



ECOLOGICAL FOREST MANAGEMENT

Northwest Natural Resources Group

Rolf Gersonde, 6/11/2016

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Ecological Forestry in 60 Seconds – The Element of Ecological Forestry

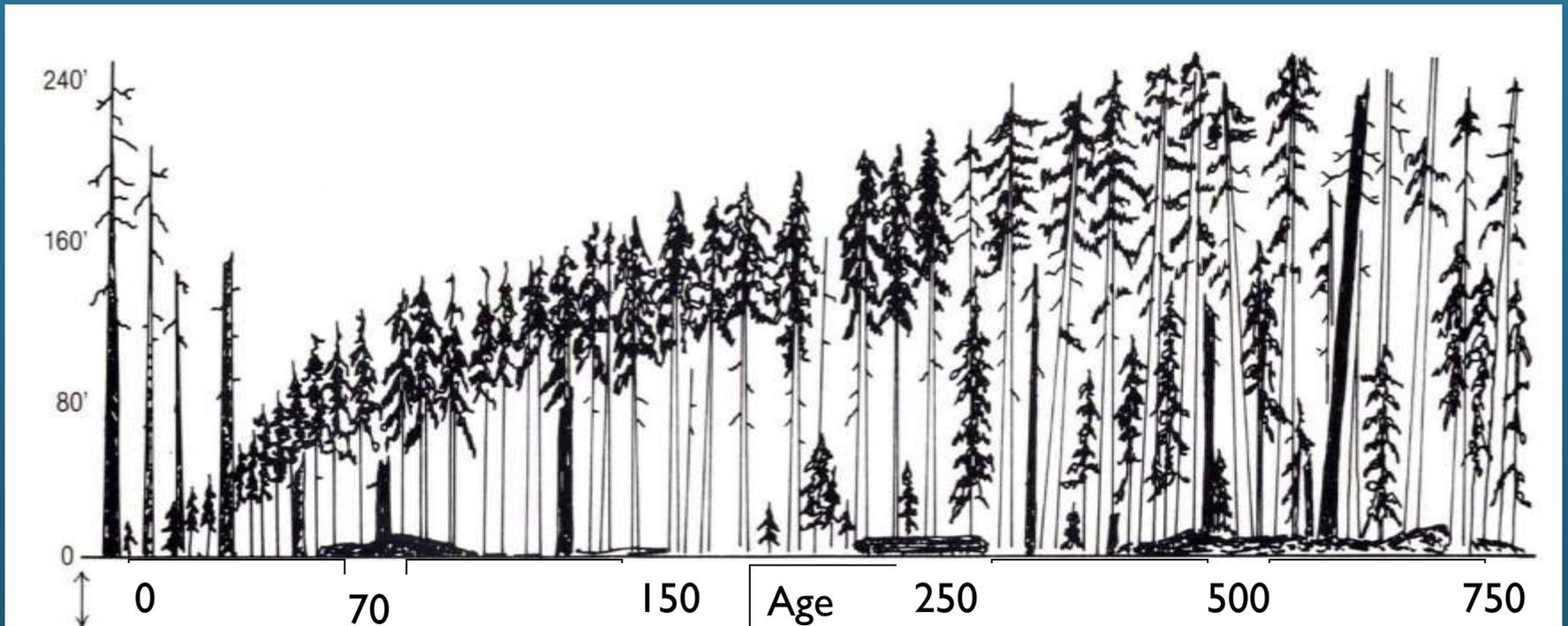
- Using site Adapted Species
- Based on Natural Processes
- Improve Soil Productivity
- Enhance Habitat and Biodiversity
- Improve Natural Capital
- Economic and Ecological Resilience

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

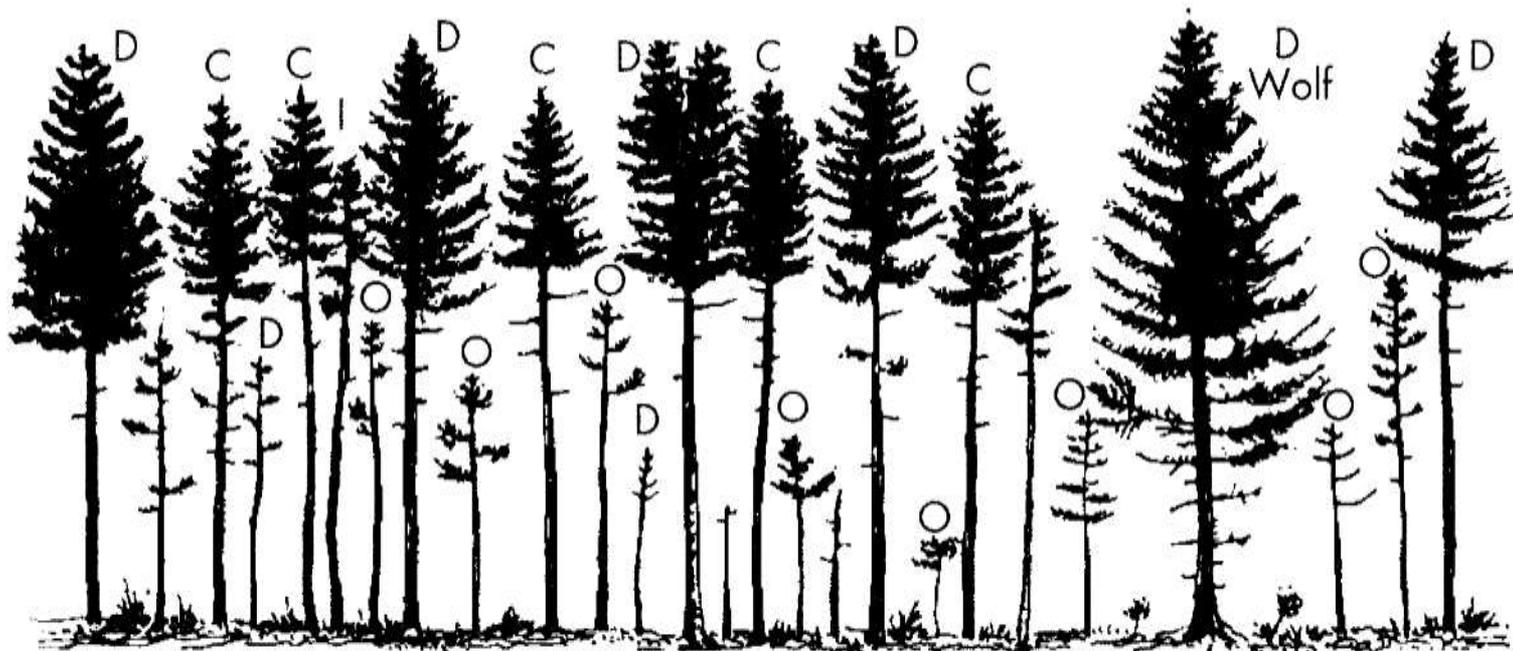


Figure 1.—A typical Douglas-fir stand, with dominant (D), codominant (C), intermediate (I), and overtopped (O) trees. A wolf tree (W)—one that occupies more space than it warrants—also is part of the stand. The relative amount of crown, height, and diameter of each tree determines its crown class.

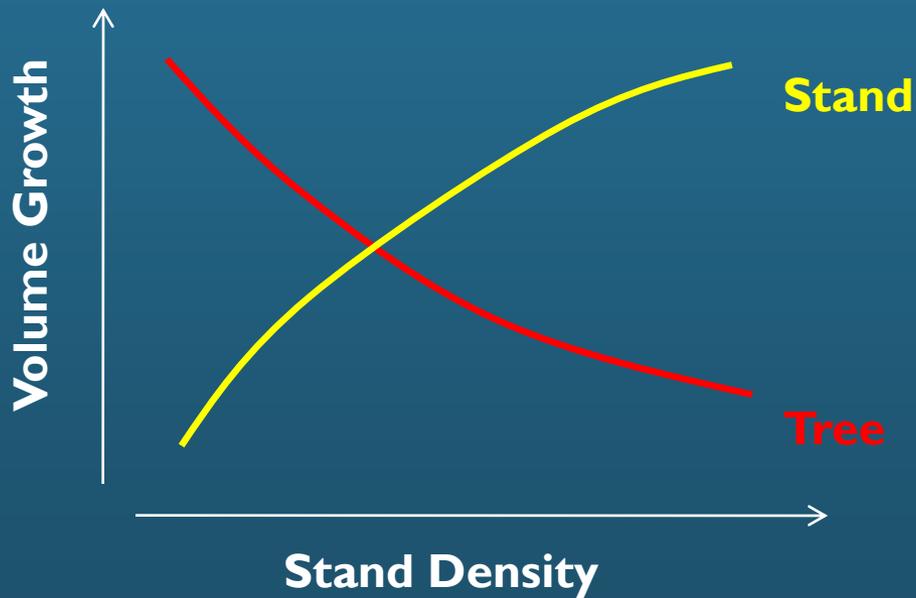
D – Dominant

C – Co-dominant

I – Intermediate

O – Overtopped

Biomass Production – Trees versus Stands



Tree Diameter Growth –

The effect of stand density on diameter growth

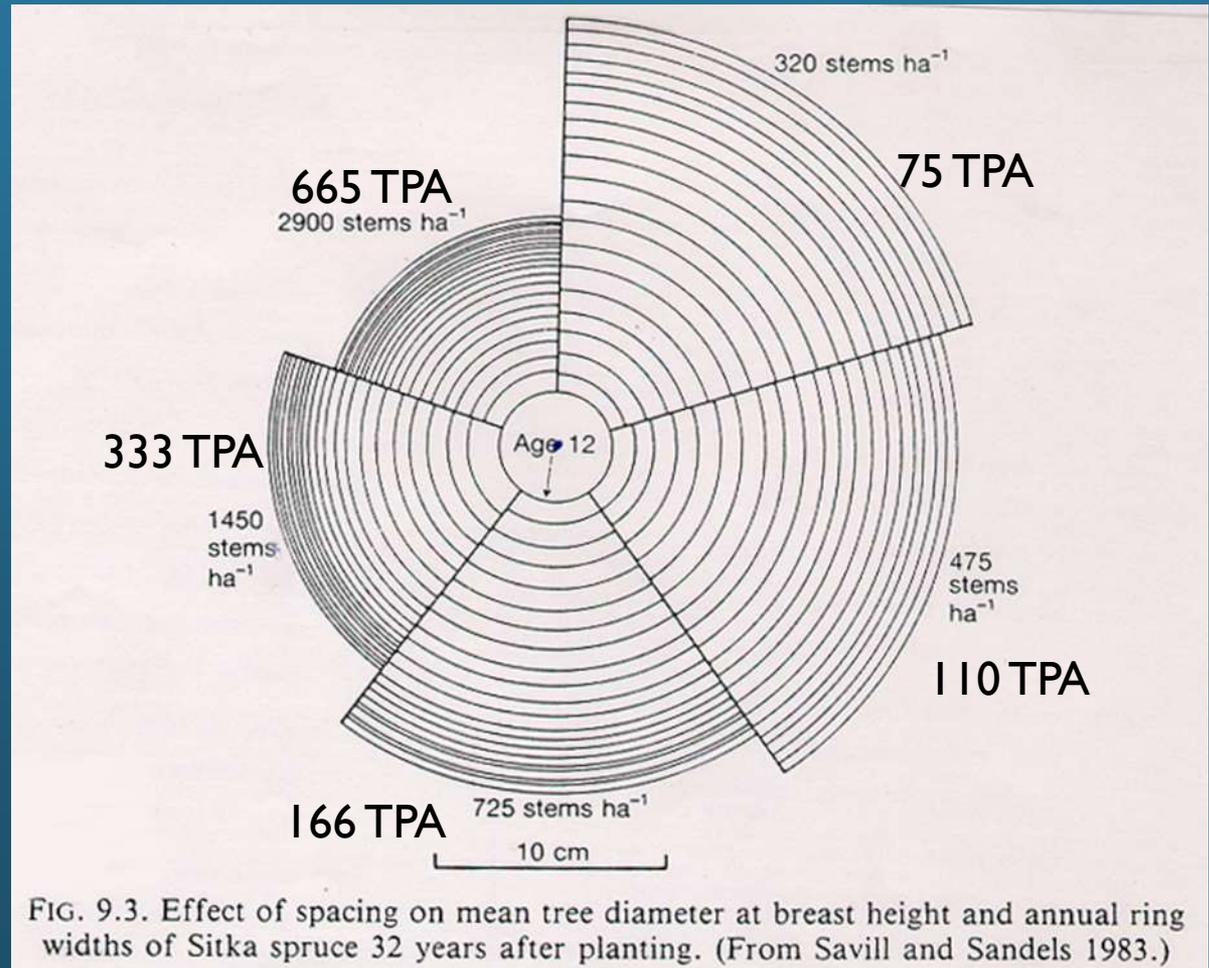
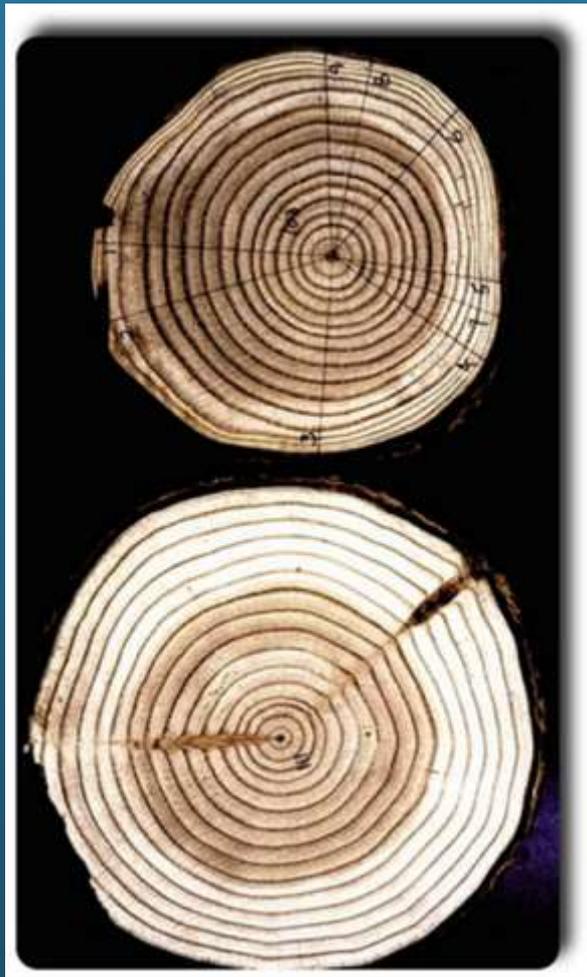
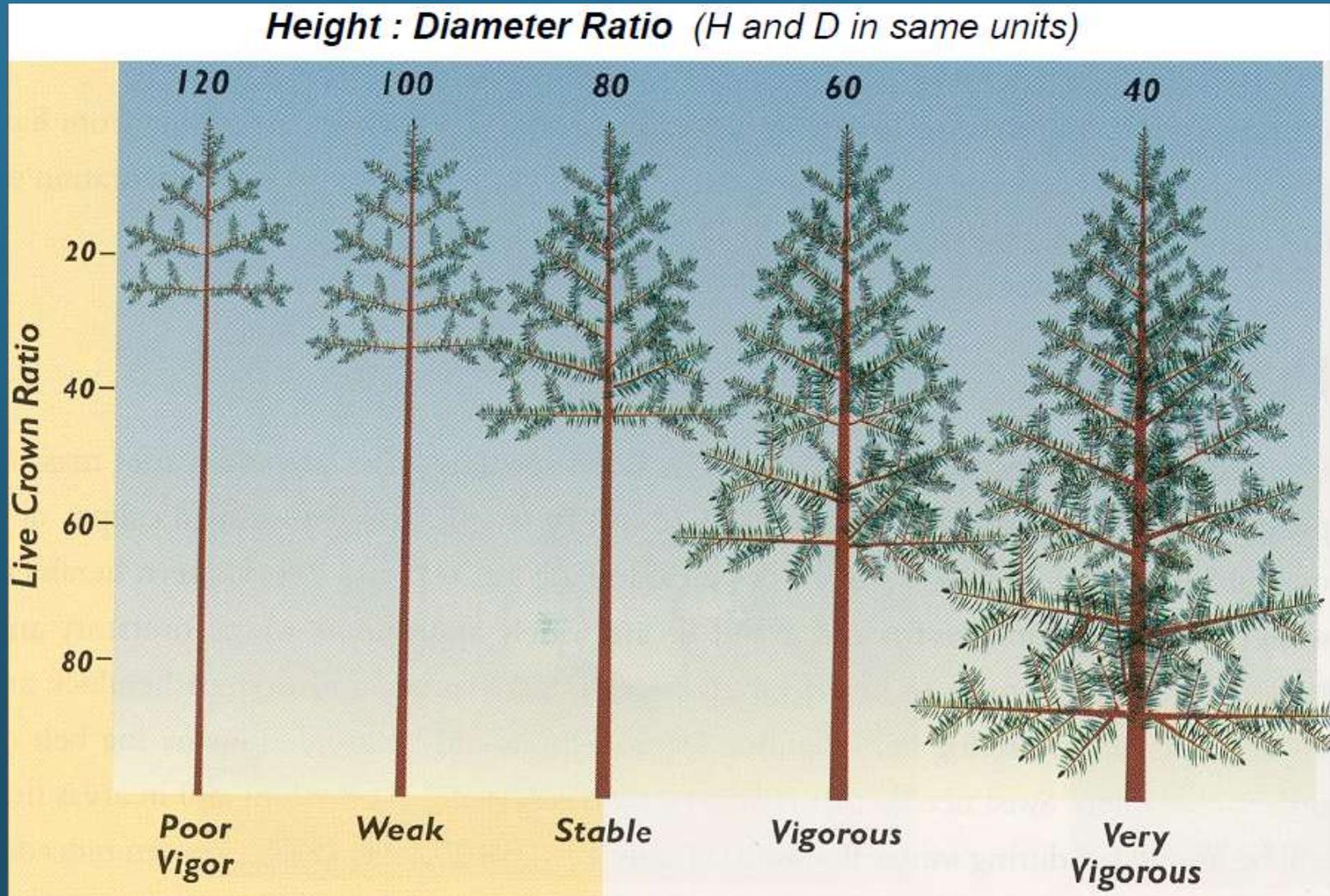


FIG. 9.3. Effect of spacing on mean tree diameter at breast height and annual ring widths of Sitka spruce 32 years after planting. (From Savill and Sandels 1983.)

