Understanding Stand Development Stages

Daniel Donato, Ph.D.

Carbon and Forest Management Work Group

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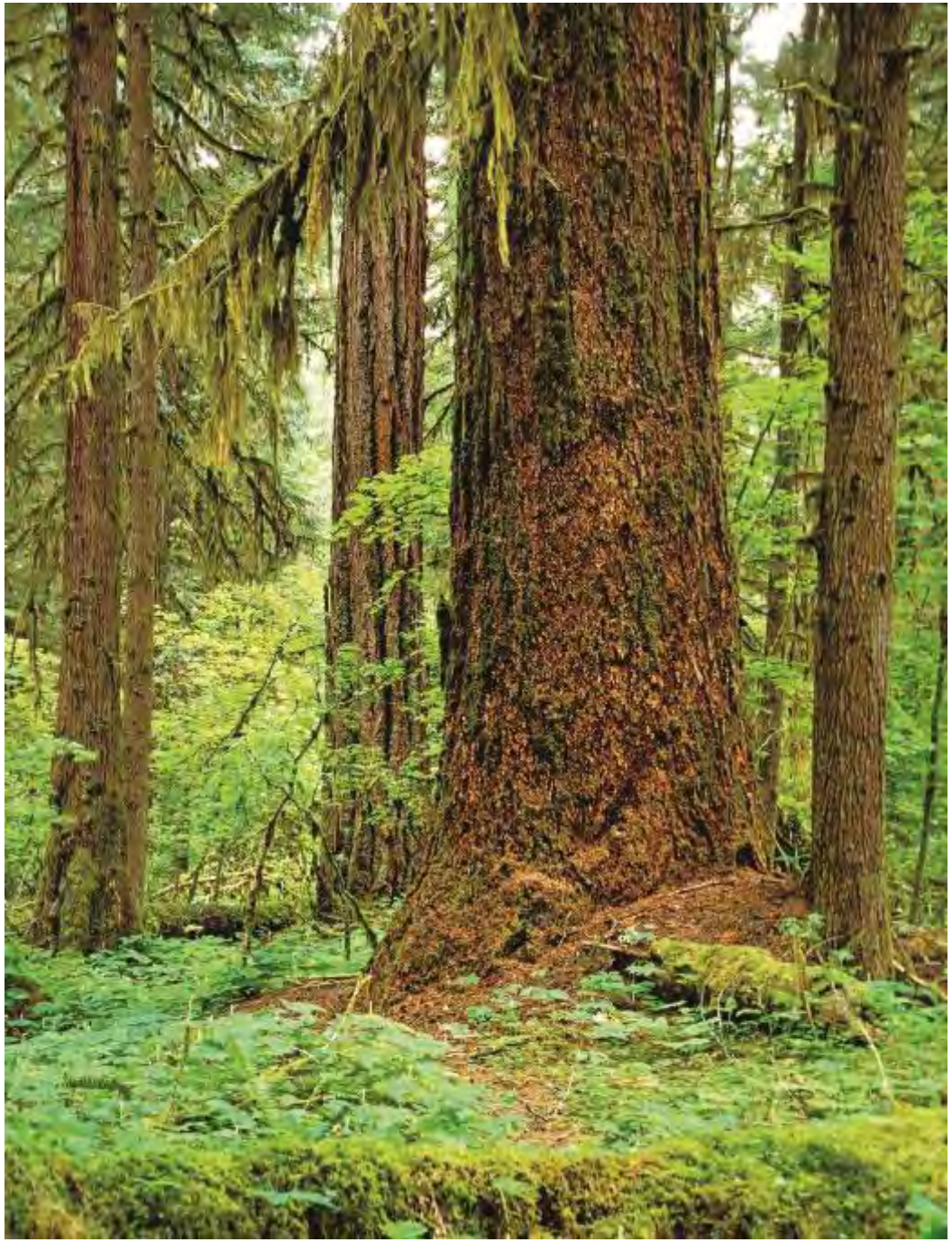

