Update on Silviculture Research

Oregon/Washington State Joint State Conference
Keeping Forest Lands in Forests
"Improving Timber Resource Values through Forest Production"
May 12, 2011

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Collaborators

- School of Forest Resources, Univ. of Wa. , Seattle, WA
  - David Briggs, Professor & Director of PFC & SMC
  - Eric Turnblom, Assoc. Prof. & SMC Silvic. Project Leader
  - C.L. Huang, Affil. Assoc. Prof.
  - Kevin Ceder, PhDc
  - Jed Bryce, MS student
- USFS PNW Research Station, Portland, OR
  - Eini Lowell, Res. Scientist, SMC Wood Quality Project Leader
- Canadian Wood Fibre Centre, Victoria, BC
  - Cosmin Filipescu
  - Ross Koppenaal

Outline

- SMC History, Research Programs, Results
- Plantation Performance
  - Yield as affected by planting density
  - Quality as affected by branch (knot) diameter
- New Technology & Directions
  - Assessment of standing tree quality
  - Biomass
- Conclusion
- Q & A

Focus

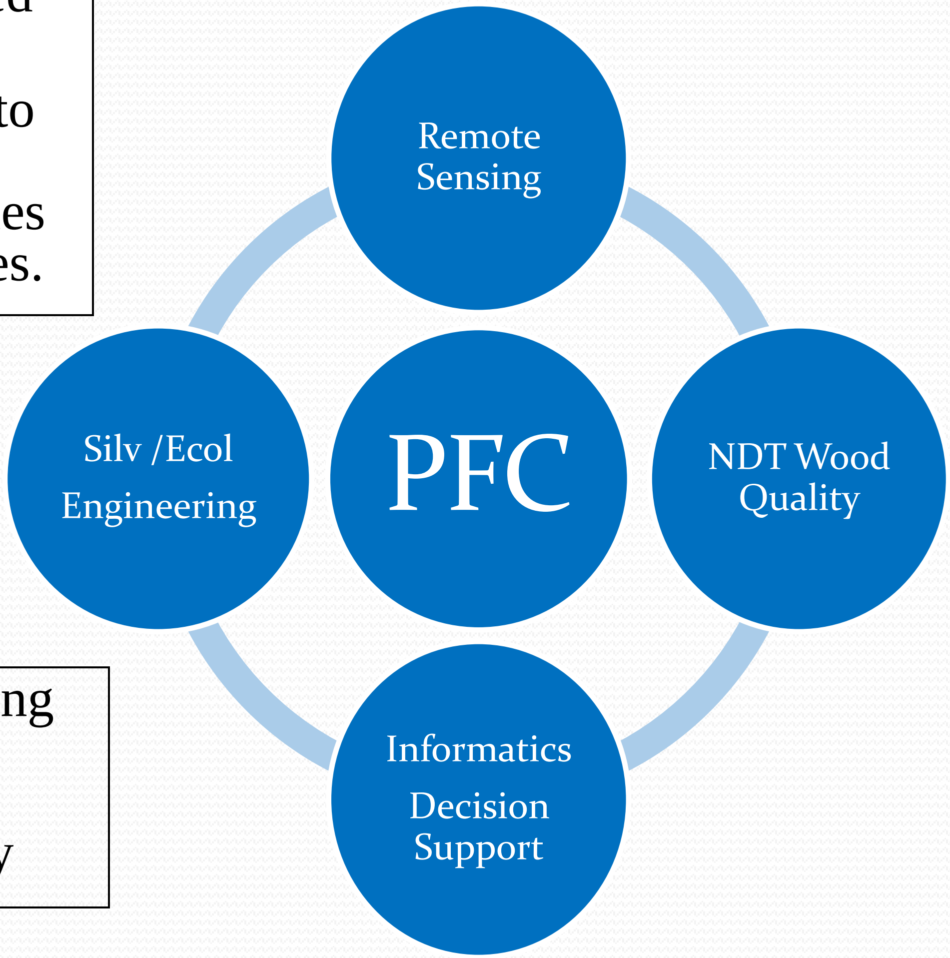
- 25.0 million ac. timberland in W. OR & W. WA
  - 11.0 million ac. (44%) owned by state, industry & tribes
  - 14.9 million ac (60%) if include other private
    - ✓ Most of the PNW timber harvest is from these forests
    - ✓ Most are managed plantations harvested at age 50 or less

Precision Forestry Cooperative

- State of Washington Advanced Technology Initiative
- Goal: To leverage research into direct economic benefits by transforming existing industries and generating new enterprises.

- $200k/yr state ATI
- $700k/yr grants

- develop high technology sensing and analytical approaches to support sustainable decision-making in the forestry industry

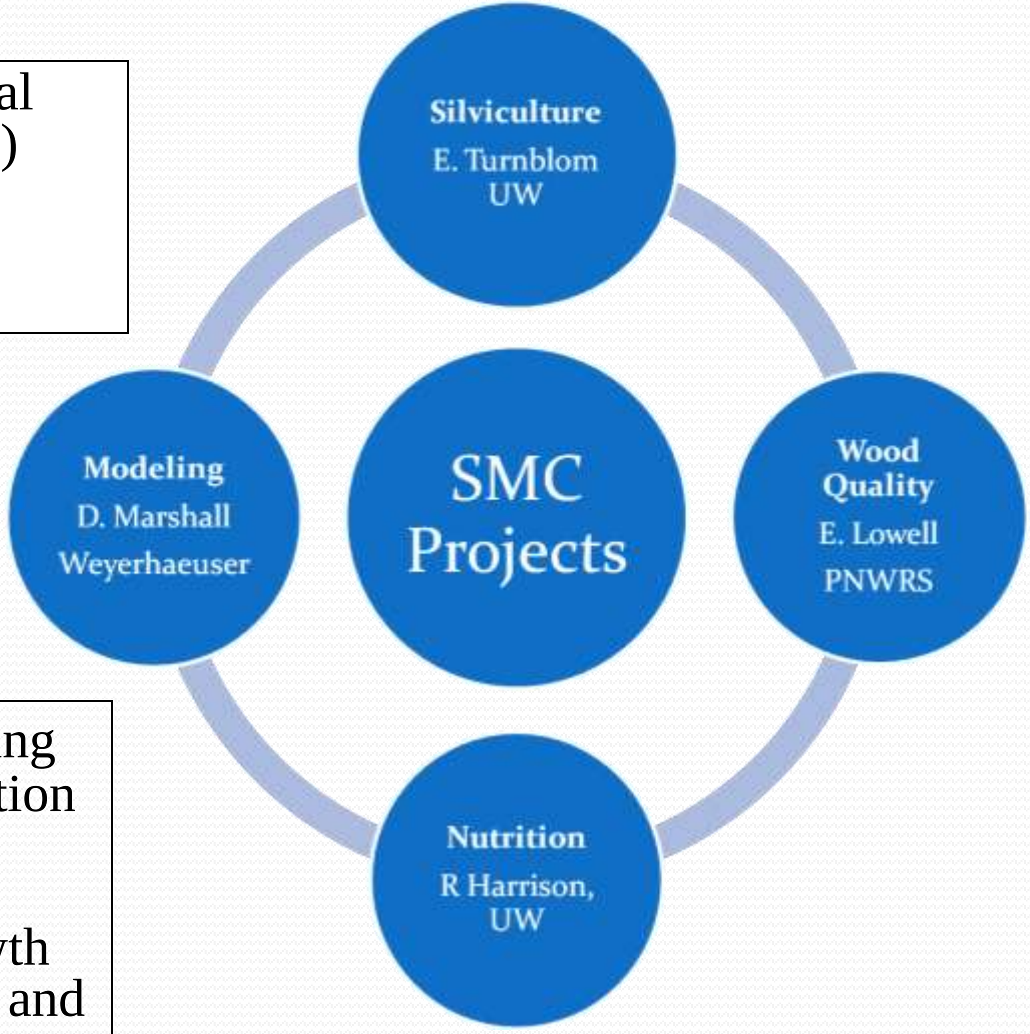


Stand Management Cooperative

Private Landowners (18), Tribal Lands (1), Federal Agencies (1) State & County Agencies (3), Analytic Organizations (3), Institutions (5), Suppliers (4)

- $600k/yr landowner
- $200k/yr institutions
- $200k/yr grants

Mission: To provide a continuing source of high-quality information on the long-term effects of silvicultural treatments and regimes on stand and tree growth and development and on wood and product quality



SMC Research Installations long-term field research

RFNRP Installations (1969-1991)

- **Phase I Unthinned Natural Stands**
  - Douglas-fir & western hemlock
  - established in 1969/70
  - up to 4 fertilization treatments
  - 20 years growth re-measurements
- **Phase II Thinned Natural Stands**
  - Douglas-fir & western hemlock
  - established in 1971/72
  - up to 4 fertilization treatments
  - 20 years growth re-measurements

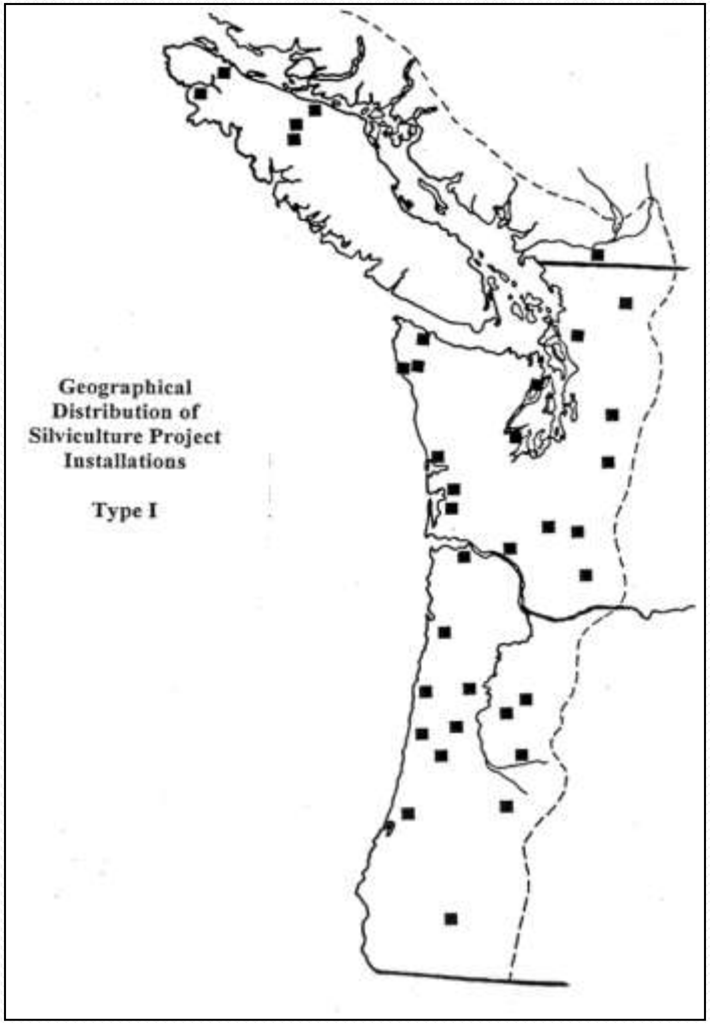
- **Phase III Young, Thinned Plantations**
  - Douglas-fir & western hemlock
  - established in 1975
  - up to 4 fertilization treatments
  - 20 years growth re-measurements
- **Phase IV PCT Plantations**
  - Douglas-fir & western hemlock
  - established in 1980
  - up to 4 fertilization treatments
  - 20 years growth re- measurements
- **Phase V Single Tree Screening Trials (true fir)**

Measurements on all Phases are complete

Database:245 installations, 3048 plots, 117,365 trees, 756,543 tree measurement sets

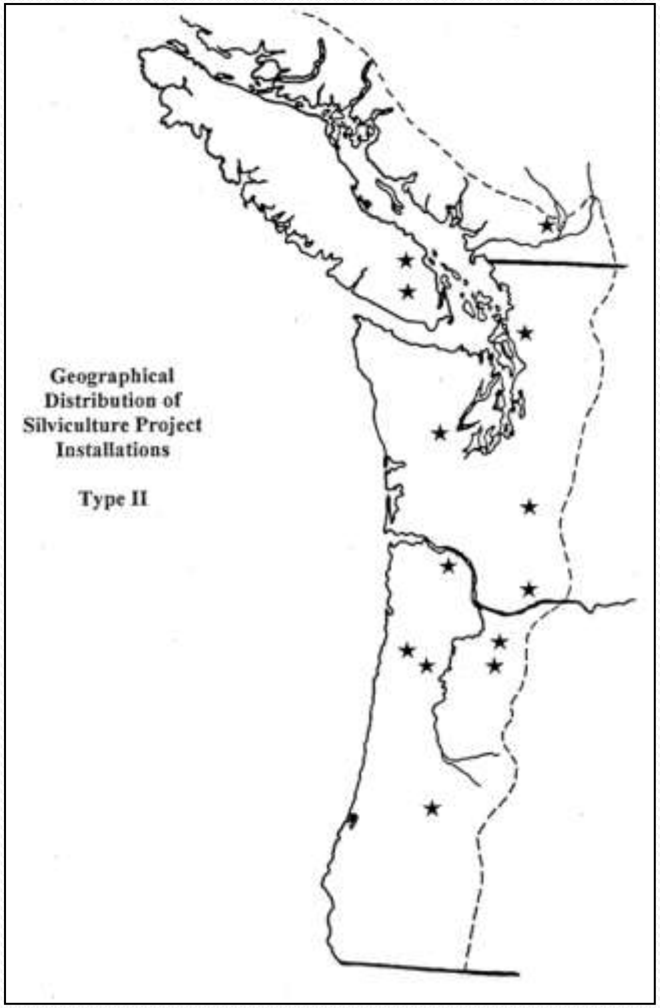
SMC Type I Installations

- **Plantations with initial stocking of 300-680 spa planted in 1970's & early 1980's**
- **Re-space (PCT) before onset of competition**
- **7 Core Treatment Plots**
  1. Keep at initial spacing (ISPA)
  2. Space to leave 1/2 (ISPA/2)
  3. Space to leave 1/4 (ISPA/4)
  4. ISPA with minimal thin
  5. ISPA/2 with minimal thin
  6. ISPA with repeated thin
  7. ISPA with heavy thin
- **Auxiliary plots at ISPA, ISPA/2 and ISPA/4**
  - Fertilization
  - Pruning
  - "best" tree selection; #2-7 use systematic selection
- **Douglas-fir (30 inst, 322 plots)**
- **W. hemlock (8 inst, 56 plots)**
- **Hypothesis: re-spacing young plantations simulates initial planting spacing**



SMC Type II Installations

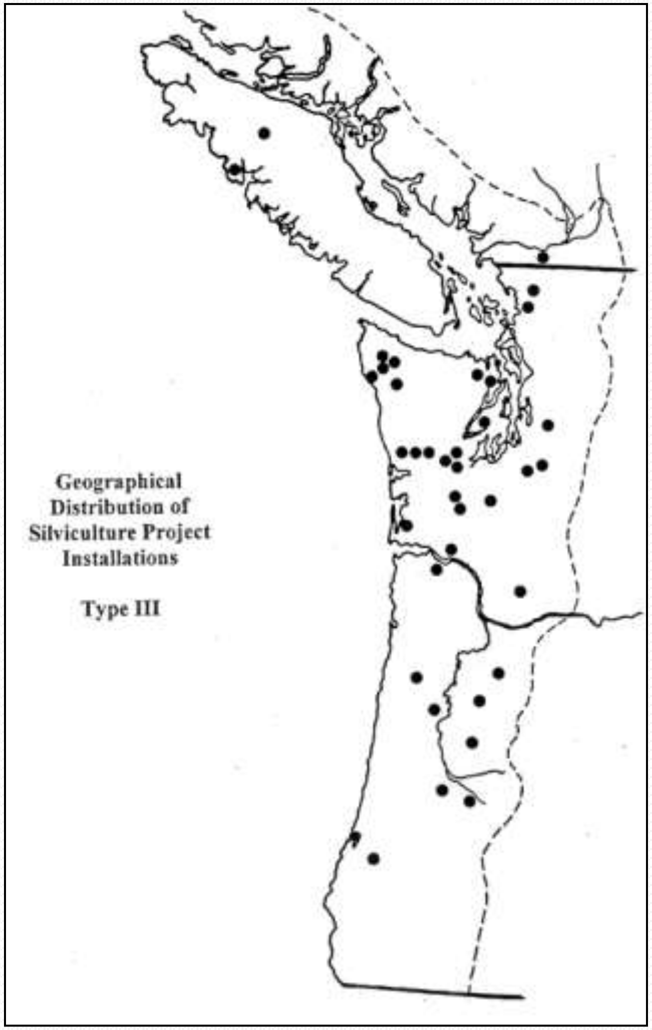
- Douglas-fir plantations & re-spaced natural stands near commercial thinning hence most planted in 1960’s. 5 plots; control and 4 following thinning regimes
- Hypothesis: Thinning these simulates response that Type I’s will have to thinning when they reach this age
- Douglas-fir (12 inst, 60 plots**)**