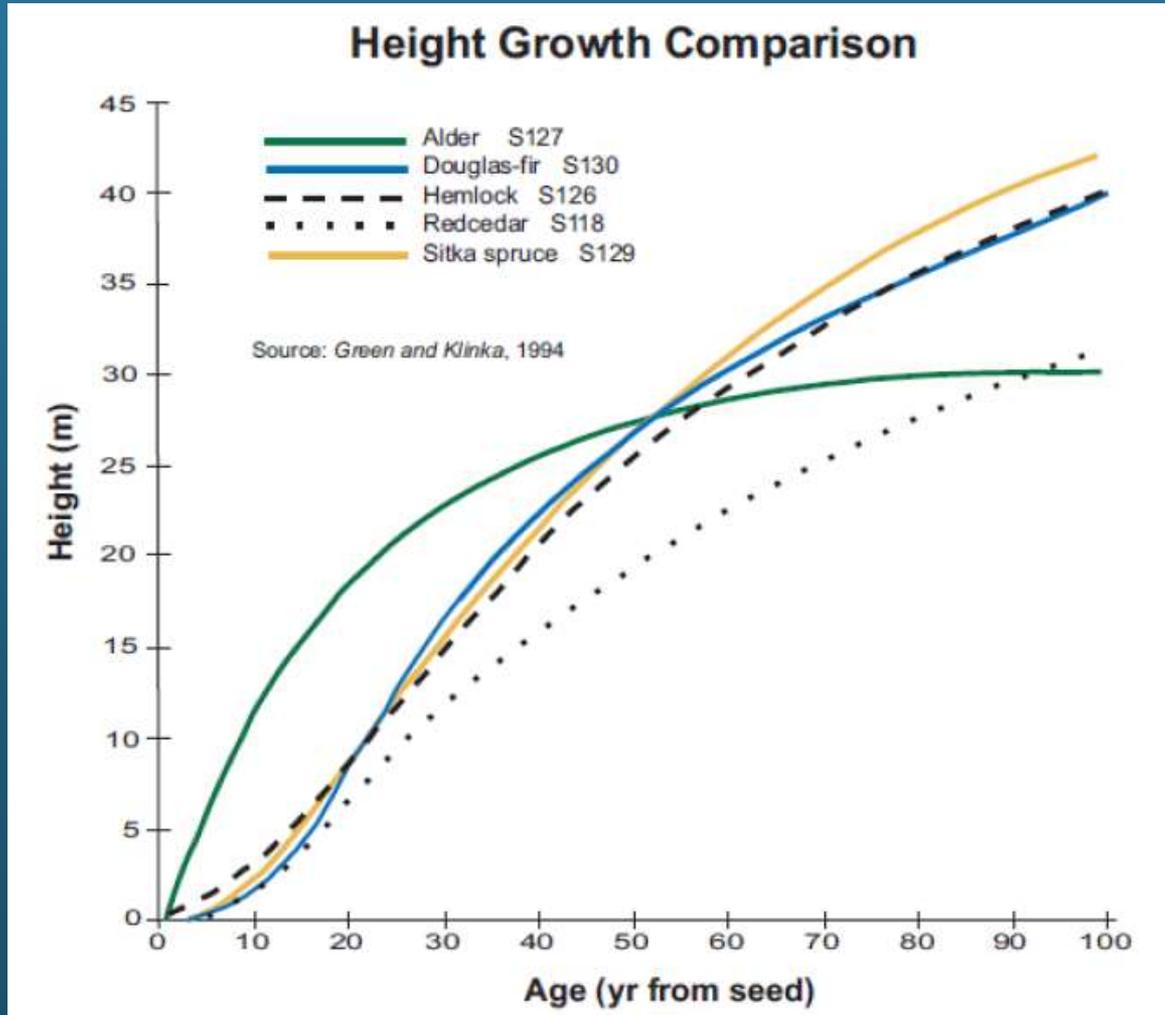
Tree Vigor and Stability -

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



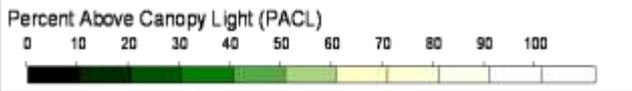
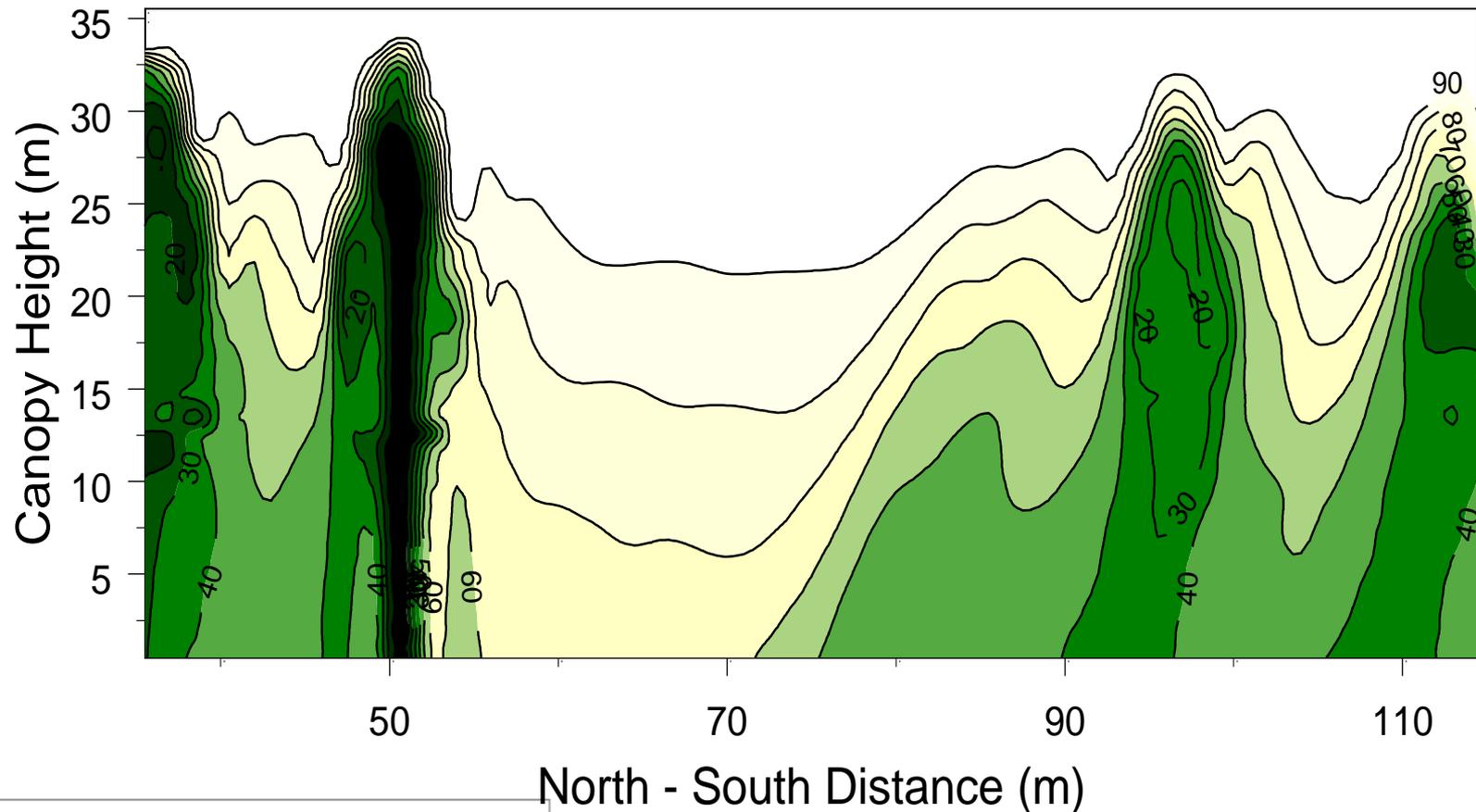
Natural Regeneration

- 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



Douglas-fir



Western hemlock



Western white pine

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

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

Understory Growth – Morphological Plasticity



Noble fir



Pacific silver fir



Western hemlock

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

Soil Nutrients



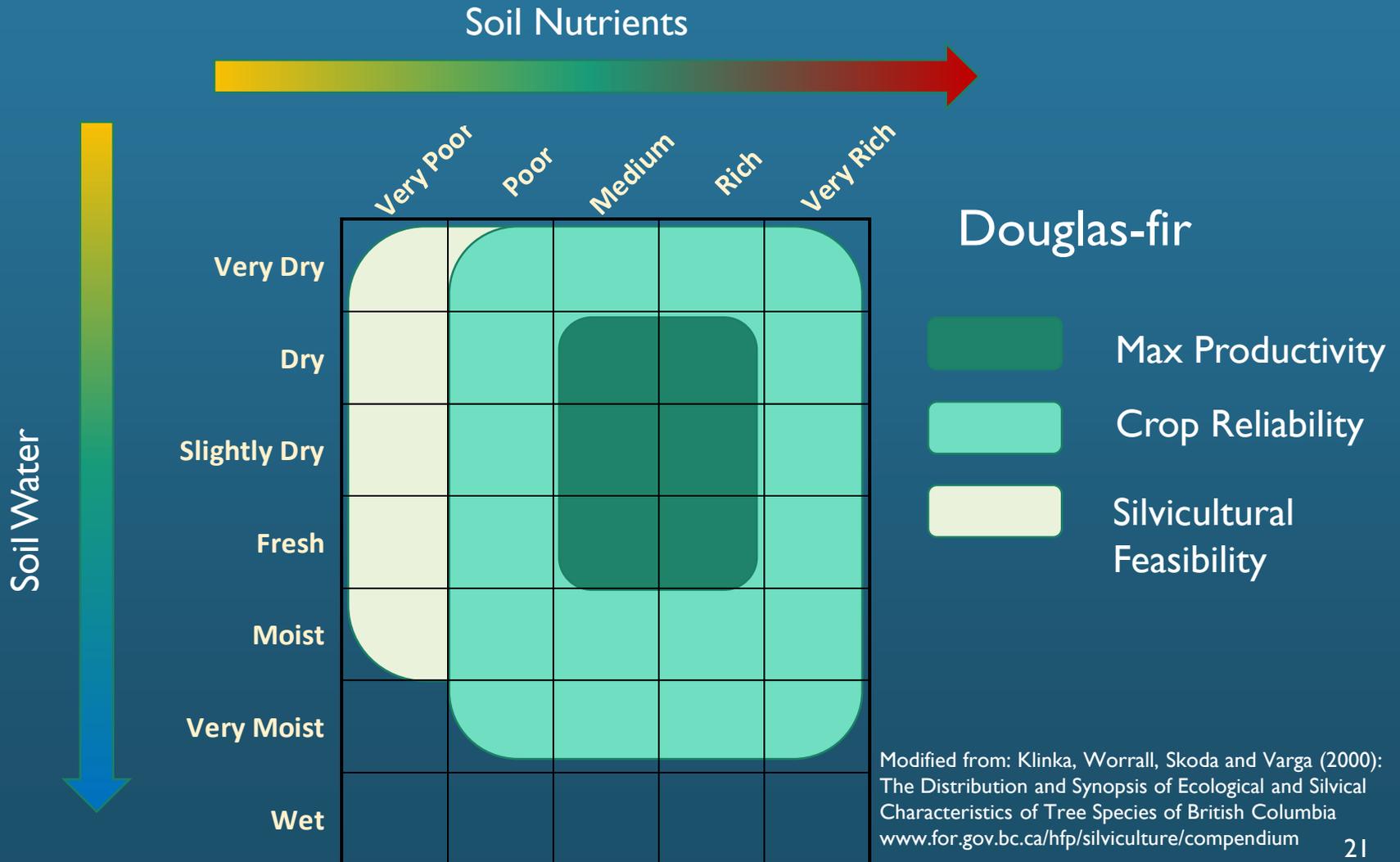
Site and Tree Species



Soil Water



Tree species and Ecological Amplitude



Modified from: Klinka, Worrall, Skoda and Varga (2000):
 The Distribution and Synopsis of Ecological and Silvical
 Characteristics of Tree Species of British Columbia
www.for.gov.bc.ca/hfp/silviculture/compendium

Understory Species as Indicators of Site Conditions

Site Classification - Edatopic Grid



Soil moisture regime

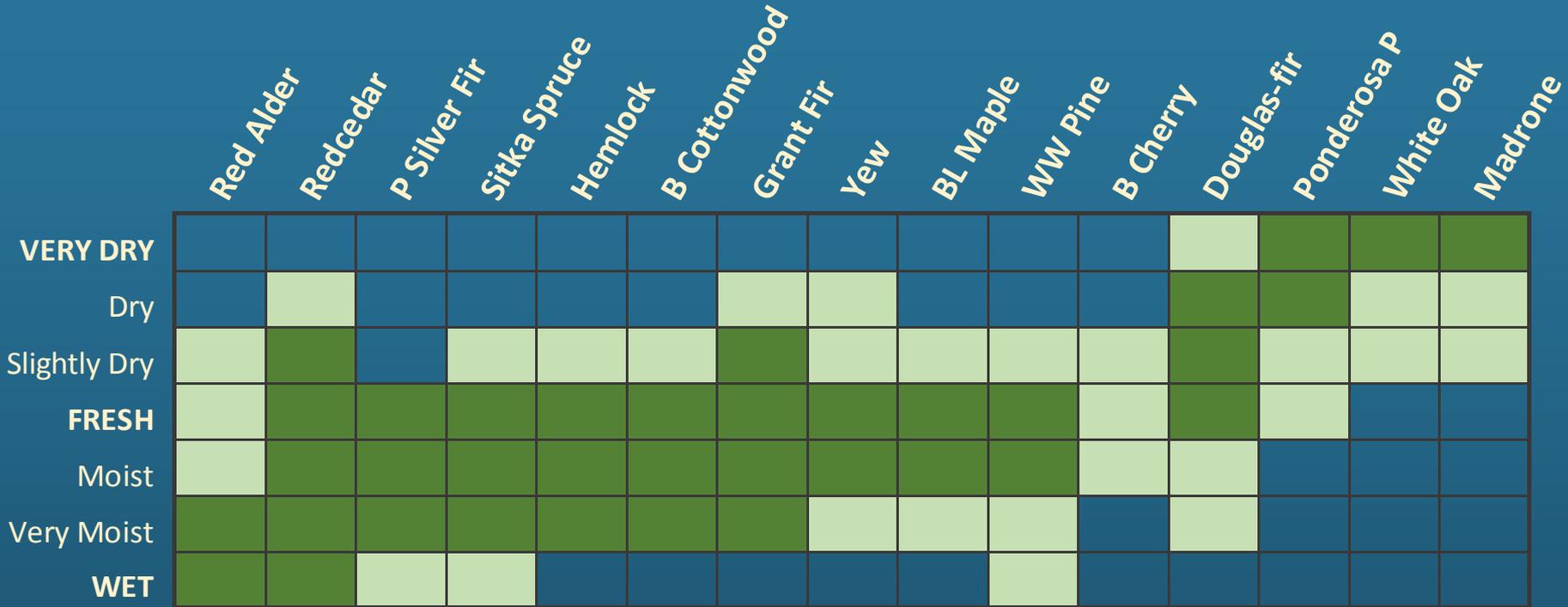
CWHvm subzone

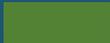
Soil nutrient regime

		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		
2						
SD	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					
F	5	06 Blechnum (Deer fern) imperfectly to poorly drained sites; predominantly in the CWHvm1 variant drier slope-skeletal wetter depression			07 Rubus (Salmonberry) water-receiving, seepage sites drier slope-rocky slope-skeletal wetter gully-ravine stream-edge - alluvial	
M	6					
VM	7	14/11 Lysichiton (Skunk cabbage) water-collecting (waterlogged) sites gleysolic organic				
W						