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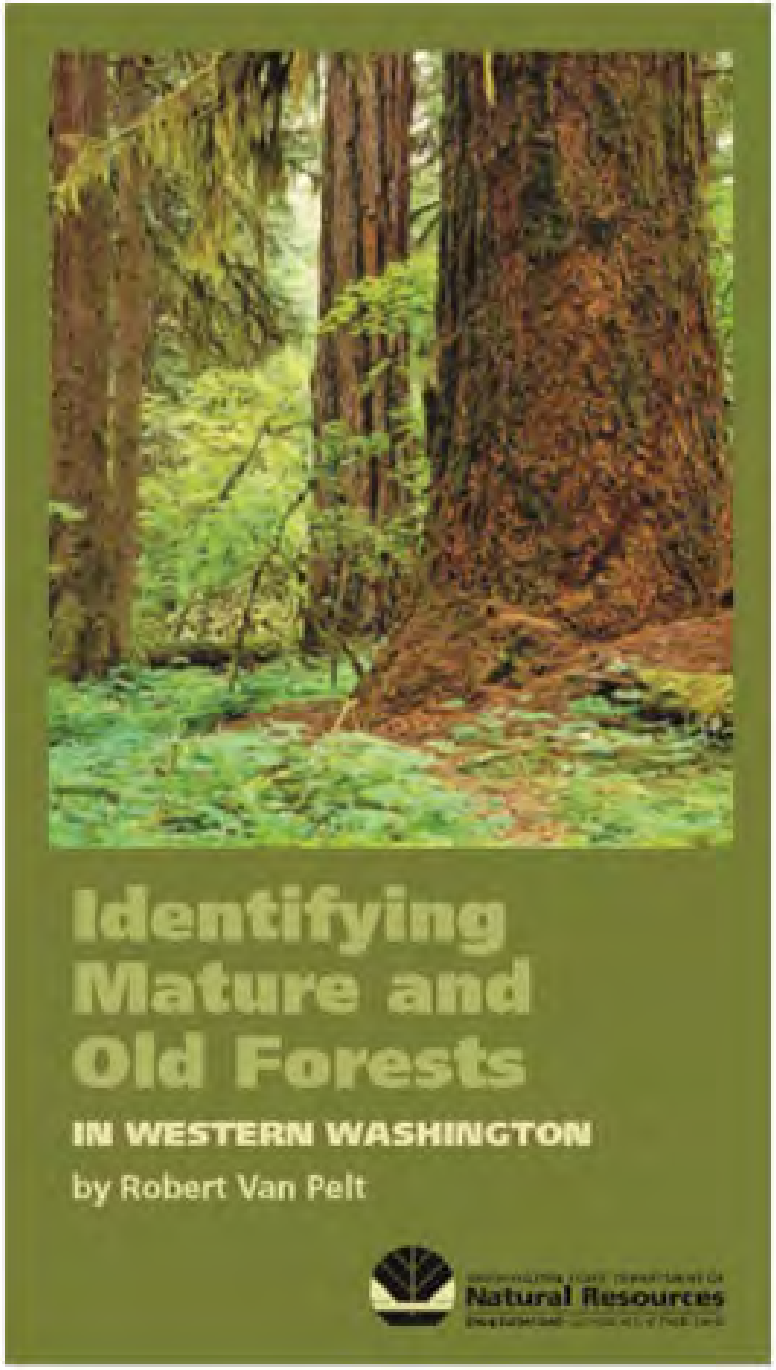
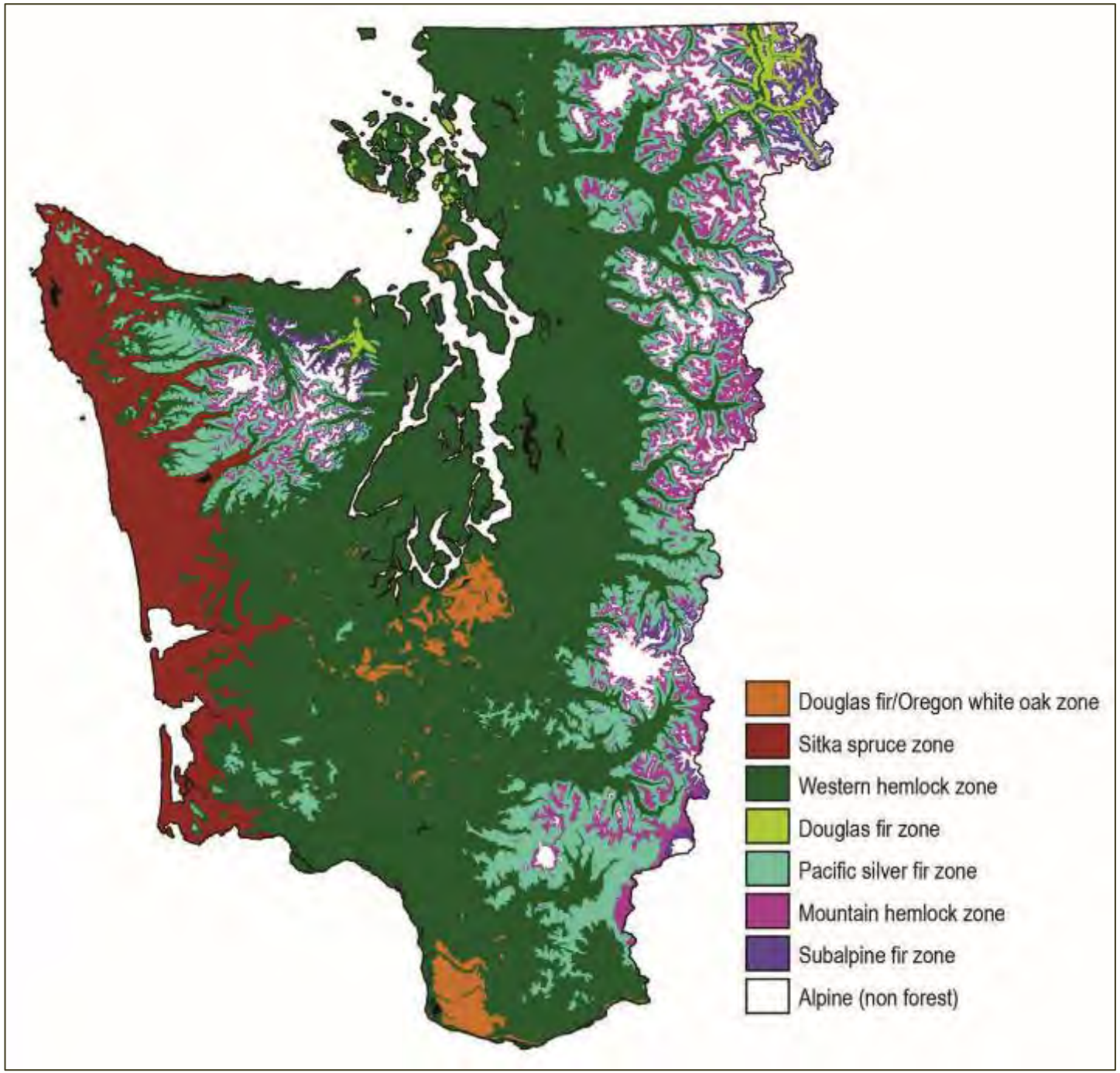
Disturbances and structural development of natural forest ecosystems with silvicultural implications, using Douglas-fir forests as an example

Jerry F. Franklin[a,*], Thomas A. Spies[b], Robert Van Pelt[a], Andrew B. Carey[c], Dale A. Thornburgh[d], Dean Rae Berg[e], David B. Lindenmayer[f], Mark E. Harmon[g], William S. Keeton[a], David C. Shaw[h], Ken Bible[a], Jiquan Chen[i]

