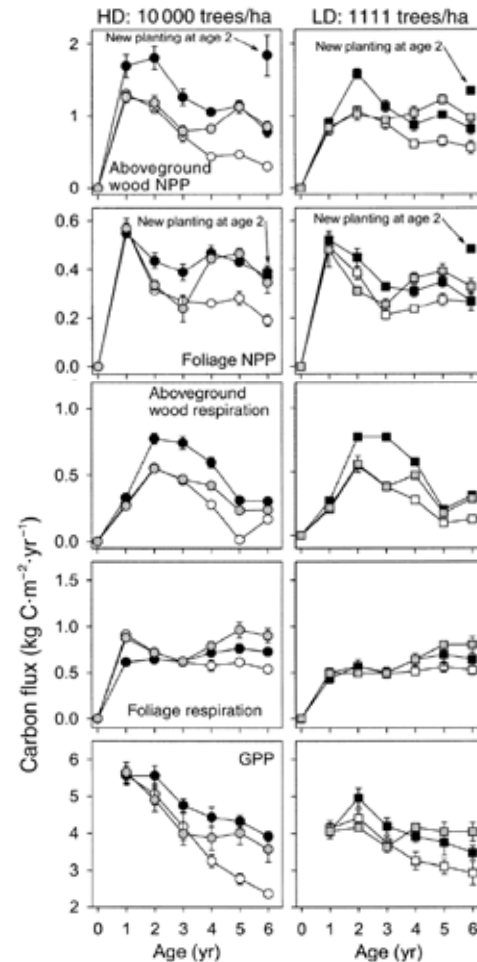
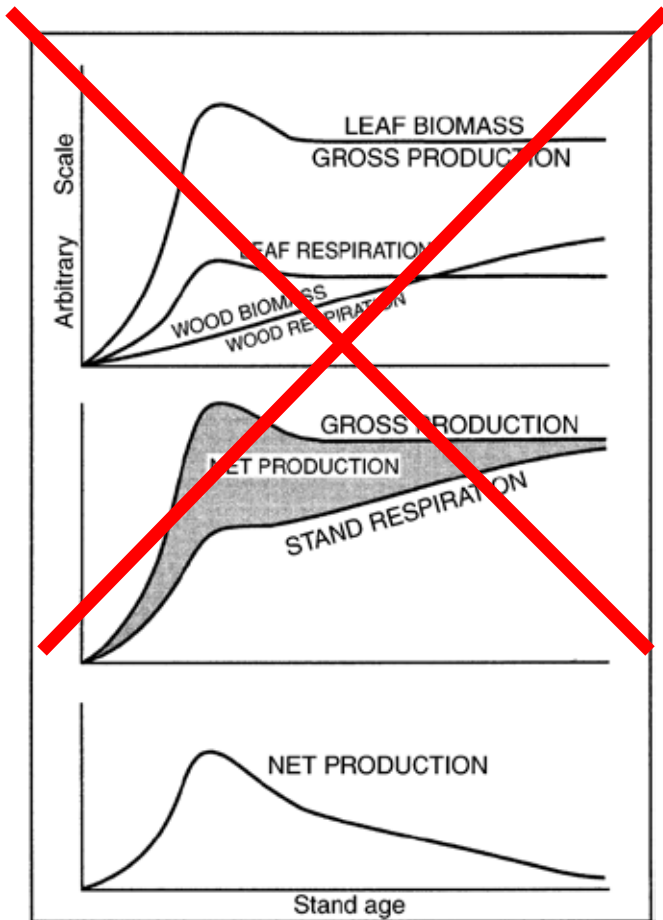


Stand Dynamics

- Objectives
 - Stand Dynamics
 - Understanding the ecology of stand dynamics to inform forest management
 - **First:** questions, take-home points, things you learned, etc. from reading assignment