Modified from:
www.for.gov.bc.ca/hfp/silviculture/compendium

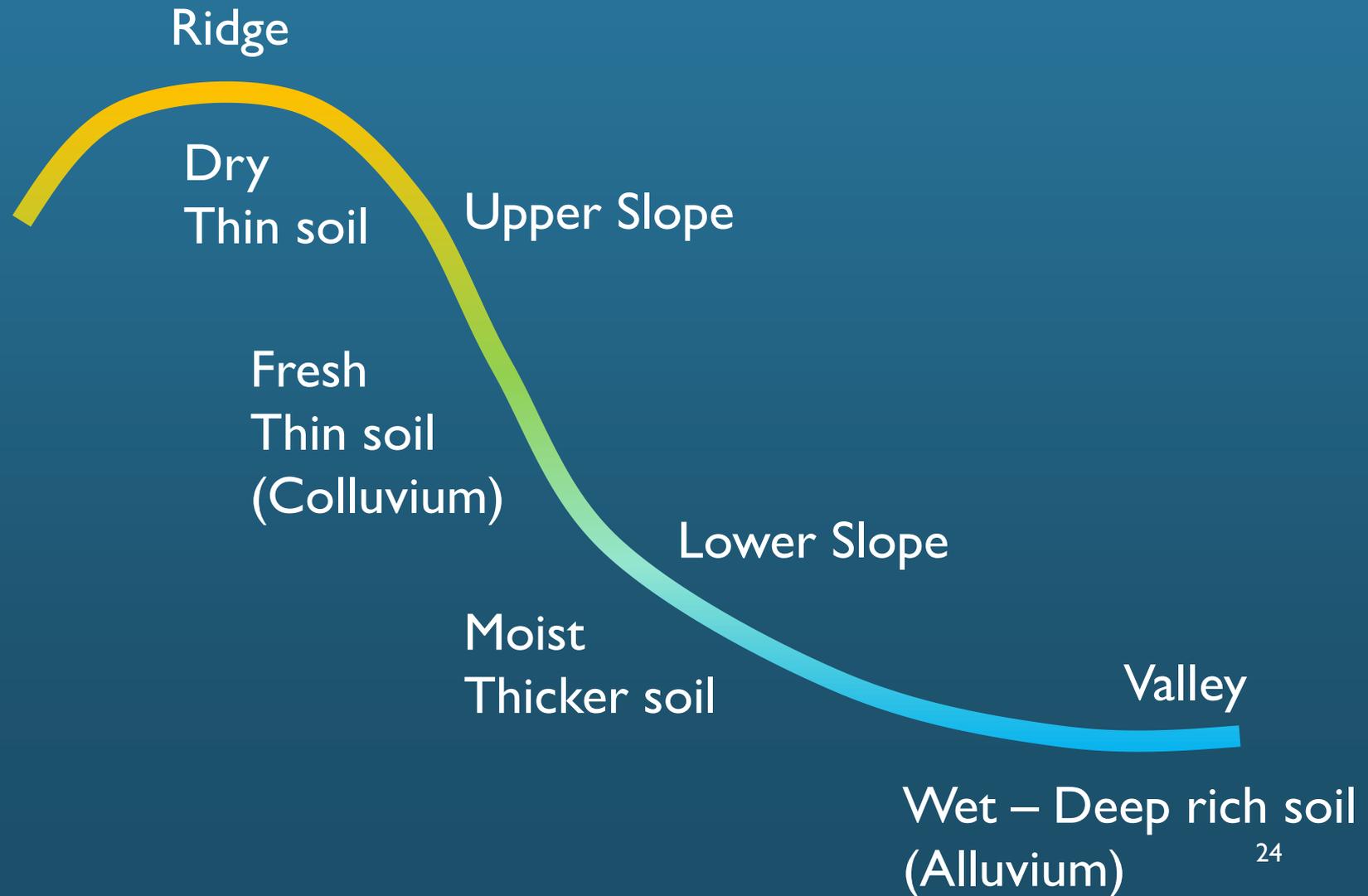
Tree Species and Soil Moisture



 Maximum Sustainable Productivity
 Crop Reliability
 (Silvicultural Feasibility)

Modified from:
www.for.gov.bc.ca/hfp/silviculture/compendium

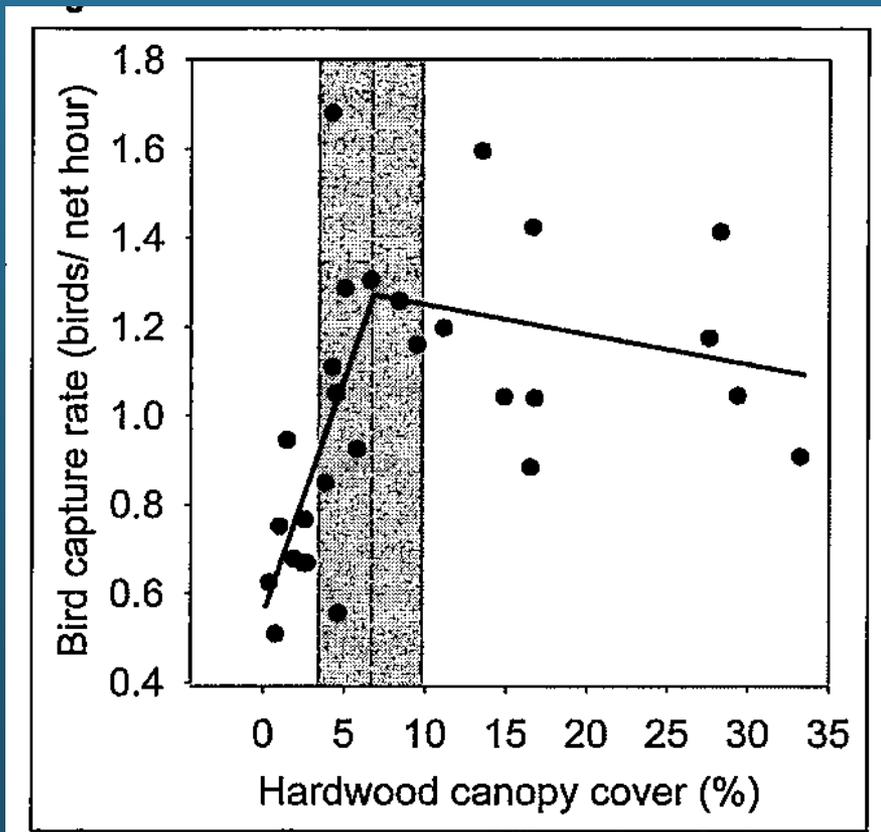
Soil Moisture and Topographic Position



Mixed-species Forests



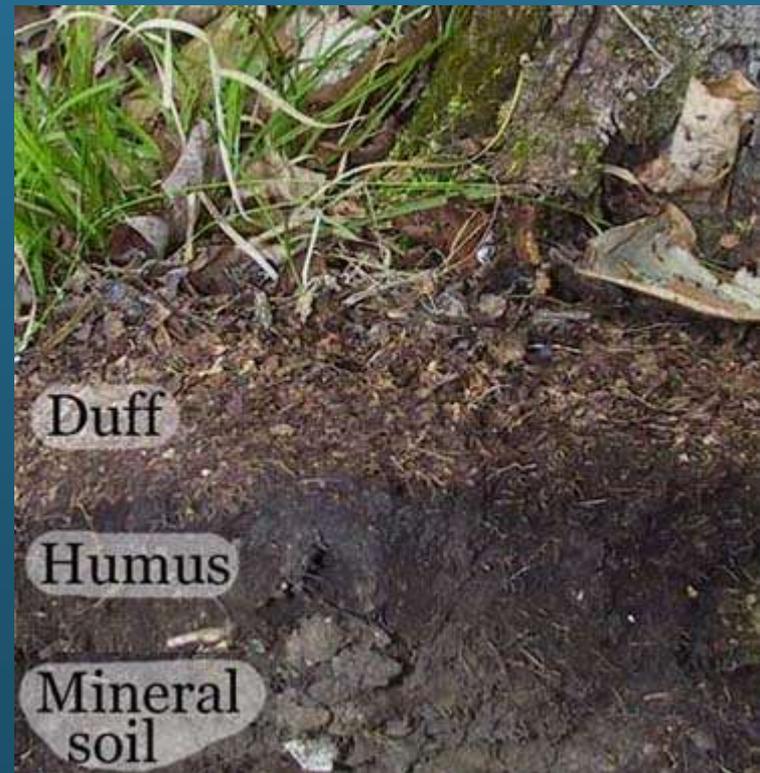
Percent hardwood mixture in conifer forests affects song bird density



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



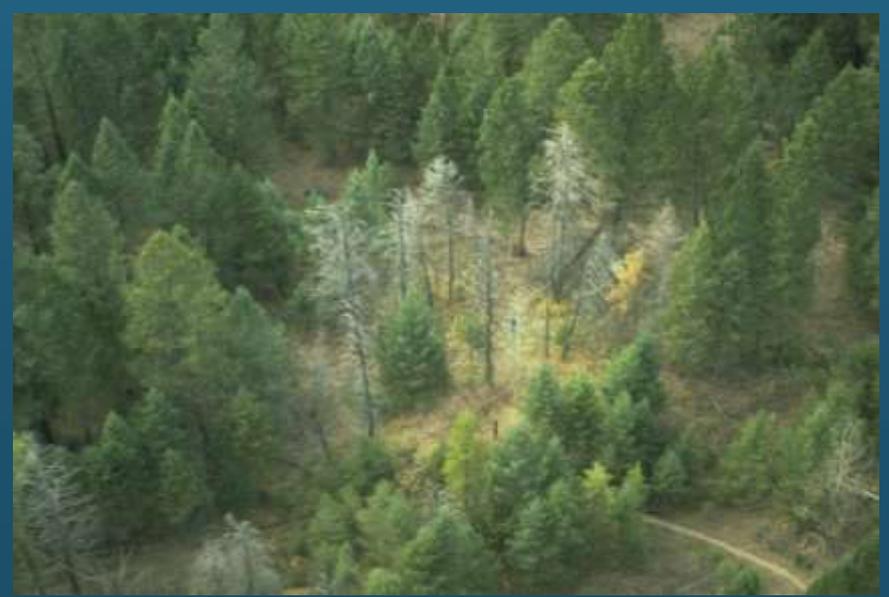
Mycorrhiza



Frankia alni
bacteria

Root Disease Indicators

Photos: www.forestryimages.org
and www.fs.fed.us





Armillaria root disease

- Widespread
- Most tree species
- Manage for Tree Vigor



Phellinus or Laminated Root Rot

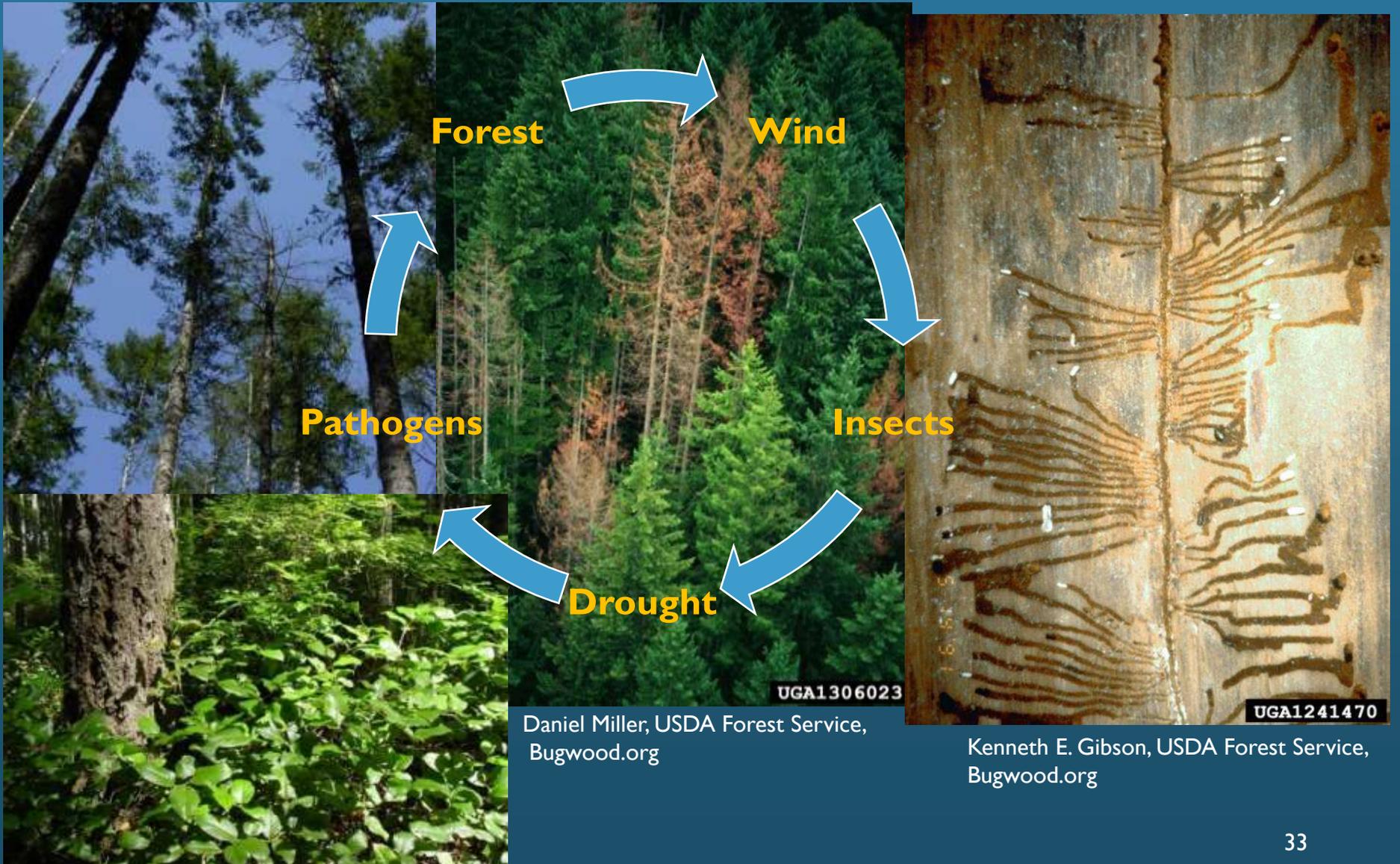
- Localized
- Species specific
- Manage for Species Conversion