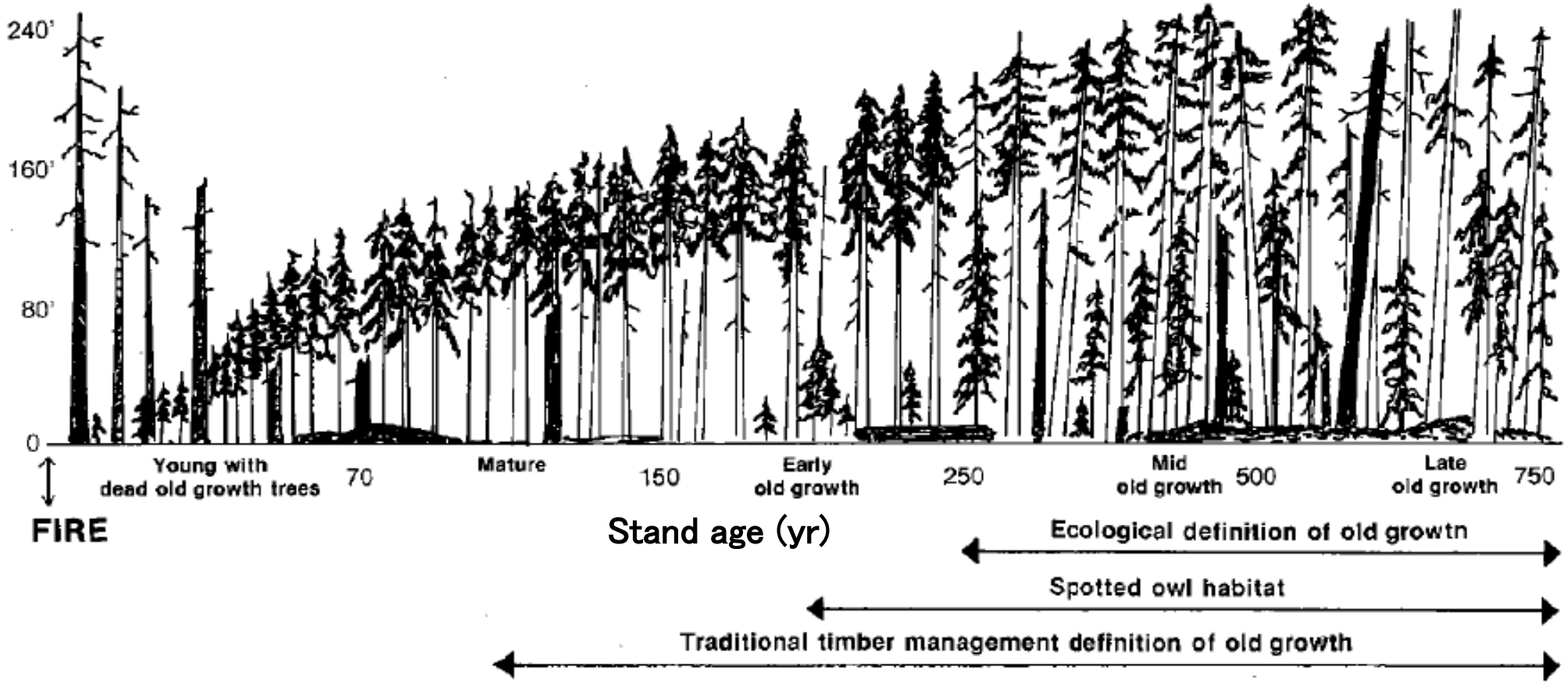


Forest Zones in Washington State



Old Growth Varies Across Forest Zones in Washington State

Long-term Stand Development



from Franklin and Spies (1991)

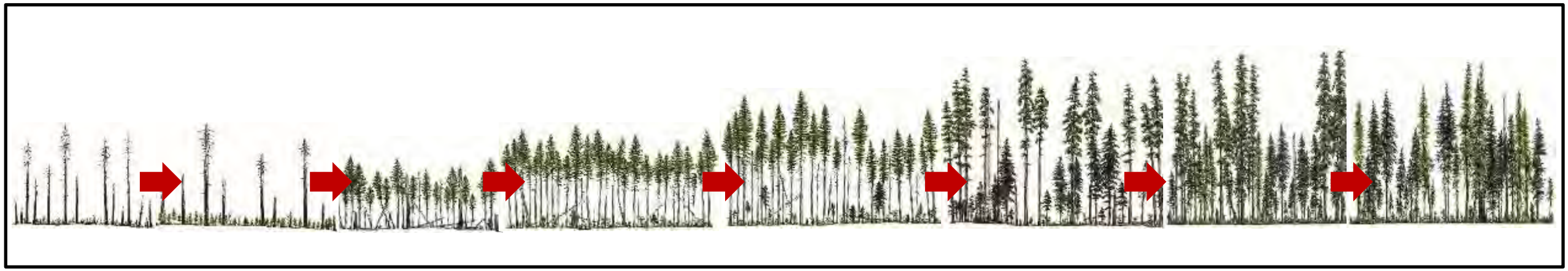
Forests are not Static

Disturbance and legacy creation
Establishment of a new cohort of trees or plants
Canopy closure by tree layer
Competitive exclusion (shading) of ground flora
Lower tree canopy loss
  Death and pruning of lower branch systems
Biomass accumulation
Density-dependent tree mortality
  Mortality due to competition among tree life form; thinning mortality
Density-independent tree mortality
  Mortality due to agents, such as wind, disease, or insects
Canopy gap initiation and expansion
Generation of coarse woody debris (snags and logs)
Uprooting
  Ground and soil disruption as well as creation of structures
Understory re-development
  Shrub and herb layers
Establishment of shade-tolerant tree species
  Assuming pioneer cohort is shade-intolerant species
Shade-patch (anti-gap) development
Maturation of pioneer tree cohort
  Achievement of maximum height and crown spread
Canopy elaboration
  Development of multi-layered or continuous canopy through
    Growth of shade-tolerant species into co-dominant canopy position
    Re-establishment of lower branch systems on intolerant dominants
Development of live tree decadence
  Multiple tops, dead tops, bole and top rots, cavities, brooms
Development of large branches and branch systems
Associated development of rich epiphytic communities on large branches
Pioneer cohort loss

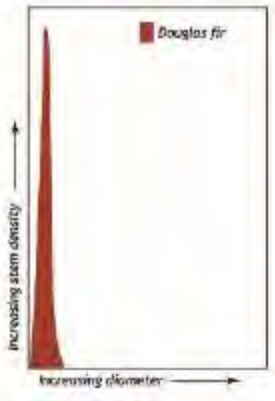
Time

Franklin et al. (2002)

Stand Development Over Time



Stand initiation | Canopy closure | Competitive exclusion & Biomass accumulation | Maturation I | Maturation II | Vertical diversification | Horizontal diversification | Pioneer cohort loss

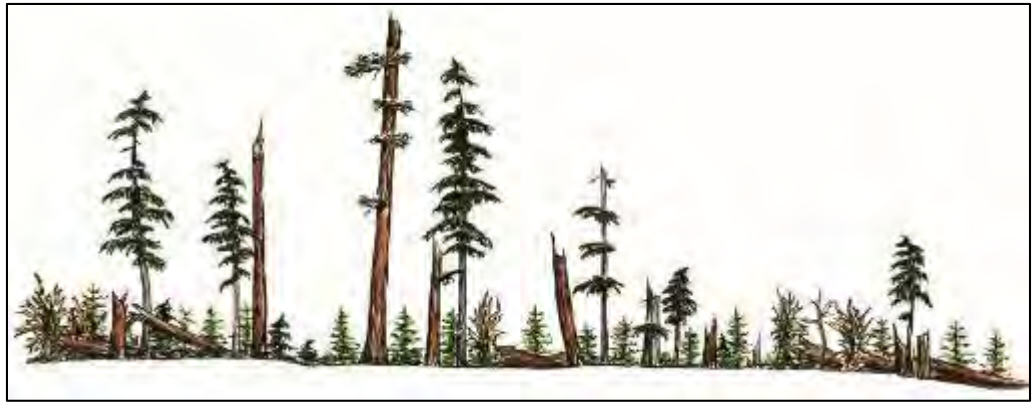


Cohort Establishment Phase

New, dominant tree cohort established

- **How fast does regeneration occur?**
- **How dense?**
- **What species?**
- **Snag and logs are abundant (natural disturbance)**