SMC Type III Installations

- Plantings at 100 (21x21), 200 (15x15) , 300 (12x12), 440 (10x10), 680 (8x8), and 1210 (6x6) stems per acre
- At least 3 acres of each
- Planted late 1980's & 1990's
- 47 installations (564 plots)
  - 38 Douglas-fir
  - 6 western hemlock
  - 3 50/50 DF/WH mix

- Hypotheses: Effect of planting spacing, thinning, and pruning on, growth, yield, quality, habitat, etc. Effect of thinning

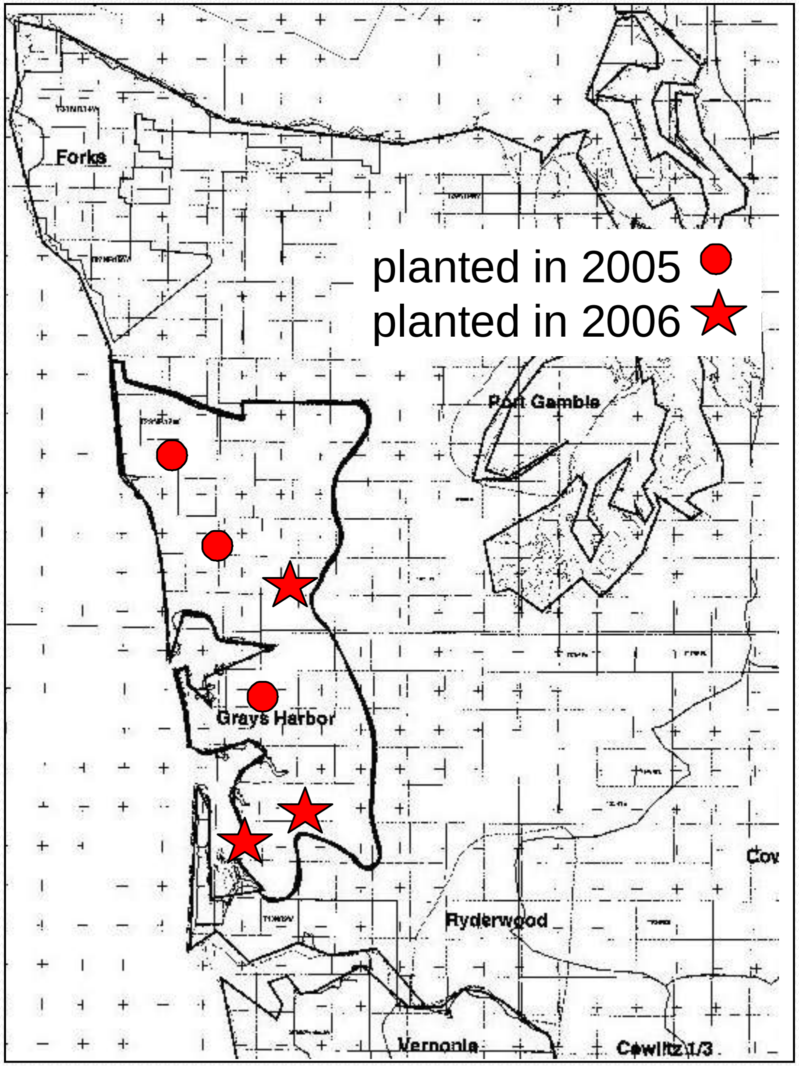


Genetic Gain Trial/Type IV (GGTIV)

- SMC & Northwest Tree Improvement Cooperative (OSU) Collaboration
- 3 levels of genetics
- 3 spacings 7x7, 10x10, 15x15
- 2 competing vegetation tmts
- Douglas-fir (6 installations , 132 plots)

  3 installations planted in 2005

  3 installations planted in 2006



Type V: Paired Tree Fertilization

1. to evaluate the potential for response of 15-25 year-old stands to N fertilization within a given vegetation / geology type.
2. To track N through the system (N15 isotope)
3. to predict potential response from site and stand variables so managers can focus fertilization resources on sites most likely to respond

- 74 Installations 2007-pres.
- Closely matched tree pairs, one fertilized, one not fertilized

Carry-over effect

1. to evaluate the effect of the fertilization regime applied to a stand on the growth and yield of the next stand.

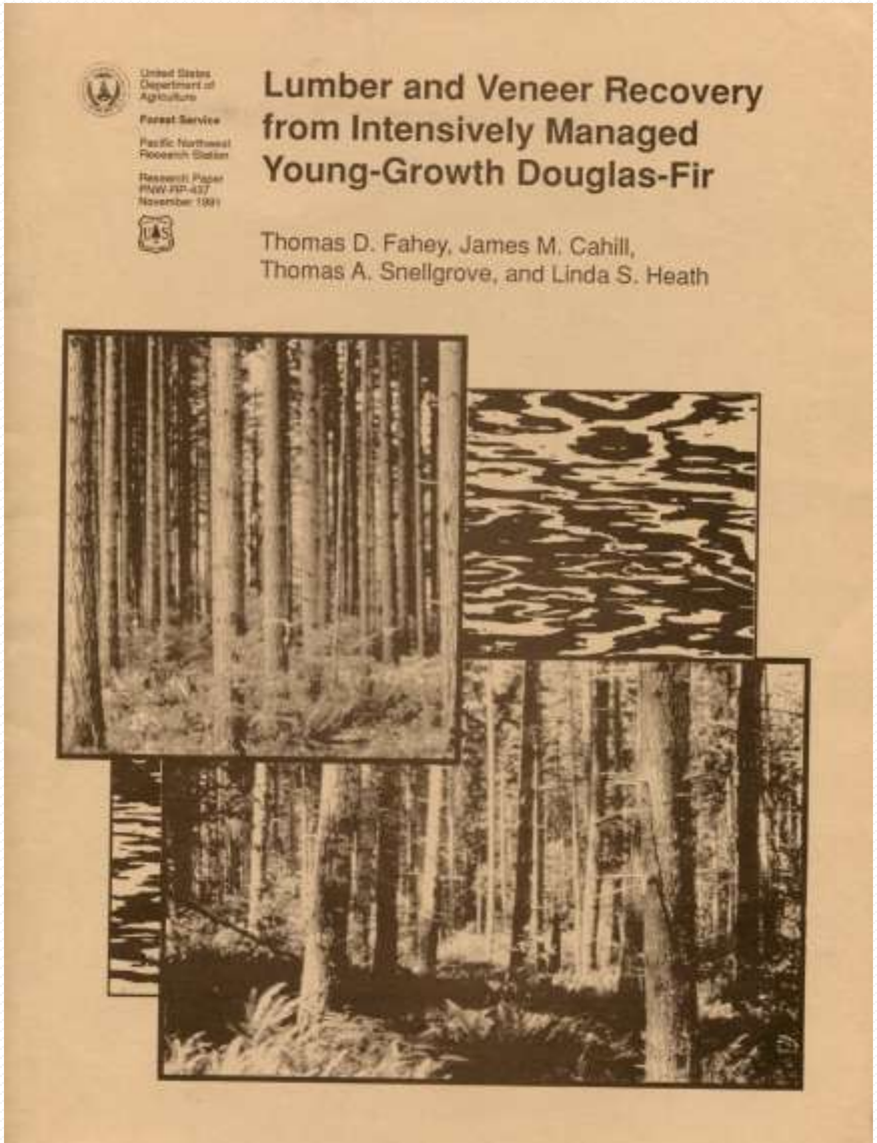
- Recently harvested and replanted RFNRP installations
- 7 established in1997-1999

Long-term Site Productivity

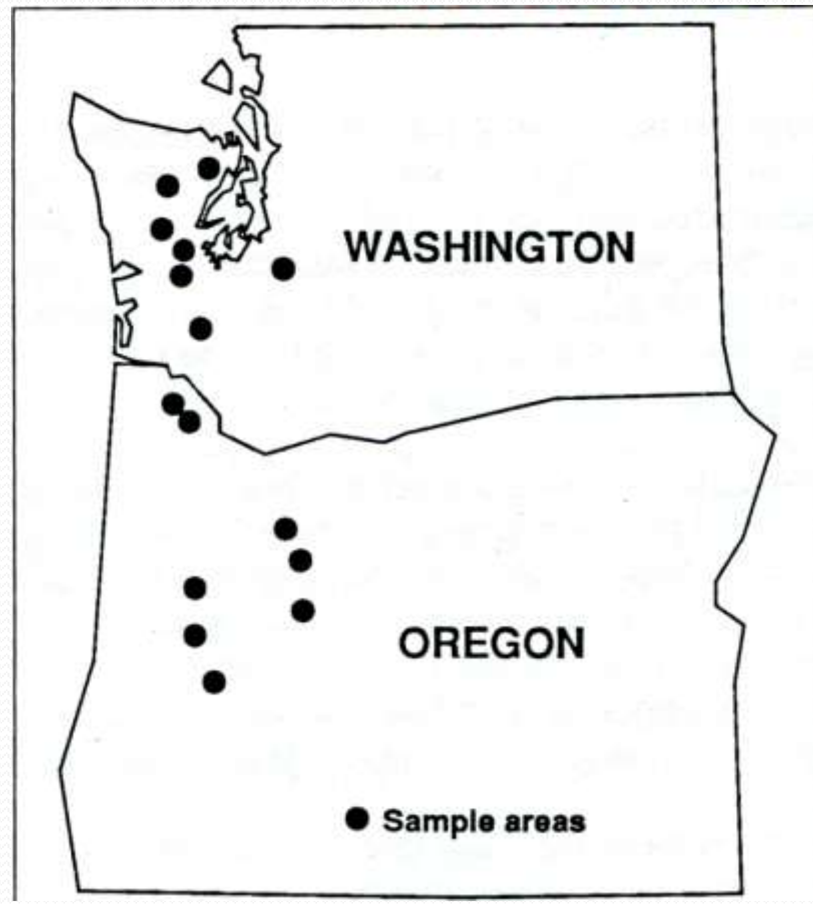
- **Fall River, WA**
  - Weyerhaeuser Company, University of Washington, USFS:
  - Support from
    - NCASI to pursue work plan—funding for process work
    - Weyerhaeuser Company—installation and process work
    - Olympic Natural Resources Center Grant--lysimeter study
    - USFS, USFS/AF&PA Agenda 2020 Competitive Grant—process work
- **Matlock, WA & Mollalla, OR**
  - USFS—PNW Olympia Lab, Green Diamond, Port Blakely, Oregon State University, University of Washington
  - Support from
    - Green Diamond / Port Blakely—installation and maintenance
    - USFS, Agenda 2020 (linkage with AF&PA)—funding for process work

Results & Products

Veneer/lumber from managed stands

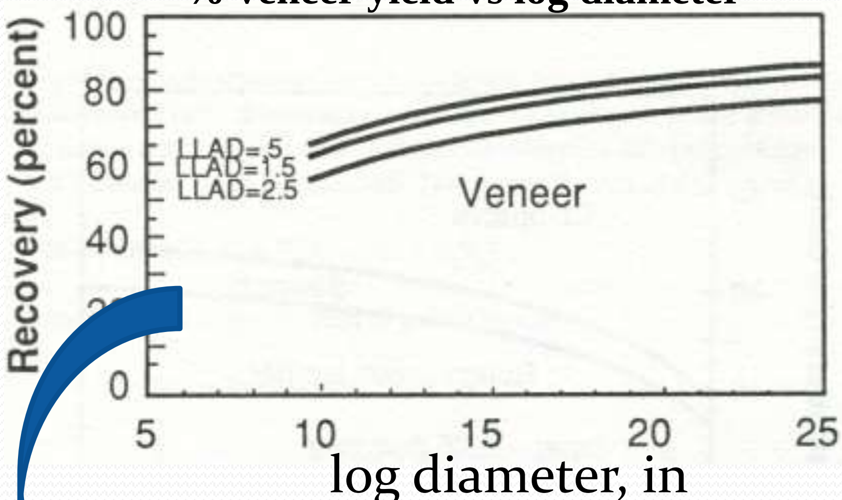


Sample trees from plantations thought to be representative of future plantation management

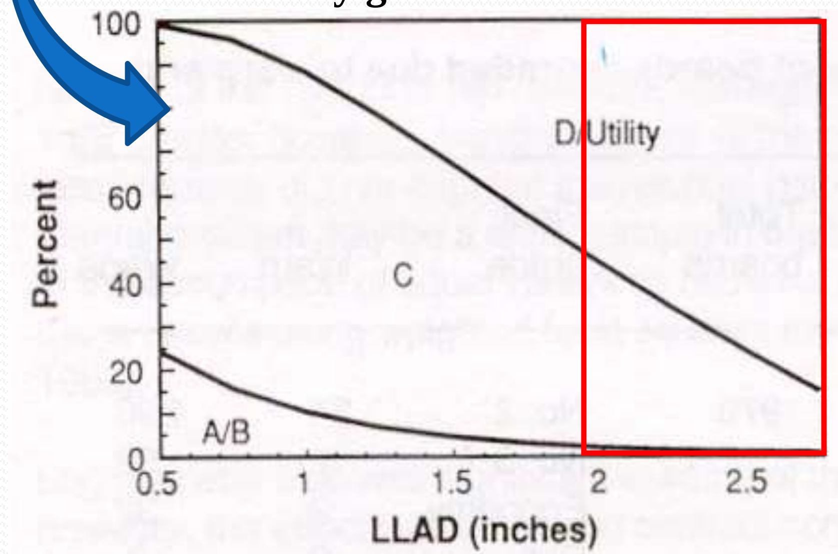


Yield of visually graded veneer

% veneer yield vs log diameter



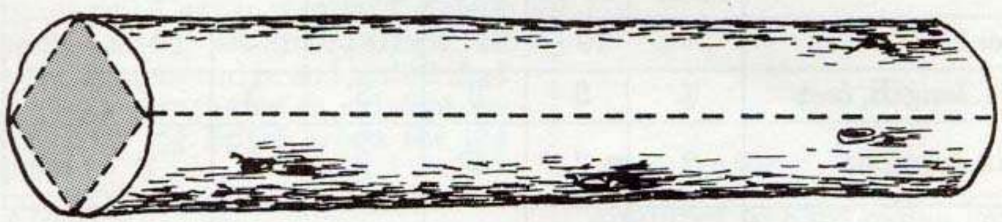
% visually graded veneer recovered



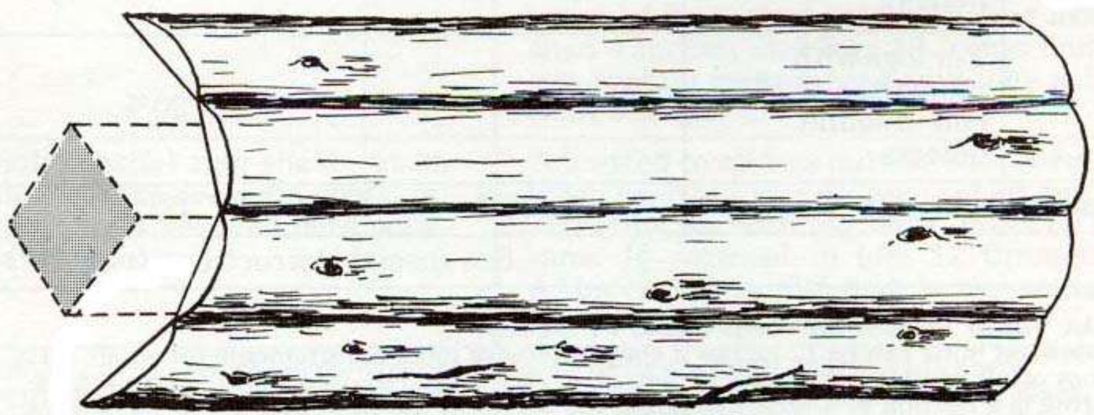
- LLAD
  - largest limb average diameter
  - Measure diam. of largest knot on each log face, o if clear, and average them
- As LLAD increases
  - Get less veneer from log
  - Grade of veneer obtained is low

LLAD "largest limb average diameter" = branch index (bix), a log quality index

Selecting the grading face.