Stand Dynamics

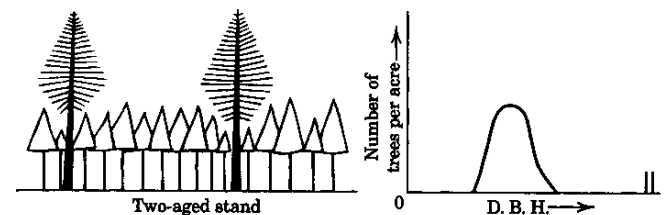
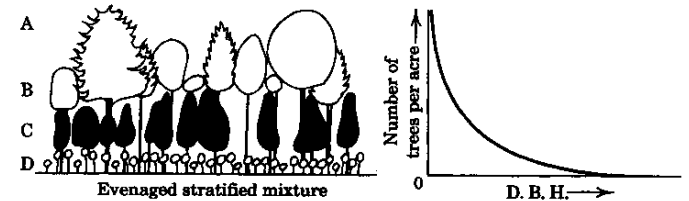
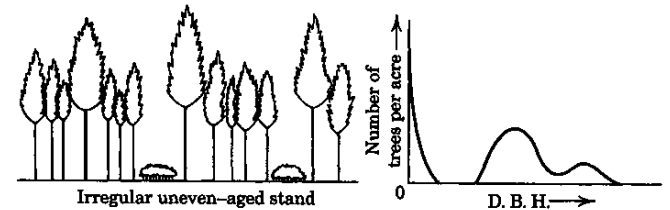
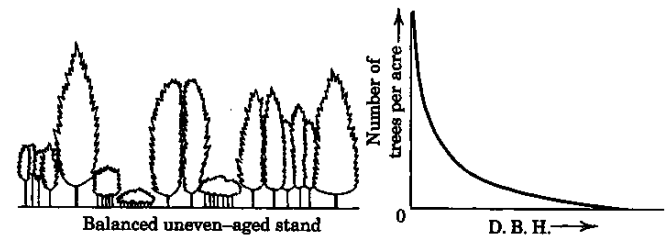
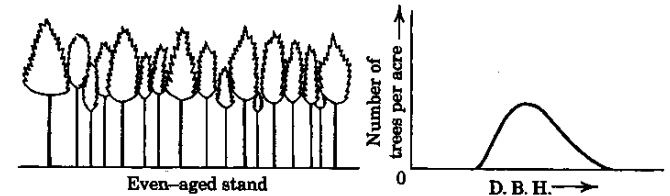
- Age-related decline in forest productivity



(Ryan et al. 2004)

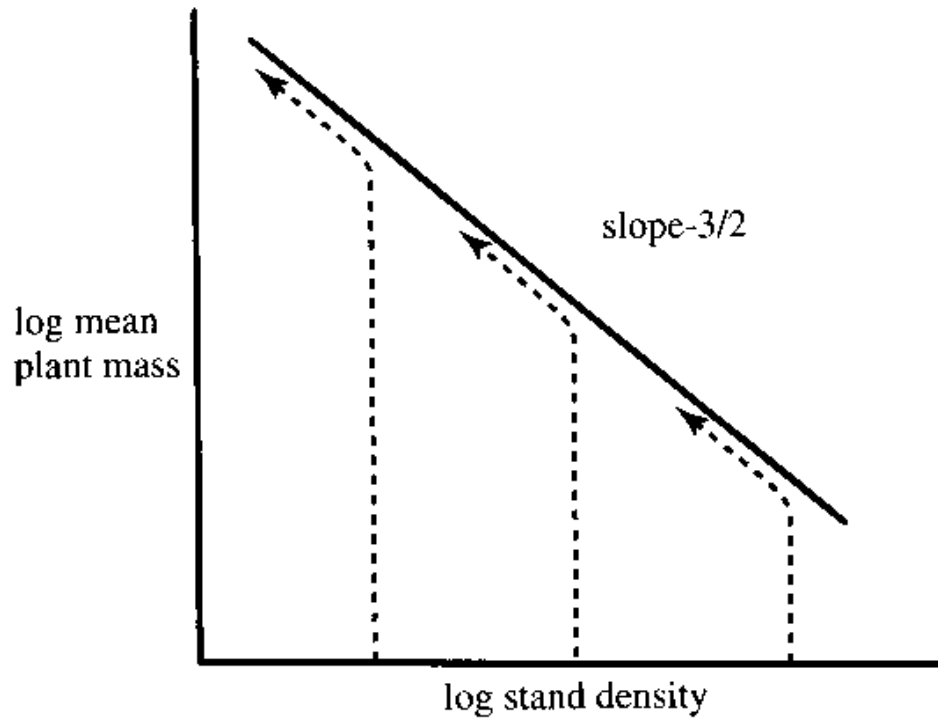
Stand Dynamics

- Age / Cohort Classes & Size Class Distributions
 - Pure vs. Mixed (single species vs. multi-species; monoculture vs. polyculture)
 - Even-aged vs. Uneven-aged
 - Single-cohort vs. Multi-cohort (vs. Double-cohort)



