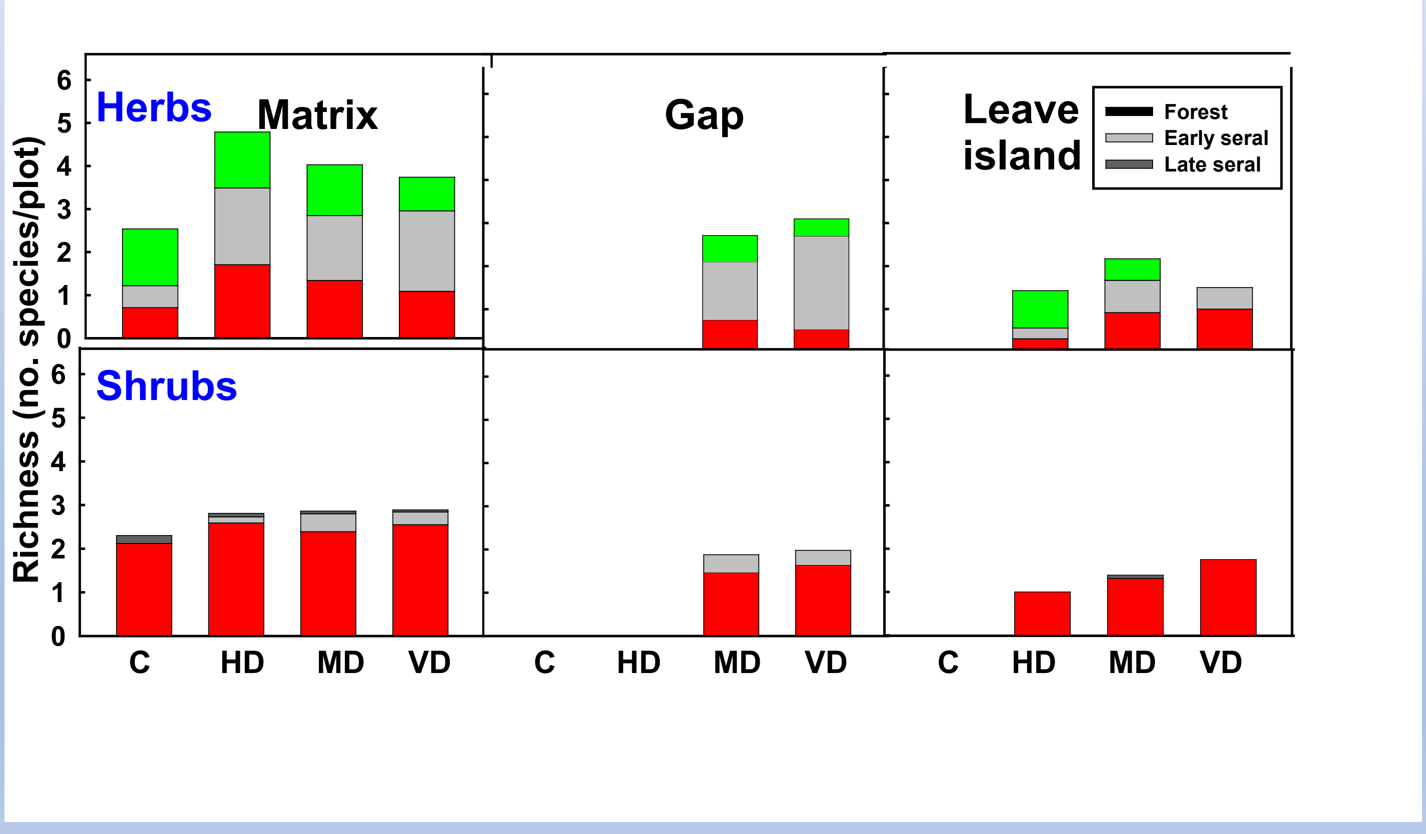
> 30% cover - thinning = ⬇

< 30% cover - thinning = ⬆

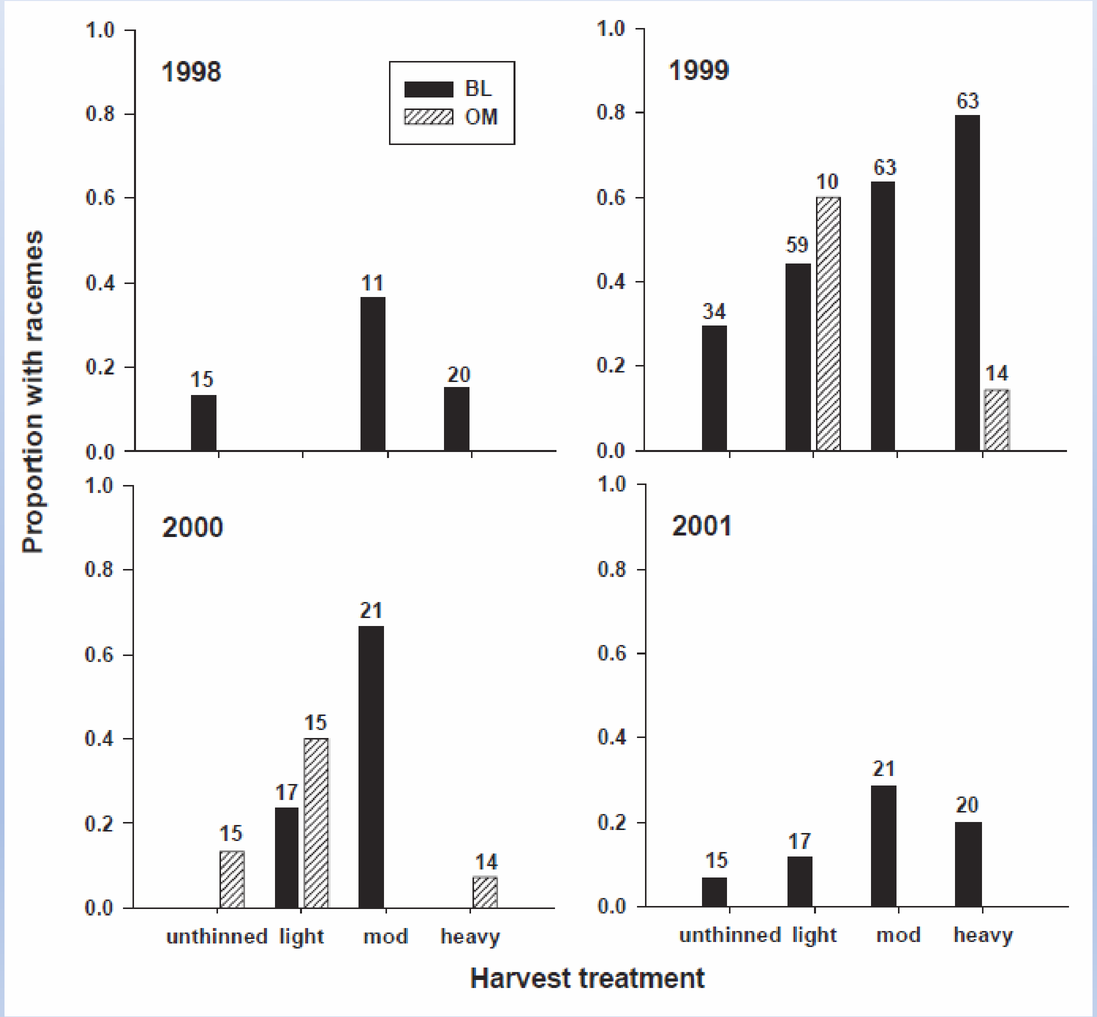
Wilson et al. 2007

Habitat: Understory vegetation

Where does the higher vascular plant species richness come from?