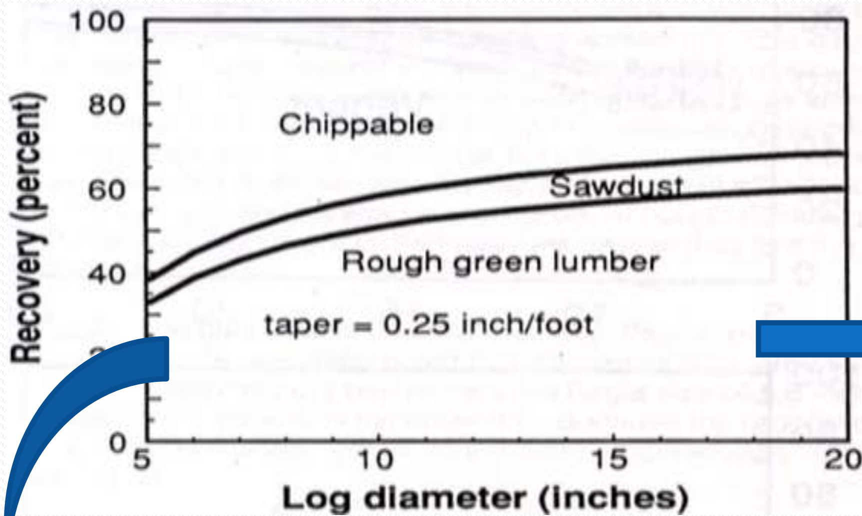


LLAD ➔ measure diameter of largest knot in each face, clear = 0, & average

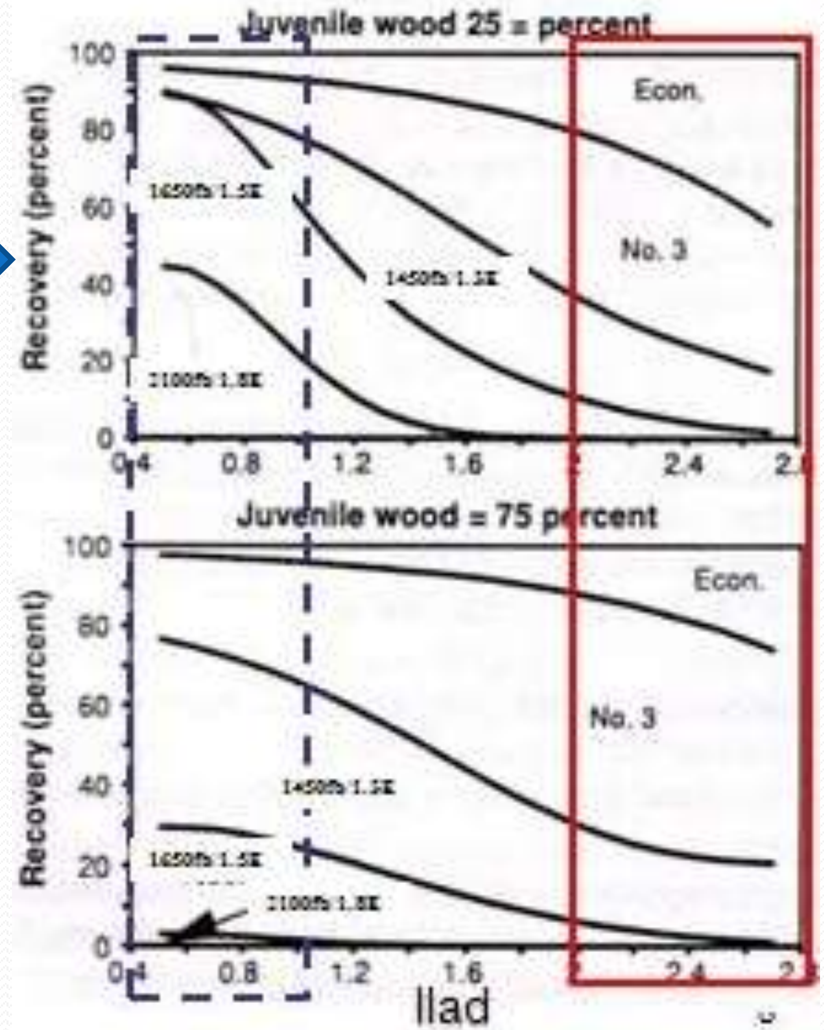


Yield of lumber

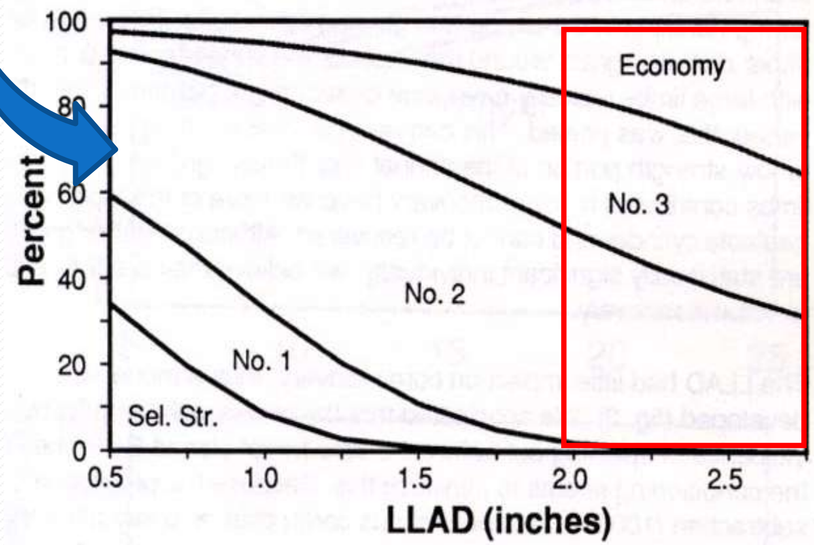
% veneer yield vs log diameter



%MSR Graded Lumber Recovered



%Visually Graded Lumber Recovered

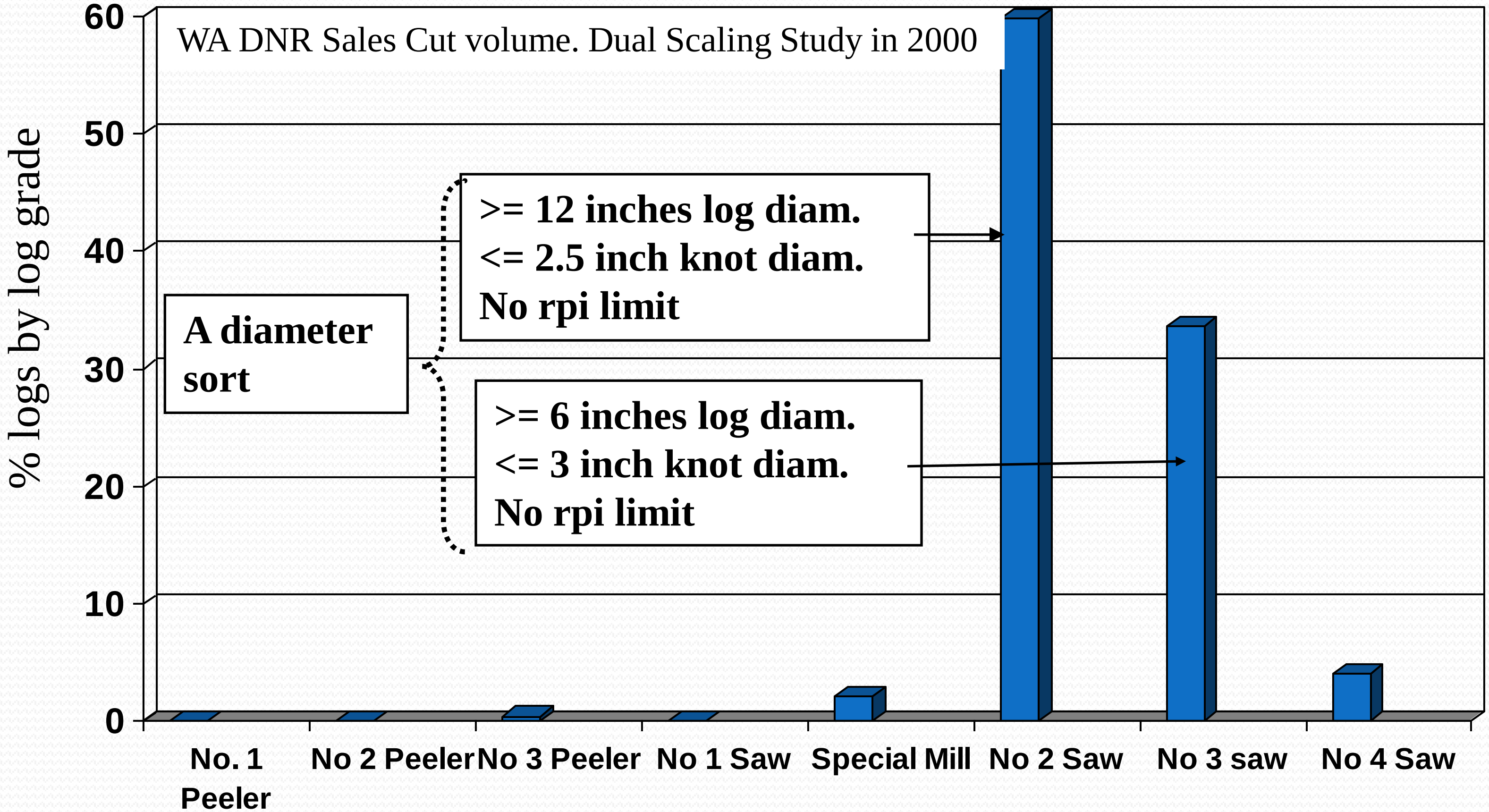


Peeler/Sawlog Grading System

Most logs are #2 & #3 Saw ➔knot diam. less than 2.5i or 3 in OK

Recovery graphs for 0 <= LLAD <= 2.5

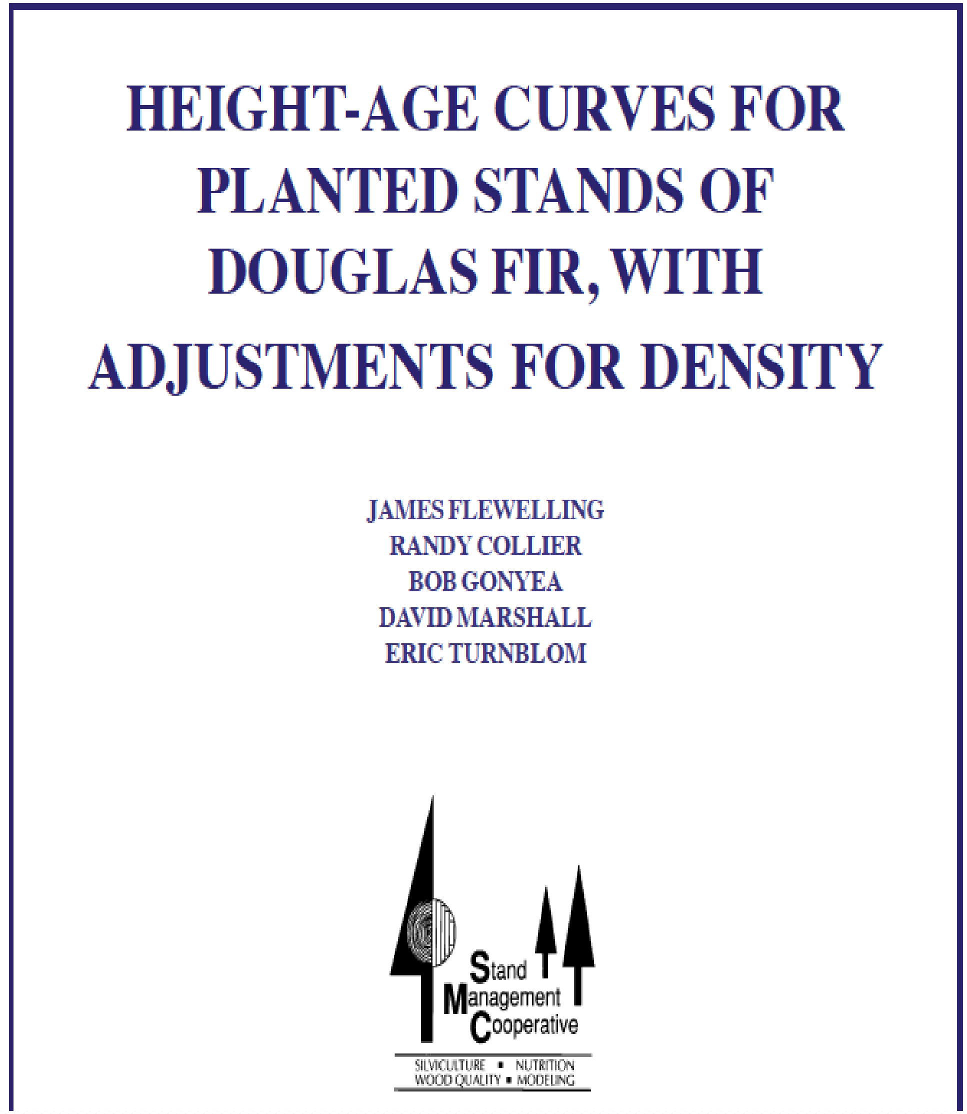
Mill studies ➔ no relationship between log grades product grade recovery



Source: _____. 2001. Critique of cross-Border Comparisons Relating to British Columbia in the Department of Commerce’s Preliminary Determination. In the matter of: Countervailing Duty Investigation of Certain Softwood Lumber Products from Canada. Joint Report by H&W Saunders Ltd and Wesley Rickard, Inc. to Province of British Columbia and the BC Lumber Trade Council. Folio # 3.

Density-Adjusted Height-Age Curves

- Long-held convention is that height growth is little affected by stand density, but is reduced at extremely high densities, especially on poor sites (Reukema)
- Not really true in plantations
- New site index curves with base age 30 "Flewelling SI"


HEIGHT-AGE CURVES FOR PLANTED STANDS OF DOUGLAS FIR, WITH ADJUSTMENTS FOR DENSITY

JAMES FLEWELLING
RANDY COLLIER
BOB GONYEA
DAVID MARSHALL
ERIC TURNBLOM

Stand Management Cooperative

SILVICULTURE • NUTRITION
WOOD QUALITY • MODELING

Density-Adjusted Height-age Curves

G & Y Models
SMC ORGANON

SMC ORGANON (1997)

- Data sets from members
- Quality links to the mill study

SMC ORGANON (2005)

- diameter growth, height growth, & mortality equations updated with SMC installation data

Edition 9.0 (1/30/11)

- Includes the new RA plantation model

Edition 9.1 (2/28/11)

- New taper equations for DF

Integration of ORGANON into the FVS interface

G & Y Models
age 0-15: Conifers-PNW Variant

Bootstrap Evaluation of a Young Douglas-Fir Height Growth Model for the Pacific Northwest

Nicholas R. Vaughn, Eric C. Turnblom, and Martin W. Ritchie For. Sci. 56(6): 592-602.