➤ Ecological Forestry manages for Species Diversity

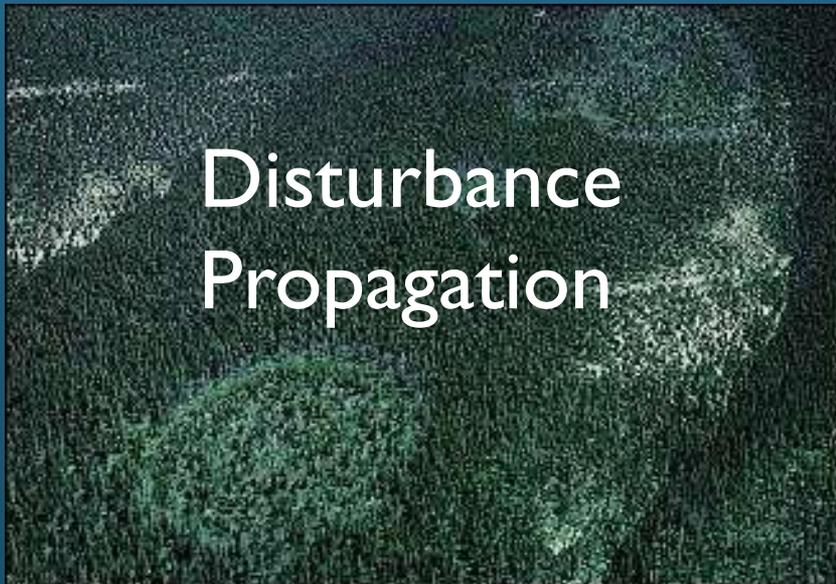
Bark Beetle Indicators



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



Landscape level effect of tree species diversity on disturbance propagation



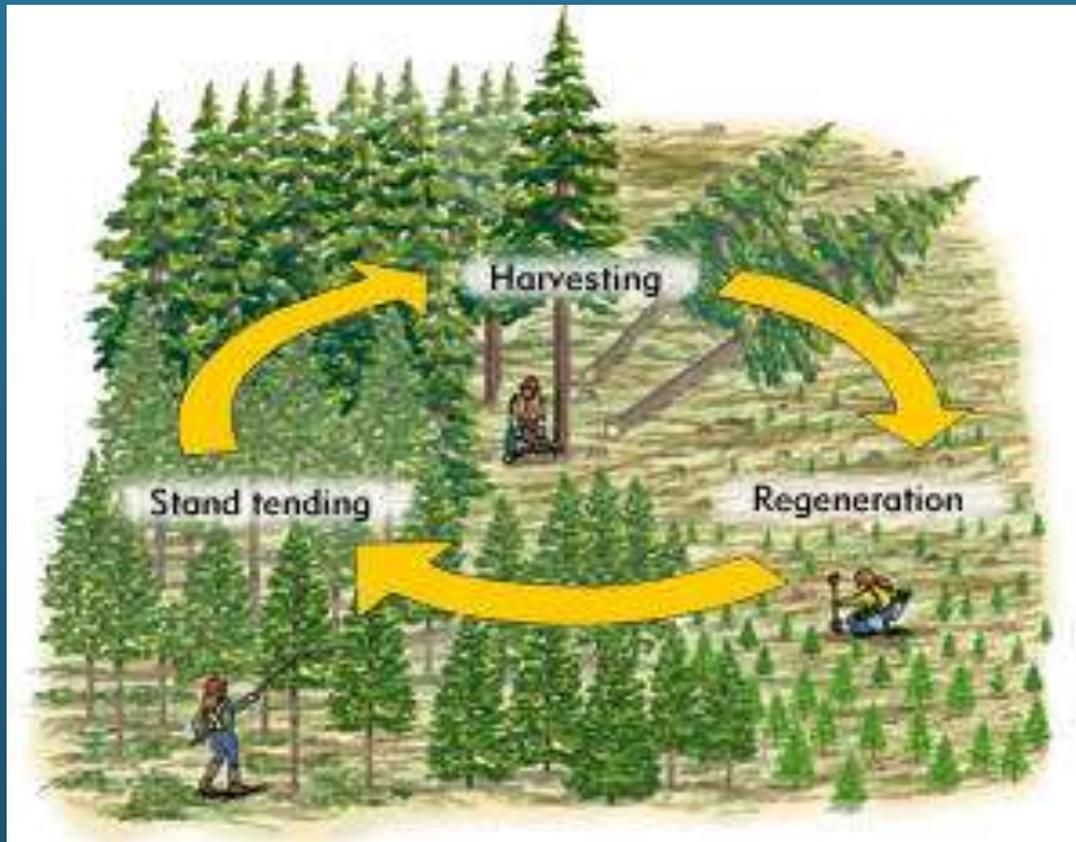
Disturbance
Propagation



Species
Diversity

Silvicultural System –

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



Even-aged System

- Clear Cut
- Seed Tree
- Shelterwood
- Thinning

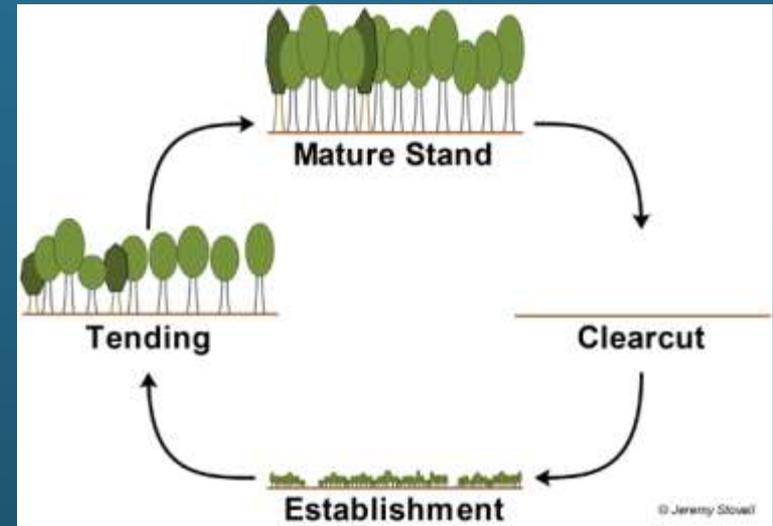
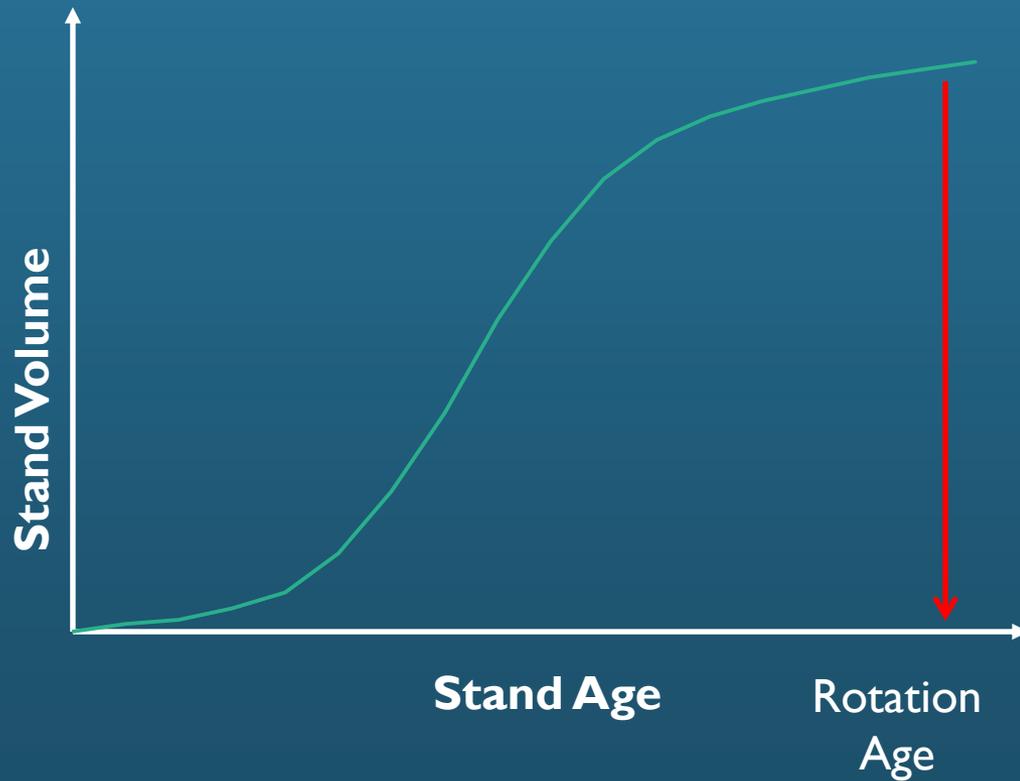
Two-aged System

- Variable Retention
- Coppice with Reserves

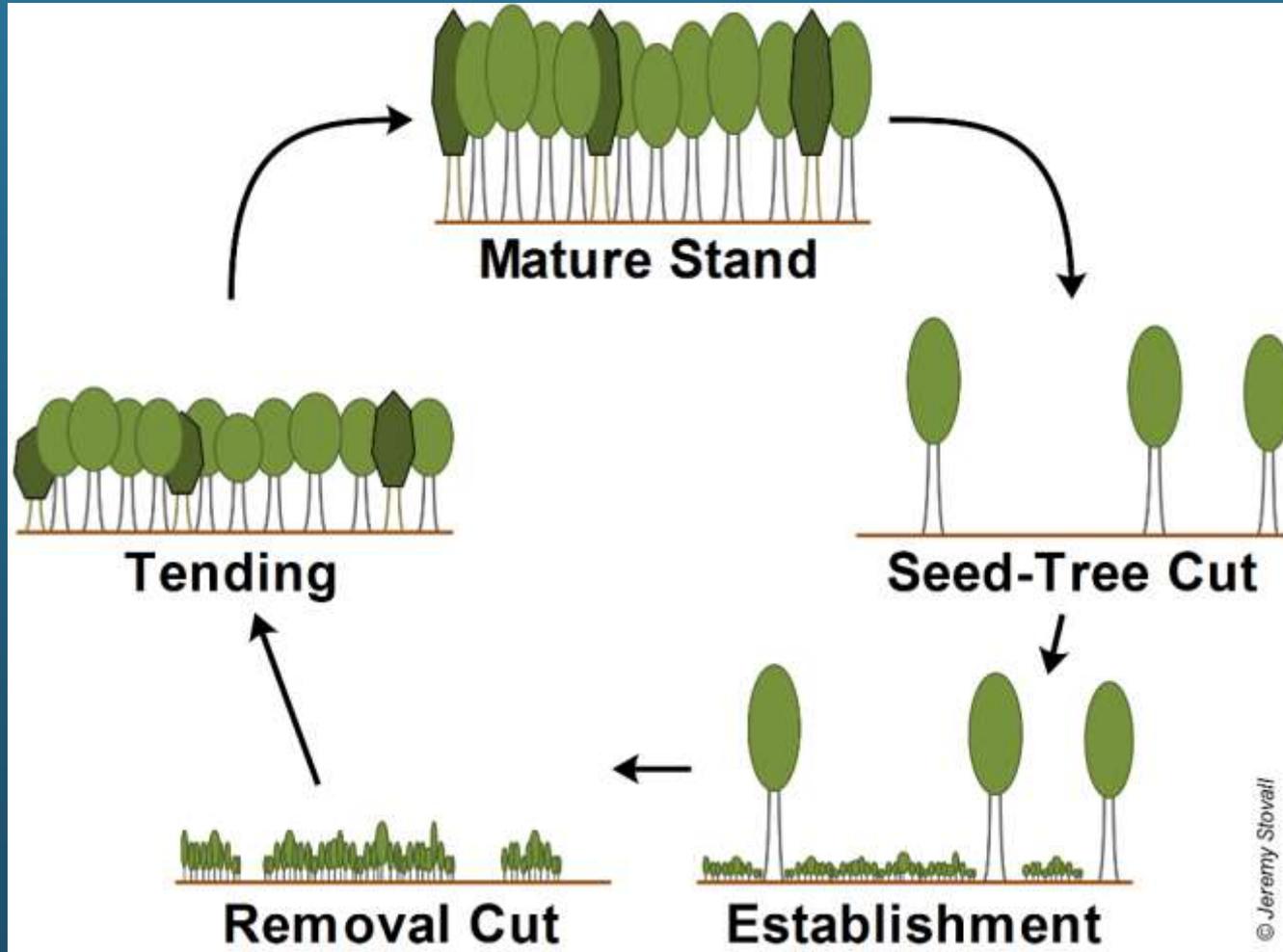
Uneven-aged system

- Group Selection
- Thinning
- Single Tree Selection

Stand Volume and Rotation in Even-aged System

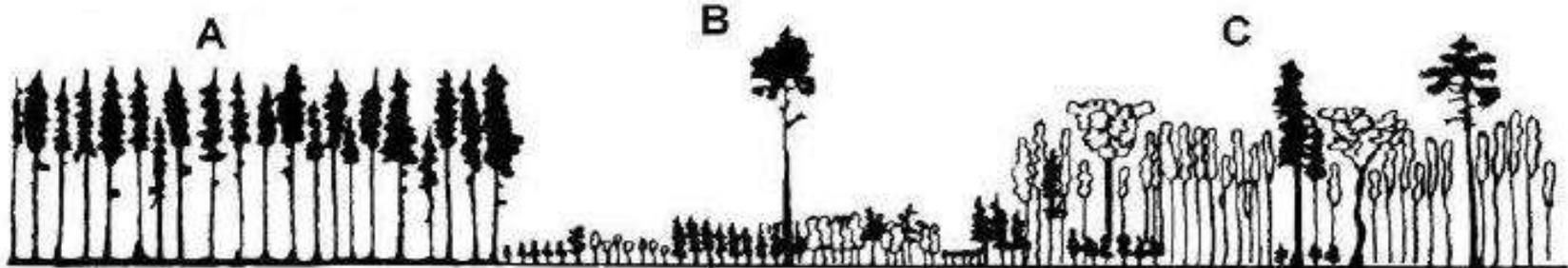


Seed-Tree and Shelterwood Regeneration Methods



Continuum of Silvicultural Approaches – A- individual tree selection, B-group selection, C- mixture of individual tree and group selection

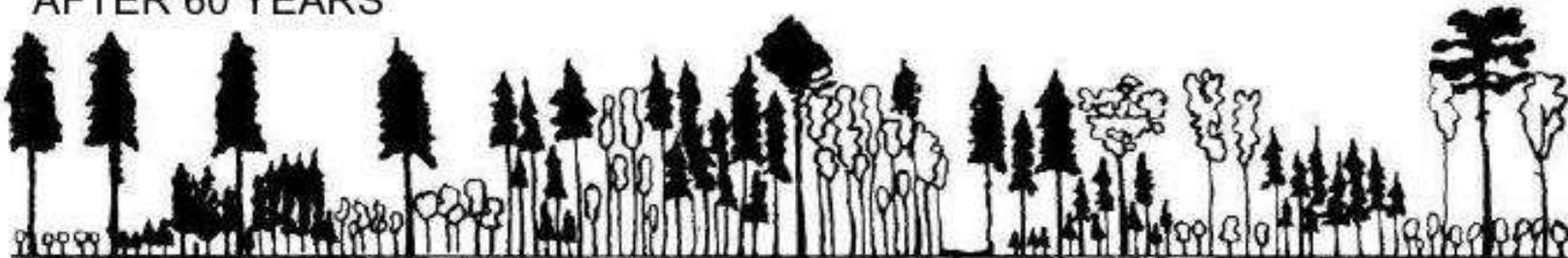
INITIAL CONDITION



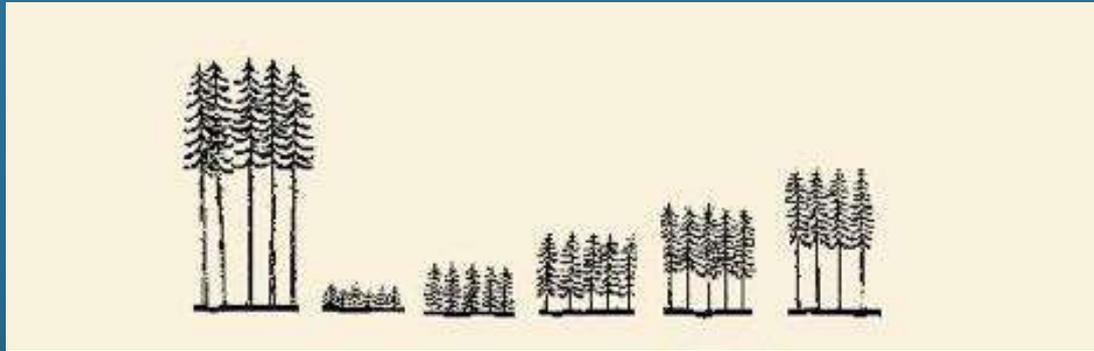
AFTER 30 YEARS



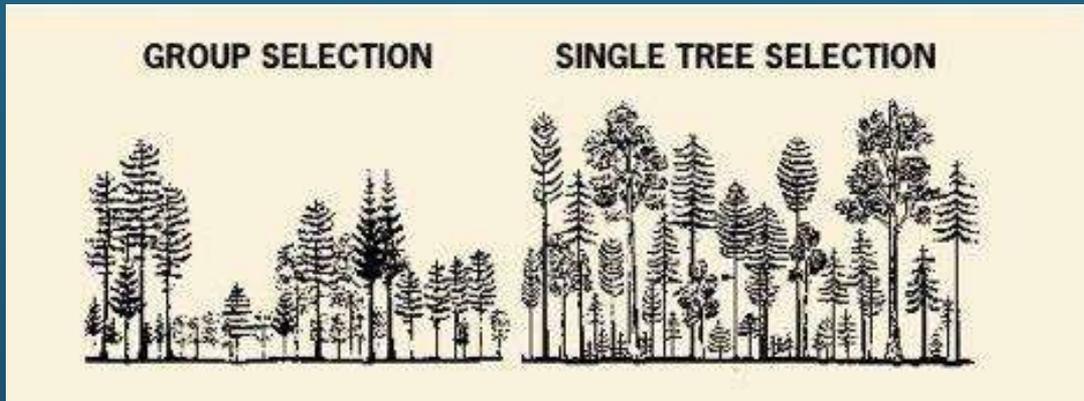
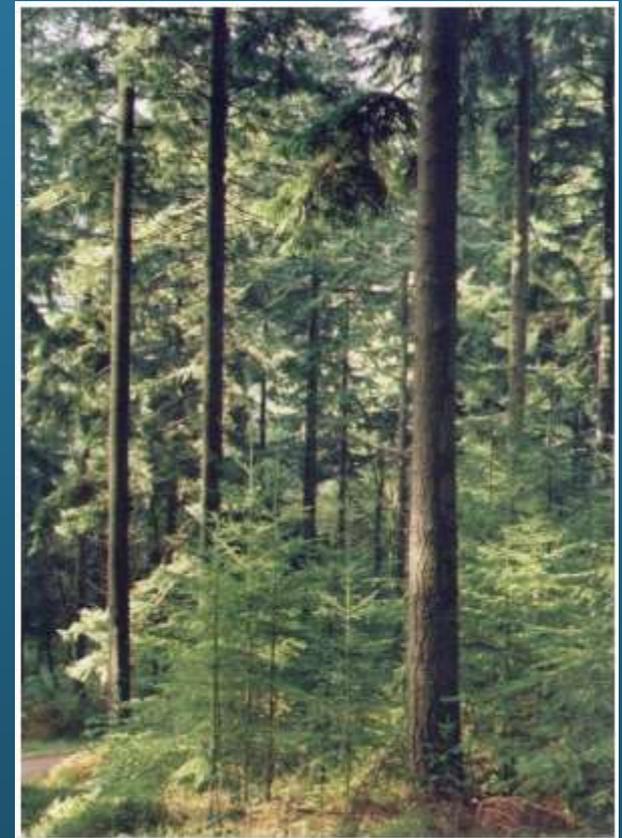
AFTER 60 YEARS



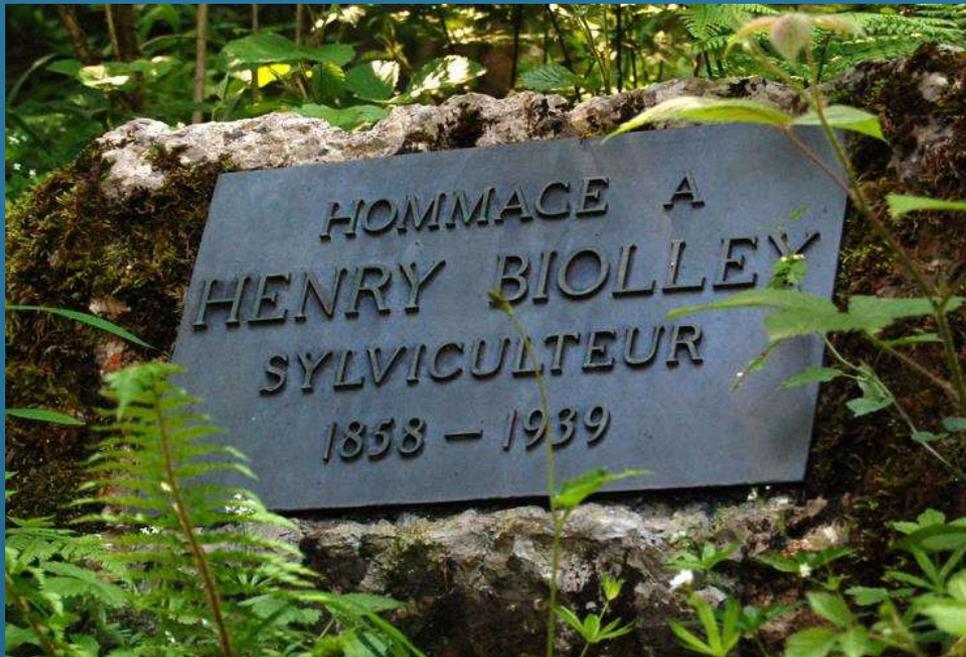
What is Uneven-aged Management?