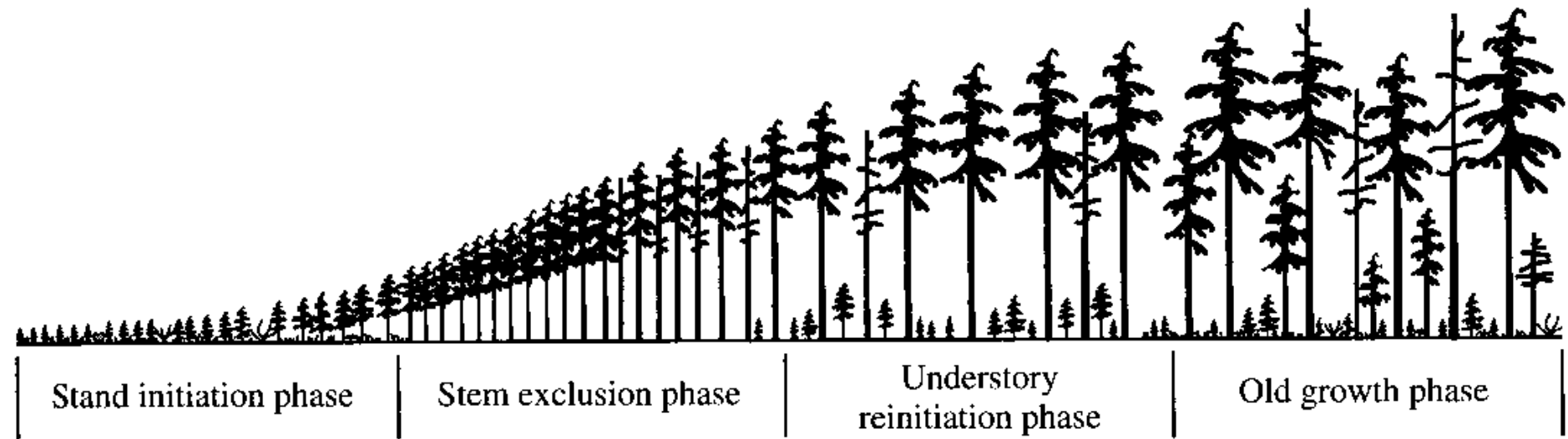
Stand Dynamics

- Self-thinning rule – Tree Mortality



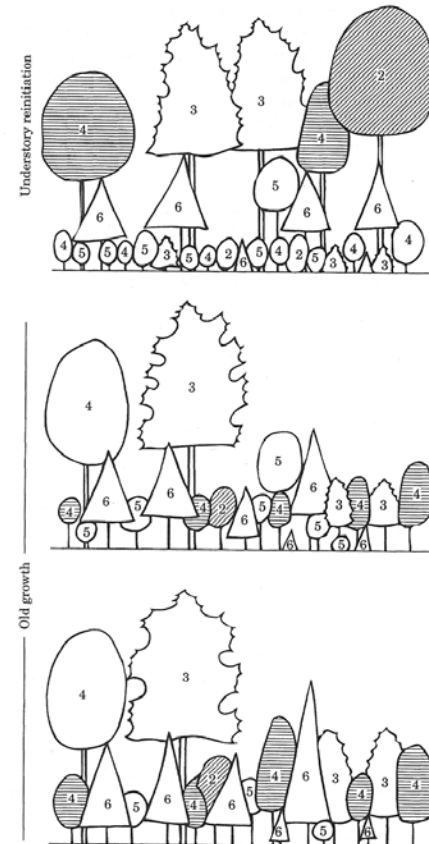
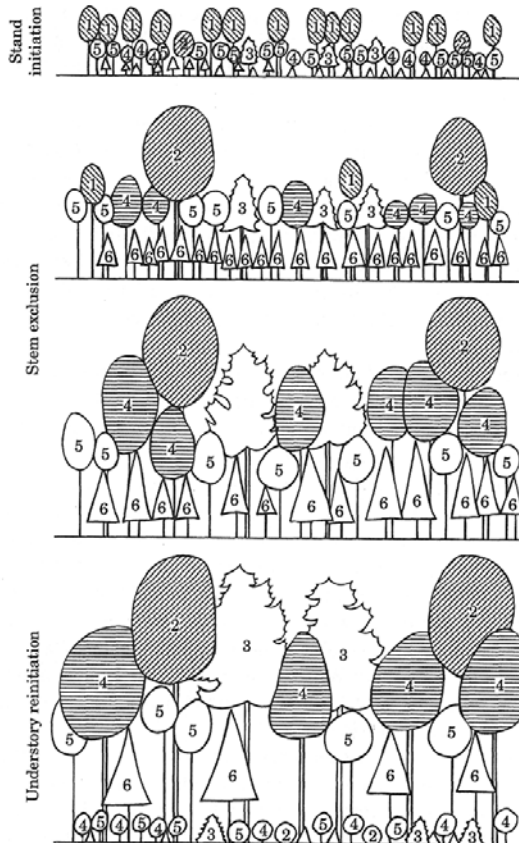
Stand Dynamics

