

Western conifer tree and stand responses to timing of thinning on various productivity classes: *Current knowledge and future directions*

Mark Coleman



Purpose for thinning

Influence development of remaining stock

- Composition
- Growth
- Value
- Vigor
- Services
- Fuels



Tree and stand responses to thinning

... are controlled by competitive interactions

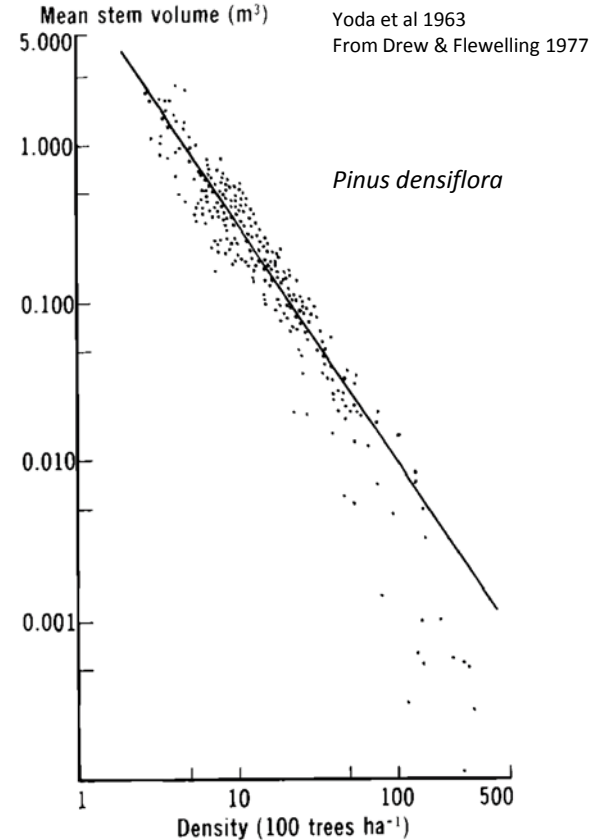
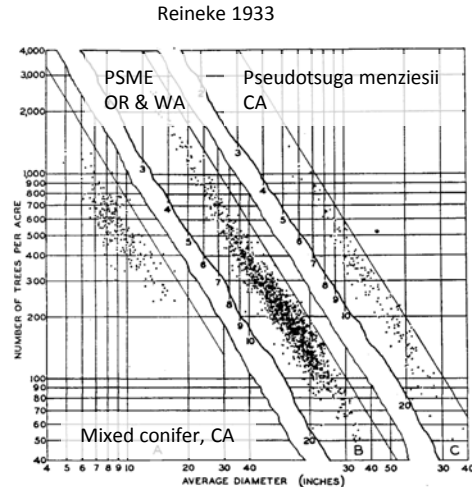
Tree- and stand-density principles [laws]

1. Crowded stands will self-thin
2. Two-phased self-thinning trajectory
3. Competition decreases average tree size



1. Crowded stands self-thin

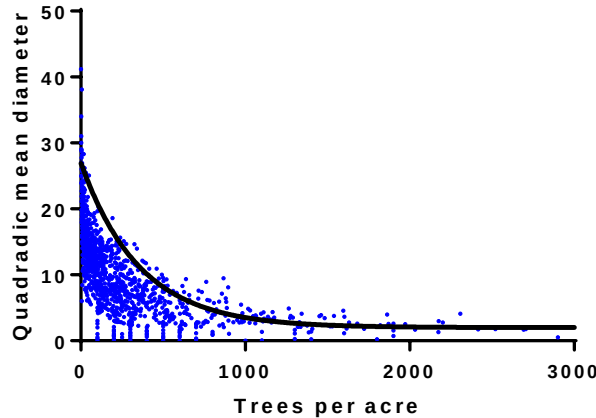
- Reineke's Stand Density Index
- Yoda's $-3/2$ Power law
- Maximum average size is a function of density
- Continued tree growth requires lower density
- Maintains constant yield
 - as piece size increases
 - stand density decreases