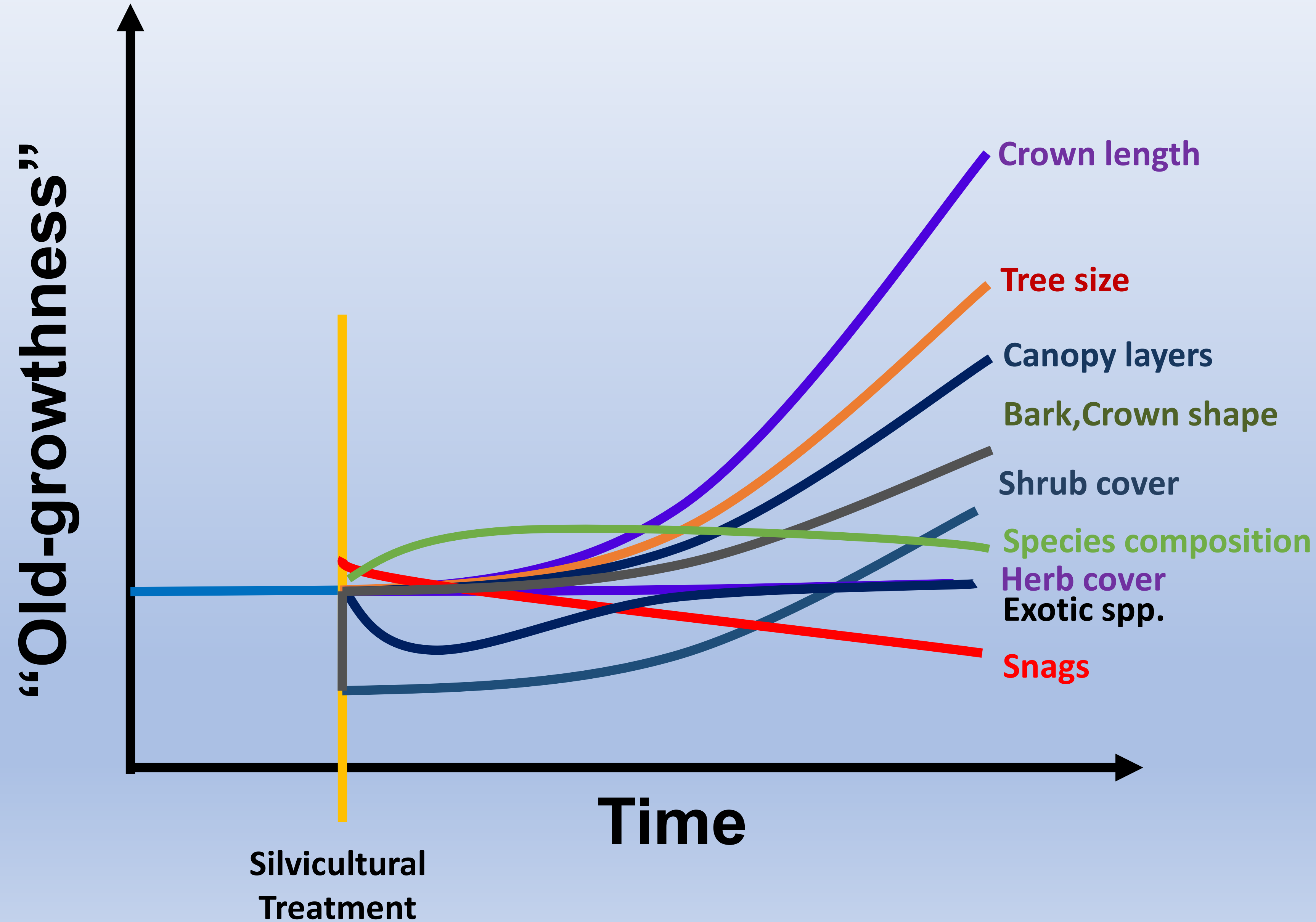


Habitat: Plant not equal plant

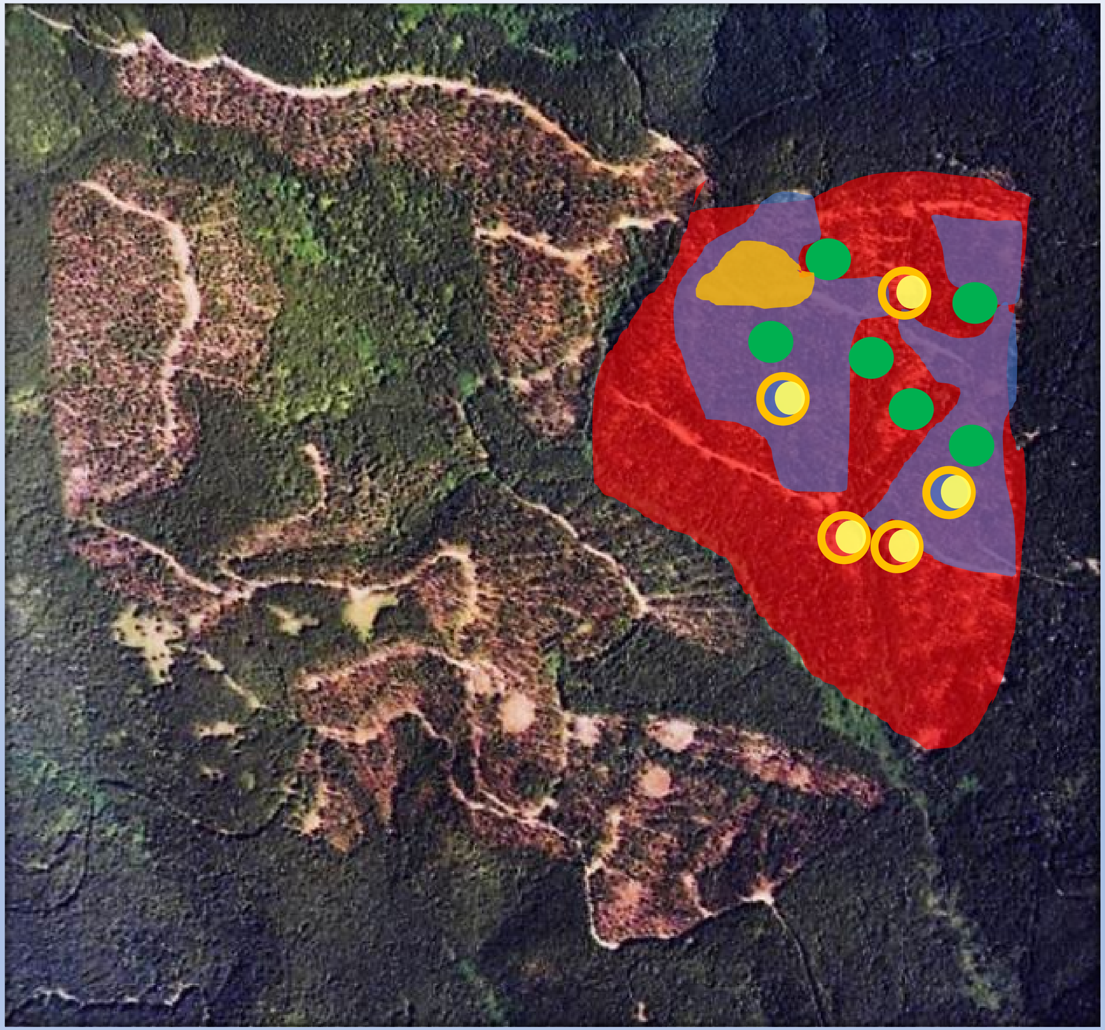


Wender et al. 2004

Habitat components



Habitat components = treatment design elements



Seedling establishment

Seedling/sapling growth
