



# ECOLOGICAL FOREST MANAGEMENT

Northwest Natural Resources Group

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# Ecological Forestry in 60 Seconds – The Element of Ecological Forestry

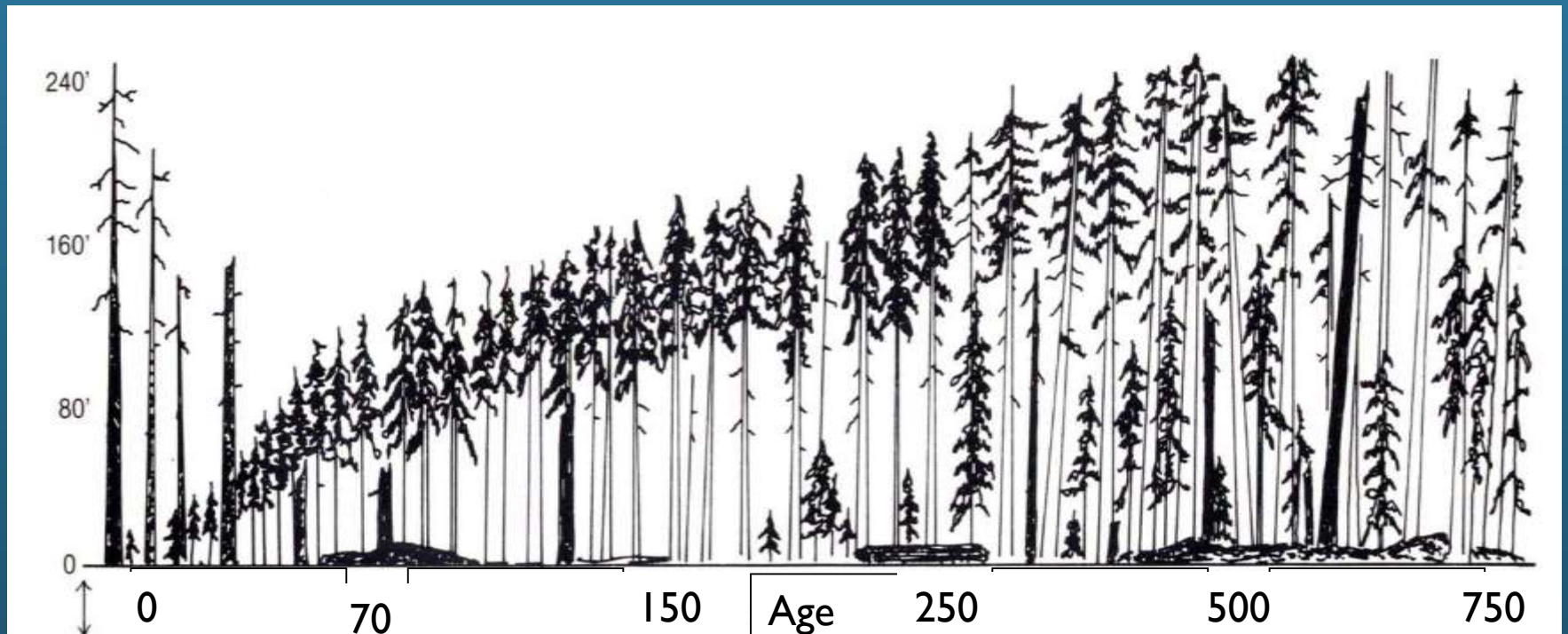
- Using site Adapted Species
- Based on Natural Processes
- Improve Soil Productivity
- Enhance Habitat and Biodiversity
- Improve Natural Capital
- Economic and Ecological Resilience

# Ecological Forestry in 90 Minutes – Outline of the Presentation

- Forest Stand Dynamics
- Forest Ecology
- Silviculture and Multi-aged Management
  - Group Selection Example
  - Single Tree Selection Example
- Tools for Assessment and Management
- Operations

# Forest Stand Dynamics

Stand Development Stages following a major disturbance



Stand Initiation

Stem Exclusion

Understory  
Re-Initiation

Diversification – Vertical - Horizontal

Franklin and Van Pelt 2004



# Seedling/Sapling – Stand Initiation Early Seral Vegetation





# Canopy Closure in Young Forests





# Competitive Exclusion Phase – Crown Differentiation and Self-thinning



# Crown Differentiation –

## The development of crown classes during early stand development

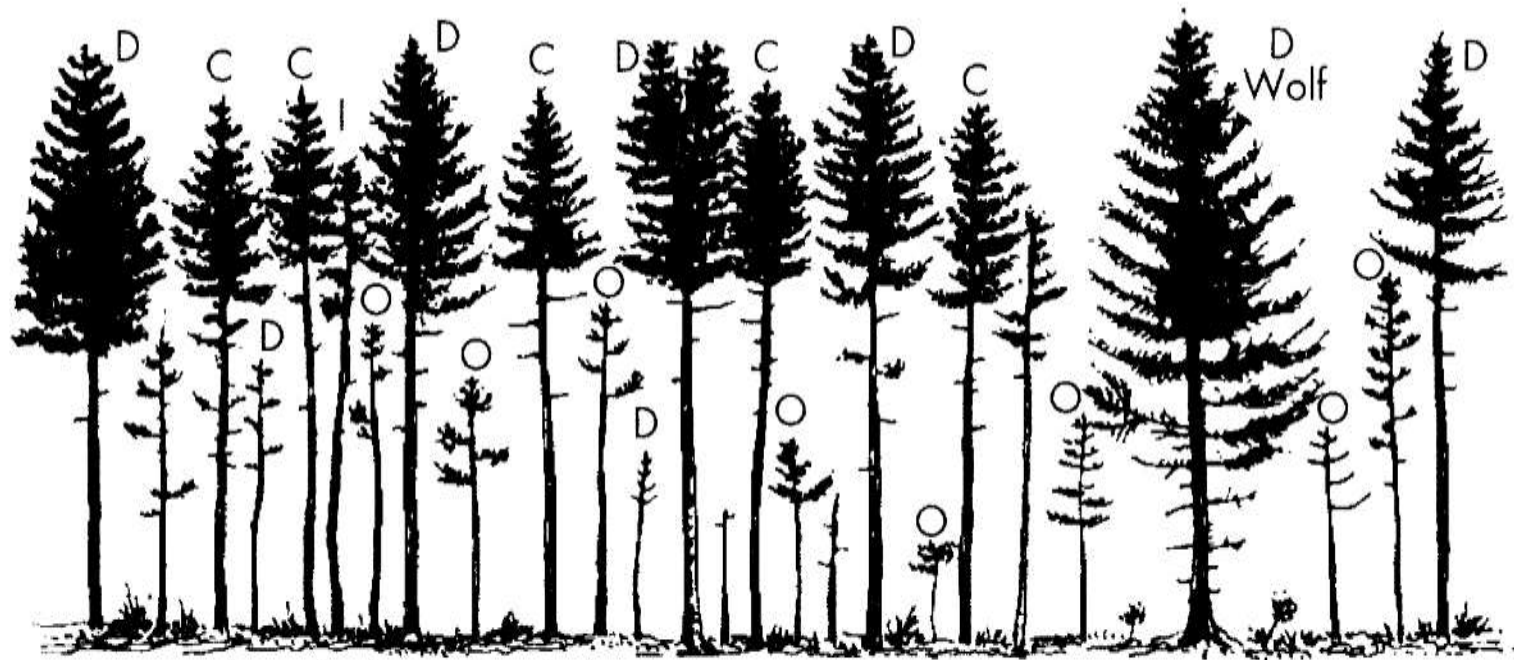
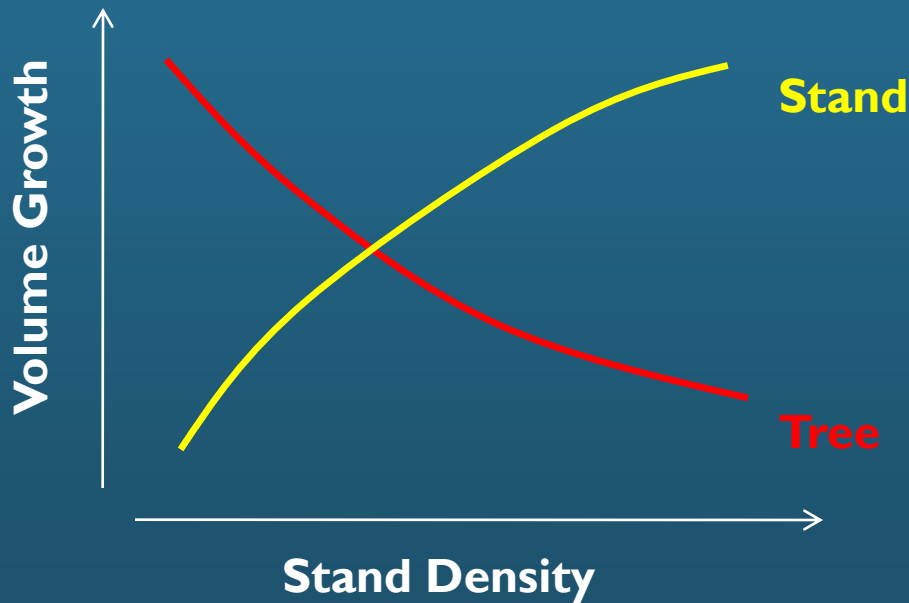


Figure 1.—A typical Douglas-fir stand, with dominant (D), codominant (C), intermediate (I), and overtopped (O) trees. A wolf tree (W)—one that occupies more space than it warrants—also is part of the stand. The relative amount of crown, height, and diameter of each tree determines its crown class.

D – Dominant	C – Co-dominant
I – Intermediate	O – Overtopped

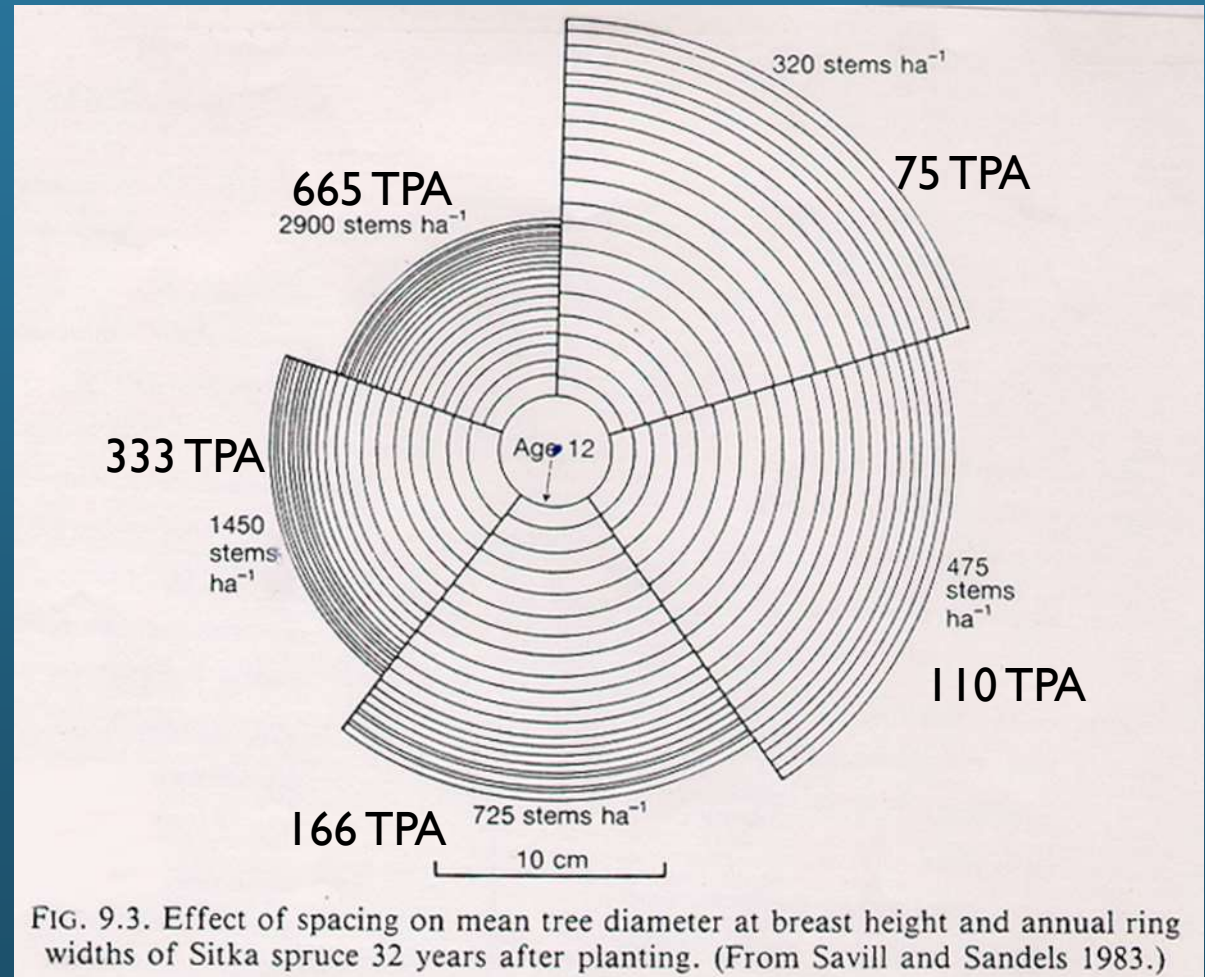


# Biomass Production – Trees versus Stands



# Tree Diameter Growth –

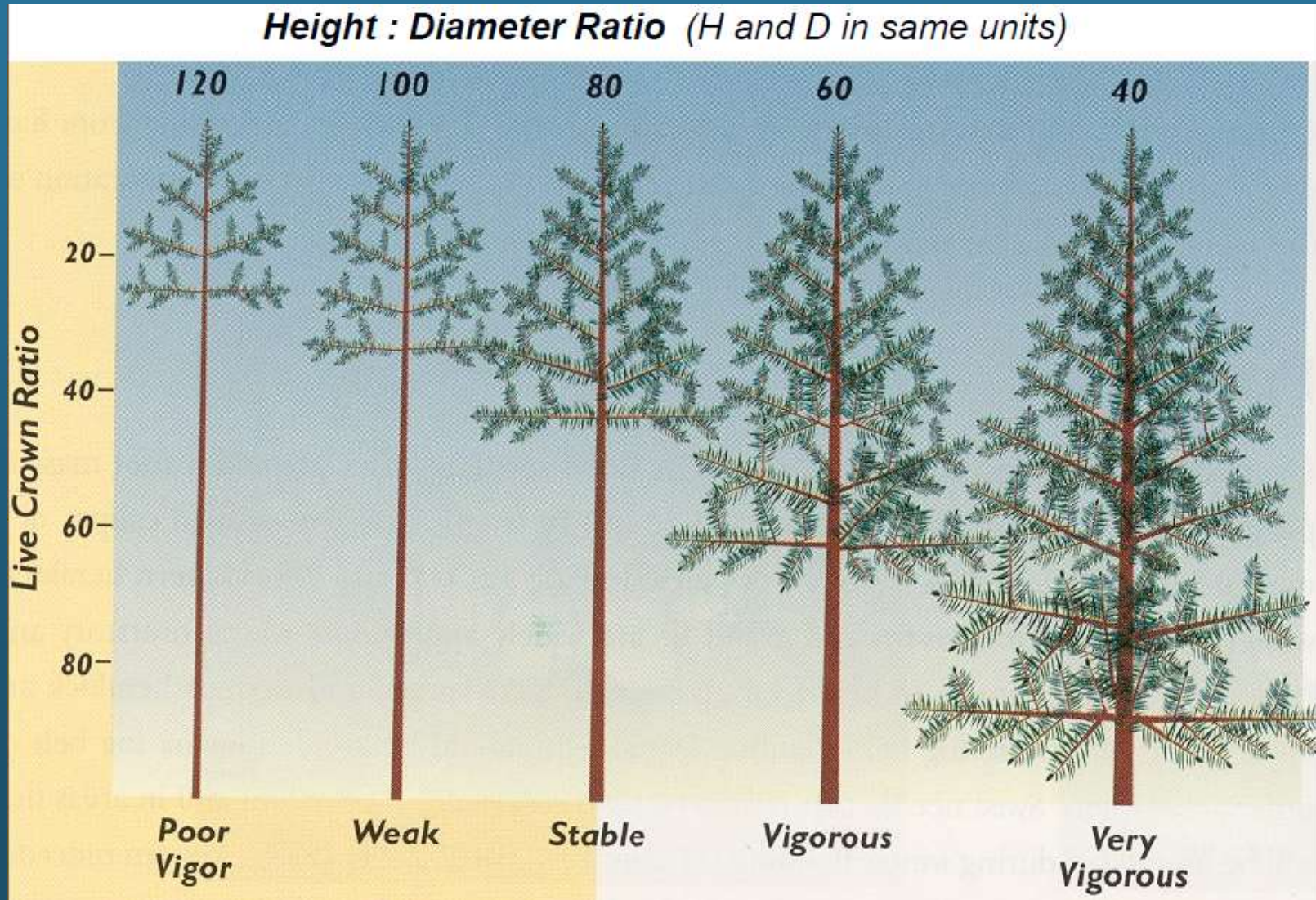
## The effect of stand density on diameter growth