Post-Fire



Post-Wind

Post-Harvest

Types of Forest Disturbance

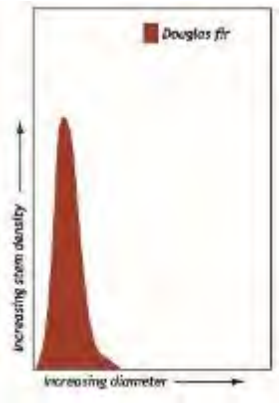
Fire

Wind

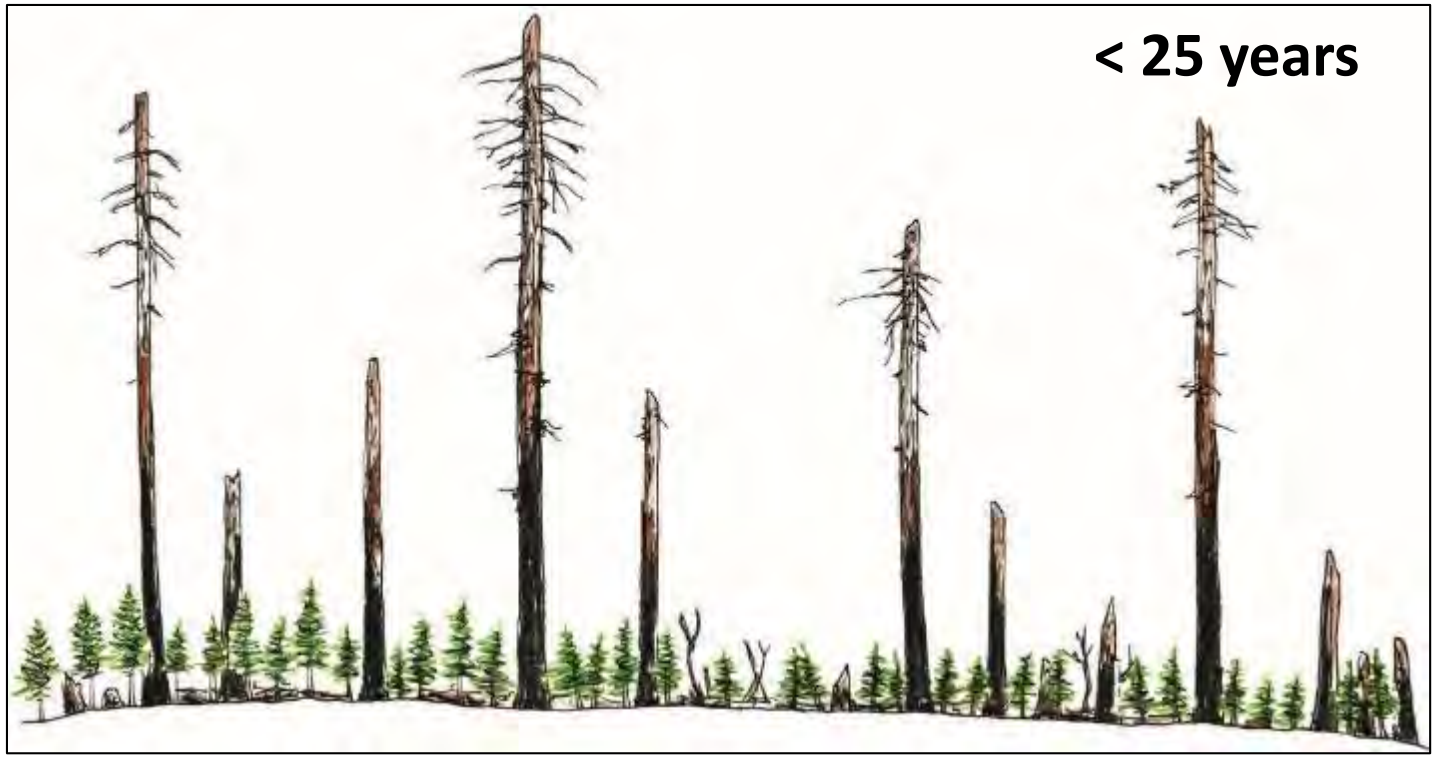
Ground disturbance

Harvest

Mount Saint Helens Blast Zone



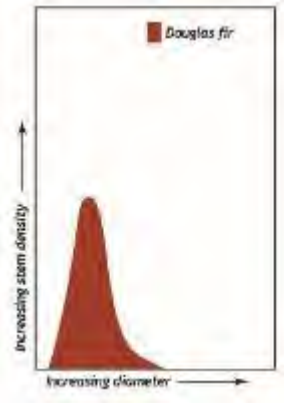
Canopy Closure Phase



Tree crowns begin to overlap

- **Trees take control of site**
- **Deep shade develops**
- **Ground vegetation shifts from sun-loving to shade-tolerant**
- **Snags and logs are abundant**

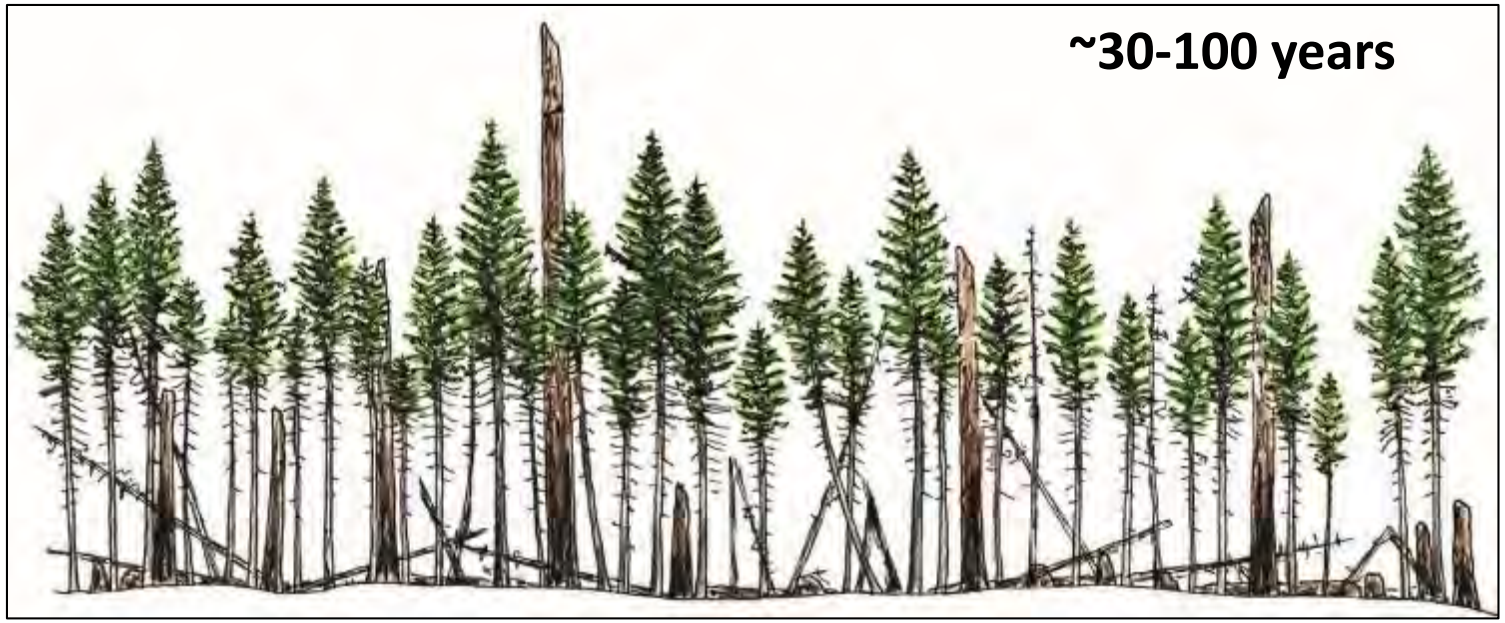
Canopy Closure Stage, Mt. St. Helens Blast Zone (~30 Years After Eruption)



