Appendix A

STAND MANAGEMENT COOPERATIVE SPRING MEETING
May 8th 2013, 8:30- 4:00
Heathman Lodge, Vancouver, WA

May 8	AGENDA
8:30	Coffee & Rolls
9:00	Welcome & Introductions: *Dean Stuck*, Policy Committee Chair; *Greg Ettl*, Director 1. Sierra Pacific
9:10	Accomplishments 1) 2012 at a glance ✓ Budget ✓ Research highlights ✓ SMC member visits ✓ External funding 2) Meetings ✓ Policy Advisory Committee (PAC) Meetings ✓ Installation Review Committee (IRC) ✓ Review Measurements Approach Committee (RMA) ✓ Technical Advisory Committee (TAC) ✓ CAFS Annual Meeting, St. Simons Island, Georgia
	Technical Reports
9:25	Wood Quality TAC Report-Eini Lowell, Wood Quality Project Leader
9:35	Nutrition TAC Report-Rob Harrison, Nutrition Project Leader ✓ Plot based paired tree studies ✓ Student updates
9:55	Modeling TAC Report-Dave Marshall, Modeling Project Leader
10:05	Silviculture TAC Report –Eric Turnblom, Silviculture Project Leader ✓ CAFS Type IV ✓ Technical reports, modeling methods ✓ Student updates
10:25	**Break**
10:40	Tim Harrington, (PNW Research Station), *Matlock and Molalla long-term soil productivity studies*
11:00	Doug Mainwaring, (OSU Faculty Research Assistant*), Summary of current results from the Giustina fertilization trials*
11:20	Doug Maguire, *CIPS development of modifier functions for estimating direct effects of respacing, thinning, and fertilization on individual-tree*
11:40	Student Presentations 1) Jason James, (MS student, Harrison), *Status of paired-tree study for predicting response to fertilizer* 2) Stephani Michelsen, (PhD student, Harrison), *15N tracer to track fate and efficiency of N fertilizer*
12:00	**Lunch**

1:00	Director's Introductory Preface: SMC Budget and Research 1) RFP's a. Eini Lowell b. Eric Turnblom
11:10	Eini Lowell, Wood Quality Project Leader RFP PROJECT TITLE: *Wood Quality Measures of Trees from SMC/CIPS Paired-Tree Fertilization Projects*
11:30	Eric Turnblom Silviculture Project Leader RFP PROJECT TITLE: *Stand and Tree Response to Varying Timing and Intensity of Pre-Commercial Thinning*
1:50	Director's Comments 1) Policy Advisory Committee Meeting Summary 2) Budget and research limitations
2:00	**Break**
2:10	Discussion on proposals
2:40	1) 2013 Plans ✓ Working toward SMC products ✓ Separate TAC Meetings for Nutrition and Silviculture June/July 2013 ✓ RFP Continuation August 2013 ✓ Budget, BLM ✓ SMC September fall meeting ▪ Location, date, structure, any interests in a half day workshop ▪ Using the Type I, II, III models web interface 2) Other Meetings, Conferences, & Workshops ✓ IUFRO-Darly Lederle, USFS
3:00	Other Business
3:30	Adjourn

Wood Quality TAC Report

SMC Spring Meeting

May 8, 2013 Vancouver, WA

Agenda 2020 (2004) data

Update on lumber analysis

In preparation:

Characteristics of Douglas-fir lumber produced under various thinning regimes

Lowell, E.C., Huang, C.L., Briggs, D.G. and Dykstra, D.P.

Agenda 2020 (2004) data

Update on (veneer) analysis with SCION

Submitted to New Zealand Journal of Forestry Science:

Lowell, E.C., Todoroki, C.L., Dykstra. D.P. and Briggs, D.G. "Linking acoustic velocity of standing Douglas-fir trees to veneer stiffness: a tree-log-product study across thinning treatments"

(based only on veneer data from Installation 803, Beeville Loop)

In preparation:

Analysing x-ray densitometry profiles for thinning response

Upcoming presentation and proceedings paper:

Lowell, E.C., Todoroki, C.L., Dykstra, D.P., Briggs, D.G. "Examination of acoustic velocity along veneer value-chain in Douglas-fir trees".

18th International Nondestructive Testing and Evaluation of Wood Symposium. Madison, WI (9/24-27/2013)

LOGS Study Update

Figure 1.—Locations of levels-of-growing-stock study installations.

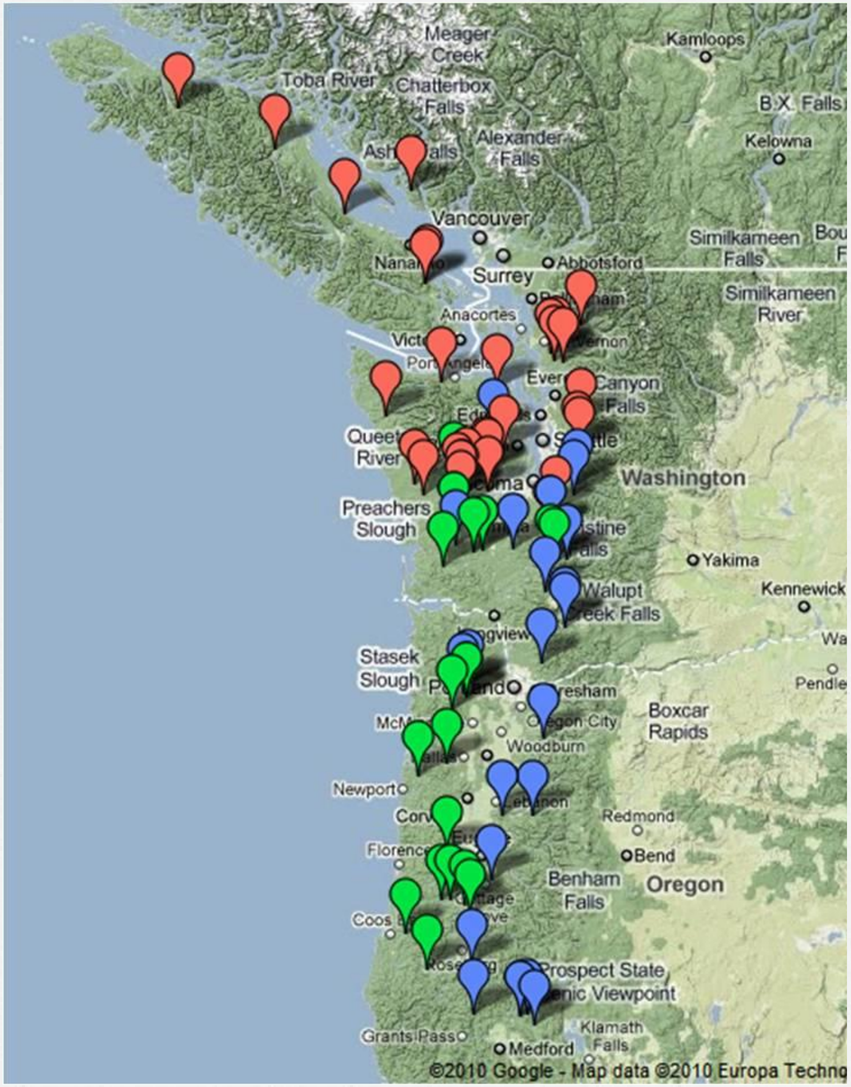
- CJFR manuscript to be submitted May 2013 for special issue from IUFRO conference last July
  - "Modeling regional and climatic variation of annual wood quality attributes in intensively managed Douglas-fir forests in the Pacific Northwest."
- Abstract offered to IUFRO:
  - "Measurement methods and Modeling approaches for predicting desirable future Wood properties"

  Nancy, France October 2013

CAFS Type IV Update

Eric Turnblom has provided a project summary that is contained in the handouts.

Agenda 2020 (2008) Type V Installations



aka Paired Tree Study
SMC-CIPS

Wood quality work started on two high responding CIPS sites (Sweet Home and Vernonia Oregon)

SMC – OSU CIPS – PNW cooperative effort

Graduate student (MS) Luyi Li working on project with Eric Turnblom

Proposal to SMC developed

"Wood Quality Measures of Trees from SMC/CIPS Paired-Tree Fertilization Projects"
(Lowell, Turnblom, Maguire)

- Original intent on Type V was to include collection of WQ data
- WQ TAC was able to coordinate destructive sampling of Douglas-fir trees with Doug Maguire to obtain samples.
- This proposal would increase the number of samples and provide data from SMC Type V installations
  - high responders: 9 installations stratified by 3 soil type (3 installations/soil type)
- Proposal to be presented later at this meeting

Manuscript

Lowell, E.C., Maguire, D., Briggs, D.G. Turnblom, E.C., Jayawickrama, K., Bryce, J.

“Effects of genetics and silviculture on branch/knot attributes of Coastal Pacific Northwest Douglas-fir.”

Invited submission to Canadian Journal of Forest Research based on presentation by Maguire at the IUFRO All-Division 5 Conference, Estoril, Portugal July 2012.

To be submitted May 2013

Northwest Advanced Renewables Alliance

- ❖ This is part of a larger AFRI (Agriculture and Food Research Initiative) grant to produce aviation jet fuel from biomass that has both a westside and eastside feedstock component

- ❖ Feedstock team testing Douglas-fir trees from SMC Type I installation buffer zones

UPDATE:

- ❖ Logging slash (tops and limbs) from west side Douglas-fir forests in Oregon and Washington the focus of raw material suuply for the next pilot supply chain coalition.

SMC NARA members:

- ❖ Doug Maguire and Greg Johnson, Feedstock
- ❖ Rob Harrison, Feedstock, Sustainability Measurement
- ❖ Eini Lowell, Outreach Team

Wood Quality TAC meeting held jointly with other TACs in Vancouver, WA in January 2013.

Proposed Strategy (or is a WQ TAC really needed?)

- Continue to work with other TACs to build in wood quality components (e.g. Agenda 2020 paired tree study)

- Work with academic institutions to support graduate students interested in wood quality projects

Appendix C

SMC Nutrition Report

Spring 2013 meeting,

Vancouver, WA

SMC Nutrition Report, Spring, 2013

Rob Harrison, nutrition head

1) **Paired-Tree - Jason James**
2) **15N – Stephani Michelsen-Correa**
3) Fall River/LTSP studies
4) Student Updates, funding
5) Plot-based paired-tree studies

http://www.forestsoils.org/publications/SMC-2013Spring/

SMC Type V

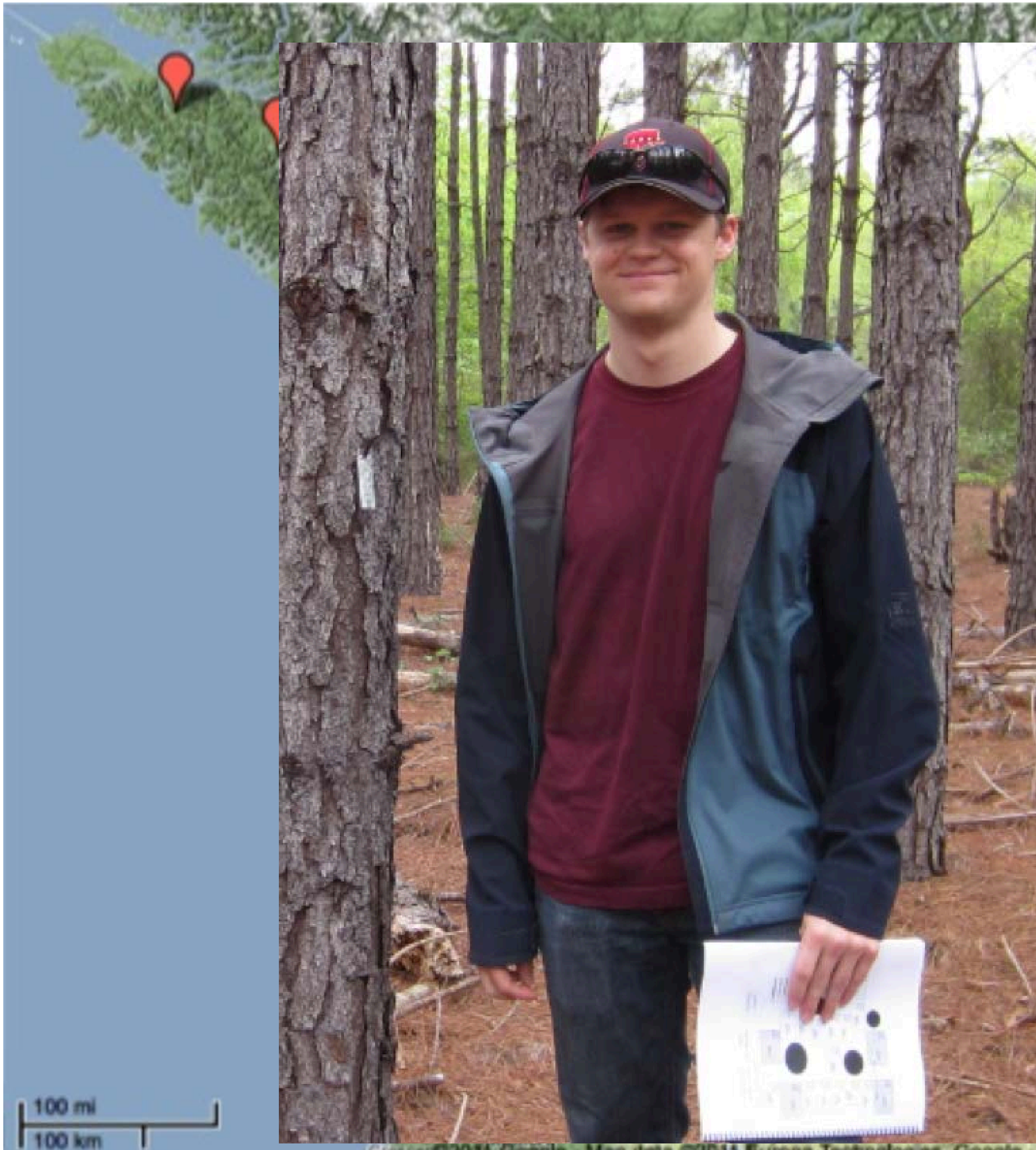
paired-tree study sites

<u>Soil origin:</u>

Red = glacial

Blue = volcanic

Green = sedimentary



Type V

-tree study sites

igin:

glacial

volcanic

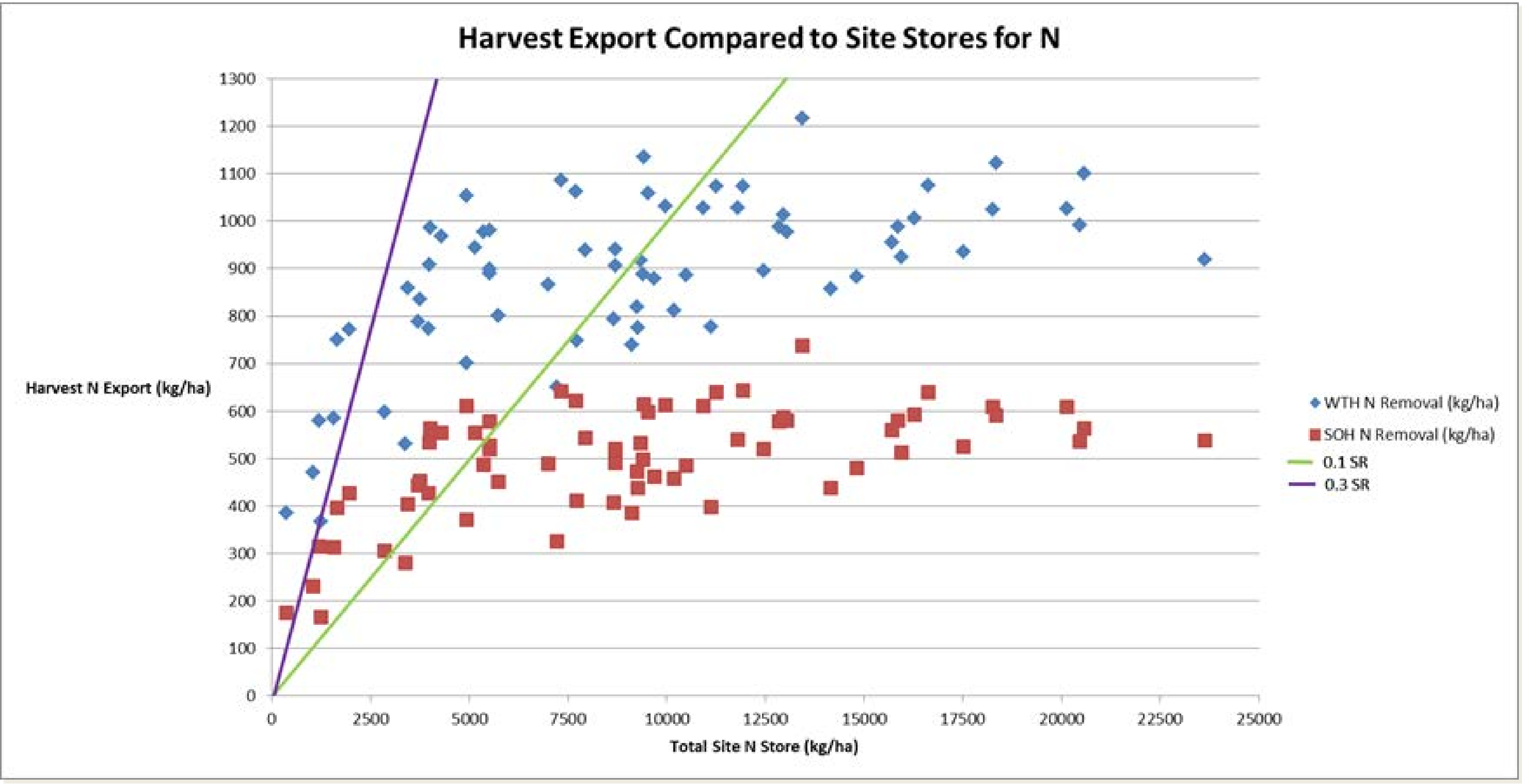
= sedimentary

Risk to Long-term Site Productivity Due to Whole-tree Harvesting in The Coastal Pacific Northwest

Austin Himes thesis work, now working for Greenwood Resources,

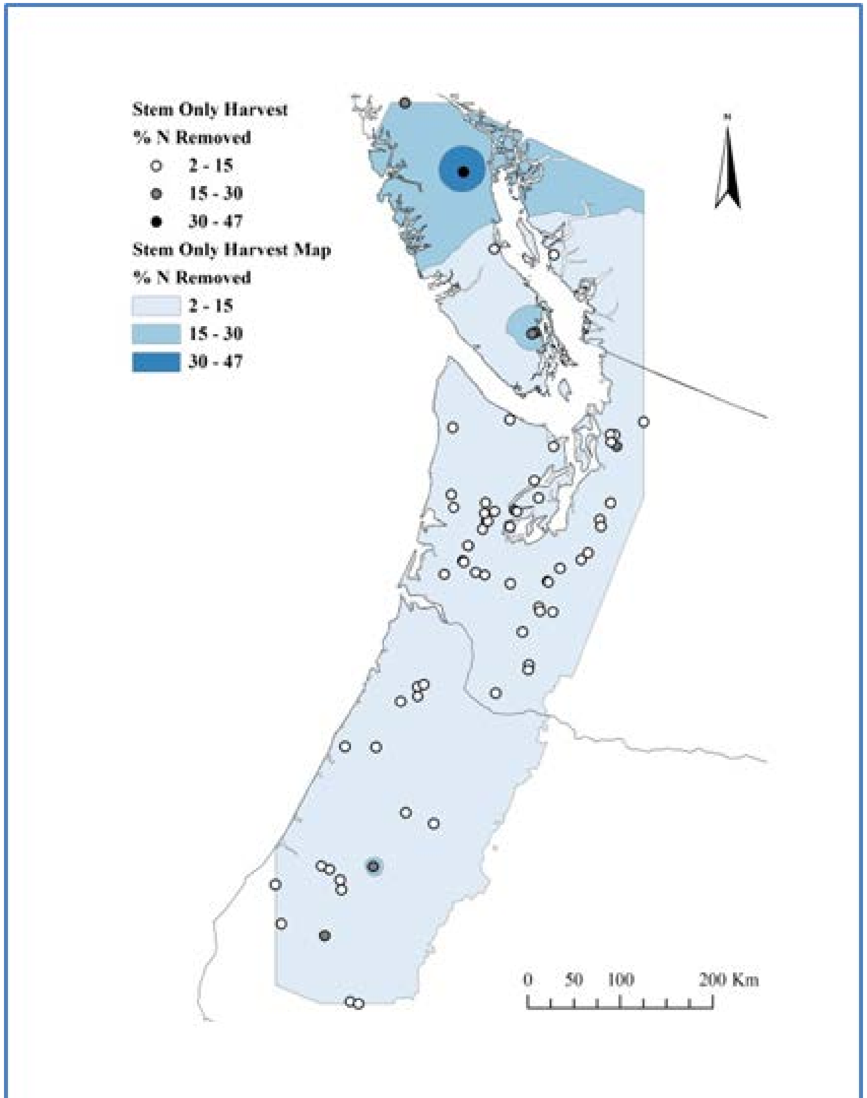
Forest Science, accepted with rewrite (minor and "no edits")

Results



Harvest Export Compared to Site Stores for N
Harvest N Export (kg/ha)
Total Site N Store (kg/ha)
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
0
2500
5000
7500
10000
12500
15000
17500
20000
22500
25000
WTH N Removal (kg/ha)
SOH N Removal (kg/ha)
0.1 SR
0.3 SR

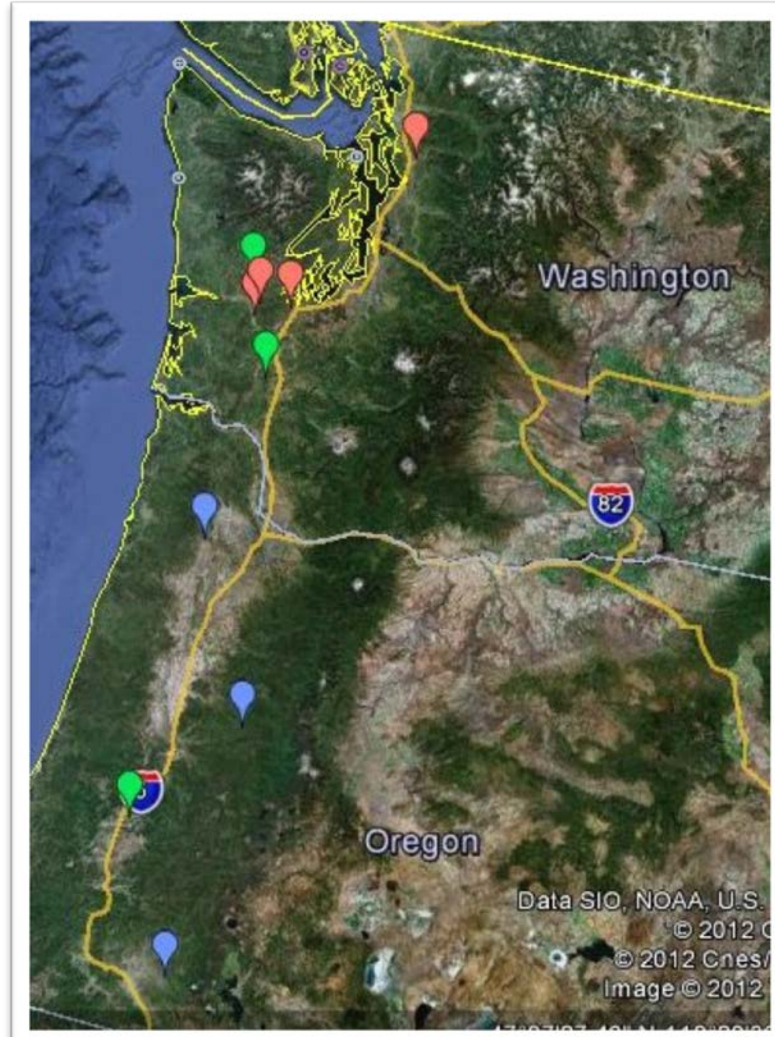
Results



Stem Only Harvest
% N Removed
2 - 15
15 - 30
30 - 47
Stem Only Harvest Map
% N Removed
2 - 15
15 - 30
30 - 47
N
0 50 100 200 Km

Paired Tree Study and 15N

- Objectives:
  - Quantify amount of fertilizer N distributed to each ecosystem component and compare among four different types of N fertilizers (3 controlled release) over a 1 year period
  - Determine the effectiveness of three controlled-release urea fertilizers in minimizing volatilization loss



Sites selected from subset of SMC Paired Tree Study

Pa d 15N

- Objectiv
  - Quant
    N distr
    ecosys
    compa
    differe
    fertiliz
    releas
  - Deterr
    of thre
    urea fe
    volatili

from subset of SMC Paired Tree Study

Harvest intensity and competing vegetation control have little effect on soil carbon and nitrogen pools in a Pacific Northwest Douglas-fir plantation

Erika J. Knight

A thesis submitted in partial fulfillment of the requirements for the degree of

Master of Science

University of Washington
2013

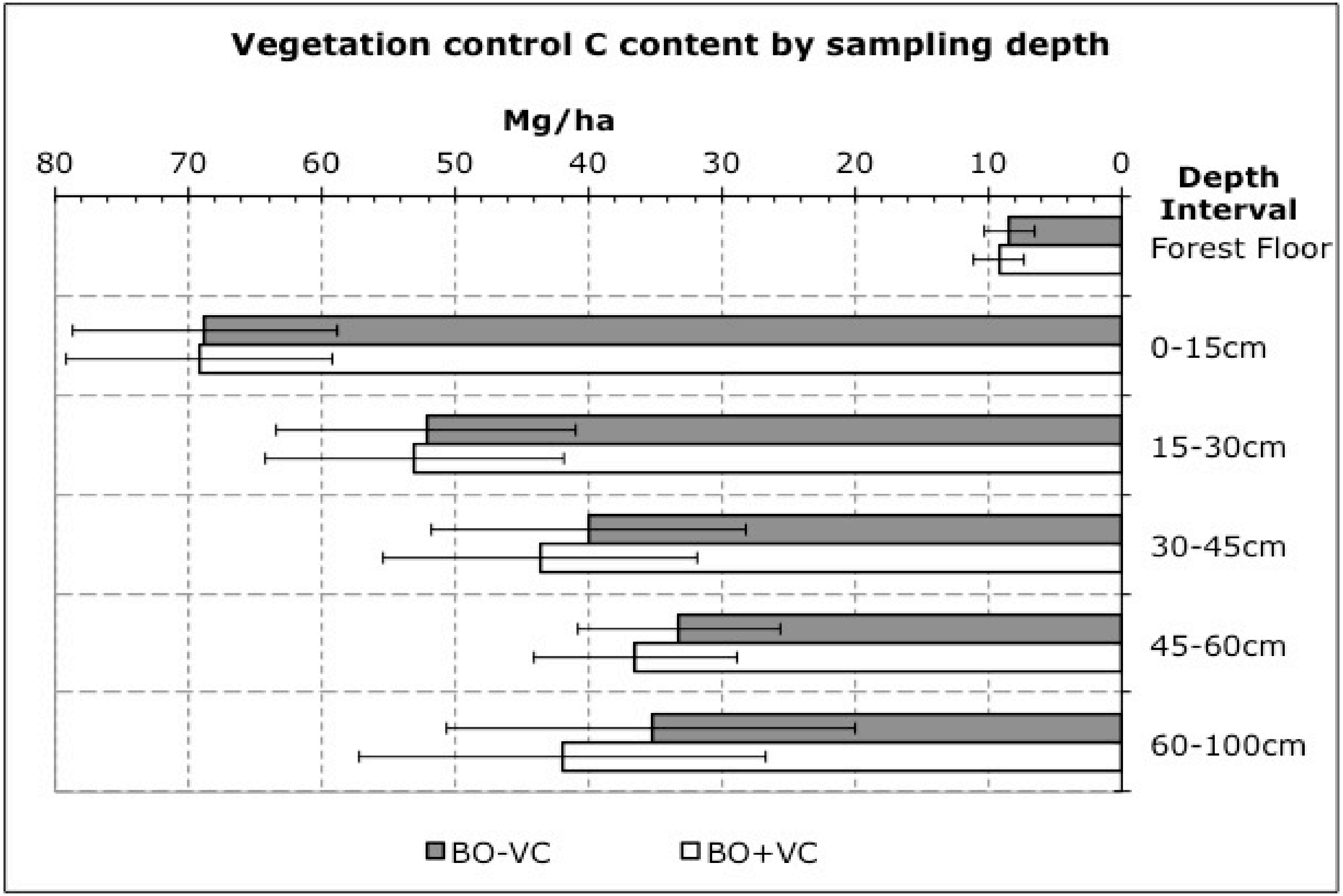
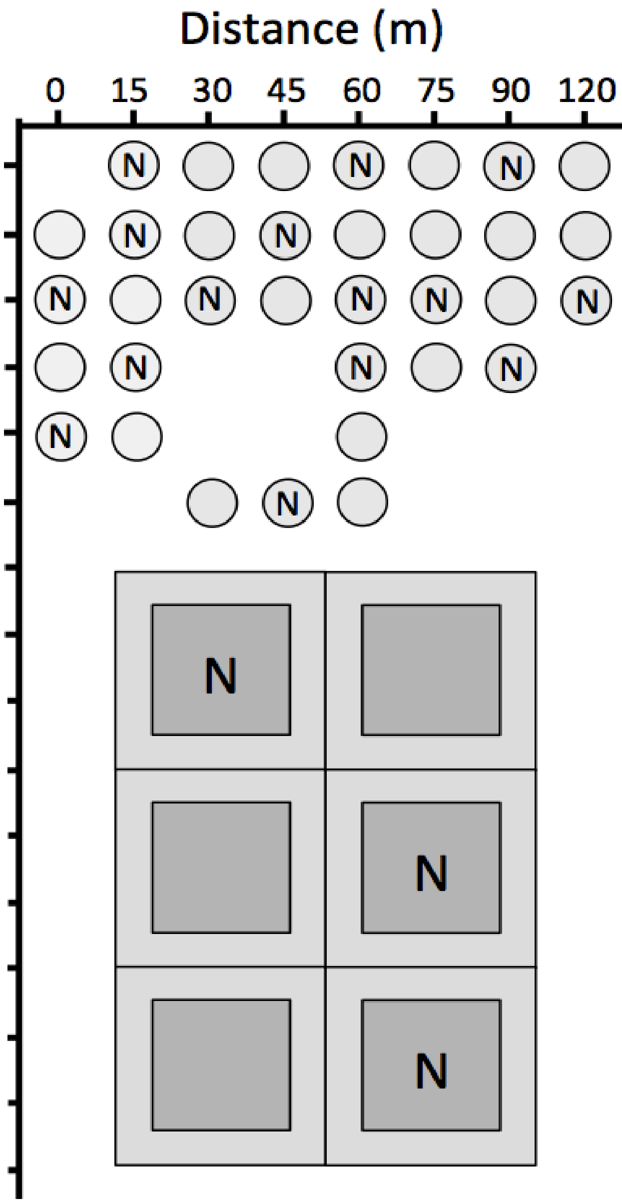


Figure 3. Mean treatment values for carbon content by depth interval for the vegetation control comparison. Error bars represent the 90% confidence interval around the mean. There were no significant differences between treatments (α=0.10).

New Initiatives/Future Research/Grads/Resources

- $20K NCASI for 2013
- Approx $300K/y equiv. TA/Gessel fellowships greatly increased
- partial salary buyback by UW Extension for Rob 3 months per year, about $30K to spend on SMC work
- funding of $195,000 for 15N work, Fox et al. will pay for 15N and analysis for SMC paired-tree sites; rated #1 in all of proposals presented at CAFS meeting this year
- bioenergy grant from USDA, $321K to SMC, also funding to OSU and Weyerhaeuser for biomass work, new Springfield OR site located and work is underway
- Erika Knight, Betsy Vance graduating.
- Three graduate students added in 2012 continuing in 2013: Stephani Michelsen-Correa (PhD), Jason James (MS) and Marcella Menegale (PhD). Three new to be added, Christiana Dietzgen (PhD), Erin Burke (MS) and Matt Norton (MS).
- Two presentations at CAFS, five at NAFSC, five at SSSA, other conferences and meetings



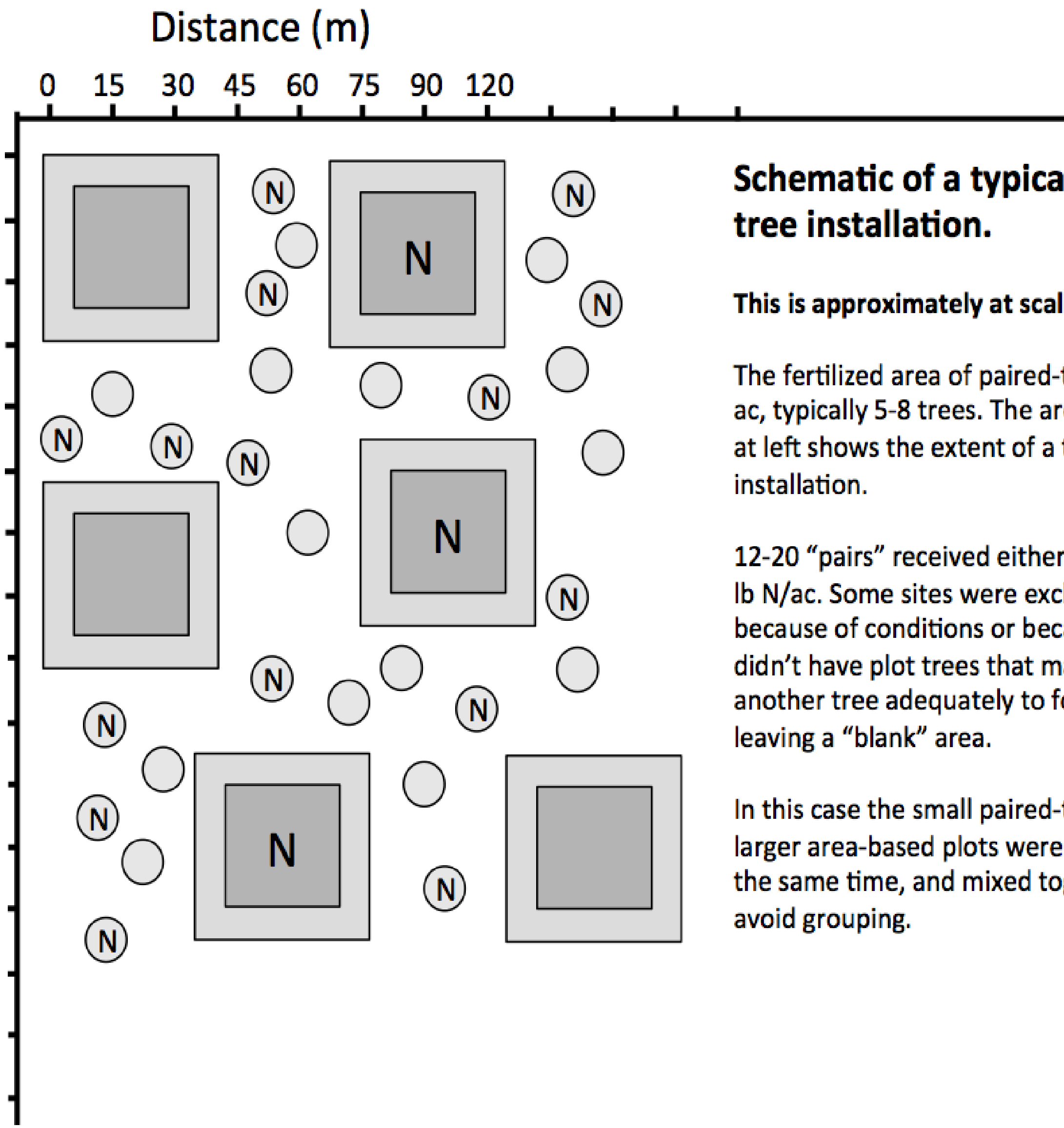
Schematic of a typical paired-tree installation.

This is approximately at scale.

The fertilized area of paired-tree plot 0.02 ac, typically 5-8 trees. The area of circles at left shows the extent of a typical installation.

12-20 “pairs” received either no N or 200 lb N/ac. Some sites were excluded because of conditions or because they didn’t have plot trees that matched another tree adequately to form a “pair”, leaving a “blank” area.

The proposed inclusion of six 0.2 acre measurement plots (3 control and 3 200 lb N/ac) would require an area typically larger than most paired-tree installations use.



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In this case the small paired-tree and larger area-based plots were located at the same time, and mixed together to avoid grouping.

Appendix D. First-cut (Bob Gonyea's analysis) of potential areas that could house six 1/5 acre plots with 25 ft buffers. About 27 sites appear to have this potential, but it will take further work, including cooperator input and perhaps site visits, to be sure.