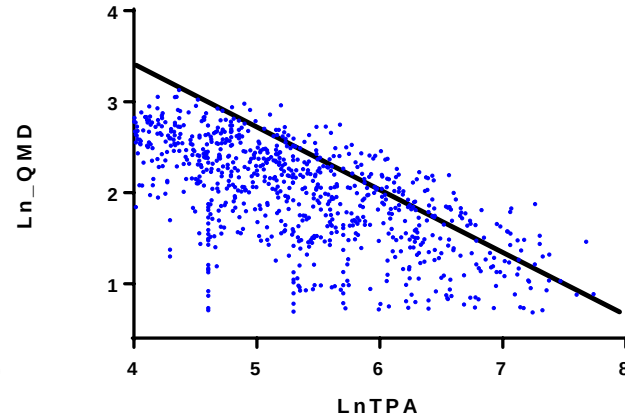
Maximum size-density function

- Non-linear exponential function
- Log transformed into linear function

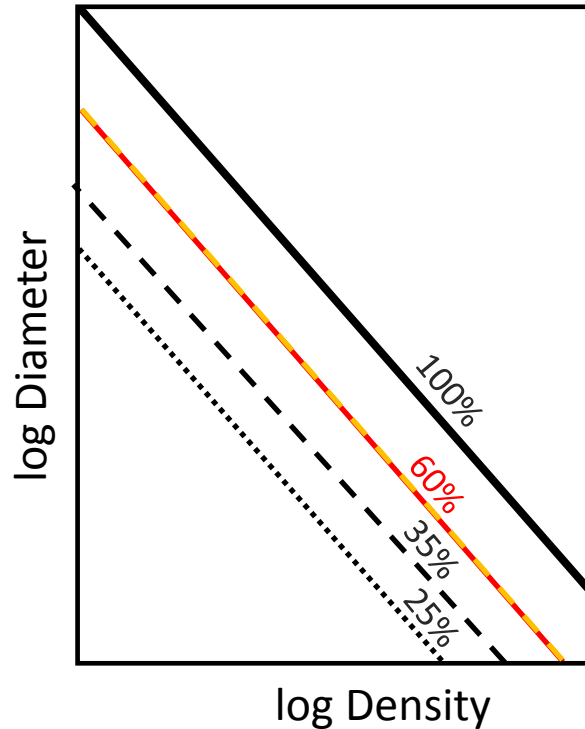
$$y = \beta_0 e^{\beta_1 x}$$



$$\ln(\text{QMD}) = \beta_0 + \beta_1 \ln(\text{TPA})$$



Stand density relative to Normal stands



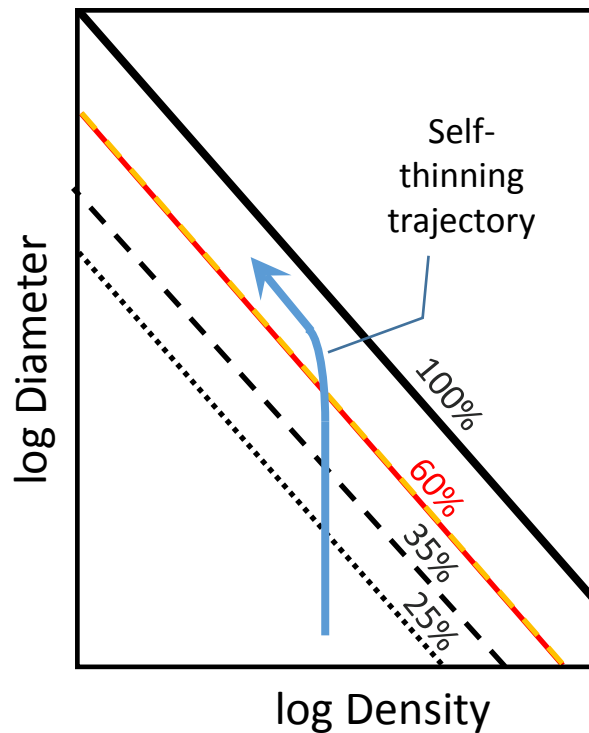
- 100% - Normal
- 60% - Eminent mortality
- 35% - Lower Management Zone
- 25% - Crown closure



2. Two-phased self-thinning trajectory

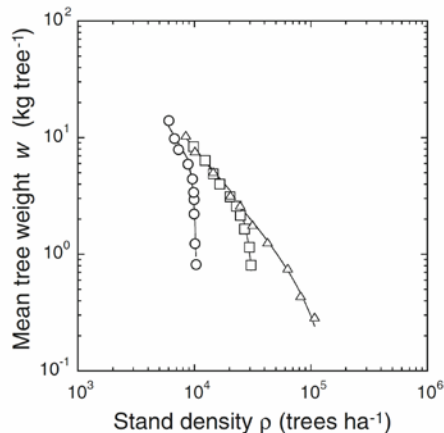
1. Non competitive
 - Rate of growth depends on SQ
2. Competitive
 - Parallel to normal line