SMC Type III & RVMM data

RFNRP/SMC Database

- > 450 installations, > 4,700 plots, > 262,000 trees

- Measurement Cycle: 2 or 4 years
  - ➢ Tree measurements
  - ➢ Understory vegetation
    - ✓ Species, height, % cover, and vertical profile (cover board), depth of duff layer
  - ➢ Branch Protocol (BH)
    - ✓ diameter of largest branch & branch count
  - ➢ Dead Tree (Snag)
    - ✓ size & condition of dead tree until it falls
- Site characterization
  - ➢ Soil, litter, & foliage samples

- Update sent to members each year

- Basis for G & Y model development and updates
- Many other “data mining” analyses

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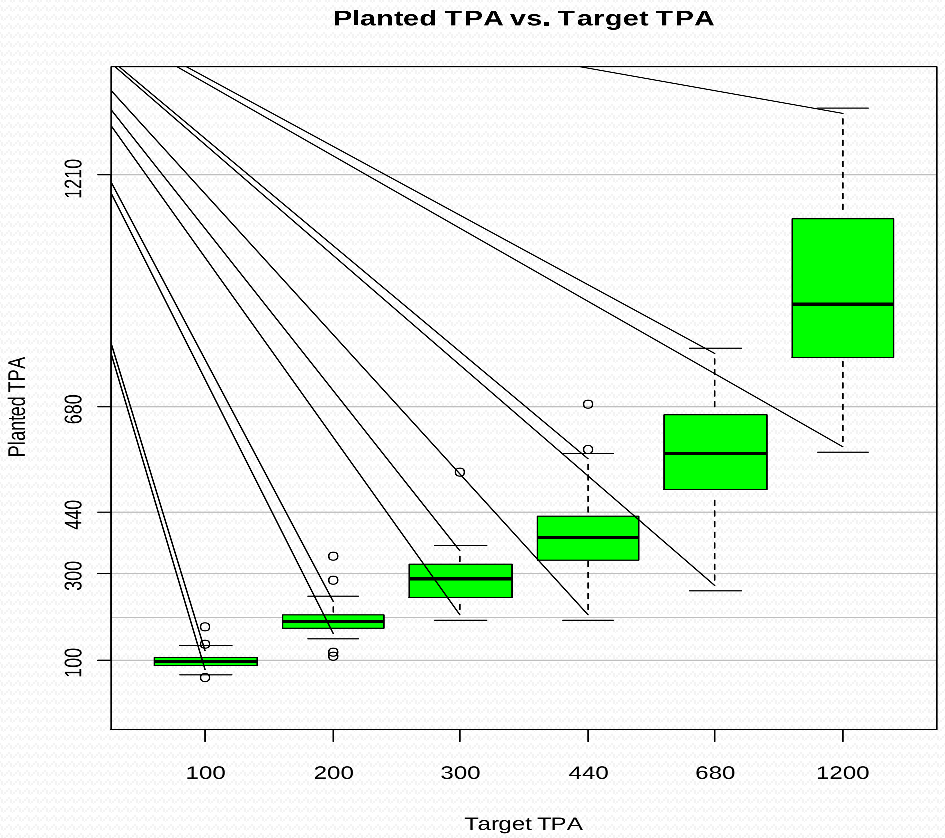
Type III Planting Densities

Treatment	Definition
100 SPA	Plant 21 x 21'
200 SPA	Plant 15 x 15'
300 SPA	Plant 12 x 12'
440 SPA	Plant 10 x 10'
680 SPA	Plant 8 x 8'
1210 SPA	Plant 6 x 6'



- Actual planting varies in each target class
- Treated as continuous variable in models

Type III Thinning: 440, 680, 1210 spa

Treatment	Definition	Thinning Regime
EL	Thin Early Lightly	RS=0.27, decrease 1 spa class
LL	Thin Late Lightly	RS=0.17, decrease 1 spa class
EH	Thin Early Heavily	RS=0.27, decrease 2 spac lasses
LH	Thin Late Heavily	RS=0.17, decrease 2 spa classes
LO(680)	Thin Late Once	RS=0.12, leave 200 spa

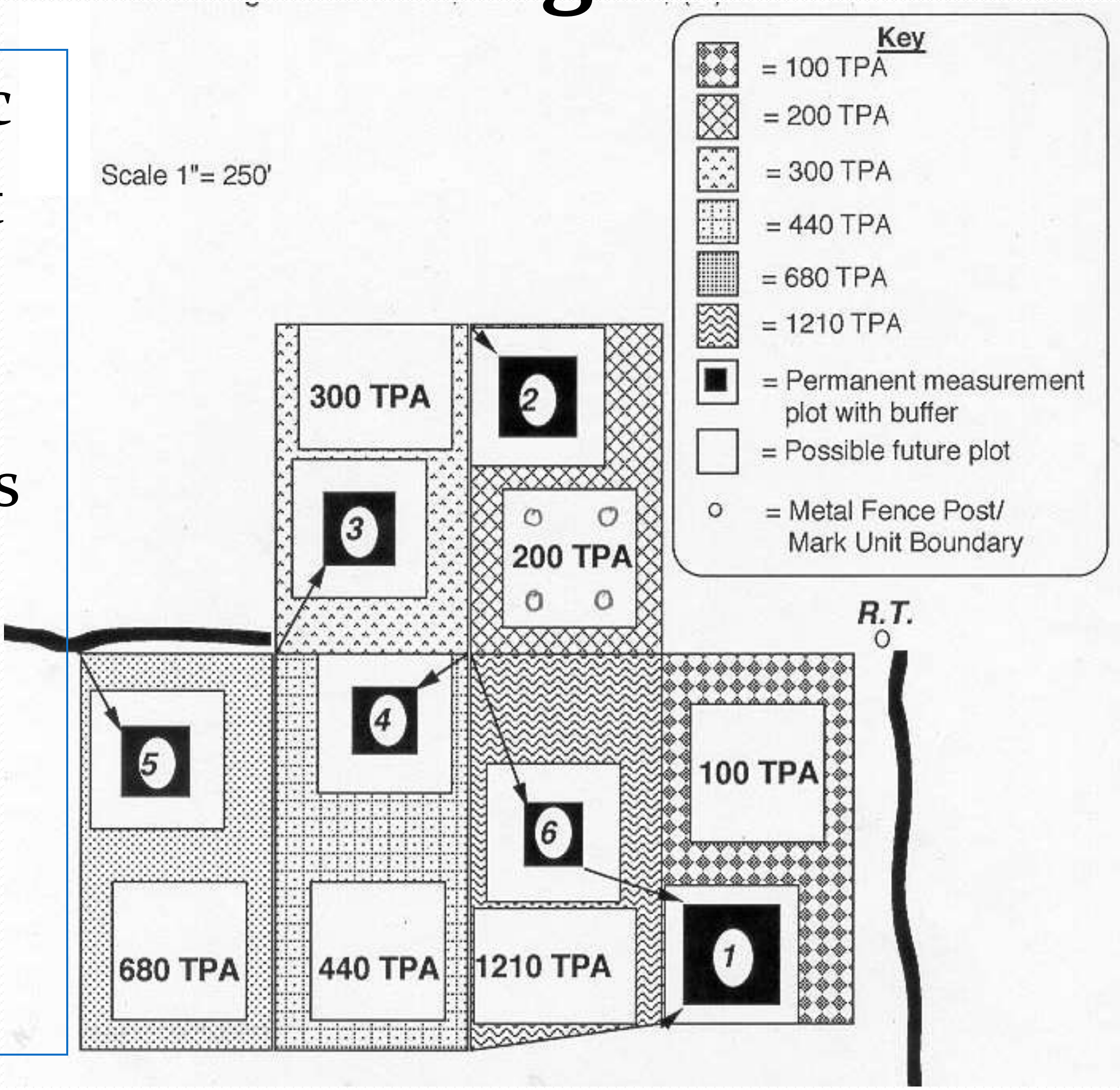
- RS = relative spacing ➔ tree height vs distance between trees

Type III Pruning: 100, 200, 300 spa

Treatment	Definition	Thinning Regime
Cal	Caliper prune all trees i.e. a diameter limit approach	None
100 P100	Prune 100 spa <= 50% LCR	None
200 P100	Prune 100 spa <= 50% LCR i.e. 100 un-pruned followers	None
200 P200	Prune 200 spa <= 50% LCR	None
300 P100	Prune 100 spa <= 50% LCR i.e. 200 un-pruned followers	None
300 P200	Prune 200 spa <= 50% LCR i.e. 100 un-pruned followers	None

Type III Plot Design

- Planting blocks >= 3 ac
- Each has a control plot
- Room for thinning or pruning plot
- Each plot has sub-plots for understory, habitat
- Extra-wide treated buffers for destructive samples



Type III Limitations

- Regional replication was favored over on-site replication
- Auxiliary treatments are a randomized incomplete block design
- Although the total number of thinned plots exceeds 60, replications of any single auxiliary treatment / spacing combination range from 2 to 10
- Similarly, there are 48 pruned plots, but the number of any particular pruning method / spacing combination ranges from 4 to 9

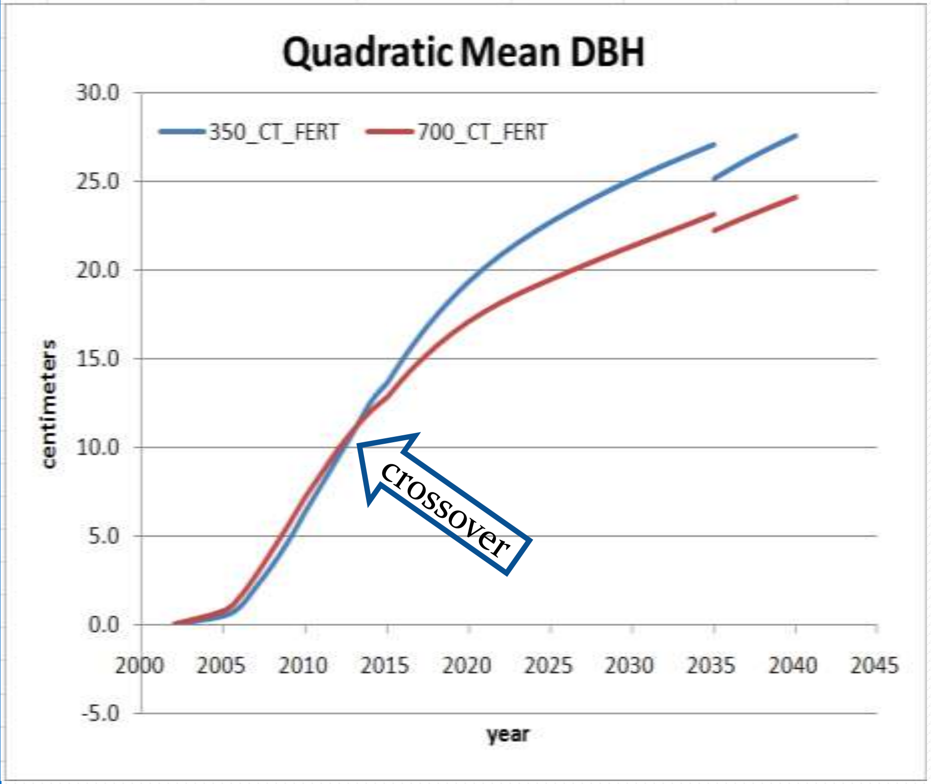
Crossover Effect

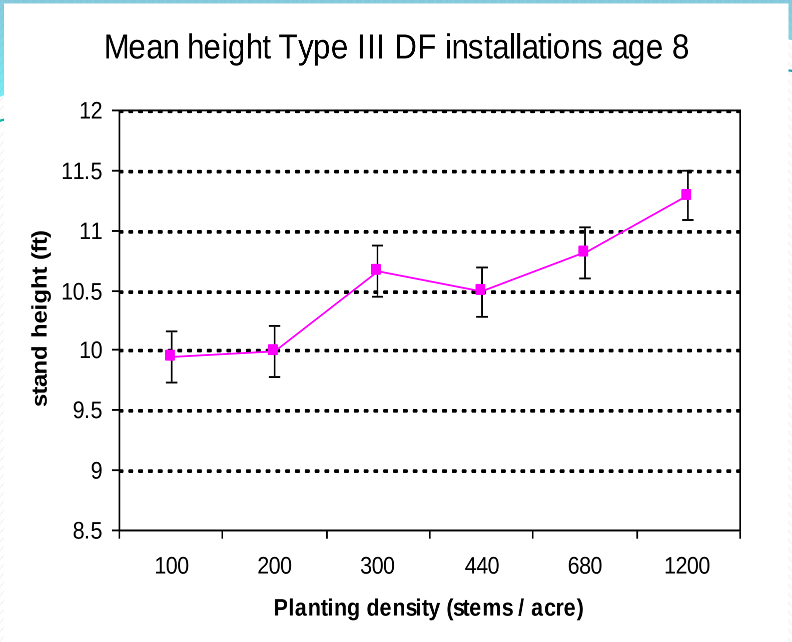
- Long held convention that diameter growth increases with wider spacing, except after heavy thinning on poor sites (Harrington & Reukema)

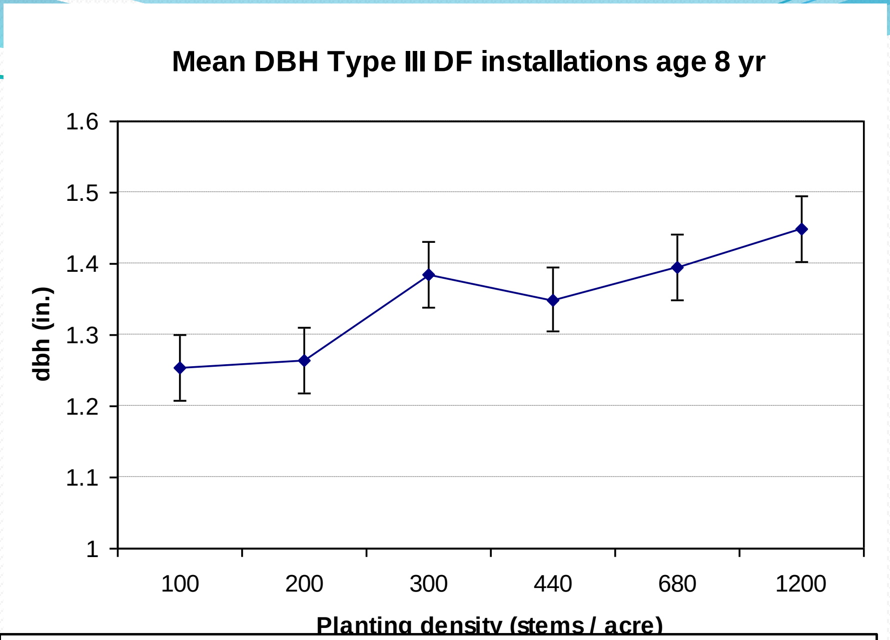
- However, closely spaced juvenile DF stands (red line) have greater height and diameter than in widely spaced stands (blue line) of same age and site (Scott et al.) ➔ "**crossover effect**"

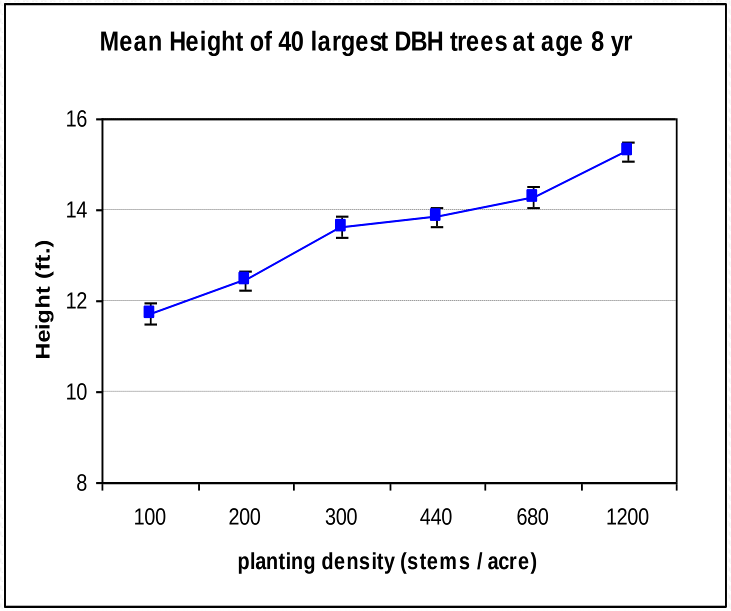
Why

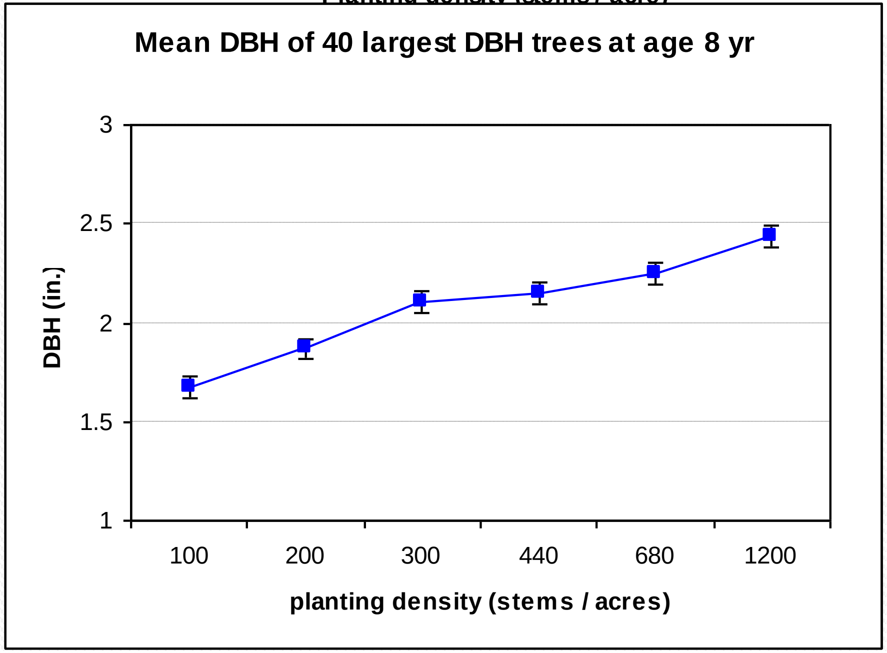
- Phytochrome signals how close competitors are
- When close put more resources into race for the sky (height) and diameter for support




Mean height Type III DF installations age 8
stand height (ft)
12
11.5
11
10.5
10
9.5
9
8.5
100
200
300
440
680
1200
Planting density (stems / acre)