Type V Potential for Additional Plots

Inst. #	Name	Potential for fixed plots
821	Adna 1 (flat)	Site has been destroyed by 2011 ice storm. Paired tree installation dropped
822	Adna 2 (slope)	Site has been destroyed by 2011 ice storm. Paired tree installation dropped
823	Arrowhead Lake	**Possibly**
824	Oppiet Rd	**Possibly**
825	Cherry Grove 1 (flat)	Not enough room
826	Cherry Grove 2 (slope)	Not enough room
827	Nestucca	**Possibly**
828	Bunker Creek	Site has been destroyed by 2011 ice storm.
829	Grants Pass	**Possible**
830	Weikswoods Flat	Site has been destroyed by 2011 ice storm. Paired tree installation dropped
831	Rancho Ranchera PP	Ponderosa Pine
832	Clarke Creek PP	Ponderosa Pine
833	Clarke Creek DF	Not enough room
834	Dudley	Not enough room
835	Weikswoods Slope	Site has been destroyed by 2011 ice storm. Paired tree installation dropped
836	Rabbit Creek	**Possibly**
837	Mill Creek #2	Stand around Paired tree installation was thinned 2 years ago
838	Star Lake	**Possibly**
839	Russel Ranch	**Possibly**
840	Coyote Ridge	Not enough room
841	Cascadia	Not enough room
842	Scott Mountain	Not enough room
843	DeVore Mountain	**Possibly**
844	Brush Creek	**Not enough room**
845	Hanes Ranch	This is one of the sites that has permanent plots already
846	Armstron-Janicki	Stand was thinned after we put in Paired tree study
847	Victoria	Not enough room
848	McKinely	**Possibly (but not ideal)**
849	Pender Harbor	Canadian Installations
850	Steel Creek	Canadian Installations
851	Upper Campbell	Canadian Installations
852	Fanny Bay	Canadian Installations
853	Copper Canyon 1	Canadian Installations
Inst. #	**Name**	**Potential for fixed plots**
855	Buck Lake	Not enough room

Type V Potential for Additional Plots

856	Murphy	Not enough room
857	Cherry Valley	**Possibly**
858	Tiger Lake	**Possibly**
859	Duckabush	Not enough room
860	Lake Aldwell	Not enough room
861	Disco Bay	Not enough room
862	Electron	**Possibly**
863	Buckley	Not enough room
864	Oil City	**Possibly**
865	Hoquim Road	**Possibly**
866	Battleground	**Possibly**
867	Cougar	**Possibly**
868	McClellan Mt.	Not enough room
869	Mitchell Hill	**Possibly**
870	Newaukam Creek	Not enough room
871	Echo Glen 2	Not enough room
872	Mineral 2	Not enough room
873	Tilton River West	**Possibly**
874	Morgan Creek	**Possibly**
875	Old River Road	Not enough room
876	Tilton River East	Not enough room
877	Wood Road	Not enough room
878	Les Smith	**Possibly**
879	Black Rock 2	**Possibly**
880	Mitchell Creek	Not enough room
881	East Humptulips 2	Possibly
882	Upper Rock Creek	Not enough room
883	Alderbrook C.C.	Not enough room
884	Carson Lake	Not enough room
885	Stoner	**Possibly**
886	Beeville rd. South	**Possibly**
887	St. Helen's	Not enough room
Inst. #	**Name**	**Potential for fixed plots**
888	Fall River Fertilization	**Possibly**
889	Deadhorse	Not enough room
890	Ditch creek road	Not enough room

Type V Potential for Additional Plots

891	Red Hill	**Possibly**
892	Castle Rock	**Possibly**
893	Frozen Creek	This is one of the sites that has permanent plots already

Appendix D

SMC Silviculture Project Report

Eric C. Turnblom

Silviculture Project Leader

Stand Management Co-op (SMC)

SMC Spring Meeting, 8 May 2013

Vancouver, WA

Silviculture Project Status

- CAFS Project: WQ Traits in GGTIV
- Technical Reports
- Student Updates

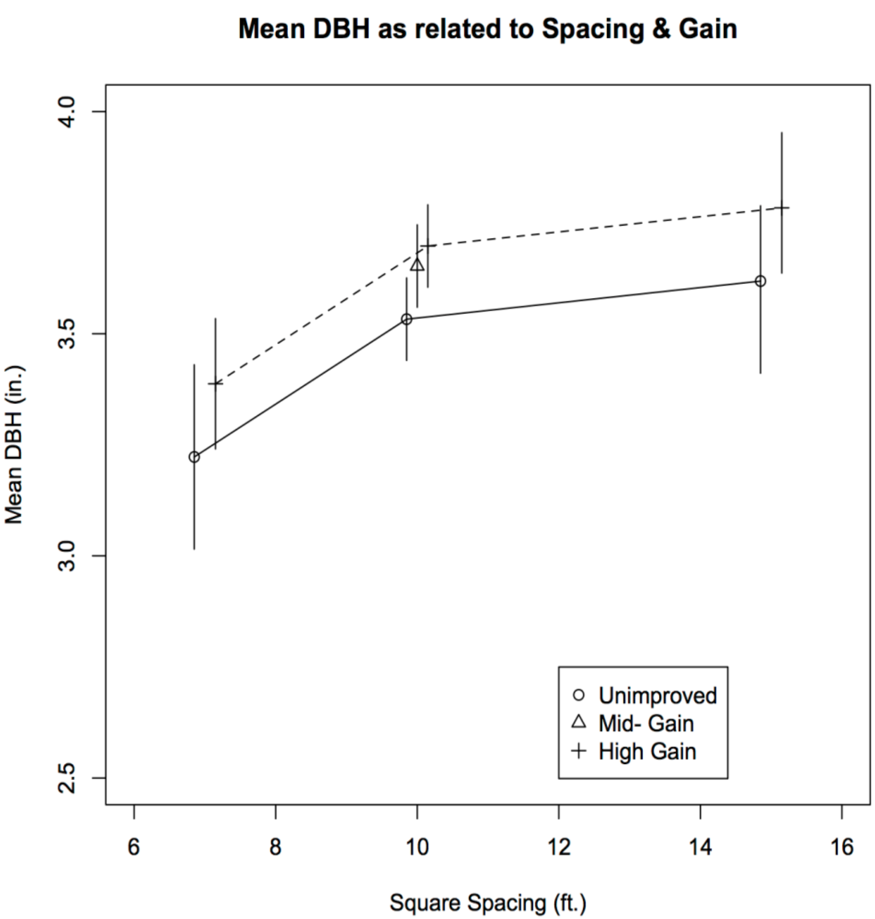
CAFS Project: WQ Traits in GGTIV

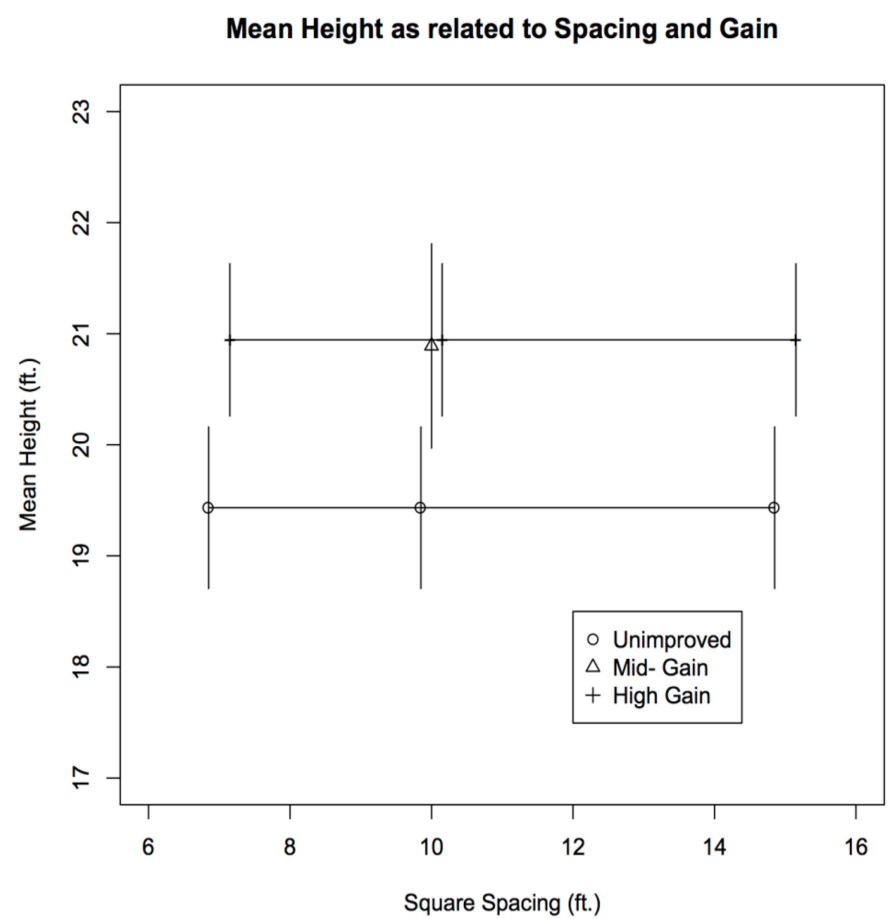
- RATIONALE: Several factors are known to affect the key wood quality traits of knot size, stiffness, density
  - Genetic selection for growth rate
  - Spacing of trees
  - Intensive early weed control
- The impacts of these factors are not well understood
- OBJECTIVE: To determine the extent of the impacts of these three factors on wood traits singly and in combination with each other; with further monitoring, determine degree to which early measurement can predict future wood quality

Experimental Plan:

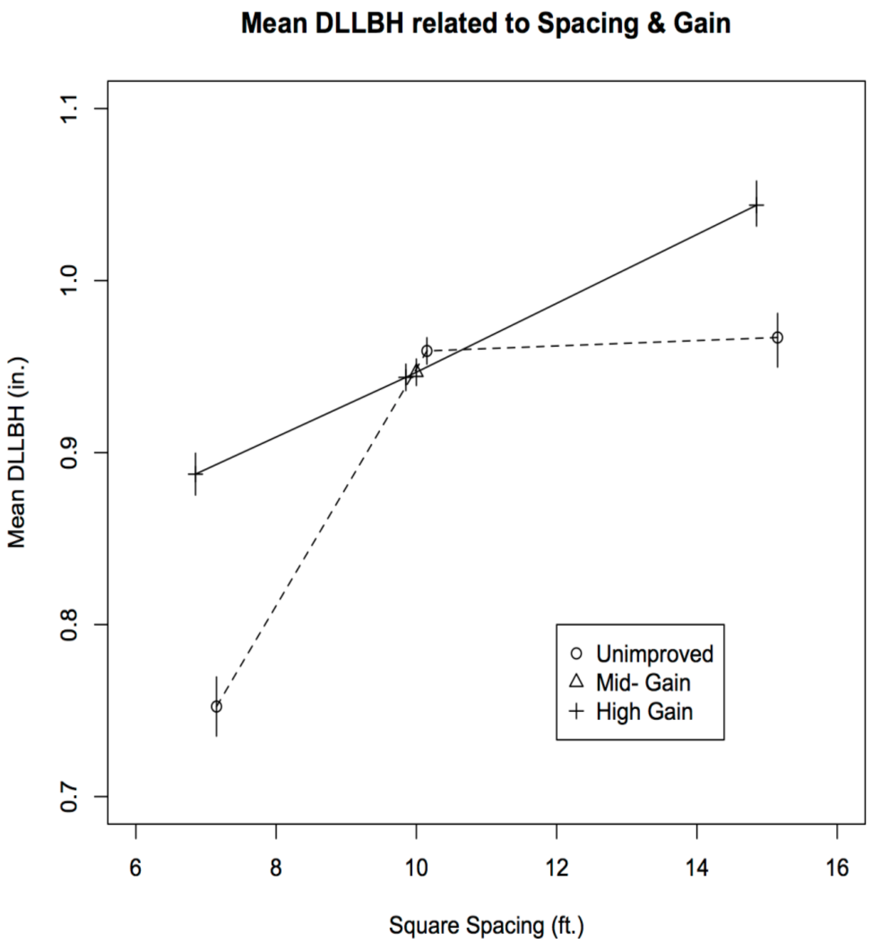
- In 2012 collect data on two of three jointly-run NWTIC Genetic Gain / SMC Type IV (GGTIV) trials planted in 2005; in 2013 visit two of three trials planted in 2006
  - Three treatment factors
    - Genetic gain (3 levels: woods-run, intermediate gain & elite)
    - Weed control (2 levels: 1 yr control vs. 5 yrs)
    - Spacing (3 levels: 7 ft, 10 ft, 15 ft)
  - Twenty-two (22) square plots at each site
  - Containerized seedlings in fenced plantations
  - About 14,800 trees total
- Measure DLLBH (knot index), Acoustic velocity (stiffness), Resistance (density) on a sample of trees

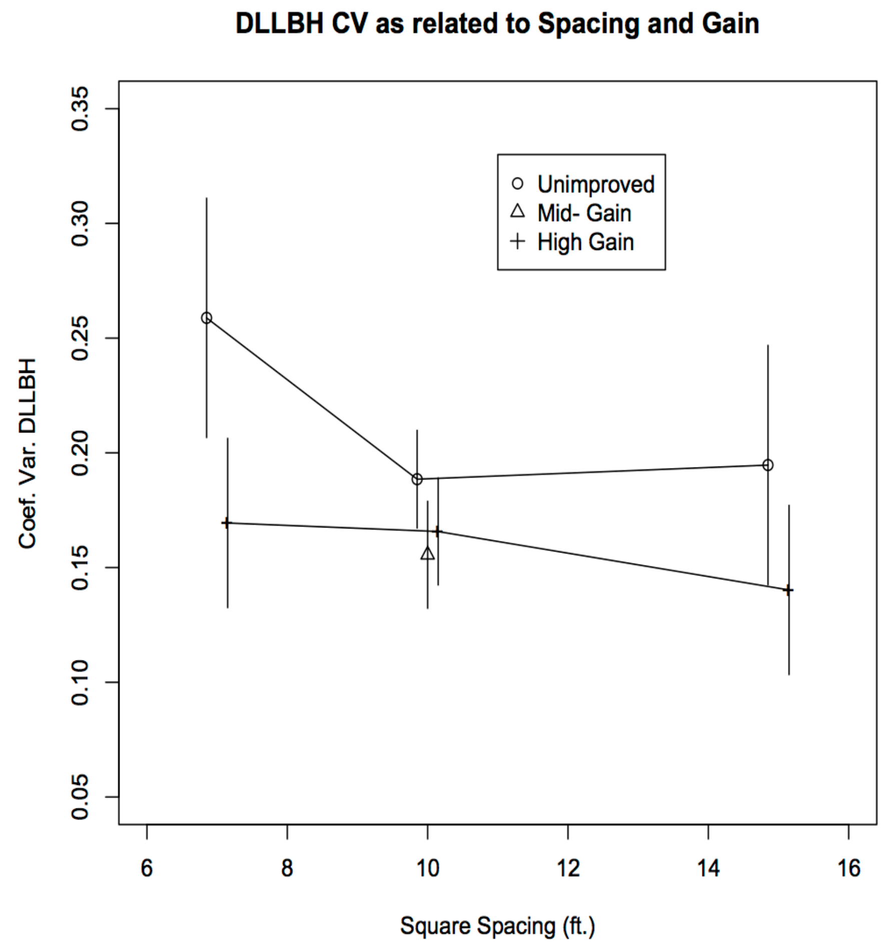
Progress to Date: DBH and Height





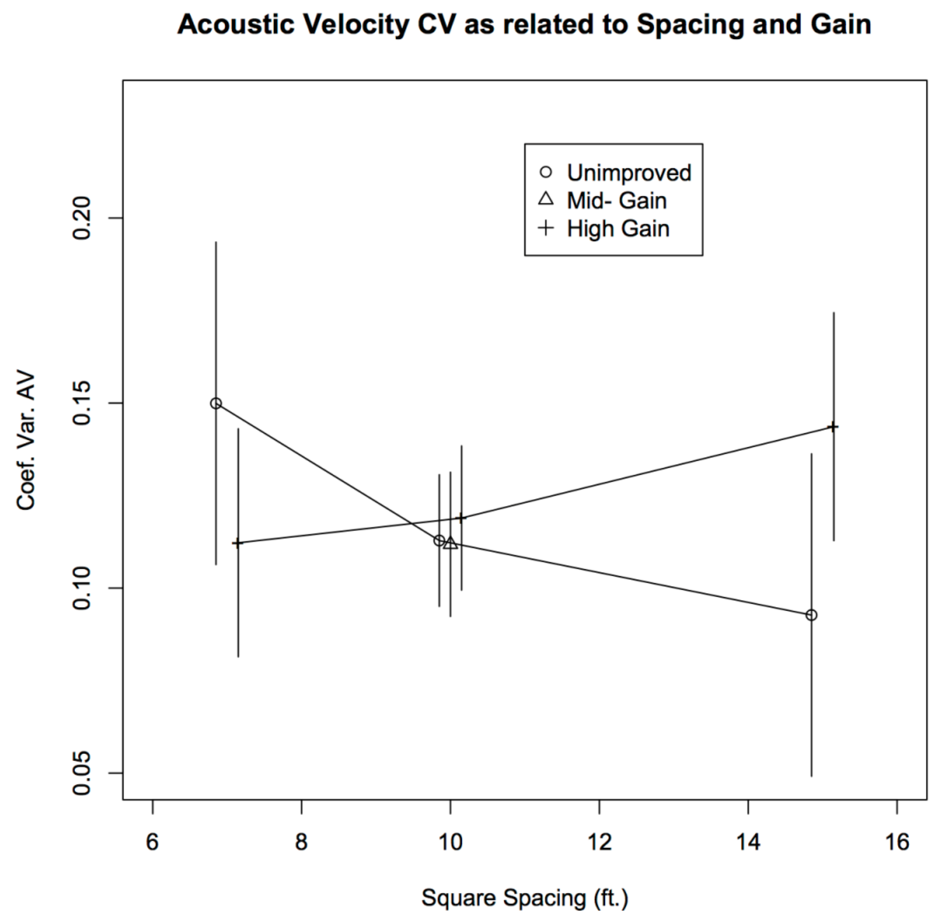
Progress to Date: Diam. of Lgst. Limb at BH.



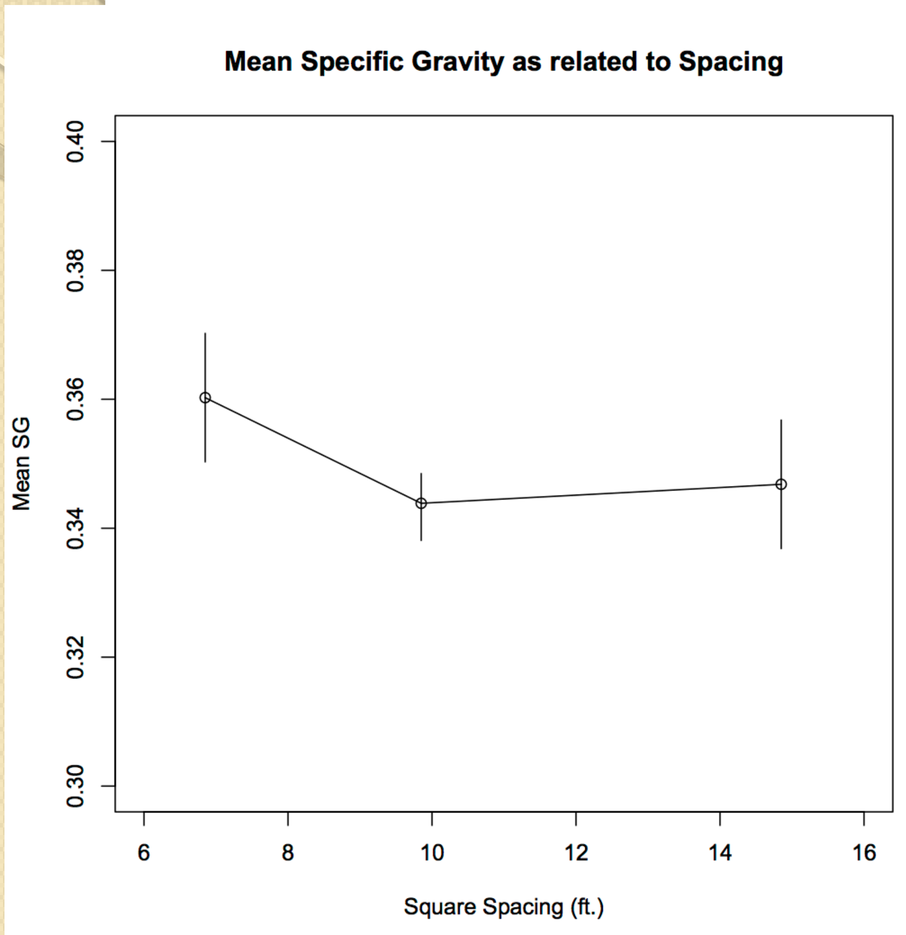


Progress to Date: Acoustic Velocity

- Very weak negative correlation w/DBH (n.s.)
- Acoustic velocity averages 2.6657 km/s overall
- Weak evidence of site effect (p= 0.11)



Results to Date: Specific Gravity



- Specific Gravity CV averages 0.0945 overall
- No evidence for effect of either Site, Spacing, or Gain on CV

Preliminary Summary

- Knot index
  - Spacing effects are generally as expected
  - Gain level produced somewhat unexpected effect
- Acoustic Velocity – no discernible effects
- Specific Gravity
  - Highest values in narrowest spacing

CAFS Project: WQ Traits in GGTIV

- Contributors
  - Dave Briggs, Eini Lowell, Keith Jayawickrama
  - CL Huang, Jeff Comnick
  - J Brad St Clair, Terrance Ye

Silviculture Project Status

- CAFS Project: WQ Traits in GGTIV
- Technical Reports
- Student Updates

SMC Performance Report

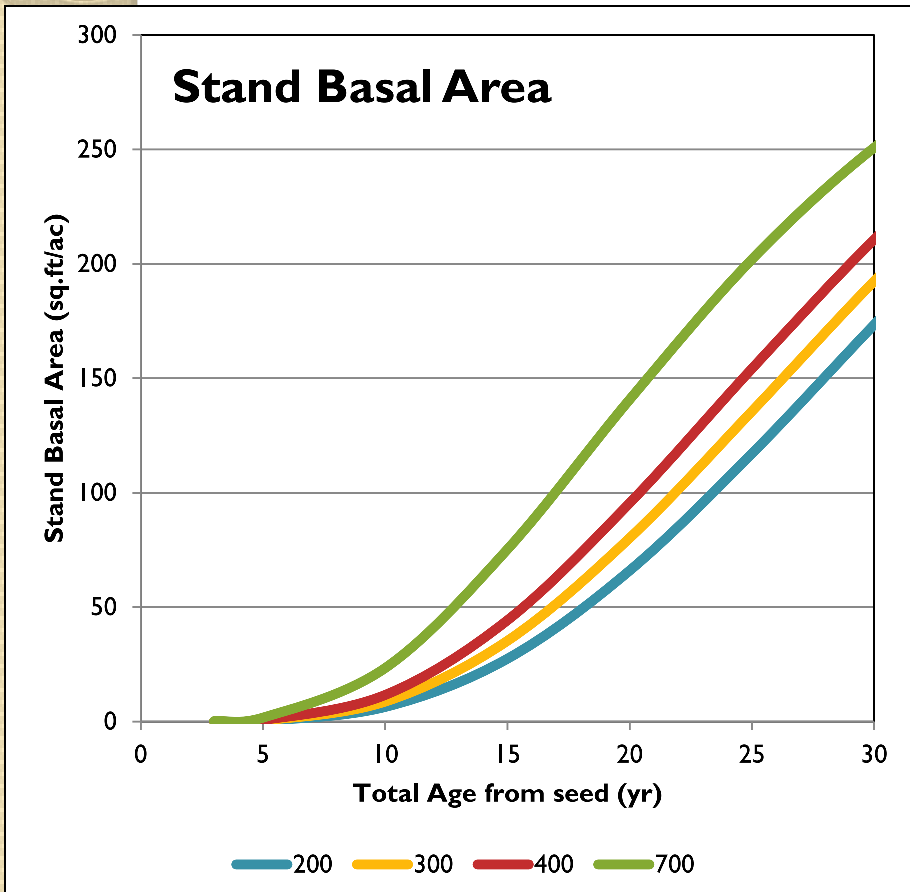
- Objectives
  - Summarize into a report how SMC Silviculture Project Type I, II and III installations have performed in terms of yield and increment
  - Produce accompanying Fact Sheets
  - Produce web-based calculator that is useful for practicing forest managers

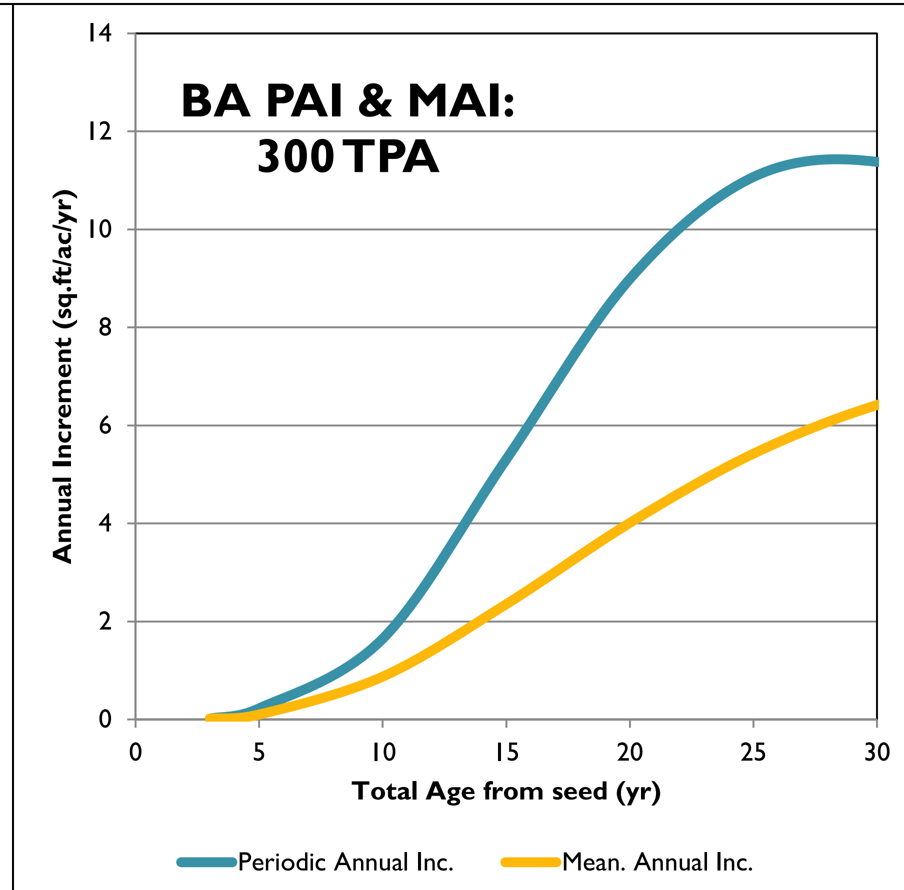
SMC Performance Report

- Modeling Strategy
  - Produce yield models using Chapman-Richards
    - BA, QMD, [TPA], CVT, CV4, CV6, BF4, BF6
  - Function parameters (asymptote, rate, shape) tested for relationships with initial stand density, site index, other site variables, treatment regimes
  - Manipulate fitted models to analyze increment
  - Use models to produce yield table summaries

SMC Performance Report

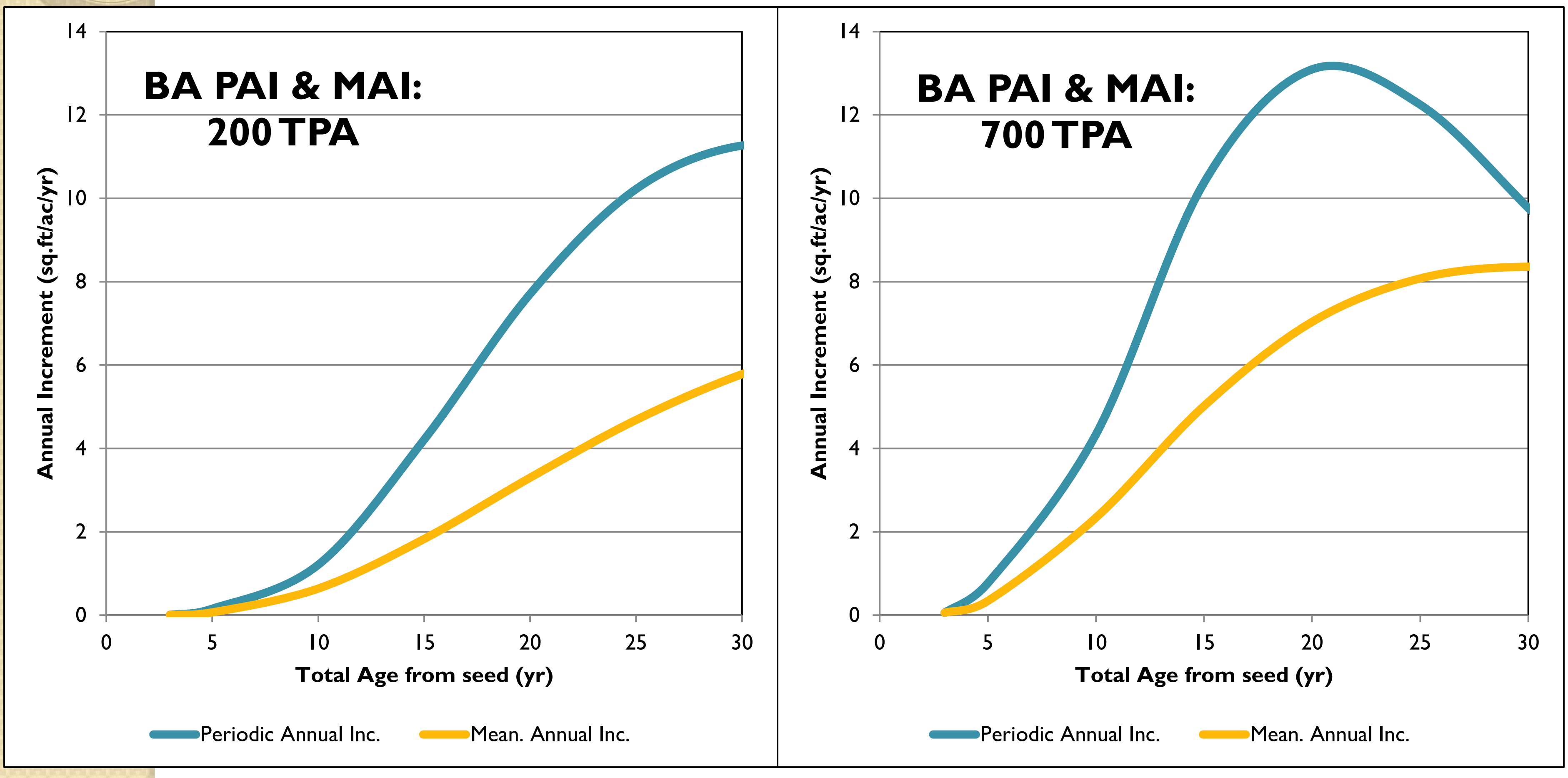
- Type III





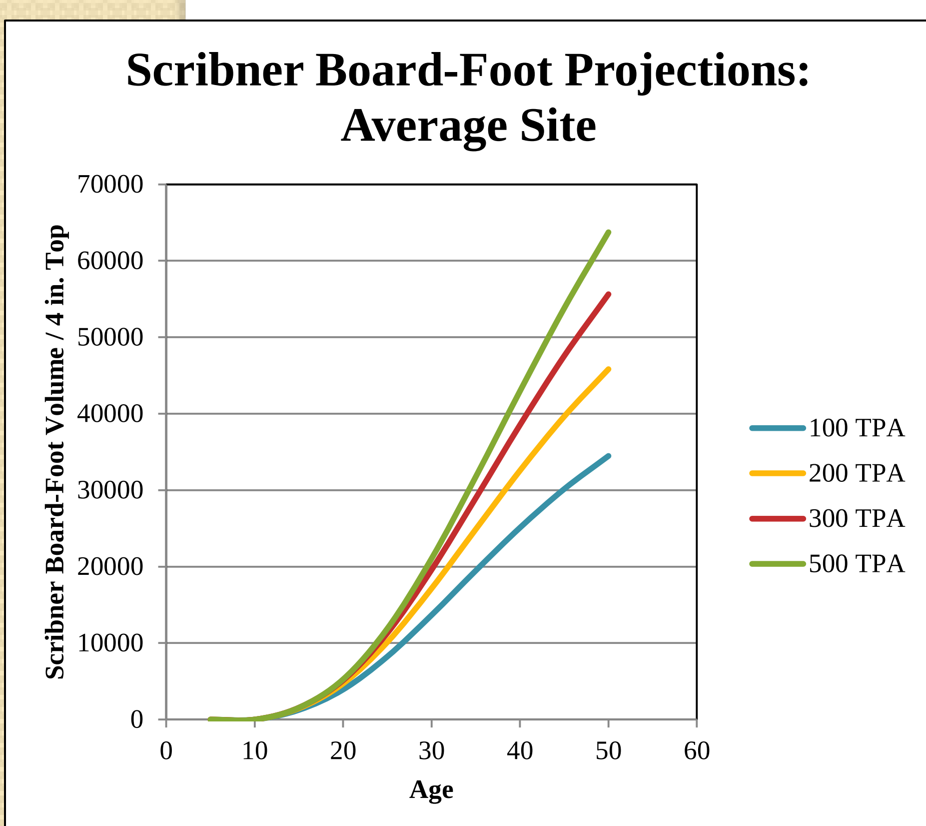
SMC Performance Report

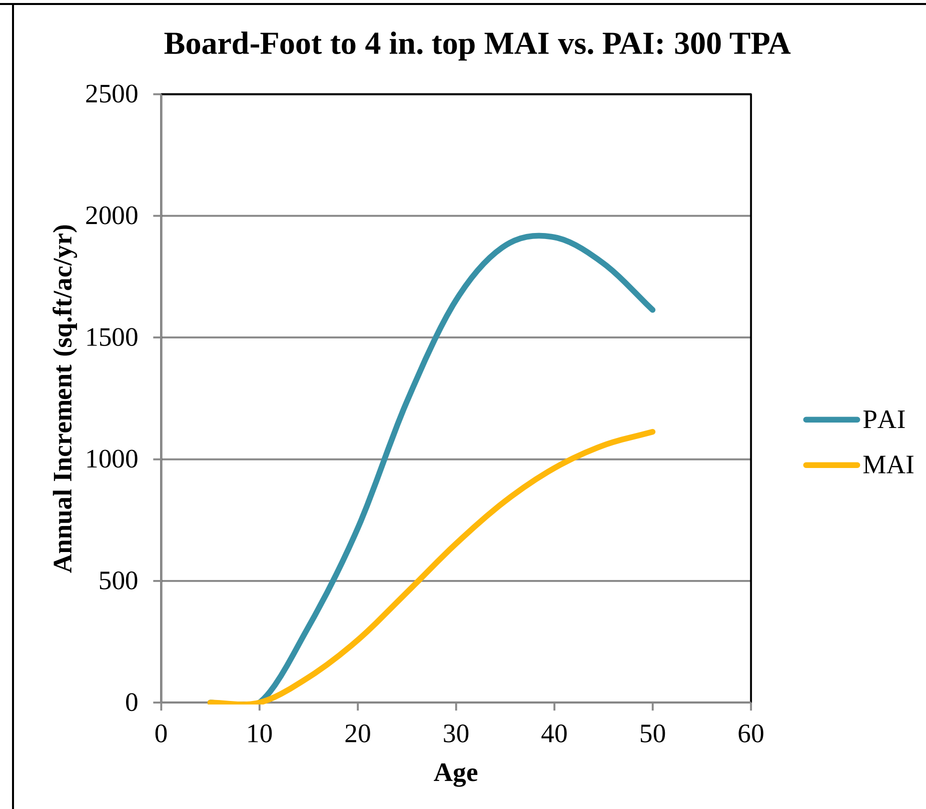
- Type III …



SMC Performance Report

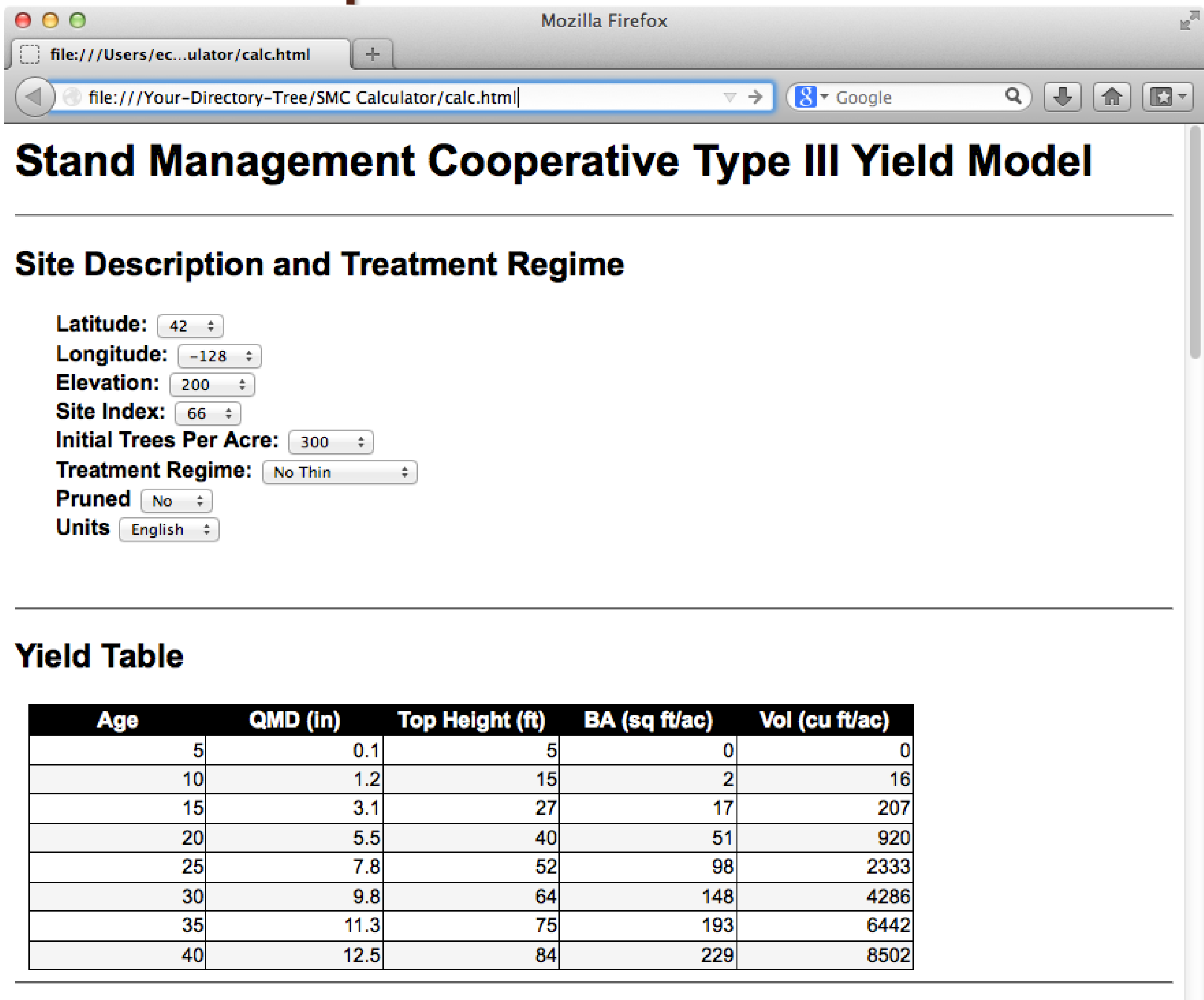
- Type I, II





SMC Performance Report

Browser-based Yield Calculator



Stand Management Cooperative Type III Yield Model

Site Description and Treatment Regime

Latitude: 42
Longitude: -128
Elevation: 200
Site Index: 66
Initial Trees Per Acre: 300
Treatment Regime: No Thin
Pruned No
Units English