- Stand Development
 - Pure, even-aged, single-cohort stand



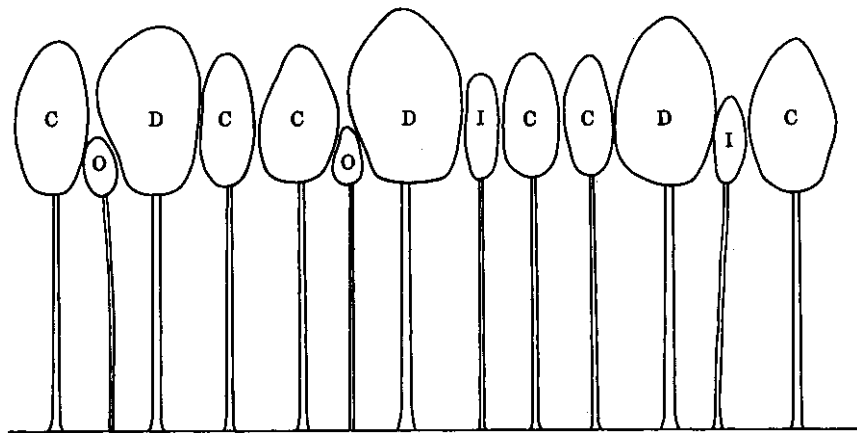
Stand Dynamics

- Stand Development
 - Mixed-species, even-aged, single-cohort stand

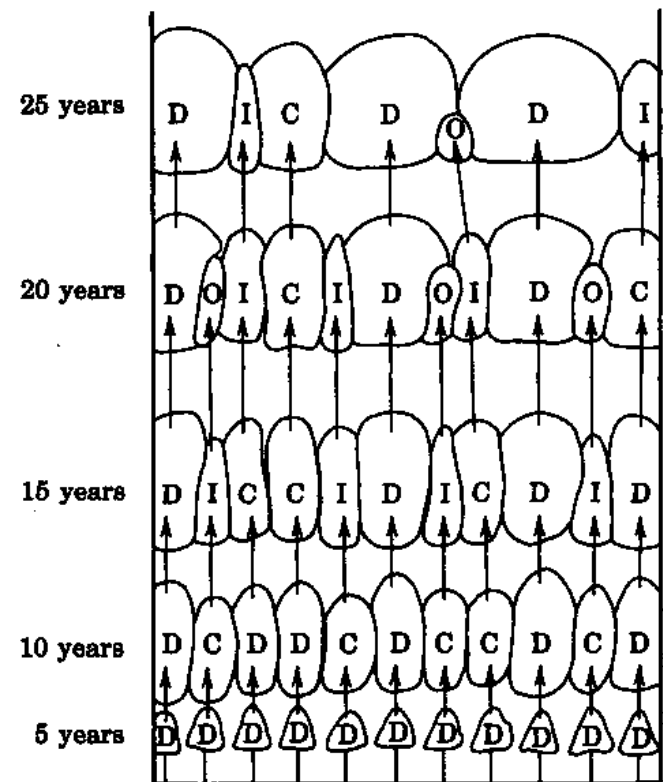


Stand Dynamics

- Crown Classes: Pure stands



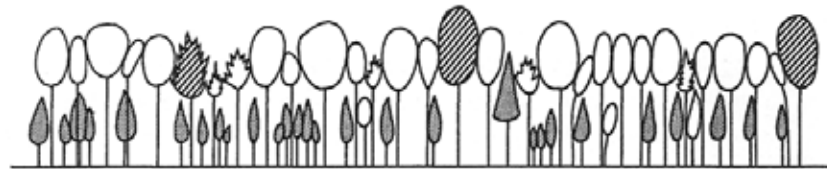
Pure Stands



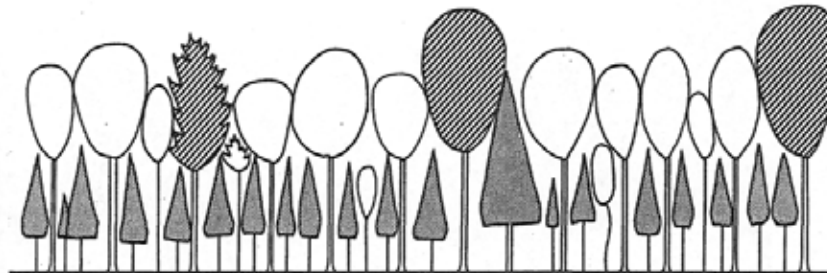
Stand Dynamics

- Crown Classes: Mixed Stands

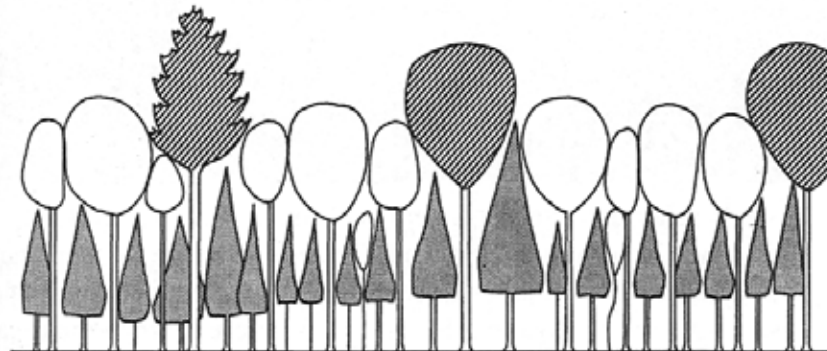
Shade Intolerant à
Shade Tolerant à



40 yrs



70 yrs



120 yrs

Stand Dynamics

- Ecological forestry (Franklin et al. 2007)
 - Emulation of natural disturbances and resulting stand development processes as models for silvicultural practice
 - 3-legged stool of ecological forestry
 - Retention of biological legacies at harvest
 - Intermediate treatments to enhance stand heterogeneity (structural & compositional)
 - Allowance of appropriate recovery periods between harvests

Stand Dynamics

- Ecological forestry (Franklin et al. 2007)