Even-aged “age-class” Forestry



Uneven-aged Management System



HOMMAGE A
HENRY BIOLLEY
SYLVICULTEUR
1858 - 1939



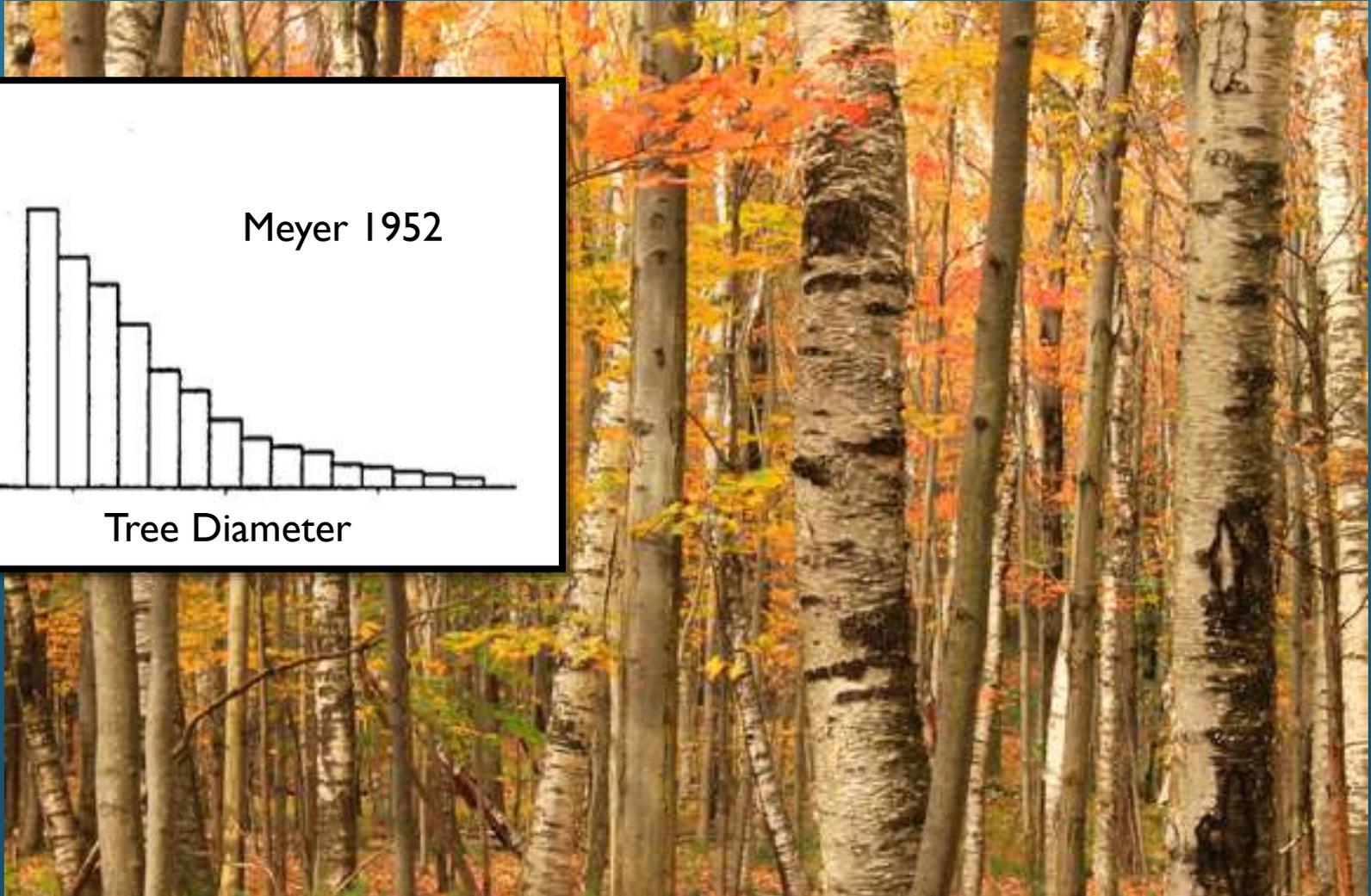
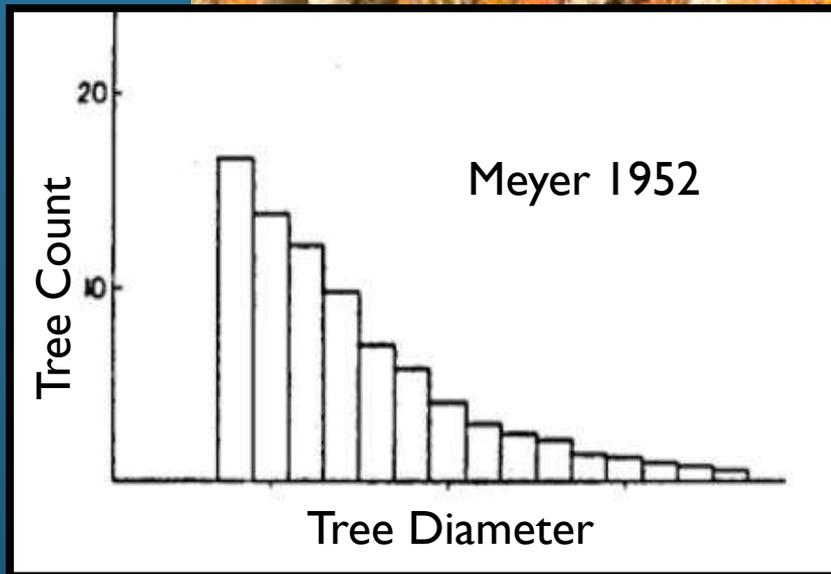
Origins of Uneven-aged forest management:

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

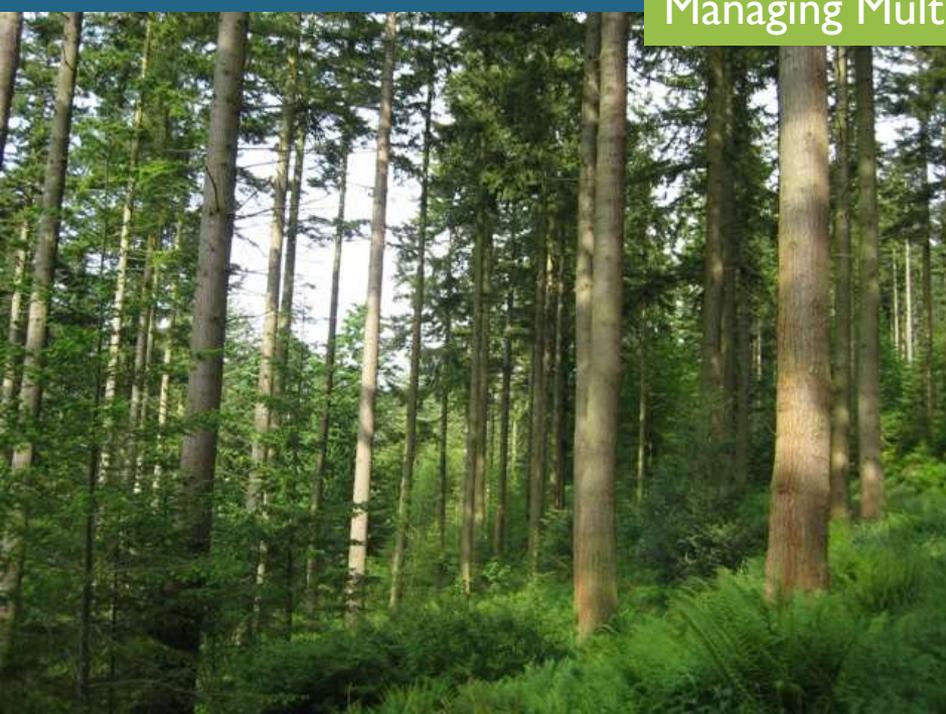
Kirkland and Brandstrom 1936

Leo Isaac 1956





Managing Multi-aged Stands



Managing Uneven-aged Stands

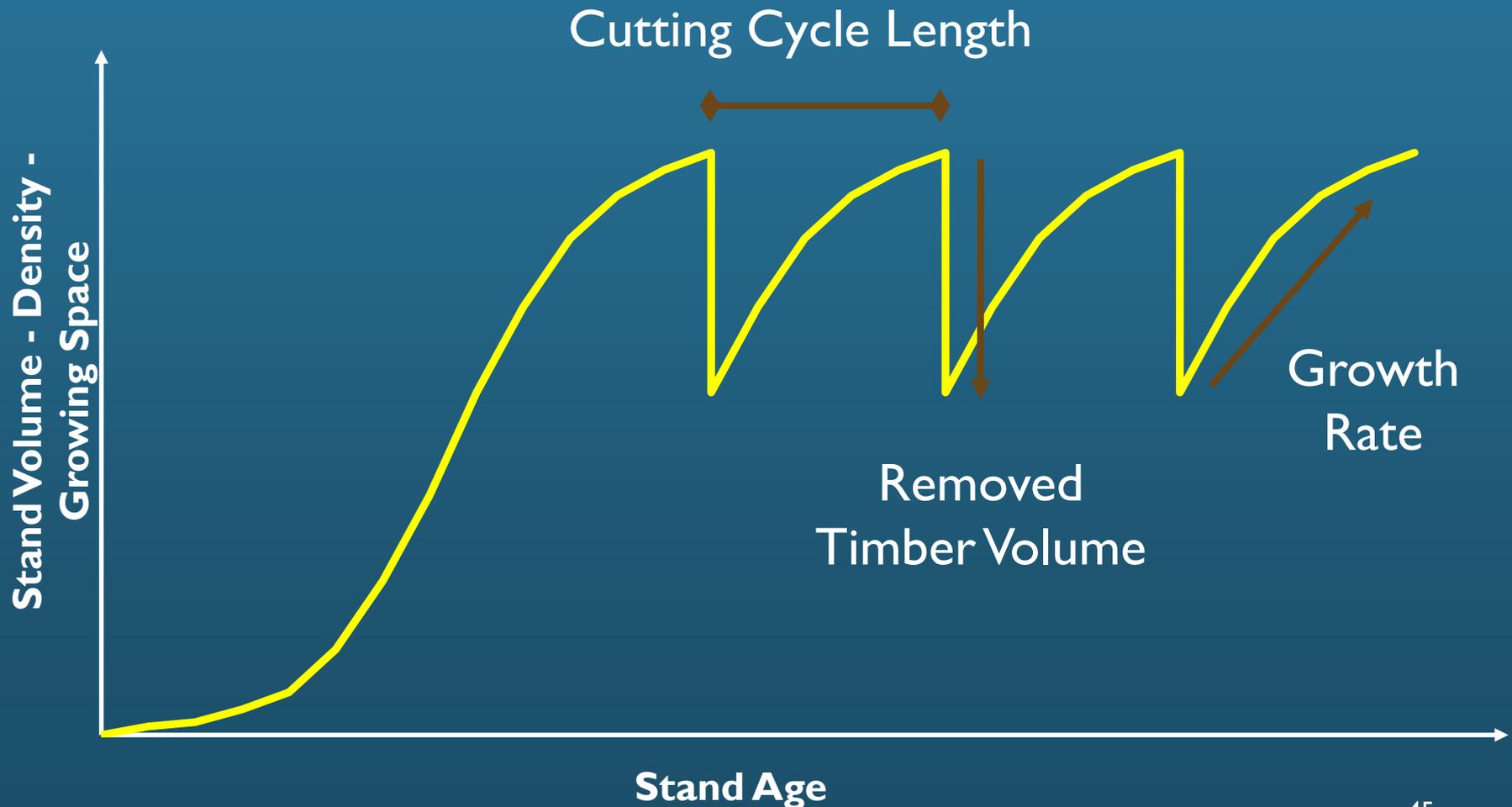
Manage stand density to:

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

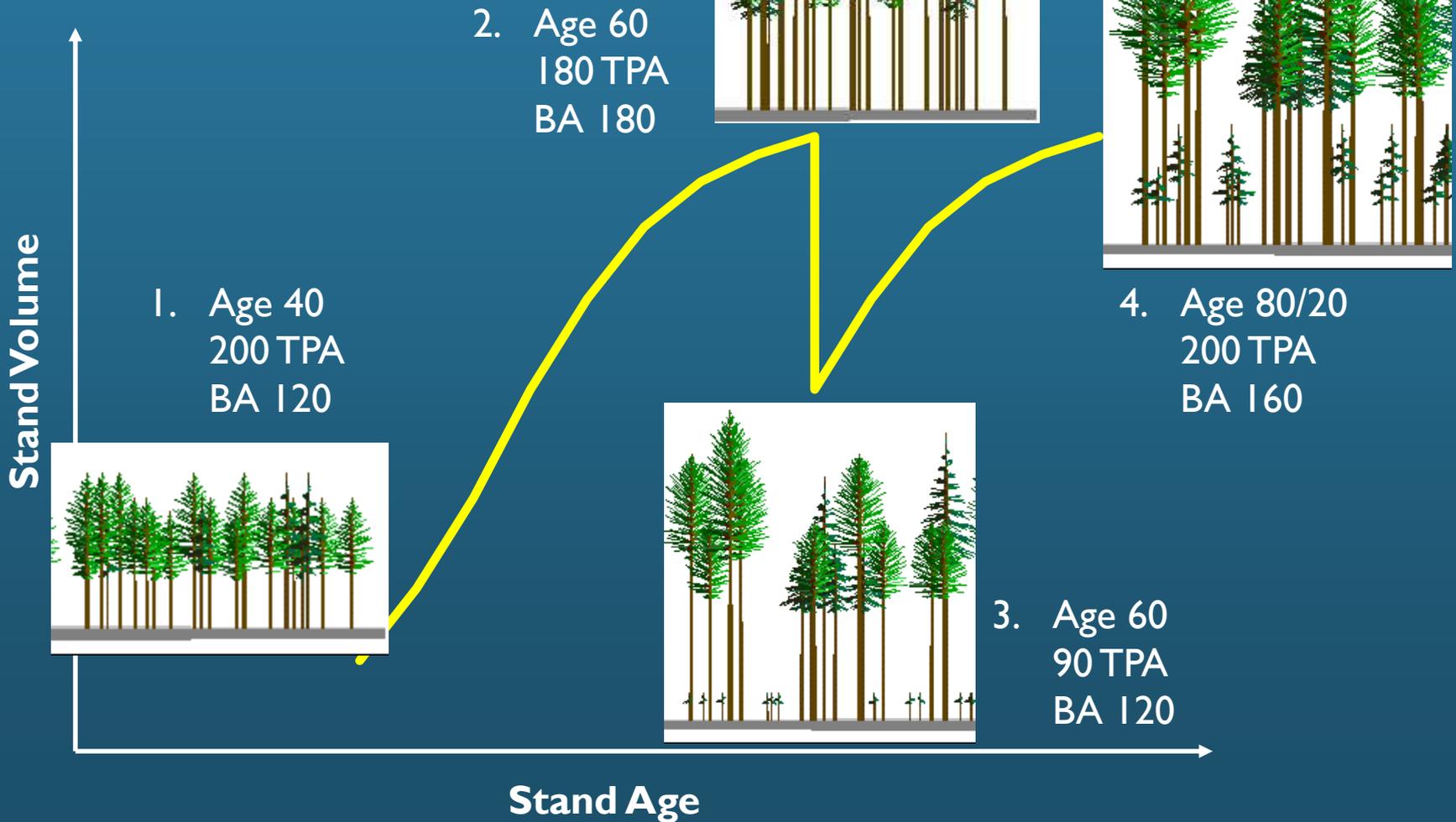
Transformation of even-aged to multi-aged stands