Yield Table

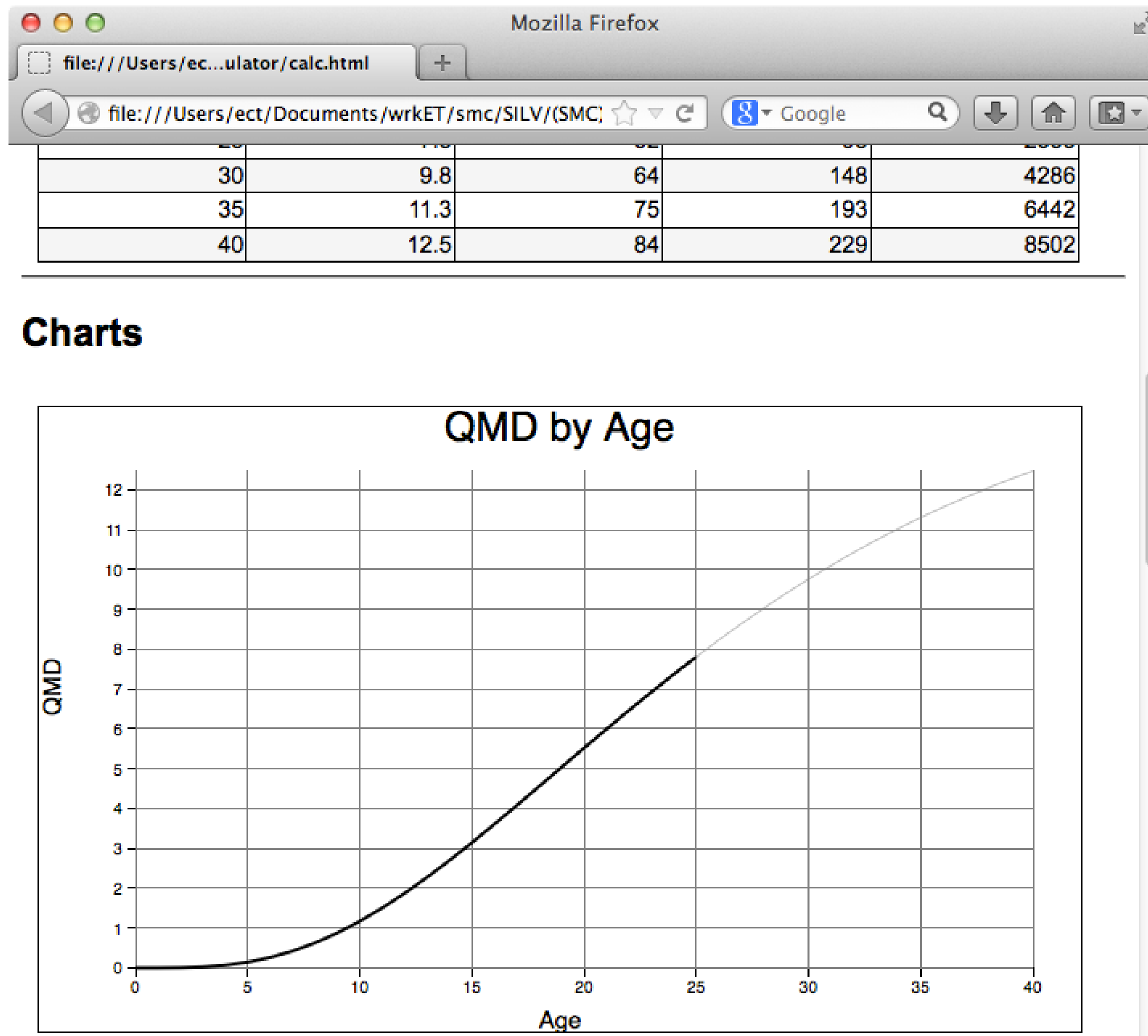
Age	QMD (in)	Top Height (ft)	BA (sq ft/ac)	Vol (cu ft/ac)
5	0.1	5	0	0
10	1.2	15	2	16
15	3.1	27	17	207
20	5.5	40	51	920
25	7.8	52	98	2333
30	9.8	64	148	4286
35	11.3	75	193	6442
40	12.5	84	229	8502

SMC Performance Report

Browser-based

Yield Calculator

…



30	9.8	64	148	4286
35	11.3	75	193	6442
40	12.5	84	229	8502

SMC Performance Report

- Contributors
  - Type III analysis
    - Kevin Ceder
  - Type I, II analysis
    - Jed Bryce, Kevin Ceder, Jeff Comnick, Nai Saetern
  - Browser-based calculator
    - Jeff Comnick

Silviculture Project Status

- CAFS Project: WQ Traits in GGTIV
- Technical Reports
- Student Updates

Student Updates

- Kevin Ceder, Ph.D. Candidate
  - Modeling vegetation dynamics in young, managed coastal Douglas-fir forests
- Luyi Li, pursuing M.S.
  - Douglas-fir wood quality properties in response to soil parent material and fertilization

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Progress Report

Impact of Genetic Gain, Weed Control, and Spacing on Wood Stiffness, Density, and Knot Index in a Large-plot trial of Coastal Douglas-fir

Introduction

Several factors are known to affect the key wood quality traits of knot size, stiffness, and density, namely, genetic selection for growth rate, spacing of trees, and intensive early weed control. However, the full impacts of these factors are not well understood.

Objectives

The primary objectives of this study are 1) to evaluate the impacts of the three factors genetic gain (3 levels: woods-run, intermediate, and elite), spacing (3 square spacings: 7, 10, 15 ft.), and weed control (weed free for 1 yr or 5 yr) on wood traits singly and in combination with each other, and 2) with further monitoring to determine the degree to which early measurement of these traits can predict future wood quality.

Methods

The Genetic Gain / Type IV trial was established over two years (2005 and 2006) at six locations in the Grays Harbor vicinity, western Washington (see Figure 1) as a joint project between the Stand Management Cooperative (SMC), the Northwest Tree Improvement Cooperative (NWTIC), and the USFS PNW Research Station. A total of 132 square plots, comprising 14,800 measured trees were established with containerized seedlings in fenced plantations.

Two sites planted in 2005 (sites 601 and 603) were measured after the 2012 growing season when the trees were nine years from seed with an average height of 19.3 feet. Acoustic velocity, an indicator of stem stiffness, resistance, an indicator of wood density, and diameter of the largest branch in the BH region, which is correlated with a log knot index commonly used in product recovery studies, were assessed in the BH region of trees. Acoustic velocity was measured using the TreeSonic with accompanying SD-02 sensors, resistance with a Resistograph F400S, and knot index with the Stand Management Cooperative's breast height branch measurement protocol. This project sets the stage for future re-measurement of these characteristics and assessment of the ability of early measurement of these properties to predict values at later age.

Current State of Knowledge

Diameters at Breast Height (DBHs) of improved trees were significantly larger than unimproved, irrespective of other factors (3.34 and 3.21 in., respectively), though there was no detectable difference between levels of improvement (elite vs. intermediate). Tree DBH was also about 0.5 in. larger in the wider spacings than in the narrowest. Heights exhibited the same pattern as DBH with respect to gain level where improved stock averaged 20 ft. compared to 18.5 ft. for unimproved, but were not affected by spacing. Significant differences between sites were also observed for DBH and height.

Diameter of the Largest Limb at Breast Height (DLLBH) exhibited a relationship with spacing that depended on gain level (a possible spacing x genetics interaction). For the improved stock, DLLBH increased linearly from a low of about 0.89" at the narrowest spacing increasing to just over 1" at the widest spacing. For the unimproved stock, DLLBH was 0.75" at the narrowest spacing, but reached somewhat of an asymptotic value at about 0.95" at the two wider spacings. It seems plausible that the improved stock is exhibiting larger branches simply because the trees themselves are larger (in both DBH and height), but this will be investigated further. Significant differences between sites were also observed for DLLBH.

As has been observed elsewhere, acoustic velocity exhibited a weak negative relationship with DBH, but averaged 2.6657 km/s overall, a low value typical for juvenile wood. There was weak evidence of a site effect on acoustic velocity ($p = 0.11$).

Specific gravity was found to vary only with spacing, being highest in the narrowest spacing (a little over 0.36) increasing to an asymptotic low value at the middle spacing (a little under 0.35); these low values again being consistent with juvenile wood. this may be indicative of and earlier transition from earlywood to latewood in the tighter spacing (i.e., a higher latewood percentage), but this would have to be investigated further. Wood stiffness is chiefly a function of both specific gravity and microfibril angle, but microfibril angle is not being measured as part of this study.

Project Timeline

- Field measurements will occur after the 2013 growing season on two sites planted in 2006 (given possible effects of site, observations from the southern portion of the breeding zone seem desirable)
- Interim report to cooperators in early 2014
- Analysis leading to manuscript submission to a peer reviewed journal in 4th quarter 2014

Potential Member Benefits

Since wood stiffness and density are known to be strongly inherited at the family level, and since previous evidence has shown a mild adverse correlation with growth rate, silvicultural treatments such as wide spacing and weed control to accelerate growth are expected to cause some reduction in stiffness and density and to increase knot size, so it would be extremely valuable to know the exact extent of that reduction (singly and together) in operational plantations. This will allow modification of silvicultural treatments as needed. Another benefit to members would be the incorporation of stem quality traits into selection criteria.

Project Budget

CAFS portion – final year (2014): $35,000 for part of data collection, data collation & checking, final analyses, final report writing

SMC portion – final year (2014): $15,000 in-kind contribution for field measurements by (SMC) field crew

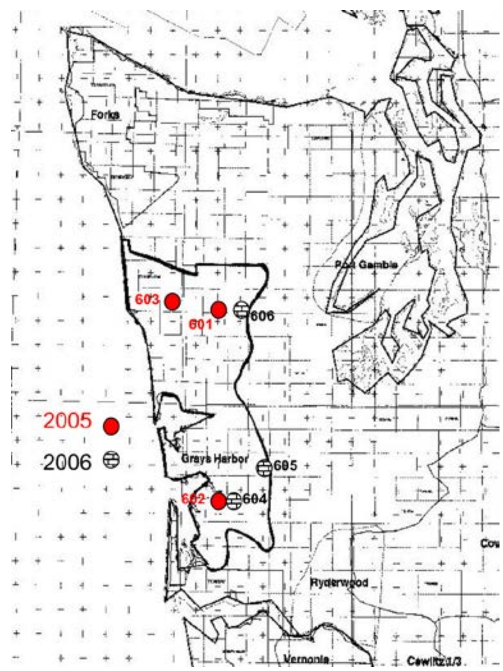

Figure 1: Locations of GGTIV installations.

SMC Member Feedback

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Appendix E

The Effects of Planting Density on Branch Size with Linkages to Wood Quality: Project Progress Report

Objectives

The primary objective of this study is to develop predictive equations for determining the diameter of the largest limb in the breast height (*DLLBH*) region of Douglas-fir. Given that recent decades have seen a decline in the quality of lumber in part due to lower density planting that promotes greater branching and crown development, it is helpful to know how these changes affect wood quality. The equations can provide forest managers with a preview of branch development as it relates to various planting densities.

Methods

The project focused on the Type III installations in which the primary areas of interest are the effects of six different planting densities (100, 200, 300, 440, 680 and 1210 TPA) on growth and yield. Though previous SMC studies have looked into both largest limb average diameter (*LLAD*) and *DLLBH*, this study is particularly useful since it allows analysis of repeated branch measurements over the past 24 years. In order to capture this change, a generalized allometric equation was used to describe *DLLBH*.

- Figure 1 displays projected values from the *DLLBH* model

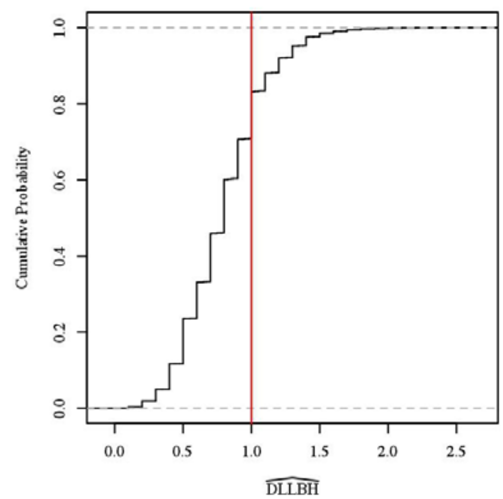

Figure 1: Percentage of predicted branches greater than 1 in.

Potential Member Benefits

- With basic tree-level descriptors managers have a good idea of how big the branches on the butt log will grow, which can help with planning
- Mills can use the information of varying densities and knot sizes to see if they are hitting targets for specific markets and lumber grades
- The model will be able to be used in growth and yield simulators to help create a continuum between silviculture and the forest products produced
- Previous studies from the SMC will allow *DLLBH* information to be connected to *LLAD* to get a full view of the potential product recovery

Project Budget

This project was supported by the Corkery budget in spring quarter of 2011 and spring quarter of 2012

SMC Member Feedback (For members-leave space)

Please provide comments and feedback here.

About the author:

Jed Bryce is a recent M.S. graduate from the University of Washington School of Environmental and Forestry Sciences

Contact: jedbryce@gmail.com

Appendix F

Research Update: Long-Term Soil Productivity (LTSP) Studies

Timothy B. Harrington
PNW Research Station

Molalla study site, age 9 years, April 2013

Collaborators (partial list):

Randall Greggs, Green Diamond Resource Company
Mike Warjone, Port Blakely Tree Farms
Rob Slesak, University of Minnesota
Stephen Schoenholtz & Brian Strahm, Virginia Tech
Dave Peter & Connie Harrington, PNW Research Station
Rob Harrison, University of Washington
Scott Holub & Tom Terry (retired), Weyerhaeuser Company

GREEN DIAMOND RESOURCE COMPANY

PORT BLAKELY TREE FARMS LP
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VirginiaTech

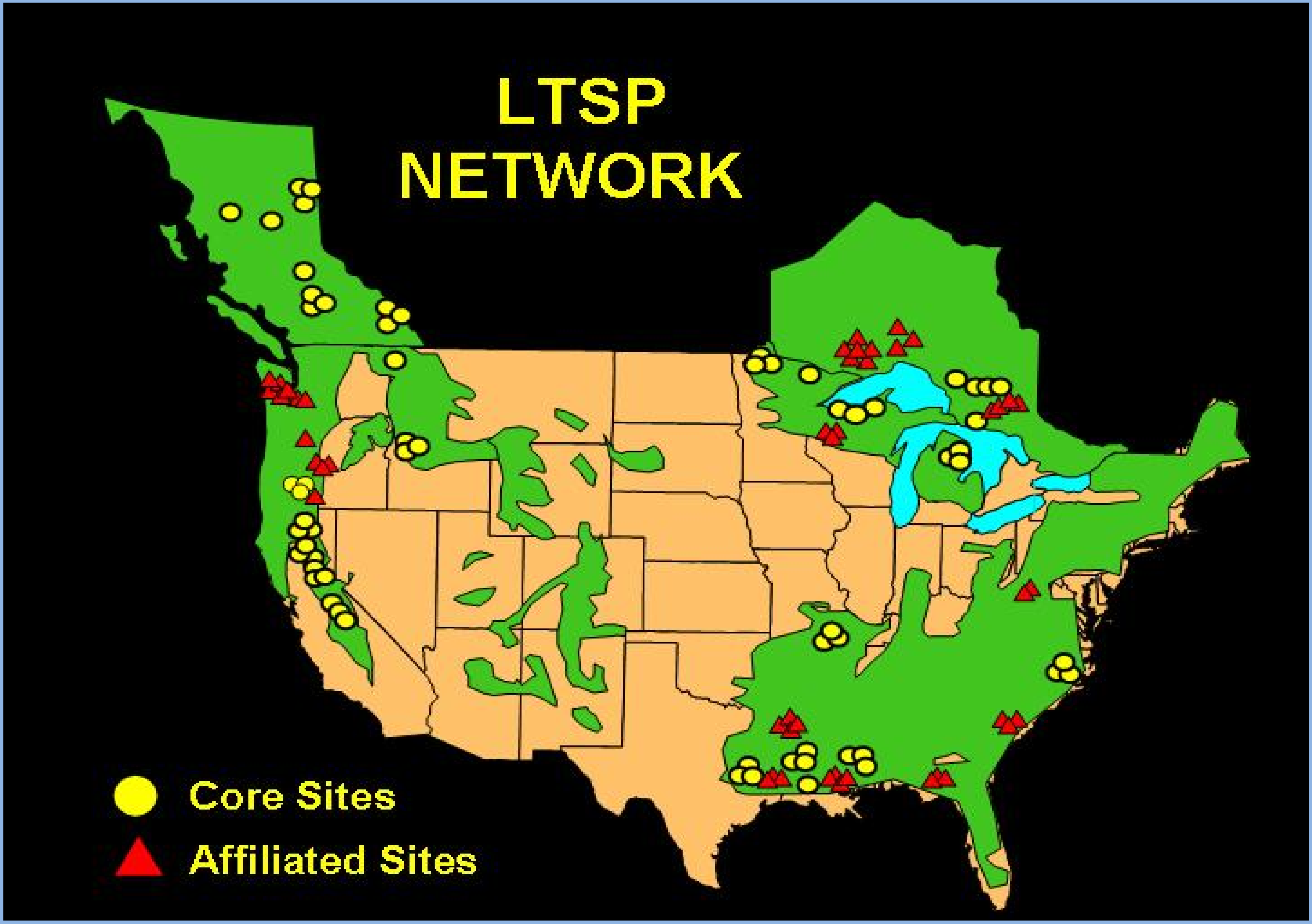
UNIVERSITY OF MINNESOTA
Driven to Discover

Research objectives

- Compare long-term productivity of planted Douglas-fir in response to bole-only versus whole-tree harvesting, with and without vegetation control.

- Assess treatment effects on:
  - Site resources and growing conditions.
  - Soil physical and chemical properties.
  - The plant community.

The research is linked to the North American LTSP network:



Site characteristics

	Fall River	Matlock	Molalla
soils	silt loam	very gravelly loamy sand	cobbly loam
precipitation	90”	100”	70”
site index	138’	118’	118’
planted	2000	2004	2004

Contrasting soil physical and chemical properties

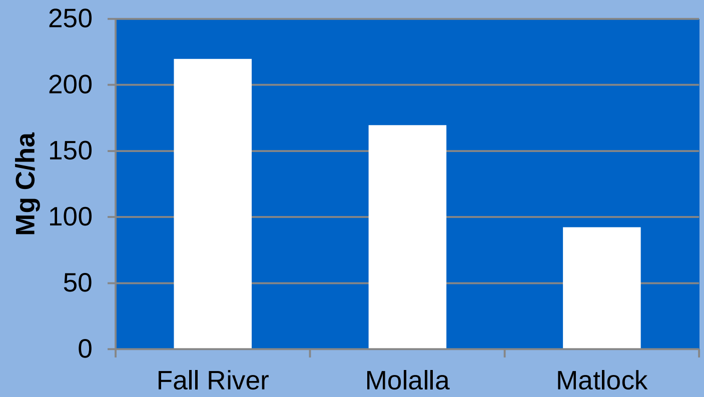
Fall River, WA

Boistfort

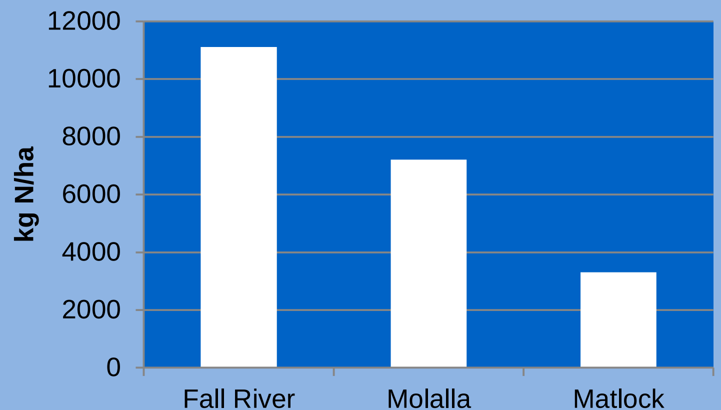
WHC:

174 mm

Mineral soil carbon to 60 cm



Mineral soil nitrogen to 60 cm



Molalla, OR

Kinney

142 mm

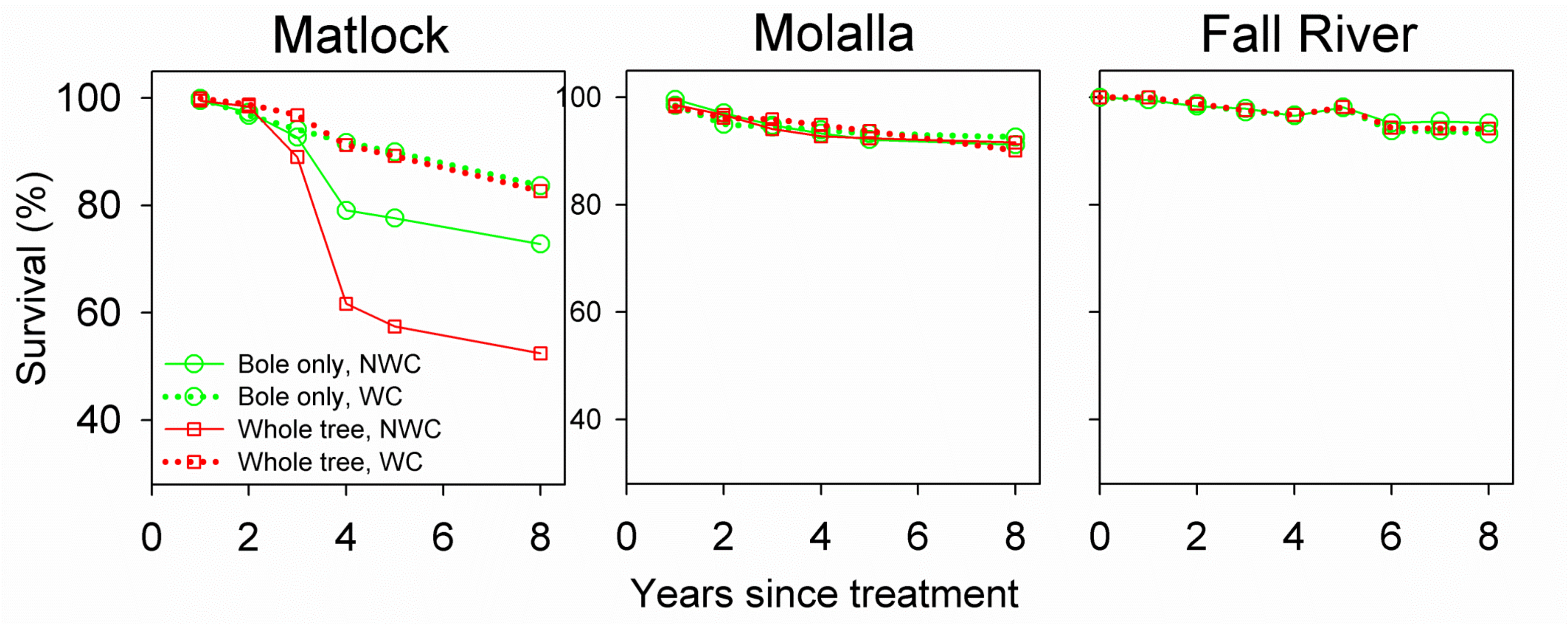
Matlock, WA

Grove

55 mm

Slide courtesy of Tom Terry

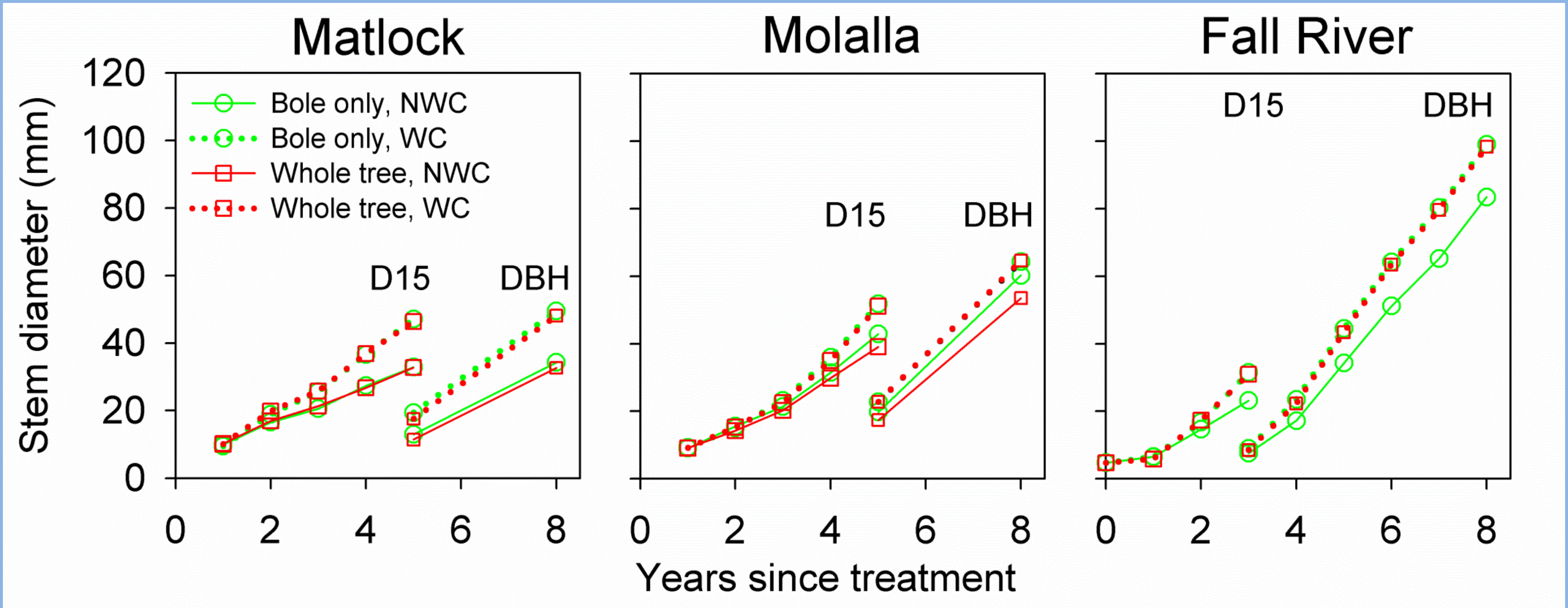
Douglas-fir survival responses



- Interaction of competitor species and soil limitations (i.e., Scotch broom on glacial outwash soils at Matlock).

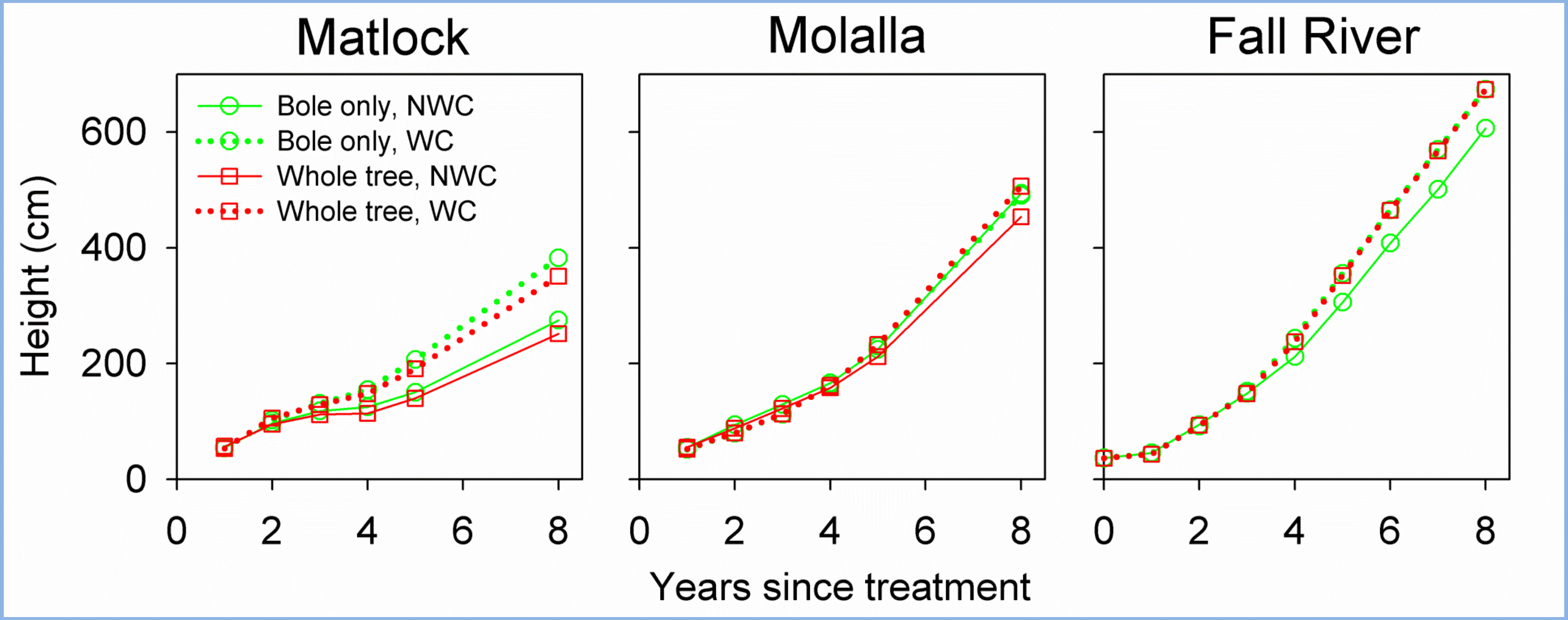
Harrington & Schoenholtz CJFR 2010

Douglas-fir stem growth responses



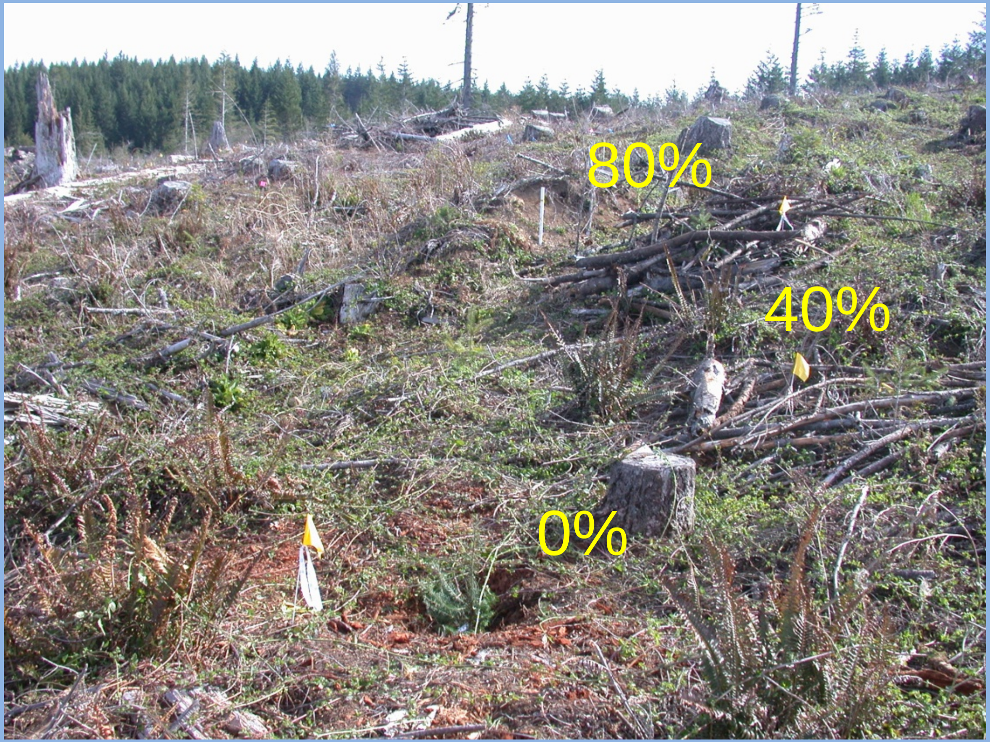
- Where vegetation was controlled, there has been no detectable effect of harvesting treatment.
- Douglas-fir productivity is varying considerably among study sites.

Douglas-fir height growth responses



- Height responses are similar to those for stem growth.
- What are the mechanisms controlling these responses?

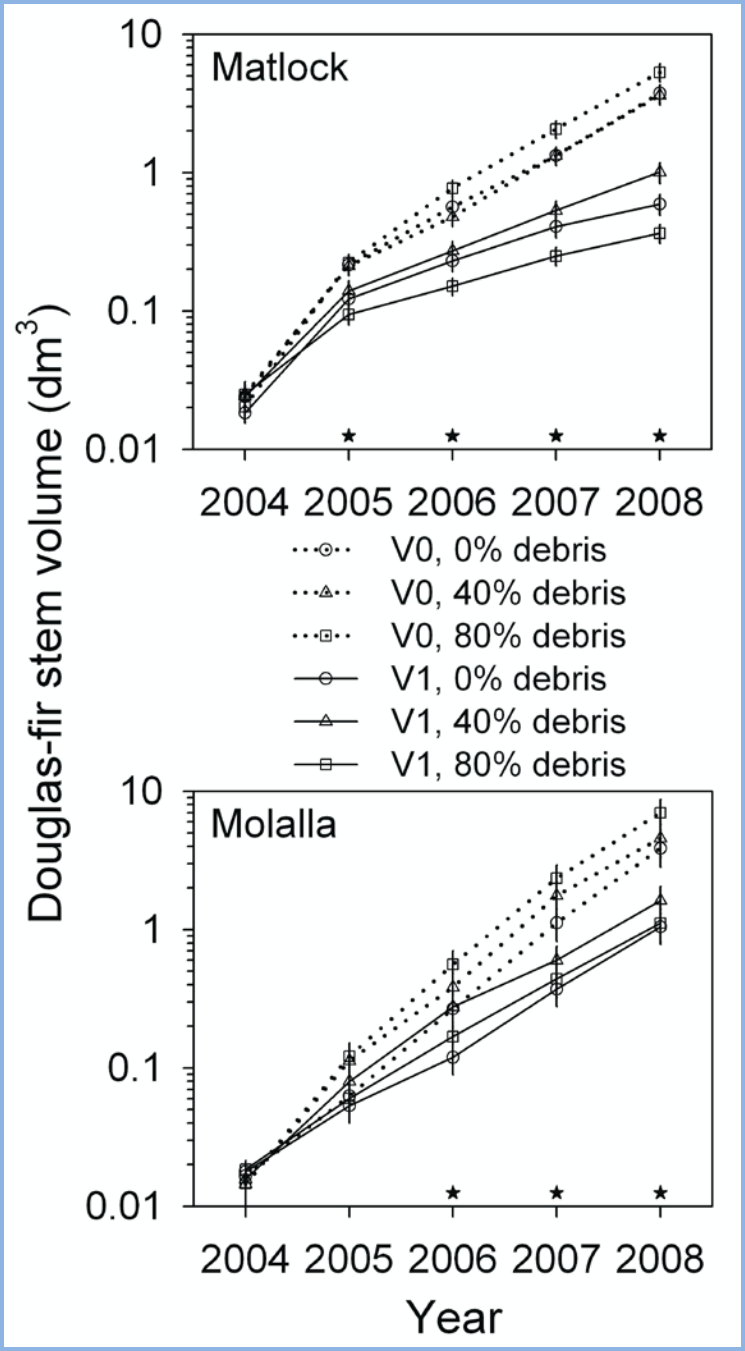
Logging debris gradient study



- Douglas-fir centered plots (2 x 2 m).
- 3 levels of logging debris cover, with and without competing vegetation.
- 8 replications per site.