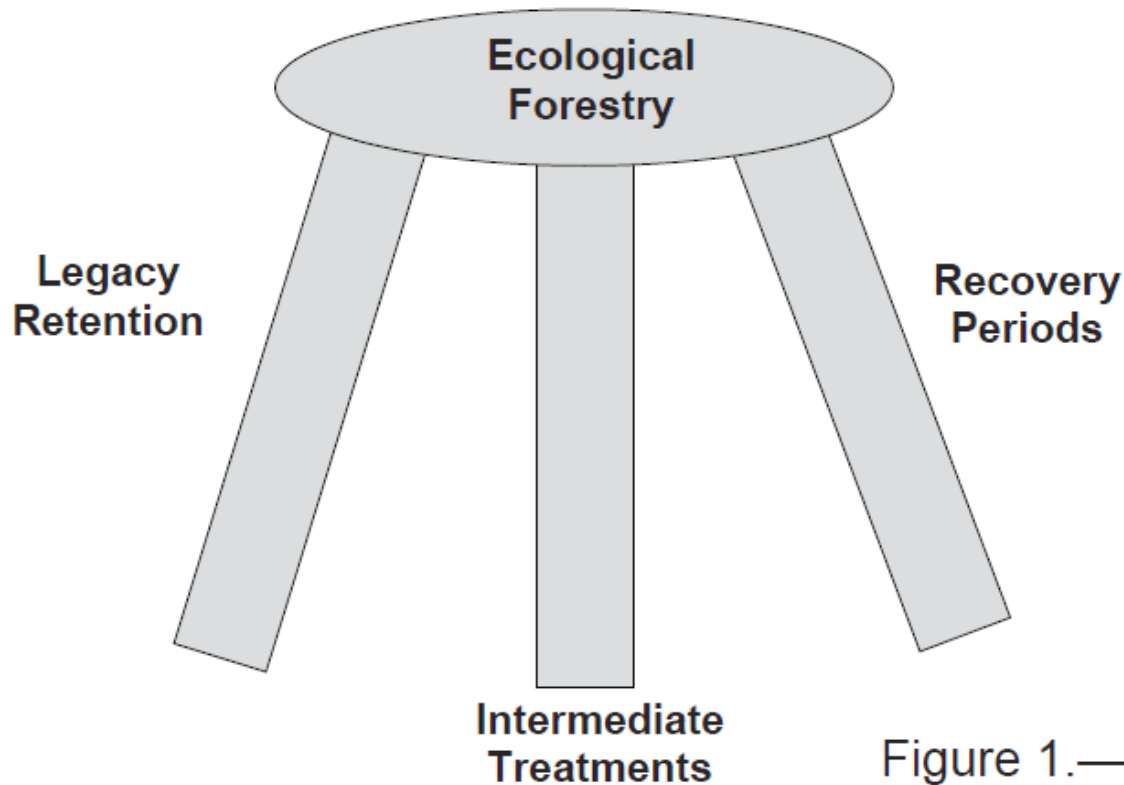


Figure 1.—The three-legged stool of ecological forestry.

Stand Dynamics

- **Biological Legacies**

Table 1.—Categories and examples of biological legacies

Legacy category	Examples
Organisms	Sexually mature and intact live trees Tree reproduction (seedling and sapling banks) Vegetatively reproducing parts (e.g., roots) Seed banks Shrub, herb, bryophyte species Mature and immature animals and microbes
Organic matter	Fine litter Particulate material
Organically derived structures	Standing dead trees Downed trees and other coarse woody debris Root wads and pits from uprooted trees
Organically derived patterns	Soil chemical, physical, microbial properties Forest understory composition and distribution

Stand Dynamics

- Biological Legacies



Stand Dynamics

- Biological Legacies

Table 2.—Biological legacies associated with wind, fire, and bark beetle disturbances