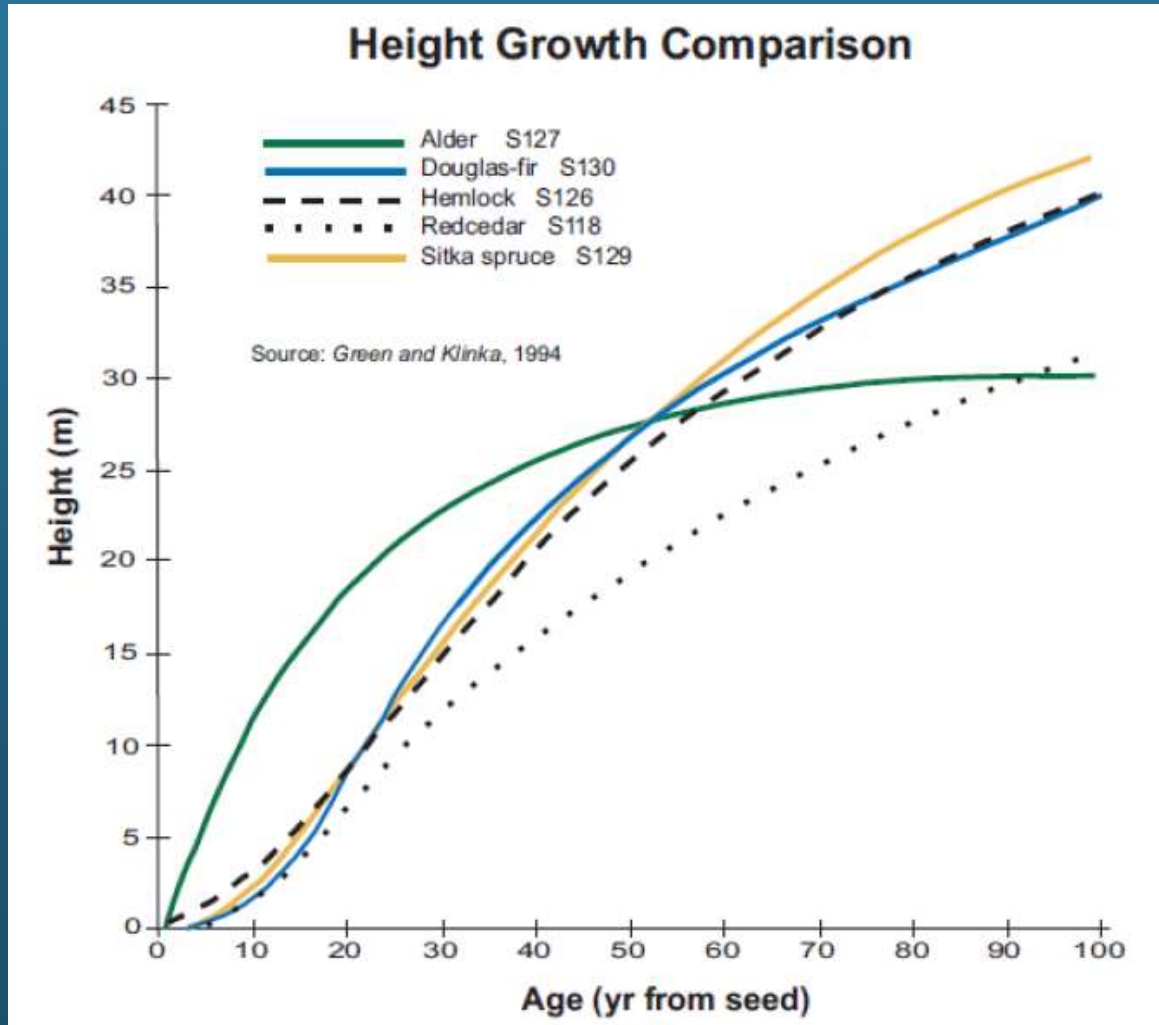
# Tree Vigor and Stability -

Live crown ratio and height to diameter ratio as indicators



# Tree Height Growth –

Height growth changes with age and differs between species





# Understory Establishment – following overstory disturbance and gap creation



# Competition versus Agent Based Mortality





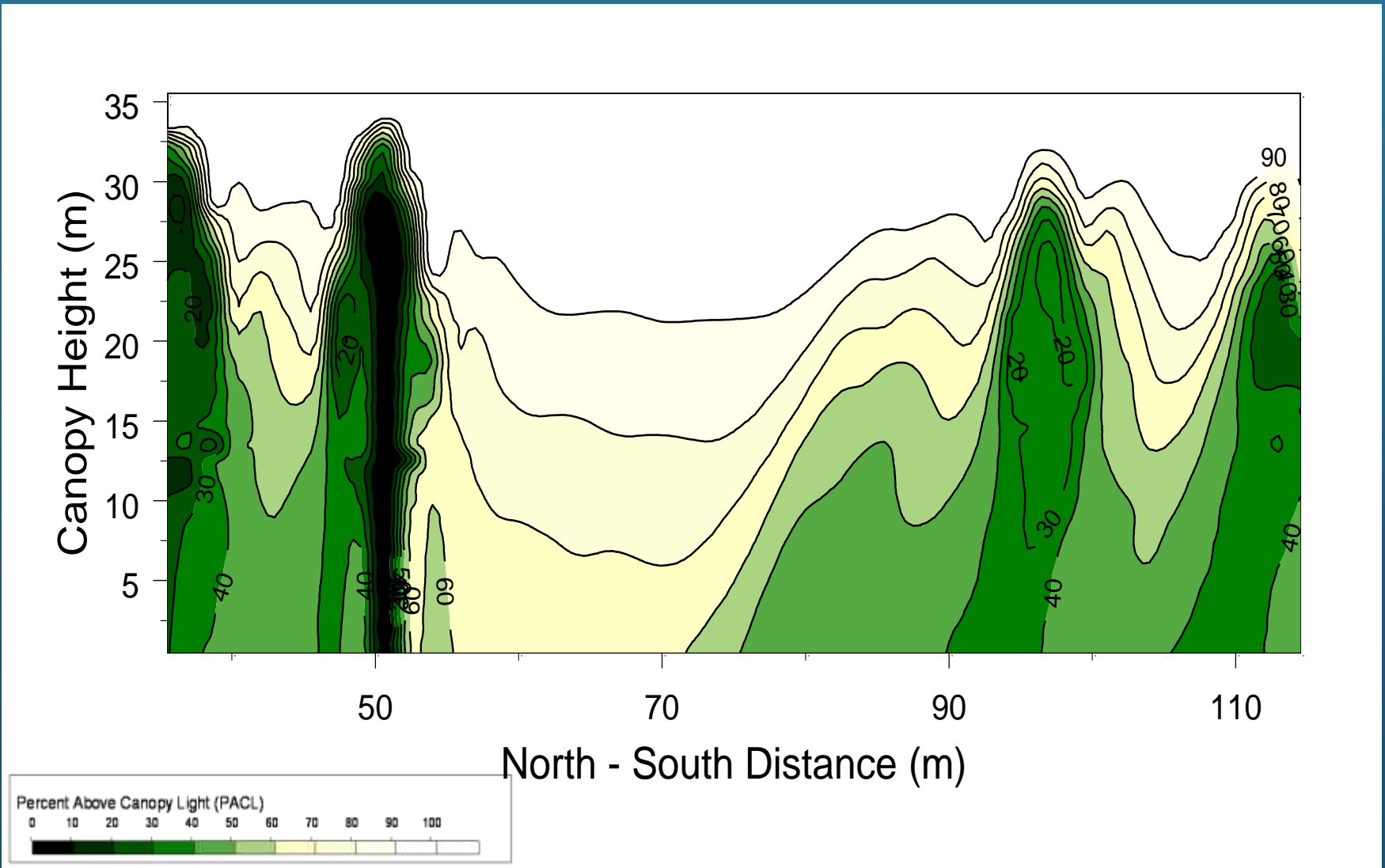
# Natural Regeneration

## - Understory Establishment Stage



- Seed Source
  - Species, Seed Year, Predation
- Environment
  - Temp, Water, Light
- Seed bed
  - Soil, Competition, Mycorrhiza

# Understory Light and Canopy Gap – Progressively more light in gap and shading of the gap edge





# Identify Shade Tolerance by Branch Morphology – Shade and Light Adapted Conifers



Grand fir



Western hemlock



Douglas-fir



Western white pine

# Shade Tolerance – Ranking of Western Tree Species (Daniel et al. 1979)

<b><u>Very tolerant</u></b>	Western hemlock	Pacific yew	Pacific silver fir	Vine maple
<b><u>Tolerant</u></b>	Western redcedar	Grand fir	Sitka spruce	
<b><u>Intermediate</u></b>	Big-leaf maple	Douglas-fir	Western white pine	
<b><u>Intolerant</u></b>	Ponderosa pine	Lodgepole pine	Red alder	
<b><u>Very intolerant</u></b>	Cottonwoods	Larch		



# Understory Growth – Morphological Plasticity



Noble fir



Western hemlock



Pacific silver fir

- Sun and shade foliage
- Terminal vs. lateral growth
- Apical dominance



Soil Nutrients



# Site and Tree Species

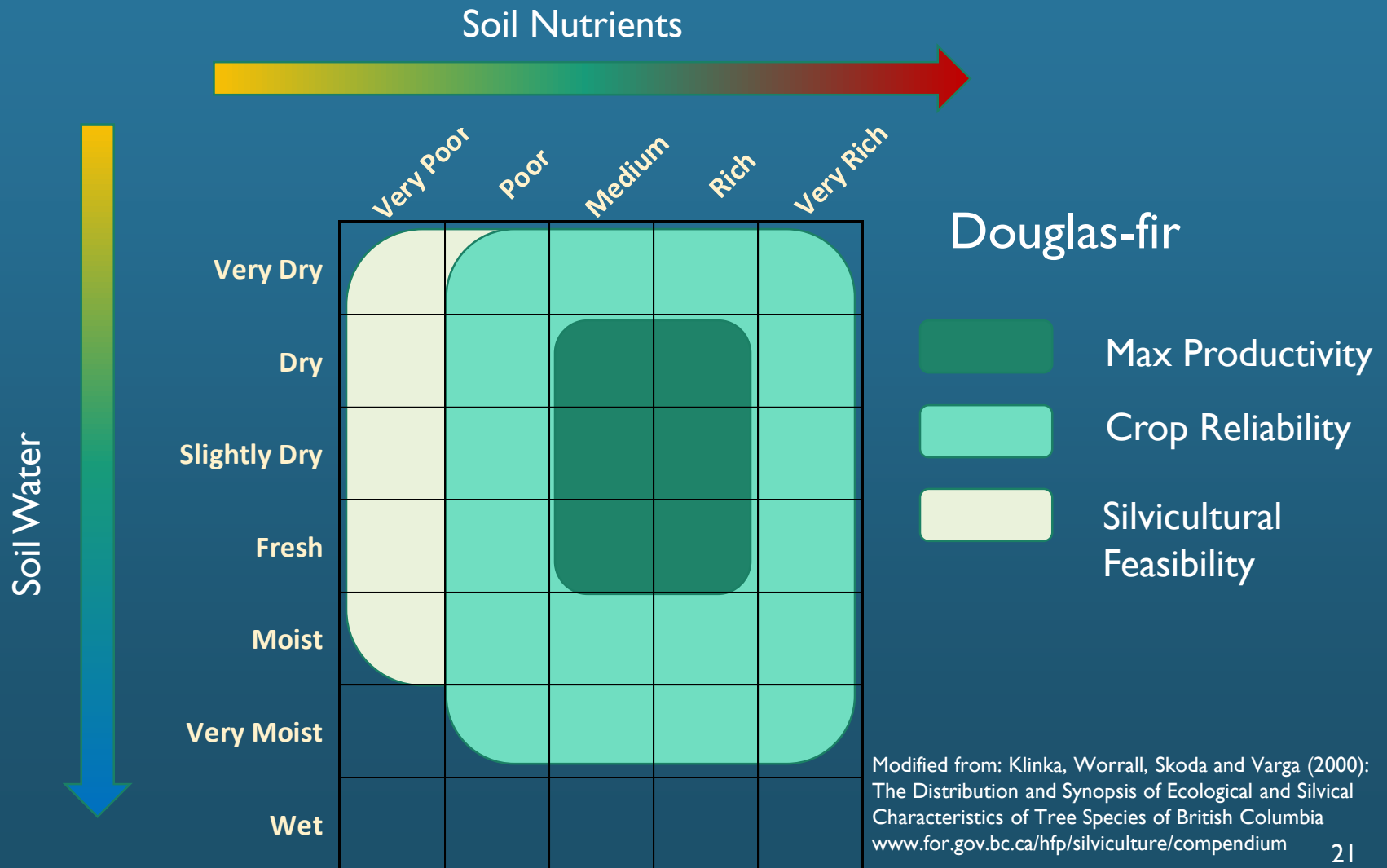


Soil Water





# Tree species and Ecological Amplitude



# Understory Species as Indicators of Site Conditions

## Site Classification - Edatopic Grid

CWHvm subzone

Soil nutrient regime

		VP	P	M	R	VR
MD	0	02 Cladina (Lichens) rocky sites crest-rocky slope-rock				
	1	03 Gaultheria (Salal) shallow soils or steep slopes crest-skeletal crest-rocky slope-skeletal slope-rocky		04 Polystichum (Sword fern) very steep, rocky or fragmental colluvial slopes slope-rocky slope-skeletal		
SD	2					
F	3	01 Vaccinium (Blueberry) near-zonal and zonal sites drier slope-skeletal zonal wetter		05 Tiarella (Foamflower) Inherently rich or weakly nutrient-enriched sites; predominantly in the CWHvm1 variant slope-skeletal flat-gentle slopes		
	4					
M	5					
VM	6					
	7					
W	7			14/11 Lysichitum (Skunk cabbage) water-collecting (waterlogged) sites gleysolic organic		

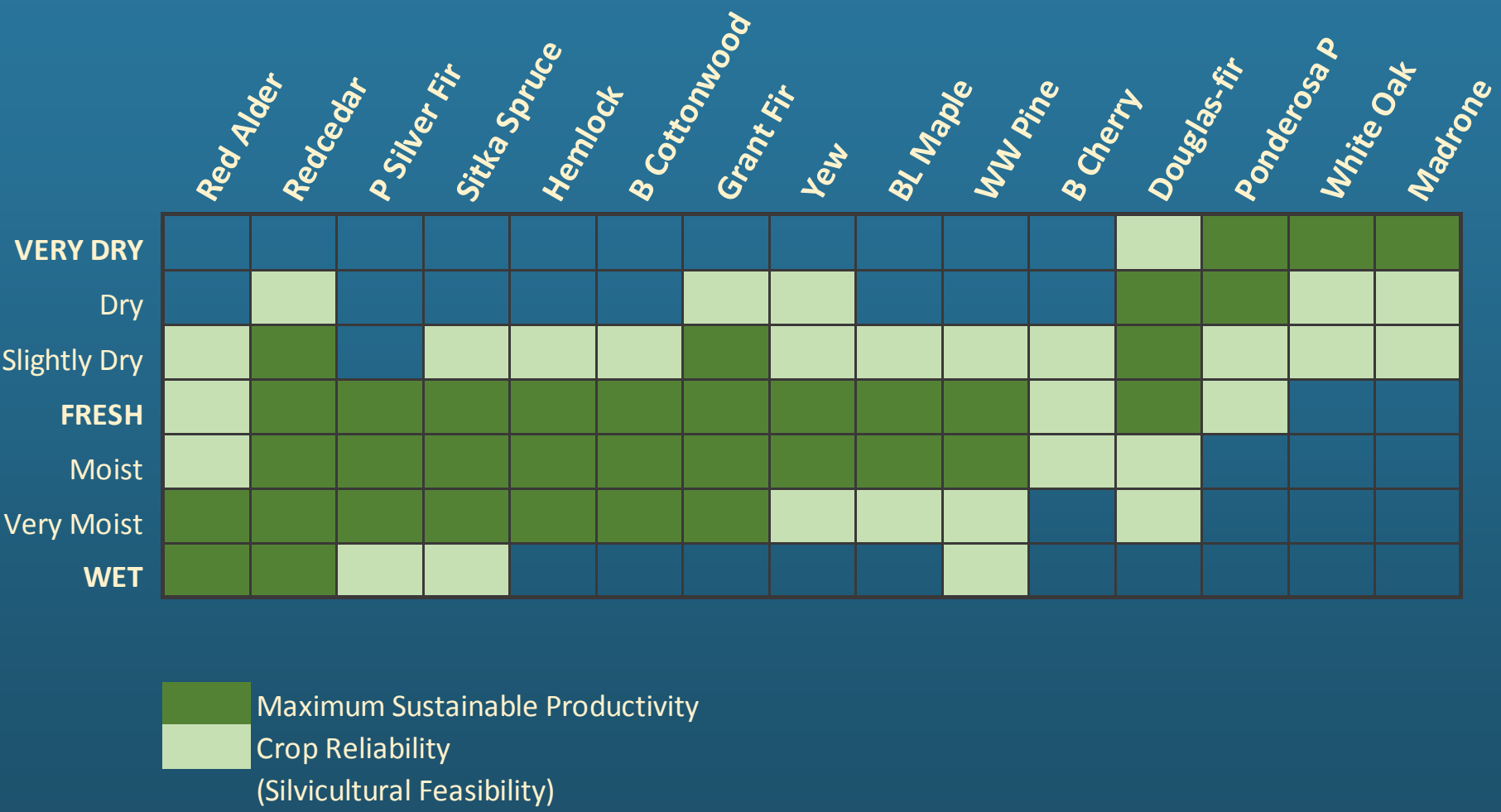
Soil moisture regime



Modified from:  
[www.for.gov.bc.ca/hfp/silviculture/compendium](http://www.for.gov.bc.ca/hfp/silviculture/compendium)