Logging debris facilitated increases in Douglas-fir seedling growth

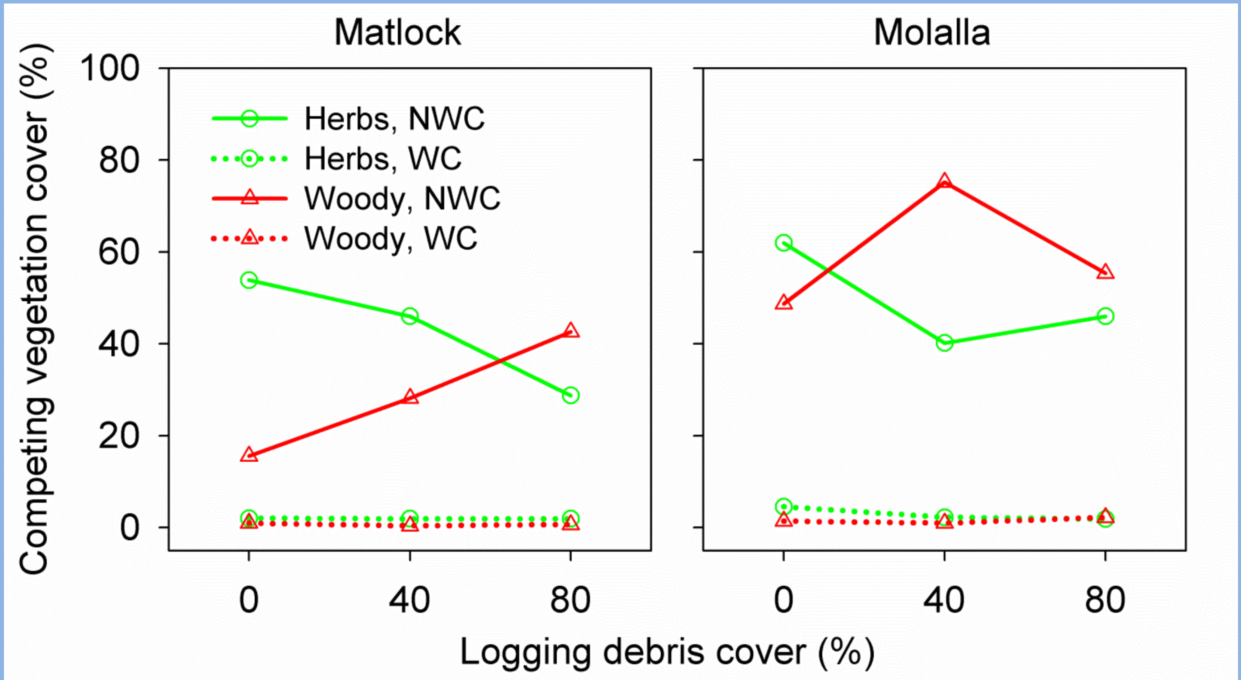
- Where vegetation was absent, 80% debris cover had best tree growth.
- Where vegetation was present, 40% debris cover had best growth.



Harrington et al. FEM 2013

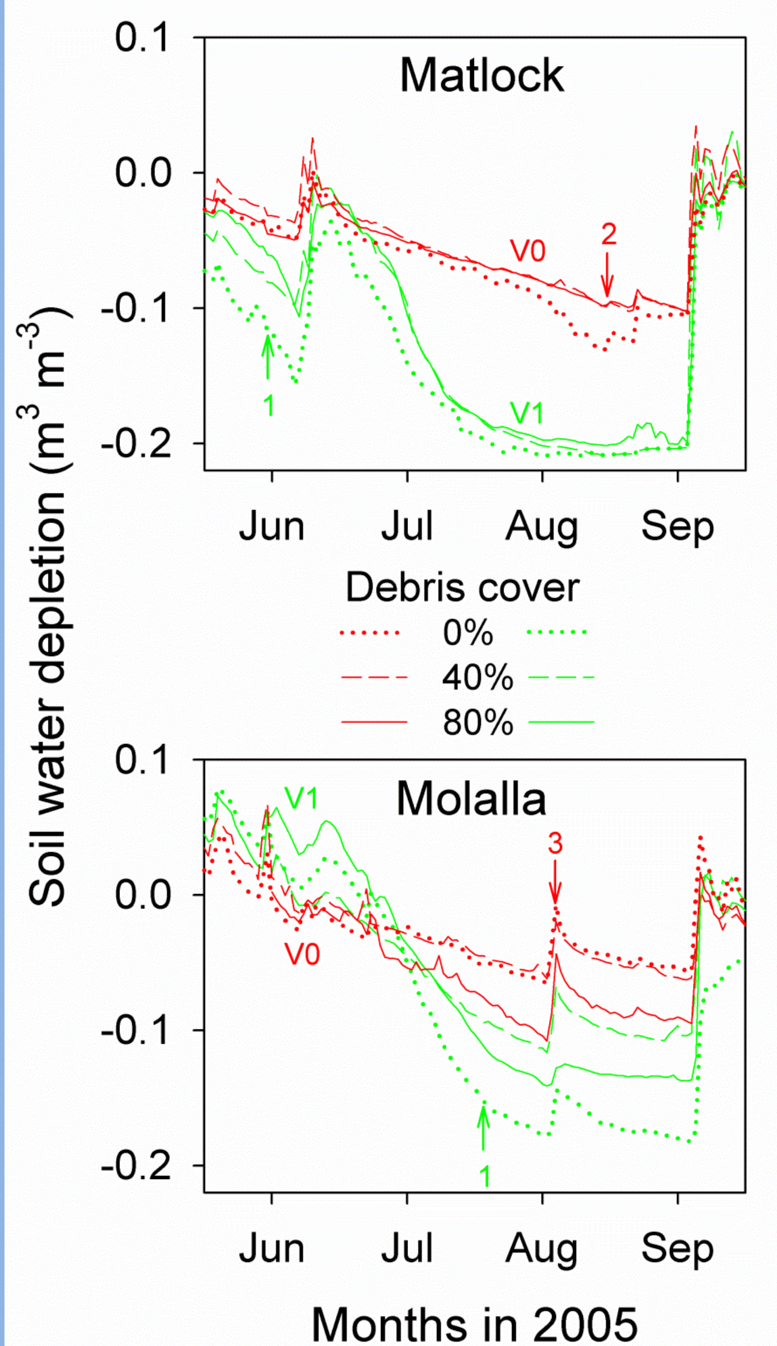
Logging debris reduced herb cover

- Proportionate decreases at Matlock.
- Interaction with *Rubus ursinus* at Molalla.



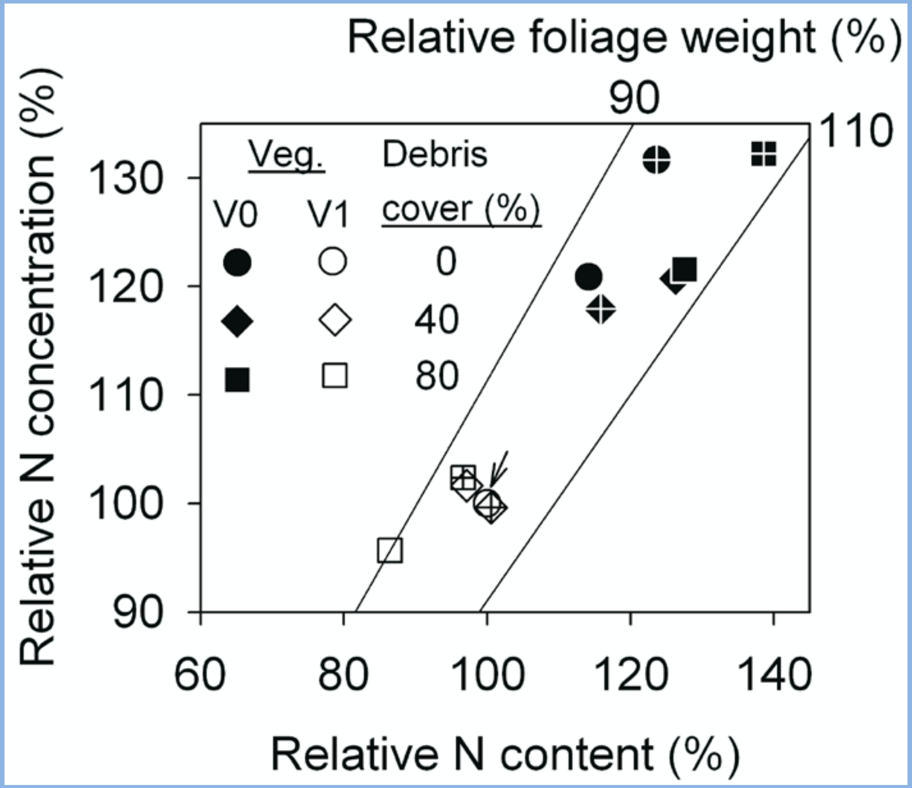
Logging debris increased soil water availability

- Reduced herb cover slowed soil water depletion (1).
- Reduced evaporation ("mulching effects") also slowed depletion (2).
- Interception losses were not detected (3).



Logging debris modified soil nitrogen availability

- Where vegetation was present at Matlock, 80% debris cover had decreased N availability.
- Where vegetation was absent, 80% debris cover had increased N availability.



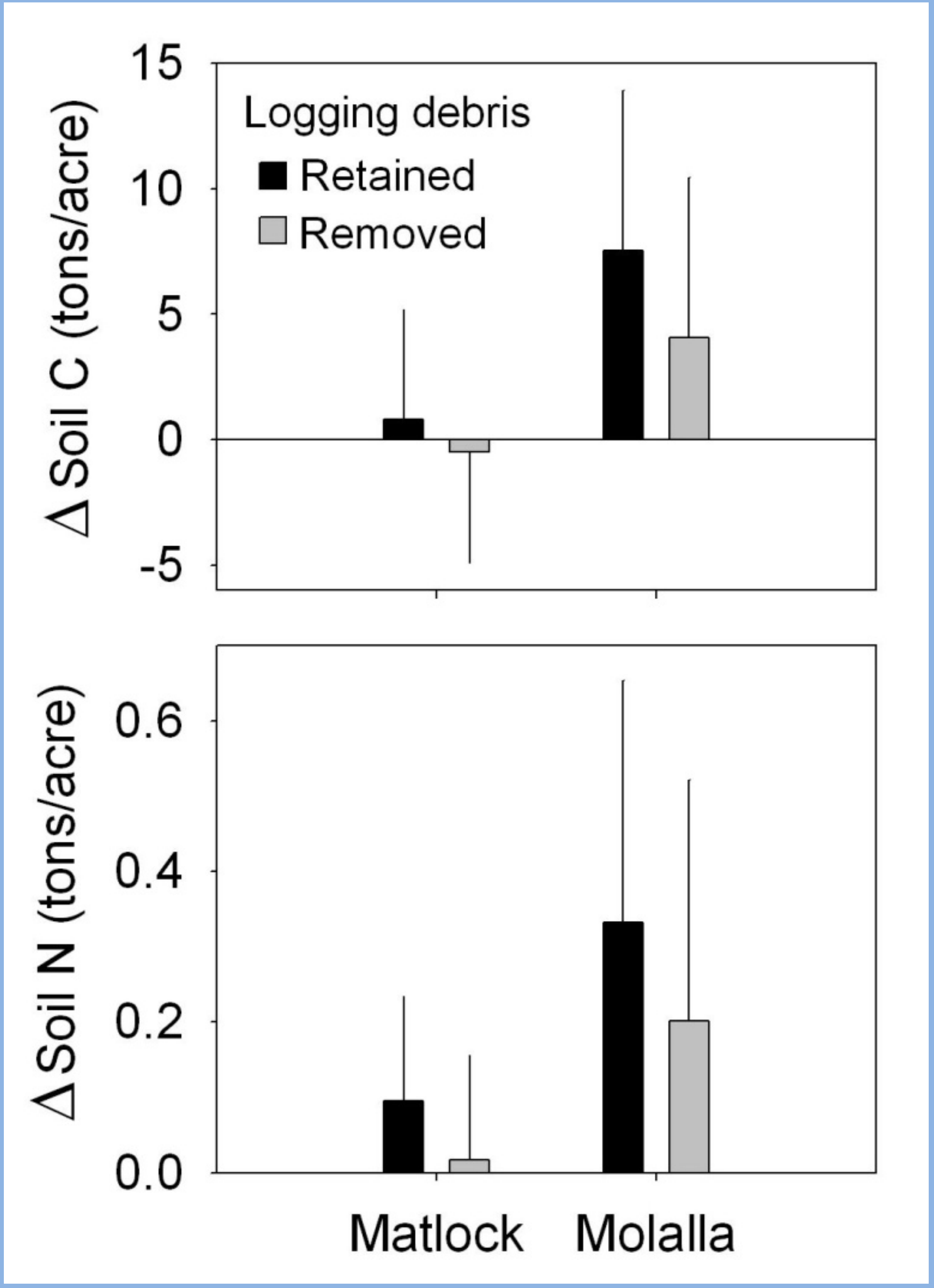
- Uncrossed symbols = Matlock
- Crossed symbols = Molalla

Take-home messages

- No detectable negative effects of harvesting intensity on Douglas-fir productivity; strong increases in tree growth from vegetation control.
- Where vegetation was present, Douglas-fir growth was greatest in 40% debris cover because of reduced herb cover and associated increases in soil water and nitrogen.
- Where vegetation was absent, Douglas-fir growth was greatest in 80% debris cover because of increased soil water and nitrogen.

Other benefits from logging debris:

- Accretion of soil C, N, Ca, & Mg where logging debris was retained (Slesak et al. 2011).
- Invasive species were inhibited by debris (CYSC, HYRA, & LEVU) (Peter & Harrington 2012).



5-yr net change in soil C & N

Recent and upcoming LTSP activities:

- 10th-year (2013) vegetation and tree growth responses to be measured at M&M.
- LTSP research to be featured on a poster at NAFSC in June 2013.
- New logging debris & herbicide study underway near Matlock.
- New M.S. student (VA Tech), Daniel Debruler, to study 10th-year soil C, N, and P responses at M&M.

New study at M&M on soil water use by Douglas-fir (diurnal variability)

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Appendix G(1)

Impact of Respacing the SMC Type I Installations

David Hann, OSU
Doug Maguire, OSU
Eric Turnblom, UW
Rob Harrison, UW

722 Silver Creek
Plot 2: ISPA/4
1990

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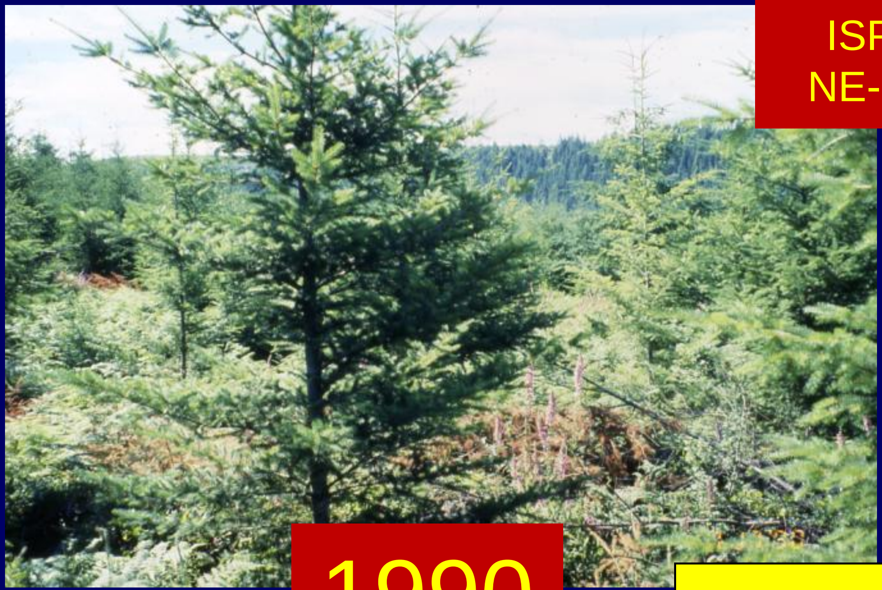
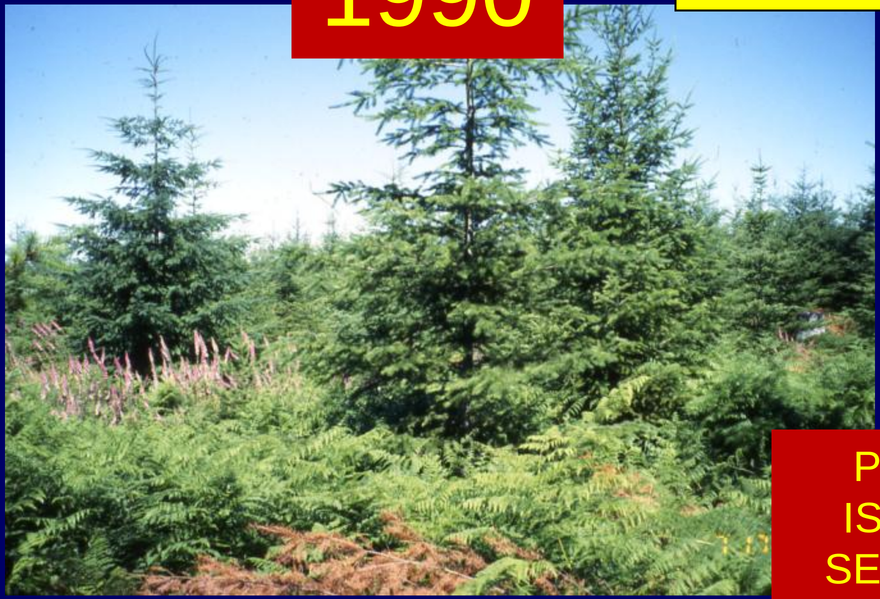
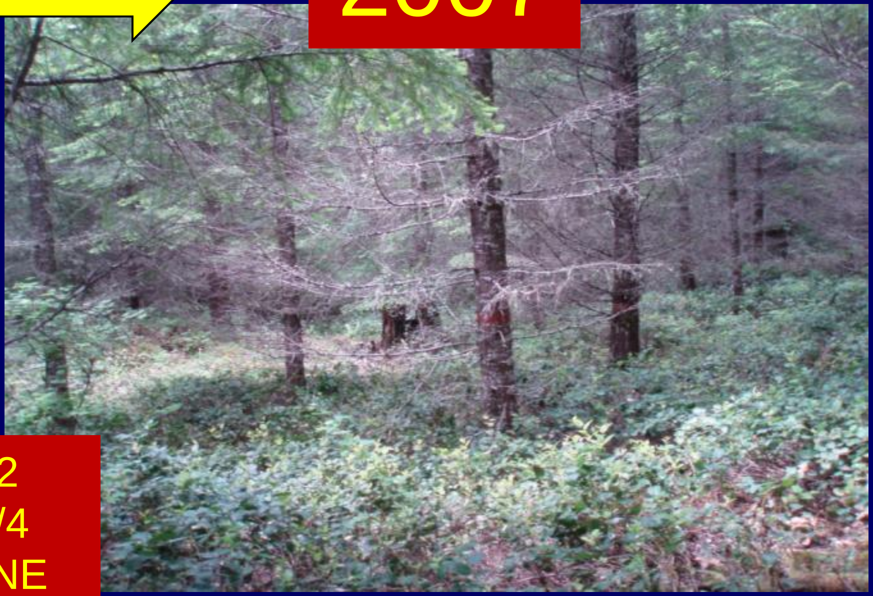
Plot 2
ISPA/4
NE-> SE



1990

2007





Plot 2
ISPA/4
SE-> NE

What are the effects of respacing on top height/site index?

What are the effects of respacing on individual tree volume growth?

Objectives of respacing analysis:

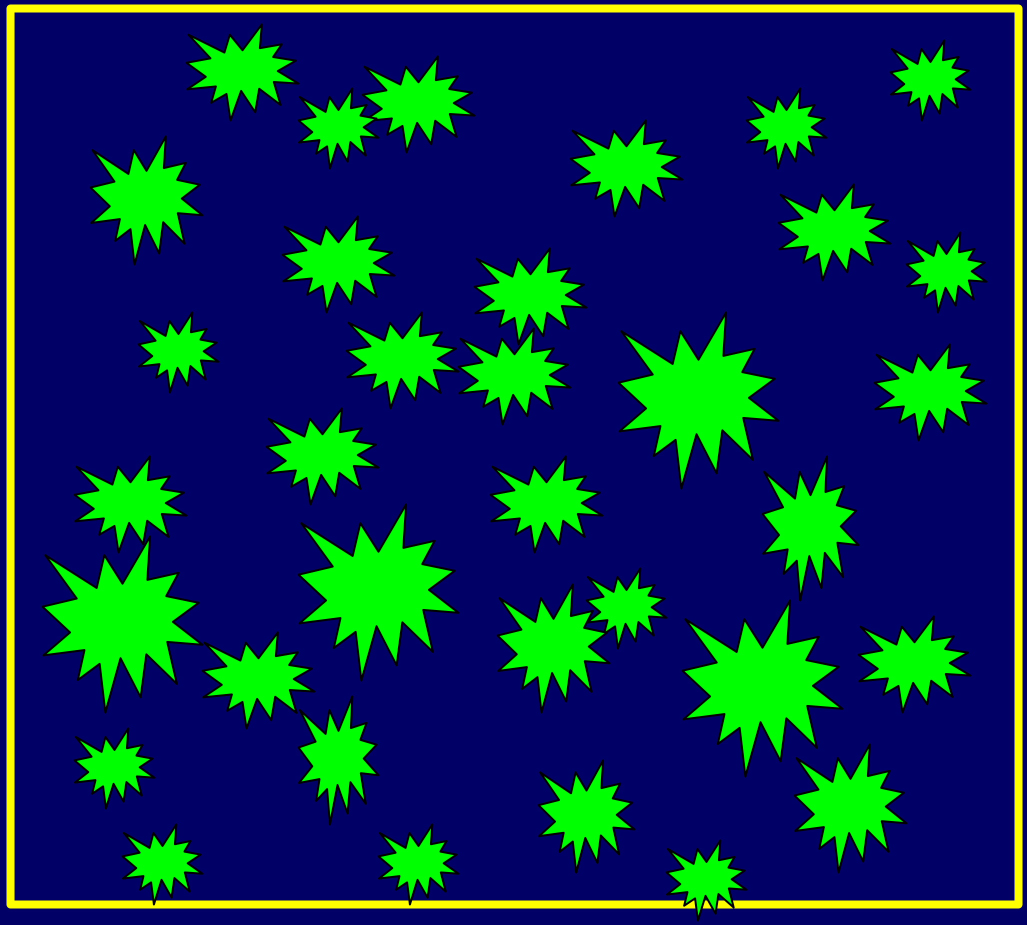
1) To test if respacing had significant effect on top height (H40) of plot
2) To test if respacing had significant effect on growth of trees and plots
3) To eliminate any possible effect of respacing from subsequent thinning and/or fertilization effects

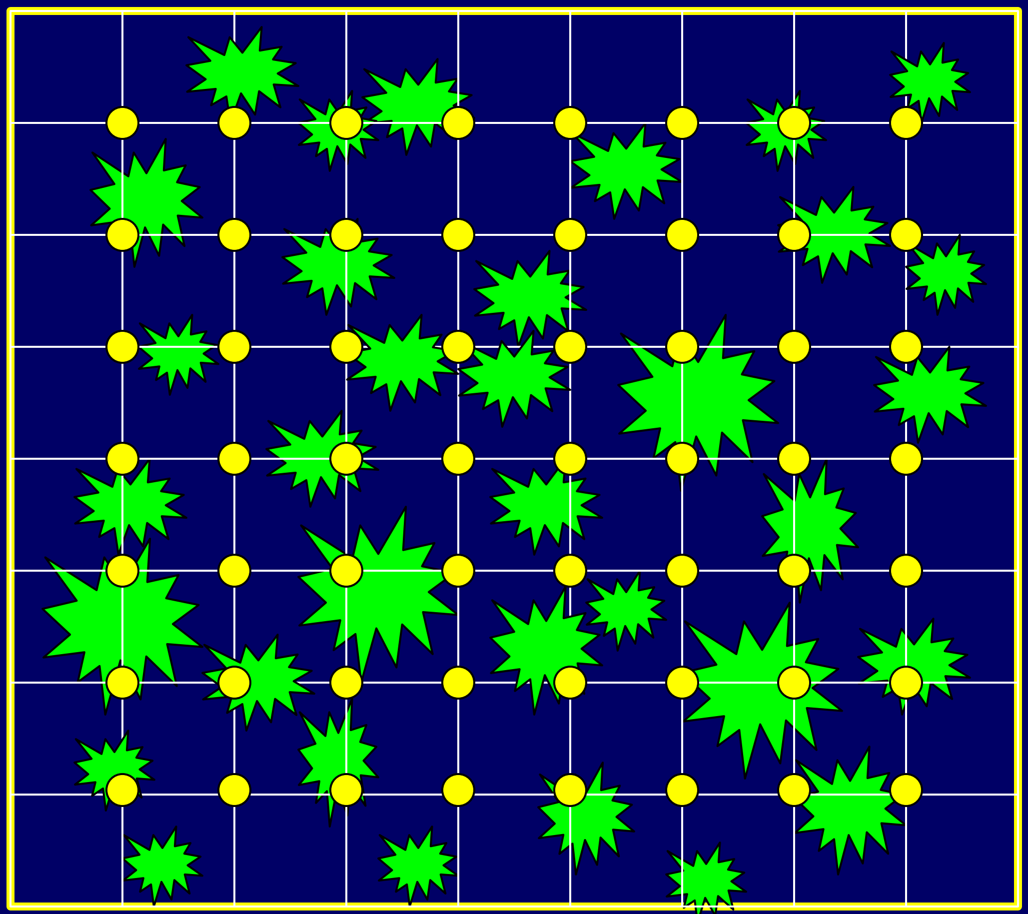
Are the Type I installations really behaving like stands planted to initial spacings corresponding to ISPA/1, ISPA/2, and ISPA/4 ?

Respacing was intended to mimic plantations established at post-respacing densities

↓

Leave trees were selected systematically rather than selectively





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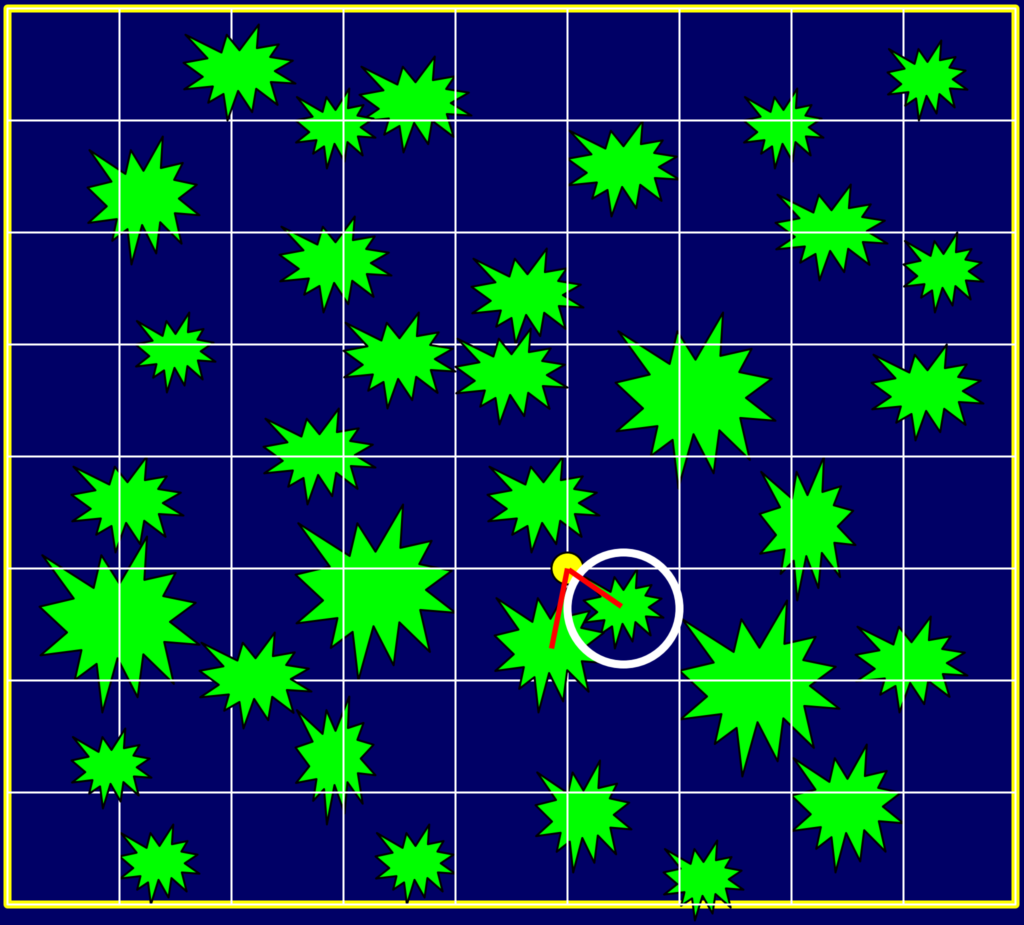

What are the effects of respacing on top height/site index?

- Is there any trend in site index over time attributable to respacing?
- Is average site index affected by respacing

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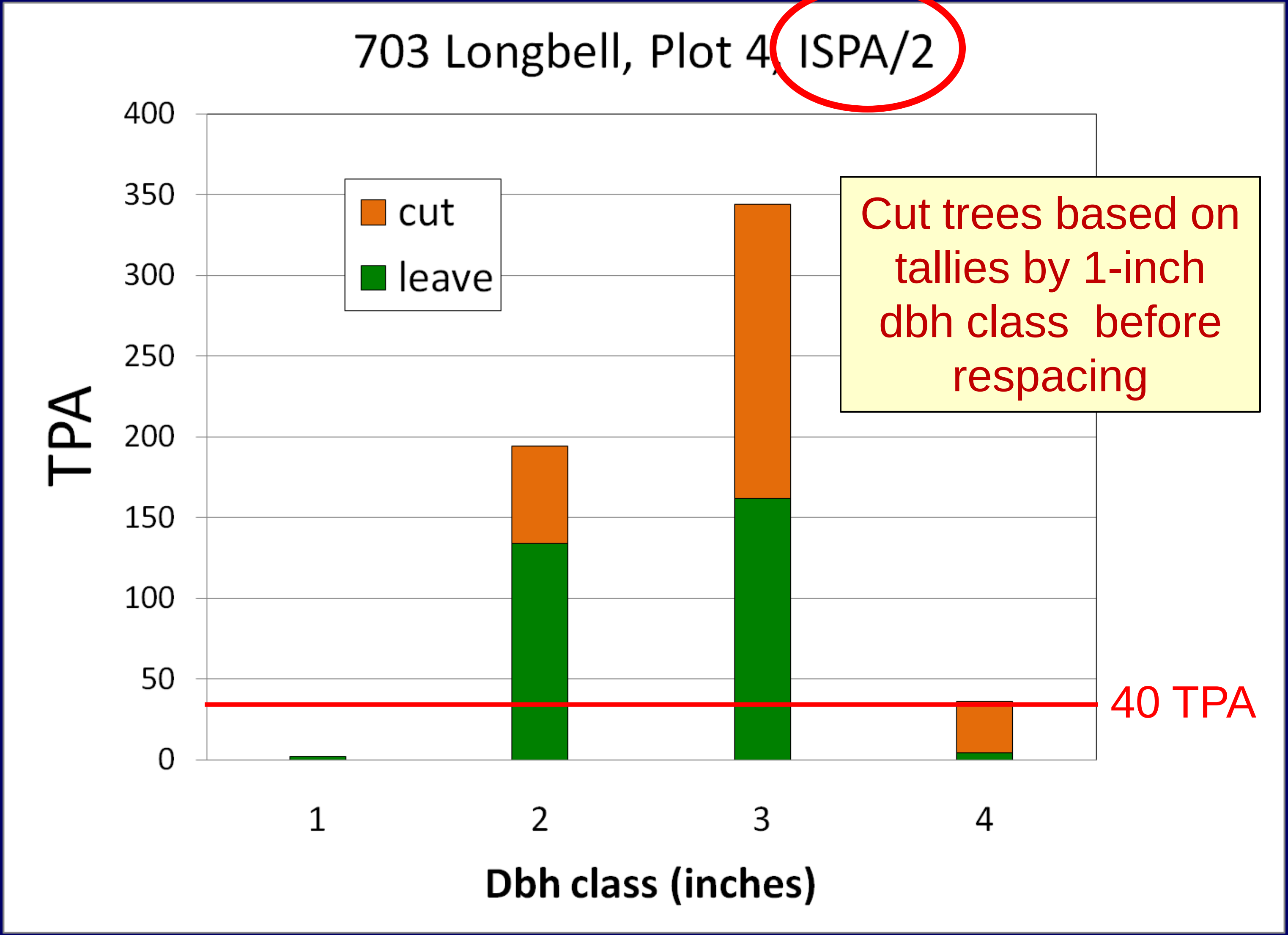