Mean DBH Type III DF installations age 8 yr
dbh (in.)
1.6
1.5
1.4
1.3
1.2
1.1
1
100
200
300
440
680
1200
Planting density (stems / acre)


Mean Height of 40 largest DBH trees at age 8 yr
Height (ft.)
16
14
12
10
8
100
200
300
440
680
1200
planting density (stems / acre)


Mean DBH of 40 largest DBH trees at age 8 yr
DBH (in.)
3
2.5
2
1.5
1
100
200
300
440
680
1200
planting density (stems / acres)

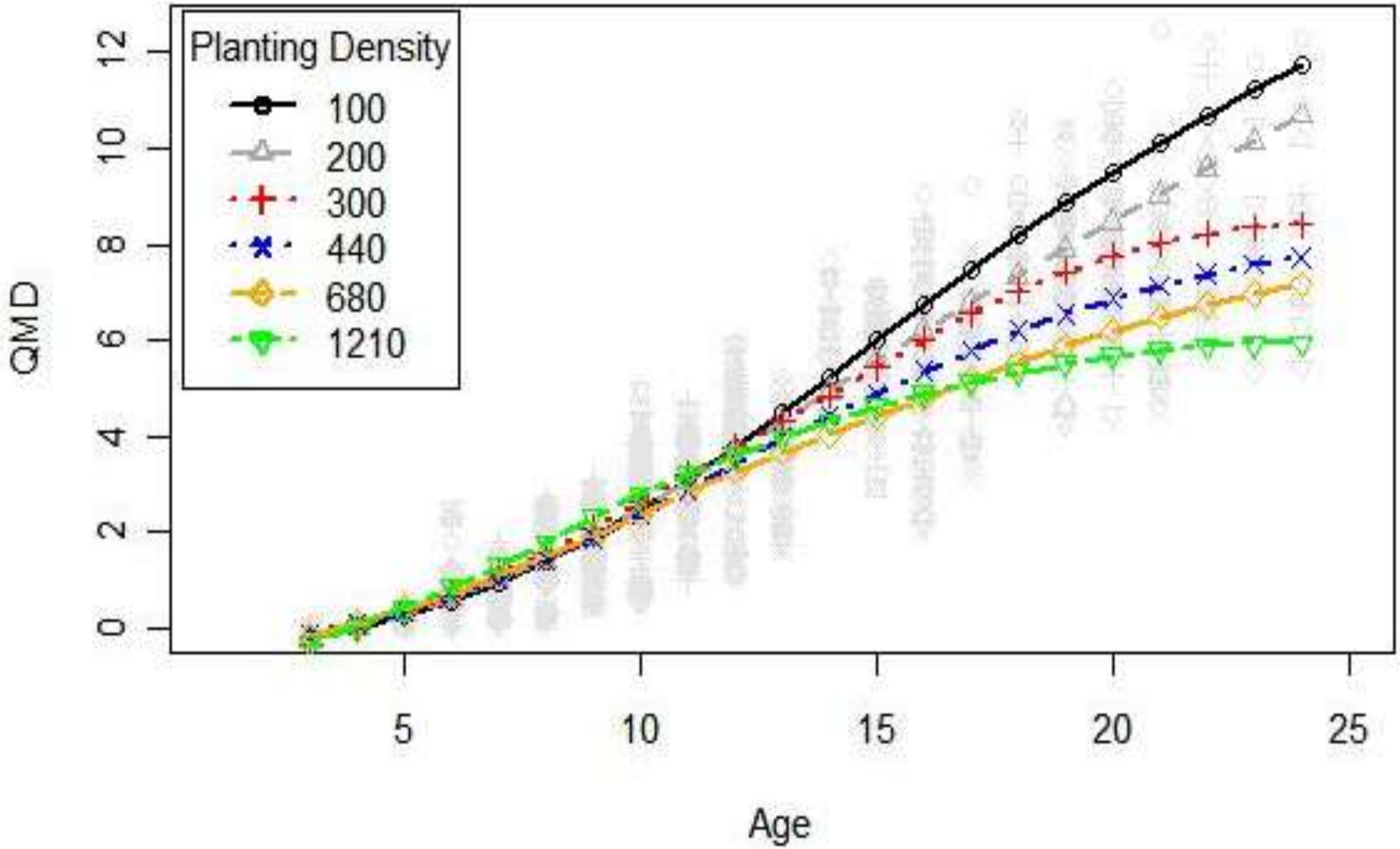
Type III Performance

1. QMD, tree level
2. Volume, tree and per acre levels
3. Branch diameter, tree level

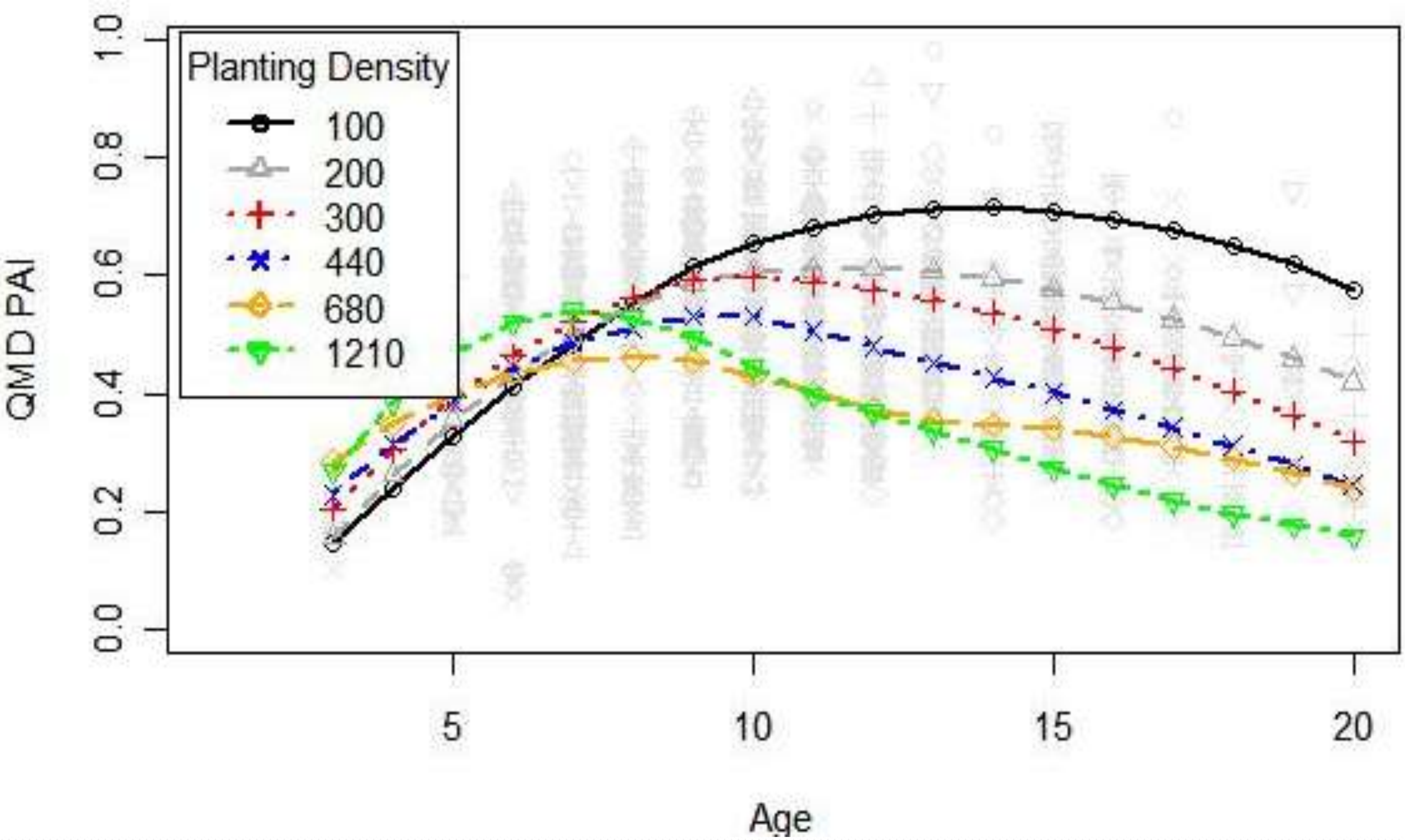
- Will not discuss other aspects nor effects of thinning and pruning treatments

- SMC held a workshop on these topics on April 20
- Will soon be available in streaming video, on-line calculator, and technical report