SQ = Site quality, analogous to resource availability

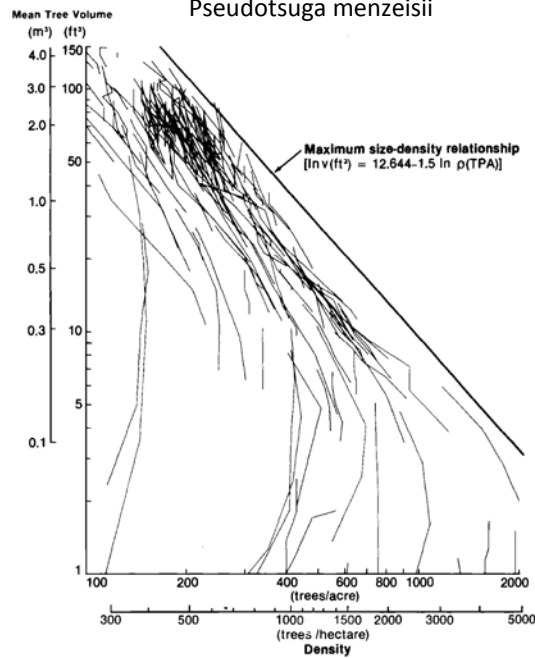


Growth-density trajectory

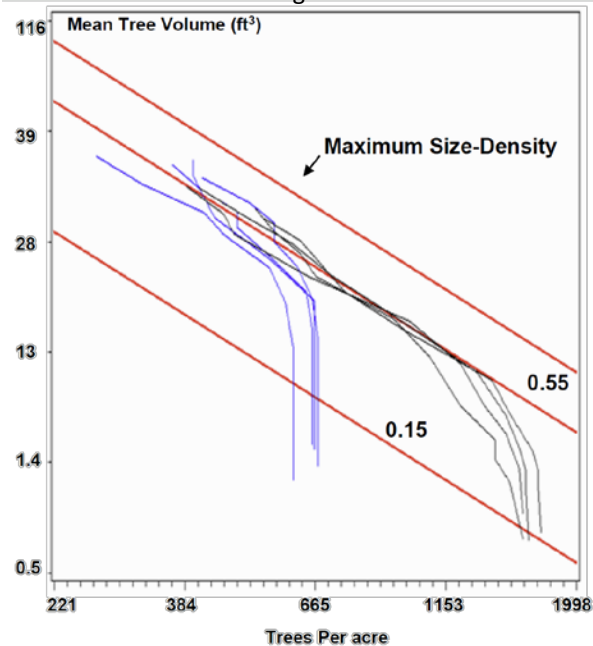
Xue et al 2010
Pinus densiflora



Drew & Flewelling 1977
Pseudotsuga menzeisii



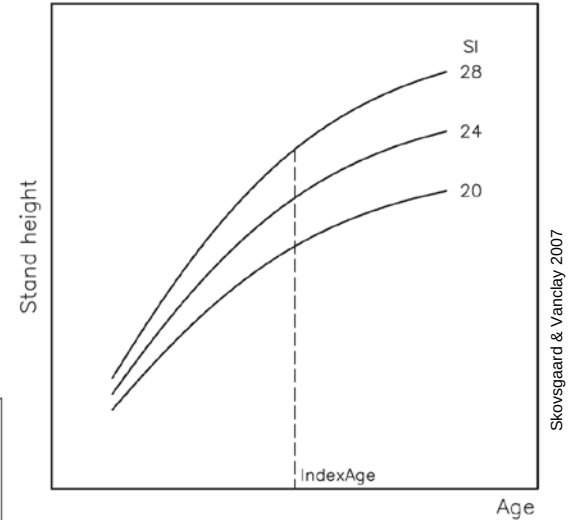
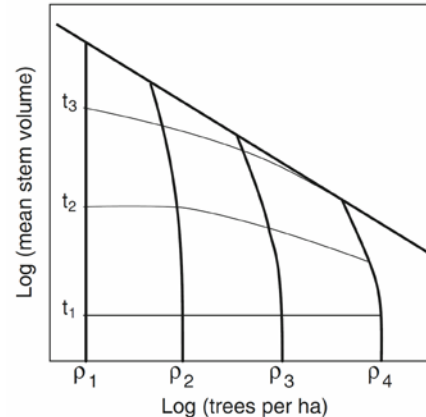
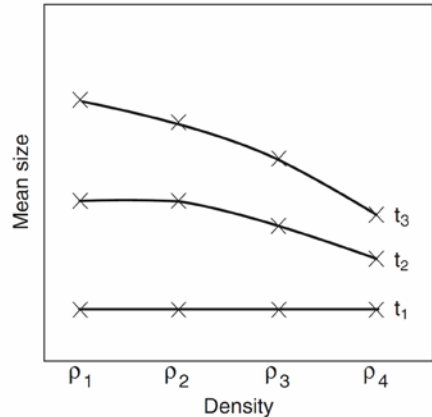
Hyink 2005
Pseudotsuga menzeisii



Before mortality occurs

3. Competition decreases tree size

- Tree size is highest at low density
 - Stronger pattern as stands develop
- To control for stage of development
 - Height is a scale for tree age within same SQ
- Self-thinning trajectory defined by connecting time lines, i.e. height curves