Early successional vegetation

Tree growth

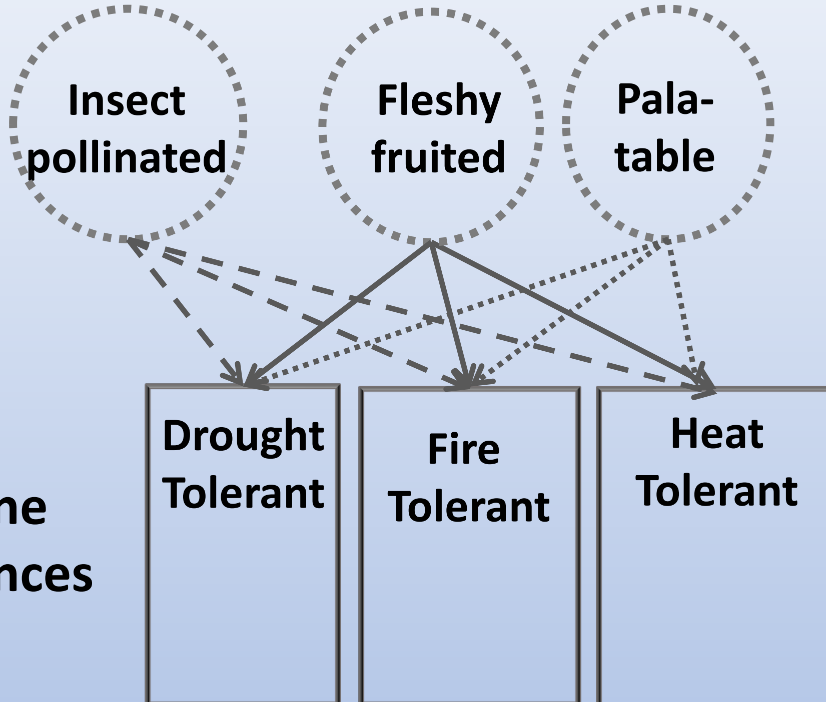
Mortality

Large tree growth
Large crowns

Match initial conditions with desired future conditions

Adaptive capacity

Traits that support ecosystem functions