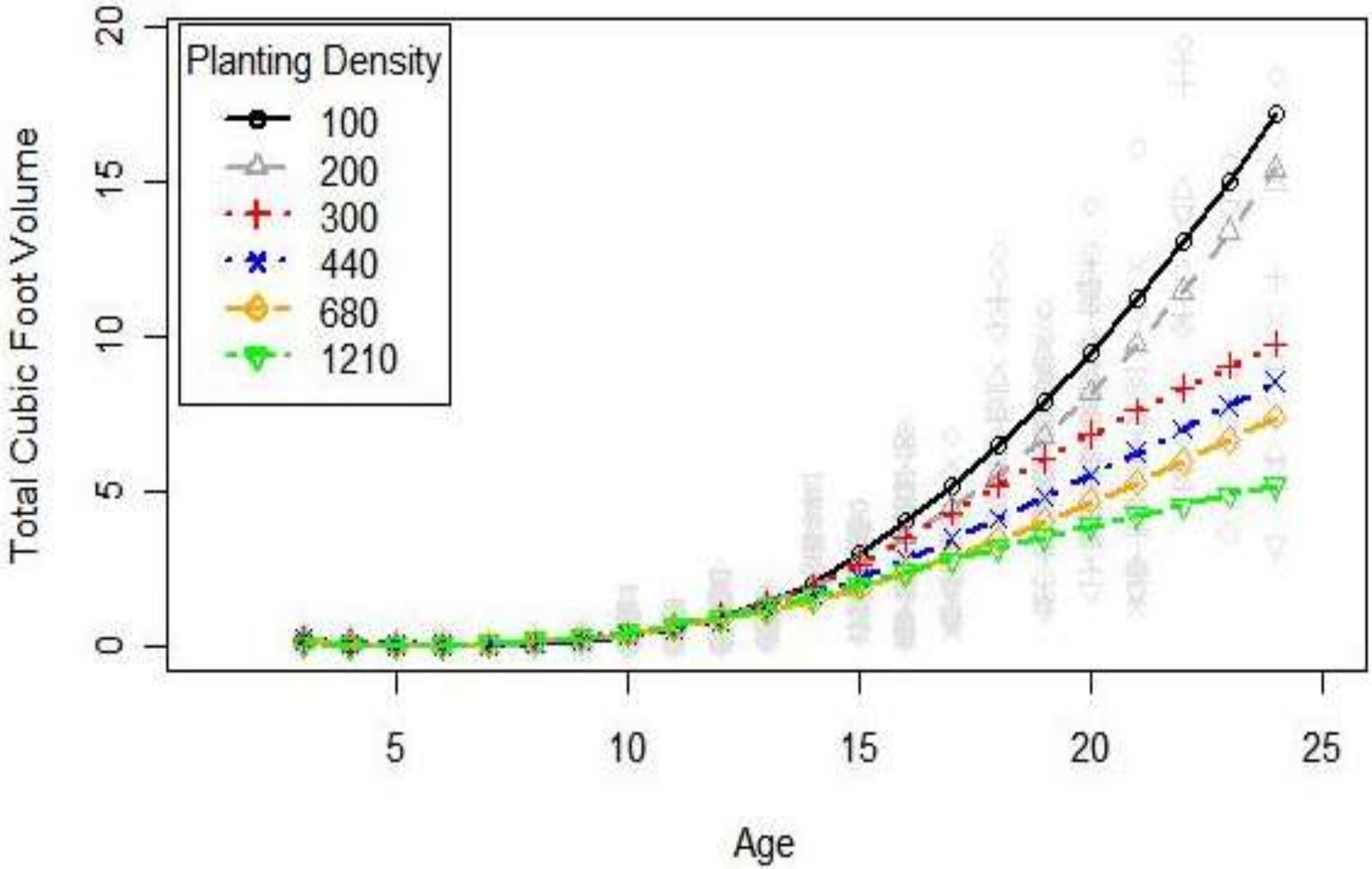
1. Mean Tree QMD vs AGE



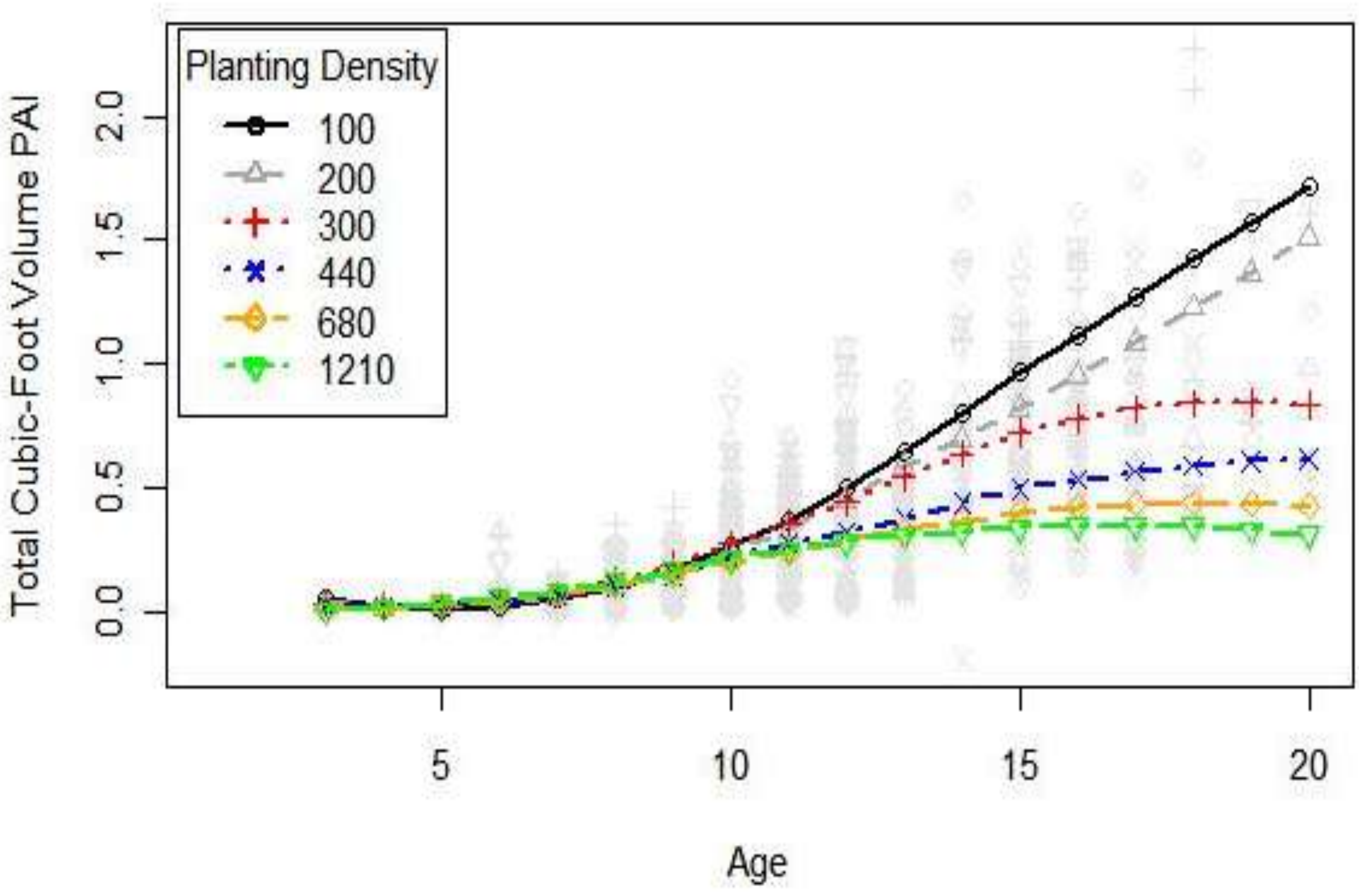
Mean Tree QMD PAI vs AGE



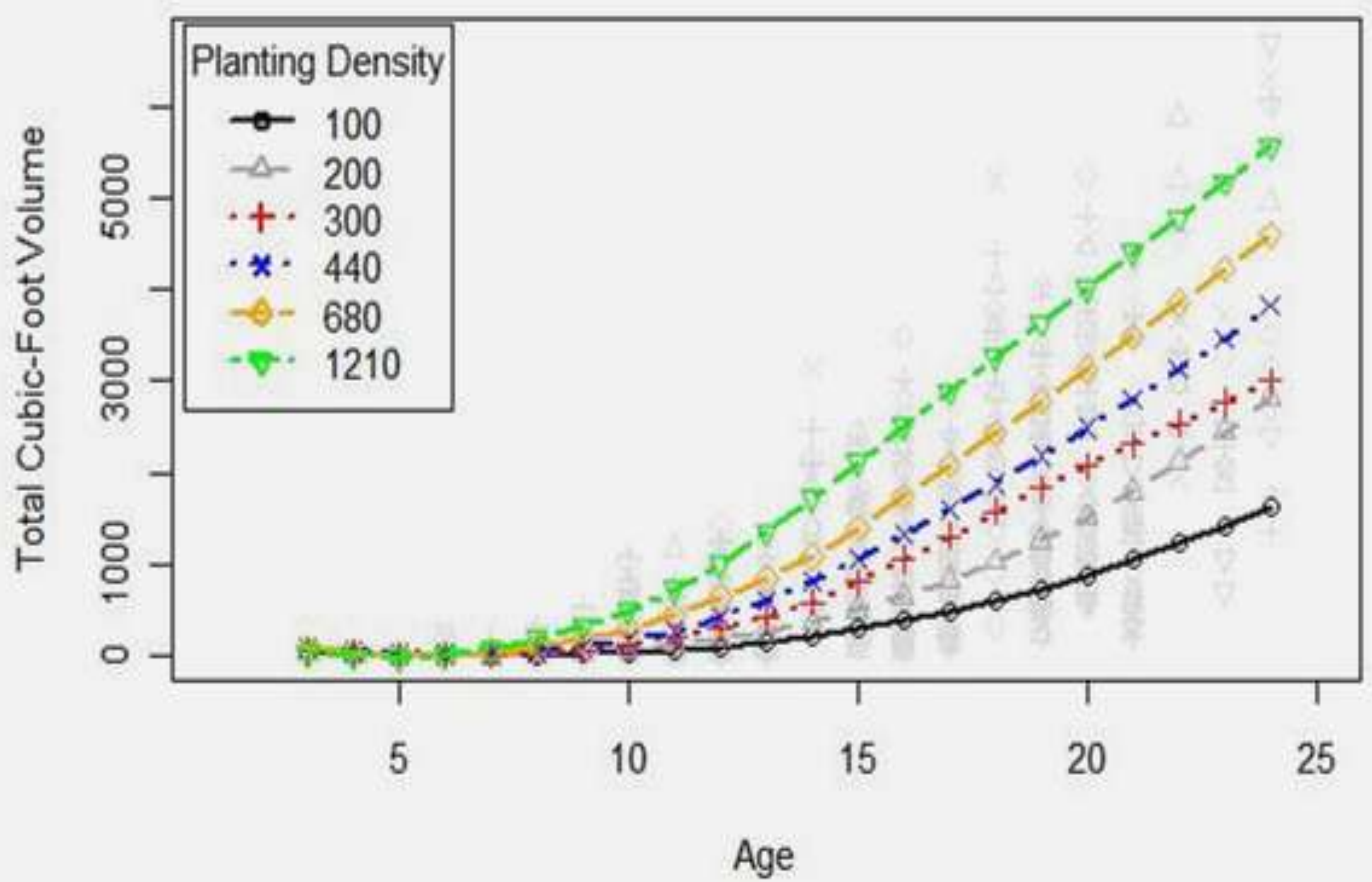
Mean Tree Total Cubic Foot Volume vs AGE



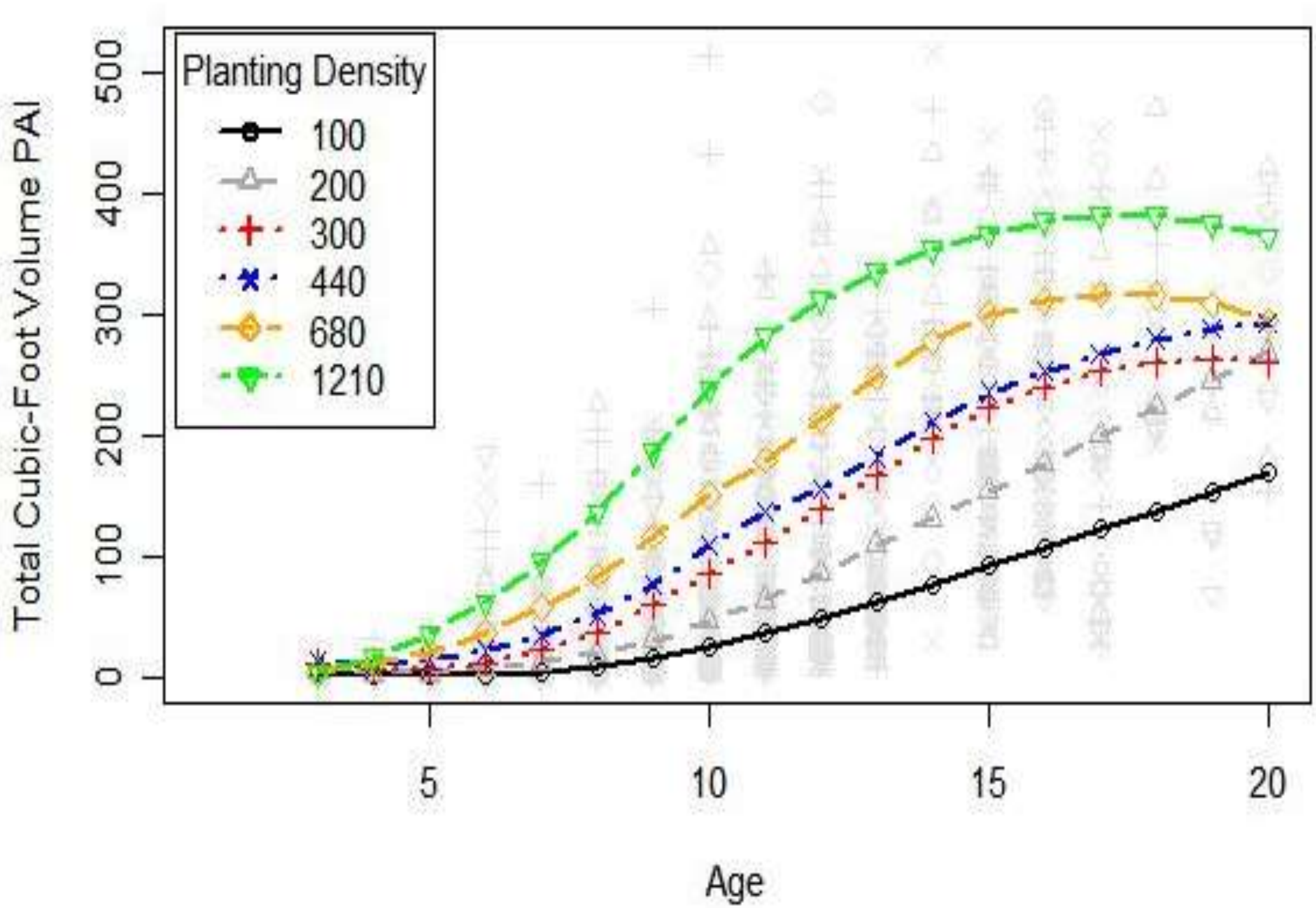
2. Mean Tree Total Cubic-Foot Volume PAI vs AGE



Per Acre Total Cubic-Foot Volume vs AGE



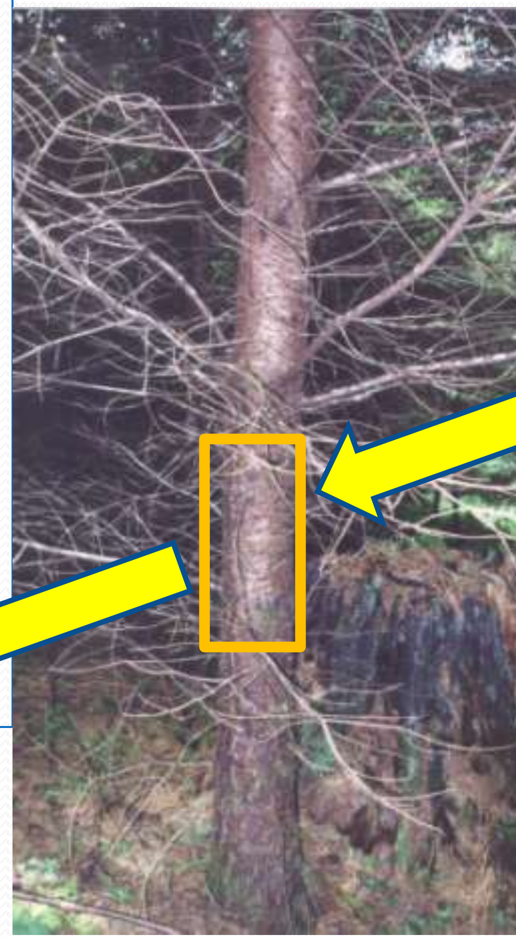
Per Acre Total Cubic-Foot Volume PAI vs AGE

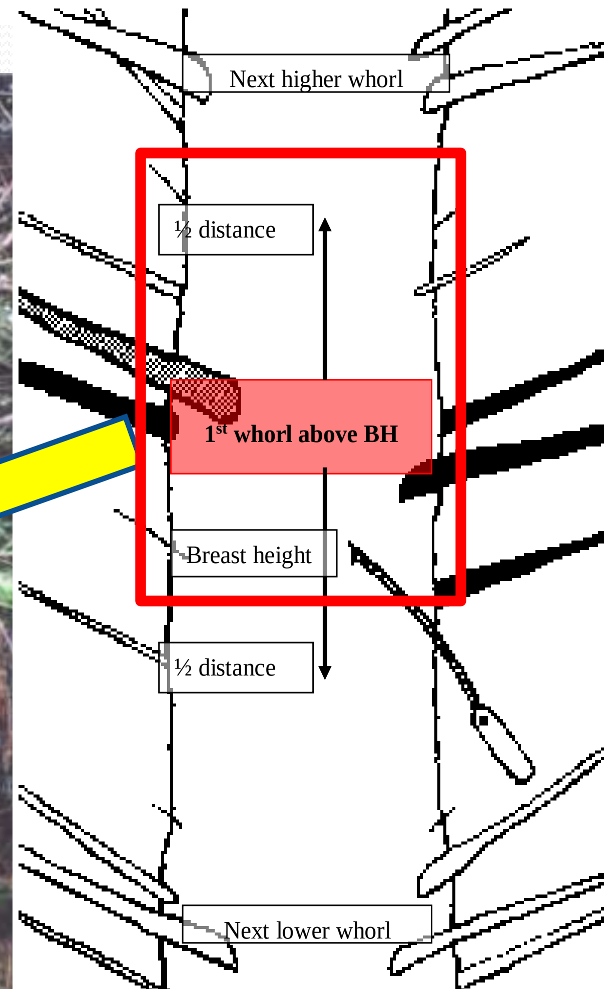


3. Branch (knot) diameter

Diameter of the largest limb in the BH region

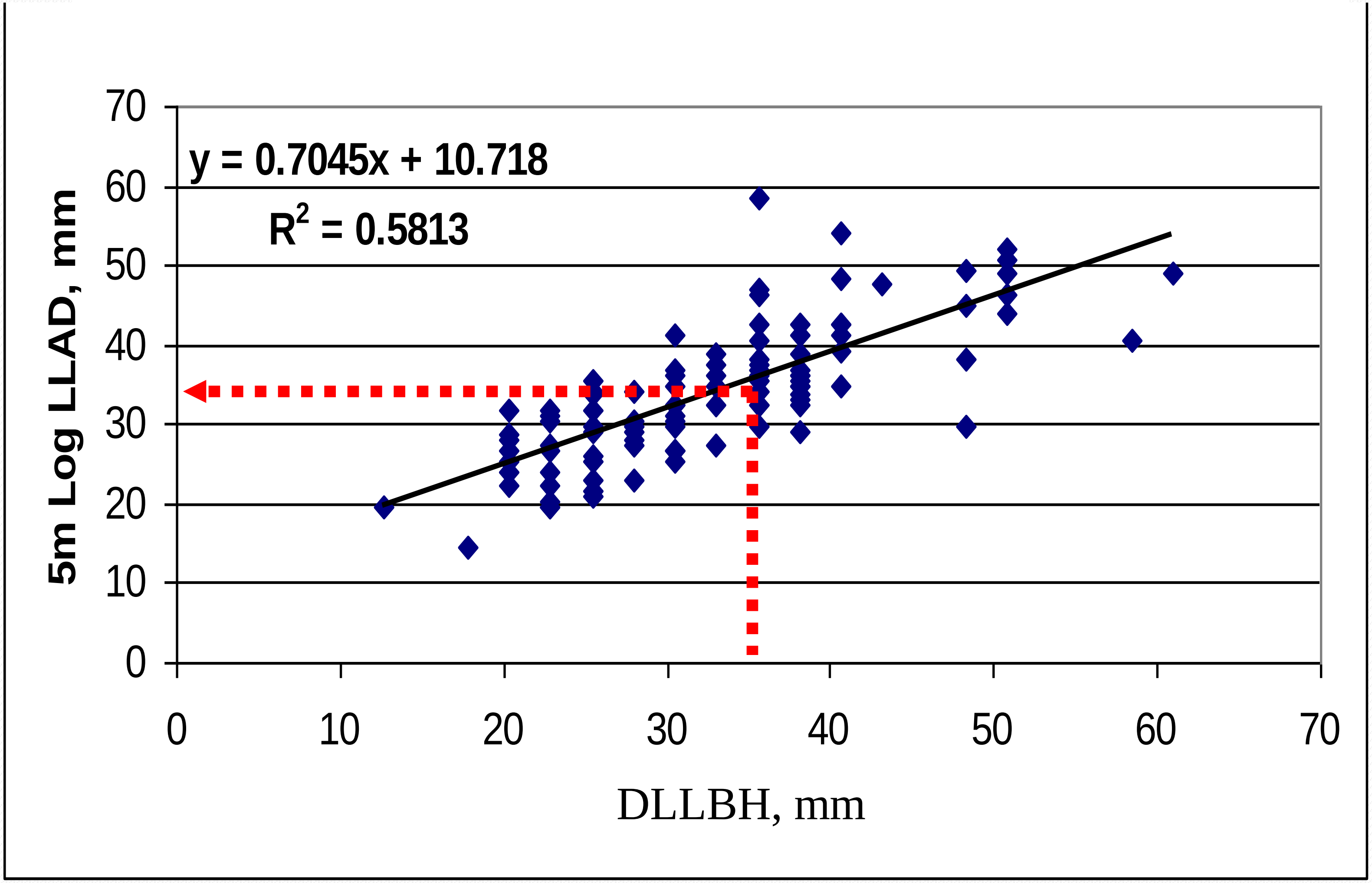
- Find first branch whorl above BH
- Go ½ way to next whorl above and below
- Measure diameter of largest limb (DLLBH)
- Simple and time effective





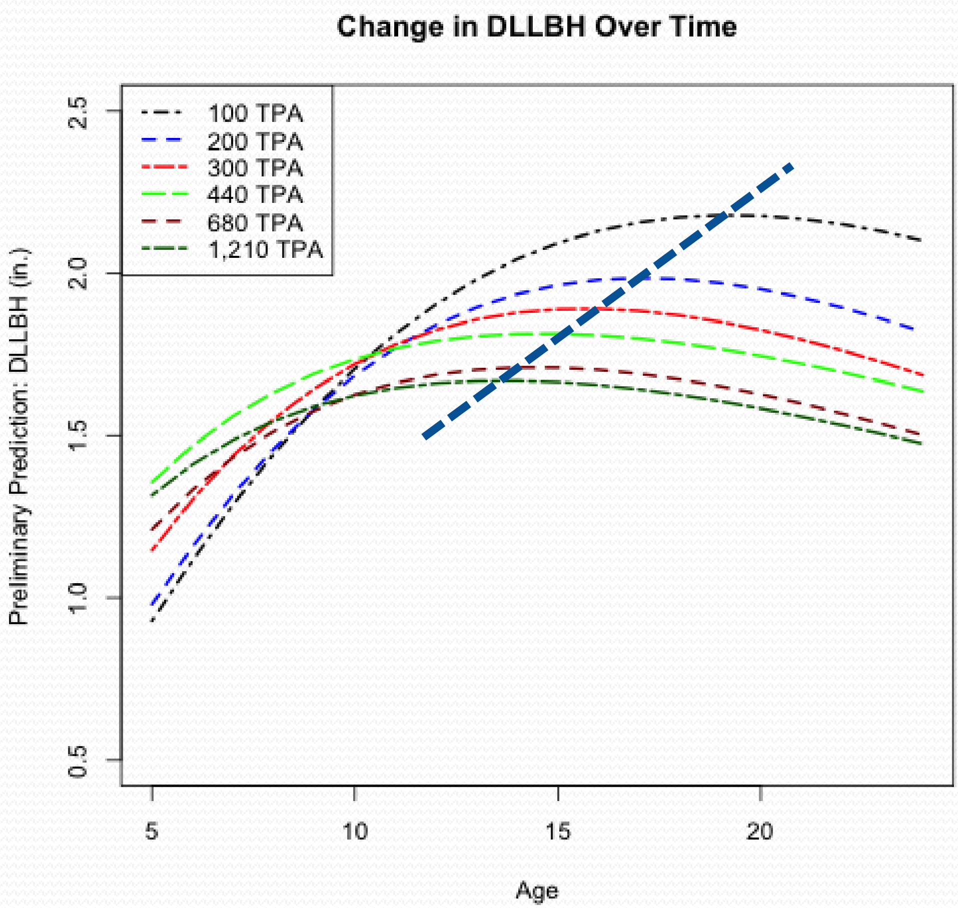
DLLBH is a good predictor of butt log LLAD