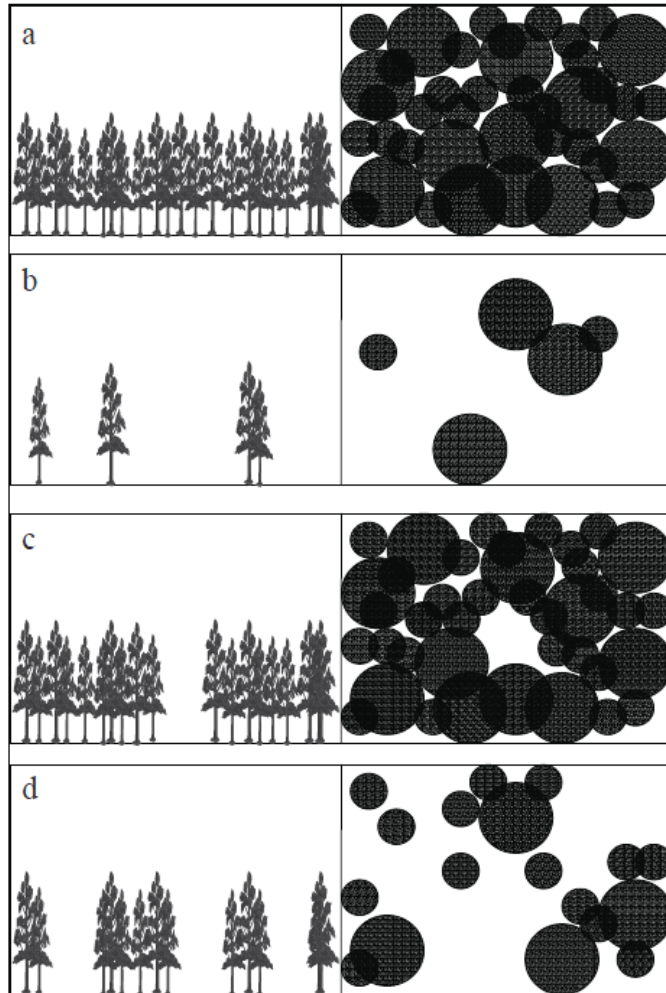
Legacy	Disturbance agent								
	Wind			Fire*			Beetle		
	Tree	Gap	Stand	Tree	Gap	Stand	Tree	Gap	Stand
Live, mature trees	NA	Few/ Absent	Few/Absent	NA	Few	Few	NA	Species dependent	Species dependent
Seedling bank	Possible	Possible	Possible	No	No/Rare	Rare	Possible	Possible	Possible
Intact understory	Possible	Yes	Yes	No	Rare	Rare	Possible	Yes	Yes
Snags	NA	Few	Few	Yes	Abundant	Abundant	Yes	Abundant	Abundant
Logs	Yes	Abundant	Abundant	No	No	Common	No	No	No
Uproots	Yes	Abundant	Abundant	No	No	No	No	No	No
Mineral seedbed	Yes	Yes	Yes	Yes	Yes	Abundant	No	No	No

Table 3.—Biological legacies associated with common regeneration harvest methods as traditionally applied

Legacy	Method					
	Even-aged		Two-aged		Uneven-aged	
	Clearcut with site prep	Seed tree with site prep	Shelterwood with site prep ¹	Shelterwood with reserves and site prep	Group selection	Single-tree selection
Live, mature trees	No	Few/No	No	Yes	Few/No (in group)	n.a.
Seedling bank	No	No	Yes	Yes	Possible	Possible
Intact understory	No	No	No	Possible	Possible	Possible
Snags	No	No	No	No	No (in group)	n.a.
Logs	Few/No	Few/No	Few/No	Few/No	Few/No (in group)	No
Uproots	No	No	No	No	No	No
Mineral seedbed ²	Yes	Yes	Yes	Yes	Possible	Possible

Stand Dynamics

- Biological Legacies



Mature stand

Stand-replacing Disturbance

Gap-scale Dynamics

Partial Canopy Disturbance

Stand Dynamics

- Intermediate Treatments: Heterogeneity



Figure 14.—Cross-section of a 650-year-old stand of western red cedar, Douglas-fir, and western hemlock (Cedar Flats Research Natural Area, Washington), illustrating the mosaic of structural patches characteristic of old-growth stands in the Pacific Northwest. This mosaic is the consequence of centuries of development, including small-scale canopy disturbance, within a stand that was initially of even structure and age. Drawing courtesy

Stand Dynamics

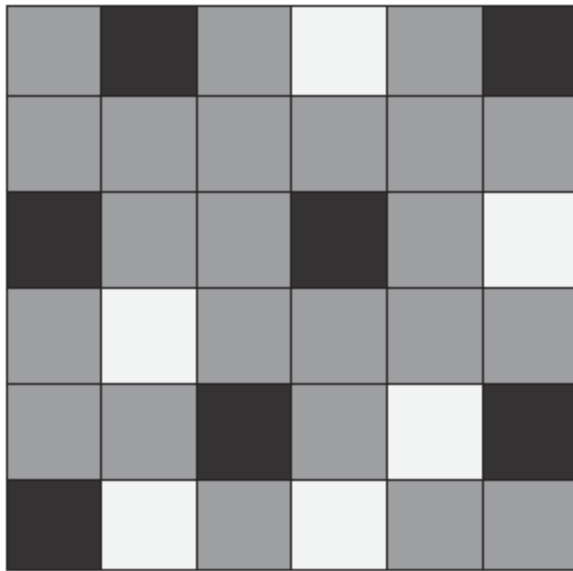
- Intermediate Treatments: Heterogeneity

Table 4.—Contrasts between the outcomes of tree mortality processes and traditional thinning treatments

Process	Unmanaged stand		Treatment	Managed stand	
	Cause	Outcomes		Purpose	Outcomes
Competitive tree mortality	Resource competition	<ul style="list-style-type: none"> -Larger trees retained -Competitively superior trees favored regardless of species -Shift toward uniform tree size distribution, but variability occurs -Tree quality and form will vary 	Silvicultural thinning	<ul style="list-style-type: none"> -Free growing space for crop trees -Capture economically valuable wood before mortality 	<ul style="list-style-type: none"> -Larger trees favored -Commercial species favored -Strong shift toward uniform tree size distribution -Poor quality trees removed
Small-scale canopy disturbance	Exogenous agents (ice, wind, fire, insects, disease)	<ul style="list-style-type: none"> -Dominant individuals removed -Creation of canopy openings -Canopy closure from adjacent trees -Height recruitment of existing regeneration -Establishment of regeneration -Establishment or growth of shrub and herbaceous plants -Generation of snags or large wood on the ground 	Few silvicultural analogs implemented as an intermediate treatment, as opposed to a regeneration treatment		

Stand Dynamics

- Intermediate Treatments: Heterogeneity



-0.10 ha grid scale
-Vary thinning by 0.10 ha units
-20% skips (black)
-20% gaps (light gray)
-60% thinned (gray)

Figure 28.—Grid approach for implementing variable density thinning.