Traits that determine response to disturbances


428

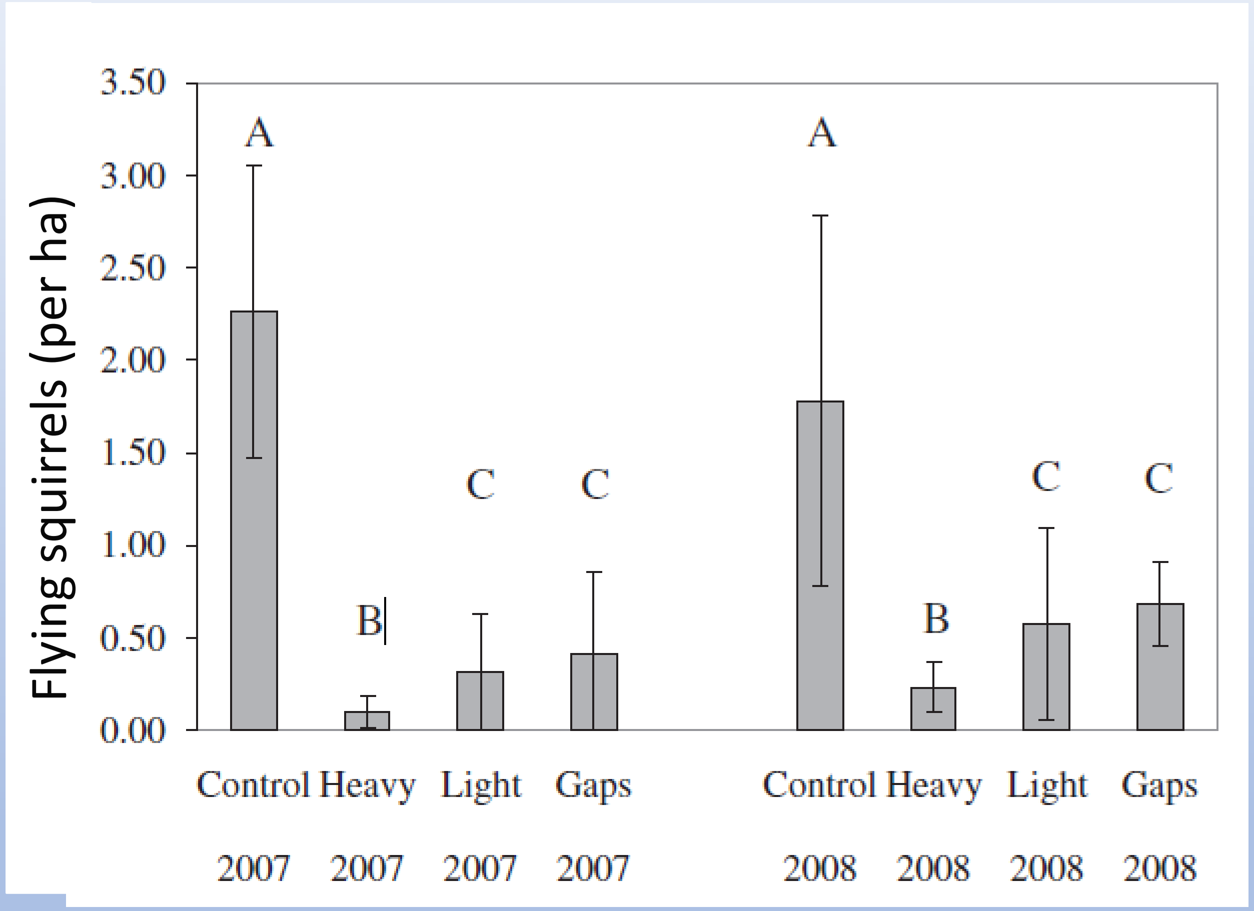
NRC Research Press

ARTICLE

Managing for adaptive capacity: thinning improves food availability for wildlife and insect pollinators under climate change conditions