LLAD of 5m (16 ft) butt log vs DLLBH of tree , mm



Type III: DLLBH vs Age by TPA

- DLLBH is measured as stem (log) surface
- Before crossover
  - widest spacing had smallest DLLBH but now has the largest & exceeds 2 inches before age 15
- After crossover
  - As TPA decreases ➔ BH branches live longer (slow crown recession) and grow faster
  - Widest spacing now has largest DLLBH which exceeds 2 inches
  - Peak of curve (dashed line) is boundary between when largest branch was alive vs dying/dead



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  - **Assessment of standing tree quality**
  - **Movement to biomass**
- Conclusion
- Q & A

A. Assessment of Standing Tree Quality

- Technology to enable measurement of quality characteristics of standing trees and logs for

  - Sorting (proprietary grades)
  - Inventory, pre-harvest planning, and timber marketing
  - Monitoring stands as part of silvicultural planning
  - Biomass estimation
  - Genetic Improvement programs

1. Branch (knot) diameter

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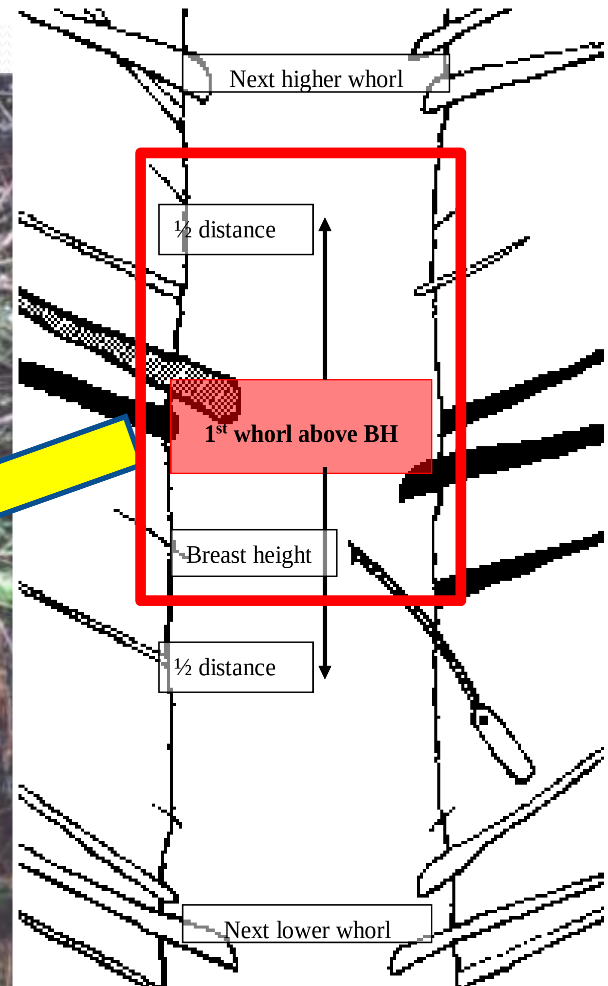


2. Acoustic velocity (stiffness)

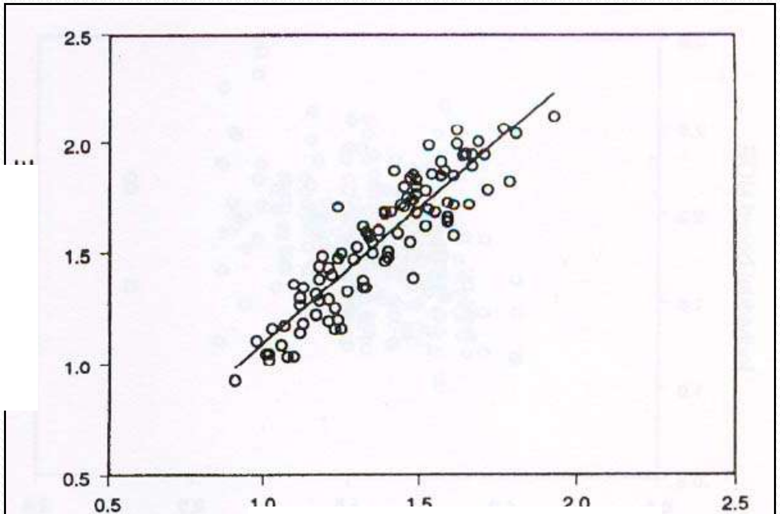
FibreGEN ST-300

Fakopp TreeSonic

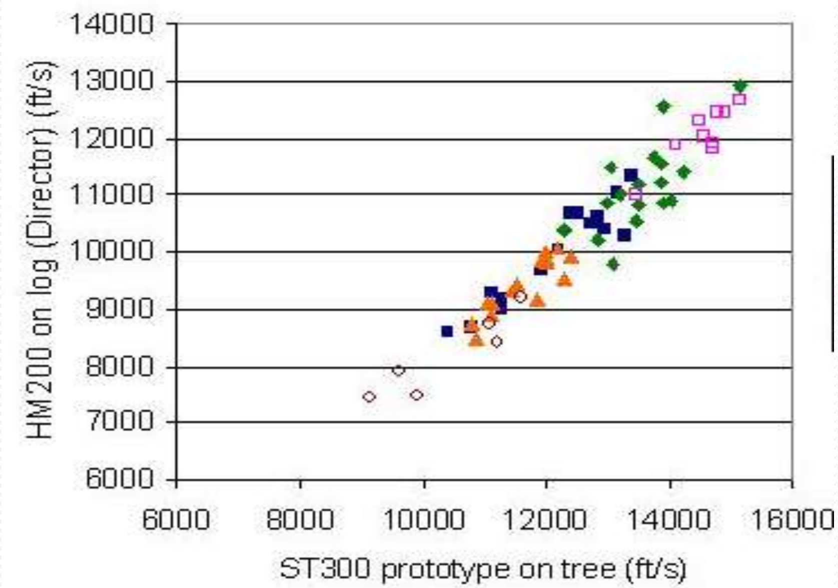
Value Chain Stiffness

- Translate a specification (grade) for product MOE into a specification for log acoustic velocity
  - ➢ Sorting at woods landing, log yard
- Translate a specification (grade) for log acoustic velocity into a specification for tree acoustic
  - ➢ Pre-harvest planning, progeny trials
- **Tree-Log-Product Value Chain**

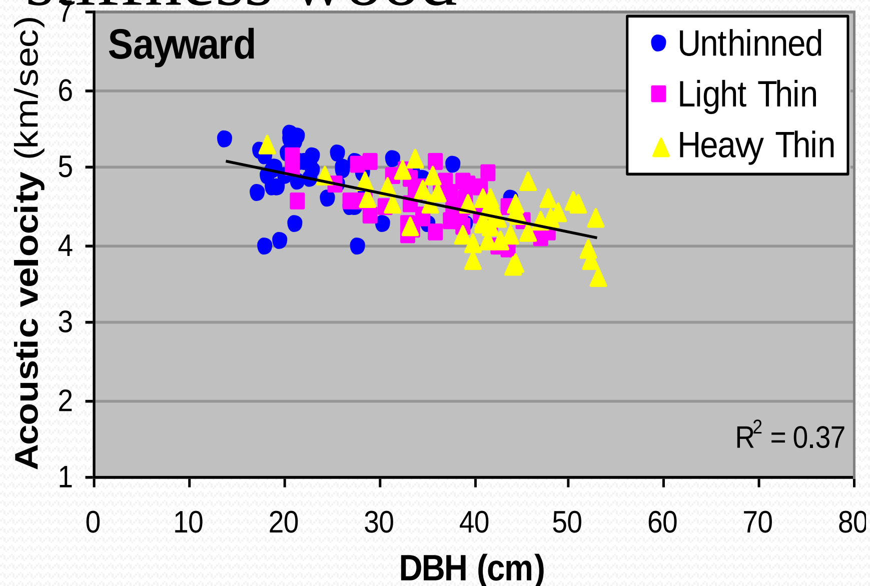
Avg product MOE in log

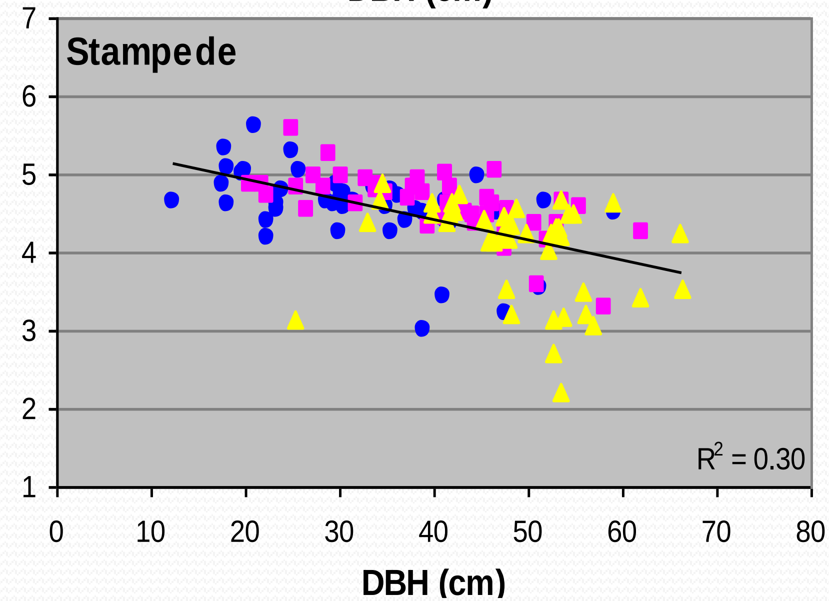


Log acoustic velocity

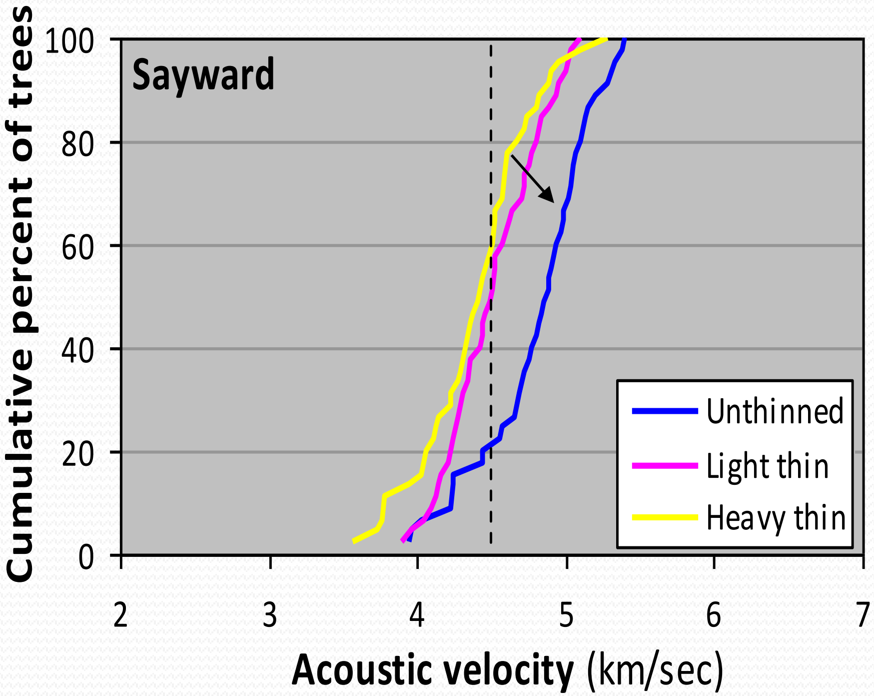


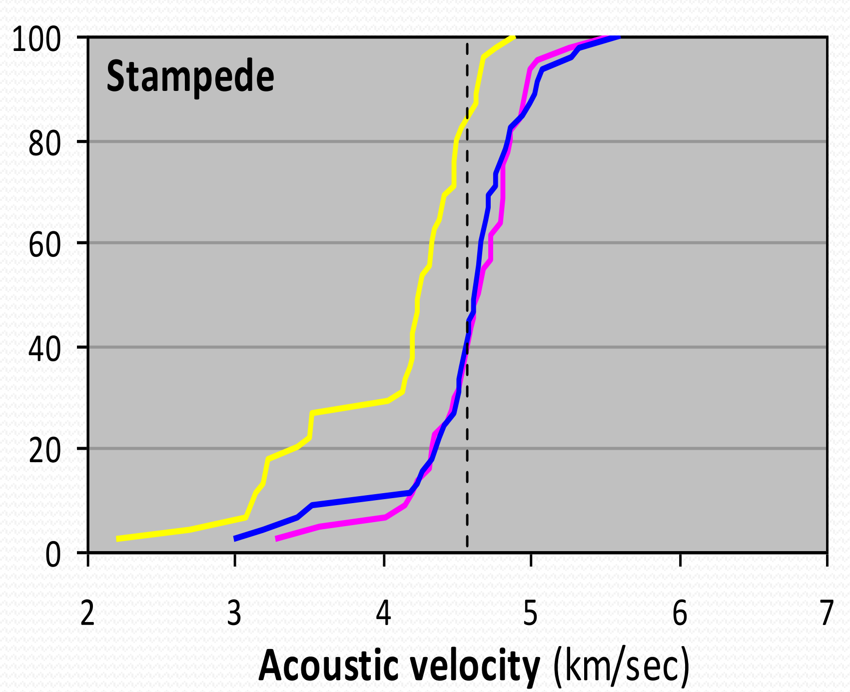
Acoustic velocity↓with↑dbh ➔ for given age/site, faster growing trees contain lower stiffness wood





What % of a stand meets a veneer stiffness spec. limit?