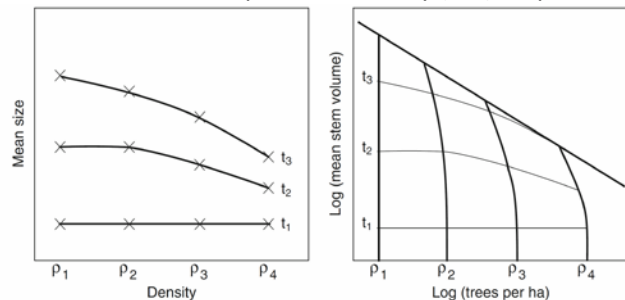


Per-tree response to competition

Examples

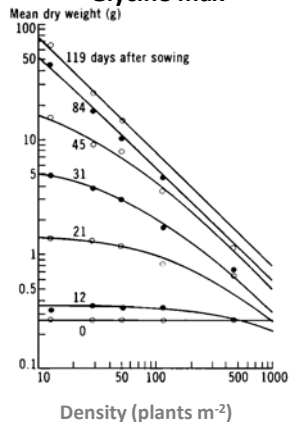
Long & Vacchiano 2014

Theoretical competition-density (c-d) response



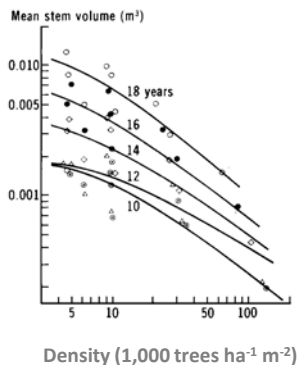
Shinozaki and Kira 1961

Glycine max



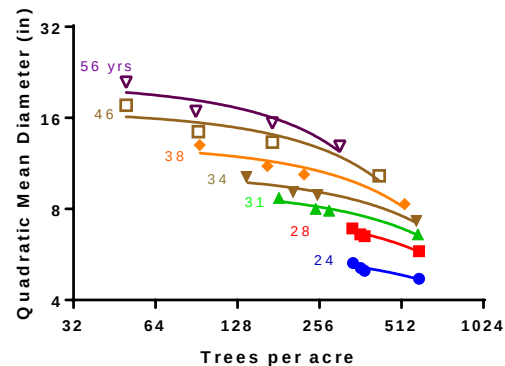
Ando 1968

Pinus densiflora

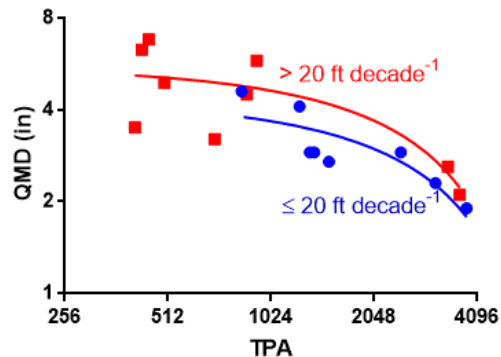


From Drew & Flewelling 1977

LOGS Skykomish



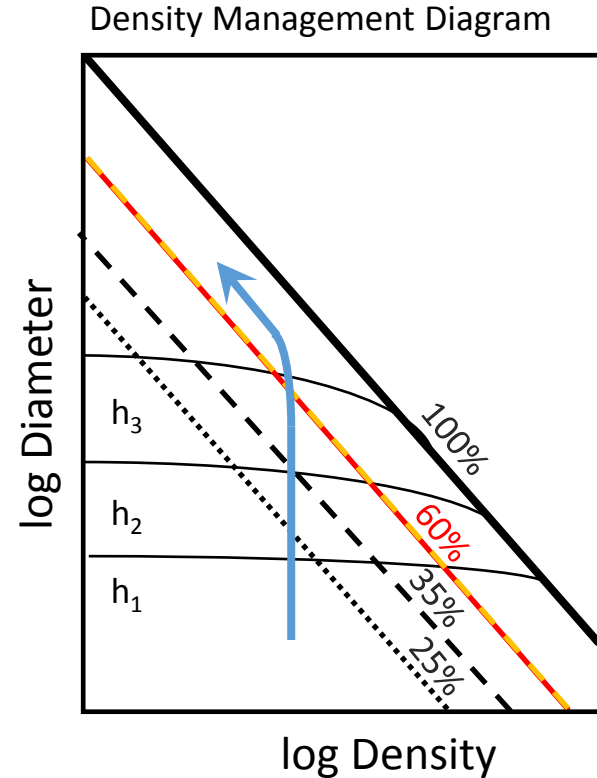
IFC PPDM



DMD provide decision support

Include three principles

- Graphical models
- Maximum size-density defines normal stands
- Relative density lines define management zone
- A family of tree size-density-height curves define development
- Stand conditions initiate self-thinning trajectory



Thinning responses emerge from three principles

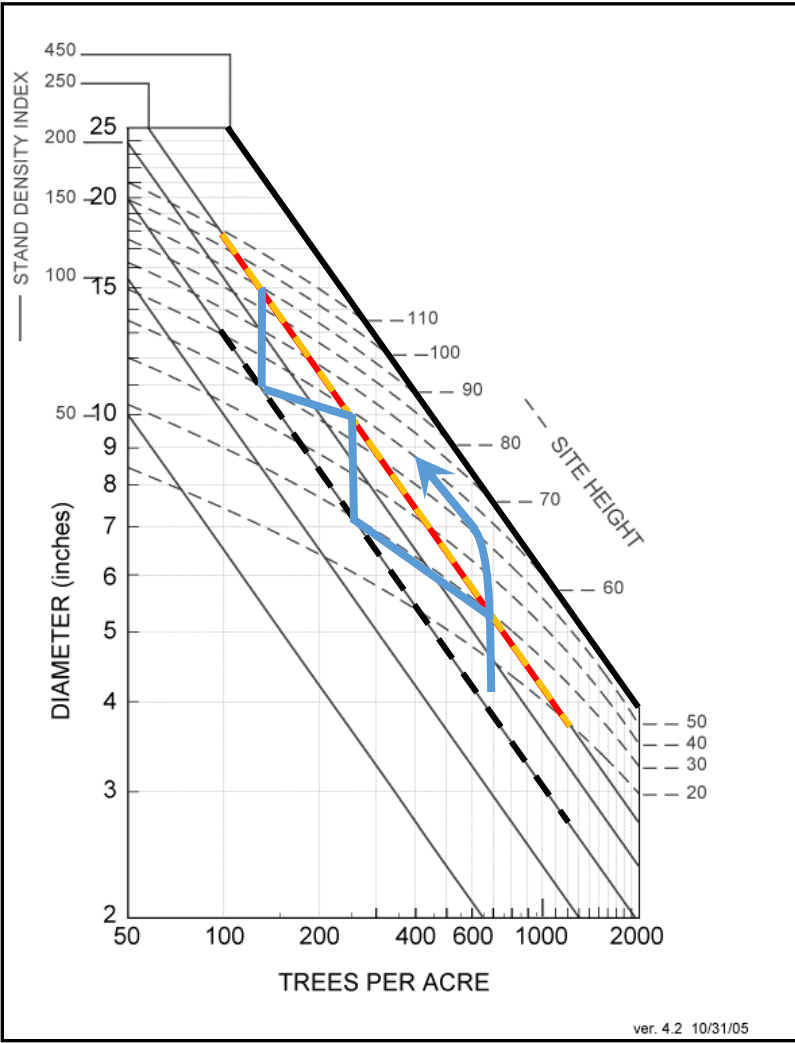
Targets:

- Simultaneously achieve largest piece size and greatest site occupancy
- Avoid competition related growth decreases
 - Including mortality