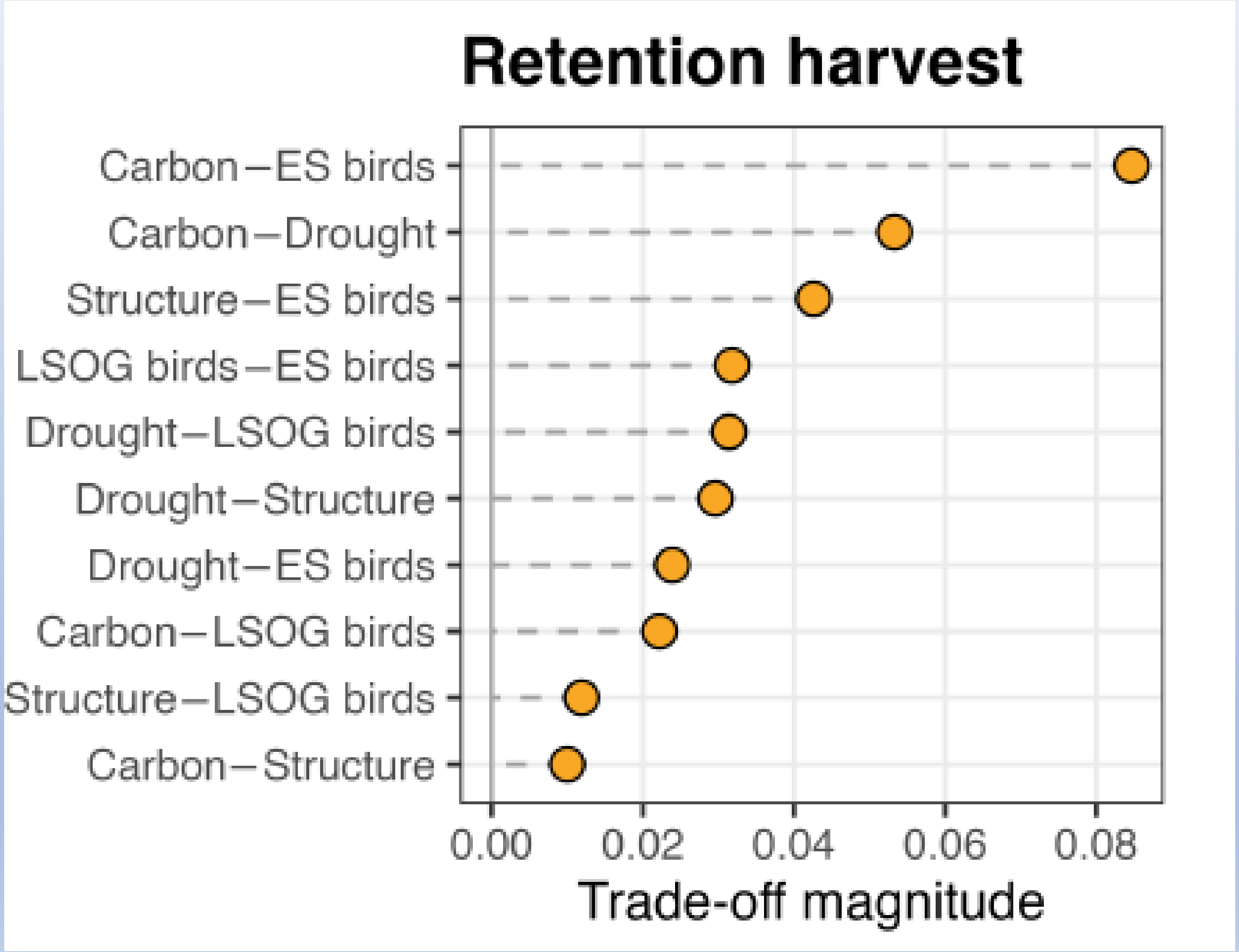
Andrew R. Neill and Klaus J. Puettmann

Habitat concerns



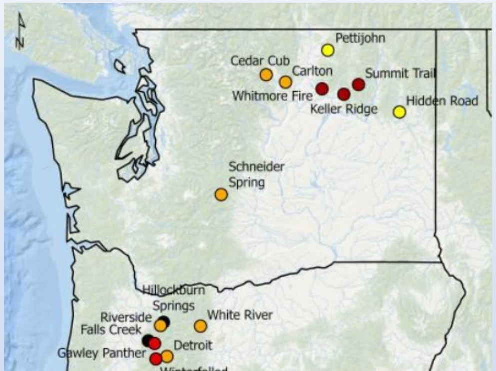
Wilson et al. 2012

Habitat – tradeoffs

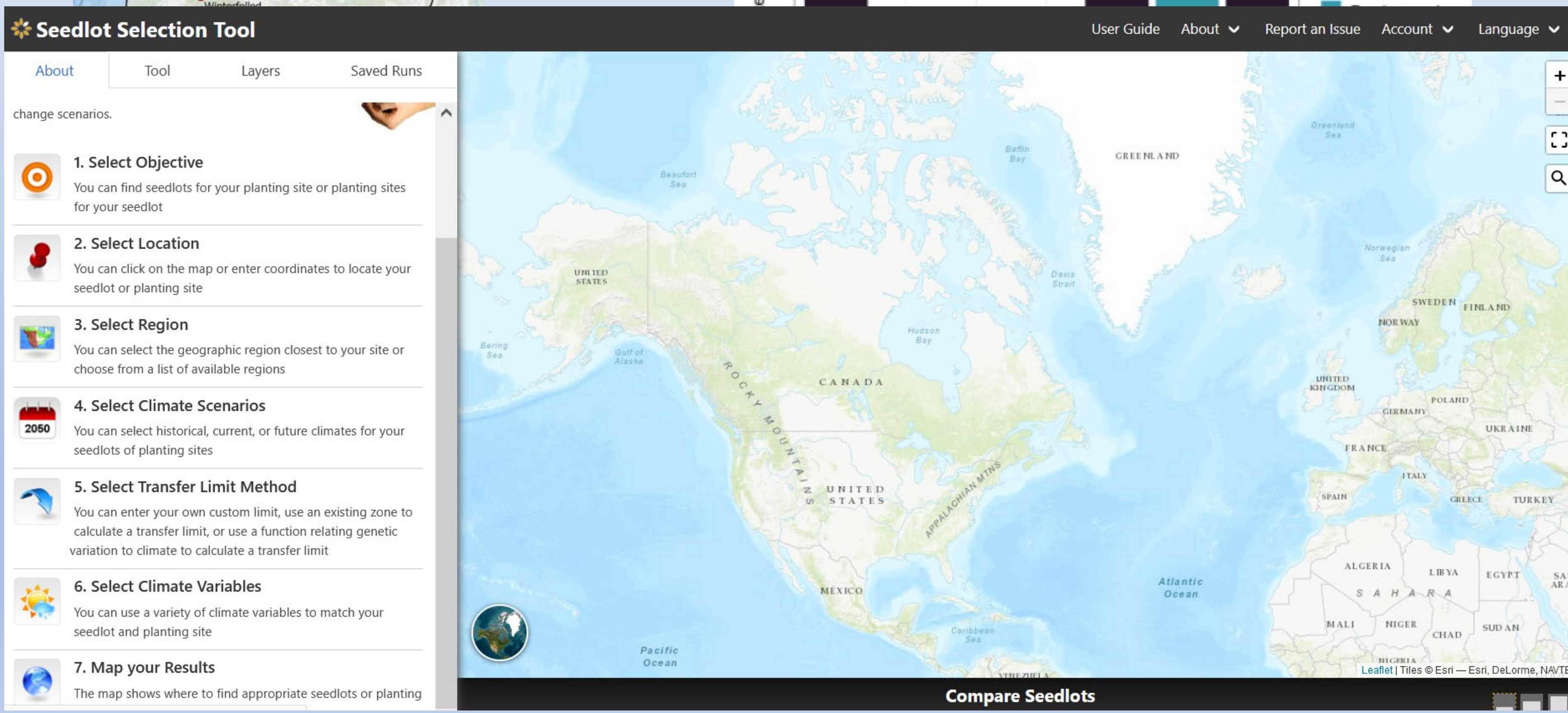


From Williams and Powers 2024 Ecosphere

Assisted migration