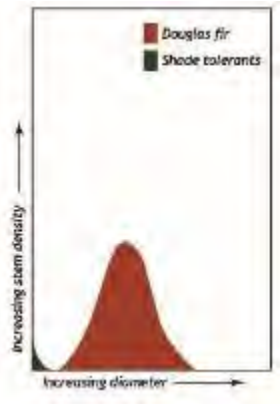
Biomass Accumulation/ Competitive Exclusion Phase

Rapid tree growth and intense competition between trees

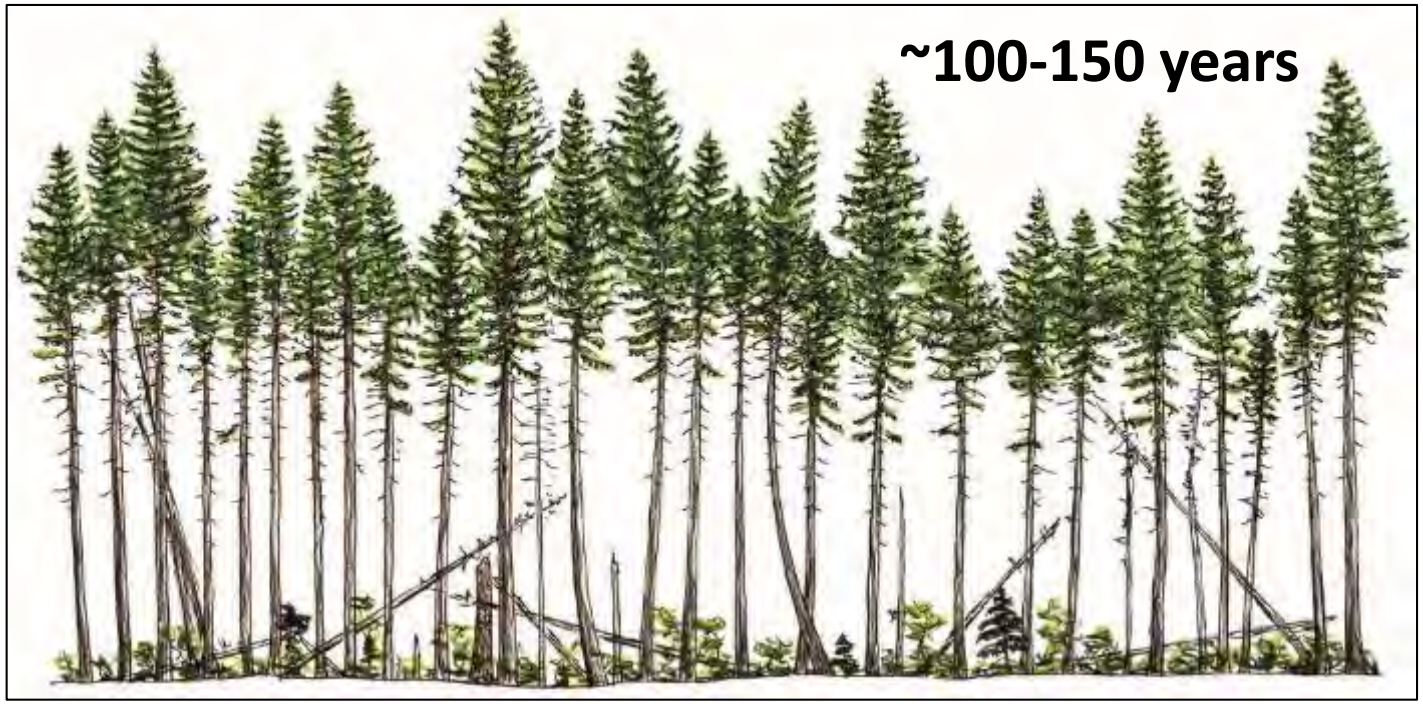
- **Trees dominate site, minimal understory**
- **Single canopy layer**
- **Density-dependent mortality**
- **Self-pruning**
- **Large snags and logs decreasing in abundance**



35-year-old Forest, South Cascades



Maturation I Phase

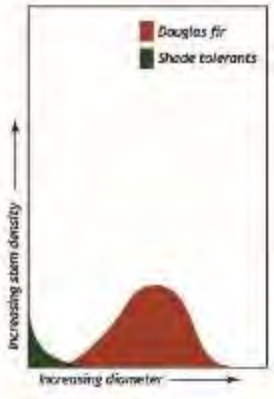


Tree growth and mortality slow down

- Origin *after* Euro-American settlement
- "Bole zone" still strongly apparent
- Shade-tolerant trees begin to establish (but under six feet tall)
- Dominant trees reach 60-70% of eventual height growth
- Large snags and logs are minimal in abundance