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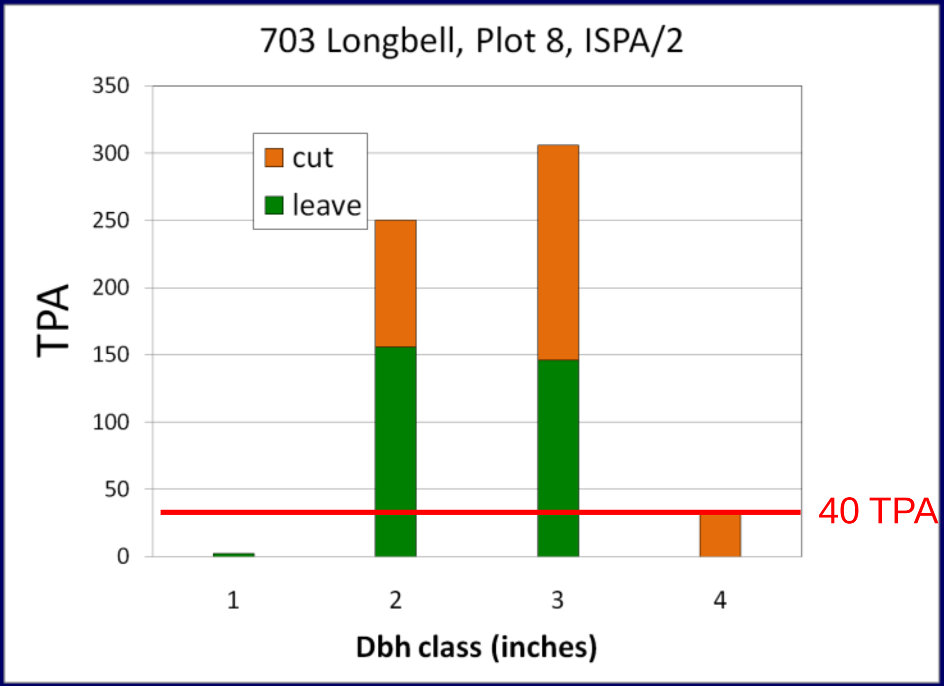
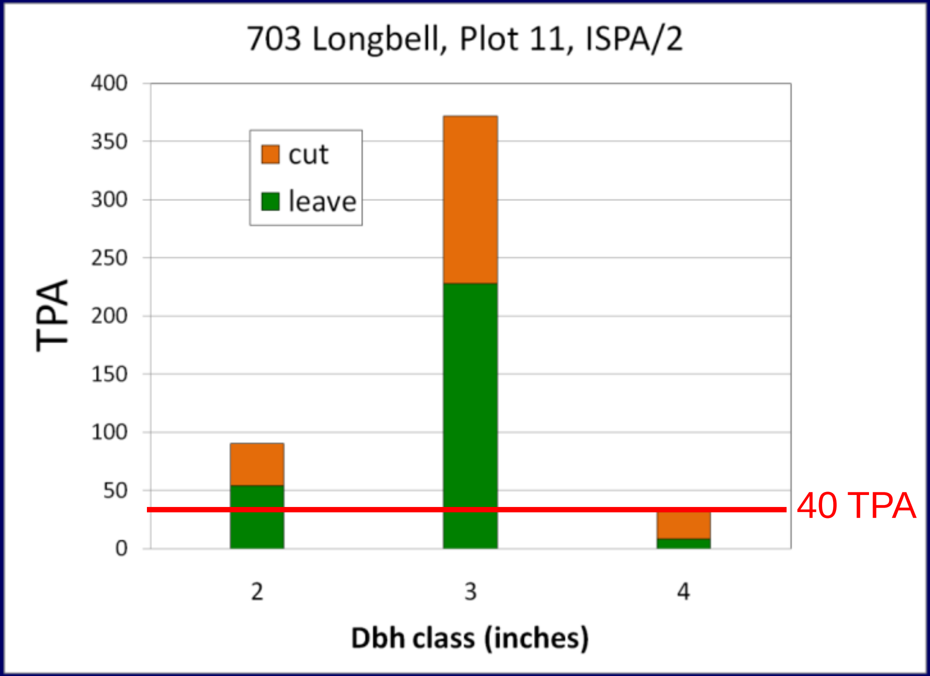
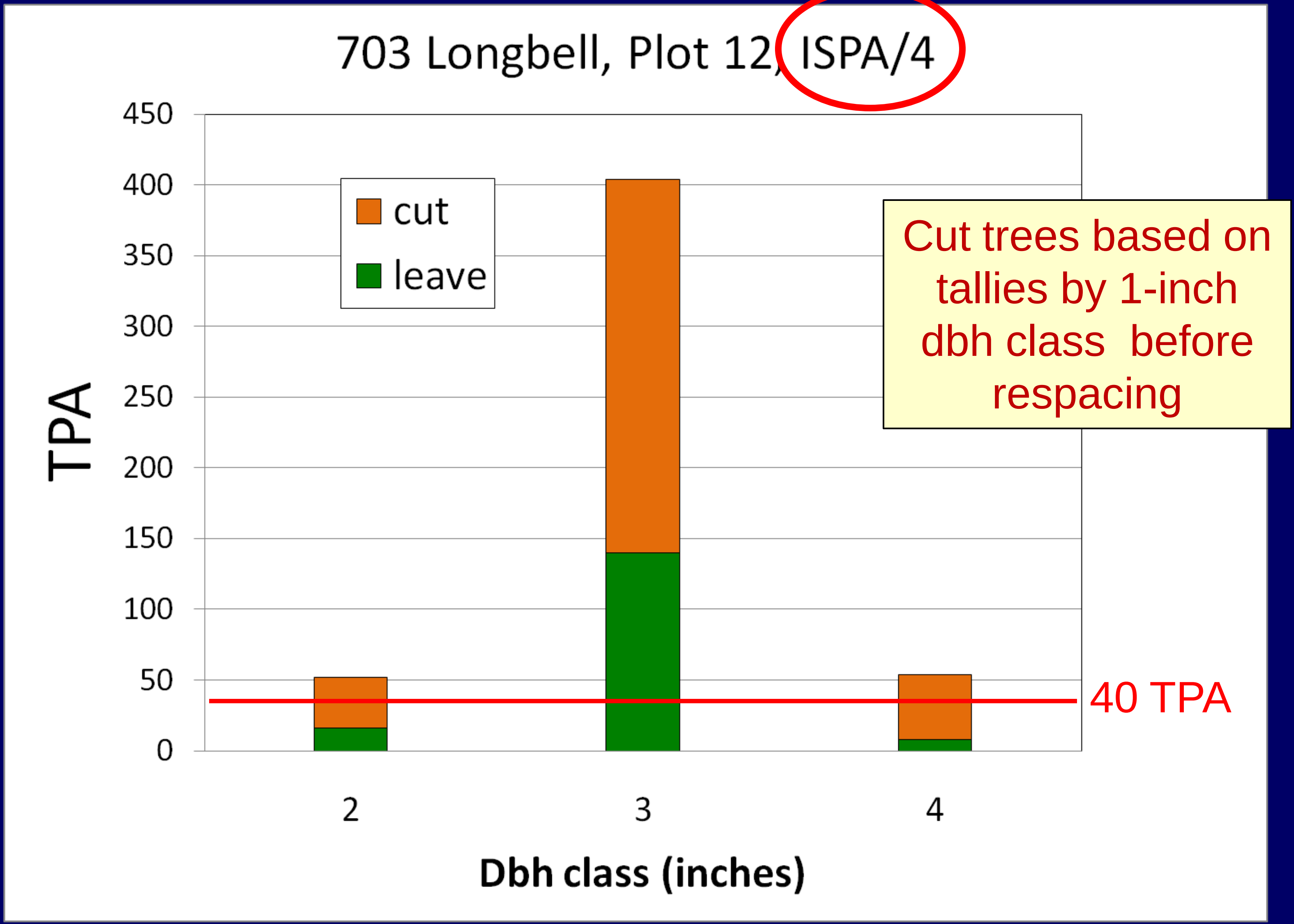


Cut :leave ratio seems a bit high on largest 1-inch dbh class at Longbell, but even if not, probable effect on D40 (H40)




703 Longbell, Plot 12, ISPA/4
450
400
350
300
250
200
150
100
50
0
TPA
cut
leave
Cut trees based on tallies by 1-inch dbh class before respacing
40 TPA
2
3
4
Dbh class (inches)

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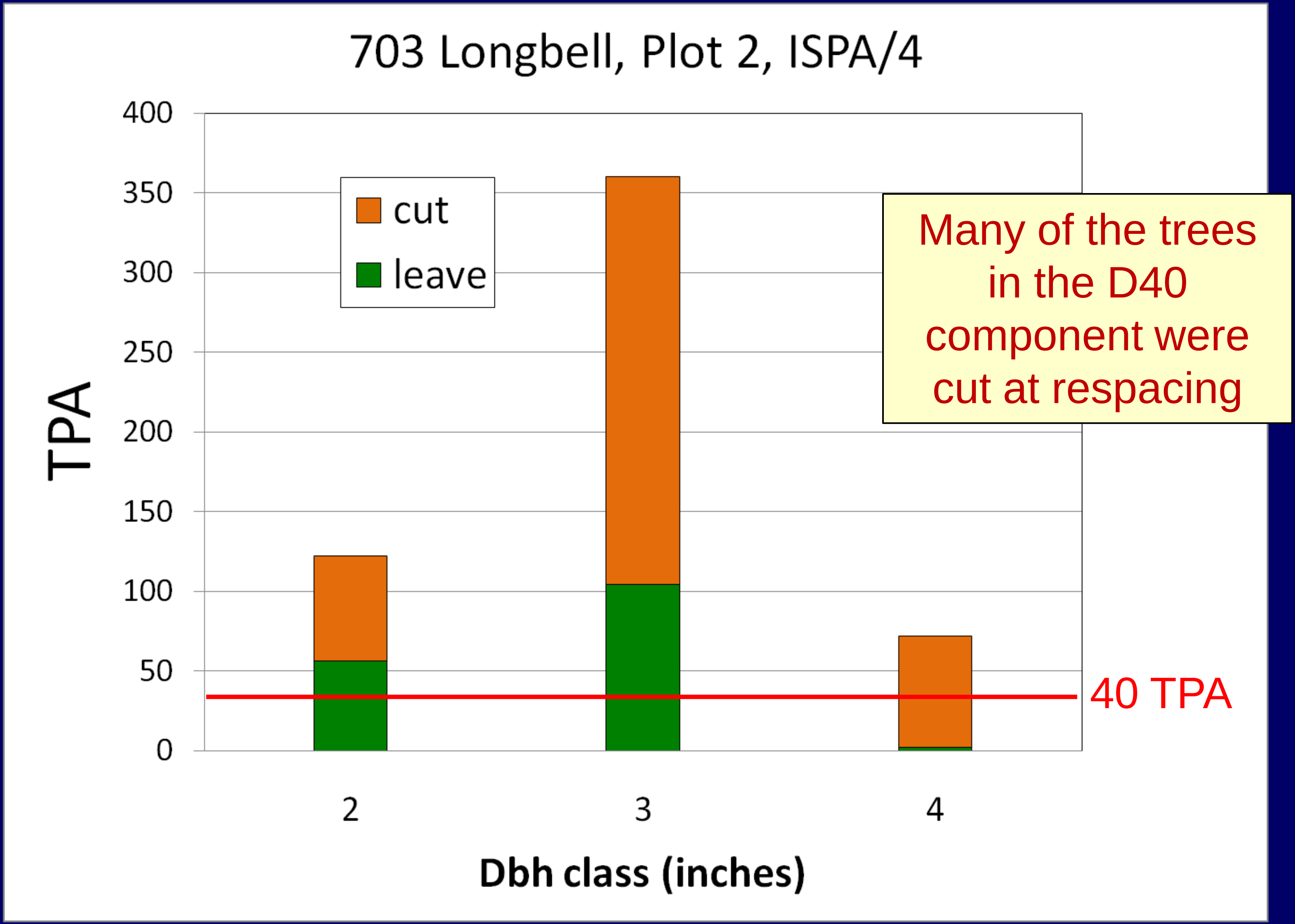
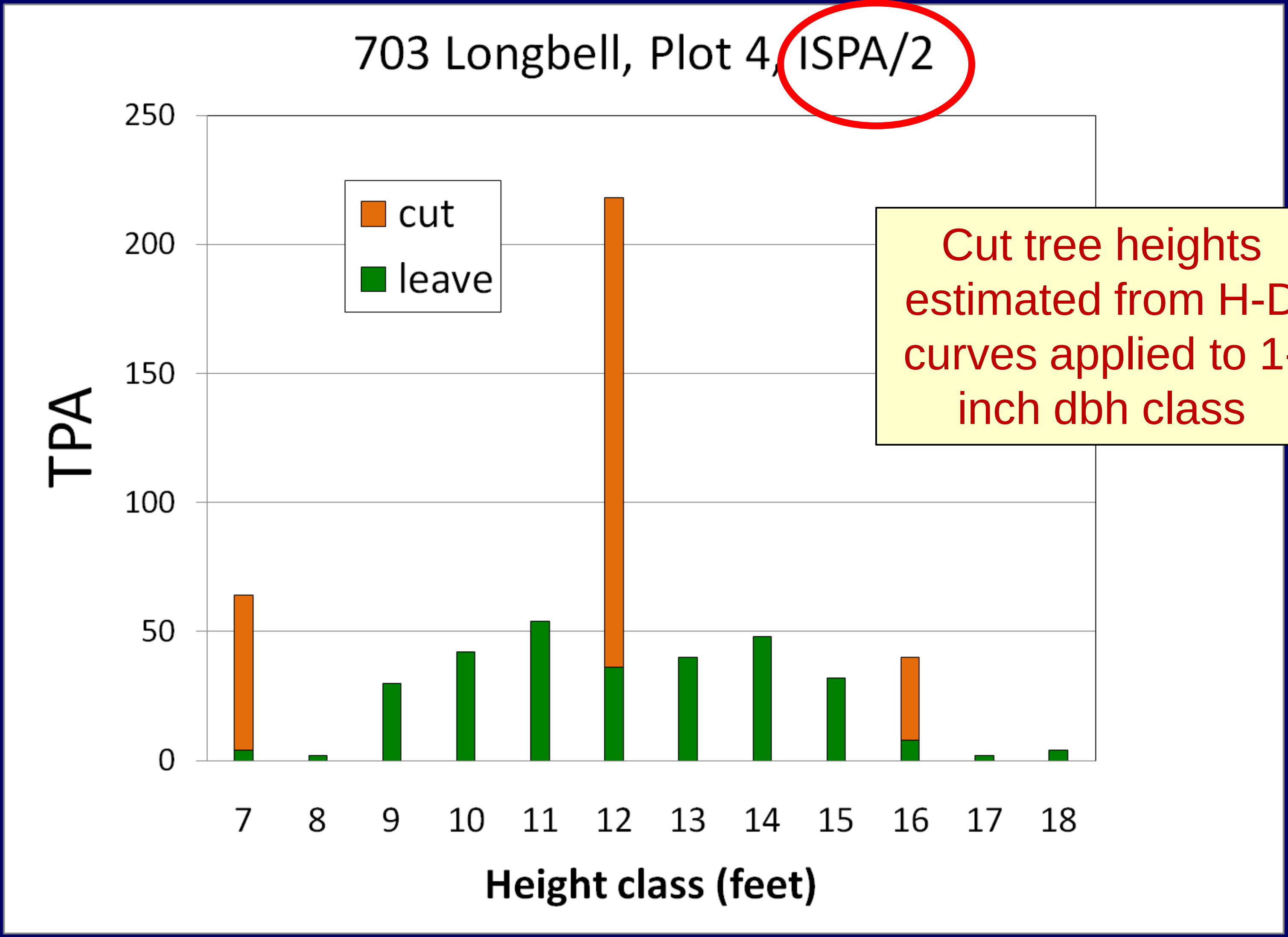
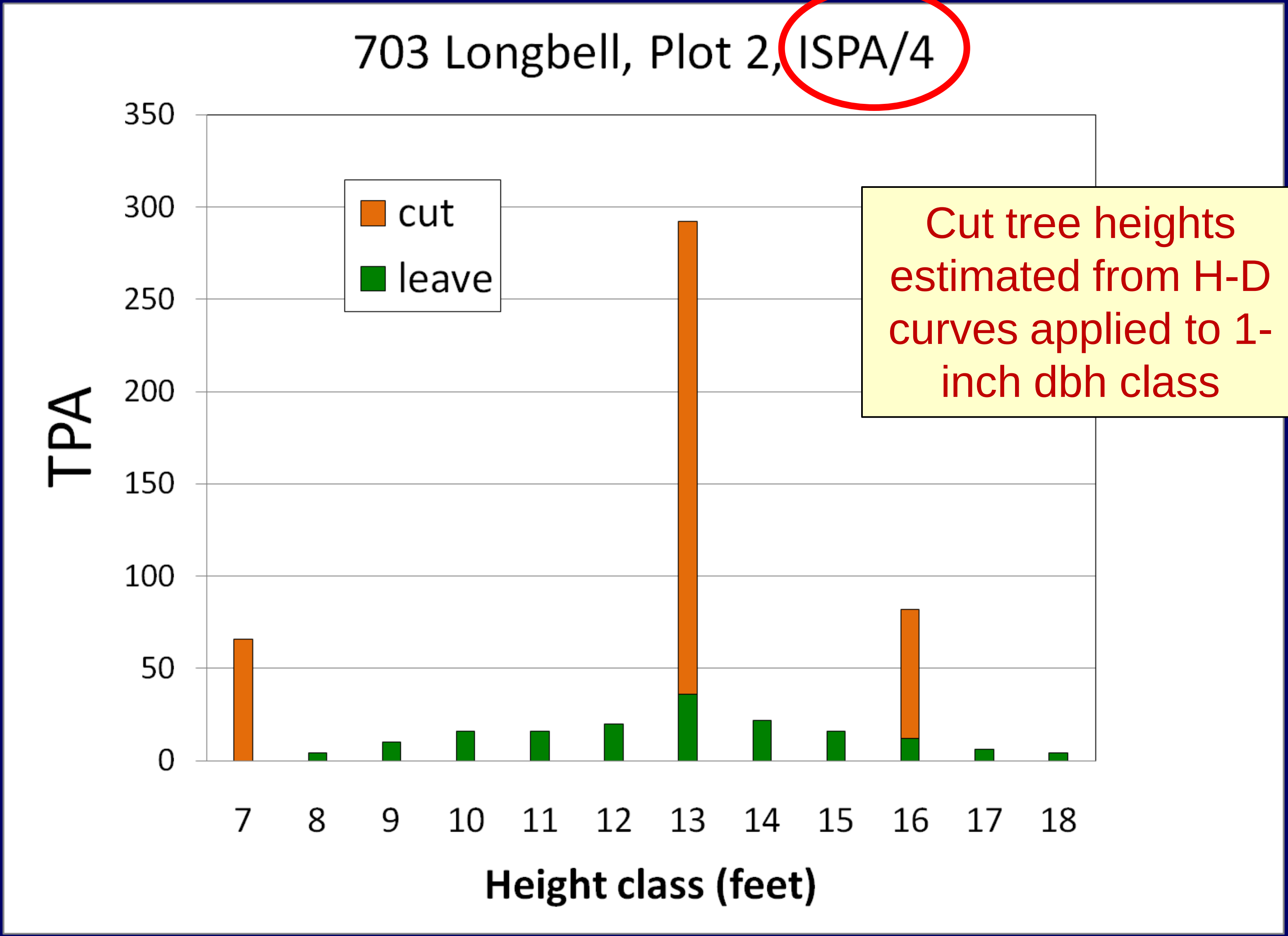
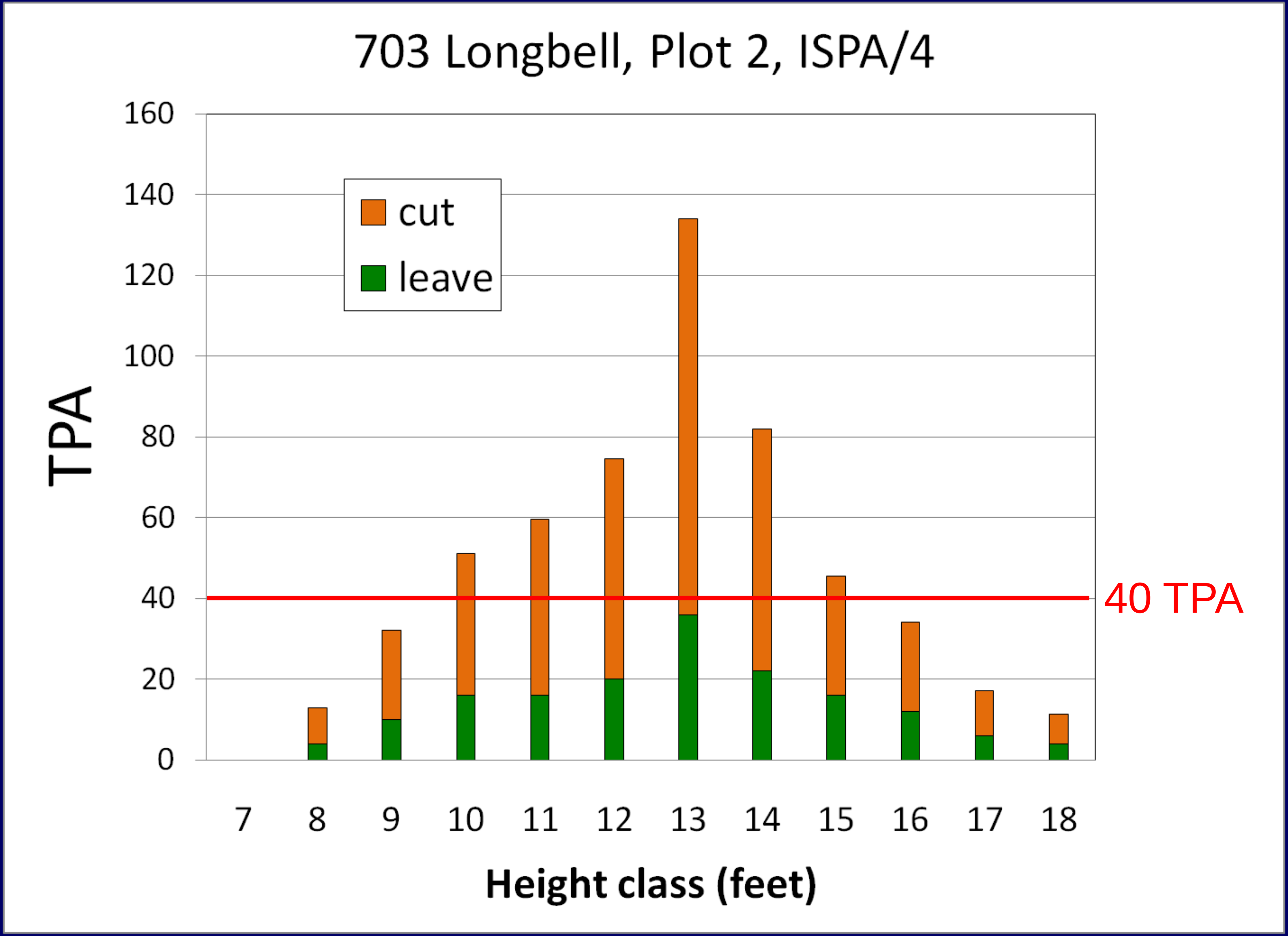


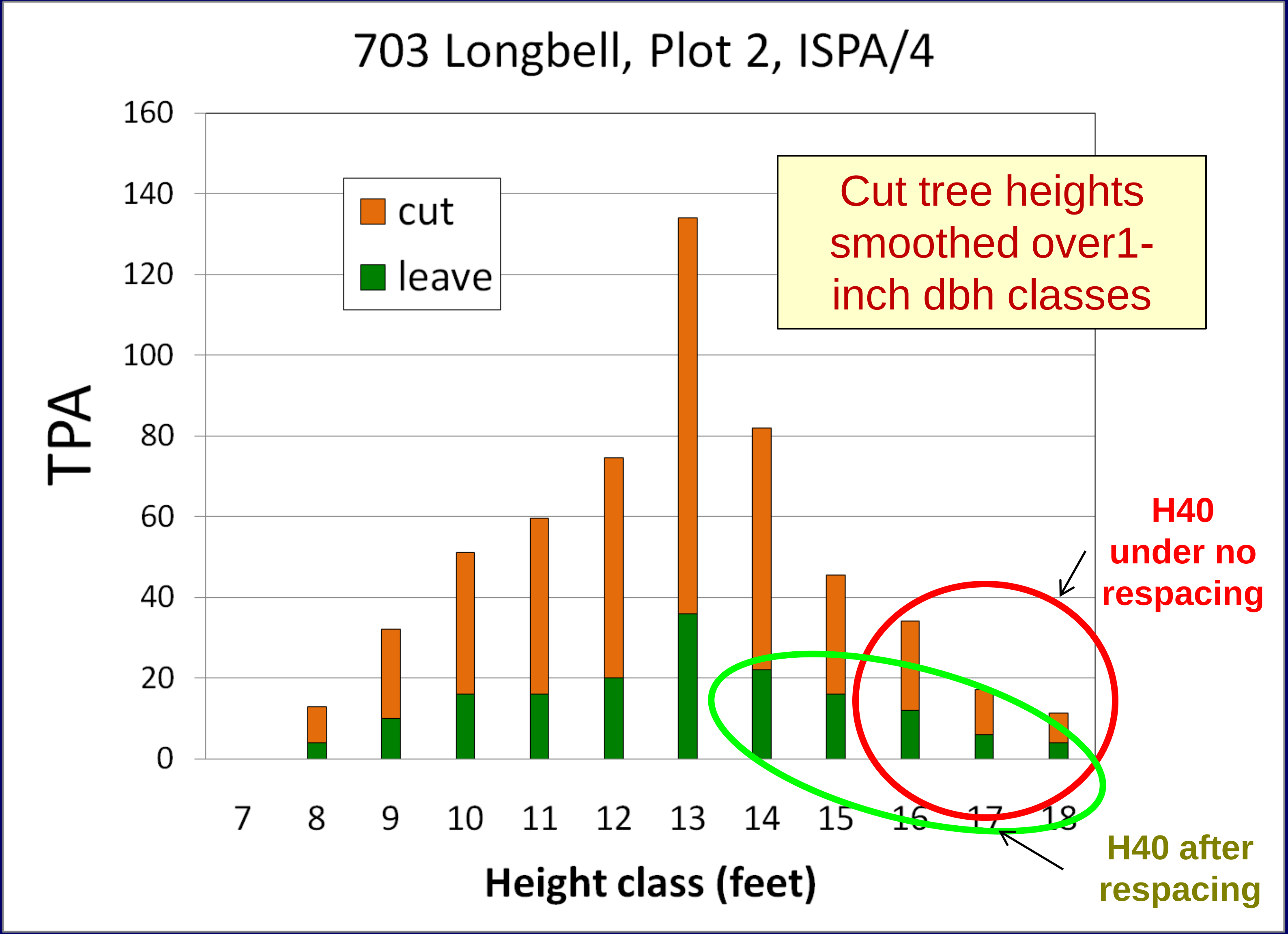


Cut tree heights estimated from H-D curves applied to 1-inch dbh class



Cut tree heights estimated from H-D curves applied to 1-inch dbh class


703 Longbell, Plot 2, ISPA/4
TPA
160
140
120
100
80
60
40
20
0
cut
leave
40 TPA
7
8
9
10
11
12
13
14
15
16
17
18
Height class (feet)


703 Longbell, Plot 2, ISPA/4
TPA
160
140
120
100
80
60
40
20
0
cut
leave
Cut tree heights smoothed over1-inch dbh classes
H40 under no respacing
7
8
9
10
11
12
13
14
15
16
17
18
Height class (feet)
H40 after respacing

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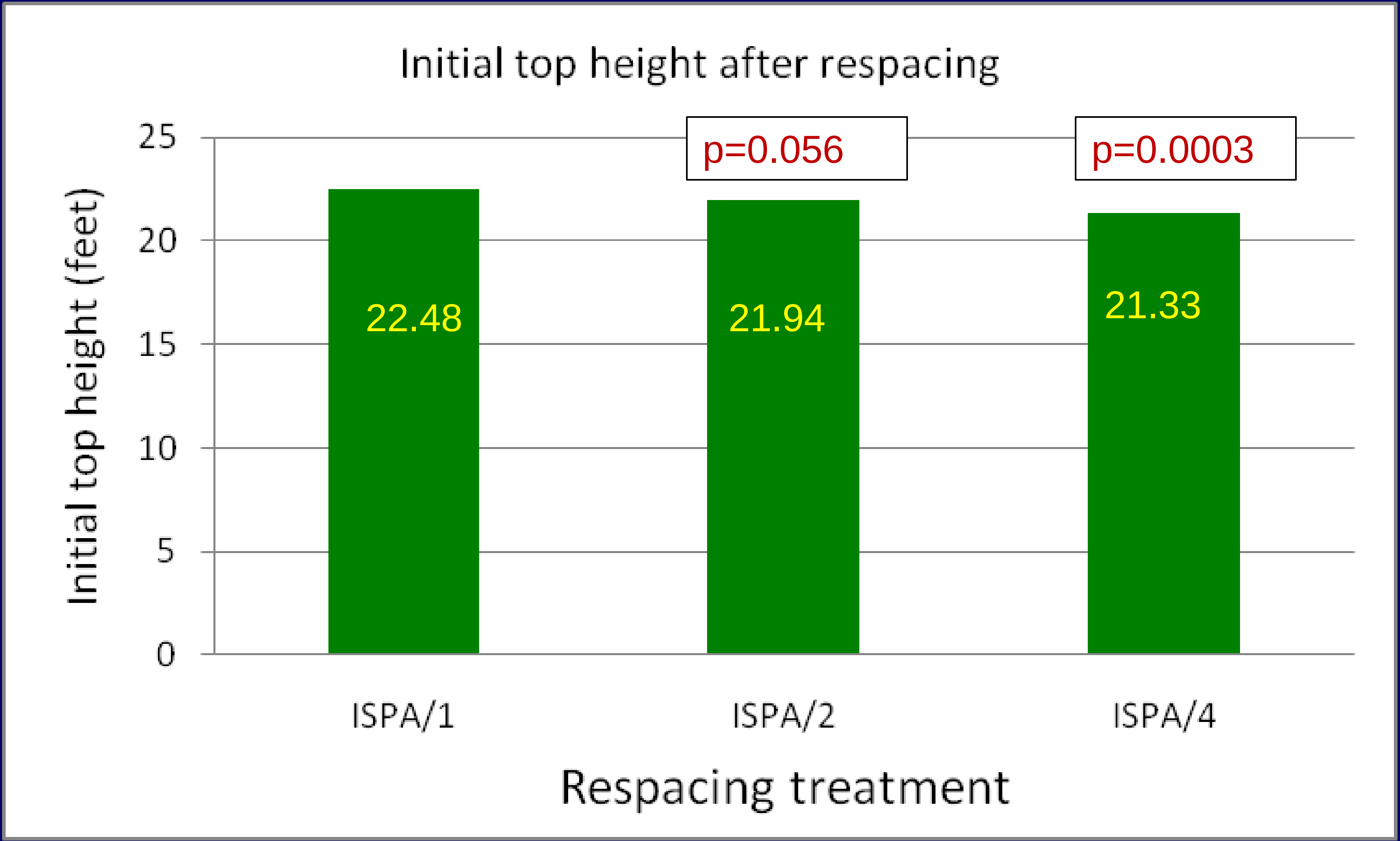

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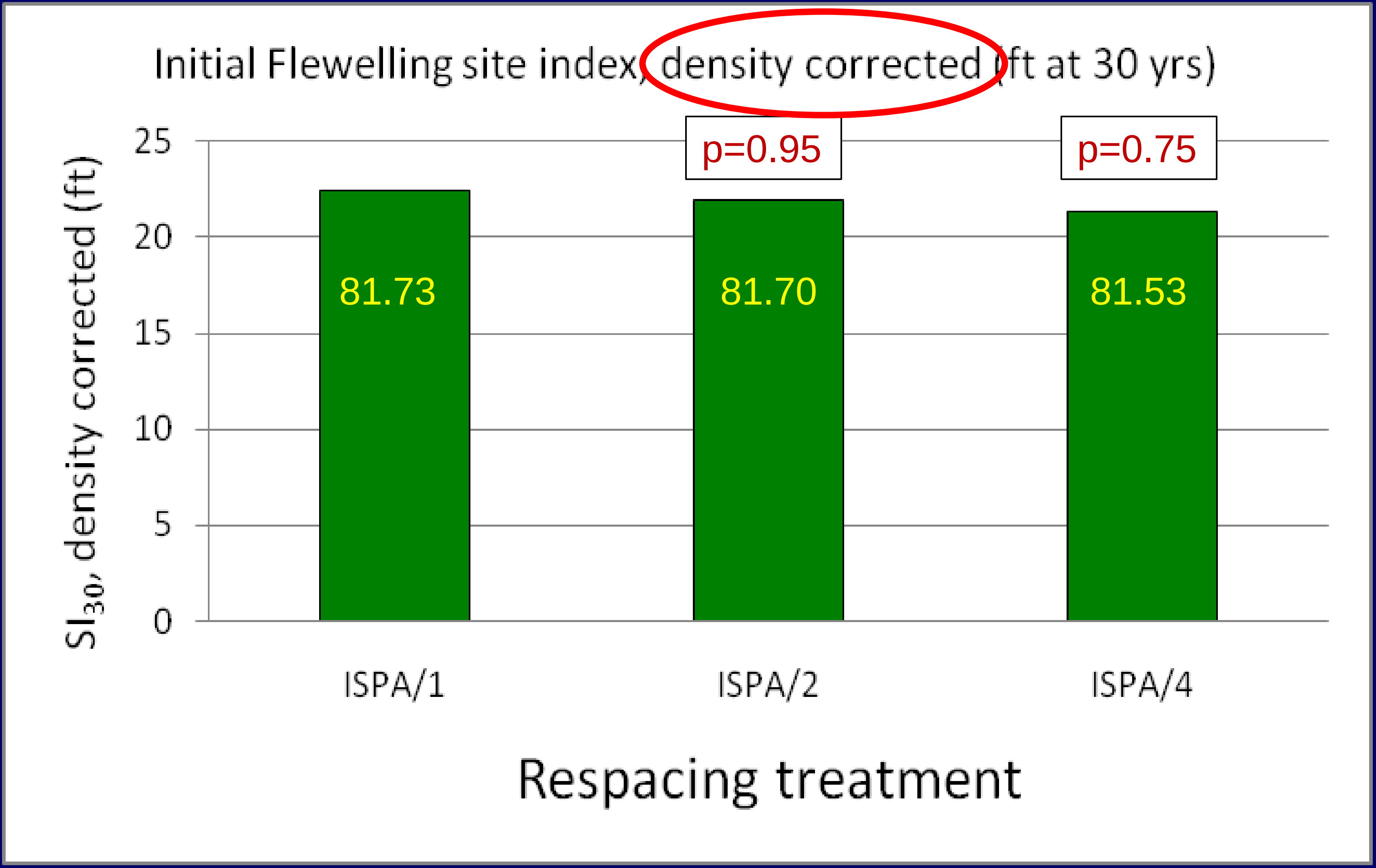

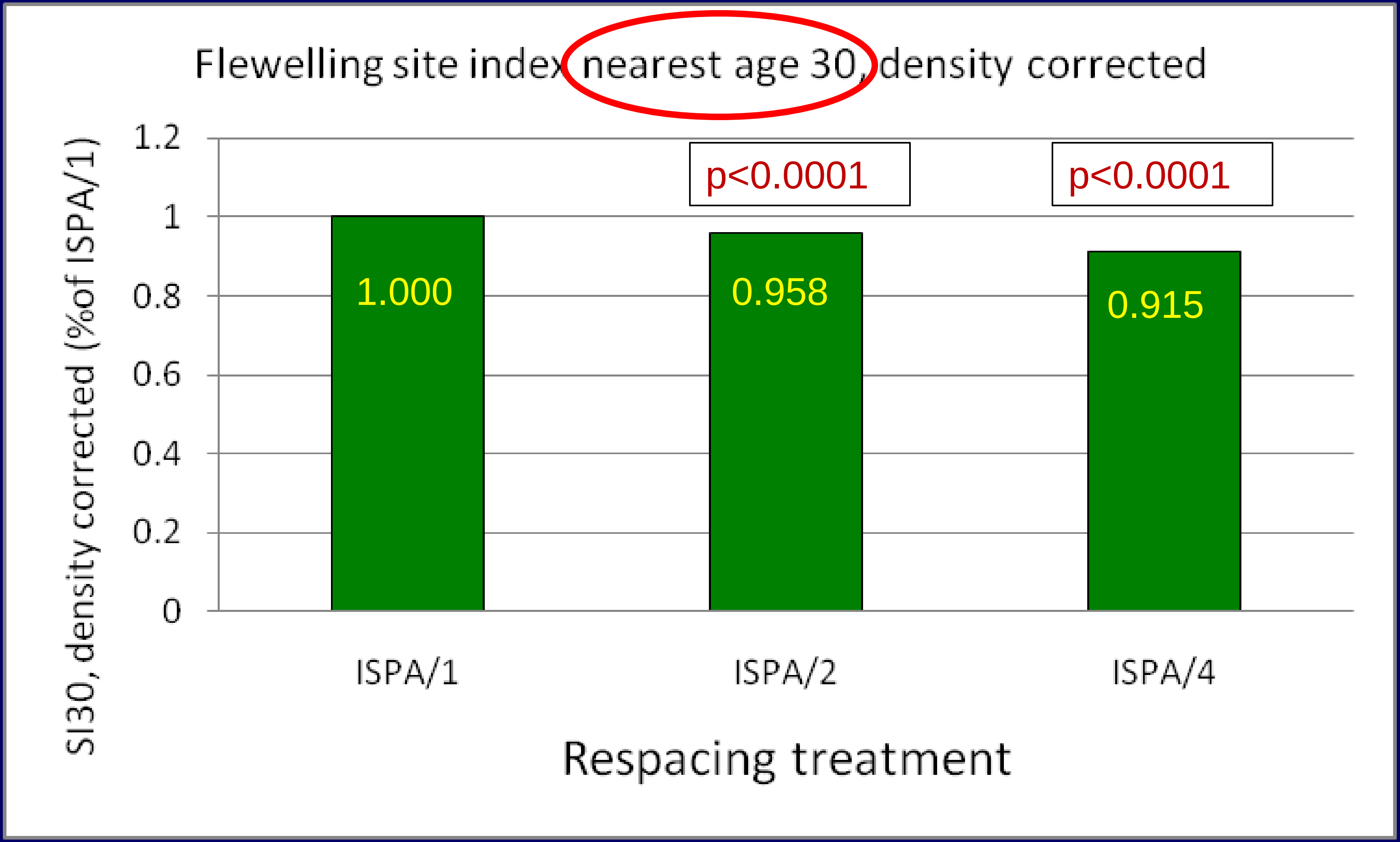
Flewelling site index nearest age 30, density corrected
SI30, density corrected (%of ISPA/1)
1.2
1
0.8
0.6
0.4
0.2
0
p<0.0001
p<0.0001
1.000
0.958
0.915
ISPA/1
ISPA/2
ISPA/4
Respacing treatment

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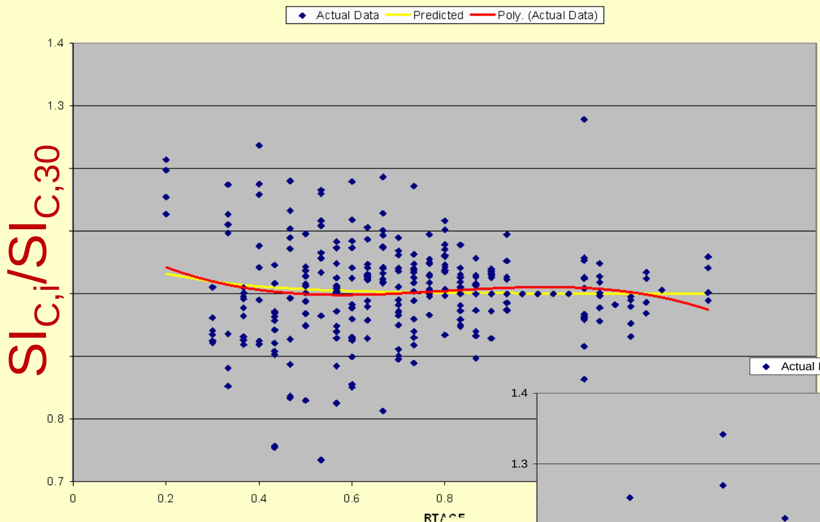
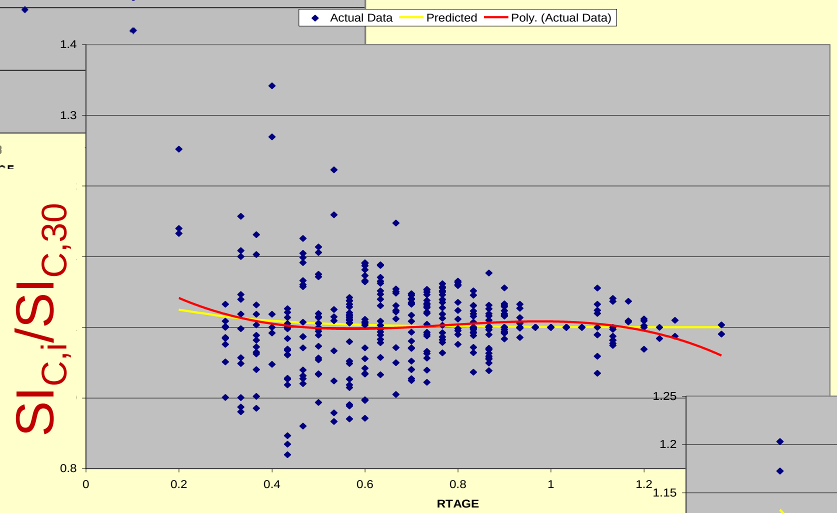
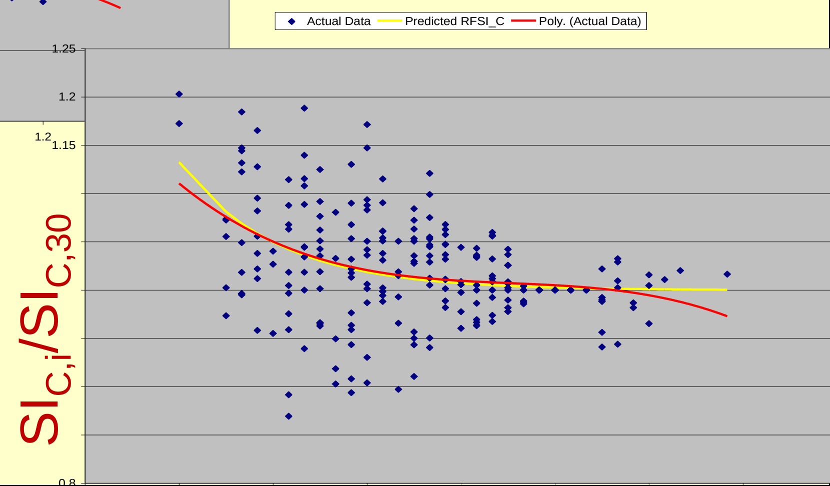
Ratio of SI at birth age *i* to SI at birth age 30



No significant trend over time for **ISPA/1**



No significant trend over time for **ISPA/2**



Statistically significant decline over time for **ISPA/4**

Conclusions:

1) Respacing lowers initial H40
2) Density correction in Flewelling system facilitates accurate estimation of SI in spite of respacing
3) Significant decline in SI30 in ISPA/4 (why?)