Cutting Cycle

- cutting cycle length depends on cutting intensity and growth rates

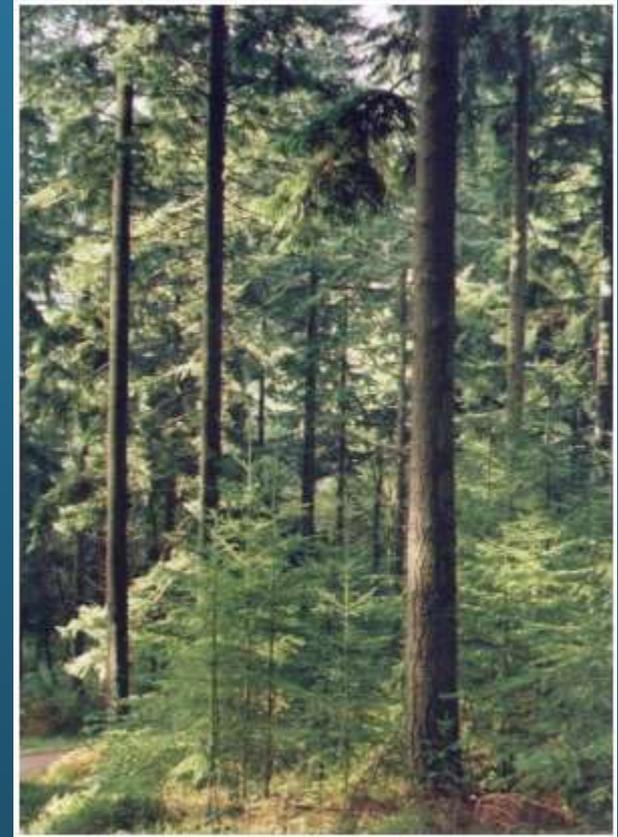
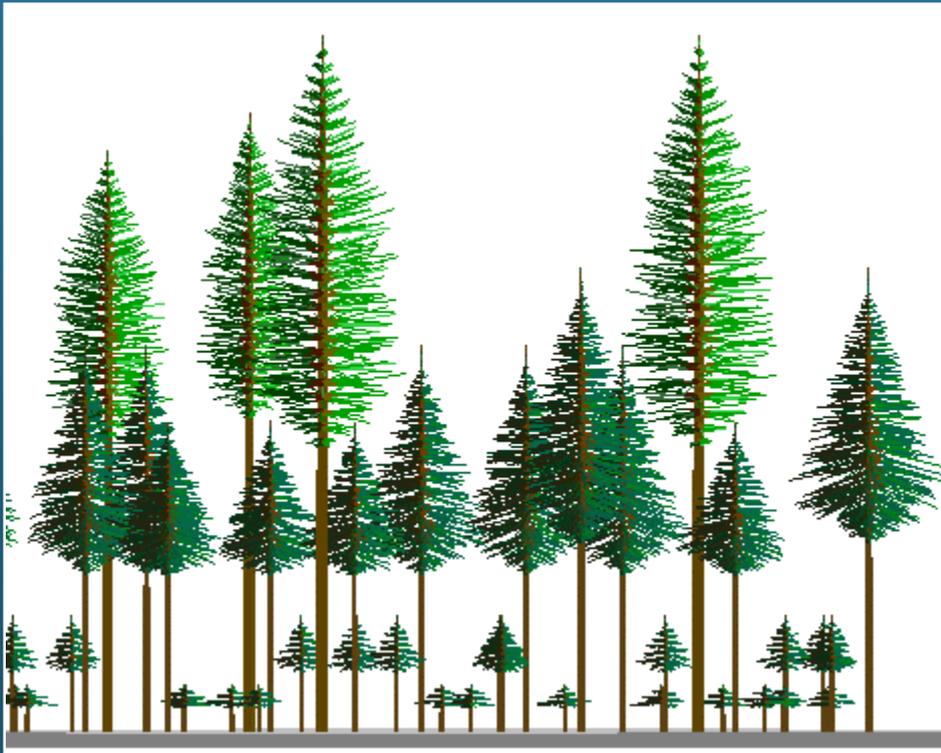


Cutting Cycle

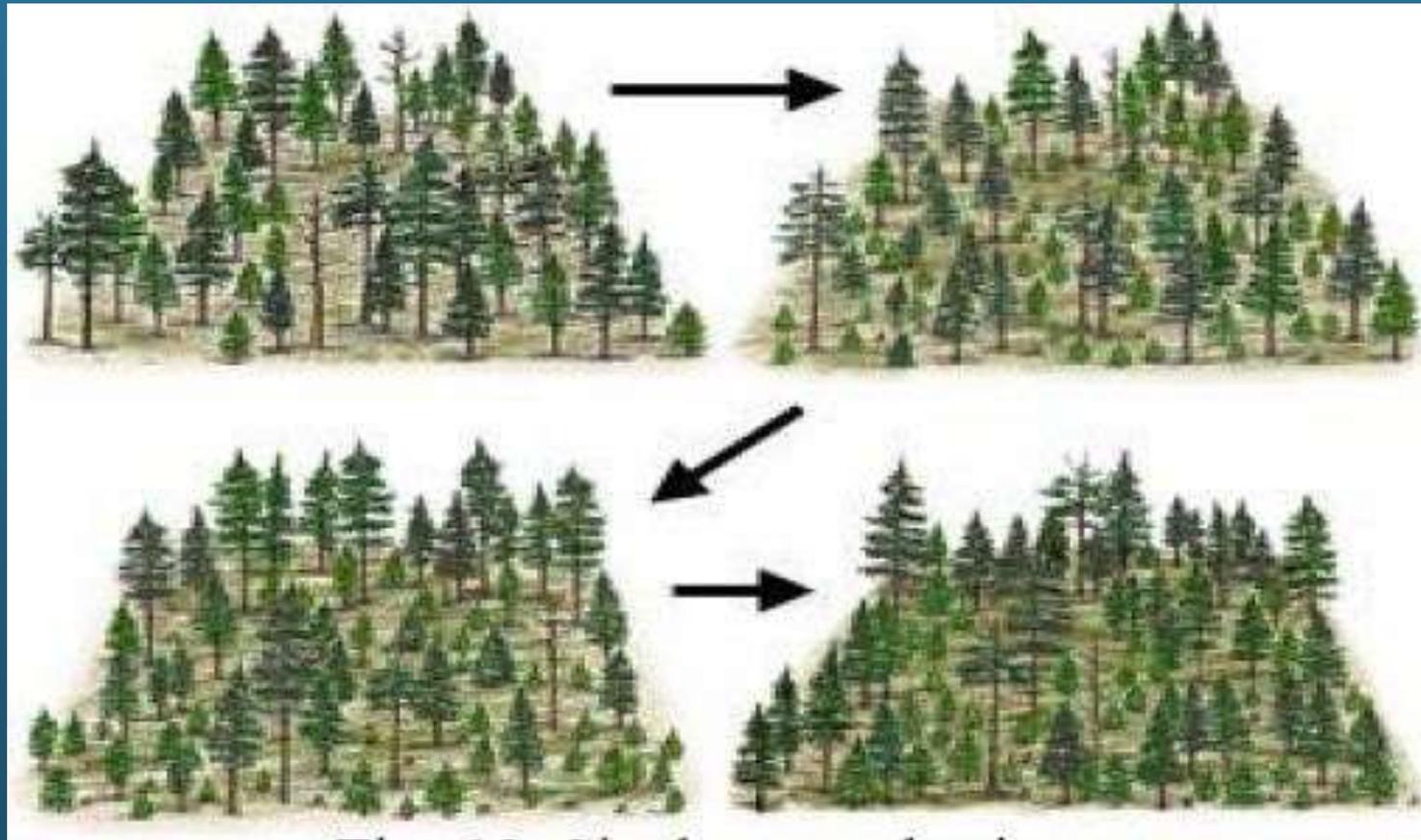


Single Tree Selection –

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



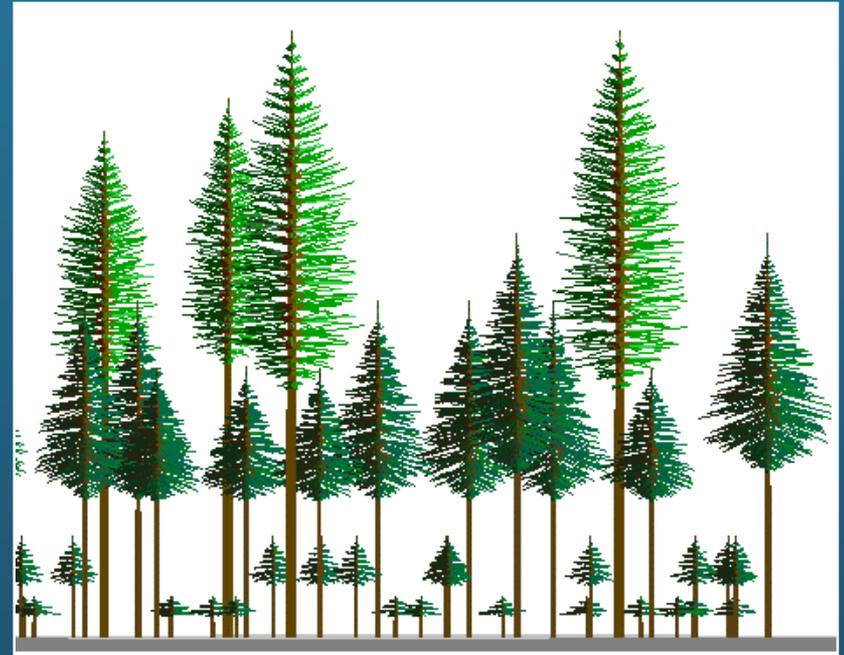
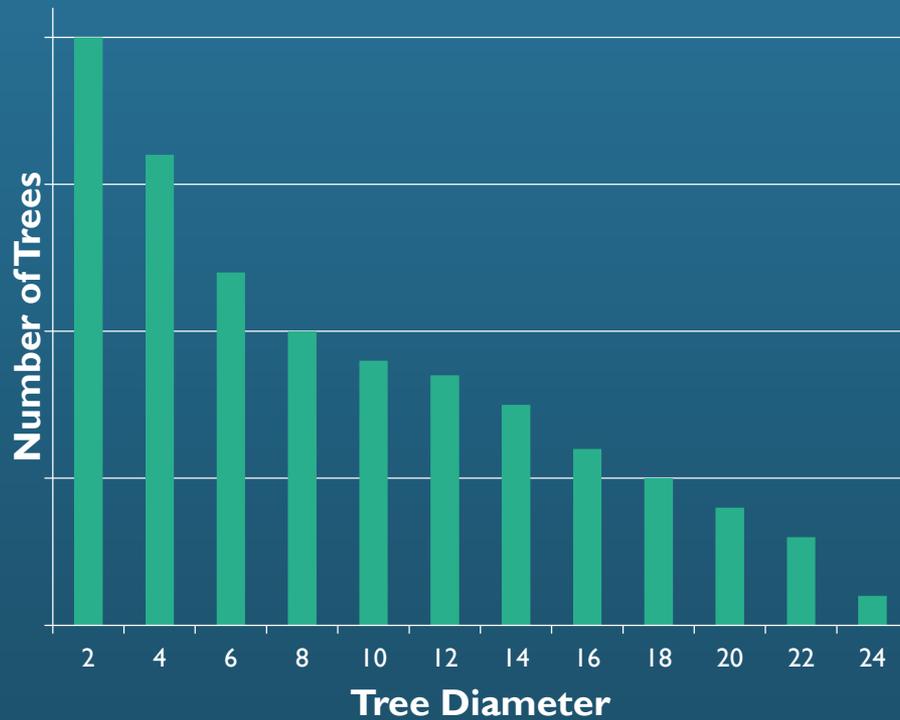
While individual trees are removed,
the stand structure remains the same



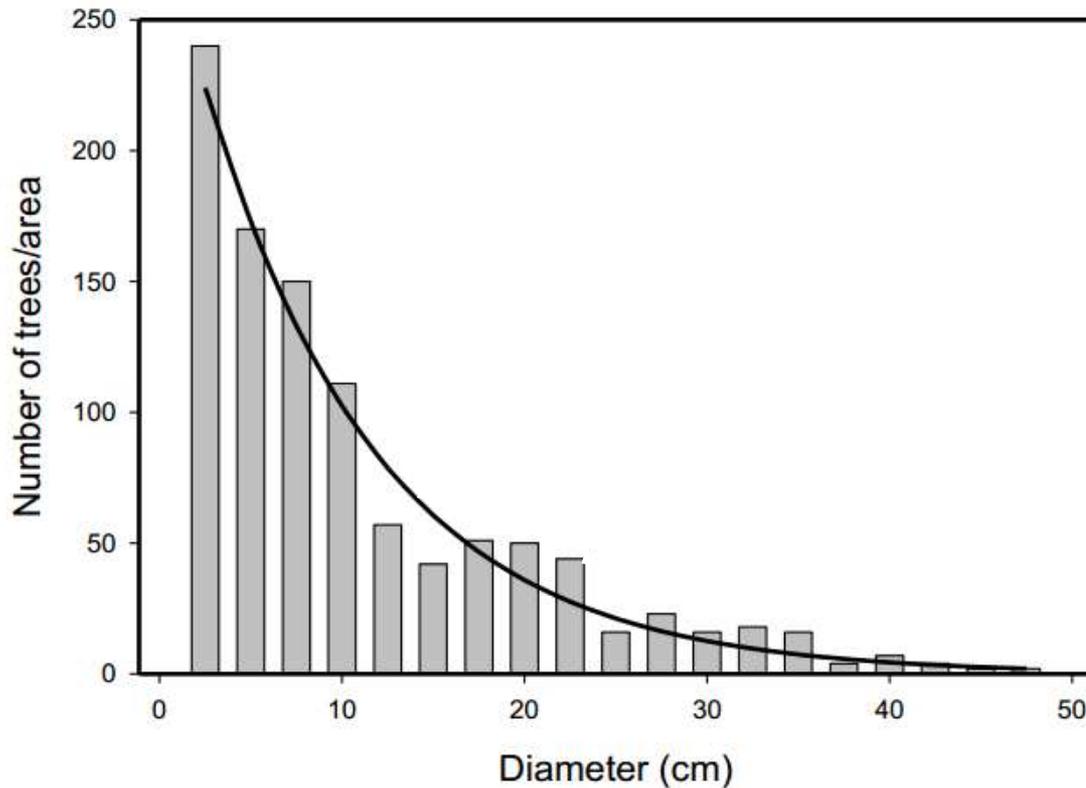
Single Tree Selection

– 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”

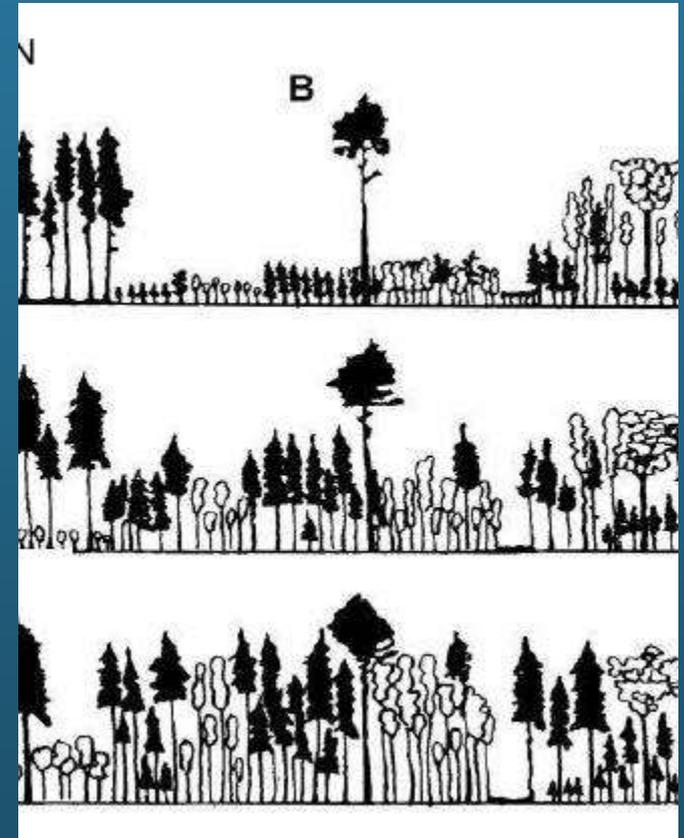
At each cutting cycle
we thin trees in classes
that exceed the guide
curve.

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:

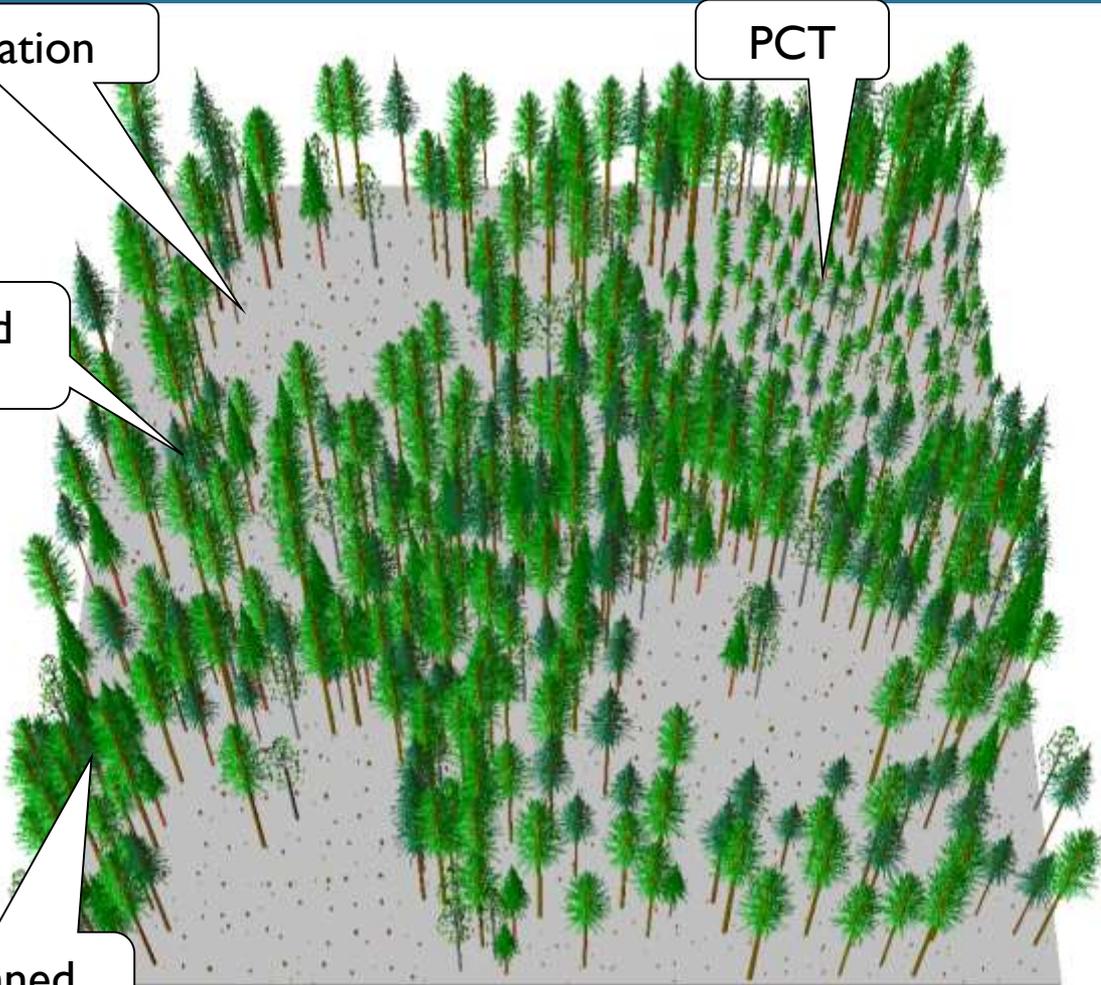
Group-Selection
Harvest

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



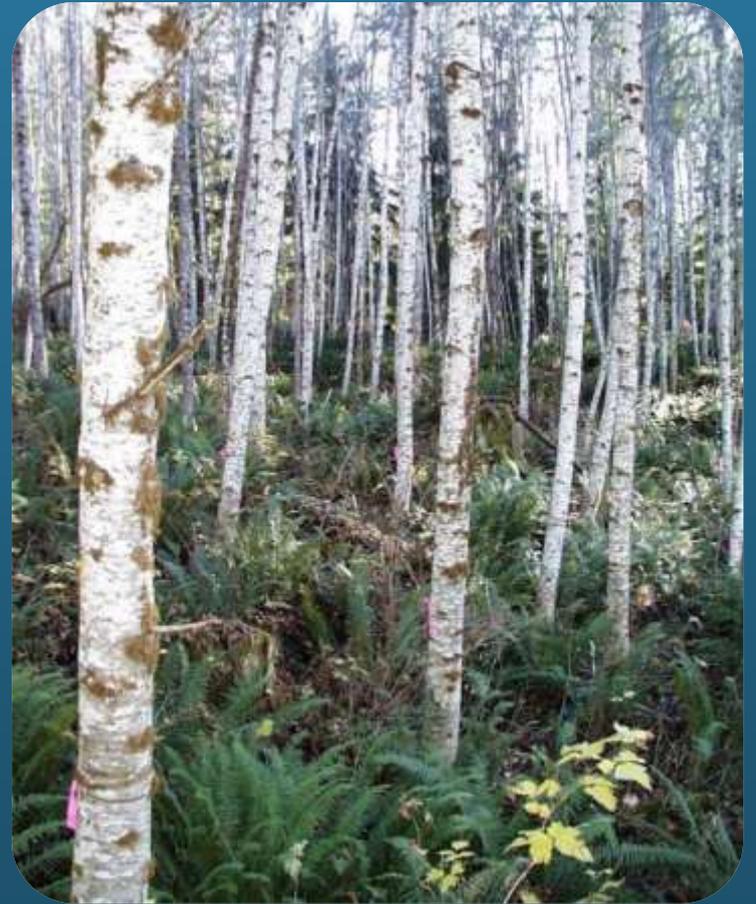
Planted 230 TPA, Age 13

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

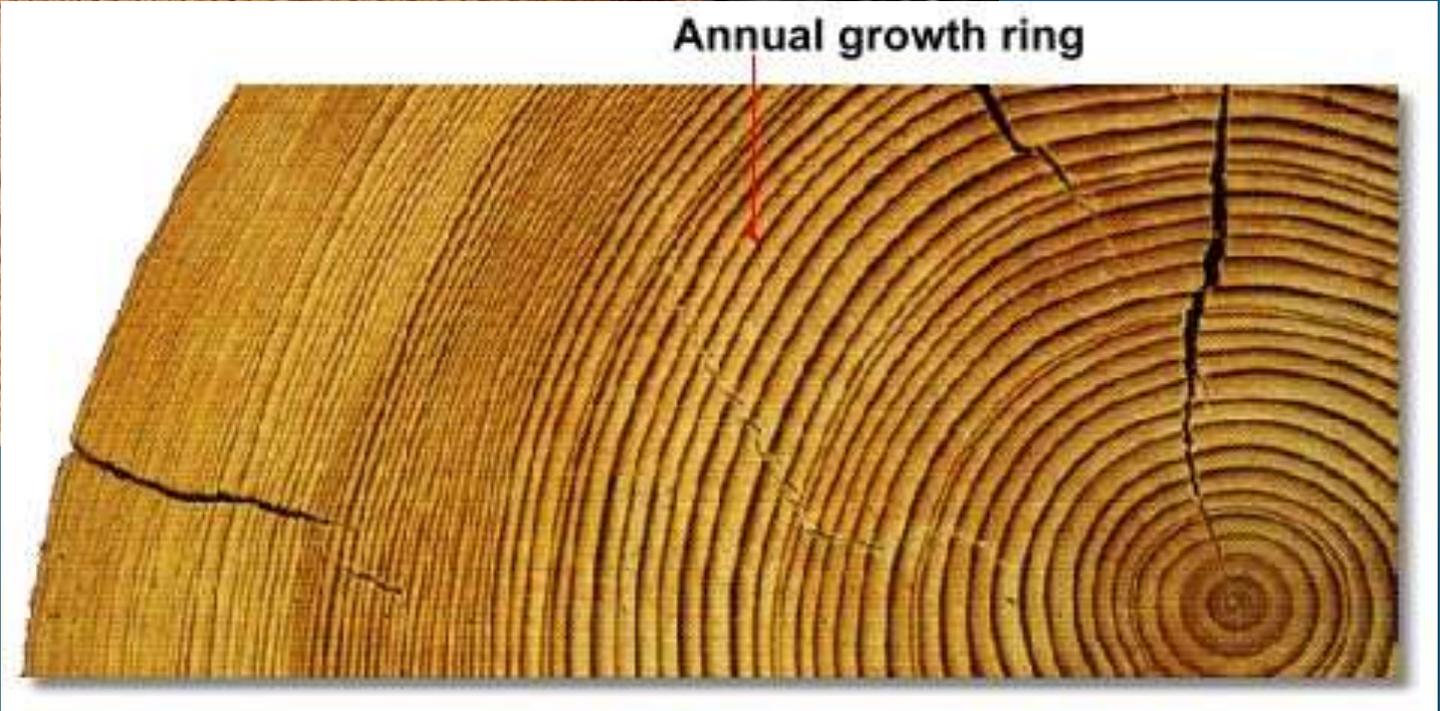


Photo: Hardwood Silviculture Cooperative

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

Assessment and Monitoring

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

Decisions

Timing
Cutting Intensity
Cutting Cycle
Length

Indicators

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

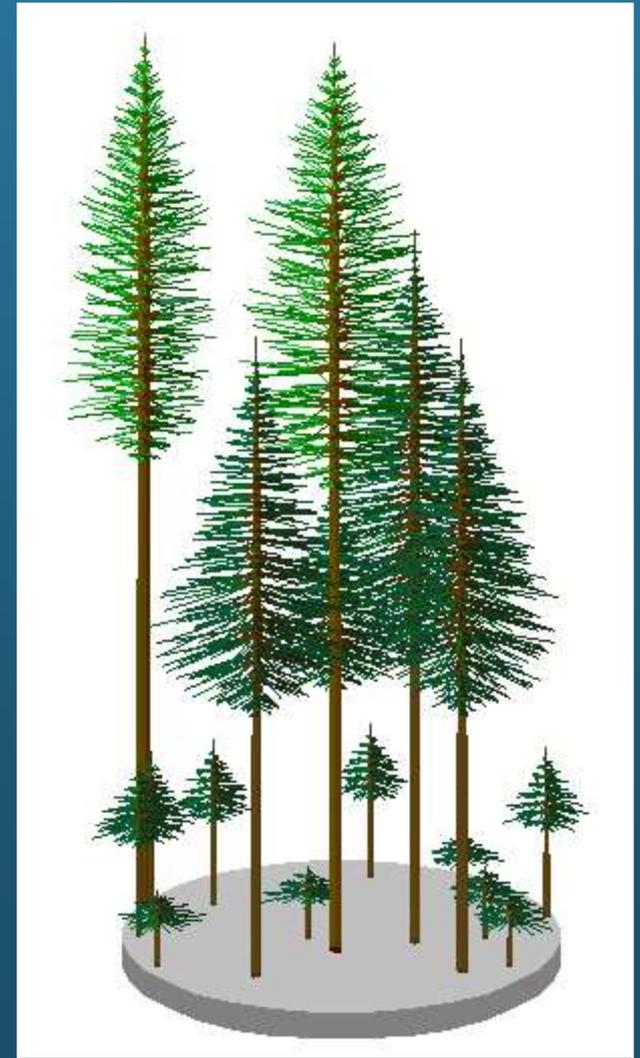
Attributes

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

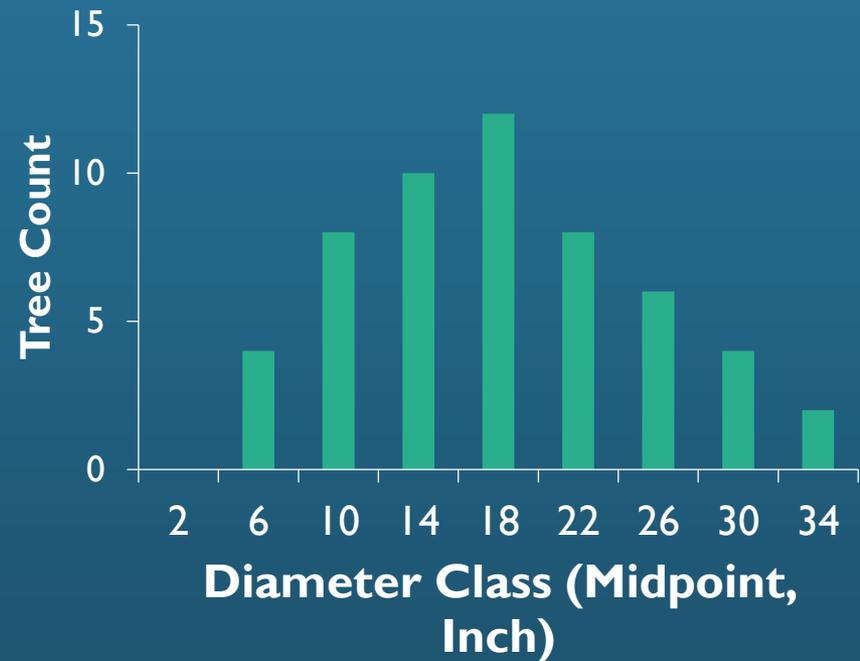
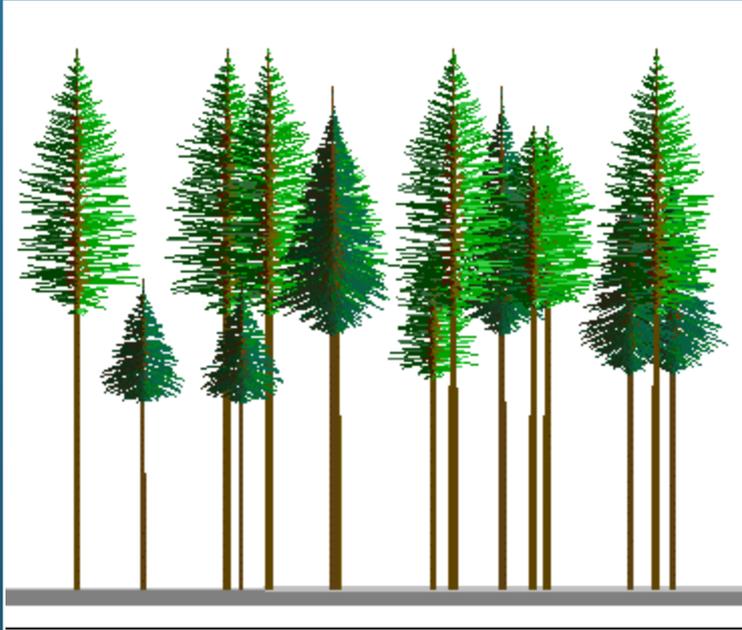


Tools For Assessment – Sampling to establish a diameter distribution

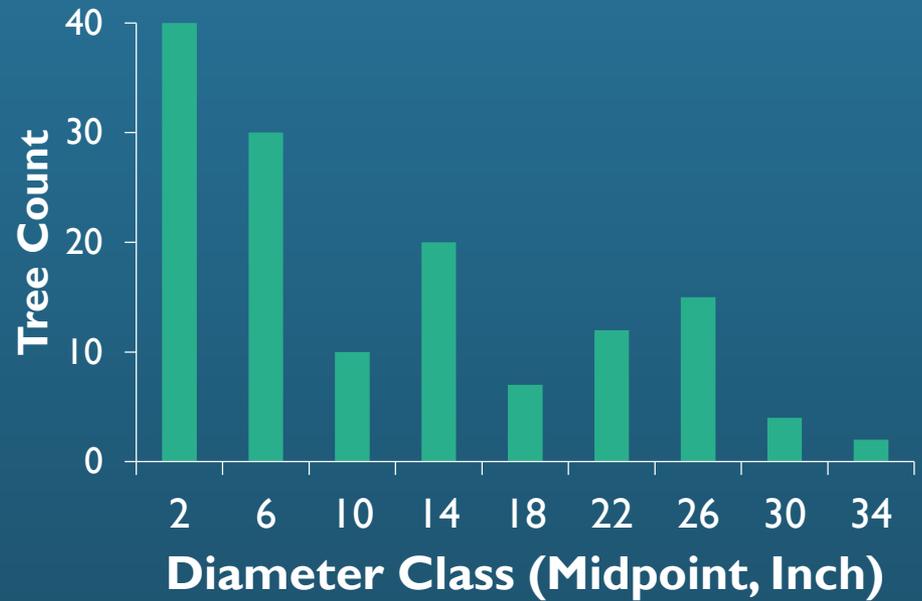
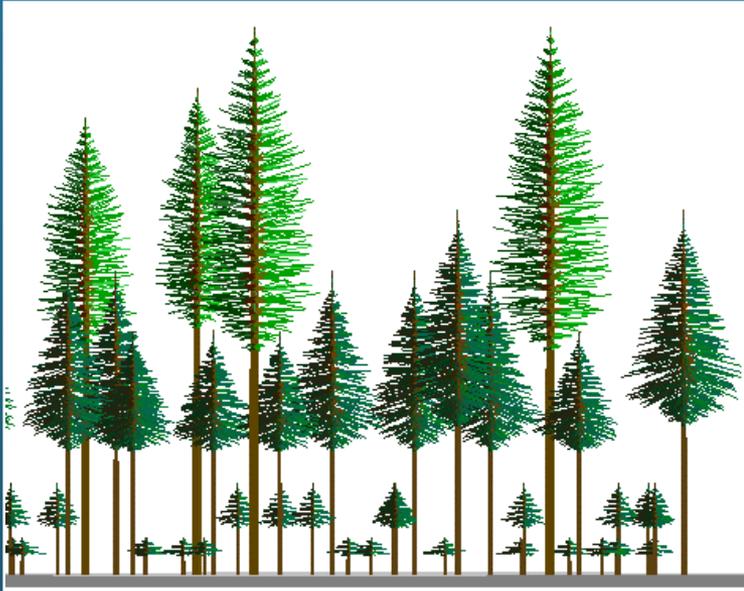
Tree Diameter Tally Sheet				
DBH Class (Inches)	Plot 1 Count	Plot 2 Count	Plot 3 Count	Sum Tree Count
0-4	0	0	0	0
4-8	2	1	1	4
8-12	4	1	3	8
12-16	6	2	2	10
16-20	2	2	8	12
20-24		6	2	8
24-28		1	5	6
28-32	4			4
32-36	1	1		2



Diameter Distribution of Even-aged Stand



Diameter Distribution of Multi-aged Stand



Growing Space Allocation

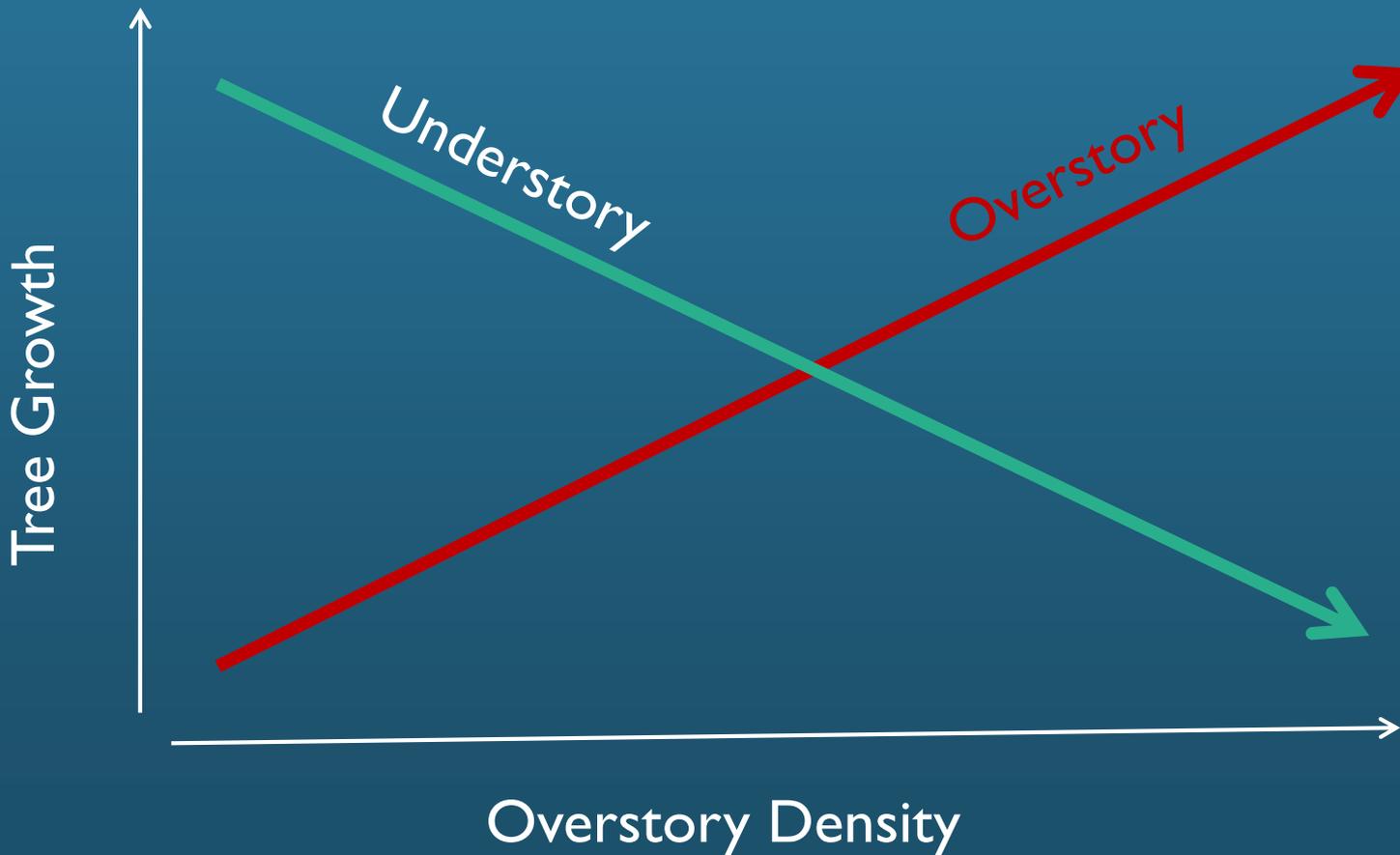
Resource requirements are proportional to size