100-year-old Forest, Yacolt Burn

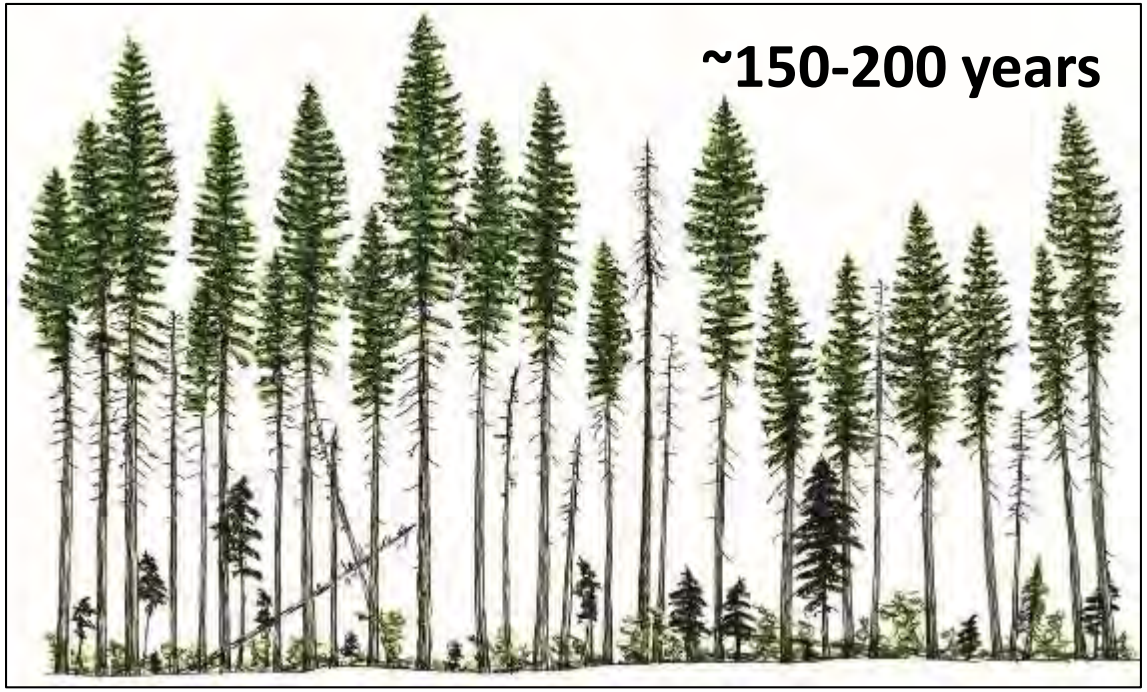
The “bole zone”



Maturation II Phase

Continued opening of stand

- Origin *before* European-American settlement
- Shade-tolerant trees recruit into mid-story
- Epicormic branching appears
- Bole zone *begins* to fill in
- Shift in mortality to non-density-dependent
- Dominant trees reach 80-90% of eventual height growth



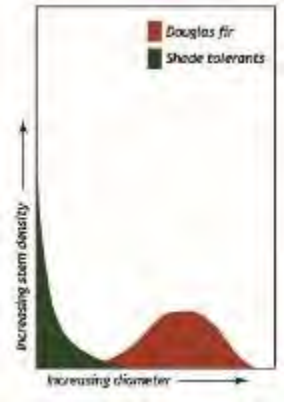
~160-year-old Forest, Capitol State Forest

Maturation II

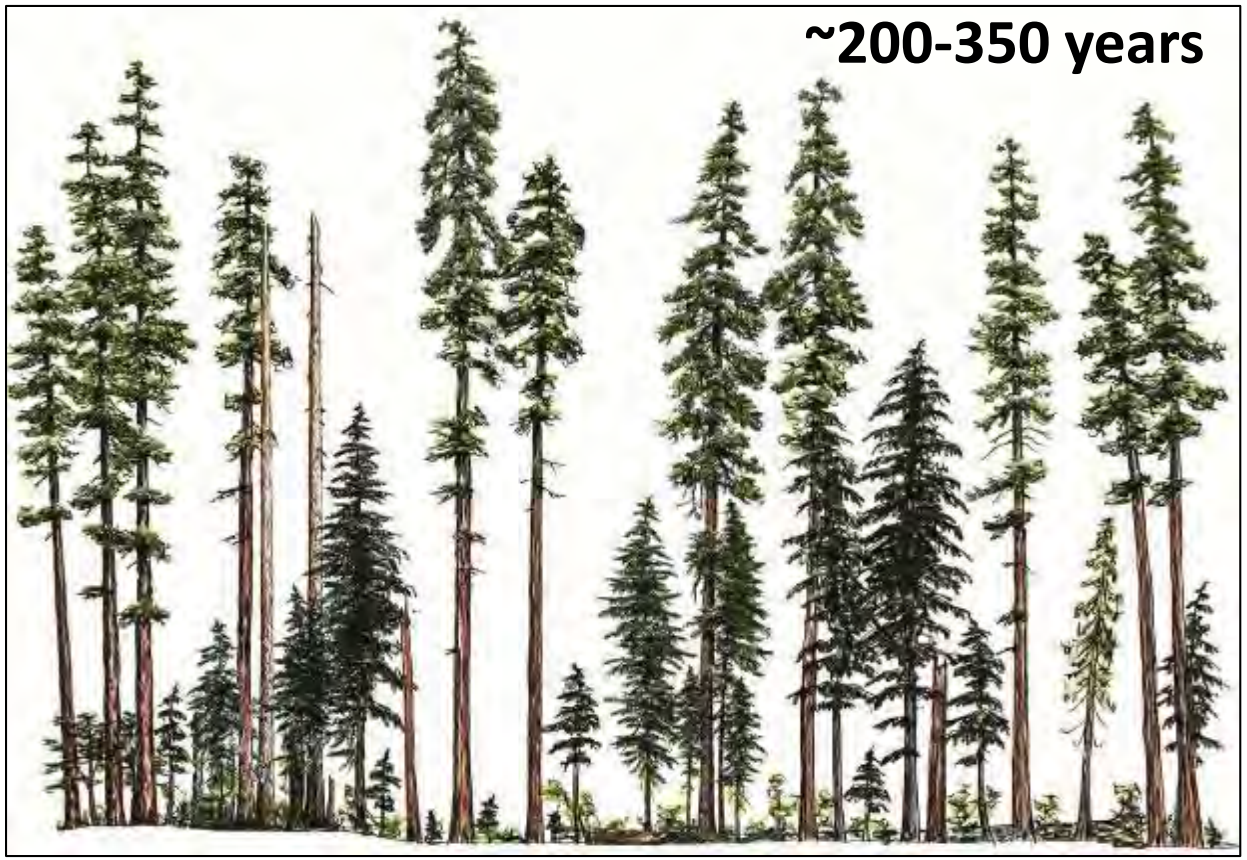
~160-year-old Forest, Black Hills

160-year-old Forest, South Cascades

Epicormic Branching



Vertical Diversification Phase



Classic “old-growth”