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Significant decline in SI30 in ISPA/4:

- Gonyea and Hasselberg picked the lowest density plots for the ISPA/4 (!!)
- Removal of trees contributing to H40 (better growers)
- Long-lasting thinning shock
- Adverse effects of competing vegetation
- Mechanisms consistent with ***Weyerhaeuser effect***

What are the effects of respacing on top height/site index?

What are the effects of respacing on individual tree volume growth?

Previous analyses for ORGANON thinnning multipliers (MOD):

$$\Delta D = \Delta \hat{D} \cdot MOD_D$$

$$\Delta H = \Delta \hat{H} \cdot MOD_H$$

- Initial increase in diameter growth MOD>1 with approach to no direct effect (Mod=1)
- Initial reduction in height growth (MOD<1) with gradual approach to no direct effect (MOD=1)

$$\Delta V = (\Delta V_C)(MOD1_{RS})(MOD2_{RS})$$

$$\Delta V_C = \exp(\Sigma a_i X_i)$$

Start

$$MOD1_{RS} = \exp(b_1 I_{RS2} + b_2 I_{RS4})$$

$$MOD2_{RS} = [1 + X_7 \exp(b_3 + b_4 X_8 + b_5 \ln(X_8 + 1))]$$

$$\Delta V_C = \exp(\Sigma a_i X_i)$$

X_is are functions of DBH, CR, SI, BAL, BA

(1) Fit to ISPA/1 plot data alone
(2) Scale predictions to control plots on each installation
(3) Apply scaled predictions to tree data from respaced plots alone and compute ratio of observed ΔV to predicted ΔV

4) Fit ratios to combined respacing modifiers MOD1 and MOD2

$$\frac{observed \Delta V}{predicted \Delta V} = (MOD1_{RS})(MOD2_{RS})$$

$$MOD1_{RS} = \exp(b_1 I_{RS2} + b_2 I_{RS4})$$

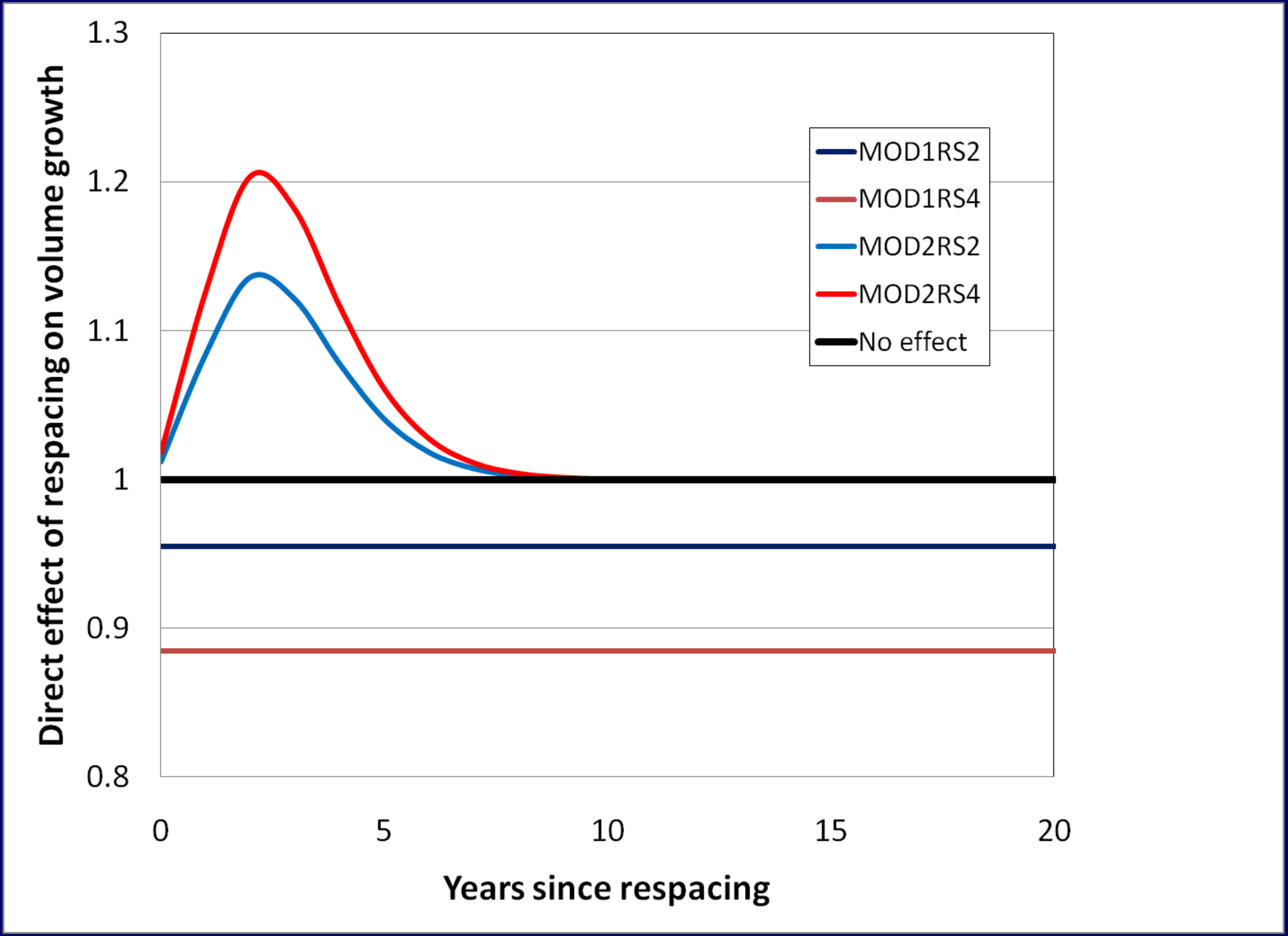
$$MOD2_{RS} = [1 + X_7 \exp(b_3 + b_4 X_8 + b_5 \ln(X_8 + 1))]$$

I_{RS2}, I_{RS4} are indicator variables for ISPA/2 and ISPA/4 respectively; i.e., constant and continuing direct effect

X_7 is the % basal area removal in respacing
X_8 is the years since respacing

Center for Intensive Planted-forest Silviculture

UNIVERSITY OF WASHINGTON
Stand Management Cooperative

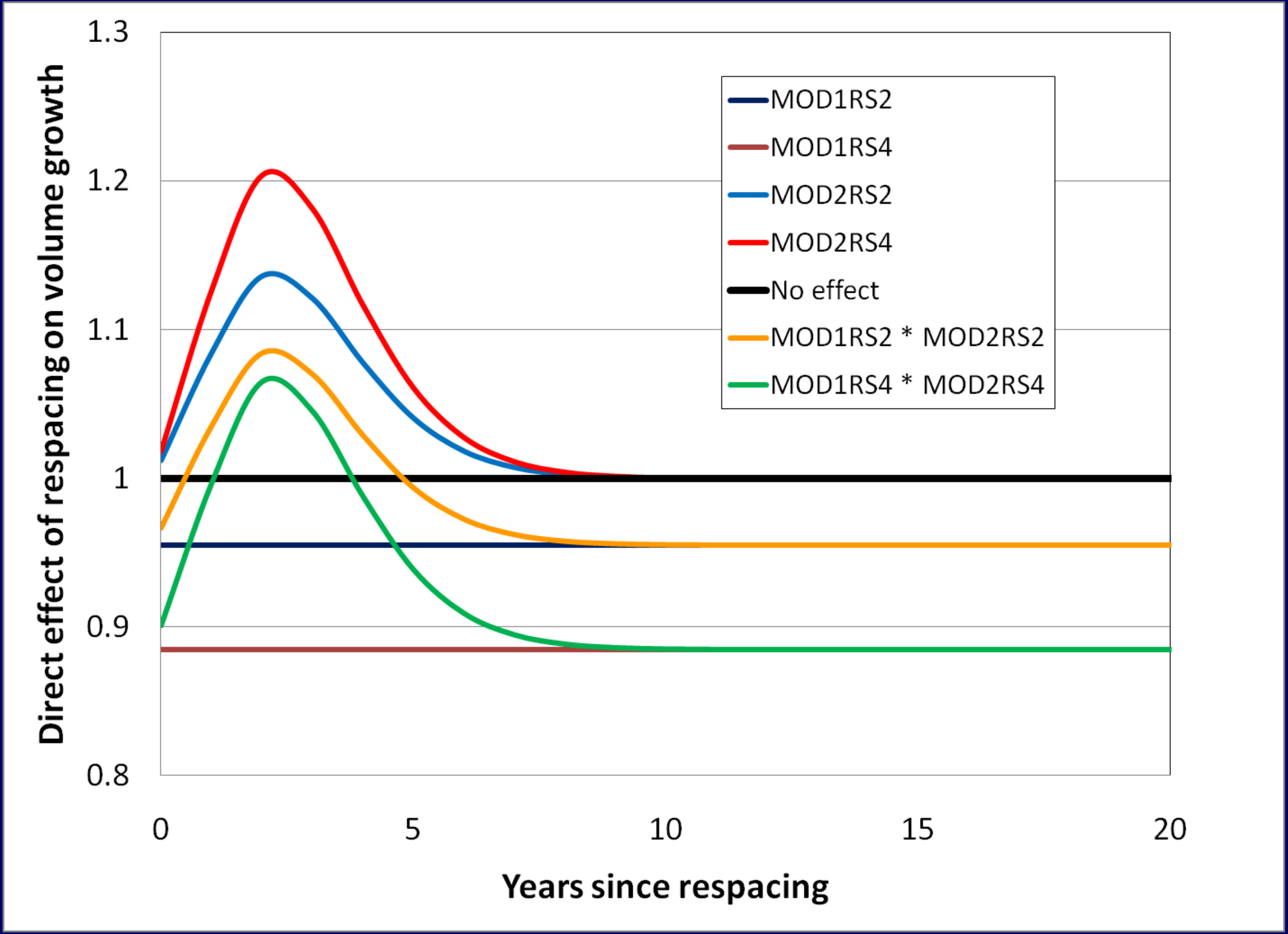


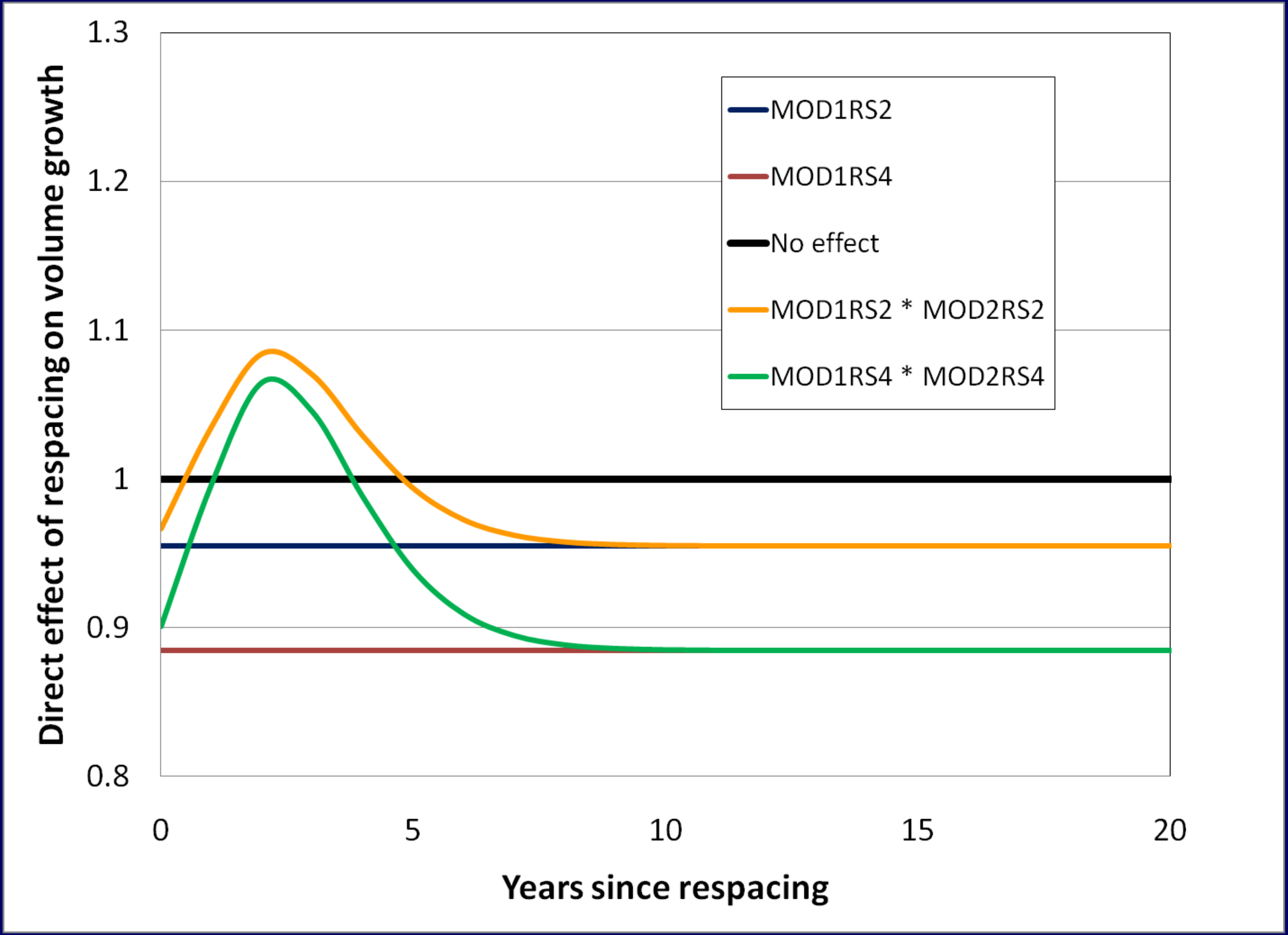
Conclusions:

1) Same type of modifier needed for respacing as needed for thinnings (i.e., evidence for release effect on residual trees)
2) The constant and continuing growth reduction from respacing is essentially undoing the density correction in the site index estimate
3) Significant decline in SI30 in ISPA/4 (why?)

Center for Intensive Planted-forest Silviculture

UNIVERSITY OF WASHINGTON
Stand Management Cooperative




Direct effect of respacing on volume growth
Years since respacing
1.3
1.2
1.1
1
0.9
0.8
0
5
10
15
20
MOD1RS2
MOD1RS4
No effect
MOD1RS2 * MOD2RS2
MOD1RS4 * MOD2RS4

Thinning and fertilization multipliers

- Similar model forms
- Modifier functions for single thinning include an adjustment to account for the effect of any initial respacing
- Modifier functions for multiple fertilizations include an adjustment to account for the effect of any initial respacing


Thanks for your attention!

Prioritizing Douglas-fir plantations for nitrogen fertilization by linking mechanisms of growth response to site and stand conditions

Appendix G(2)

Doug Mainwaring

Oregon State University

Doug Maguire

Oregon State University

Objectives

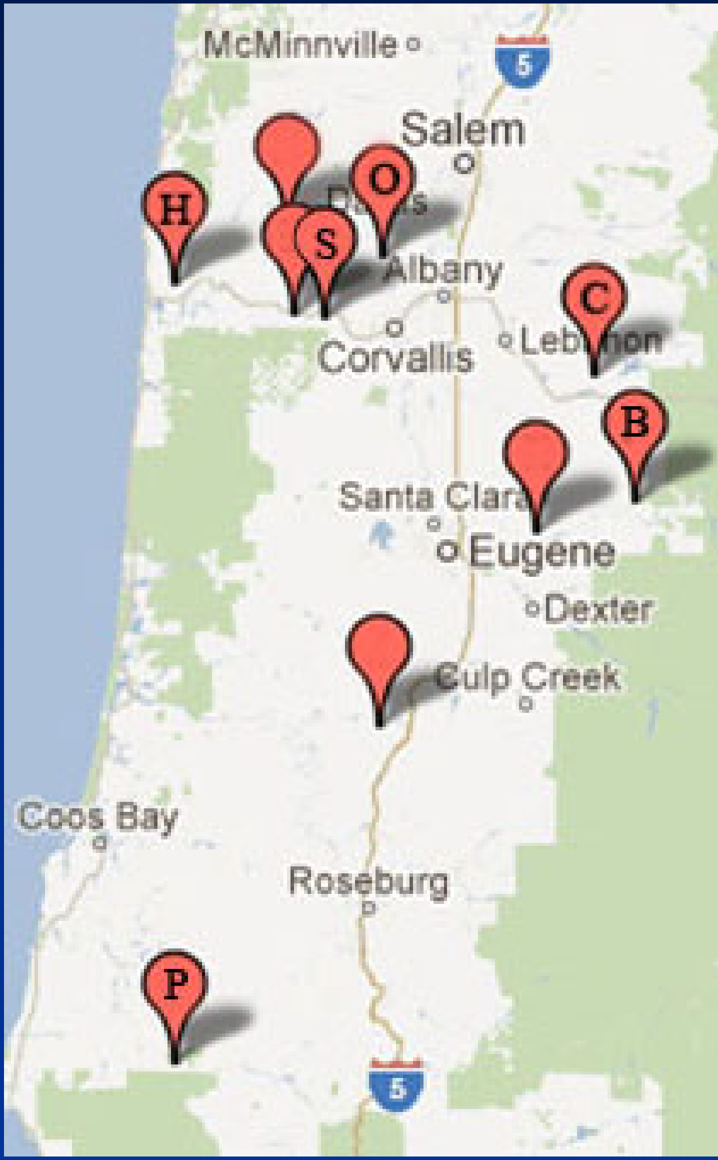
- To identify specific crown responses to fertilization

    - Foliage mass
    - Shoot growth
    - Specific leaf area
    - Bud count
    - Needle density
    - Photosynthesis

- To test whether leaf area index and water holding capacity are significant factors in predicting fertilizer response

Methods

- **Sites distributed across western Oregon**
  - **Plots installed in 15-25 year old stands**
  - **Four 0.25 acre plots with 0.1 core, and 3 x 0.05 acre for destructive sampling**
  - **Randomly assigned treatments; 2 control, 2 fertilized**
  - **Fertilized with 200 lbs N/acre**
  - **One stand with noticeable Swiss needle cast**



Methods

- Sites distributed across western Oregon
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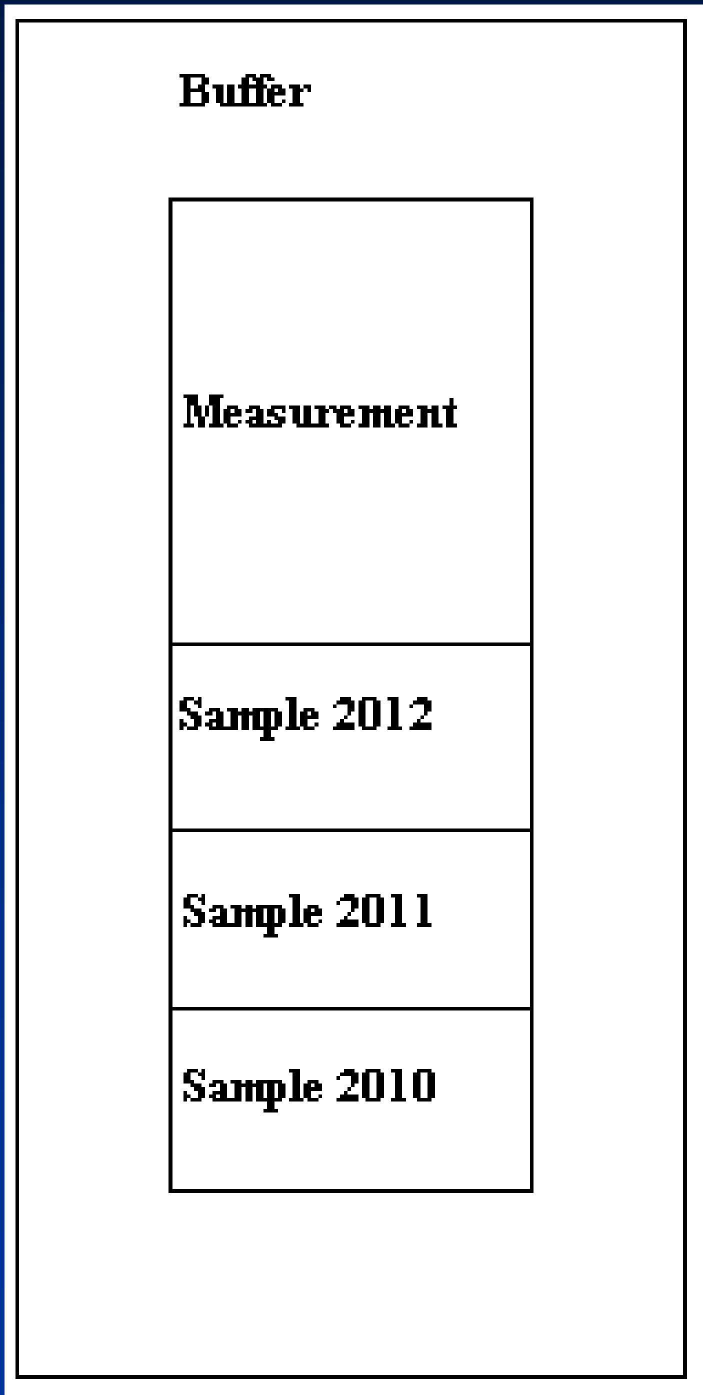


Methods, field

- All trees tagged and measured for dbh annually in years 0-3
- Ten trees across dbh dist. cored for sapwood width
- Subsample measured for height, height to live crown in years 0 and 3

Methods, field

Five sites chosen for annual destructive sampling

- Subjectively chosen to include responders/non-responders
- On 1 plot per treatment, 3 trees across dbh dist. chosen for destructive sampling in each of years 1, 2, 3 post-fert
- All live branches measured for height, branch diameter, and 6 randomly chosen (2 per crown third) for lab breakdown.

Methods, lab

- **Branches**
  - Collected fifty main-axis needles from up to 4 cohorts for SLA measurements
  - 1 and 2 year old primary terminals measured for length
  - Counted buds on 1-yr old terminal; counted 1-yr old shoots on 2-yr old terminal (budcounts)
  - Measured length of all 1-yr old lateral shoots of main axis
  - Collected 2 uppermost 1-yr old interwhorl shoots for needle density estimates
  - Cut branches into annual shoots; dried, separated, and weighed foliage and wood

Analysis

- **Expansion of branch-level foliage to whole crown**

  - **$\ln(folmass) = \alpha 0 + \alpha 1 BLOCK + \alpha 2 FERT + \alpha 3 \ln(BrD) + \alpha 4 \ln(DINC) + \alpha 5 (RHACB)$**

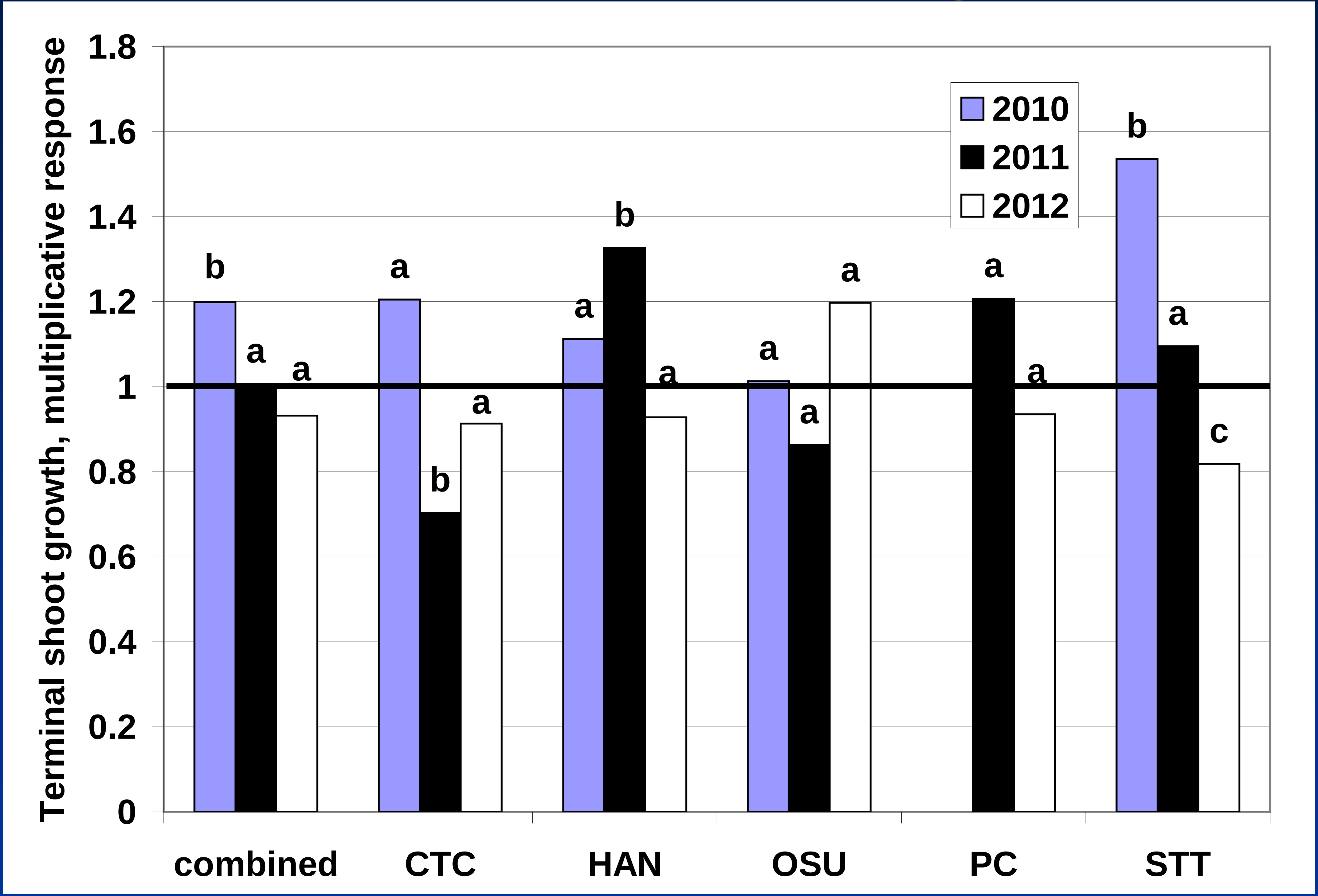
Where **BrD is Branch diameter**
DINC is depth into crown
RHACB is relative height above crown base

- **Expansion of tree-level leaf area to stand**

  - **$\ln(tLA) = -15.4488 + 2.9968 \ln(D_{cb}) + 2.9972 \ln(SI_{50})$**

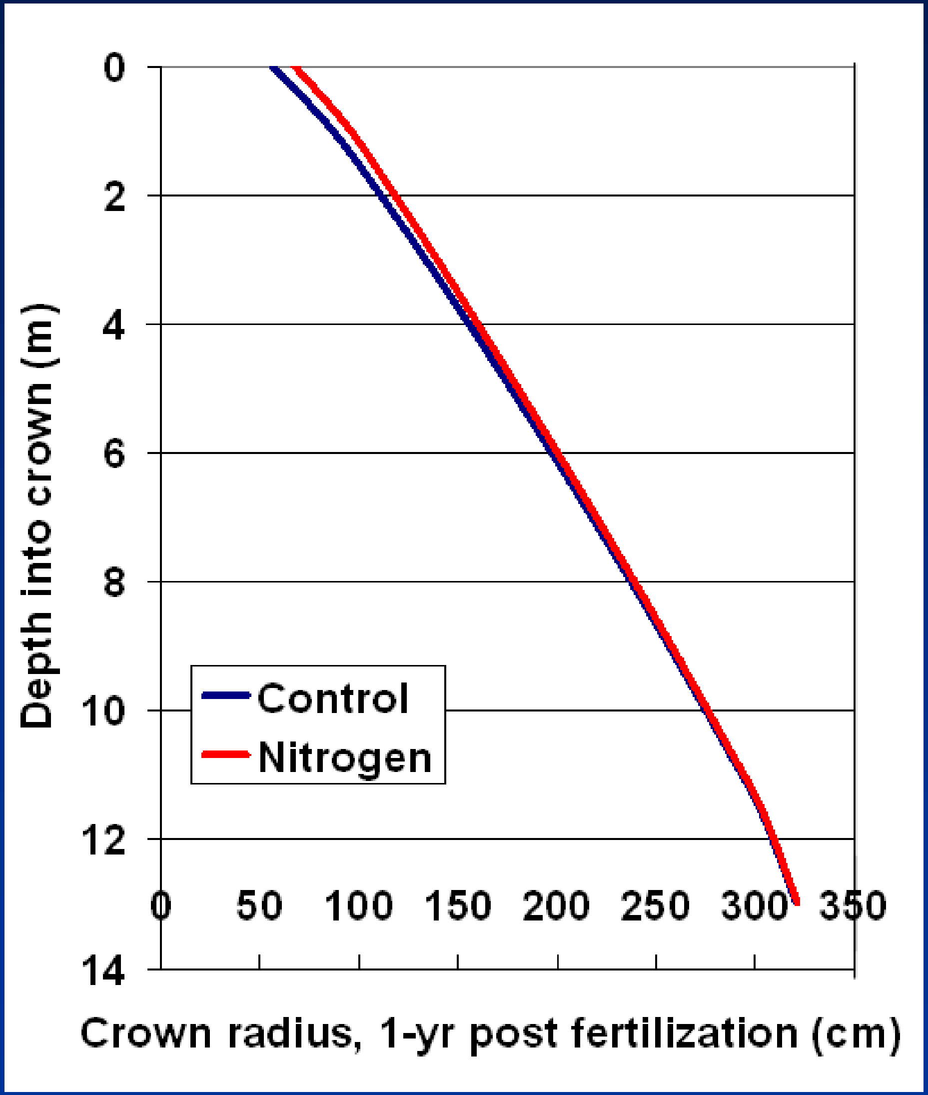
Where **D_{cb} is diameter at crown base**
SI_{50} is Bruce site index

Results, Branch terminal growth



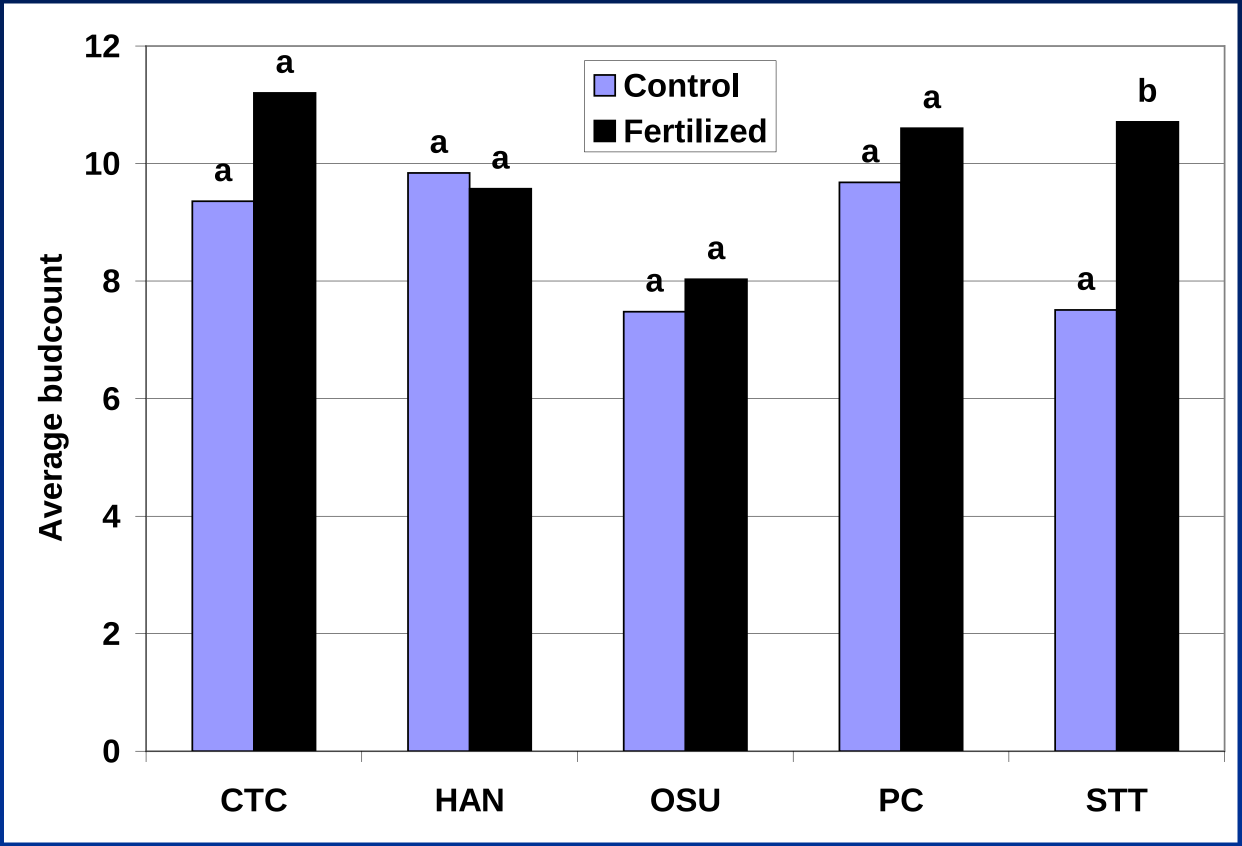
Results, Branch terminal growth

- **Branch terminal growth was negatively associated with depth into crown**



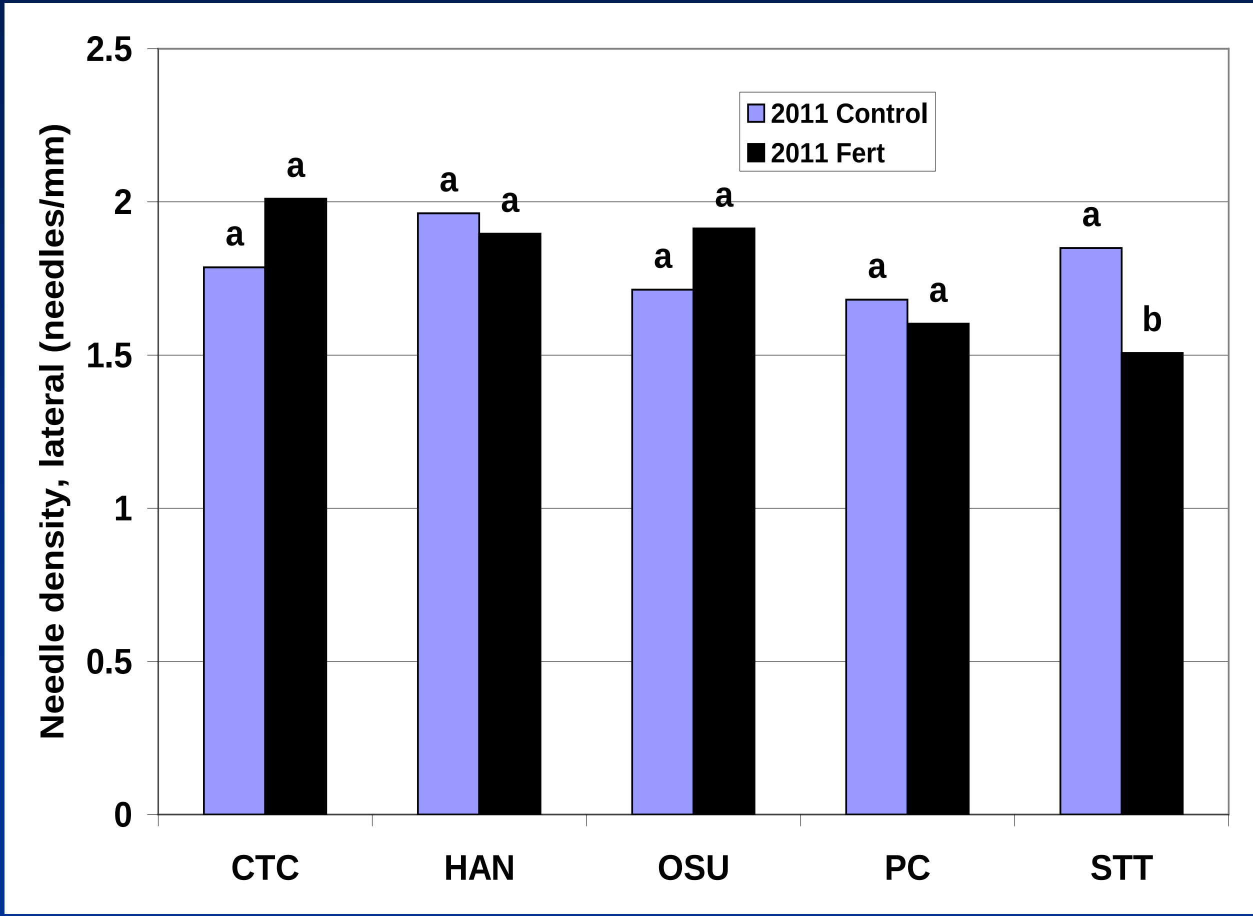
Results, Budcount

- After accounting for shoot length, branch diameter, and RHACB, fertilization marginally increased bud counts in 2011.
- No effect was apparent in 2012.