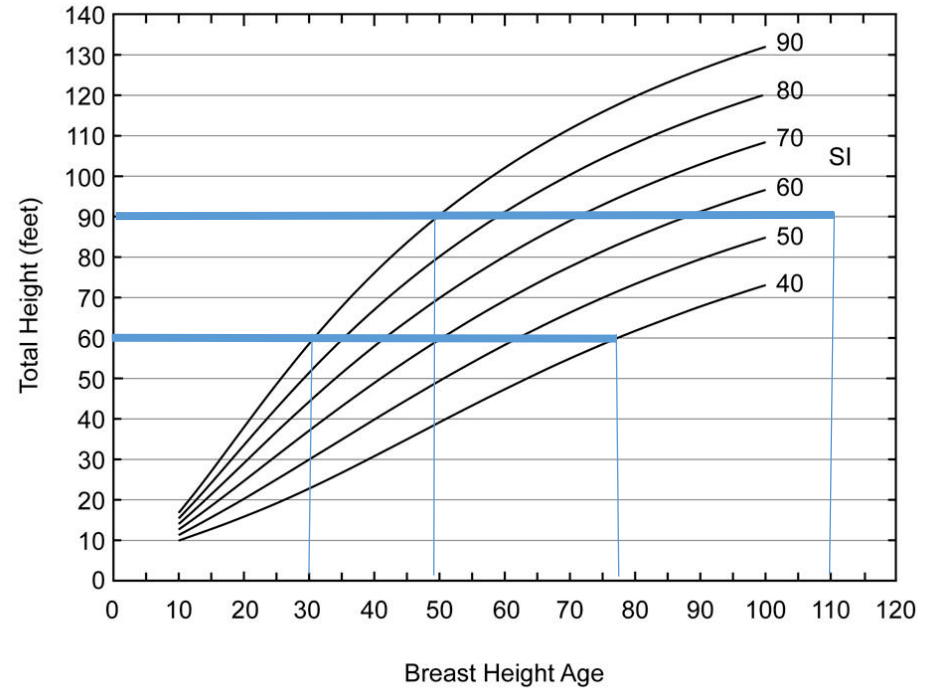


Ponderosa pine

Long & Shaw. 2005



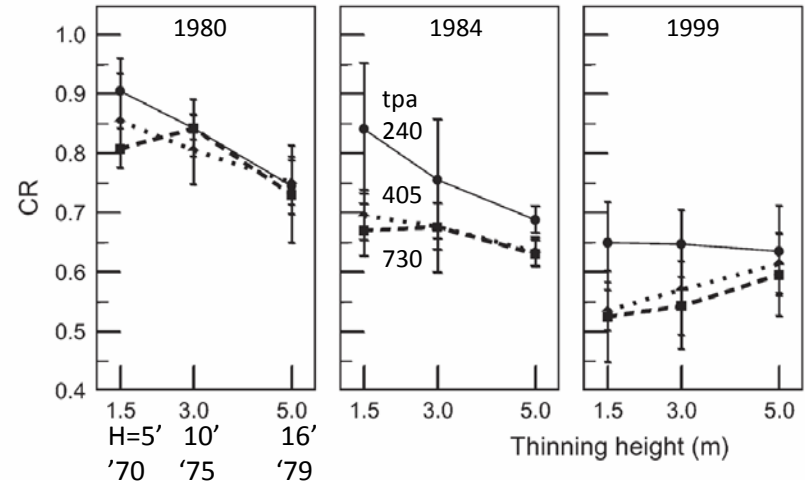
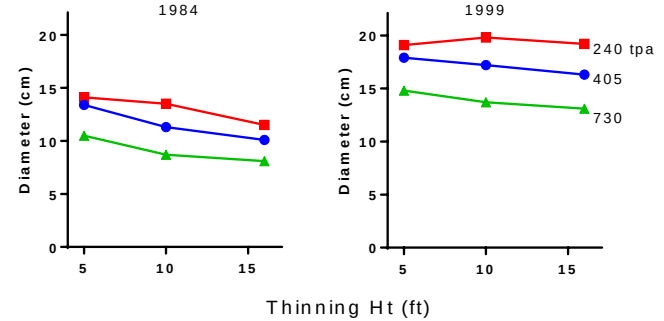
Stand w/ 700 tpa
PCT before H=30' to 12' spacing
Reaches 10" QMD at 60'
CT to 16' spacing
Reaches 15" QMD at 90 ft



Timing impacts

Open-grown, non-competitive growth

- Fastest tree growth
- Little effect of timing
- High crown ratio, large branches

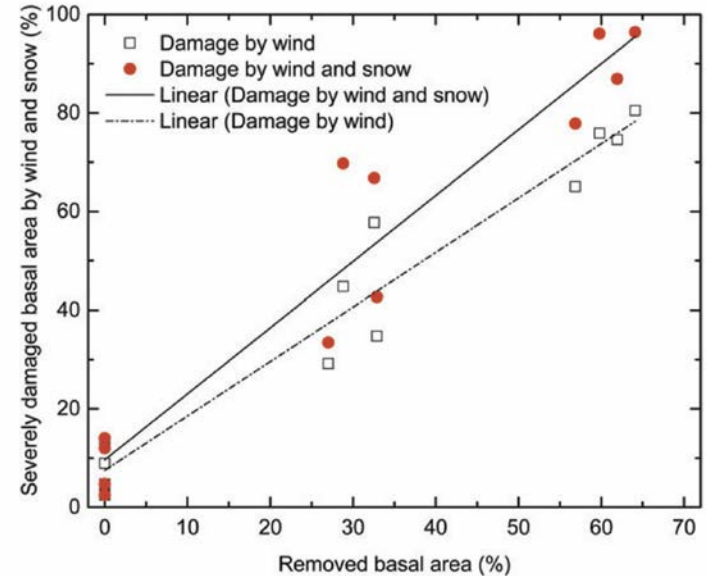
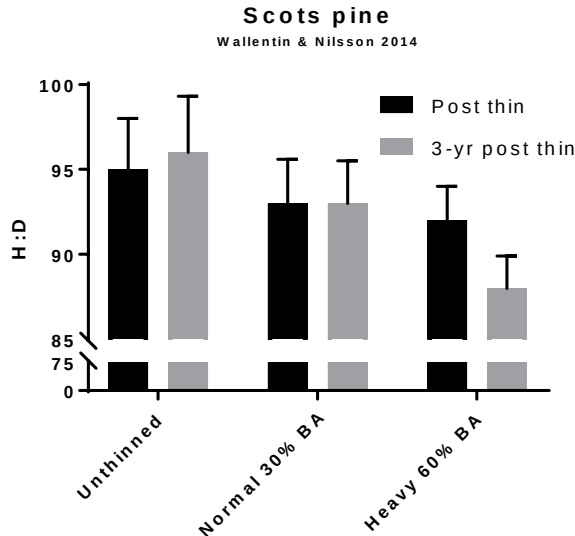


Timing impacts

Un-thinned trees

- Large H:D ratio
- Low stem taper

Thinned stands are vulnerable to storm damage.