- Usually large trees present
- Well-developed gaps in overstory
- Shade-tolerant species in mid-story to main canopy
- Epicormic branching well developed
- Vertically continuous canopy
- Recruitment of large, dead wood

280-year-old Forest, Mount Rainier

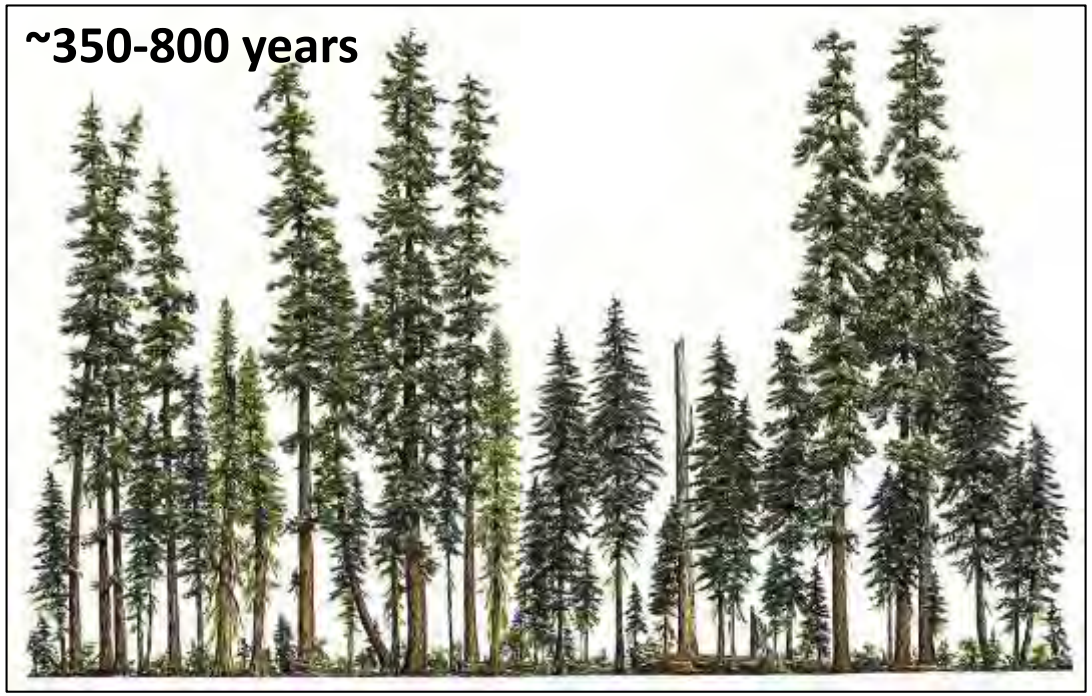
330-year-old Forest, South Cascades

280-year-old Forest, Olympic Peninsula

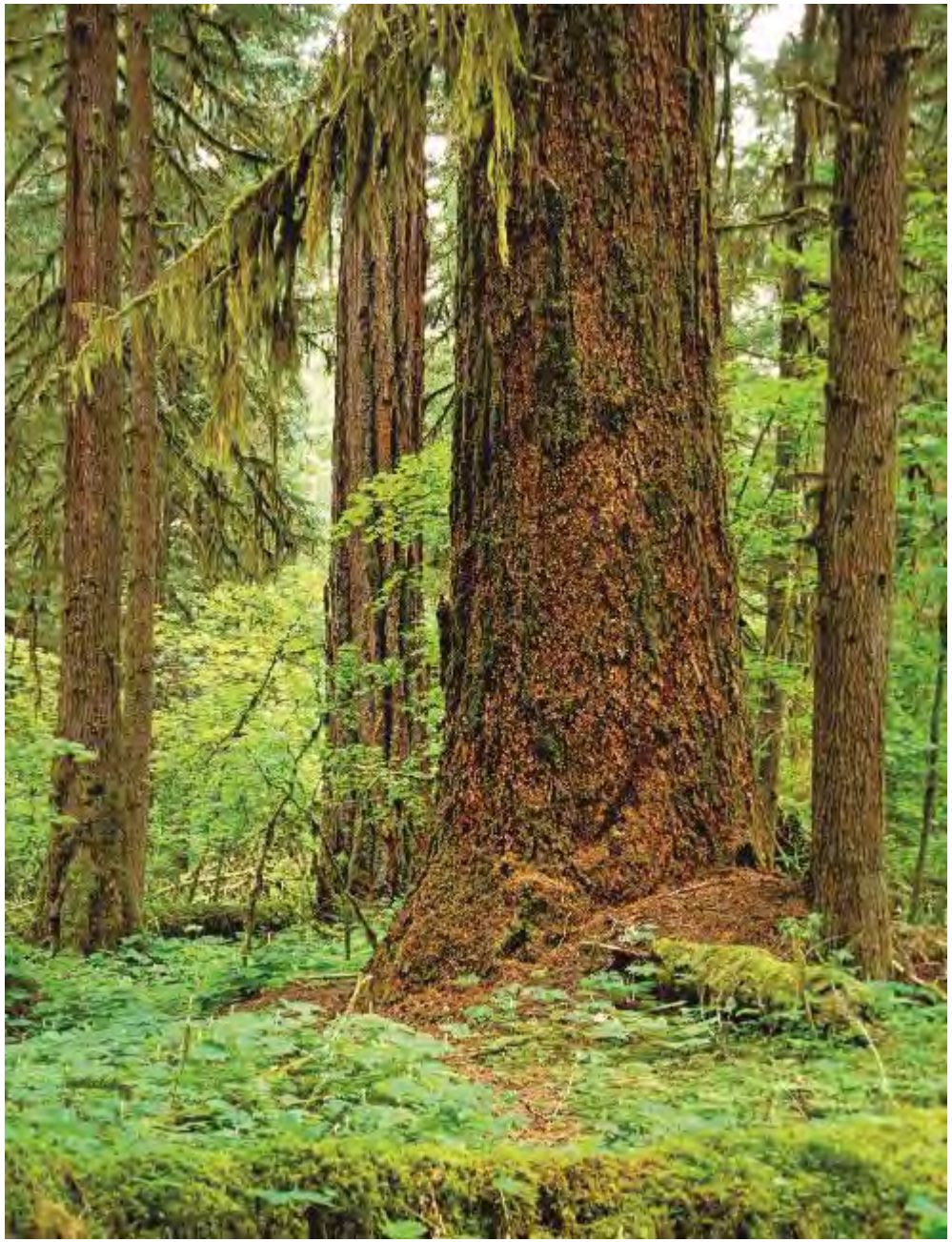
Horizontal Diversification Phase

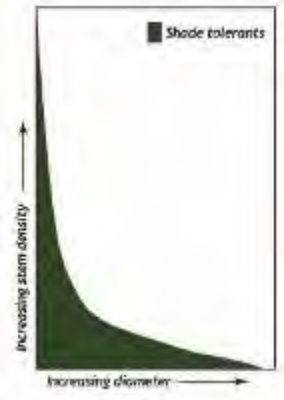
"Classic" old-growth: Multiple structural units develop