- Sayward:
- % meeting (right of) spec. line
  - 80% of unthinned
  - 50% of light thinned
  - 40% of heavy thinned

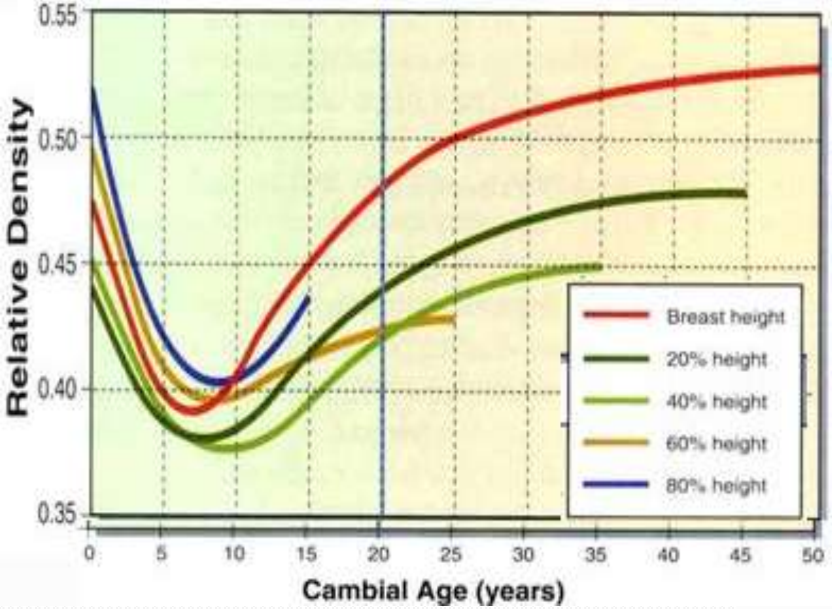
- Stampede:
- % meeting (right of) spec. line
  - 60% of unthinned
  - 60% of light thinned
  - 15% of heavy thinned

B. Biomass

- Shift from volume of stem wood to dry weight
  - 1 kg dry wood = 0.5kg Carbon and 20mj bio-energy
  - Productivity
- **Biomass ➔ o**ven-dry weight of above ground (stem, branches, foliage) and below ground components
  - usually estimated by
    1. Biomass equations (stem, branches, foliage, etc.)
    2. (stem wood volume, ft^3) x (wood density, od lb/ft^3)

    - ✓ Large errors, distorted treatment comparisons
    - ✓ "the magnitude of error associated with using regional average wood density suggests the **importance of using site-specific estimates of wood density**" (Van Tuyl et al.2005)

Specific Gravity (SG, density)



Specific gravity, SG (relative density, basic density

$$= \left[\frac{\text{density of wood}}{\text{density of water}} \right]$$

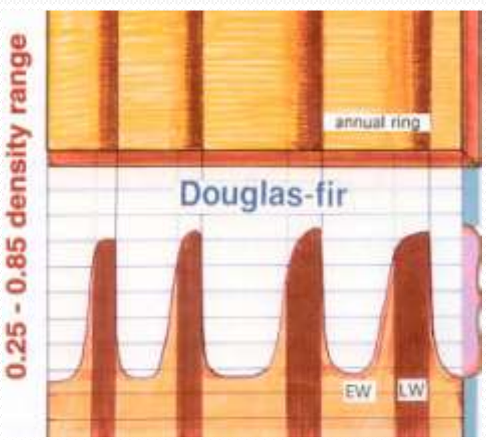
$$= \left[\left(\frac{\text{oven dry weight}}{\text{green volume}} \right) \Big/ \begin{matrix}\text{density of water} \\ (62{,}4\text{lb/ft}^3,\ 1000\text{kg/m}^3)\end{matrix} \right]$$

Wood Quality Indicator

SG is correlated with most other properties of clear wood (ex stiffness, strength)

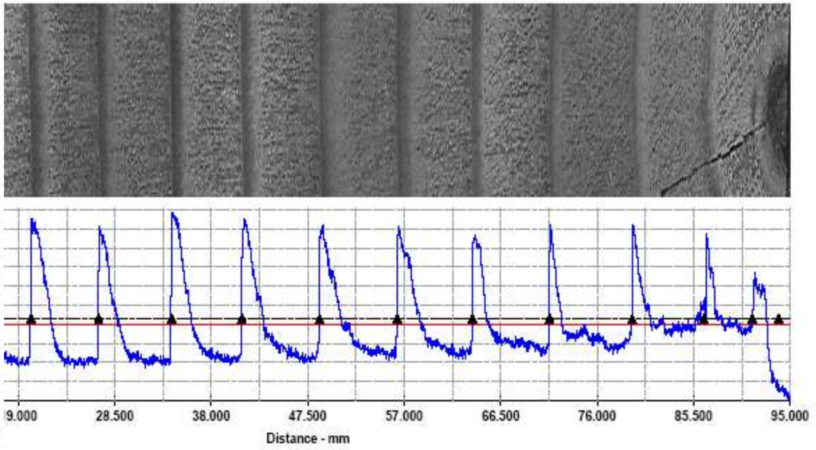
Carbon & energy content

1kg of oven dry wood =
0.5 kg Carbon
20mj energy

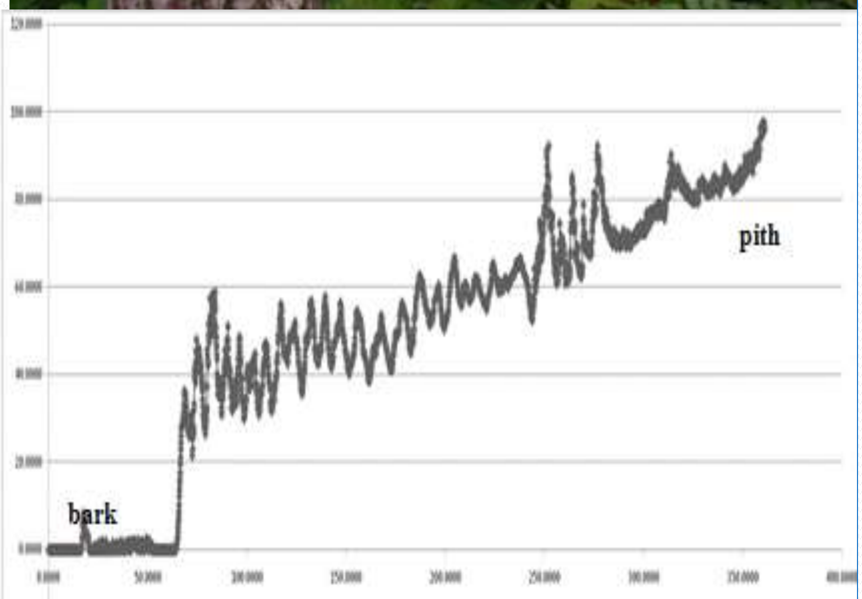


Increment core for SG

Costly, time consuming lab methods to measure SG from cores



Resistance

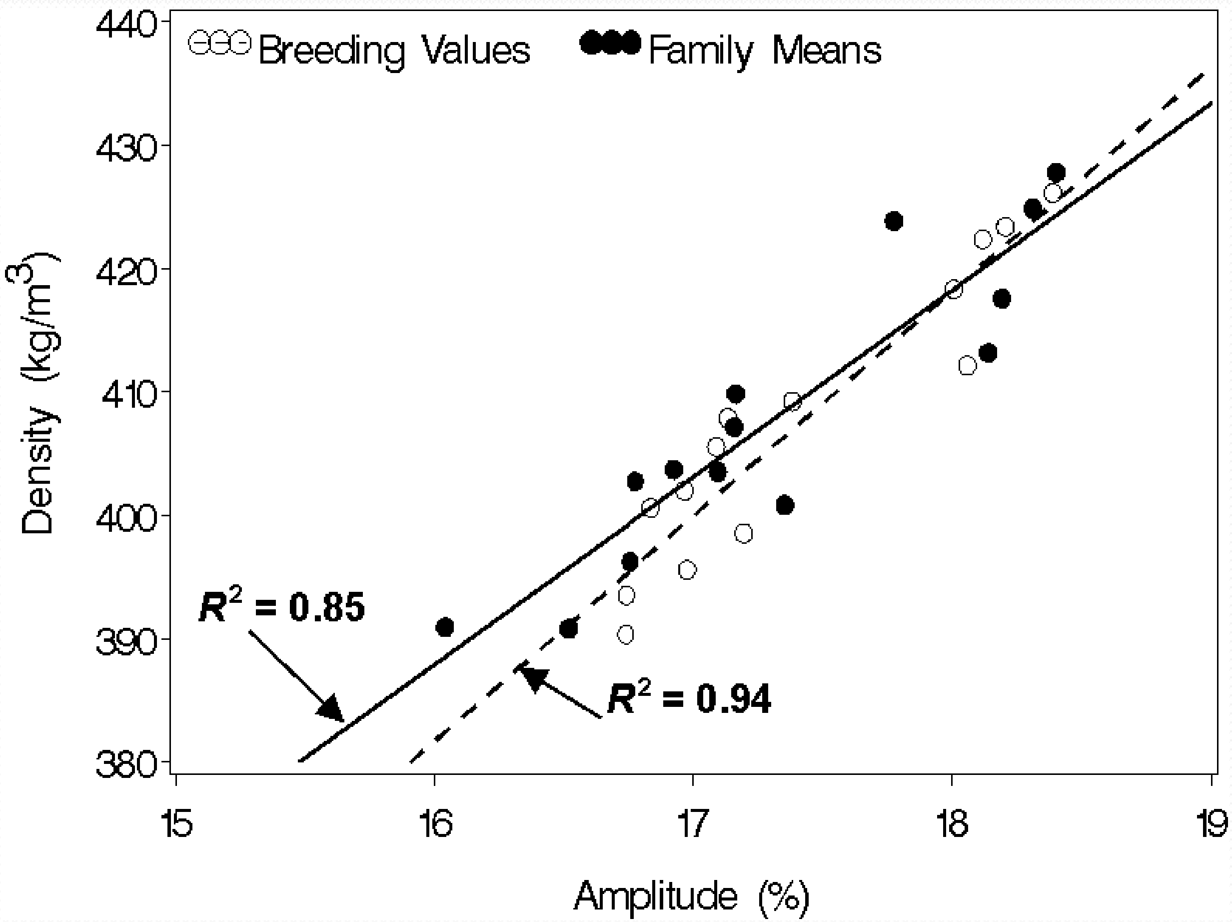


- Similar time as increment core
- Resistance data stored in memory so no costly, long time delay lab work

- Profile
  - ➢ Little resistance by bark
  - ➢ EW/LW resistance variation of rings becomes less near pith (juvenile wood).
  - ➢ increasing resistance with depth into wood
    - ✓ sawdust in the drill hole
    - ✓ drill can bend as it travels through the wood

Resistance estimates increment core SG

routine, local assessment of SG for stem biomass



Fikret Isik, F., B Li. 2003. Rapid assessment of wood density of live trees using the Resistograph for selection in tree improvement programs. Can. J. For. Res. 33: 2426–2435 (2003)

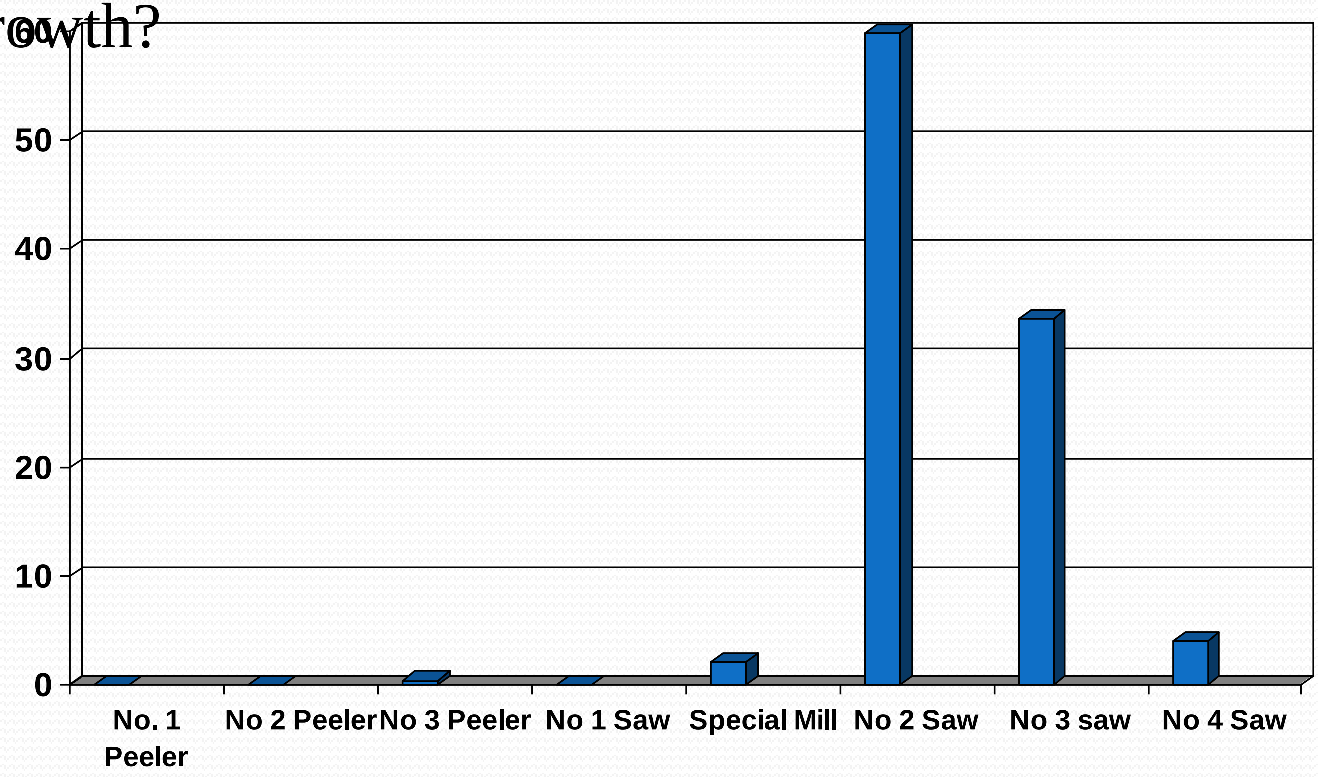
Concluding Remarks

- Type III-like plantations are out-performing predecessors.
- Those we are now planting are growing faster that Type III's due to improved genetics, improved seedling quality from nurseries, improved control of competing vegetation so seedlings can express growth potential immediately
- He consequence is that merchantable size trees can e grown in a much shorter time so rotation length has decreased.

Concluding Remarks

- **There is a problem with the Peeler/Sawlog grading system.**

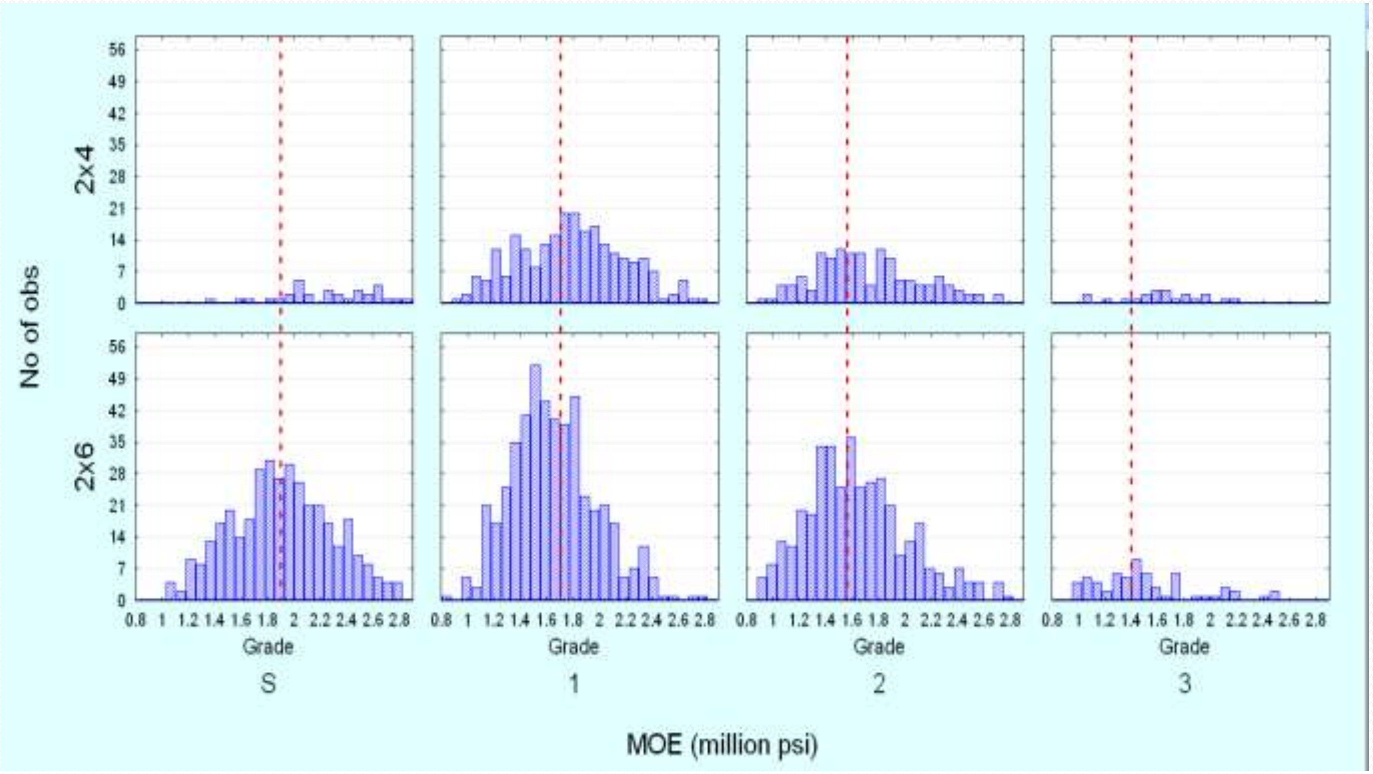
Why do we continue to use a system that was designed for old-growth?



Concluding Remarks

- **There is a problem with end product quality.**

Only half of lumber meets the visual grade MOE design value (right of vertical lines). As the large tree short rotation phenomenon collides with juvenile wood & large knots



Concluding Remarks

- **New Technologies Provide Affordable Means to Quantify Some Wood Quality Characteristics and Incorporate them into Better Planning**

1. Trees
    - Pre-harvest inventory
    - Stratifying and assessing conformance to specifications
    - Timber sales/purchases
    - Planning and monitoring effects of silvicultural treatments
    - Harvest planning and marketing
    - Genetic improvement
2. Logs
    - Sort at landing
    - Sort in Mill Yard

Questions ➔ www.standmgt.org