80%
Growing Space
In Overstory

20%
Growing Space
In Understory

Growing Space Allocation – Overstory versus Understory

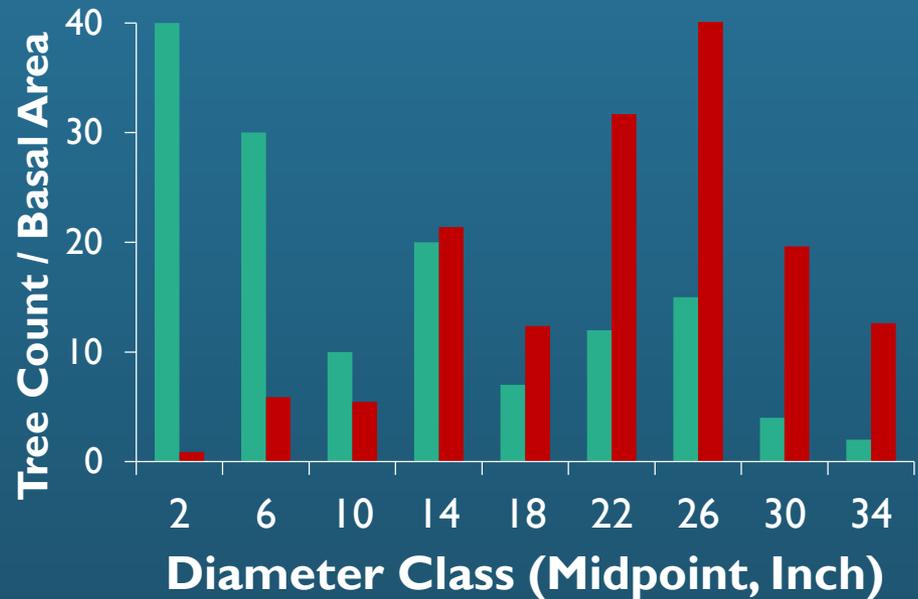
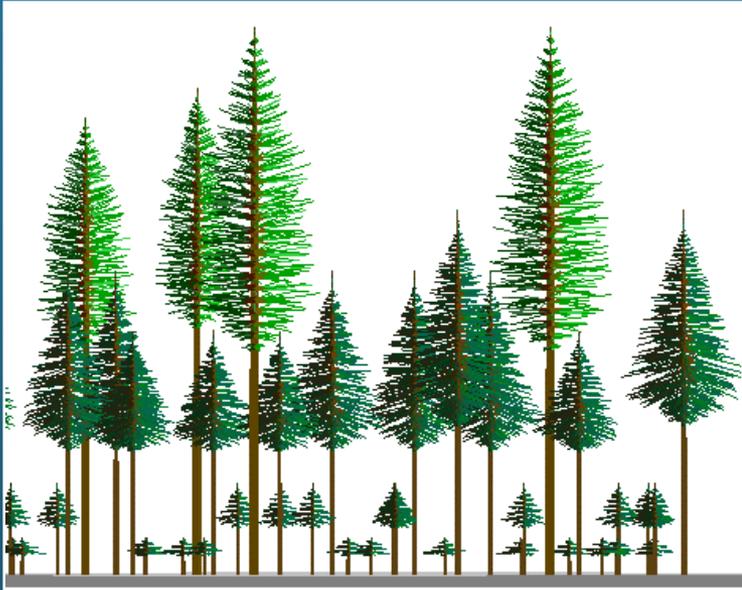


Basal Area as proxy for growing space

- 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 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

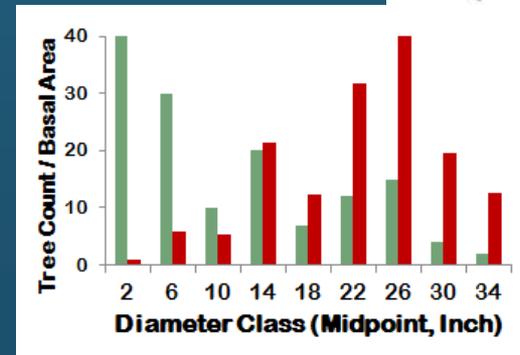
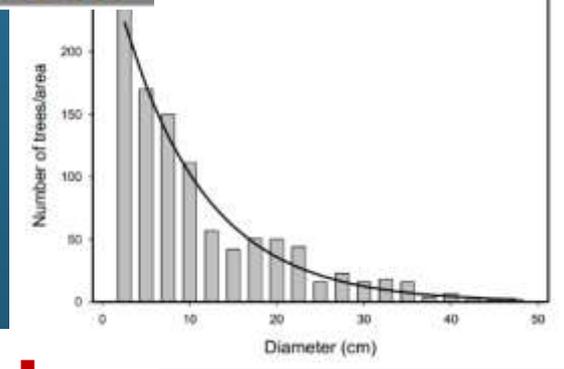
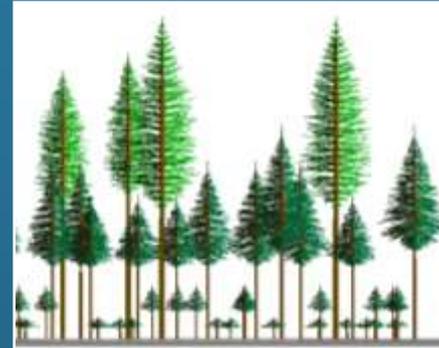
- Long-term plan as Guide not Rule

□ Create Habitat

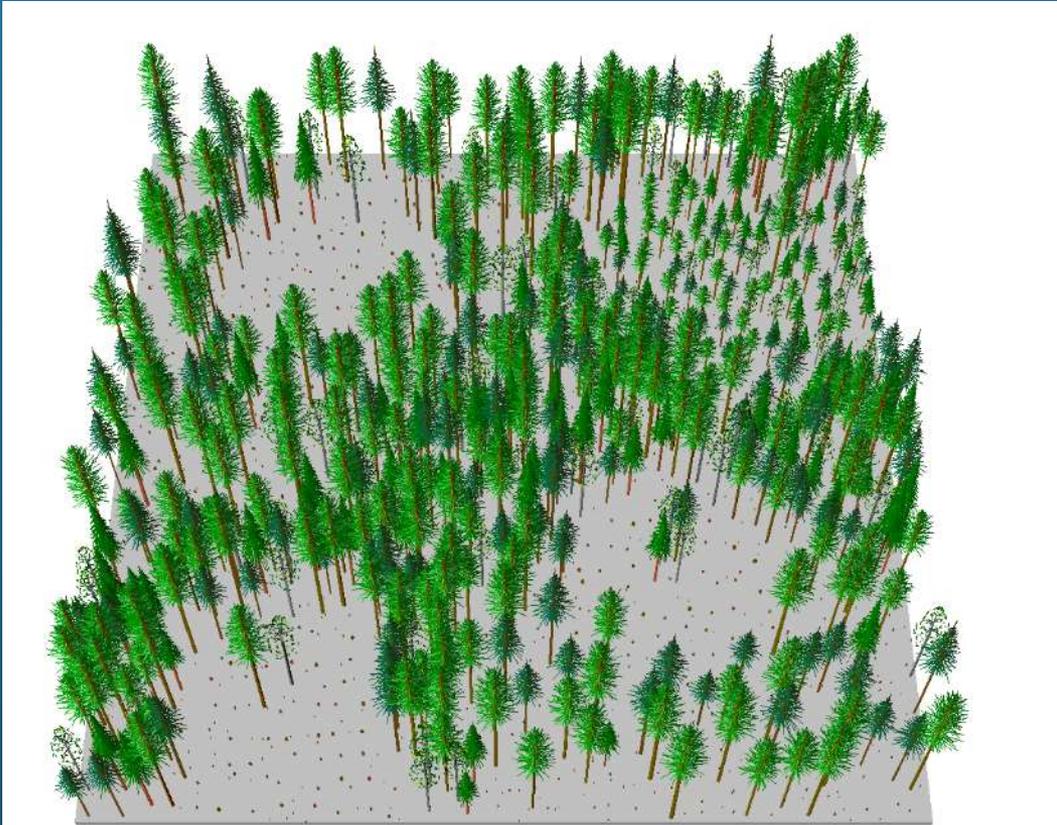
- CWD, snags, canopy layers

Tree Selection and Marking

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

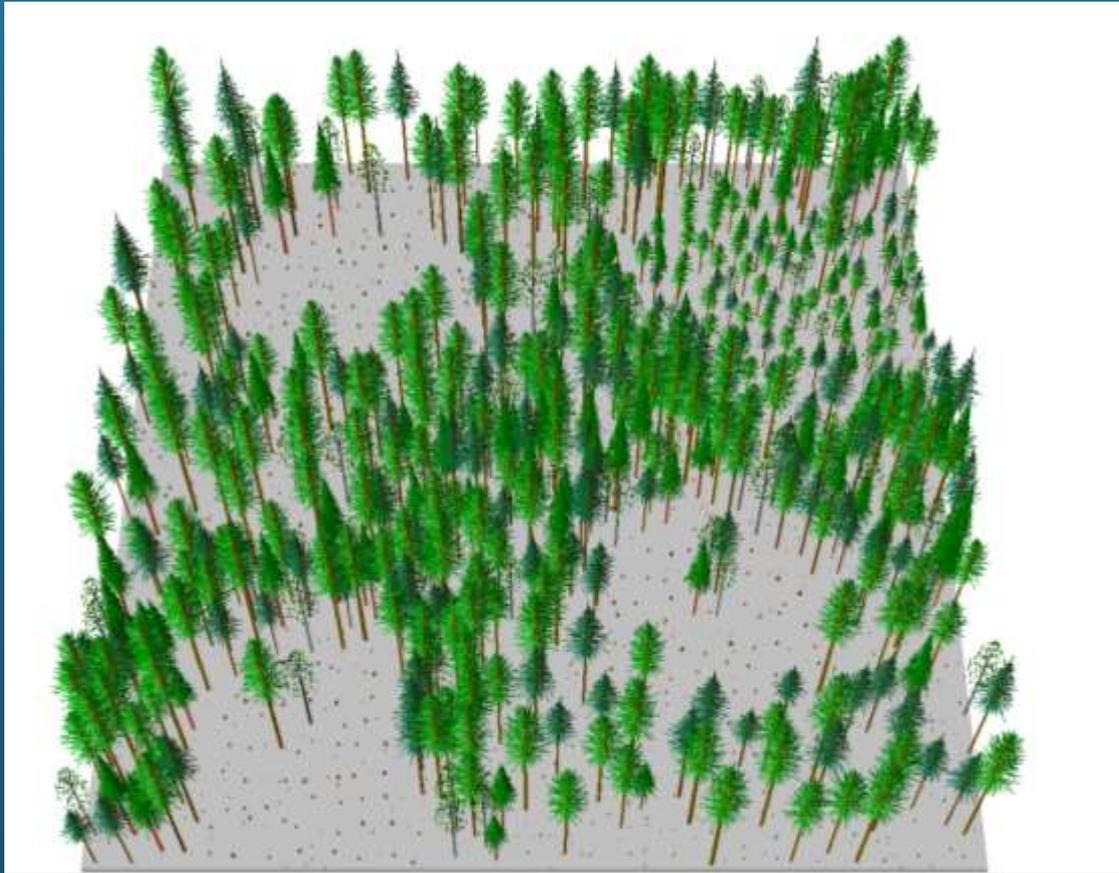


Group Selection System – Planning Operations



- ❑ 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



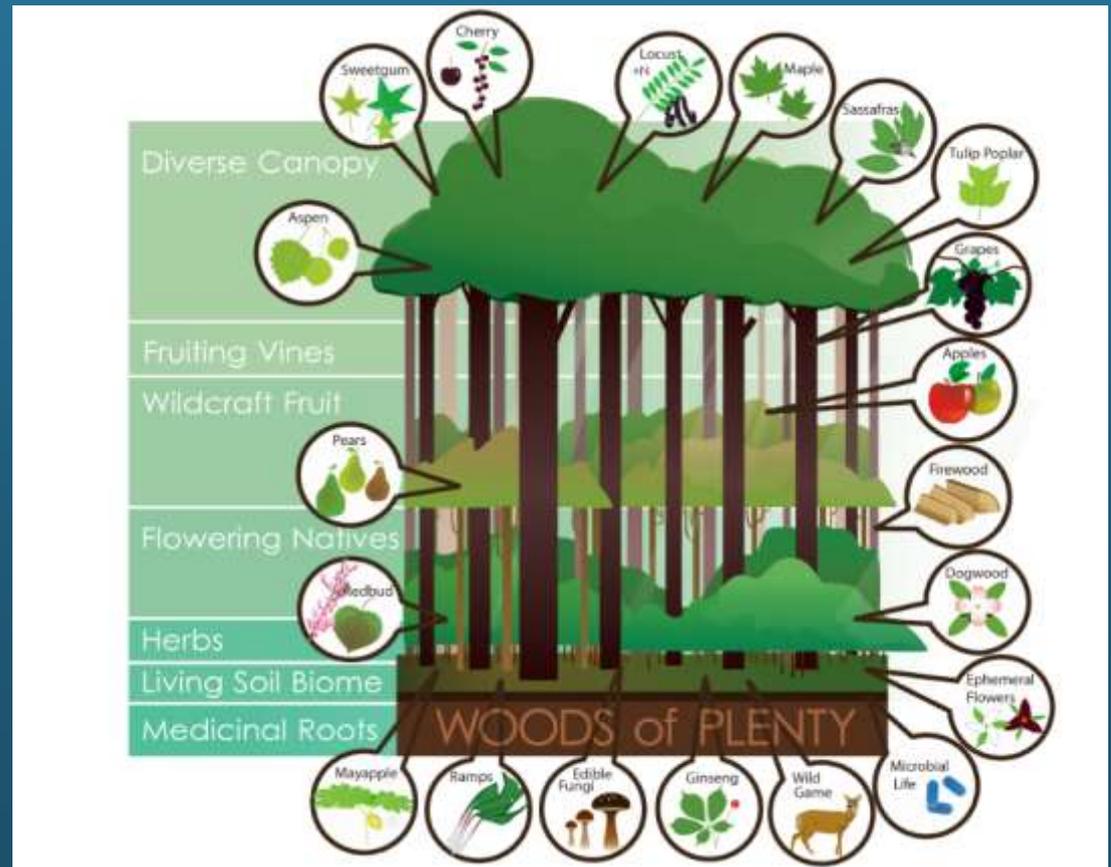
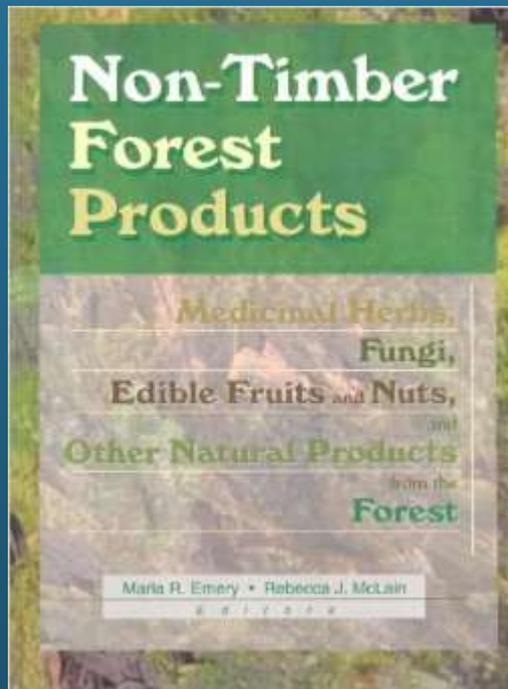
Impact of temporary skid tails and mitigation



Forest Products –

Marketing product diversity from small to large diameter wood





Harvest impacts can be opportunities for creating habitat