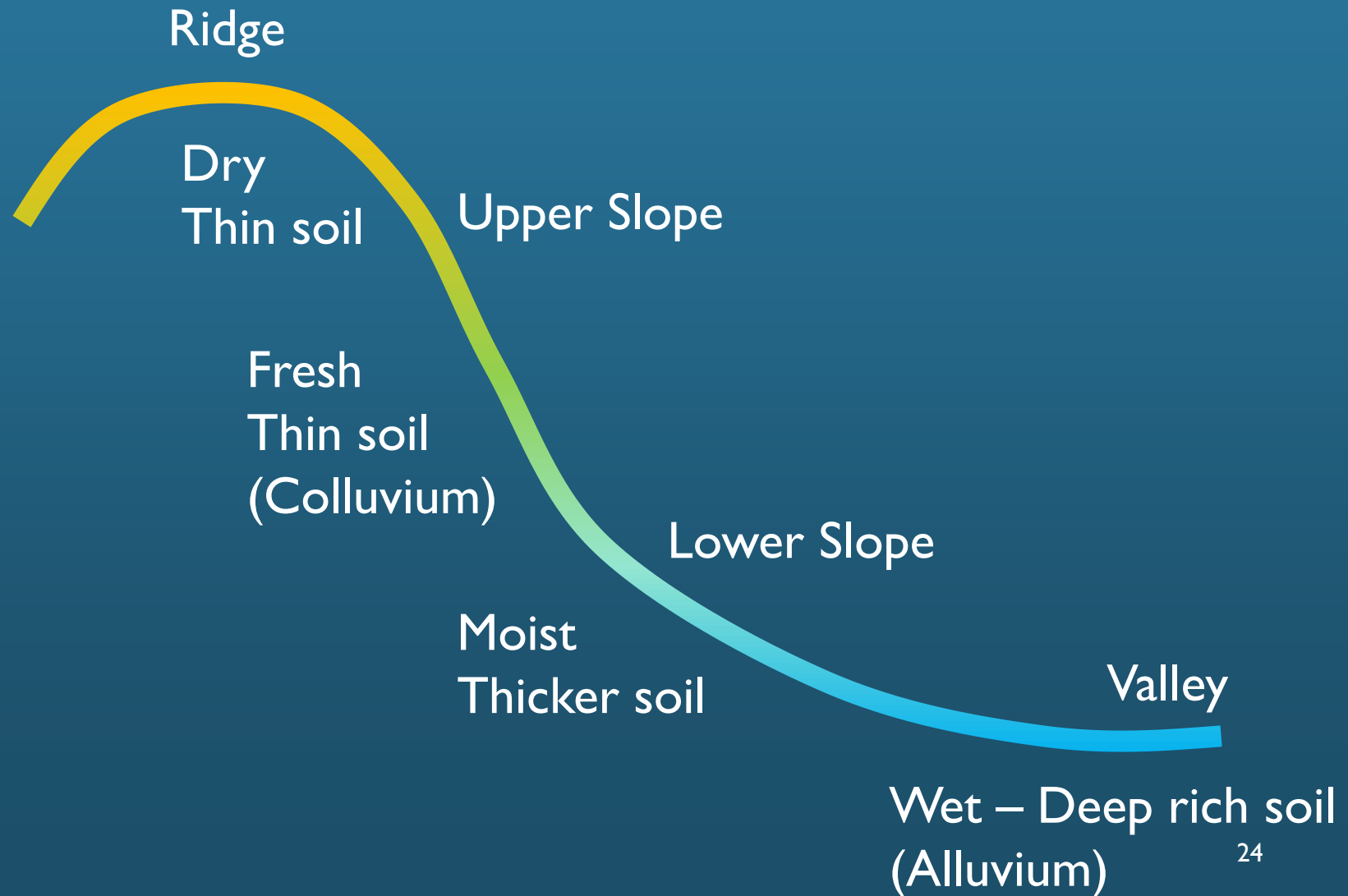


# Tree Species and Soil Moisture



Modified from:  
[www.for.gov.bc.ca/hfp/silviculture/compendium](http://www.for.gov.bc.ca/hfp/silviculture/compendium)

# Soil Moisture and Topographic Position



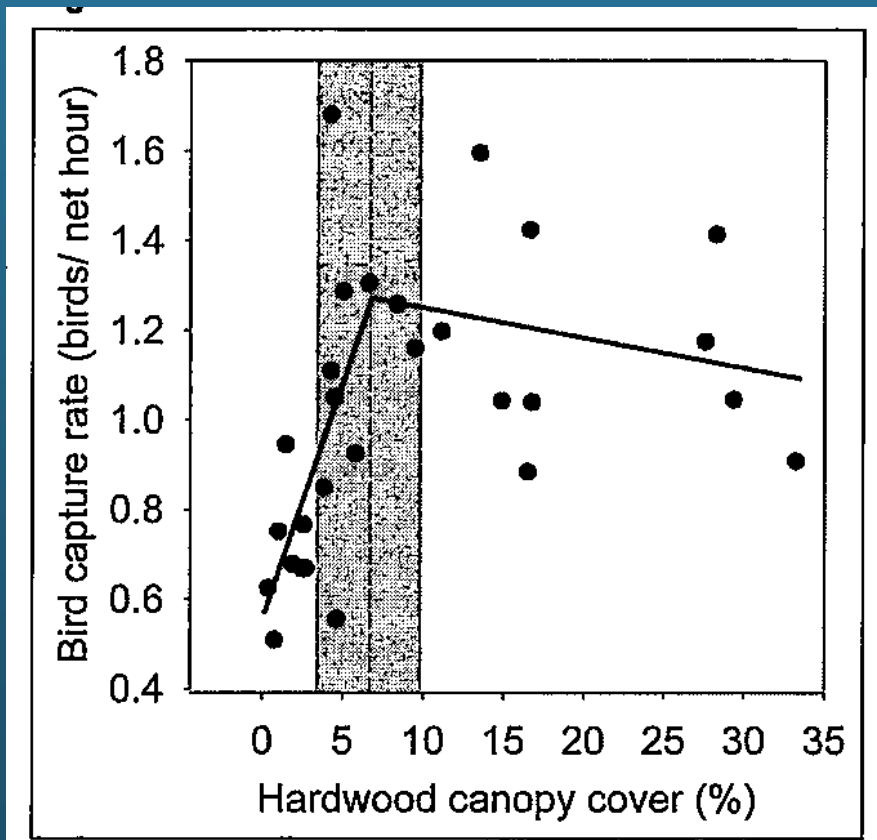


# Mixed-species Forests





# Percent hardwood mixture in conifer forests affects song bird density

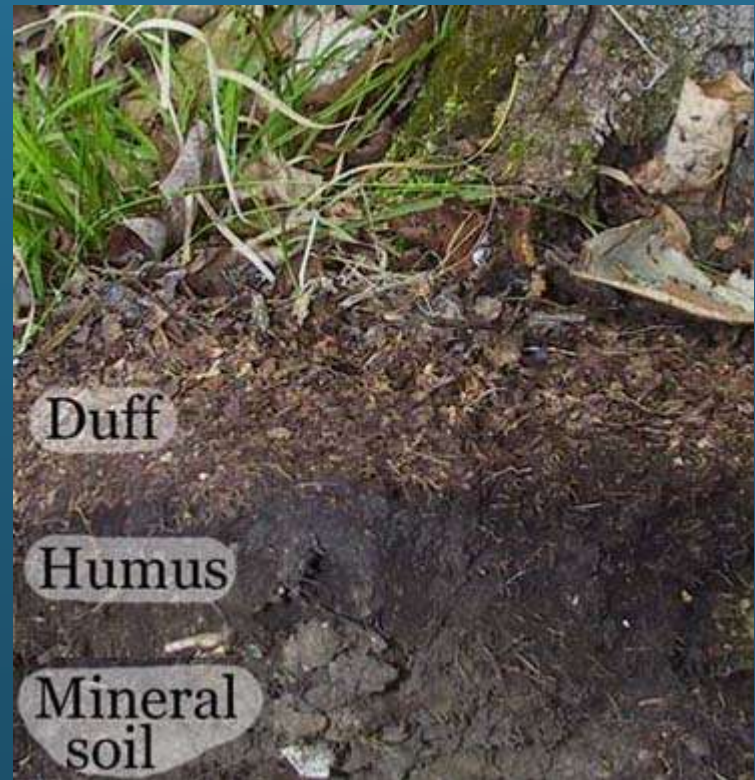


From Ellis and Betts, 2010,  
Western Forester 55(2)



# Benefits of Mixed-species Stands

Hardwood plant litter with high decomposition rates improves soil development and is forage for many species





# Mixed-Species Stands

- Species specific
  - ▣ Growing space
  - ▣ Height growth
  - ▣ Shade tolerance
  - ▣ Senescence
  - ▣ Disease & Pests



# Mixed-Species Stands

- ▣ Symbiosis
- ▣ Nutrient enrichment
- ▣ Resilience



Mycorrhiza

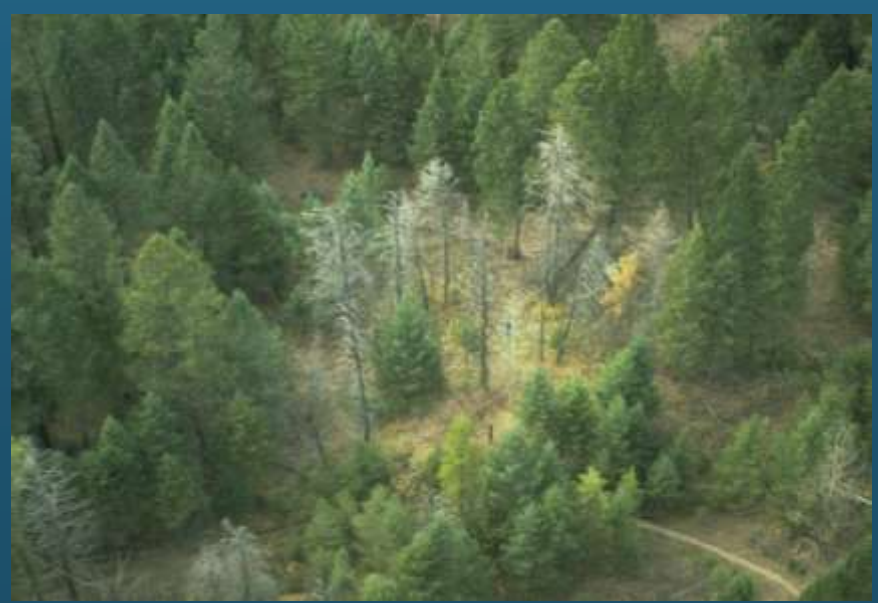


Frankia alni  
bacteria



# Root Disease Indicators

Photos: [www.forestryimages.org](http://www.forestryimages.org)  
and [www.fs.fed.us](http://www.fs.fed.us)







## Armillaria root disease

- Widespread
- Most tree species
- Manage for Tree Vigor



## Phellinus or Laminated Root Rot

- Localized
- Species specific
- Manage for Species Conversion

➤ Ecological Forestry manages for Species Diversity

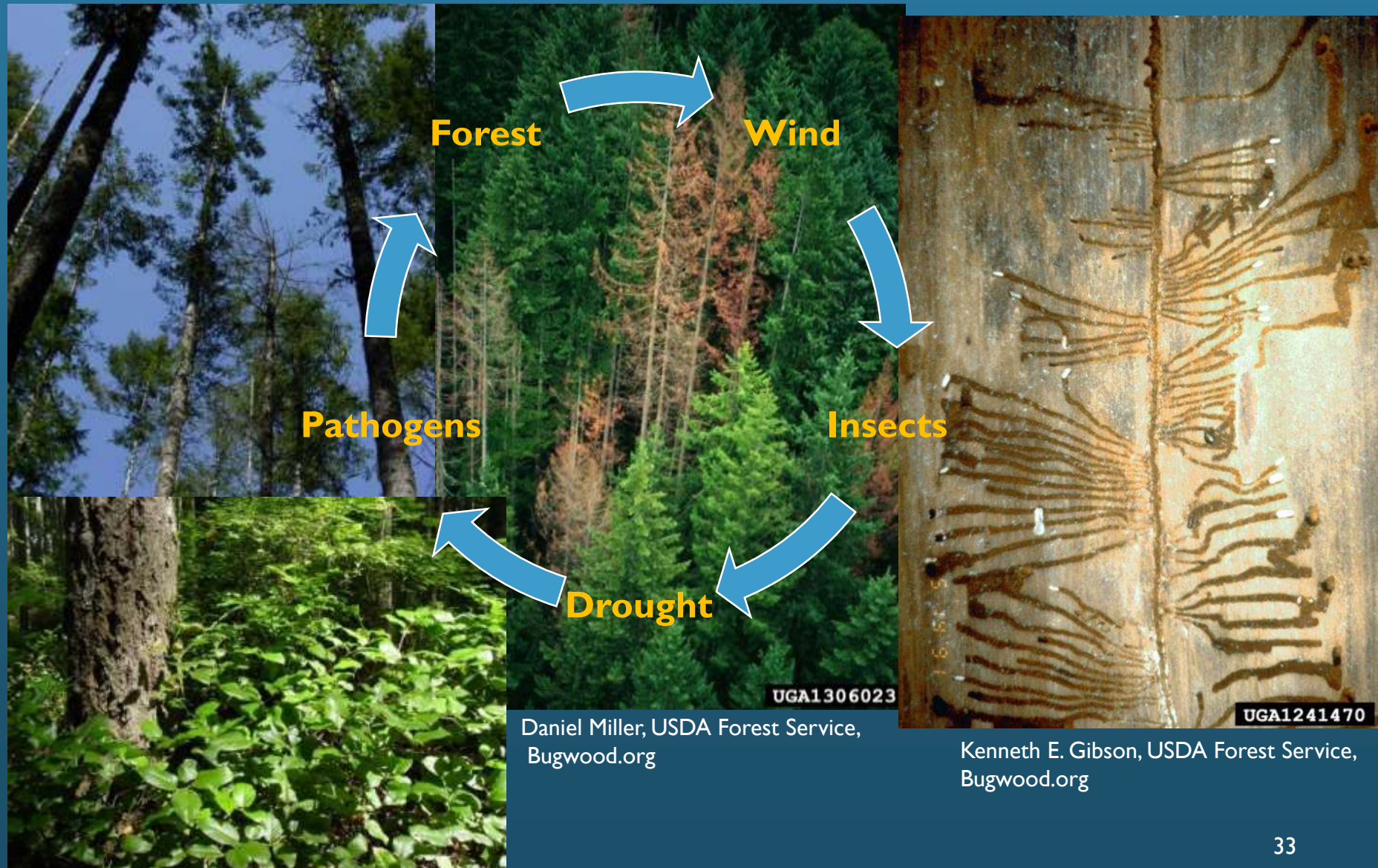


# Bark Beetle Indicators





# Positive Feedback Cycle in Disturbance Agent Complex: Forest – Wind – Insects - Drought – Pathogens





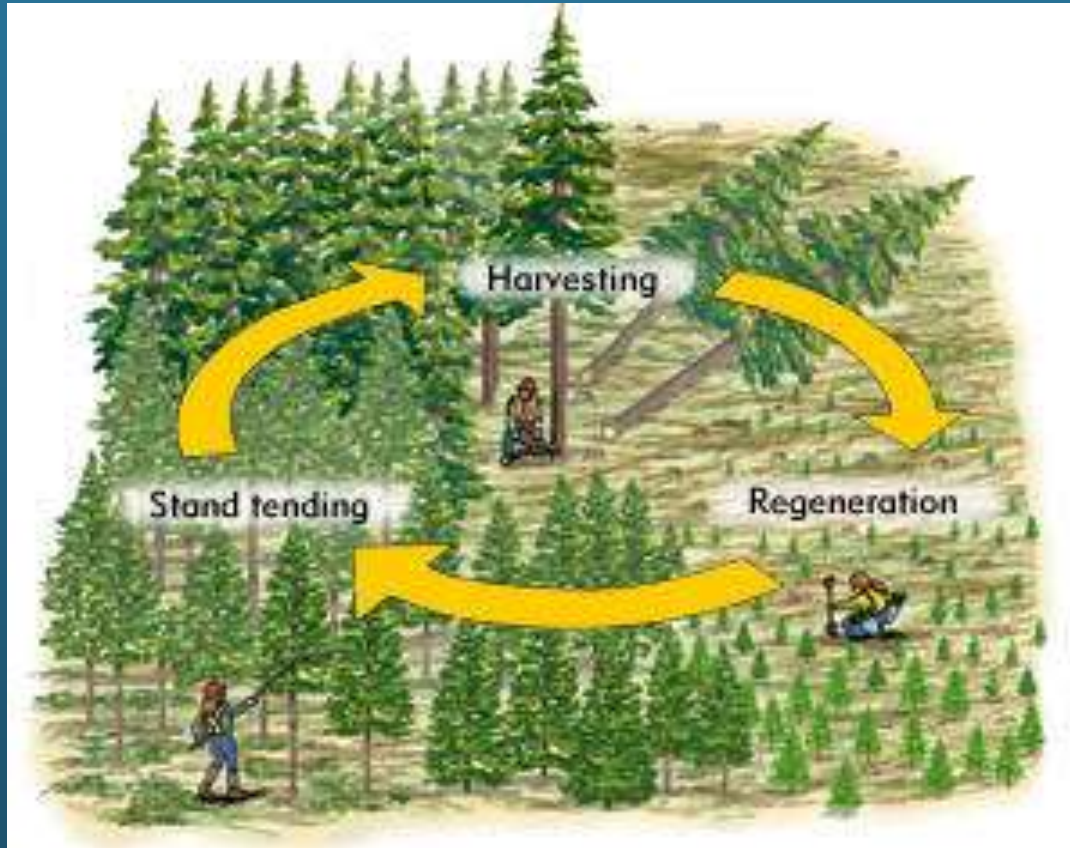
## Landscape level effect of tree species diversity on disturbance propagation