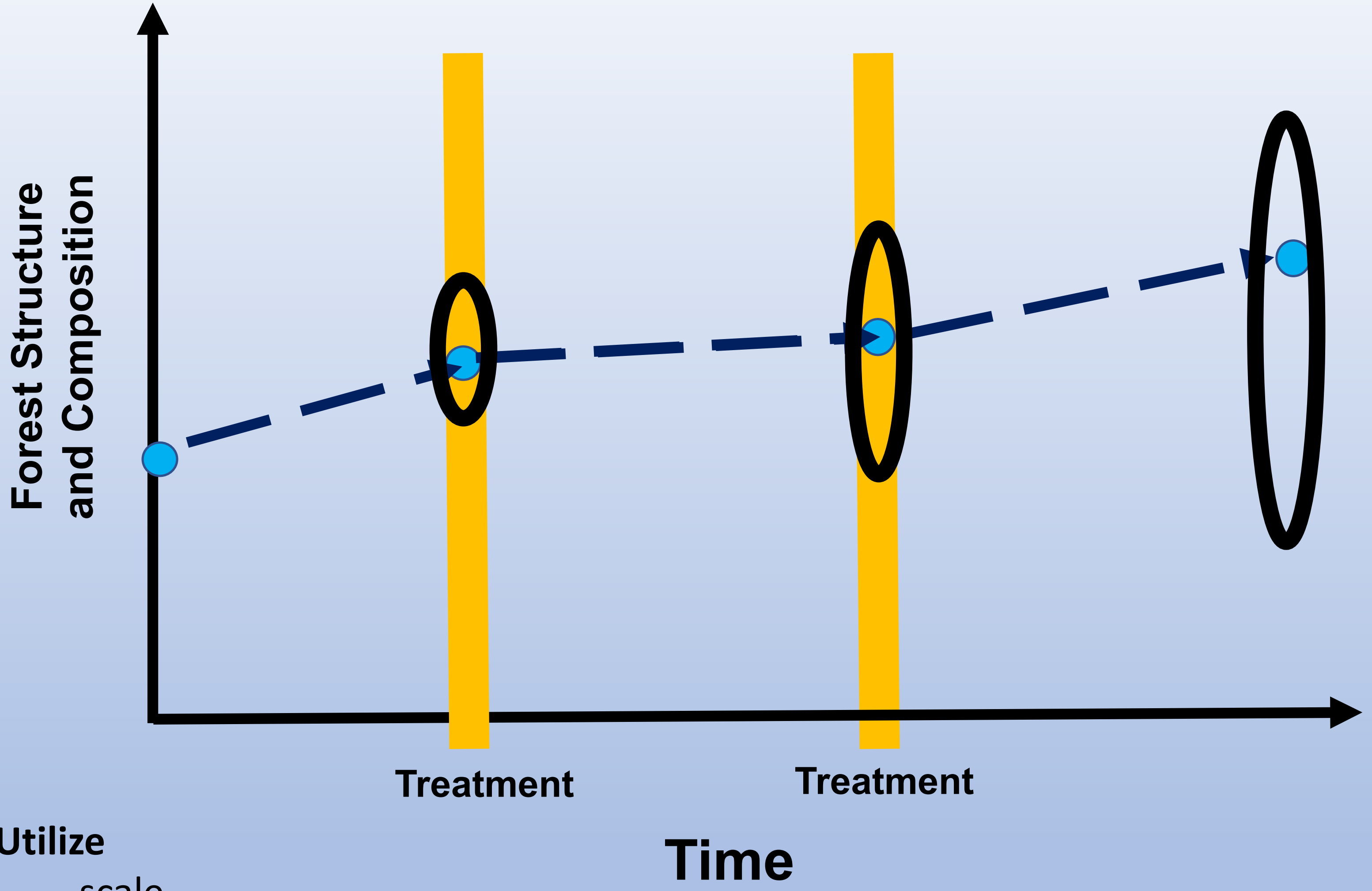


Experimental Network for Assisted Migration and Establishment Silviculture (ENAMES)



Assisted migration

https://www.seattletimes.com/seattle-news/environment/do-redwood-trees-have-a-place-in-the-future-of-was-forests-theyre-already-here/