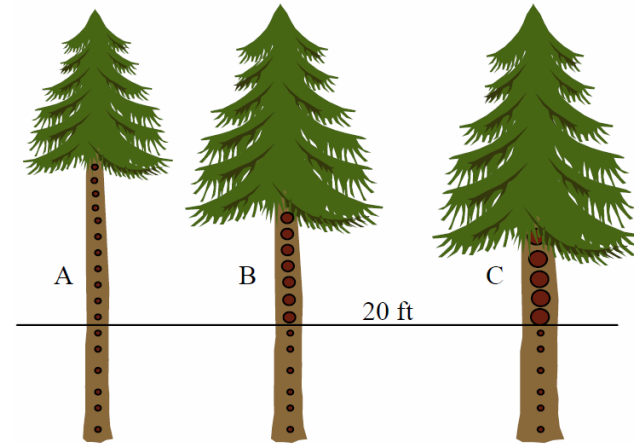
Desired future condition:

1. Uniform stocking of high quality 15" logs
 - Planting density
 - Veg control to maintain free tree growth
 - Thin to maintain stand in MZ, train stem
2. Rapid development of old growth structure
 - Follow above to accelerate development
 - Heavy second or third thinning
 - Encourage tall crowns and large branches



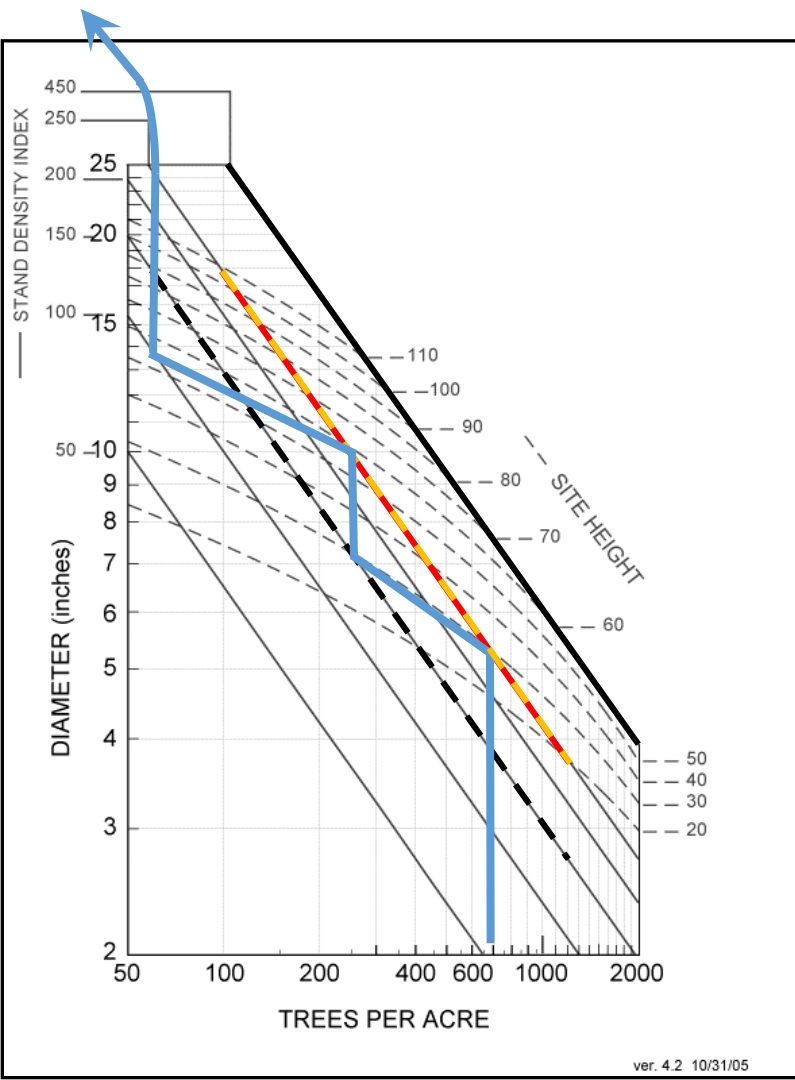
MZ=Management zone 35-60% RD

Maguire 2005



Ponderosa pine

Long & Shaw. 2005



Stand w/ 700 tpa
PCT before H=30' to 12' spacing
Reaches 10" QMD at 60'
CT to 24' spacing

Promote old-growth structure

- Heavy thin to less than 35% RD
- Open stand to encourage branch retention
- Provide light for diverse understory
- Allow stand to follow self-thin trajectory

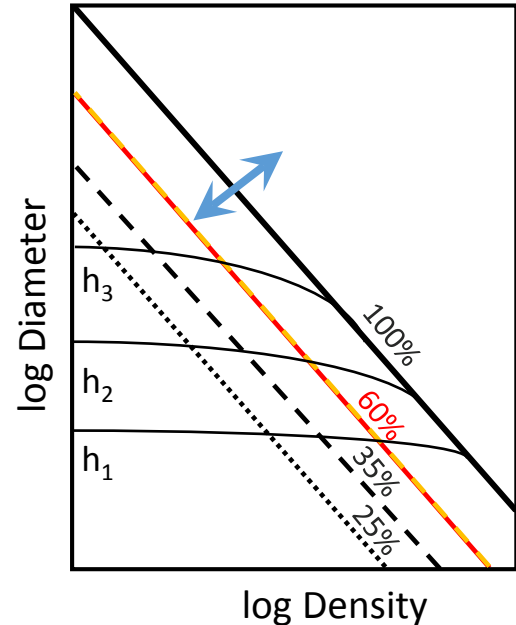
Variable maximum size density line

- Complicated by variation in position of self-thinning line
- Need for dynamic Density management diagrams
 - Relative density lines to locate MZ
 - Family of height curves to set development targets
 - Couple with site index curves (G&Y models) to adjust for SQ