# Silvicultural System –

System of coordinated regeneration, tending, control, and harvest treatments



## Even-aged System

- Clear Cut
- Seed Tree
- Shelterwood
- Thinning

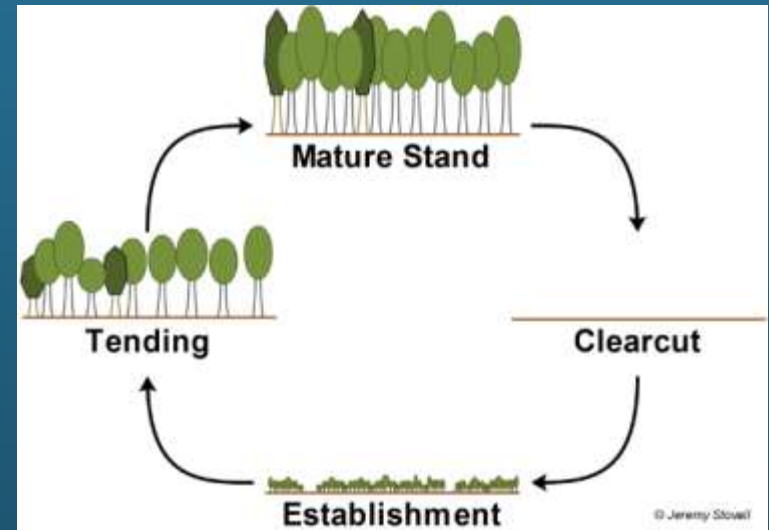
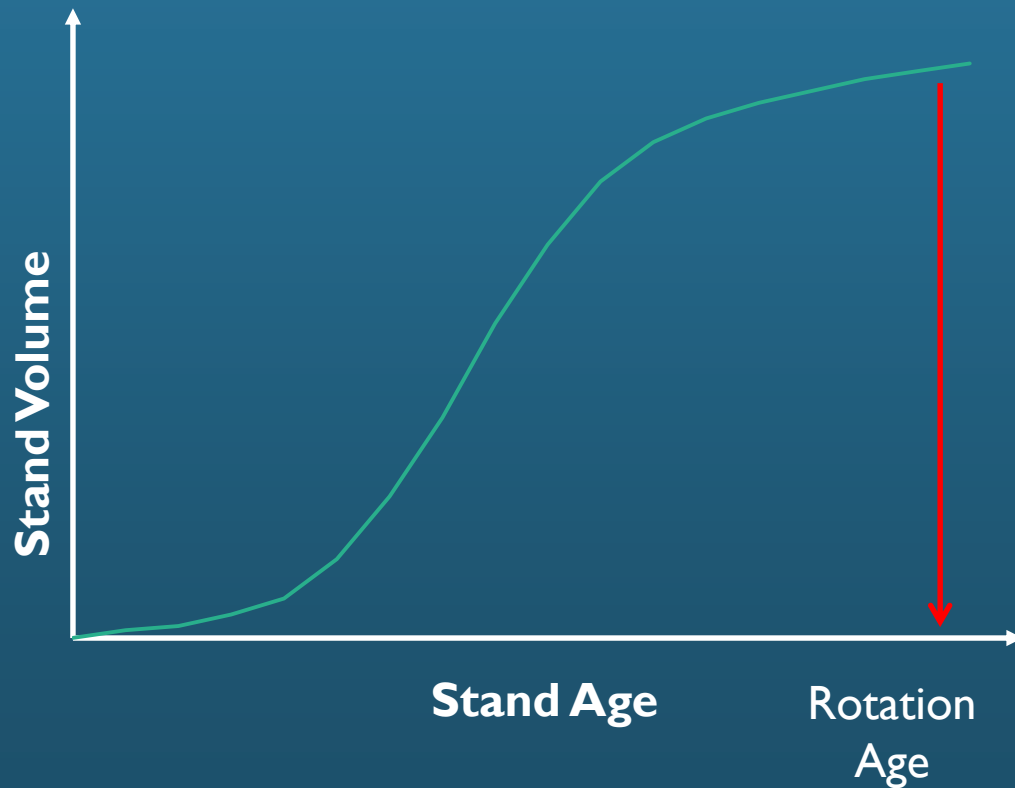
## Two-aged System

- Variable Retention
- Coppice with Reserves

## Uneven-aged system

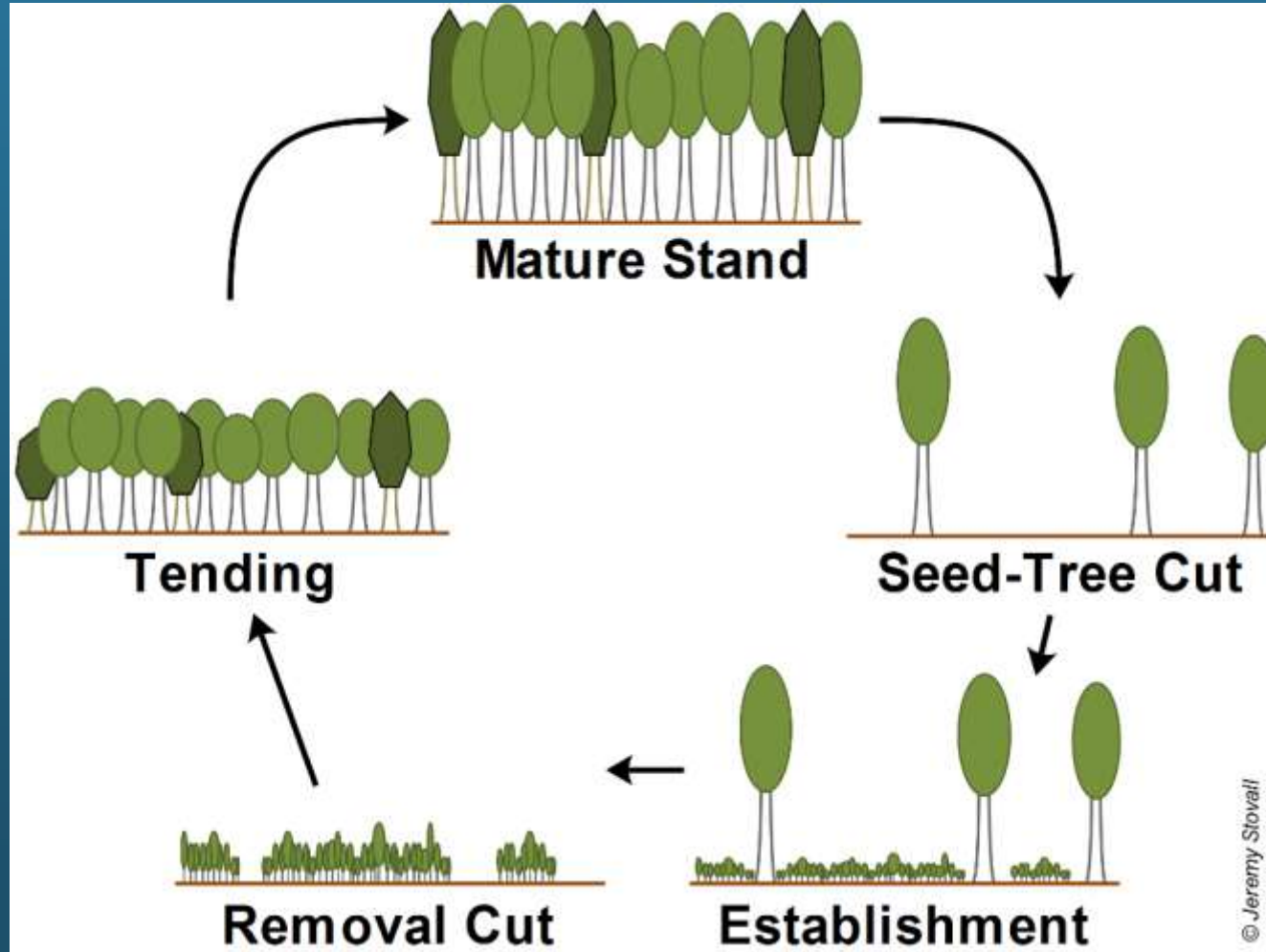
- Group Selection
- Thinning
- Single Tree Selection

# Stand Volume and Rotation in Even-aged System



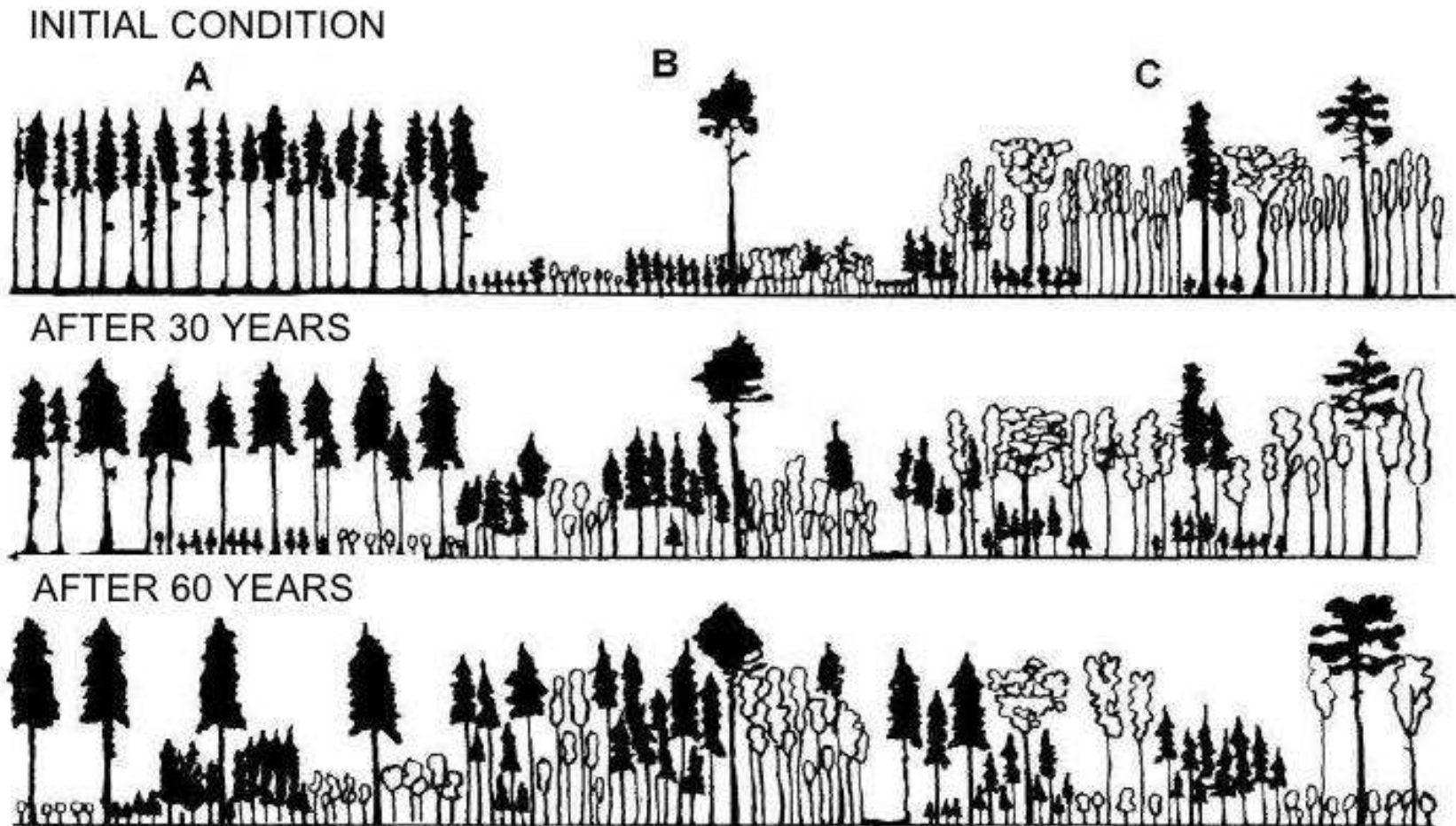


# Seed-Tree and Shelterwood Regeneration Methods



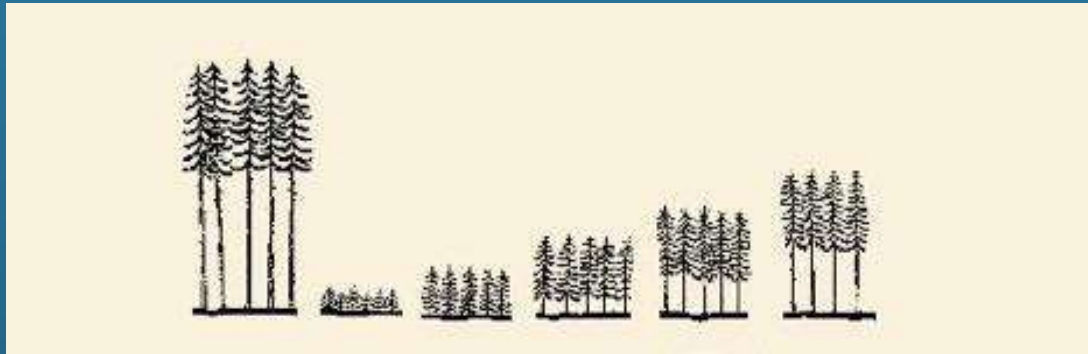
# Continuum of Silvicultural Approaches –

A- individual tree selection, B-group selection,  
C- mixture of individual tree and group selection

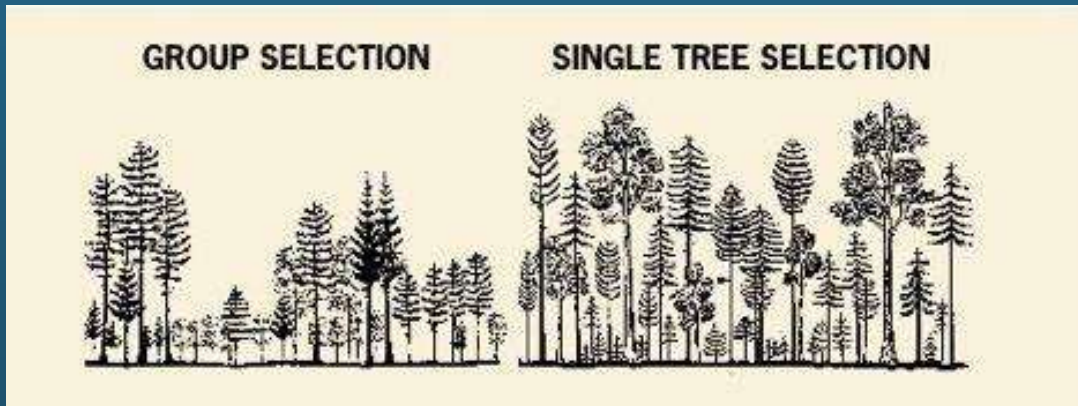




# What is Uneven-aged Management?



Even-aged “age-class” Forestry



Uneven-aged Management System







HOMMAGE A  
HENRY BIOLLEY  
SYLVICULTEUR  
1858 - 1939



Origins of Uneven-aged  
forest management:

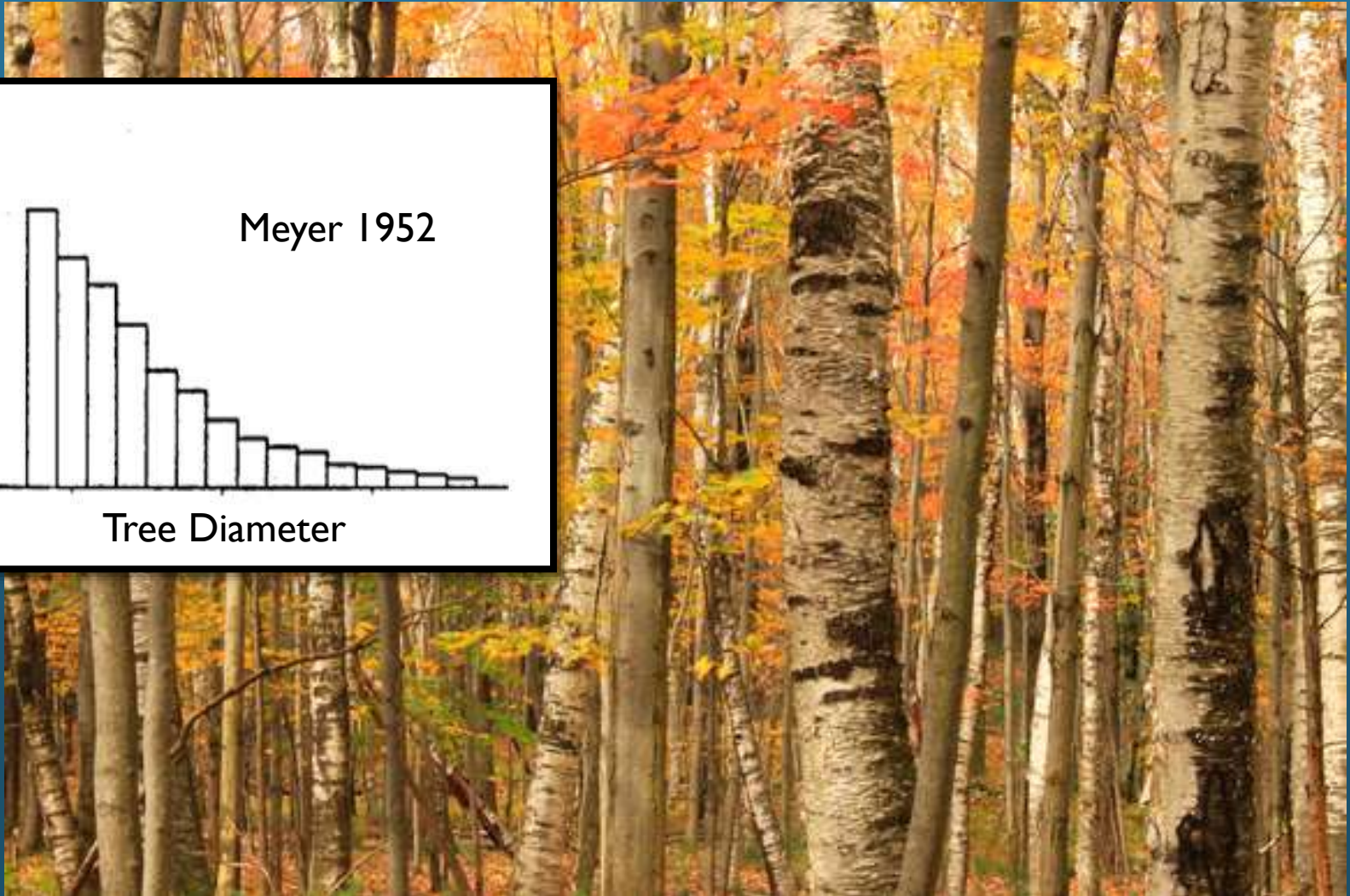
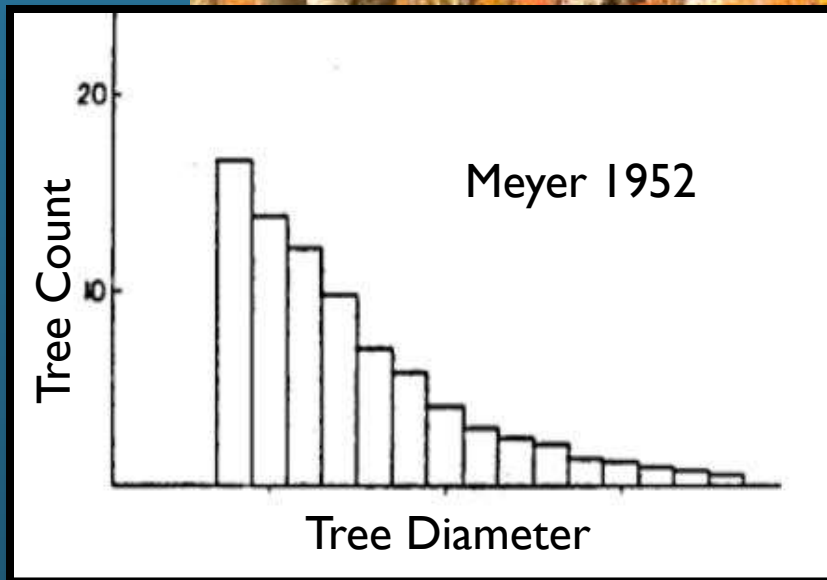
Henry Biolley (France)  
Alfred Möller (Germany)

“Dauerwald”  
“Continuous Cover  
Forestry”



# Ecological Basis

- Small-scale disturbance regime and species composition lead to characteristic diameter distribution of natural stands



# History of Uneven-aged Management in the Pacific Northwest

Kirkland and Brandstrom 1936

Leo Isaac 1956







## Managing Multi-aged Stands





# Managing Uneven-aged Stands

Manage stand density to:

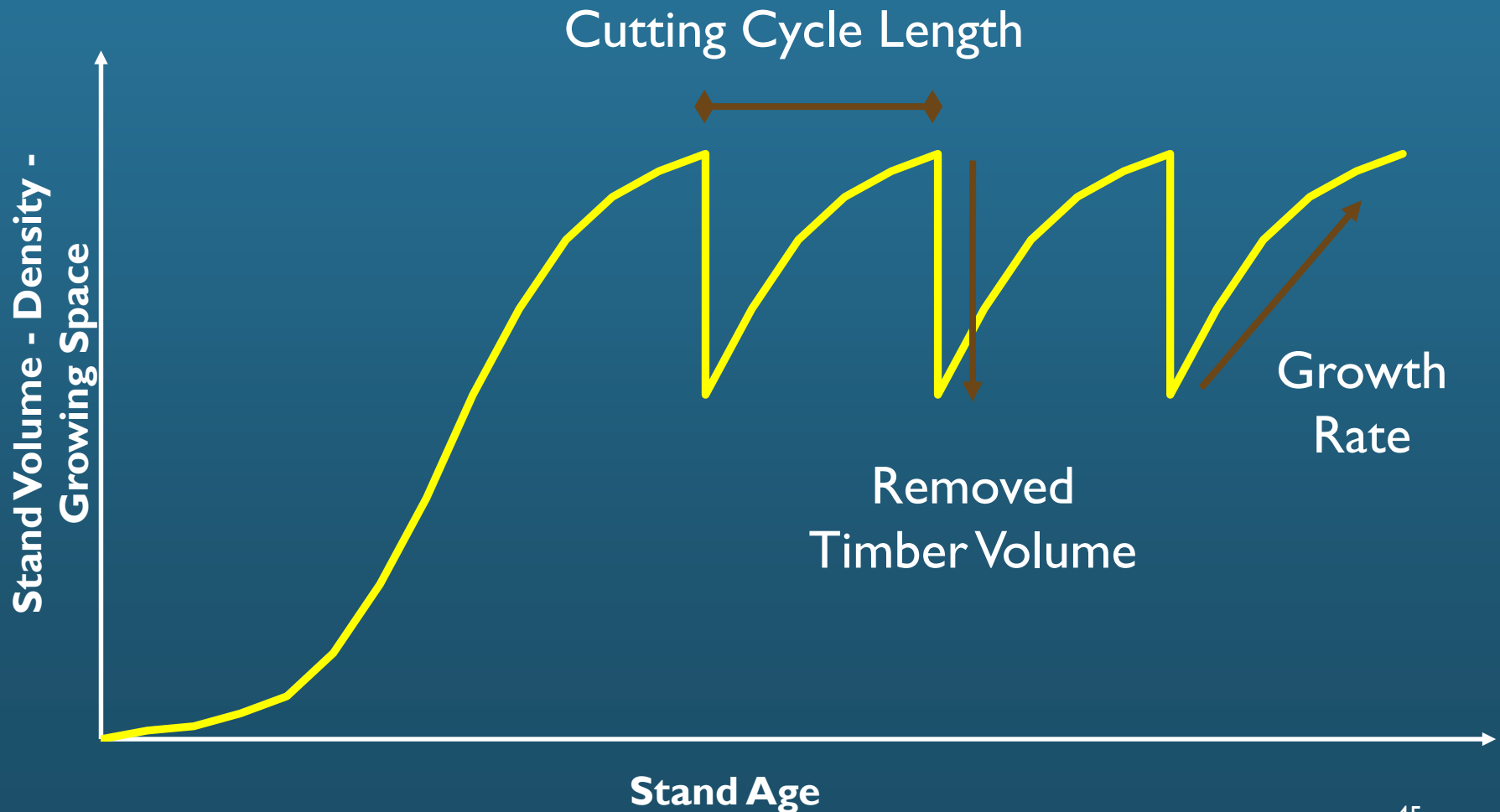
1. Sustain growth of all stand components
2. Maintain stand structure
3. Replace tree mortality and harvest through regeneration

Transformation of even-aged to multi-aged stands

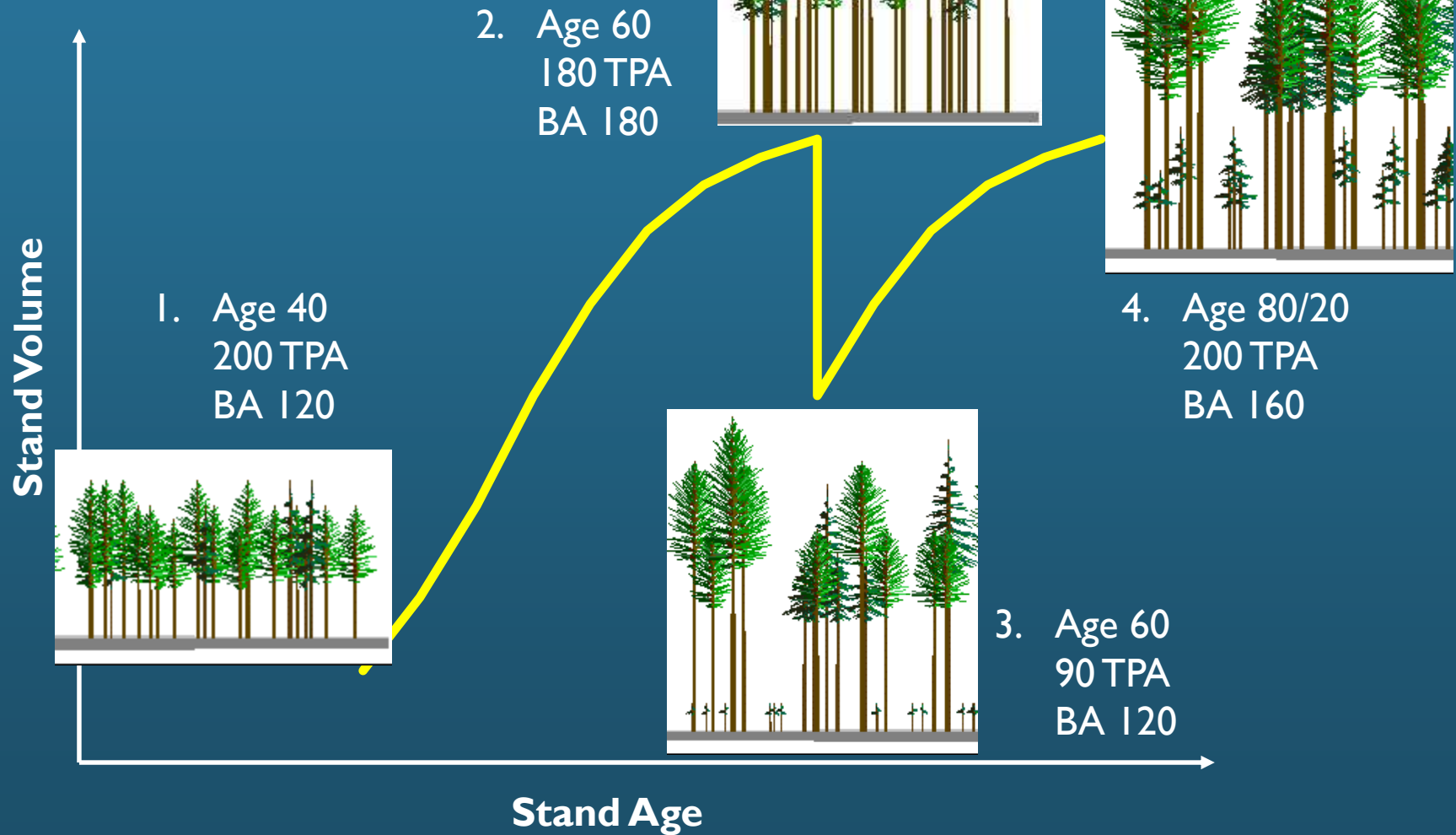


# Cutting Cycle

- cutting cycle length depends on cutting intensity and growth rates



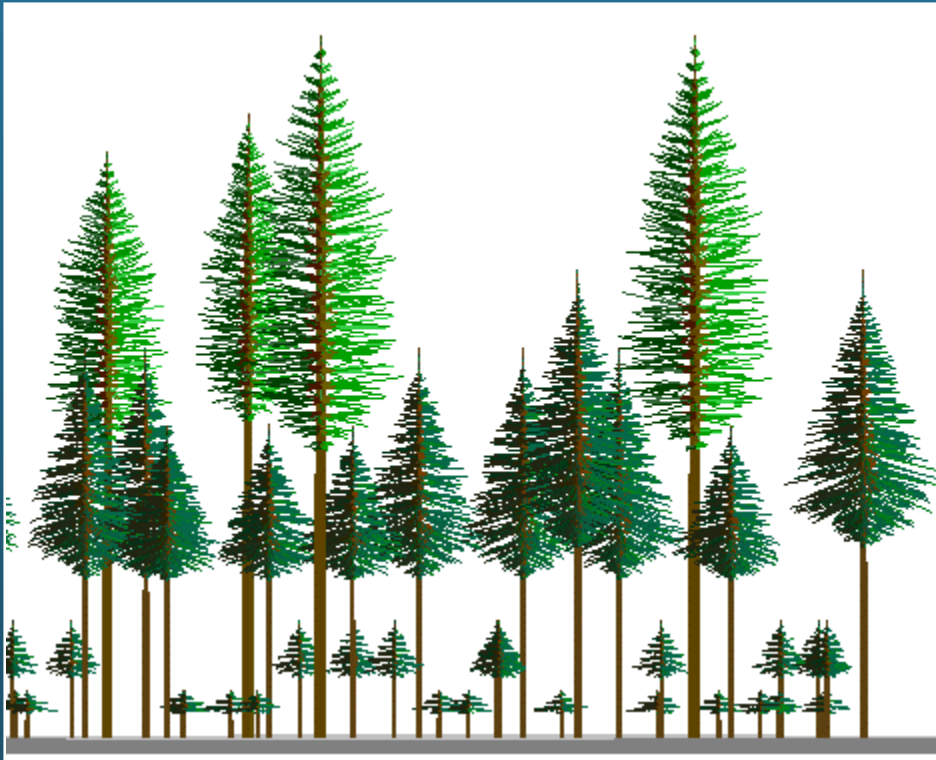
# Cutting Cycle



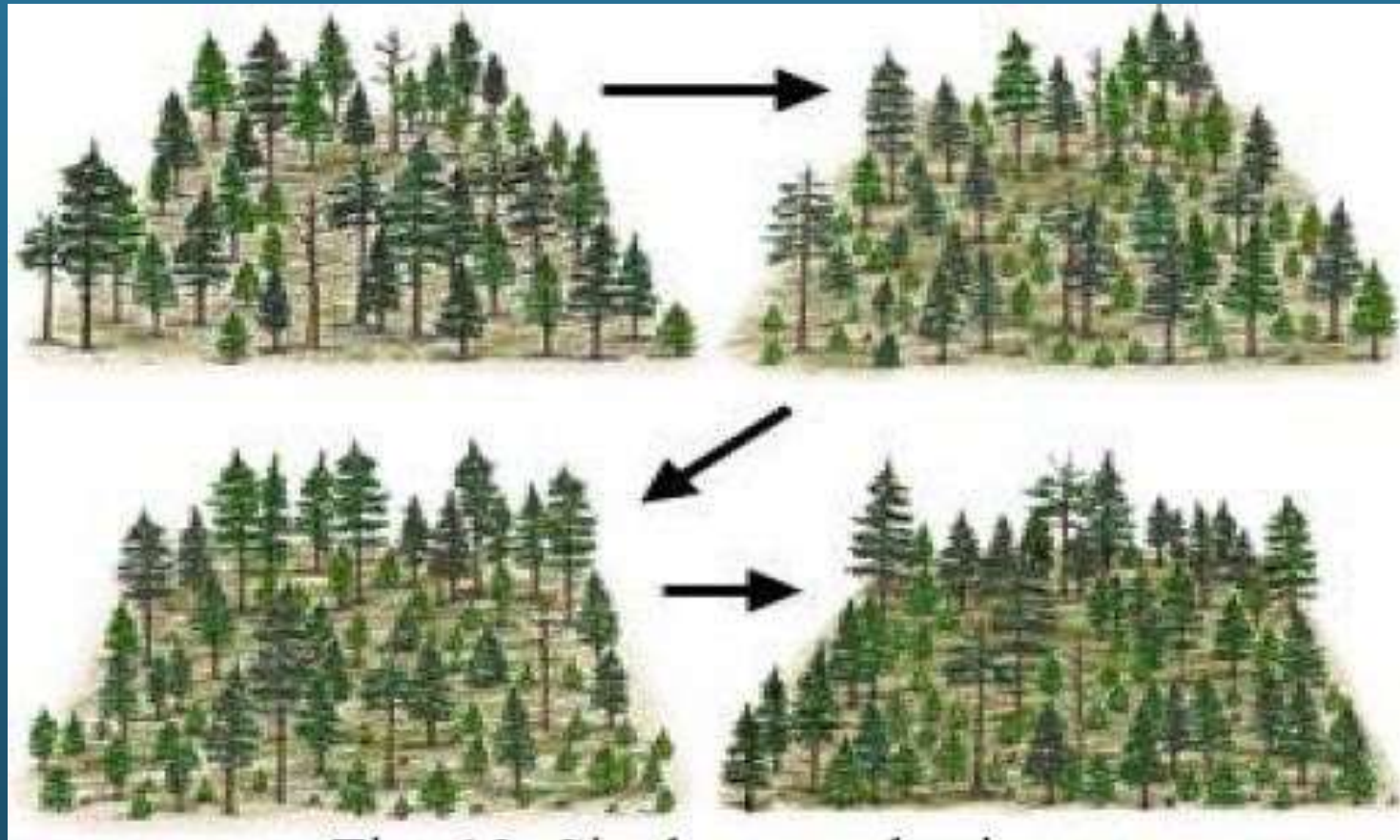


# Single Tree Selection –

Age classes are mixed at fine scale, growth and regeneration are regulated by removal of individual trees