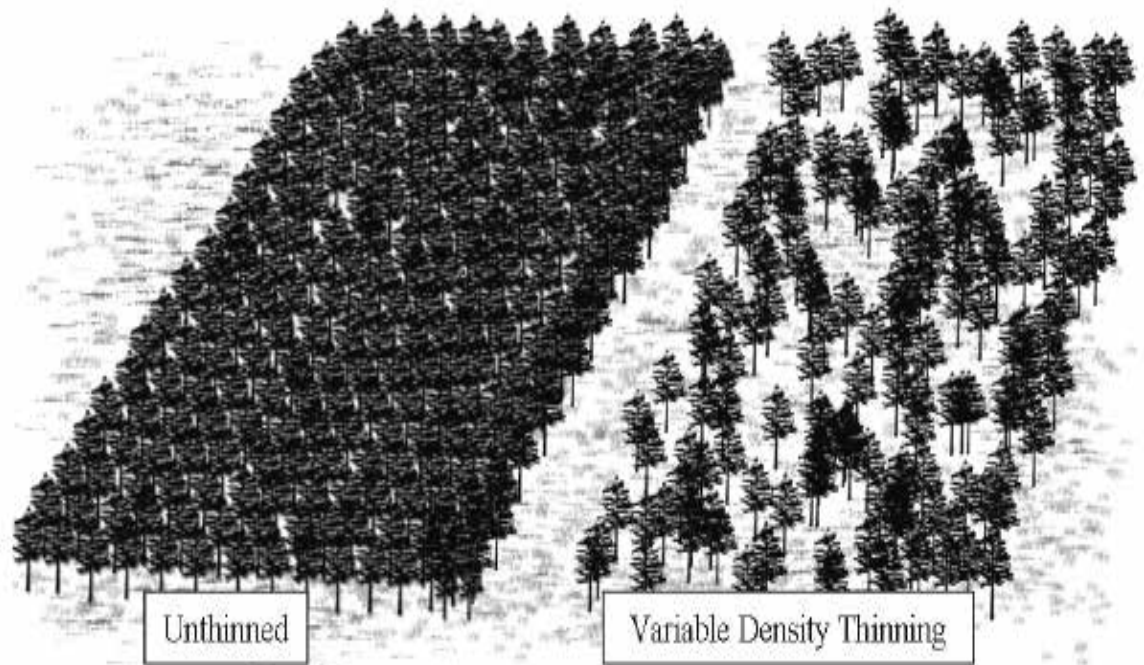
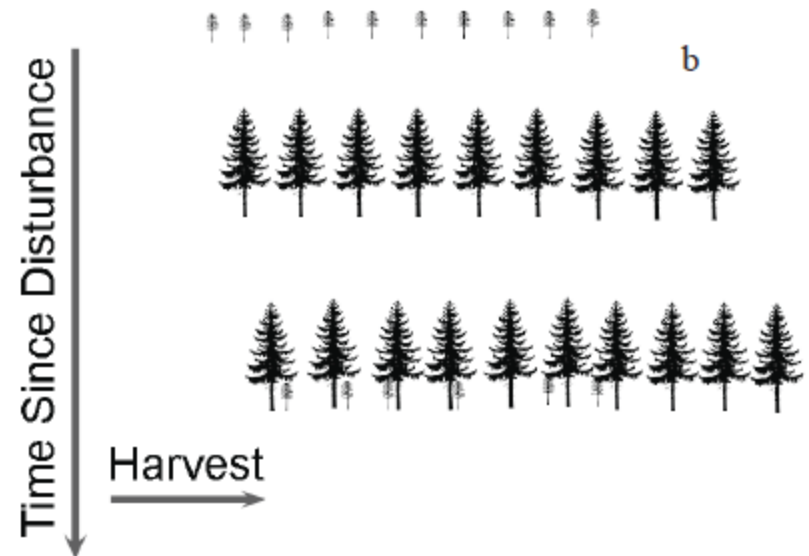
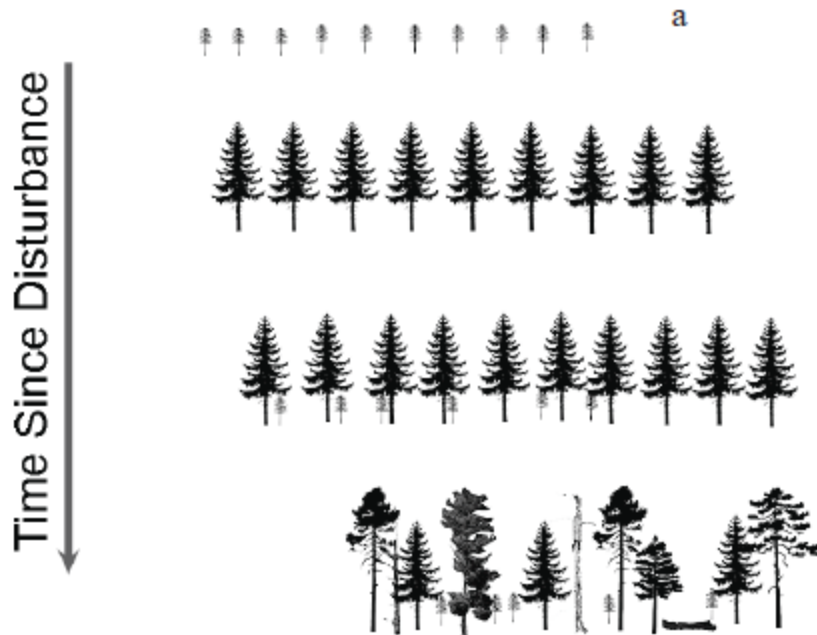