MZ=Management zone 35-60% RD

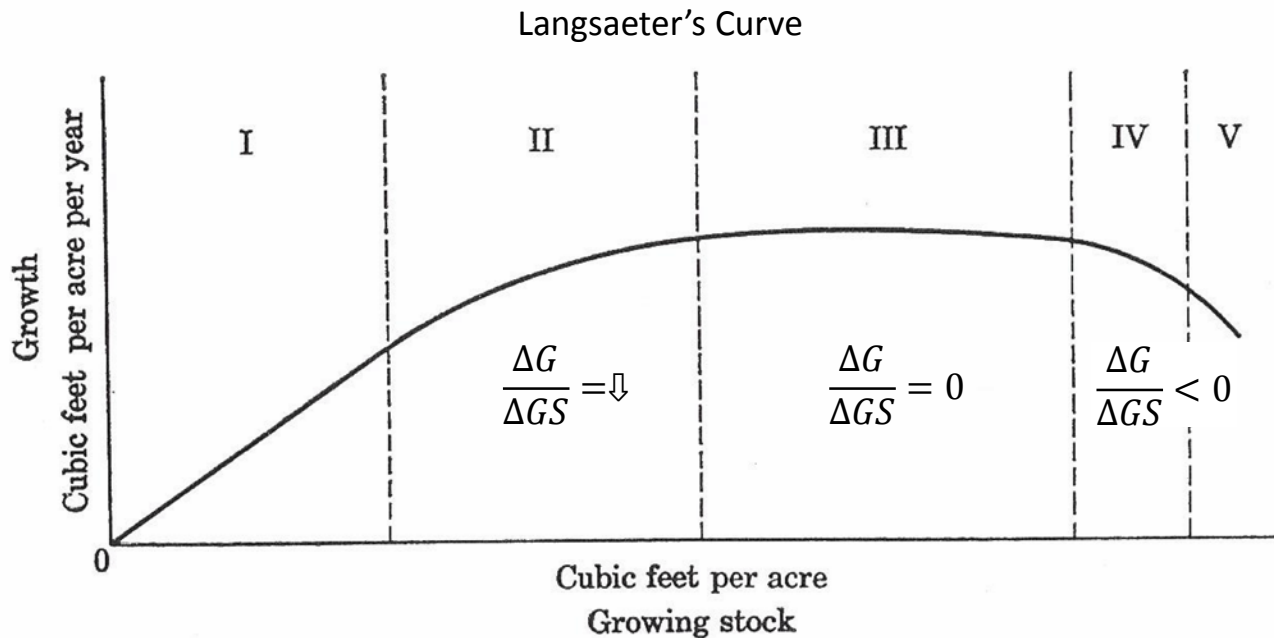
Density Management Diagram



For a give site and composition there's
Plateau in total stand productivity-density curve

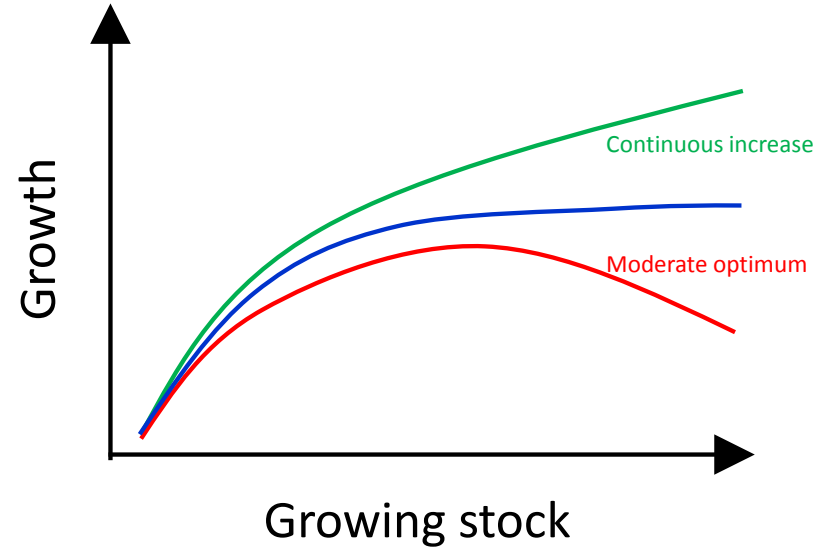
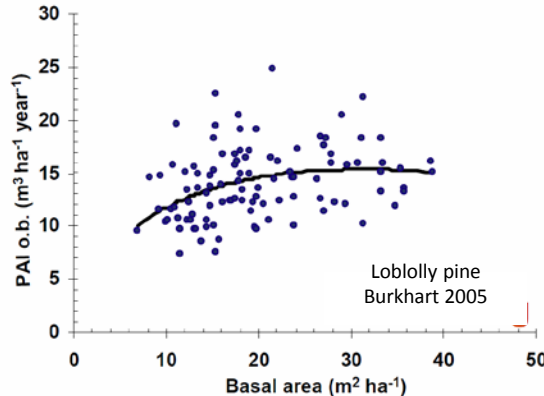
Growth phases:

- I.No competition
- II.Growth decline
- III.Constant wide optimum
- IV.Competition-caused decline