While individual trees are removed,  
the stand structure remains the same

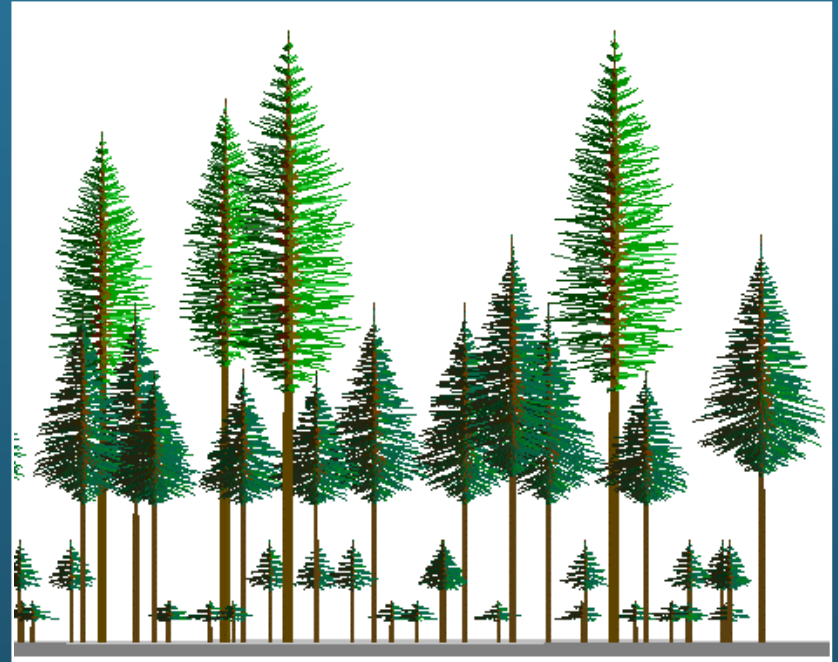
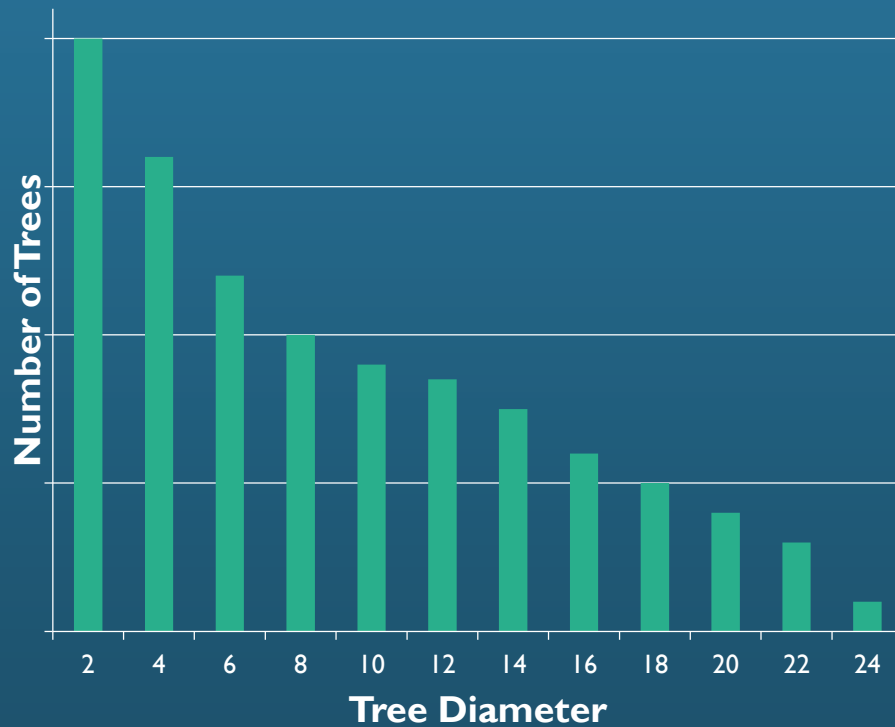




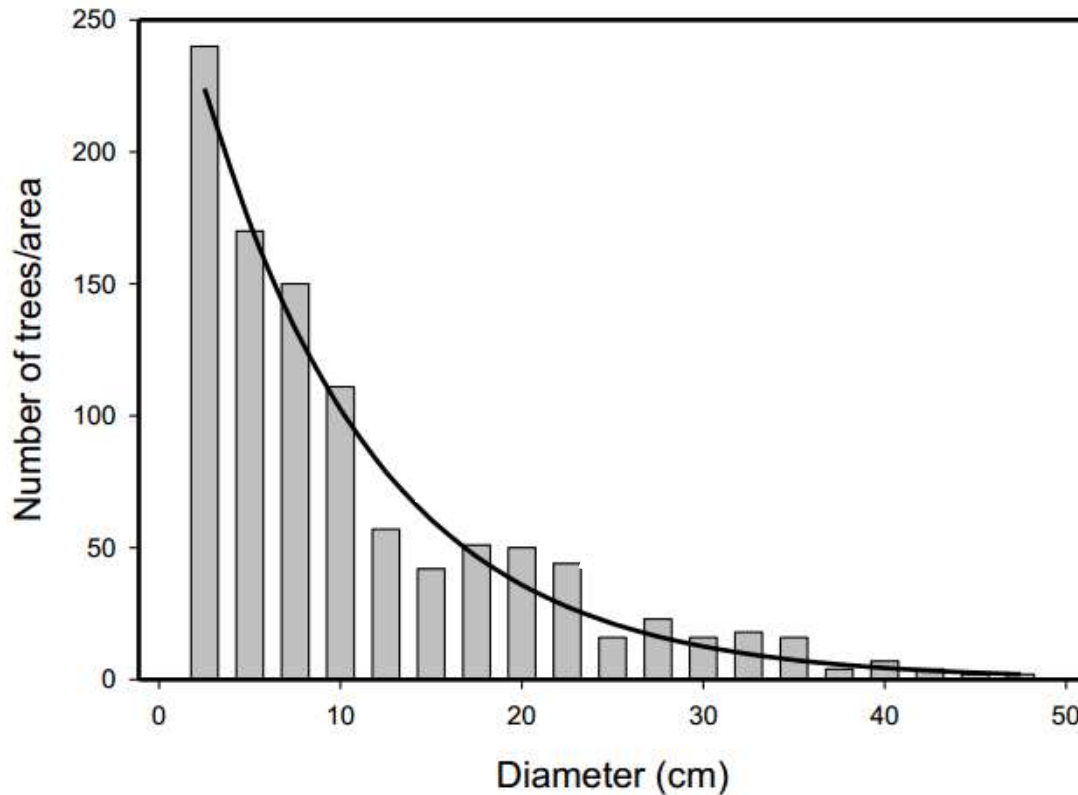
# Single Tree Selection

- developing a guide curve from tree count and diameter

Tree Tally by 2 inch Diameter Class



# Single Tree Selection



Guide Curve:  
Total basal area  
Maximum Diameter  
“slope”

At each cutting cycle  
we thin trees in classes  
that exceed the guide  
curve.



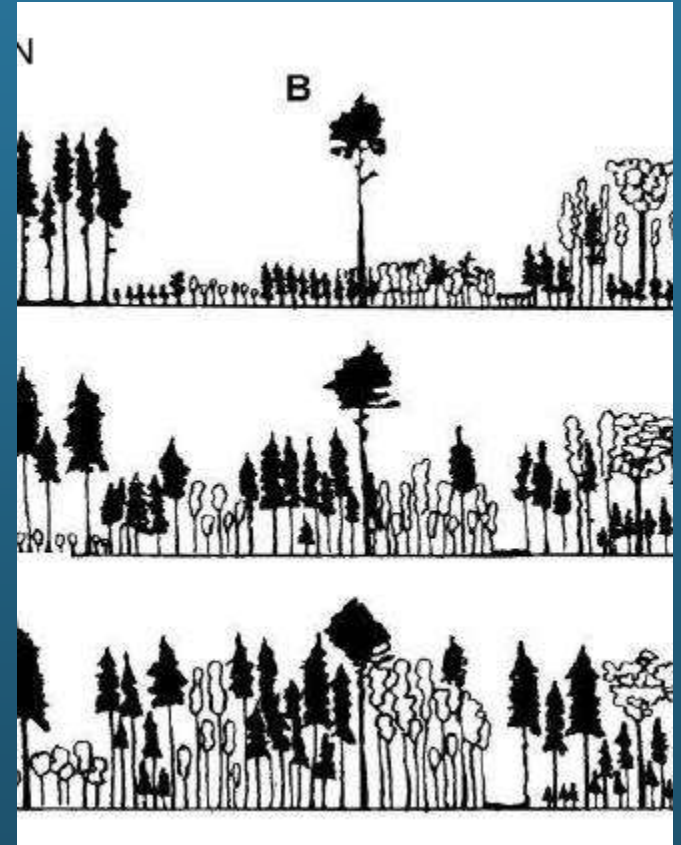
# Group Selection System - A Systematic Approach to Diverse Forests





# Group Selection System –

Age classes are mixed at group scale (1/2 – 2 acres), growth and regeneration are regulated by removing groups of trees AND thinning individual trees



The group selection system allows for mixture of shade and intolerant species in the same stand.



# Group Selection System

- Age-class mixture and management activities

Regeneration

PCT

Thinned  
Matrix

Un-thinned  
Large Tree

Activities:

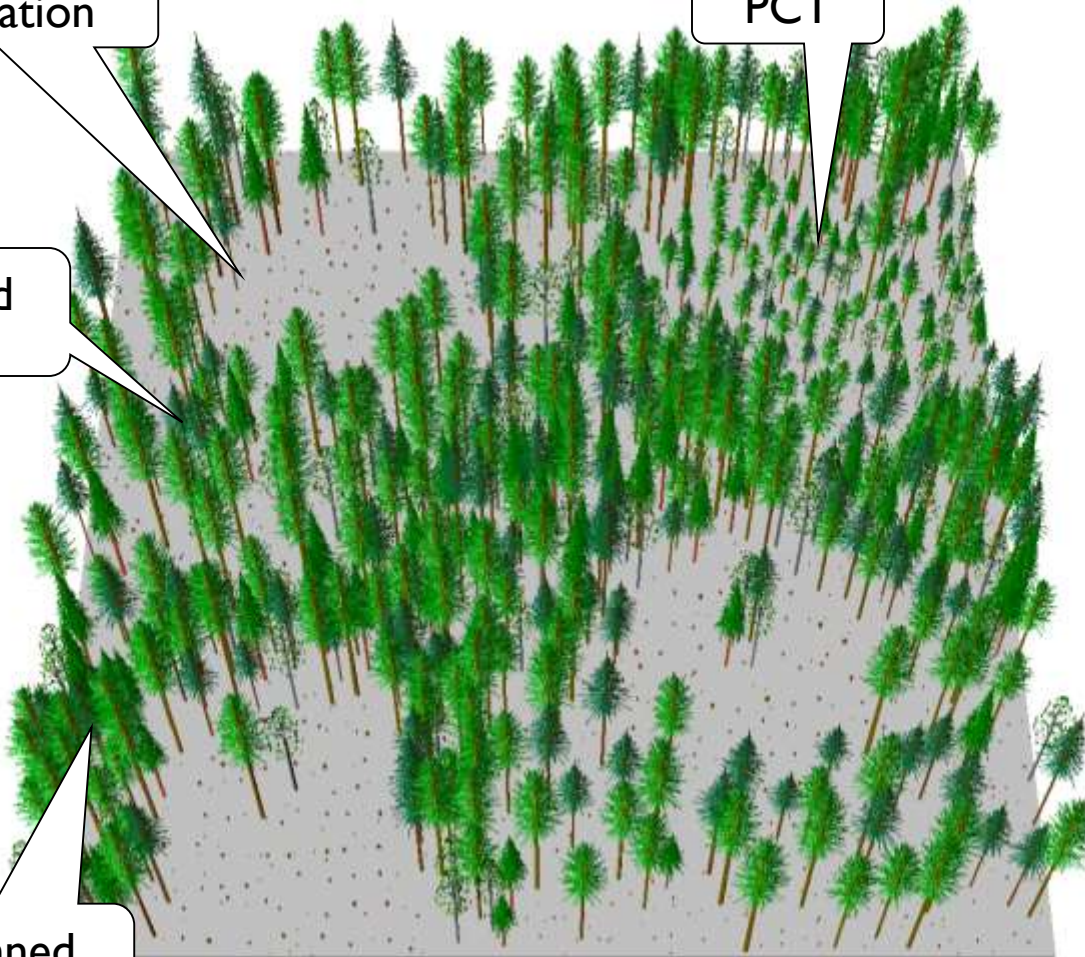
Group-Selection  
Harvest

Natural Regeneration  
Planting

Pre-comm. Thinning


Commercial Thinning

Understory Thinning



# Scheduling Group Selection Treatments

Area Control Method – Stand is divided into even areas, these areas are treated during the cutting cycle (e.g. 20% regenerated in one-acre group selection cuts, 40% commercial thinning, 20% pre-commercial thinning of regeneration in previous group selection cuts).

		Cutting Cycle					
		1	2	3	4	5	6
Stand Area							
20%		Group Selection	PCT	Commercial Thin	Commercial Thin	Group Selection	PCT
20%		Commercial Thin	Group Selection	PCT	Commercial Thin	Commercial Thin	Group Selection
20%		Commercial Thin	Commercial Thin	Group Selection	PCT	Commercial Thin	Commercial Thin
20%			Commercial Thin	Commercial Thin	Group Selection	PCT	Commercial Thin
20%				Commercial Thin	Commercial Thin	Group Selection	PCT
							
		40	60	80	100	120	140
		Stand Age					



# The Silviculture Toolbox –

Commercial and Ecological Forestry use the same tools. The difference is in when and how they are applied.