Results, Needle density

- After accounting for relative height above crown base, effect of fertilization on needle density was significantly related to site; Needle density decreased at STT



Results, Stand volume growth

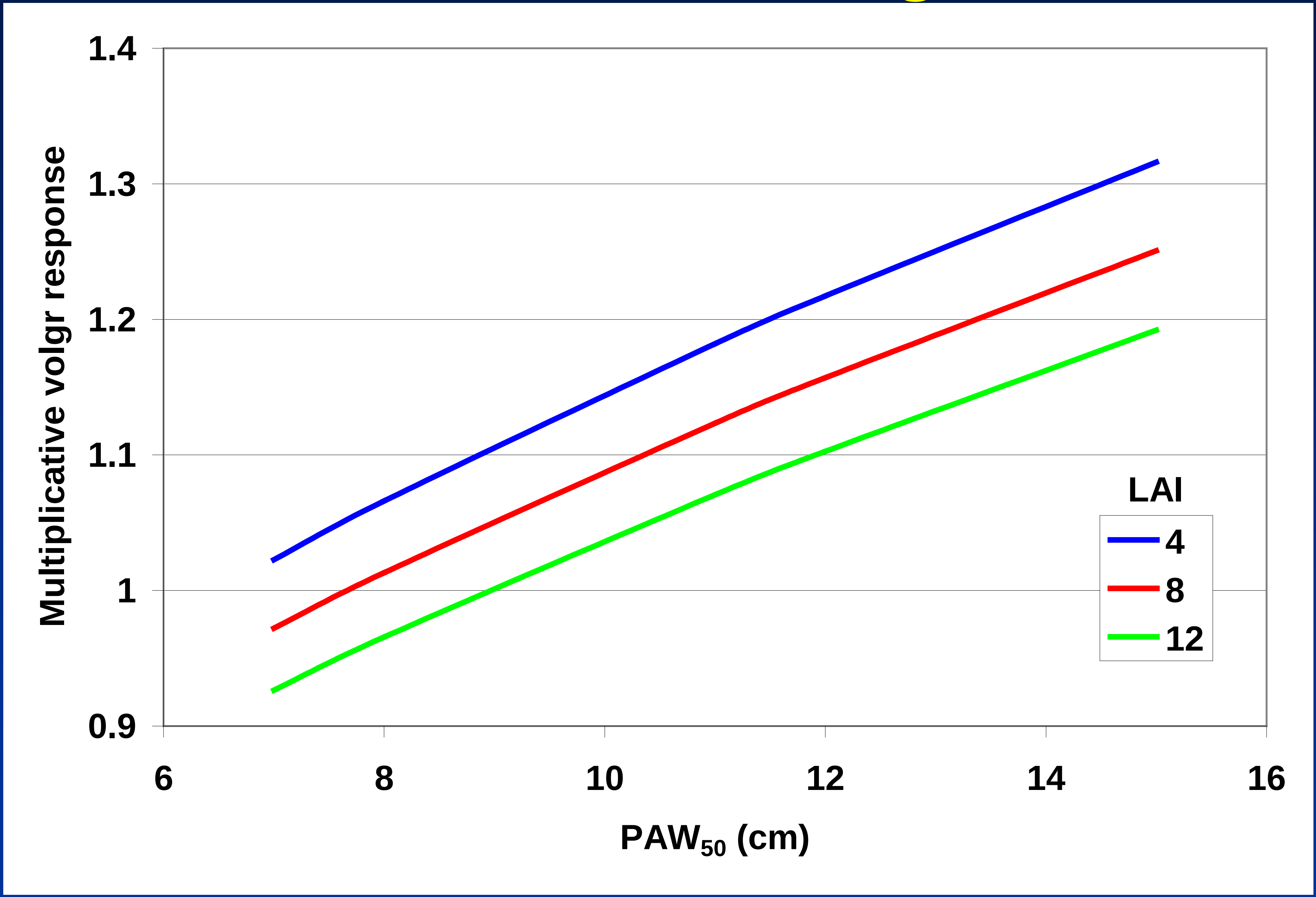
Volgr=

$\beta_0 \cdot (BA) \cdot \beta_1 \cdot LAI \cdot \beta_2 \cdot PAW_{50} \cdot \beta_3 \cdot HT_D \cdot \beta_4 \cdot \exp(FERT \cdot (\beta_5 + \beta_6 \cdot LAI + \beta_7 \cdot FR + \beta_8 \cdot PAW_{50}))$

where

Volgr	=	Plot volume growth (m^3/ha/yr)
BA	=	Initial plot-level basal area (m2ha-1)
LAI	=	Leaf area index
PAW_{50}	=	Plant available water in top 50 cm of soil (NRCS)
HT_D	=	Height of 100 largest TPH by dbh (m)
FERT	=	Effect of urea fertilization (=1 if fert, otherwise =0)
FR	=	Foliage retention (yrs, Zhao et al. 2011)

Results, Stand volume growth

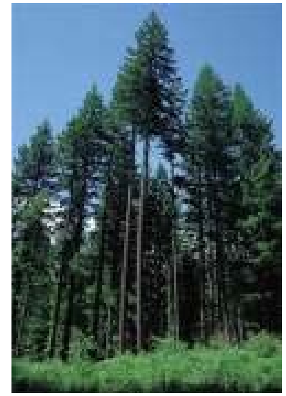


Fate of applied ^{15}N fertilizers in Douglas-fir plantations of the Pacific Northwest

Stephani Michelsen-Correa, Rob Harrison, and Betsy Vance

University of Washington

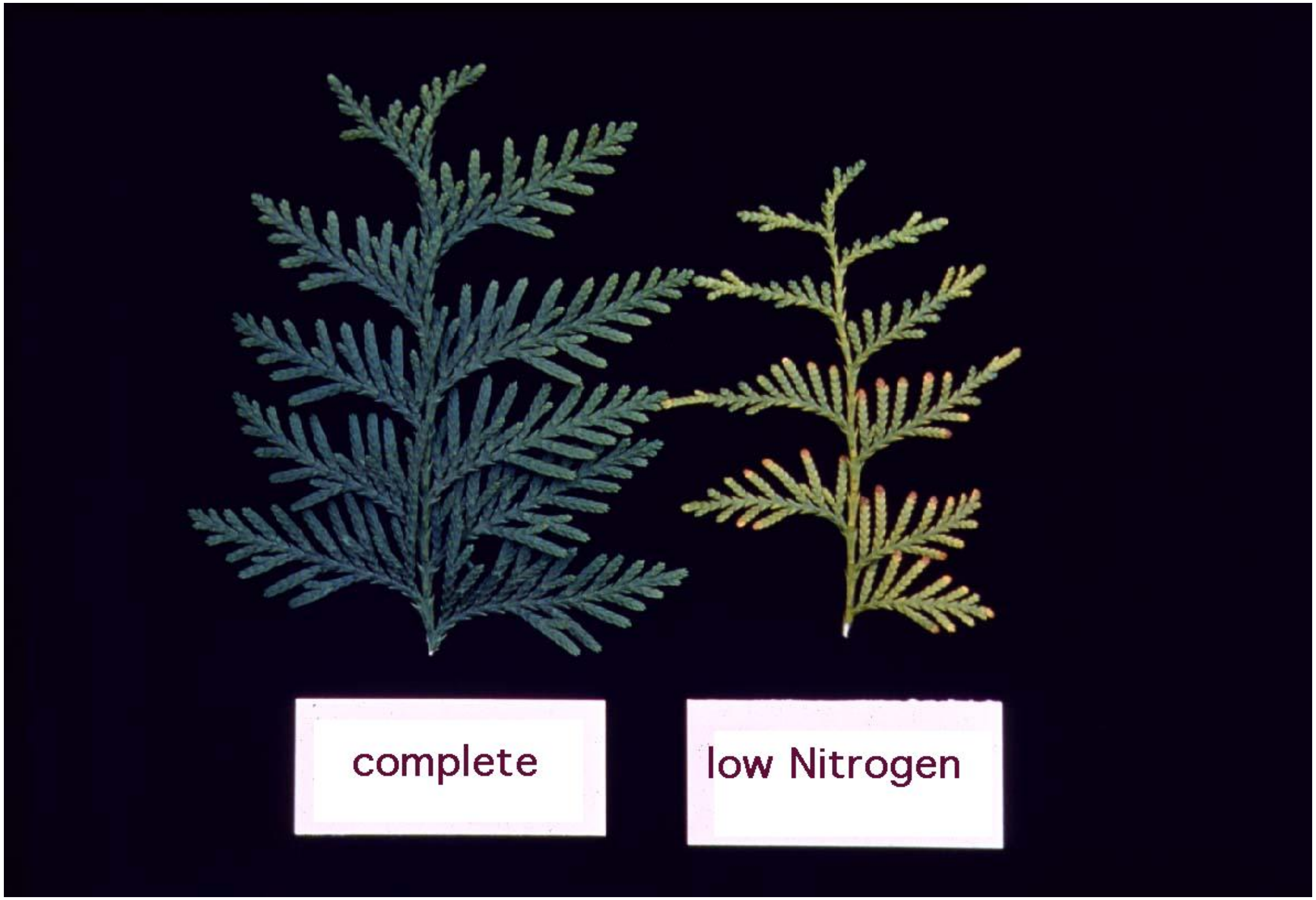
UNIVERSITY OF WASHINGTON
Stand Management Cooperative



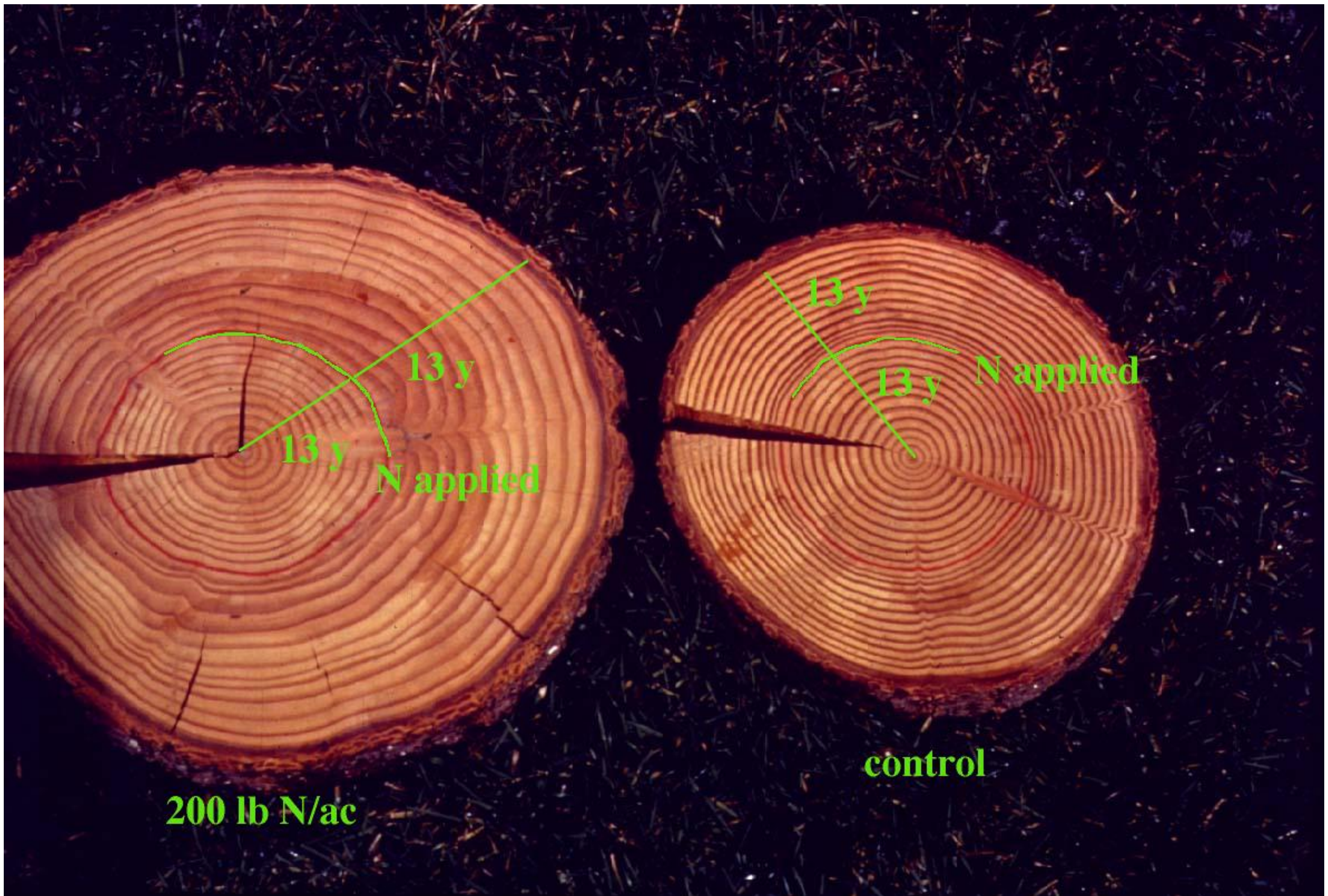

Loblolly Pine
Pinus taeda
Copyright © Robert O'Brien


Black Walnut
Juglans nigra

Nitrogen (N) is known to be a limiting nutrient in Pacific Northwest forests



Nitrogen fertilizers have been applied to intensively managed Douglas-fir plantations to reduce nitrogen limitations and increase growth



Where is the fertilizer going?

Nitrogen
85-95%

Nitrogen
12-43%

?

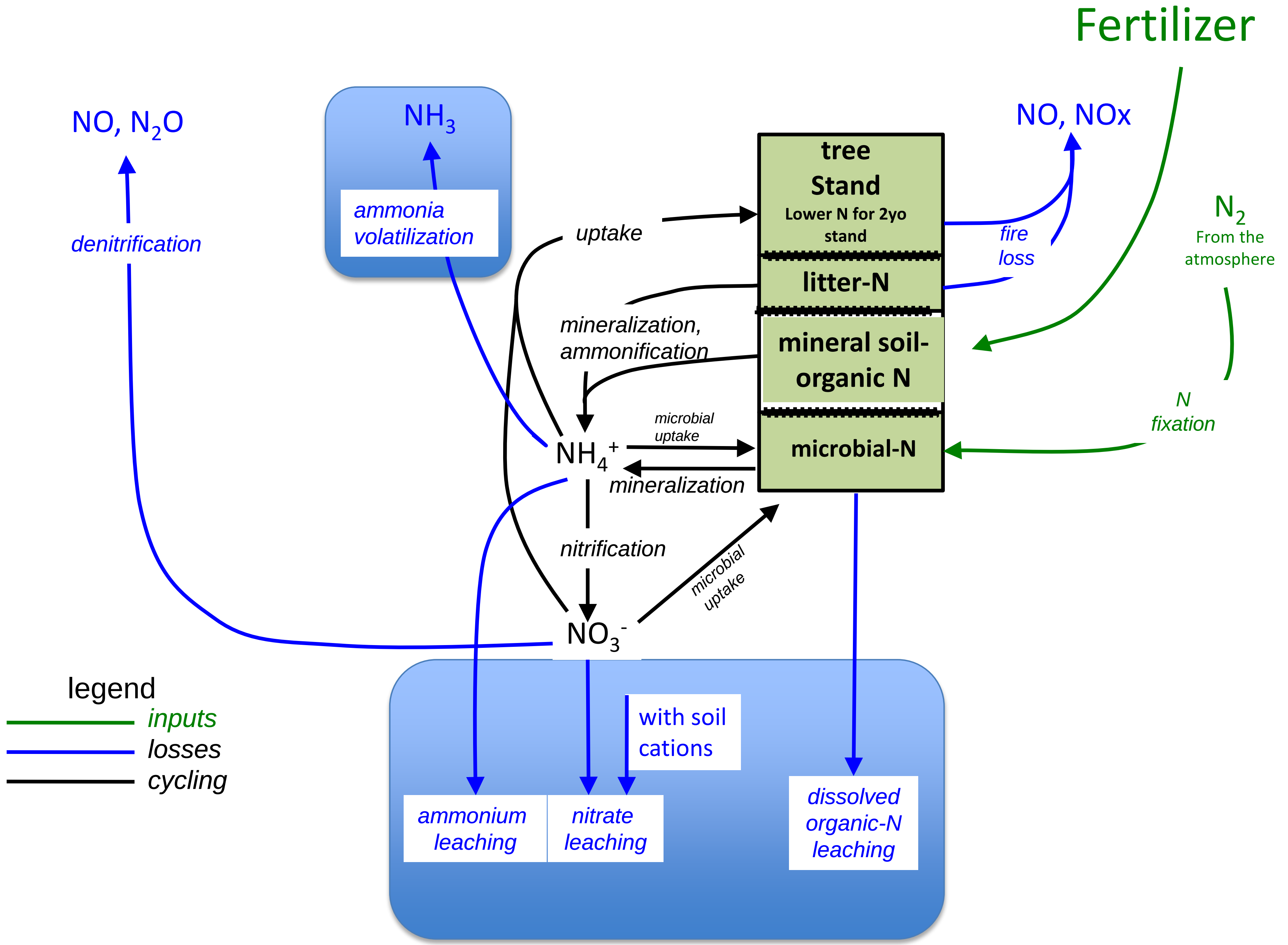
Missing Nitrogen 57-88%

Importance to SMC Members

- Reduce losses
- Fertilizer is expensive
- Increase efficiency
- Environmental consequences

?

Missing Nitrogen 57-88%


Fertilizer
NO, N_2O
NH_3
ammonia volatilization
denitrification
uptake
tree Stand
Lower N for 2yo stand
NO, NOx
fire loss
N_2
From the atmosphere
litter-N
mineralization, ammonification
mineral soil-organic N
N fixation
microbial uptake
NH_4^+
mineralization
microbial-N
nitrification
microbial uptake
NO_3^-
with soil cations
ammonium leaching
nitrate leaching
dissolved organic-N leaching
legend
inputs
losses
cycling

Research Questions

- Efficiency of urea and enhanced efficiency fertilizers (EEF's)?
- Losses due to volatilization and leaching?
- Retained in understory vegetation?

Methods

- Use of the stable isotope ^{15}N (0.5 AP, ~370 ‰ ^{15}N)

^{14}N	^{15}N
14.00307	15.0001
99.63%	0.37%

Methods

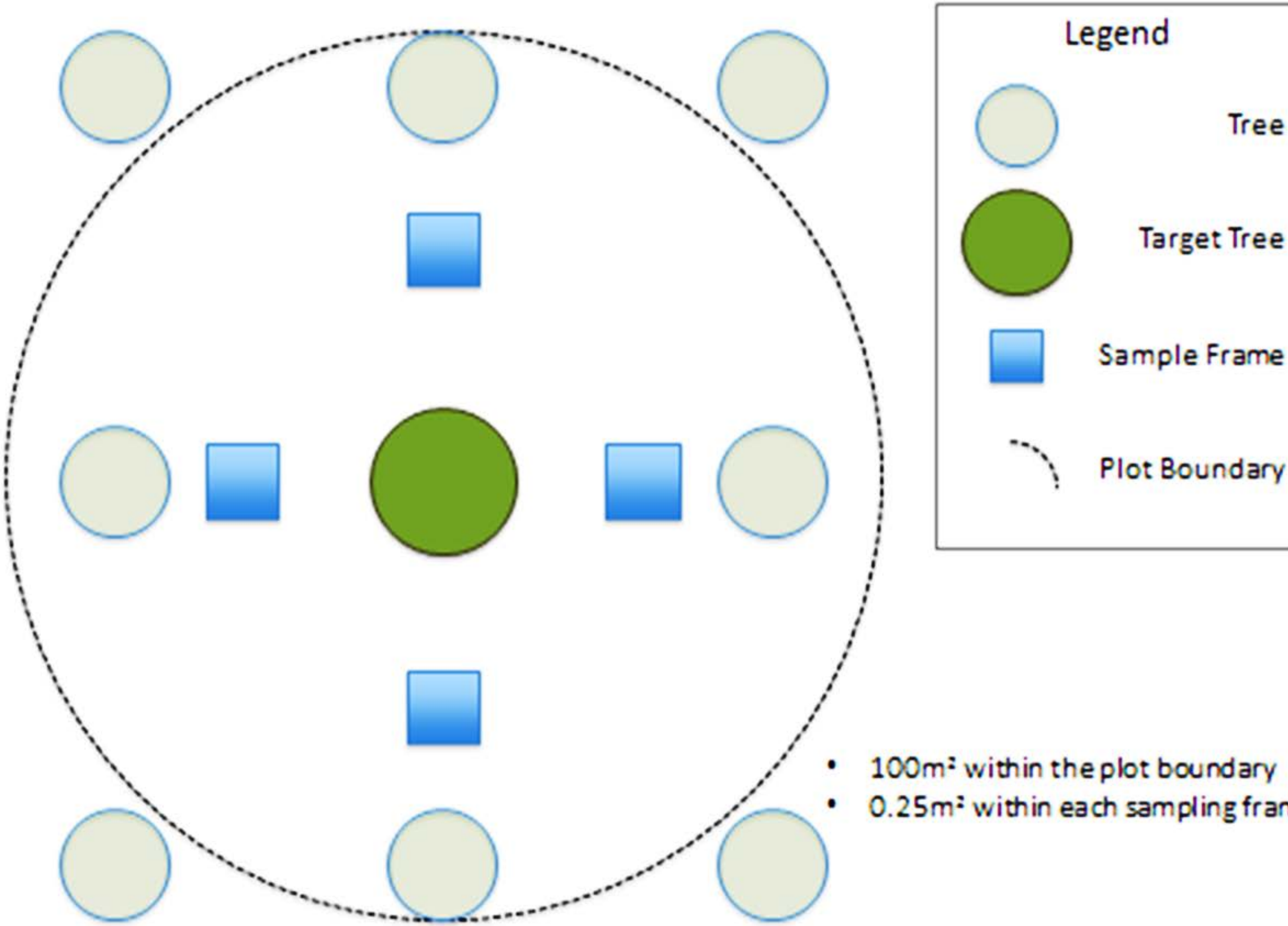
- Treatments
  - Control
  - Polymer Coated Urea
  - NBPT Treated Urea
  - CUF + NBPT Treated Urea
  - Urea