Utilize

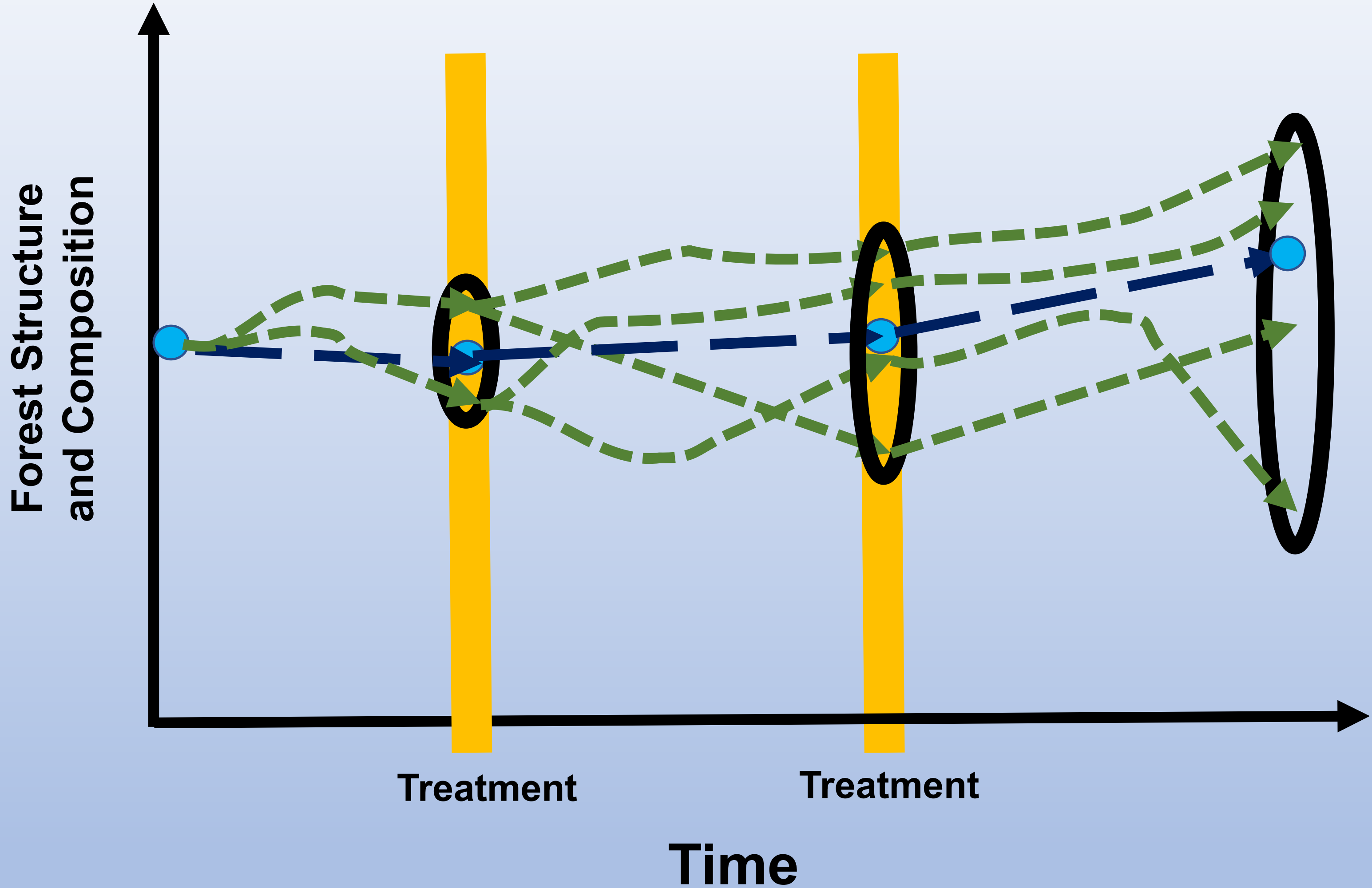
scale

initial conditions

multiple stand development models

Indigenous knowledge

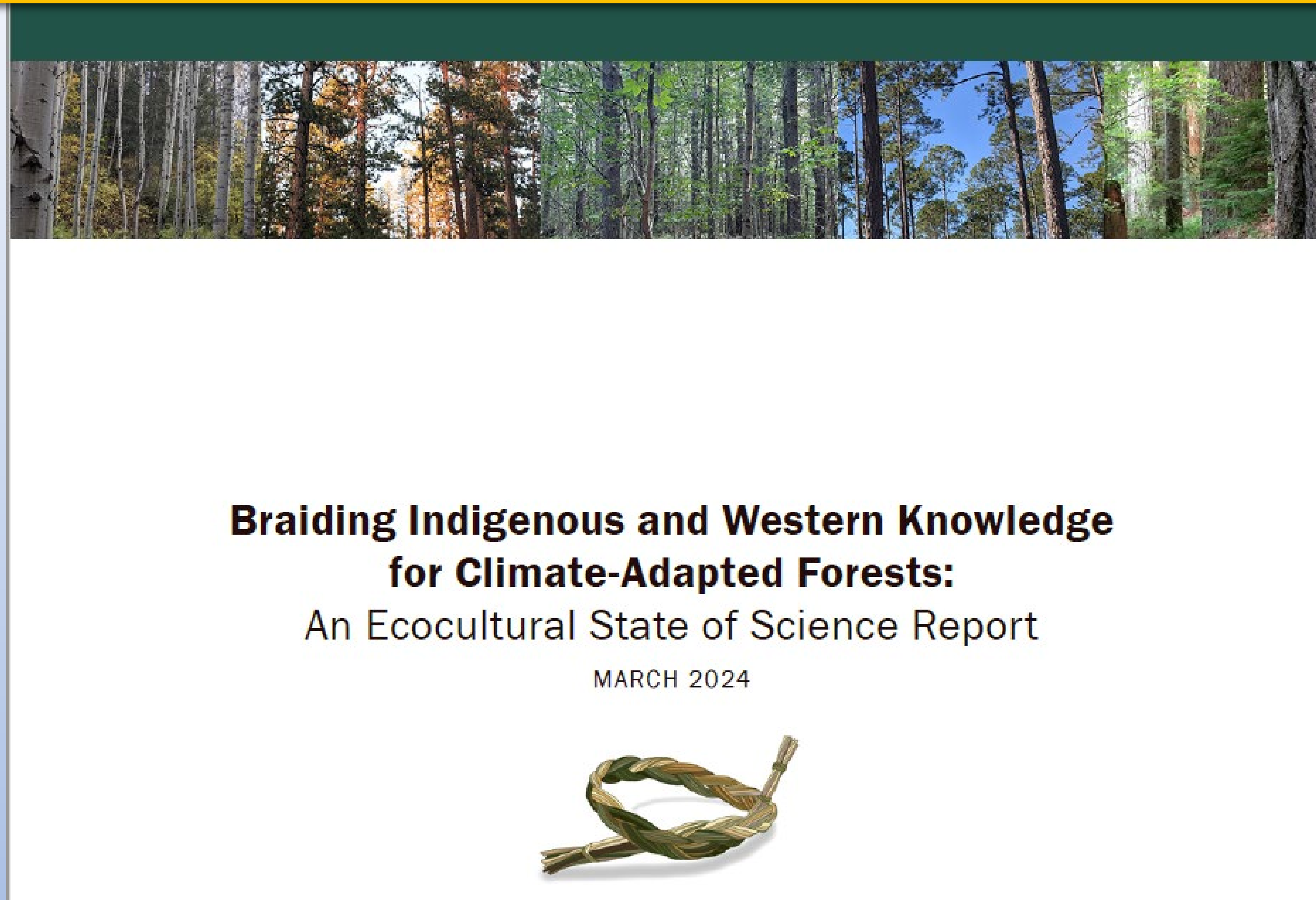
to increase silvicultural flexibility


Forest Structure and Composition
Treatment
Treatment
Time

Lessons for Ecological Forestry

- Reflect a diversity of **development models**
- Consider the **individual habitat components**
  - Emphasize the different treatment design elements
    - Stand and patch scales
- Assess all treatments in terms of **flexibility/adaptability**
- Work with variability in **initial conditions**
- Work with **different ways of knowing**, IK
- Expect and utilize **variability** in responses
- Keep **logistics** and economics in mind

Lessons for Forestry


Braiding Indigenous and Western Knowledge for Climate-Adapted Forests:
An Ecocultural State of Science Report
MARCH 2024

https://depts.washington.edu/flame/mature_forests/pdfs/BraidingSweetgrassReport.pdf

Thank you!

Questions and comments