# Pure Hardwood Stands - Alder

Hardwood Silviculture Cooperative  
<http://www.cof.orst.edu/coops/hsc/>



Planted 1200 TPA  
Age 9



Thinned to 230 TPA  
Age 12



Planted 230 TPA, Age 13



# Naturally Regenerated Hardwood Stands

Red alder, Darrington, WA, Hardwood Silviculture Cooperative,



Unthinned



Thinned to 250 TPA



# Hardwood Thinning Regime

- Planting 500-600 TPA
- PCT to 200-250 TPA (age 12)
- Pruning to retain 60% of crown
- Life branch pruning only
- 25-30 year harvest age
- 16 foot logs, 12 inch diameter
- High price of knot-free lumber
- Snow and ice damage

From John Belton 2004,  
Northwest Woodlands



Photo: Hardwood Silviculture Cooperative

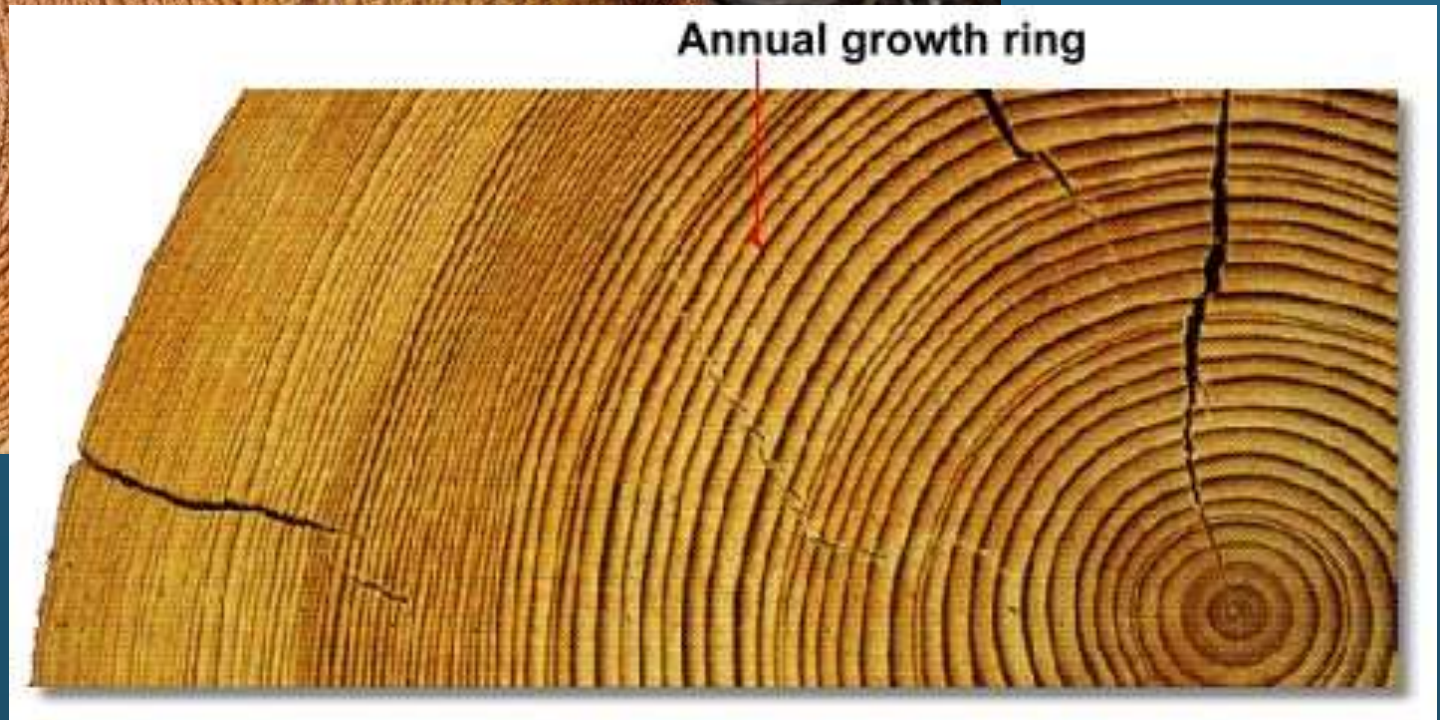


# Assessing growth and controlling density of all tree sizes and species in the same stand





# Assessment of Growth – Overstory diameter increment





# Assessment of Growth – Mid-canopy trees

- Crown ratio
- Height-diameter ratio



# Assessment of Growth – Understory trees

Growth of terminal shoot versus lateral branches -  
Douglas-fir



Large Gap >30% Light



Small Gap ~20% Light



Under Canopy >20% Light<sup>63</sup>



# Assessment and Monitoring

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## Multi-aged Sustainability Indicators:

1. Sustain growth of all stand components
2. Maintain stand structure
3. Replace tree mortality and harvest through regeneration



# Inventory Design

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## Decisions

**Timing**  
**Cutting Intensity**  
**Cutting Cycle**  
**Length**

## Indicators

**Regeneration**  
**Diameter Distribution**  
**Allocation of Growing**  
**Space**  
**Species Composition**  
**Growth of Stand**  
**Components**

## Attributes

**Density**  
**Diameter**  
**Distribution**  
**Species**  
**Diameter and**  
**Height**  
**Increment**

➤ Permanent Sample Plots or Mixed-Design



# Permanent Sample Plots

- Species composition
- Size classes
- Stand volume
- Diameter growth
- Height growth
- Mortality
- Harvest



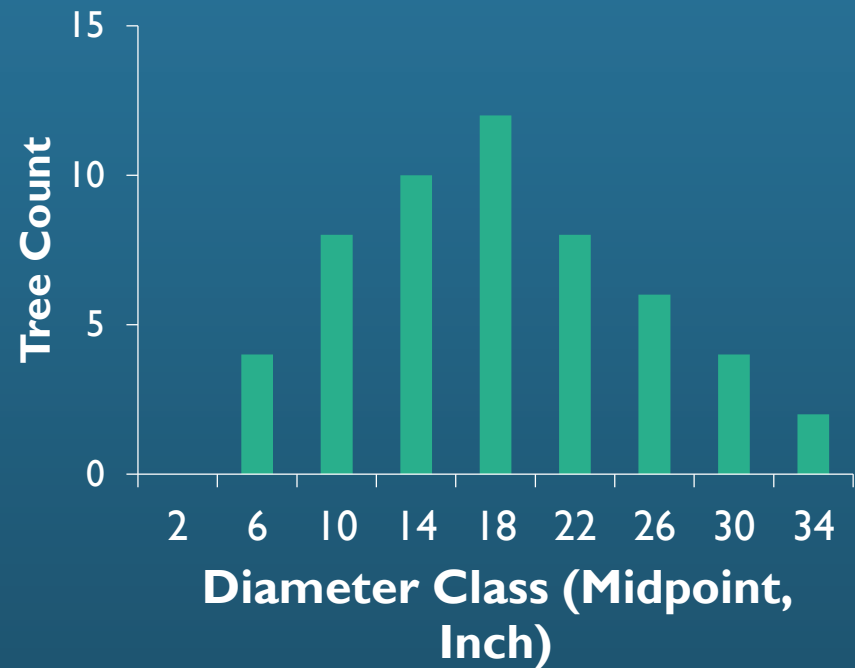
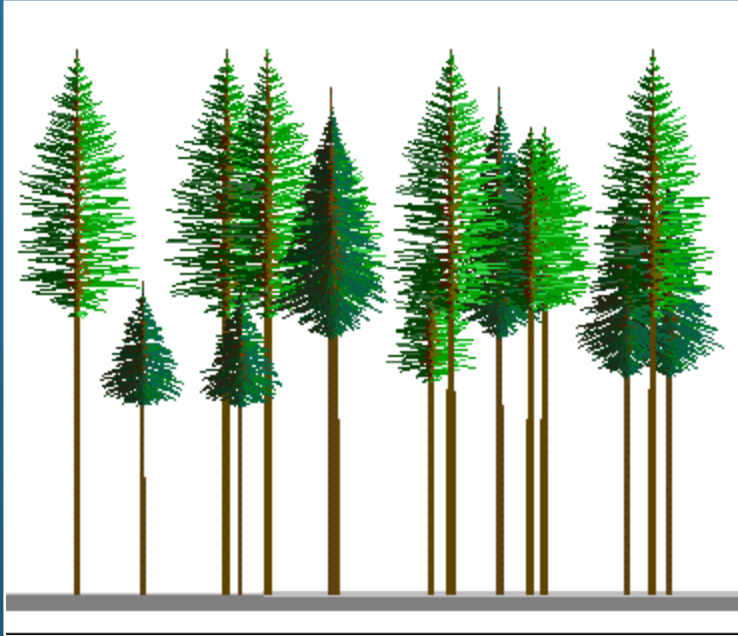
# Tools For Assessment – Sampling to establish a diameter distribution

Tree Diameter Tally Sheet				
DBH Class (Inches)	Plot 1 Count	Plot 2 Count	Plot 3 Count	Sum Tree Count
0-4	0	0	0	0
4-8	2	1	1	4
8-12	4	1	3	8
12-16	6	2	2	10
16-20	2	2	8	12
20-24		6	2	8
24-28		1	5	6
28-32	4			4
32-36	1	1		2

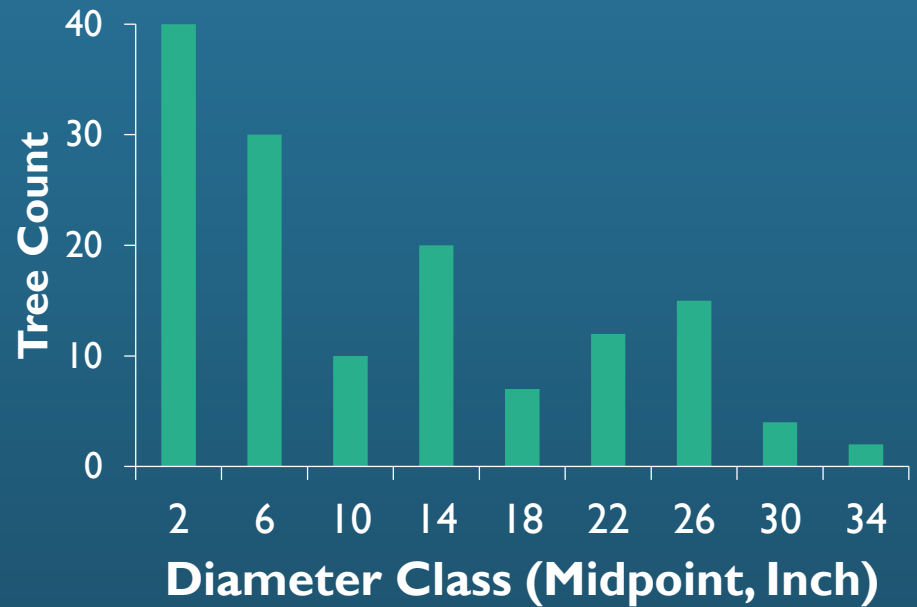
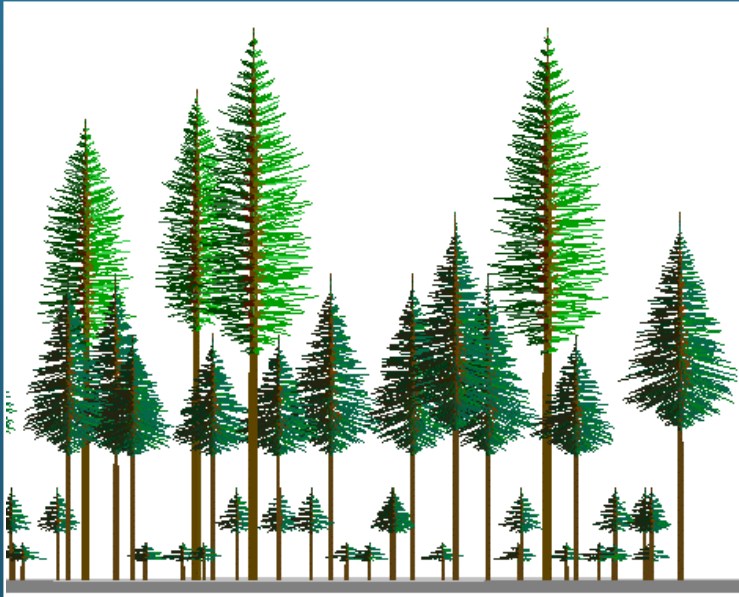




# Diameter Distribution of Even-aged Stand



# Diameter Distribution of Multi-aged Stand





# Growing Space Allocation

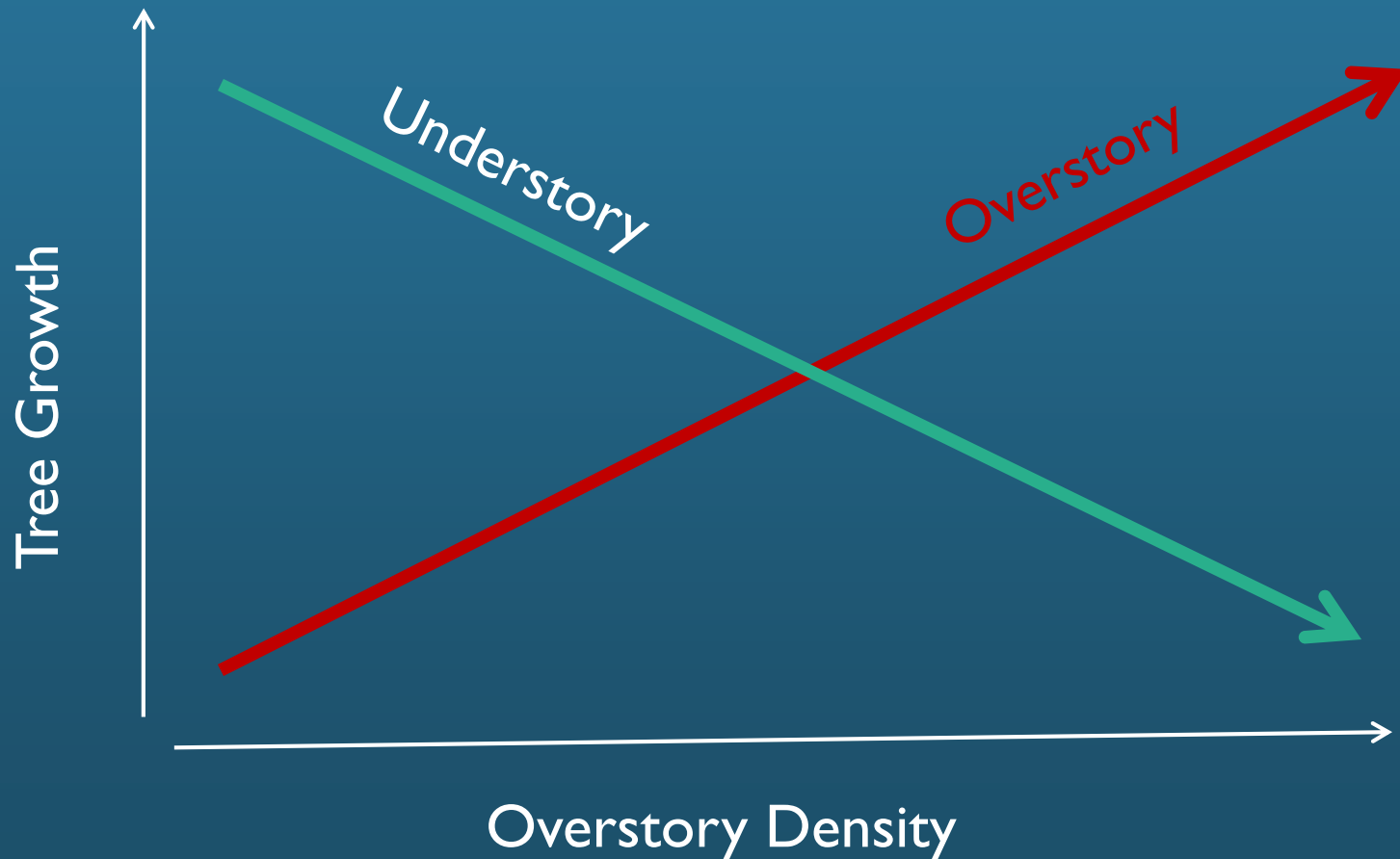
Resource requirements are proportional to size



80%  
Growing Space  
In Overstory

20%  
Growing Space  
In Understory

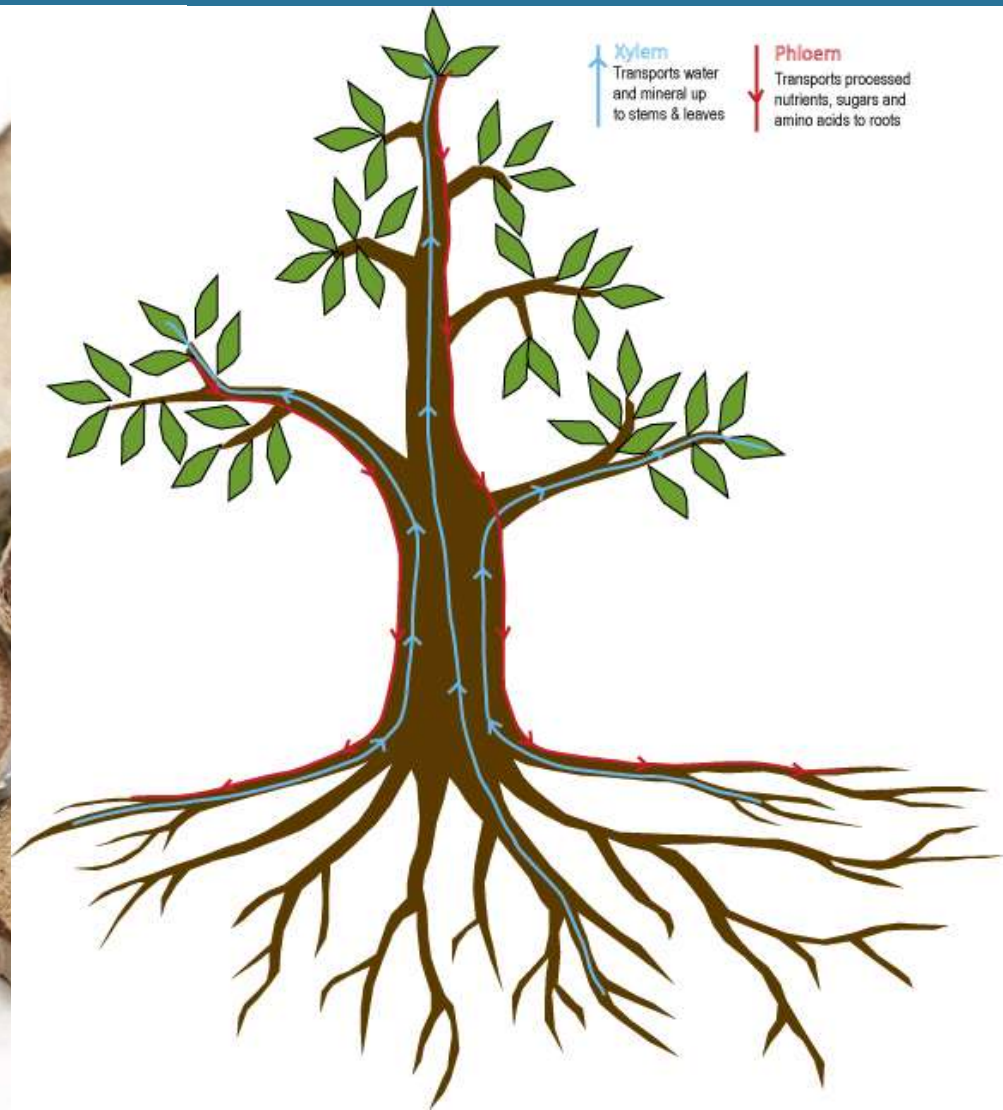
# Growing Space Allocation – Overstory versus Understory