Figure 29.—Stylized representation of variable density thinning: (a) unthinned stand; (b) thinned stand displaying horizontal variation in stand density including gaps, skips (unthinned areas), and lightly thinned matrix.

Stand Dynamics

- Recovery Periods



Stand Dynamics

- Ecological Forestry

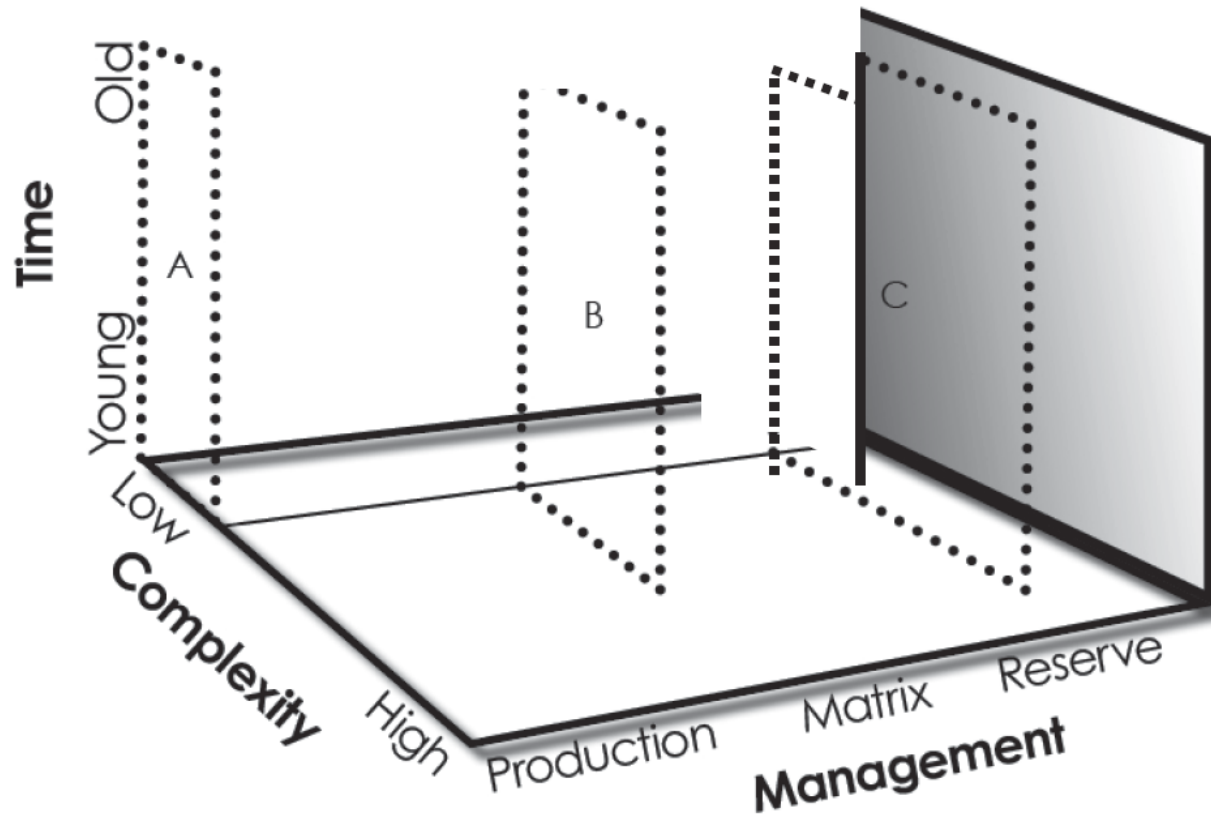


Figure 32.—Three-dimensional conceptual model for judging disparity in ecological complexity between managed forests and reference conditions.