- **Large trees, increasingly patchy**
- **Density-independent mortality continues**
- **Gaps expand → Spatially aggregated mortality and infilling**
- **Light environment controlled by shade-tolerant species**
- **Continued development of "decadence"**
- **Abundant large, dead wood**

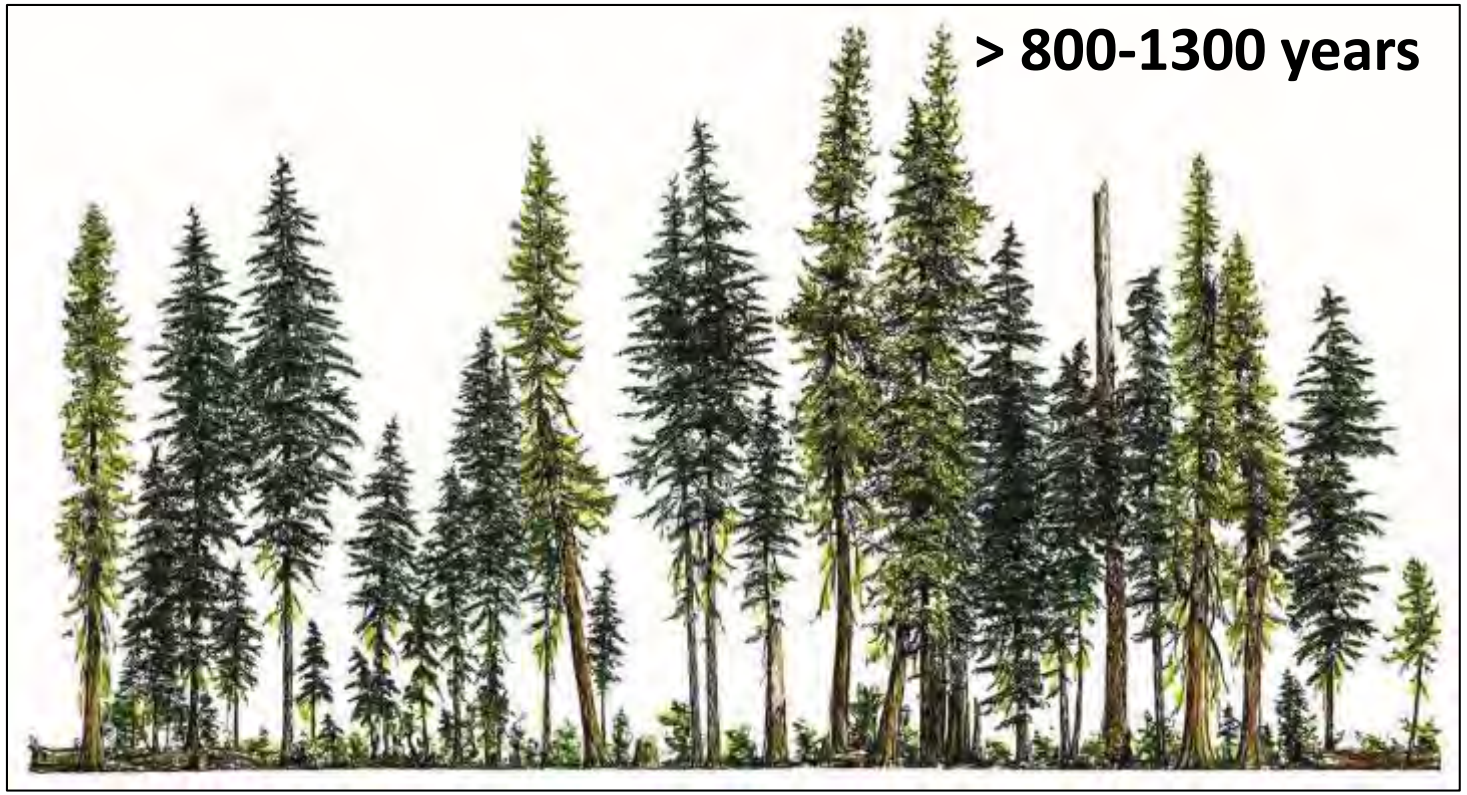


600-year-old Forest, Cedar Flats Near Mount St. Helens





Pioneer Cohort Loss Phase



Final stage of stand development

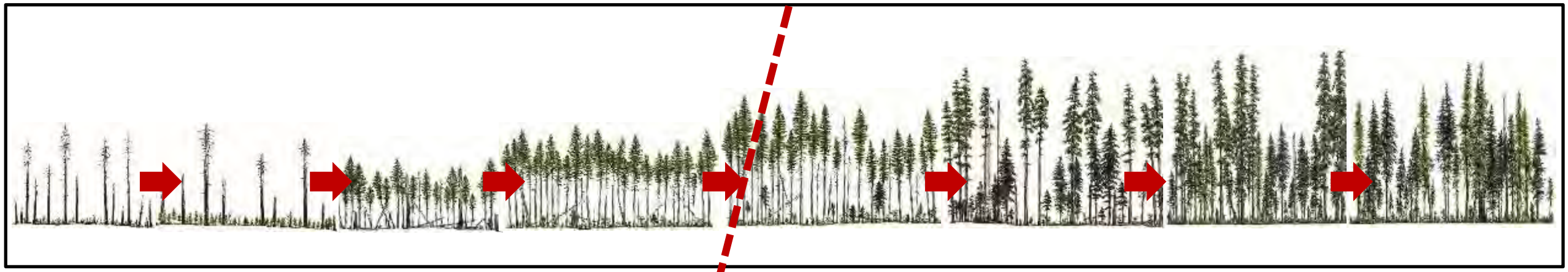
- Life span of pioneer Douglas-fir exceeded
- Shade-tolerant species dominate site
- Continued structural presence of pioneer Douglas-firs (snags, logs)
- Quasi- steady state
- Rarely reached

Poor Correlation Between Size and Age (Douglas-fir)

Productive Site (Willapa Hills)
80 Years Old → 48” Diameter at Breast Height

Poor Site (South Cascades)
400 Years Old → 24” Diameter at Breast Height

Structurally complex forest



Stand initiation

Canopy closure

Competitive exclusion & Biomass accumulation

Maturation I

Maturation II

Vertical diversification

Horizontal diversification

Pioneer cohort loss

Questions?