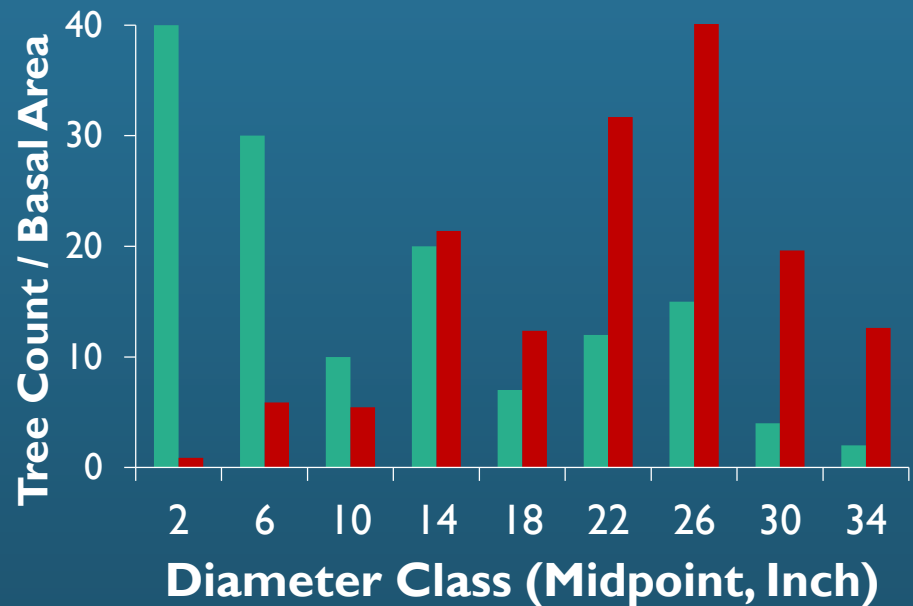
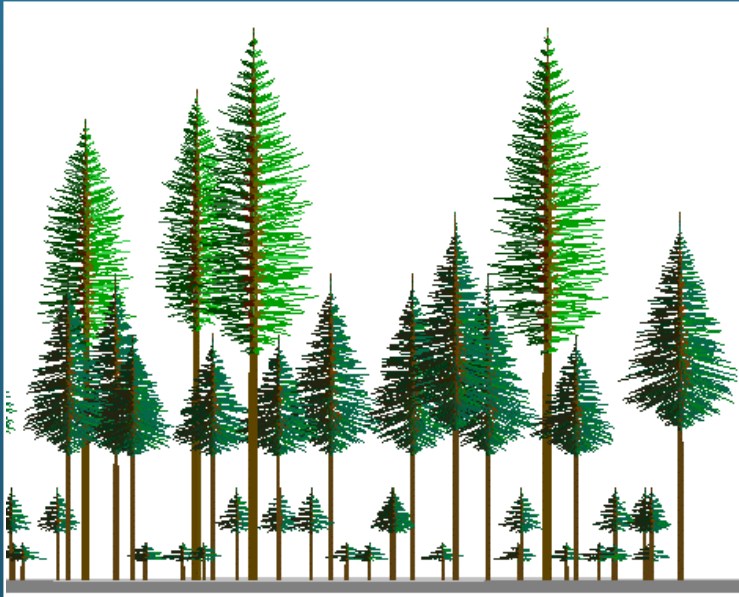


# Basal Area as proxy for growing space

- Stand basal area is the sum of the tree discs at breast height expressed in square feet per acre, and relates to leaf area, growth in space, and resource allocation



# Growing Space Distribution – Diameter distribution (green) and basal area distribution (red) by diameter classes in a three-aged stand



While there is a high number of small trees in the smaller diameter classes, they occupy a small amount of growing space (basal area) compared to the larger overstory trees.



# Thinning and Harvest

## □ Objectives

- Stocking Control, Regeneration, and Timber

## □ Timing

- Recover investment, market conditions, boat payments

## □ Make a Plan

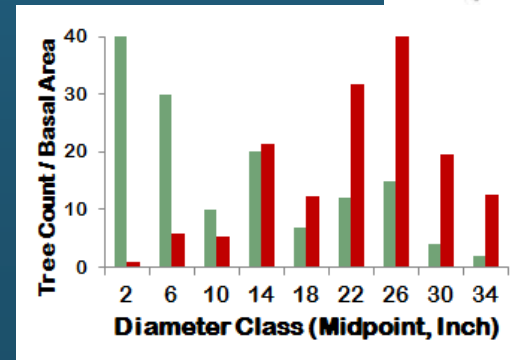
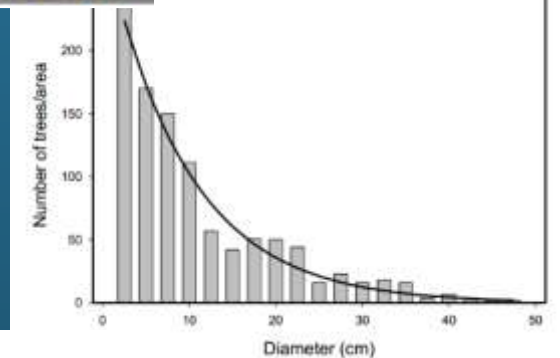
- Long-term plan as Guide not Rule

## □ Create Habitat

- CWD, snags, canopy layers

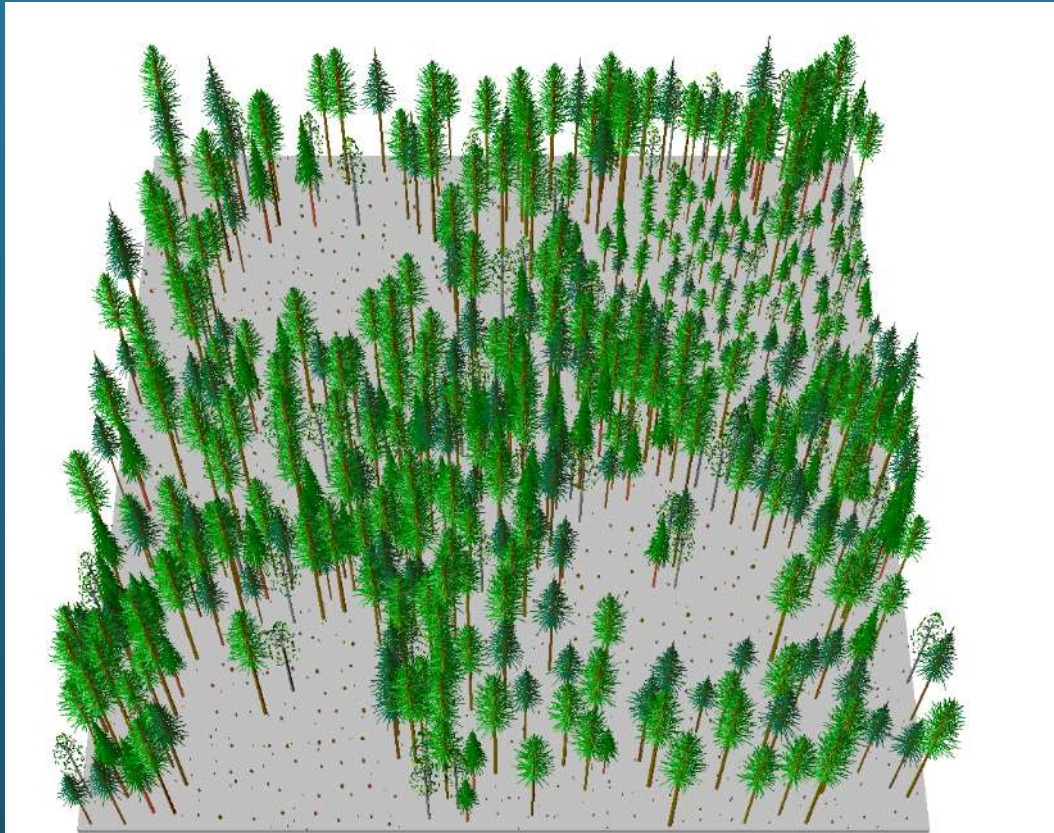
# Tree Selection and Marking

- Creating Growing Space
- Selection Guide
- Basal Area
- Diameter Distribution
- Mark your Trees



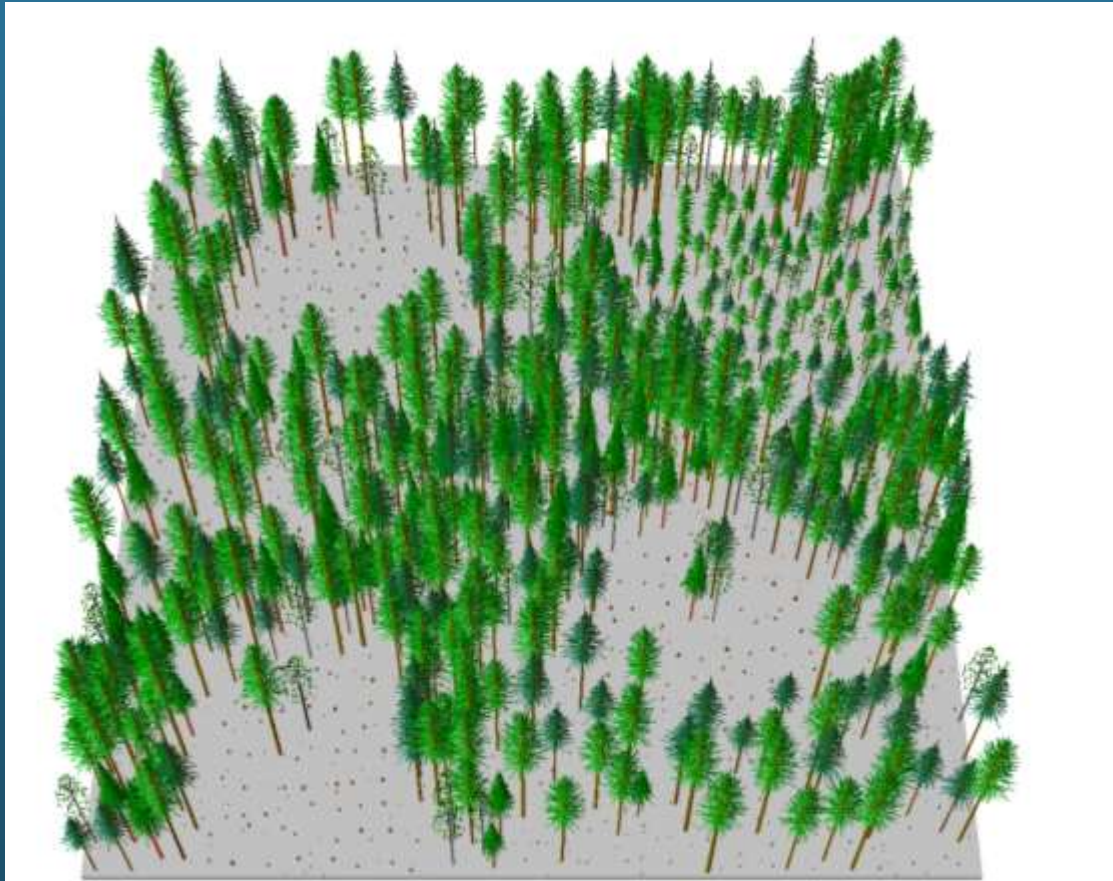


# Group Selection System – Planning Operations



- ❑ Units and Boundaries
- ❑ Forest Practices
- ❑ Roads and Trails
- ❑ Collaboration

# Group Selection System – Planning Operations



- ❑ Layout for thinning and group selection harvest
- ❑ Location for yarding corridors
- ❑ Tracking regeneration
- ❑ Prescriptions for matrix thinning
- ❑ Estimating stocking and ingrowth



# Implementation



Mechanized and hand-held cutting systems





Ground-base logging systems







Cable yarding system and yarding corridor







Impact of temporary skid tails and mitigation

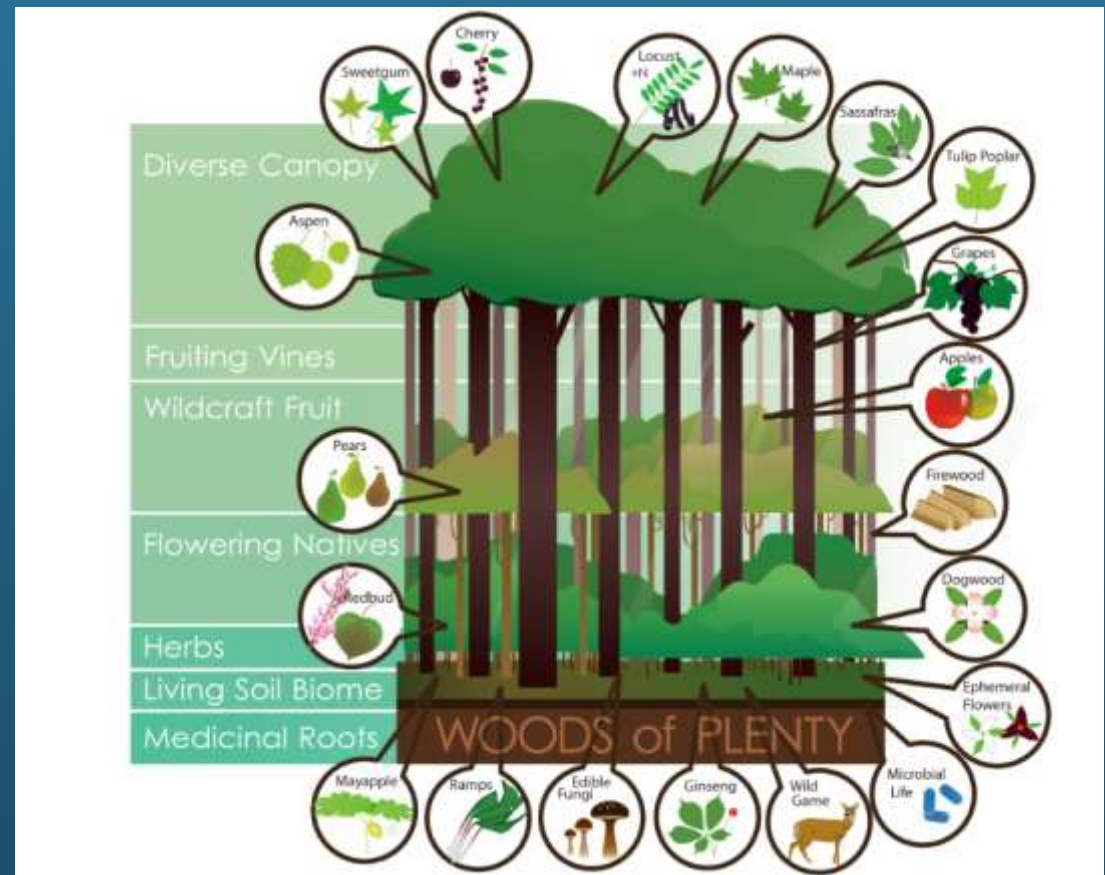
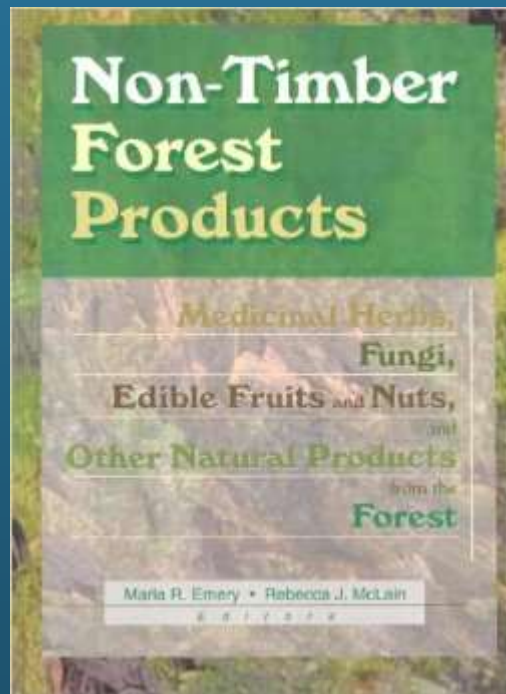




# Forest Products –

Marketing product diversity from small to large diameter wood







# Harvest impacts can be opportunities for creating habitat