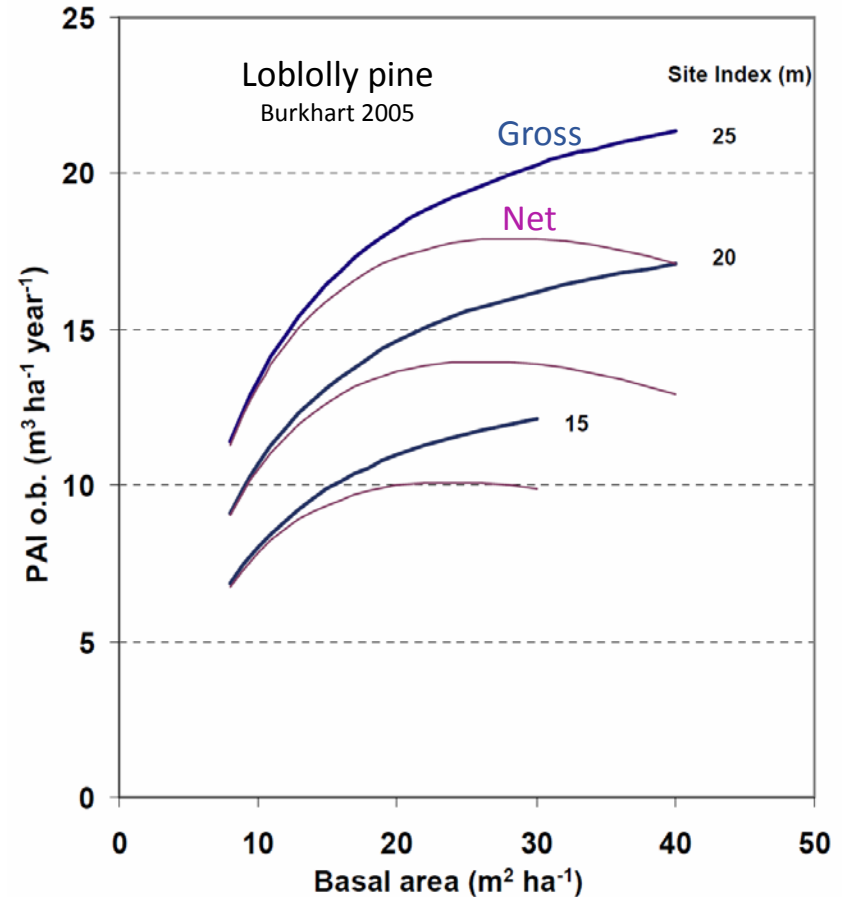
To plateau or not to plateau

- Uncertain width of plateau
- Uncertain effect of site quality
- Gross production vs Net production
- Typically noisy data causes the uncertainty



What effects the growth-density curve?

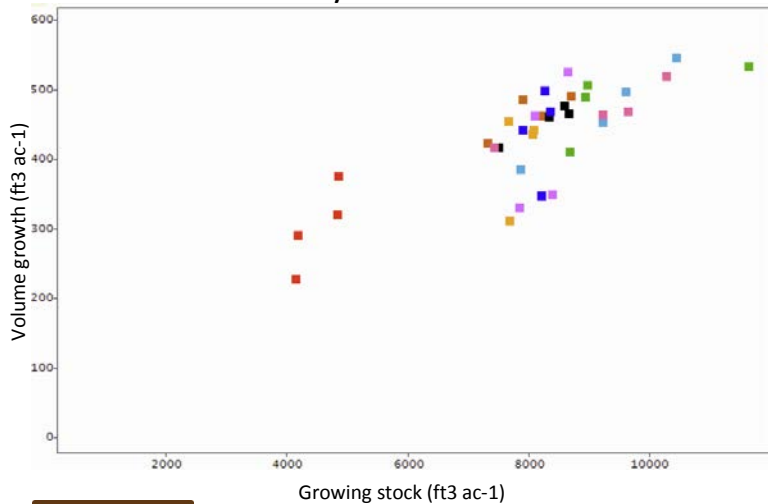
- A broad plateau creates management flexibility
 - High SQ may provide greater flexibility
 - Allows faster recovery from intensive thinning
- Low SQ follow same pattern, but develop slower
- Gross production shows continuous increase, net production peaks



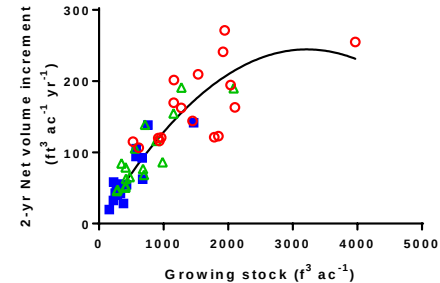
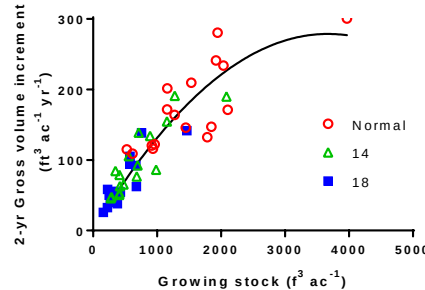
Growth-density curve

Examples for Douglas-fir

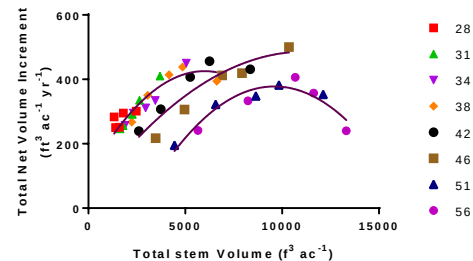
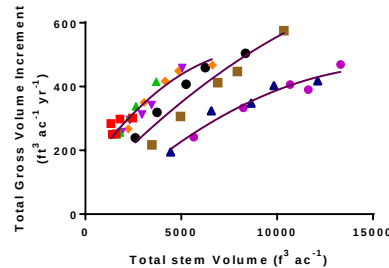
Hyink 2005



PPDM DF 2015



LOGS Skykomish



- Gross production shows continuous increase, net production peaks
- Capture mortality through thinning

Summary

- Forest stands are controlled by self-thinning limit, family of tree size-competition curves, and self thinning trajectory
- Density management diagrams use principles to predict thinning responses; achieve management objectives
- Timing of thinning affects stem and crown characteristics
- DMD must be adapted to account for effects of composition and site
- Thinning will capture the difference between gross and net production