^{15}N

15.0001

0.37%

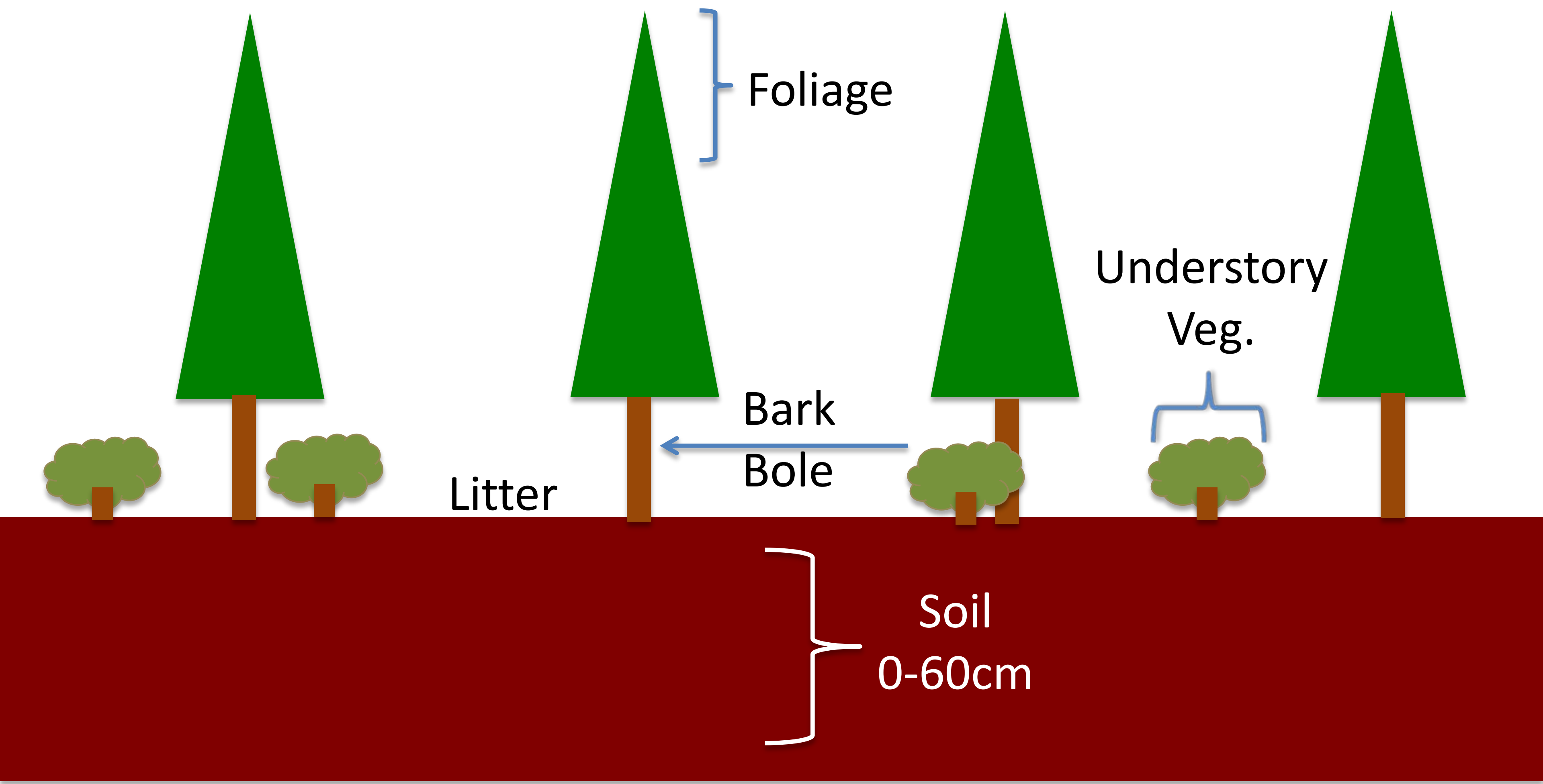
Methods



- $100 m^2$ within the plot boundary
- $0.25 m^2$ within each sampling frame

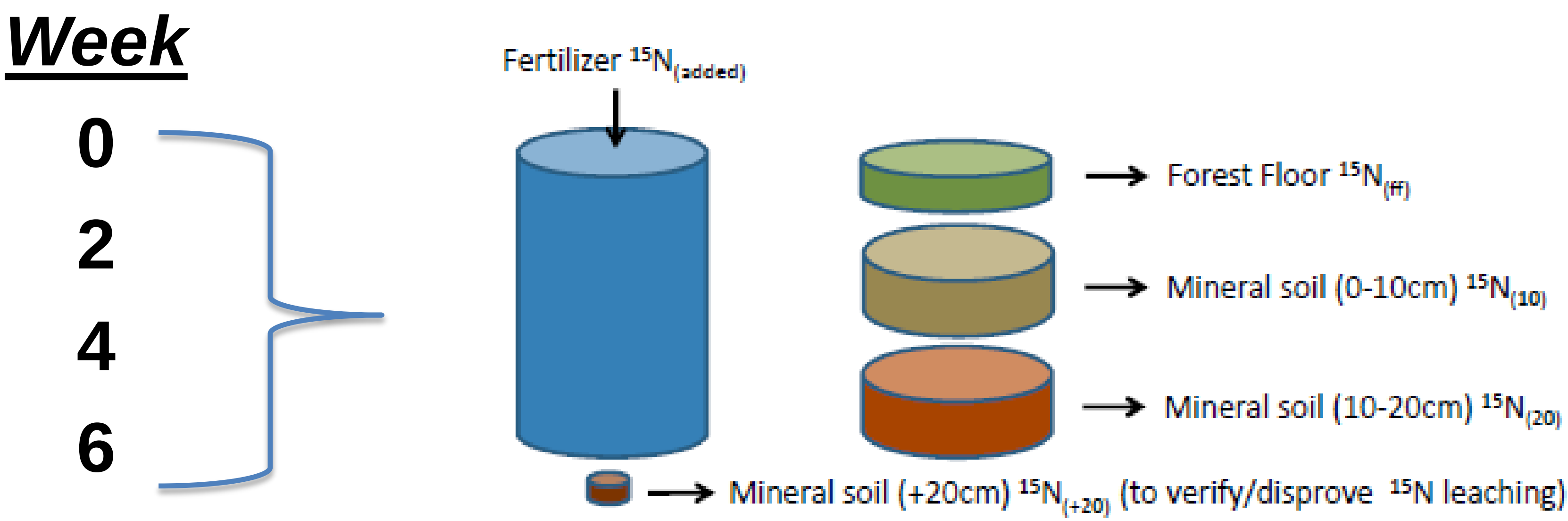
Methods

Sample ecosystem components for ^{15}N



Nitrogen loss due to volatilization

Nitrogen loss due to volatilization

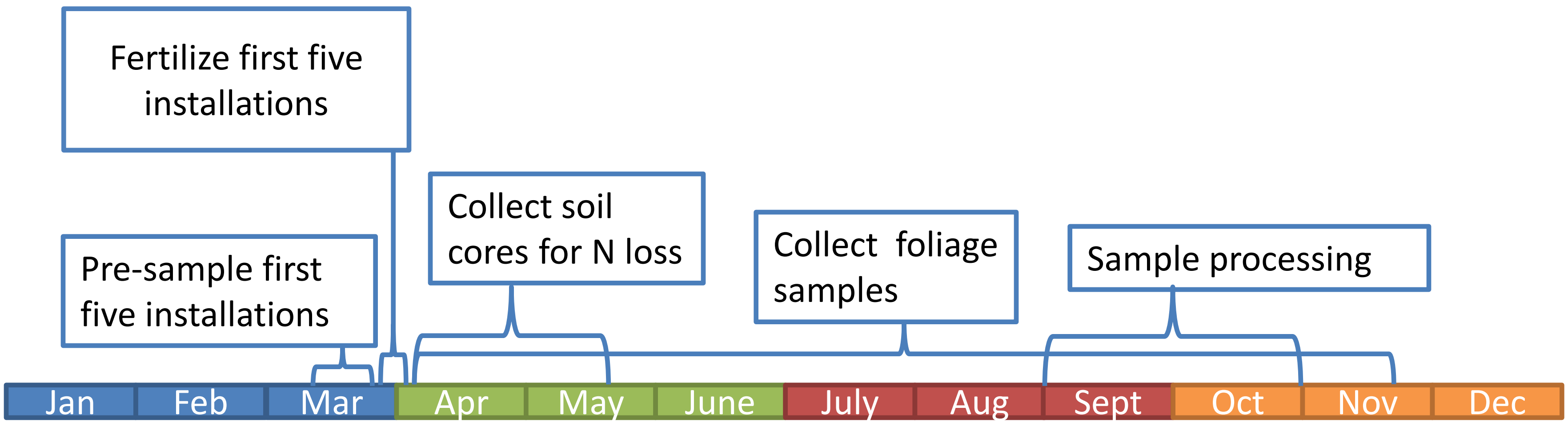


Sample Analysis

Samples are mailed to VT for analysis

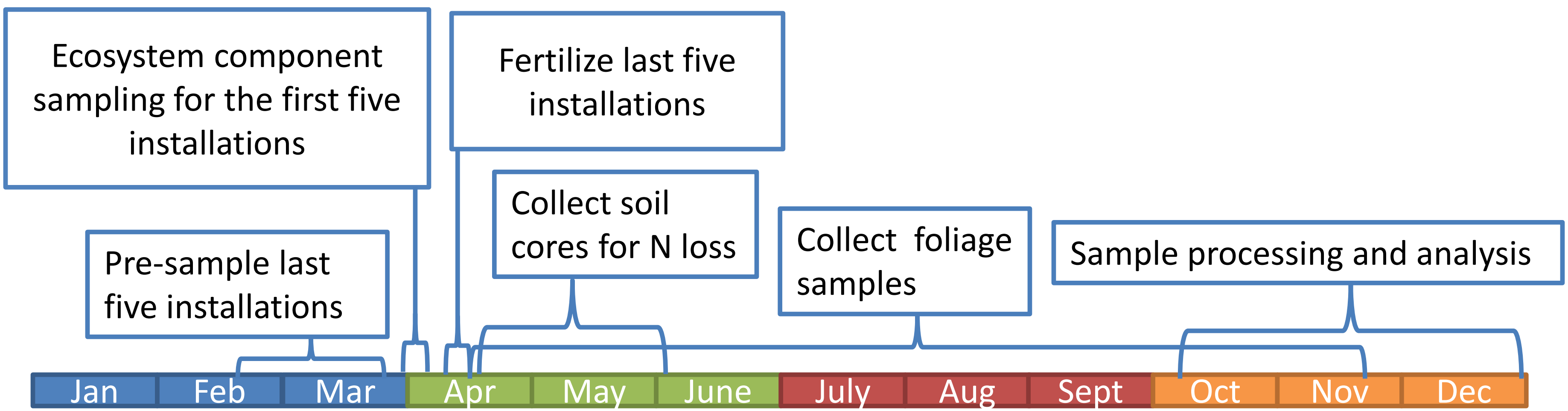
Progress

2011



Progress

2012

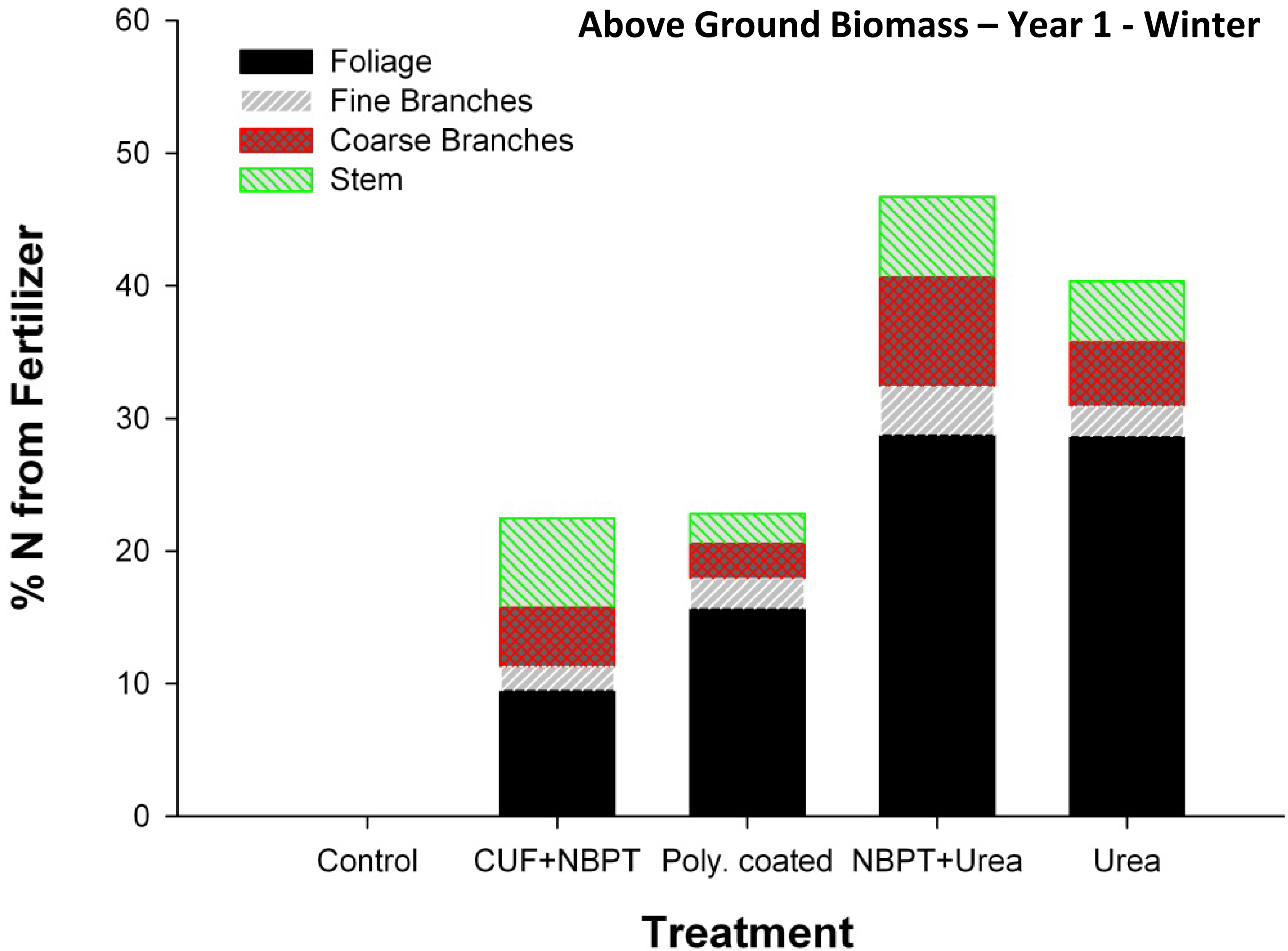


Expected deliverables in 2013

- Sampling of the last five installations completed in March

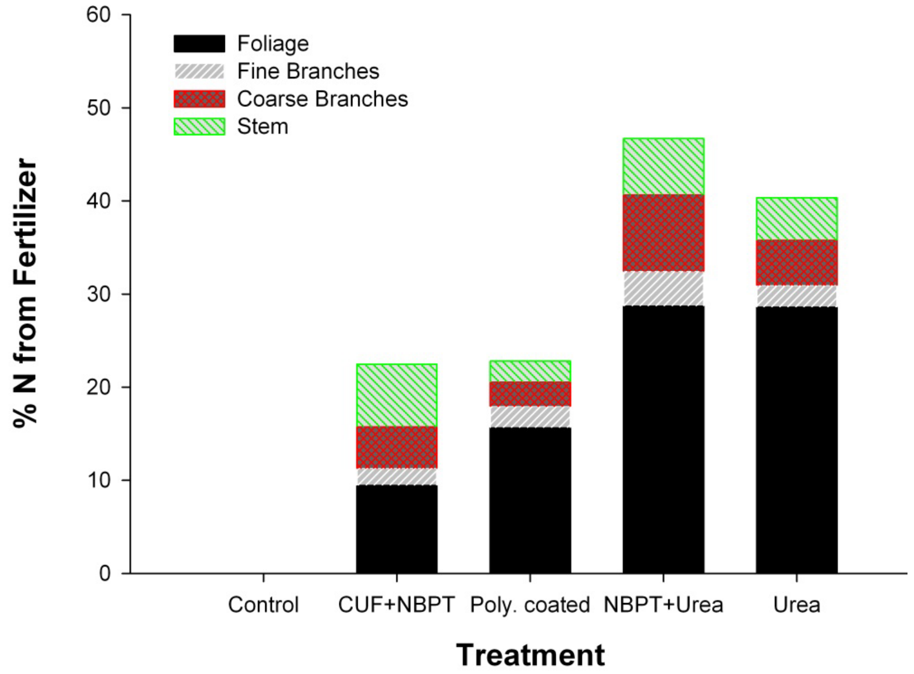
- Data processing
- Preliminary results

Preliminary results from VT



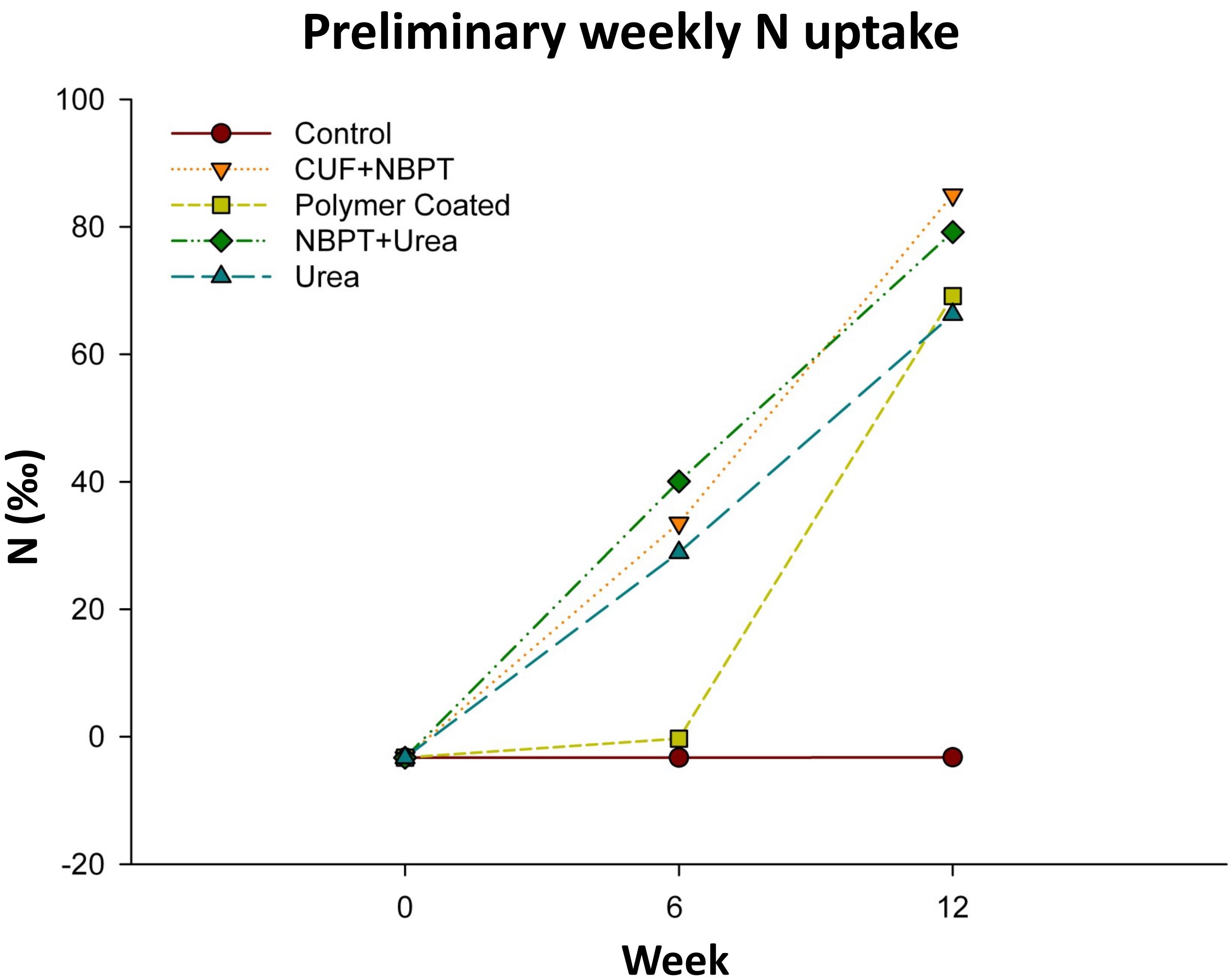
Preliminary results from VT

Above Ground Biomass – Year 1 - Winter

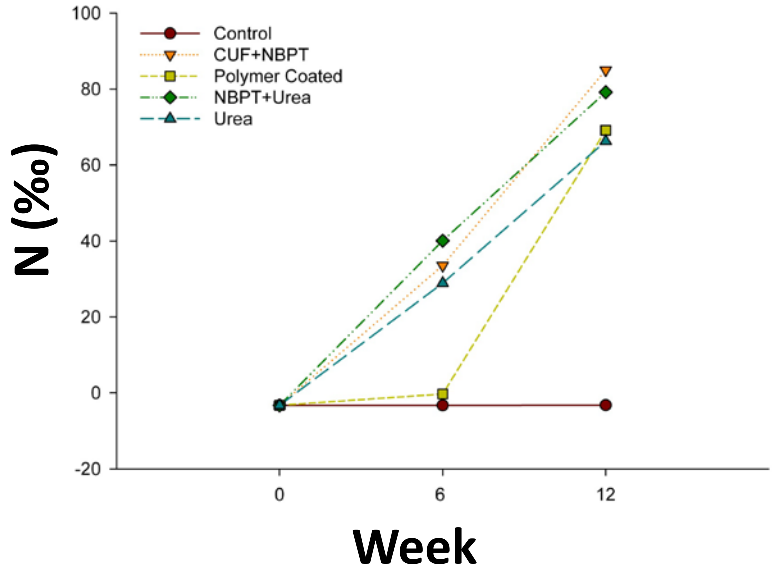


- Highest percentage of uptake is in the foliage
- Nitrogen losses

Preliminary results from VT



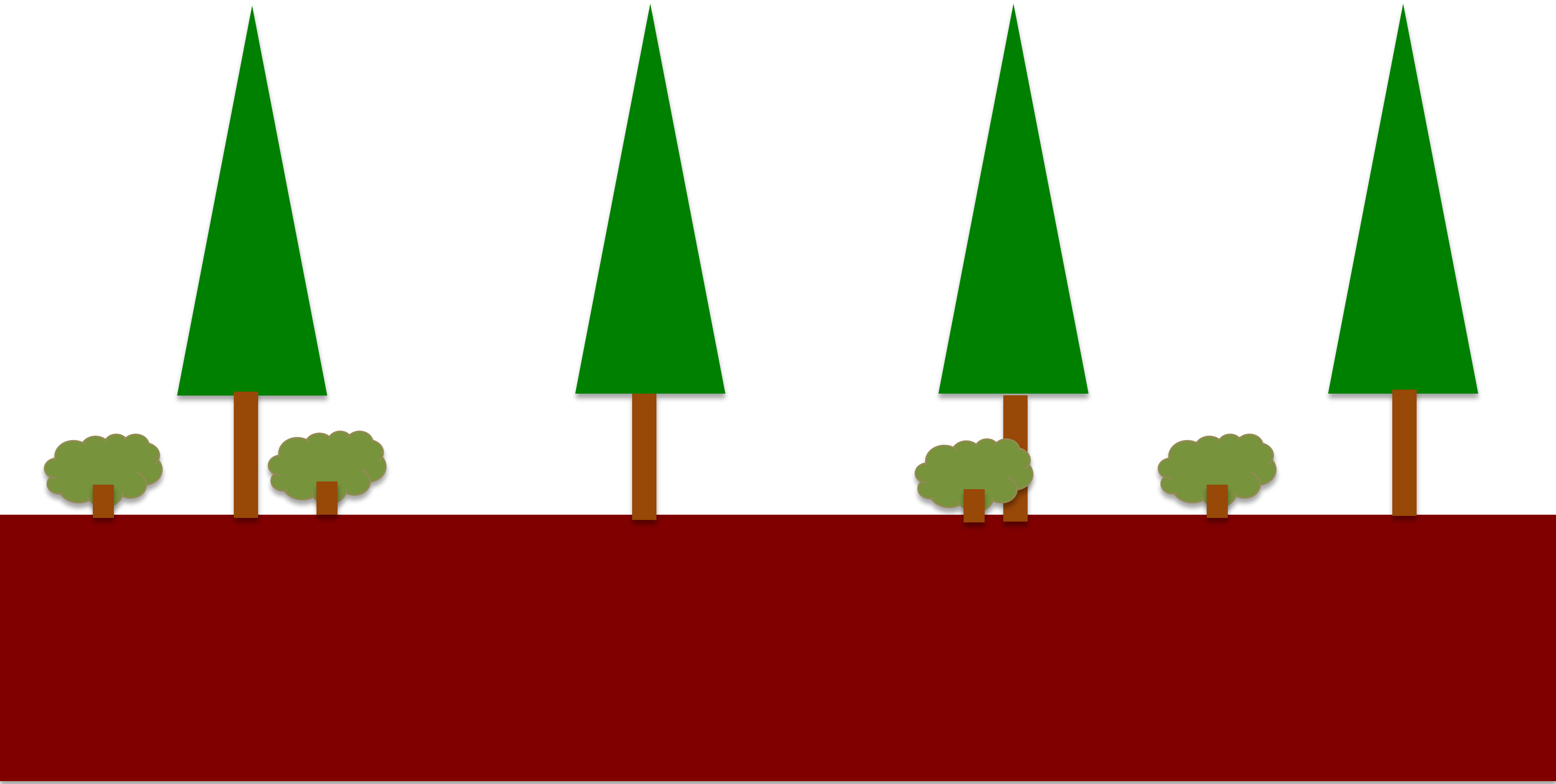
Preliminary results from VT



- Similar performance among the four fertilizers
- Polymer coated follows control for two weeks
- Consider cost vs benefits of the four fertilizers

- Reduce losses
- Increase efficiency
- Environmental consequences

? Missing Nitrogen 57-88%



Appendix H (2)

Predicting Douglas-fir Response to Fertilizer using Site-Specific Factors

Kim Littke-Hanft
Jason James
Rob Harrison
University of Washington
School of Environmental and Forest Sciences

UNIVERSITY OF WASHINGTON
Stand Management Cooperative

Rationale

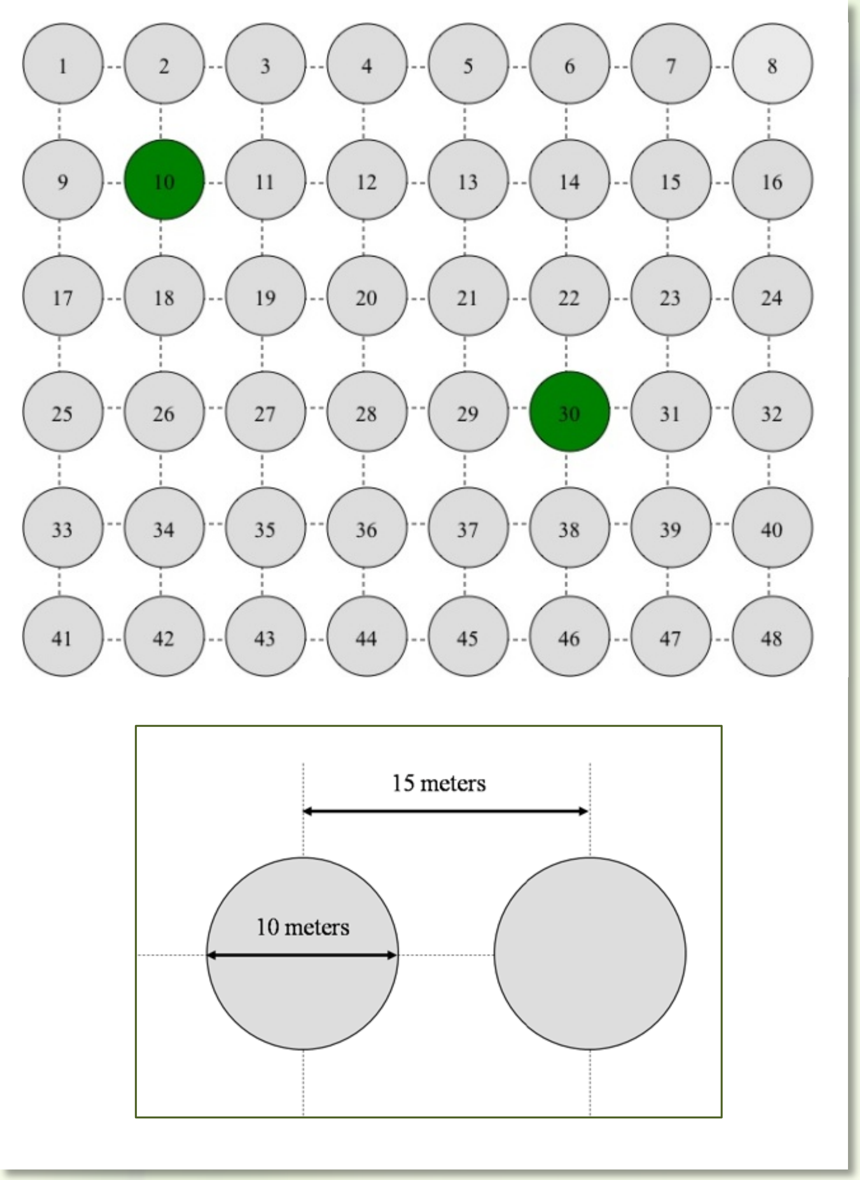
- Douglas-fir responds to urea fertilizer ~70% of the time
- Previous models explained ~50% of variation in response
- Not all nitrogen taken up into tree biomass:
    - Volatilization
    - Leaching and eutrophication
    - Wastes resources

Objectives

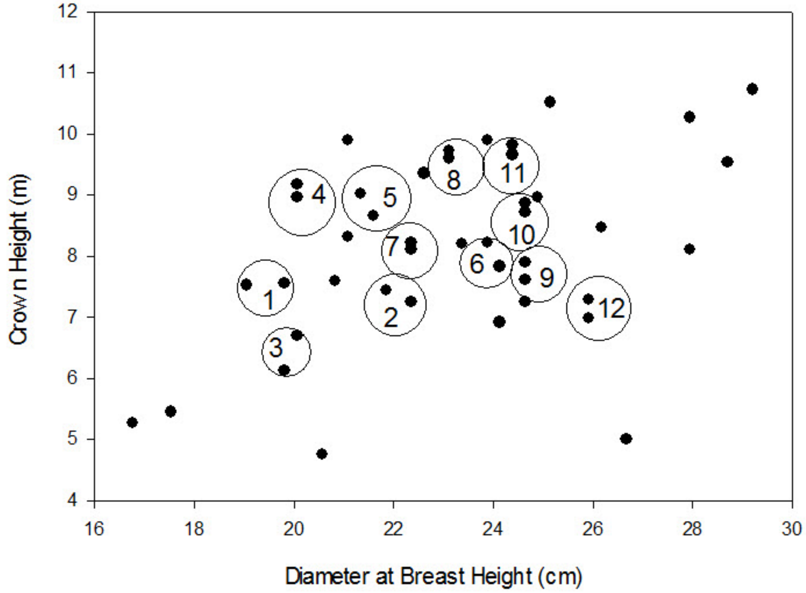
- Determine soil and site variables that:
  - Predict site-specific response to fertilization
  - Are easily obtainable
- Develop management tools from prediction models
- Focus resources on sites that are likely to respond to urea fertilization

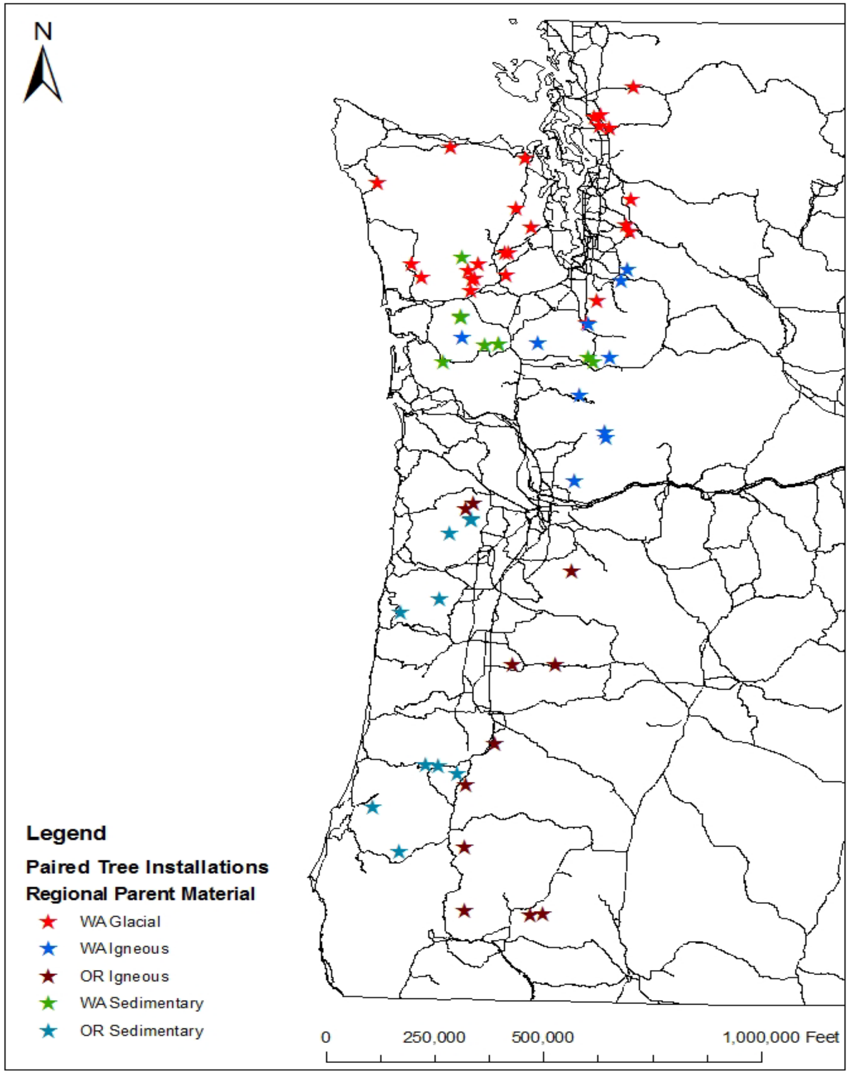
Paired-Tree Design

- 48 dominant/co-dominant Douglas-fir trees chosen on a 15-meter square grid
- Trees paired by most similar diameter at breast height and crown height
- 12-20 pairs per installation
- One tree per pair fertilized with 224 kg N ha^{-1} as urea



Paired-Tree Installations

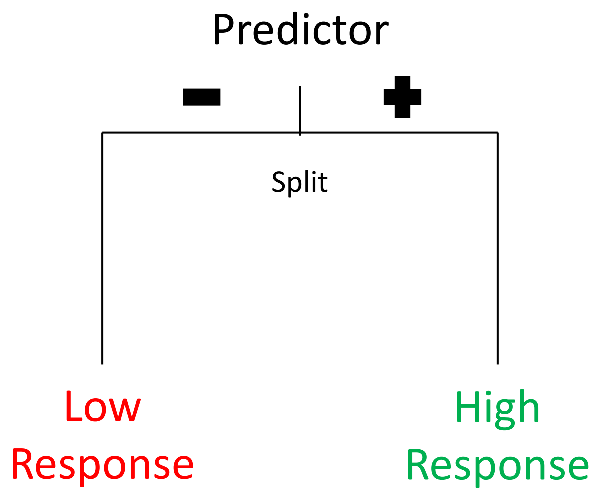




Boosted Regression Tree Models

- Produce a region of values that are important for predicting response
- Do not begin with assumptions about what predictor variables are important
- Combine two algorithms:
  - Regression trees
  - Machine Learning

Boosted Regression Tree Models



X 1000

Standard Regression Tree

- Produces binary split
- Explains greatest amount of deviance

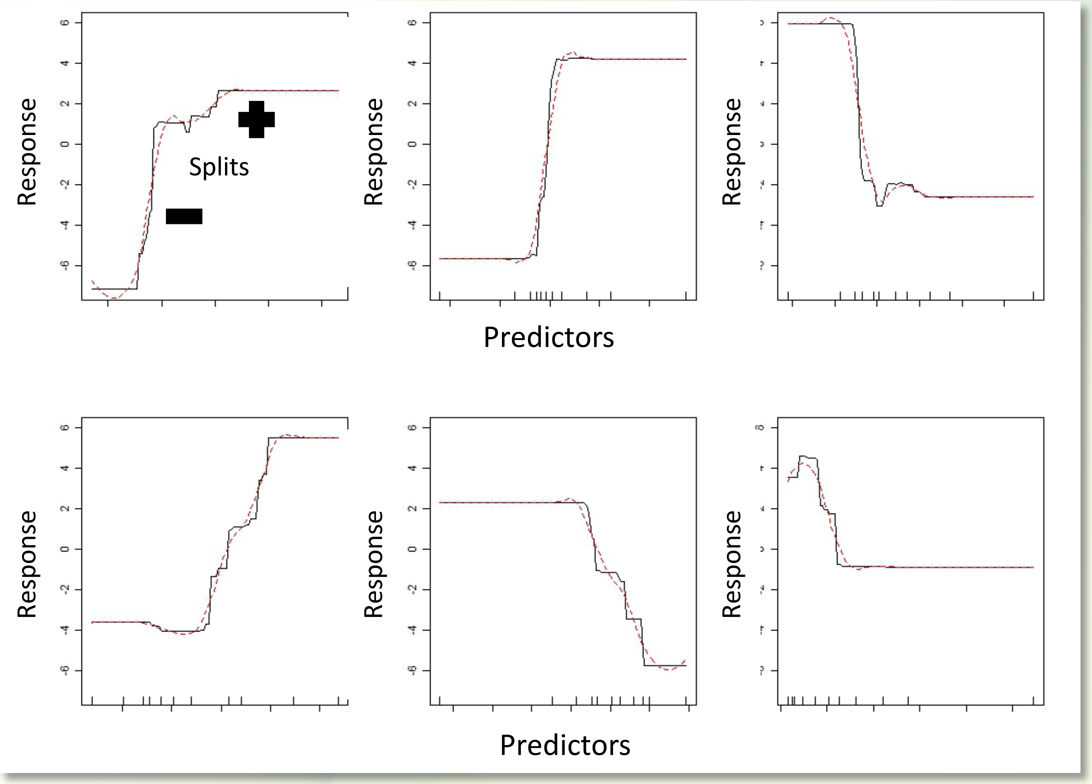
Machine Learning

- Iteratively recomputes residuals
- Fits another tree
- Gradually reduces model error

Boosted Regression Tree Models

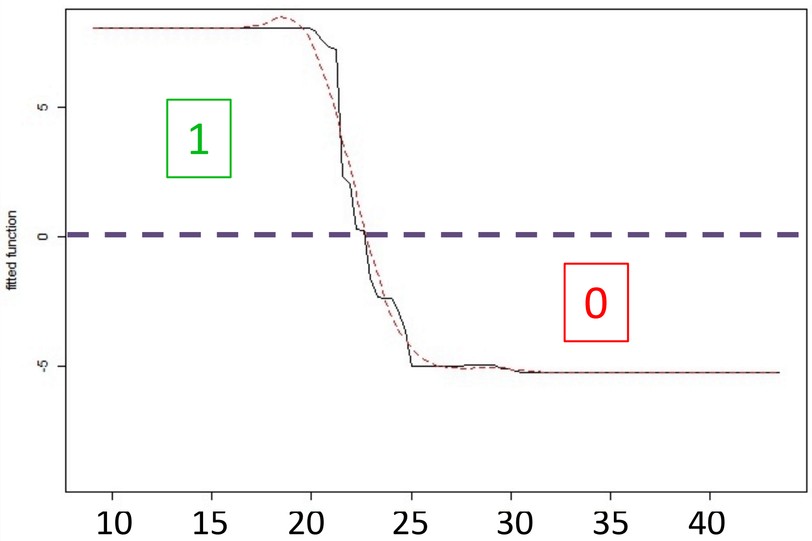
Response Model

- Range of positive response for each predictor
- Holds other predictors at mean values
- Provides importance of each predictor (%)

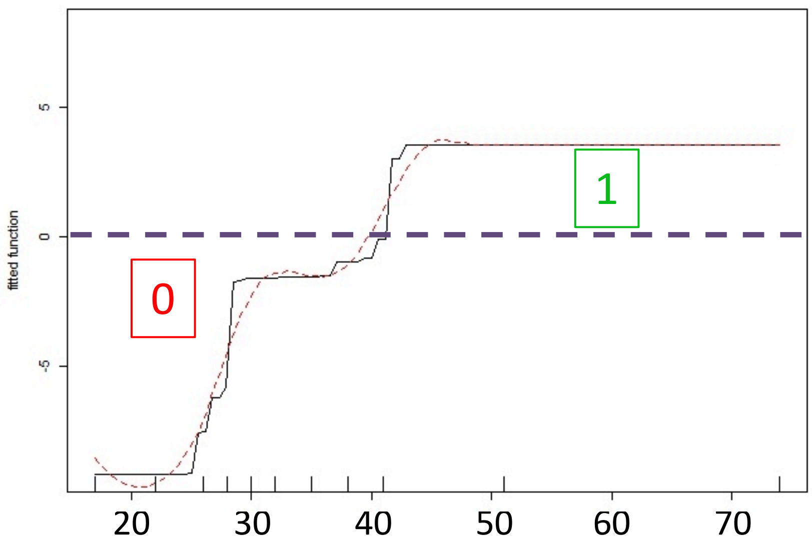


Boosted Regression Tree Models

Basal Area Response Model

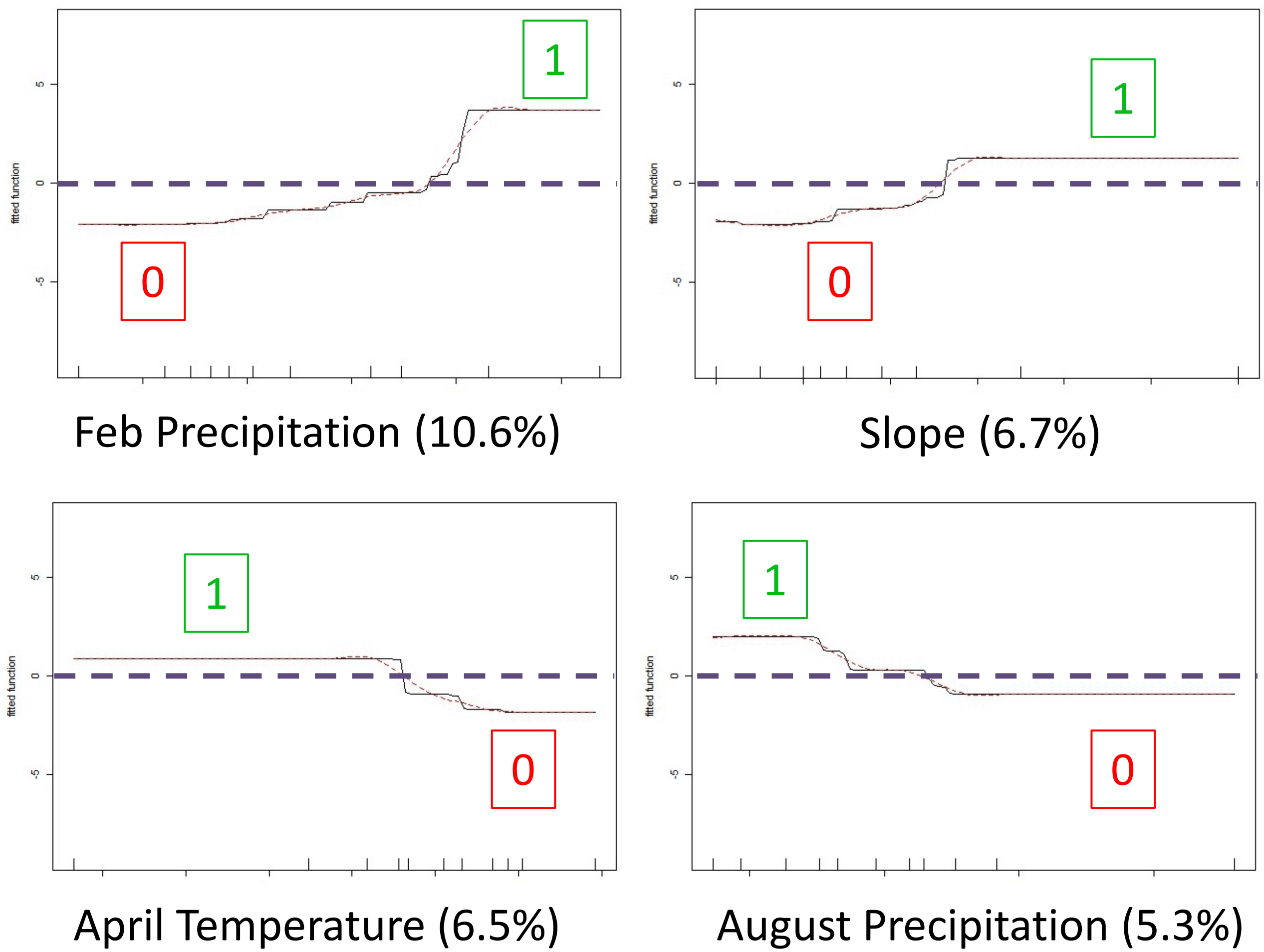


Basal Area Mean Annual Increment
(38%)



Forest Floor C:N
(32.9%)

Boosted Regression Tree Models



Implementing BRT Models

- BRT Models can be converted into decision rules in Excel
- Example
  - Basal Area MAI < 0.025 ft^2 $year^{-1}$
    - Yes = 1 * 38%
    - No = 0 * 38%
- Repeat for each model predictor
- If sum of is > 50%, then significant response to fertilization expected

Implementing BRT Models

Example Stand

Basal Area MAI ($ft^2\ yr^{-1}$)	For Floor C:N (%C:%N)	Feb Precip (inches)	Slope (%)	Apr Temp (F)	Aug Precip (inches)
0.016	63	4.7	60	36.5	2.3
< 0.025	> 35	> 9.8	> 25	< 47.3	< 1.6

Implementing BRT Models

Example Stand

Basal Area MAI ($ft^2\ yr^{-1}$)	For Floor C:N (%C:%N)	Feb Precip (inches)	Slope (%)	Apr Temp (F)	Aug Precip (inches)
0.016	63	4.7	60	36.5	2.3
Yes	Yes	No	Yes	Yes	No
38%	33%	0%	7%	7%	0%

Total = 84% → Response

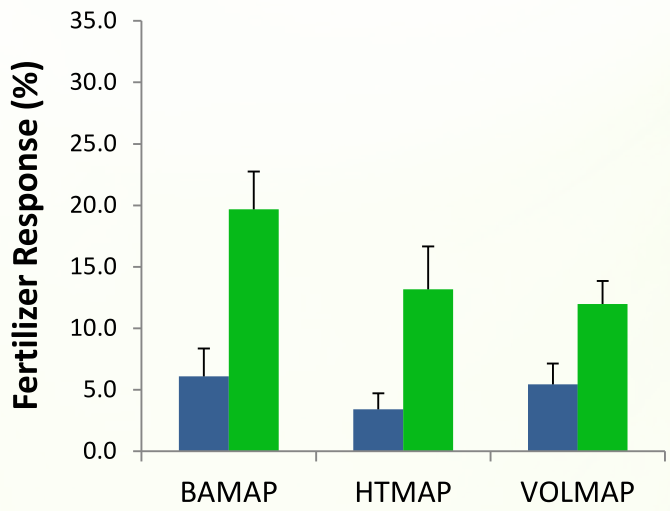
Actual:
27.6%
BA Response

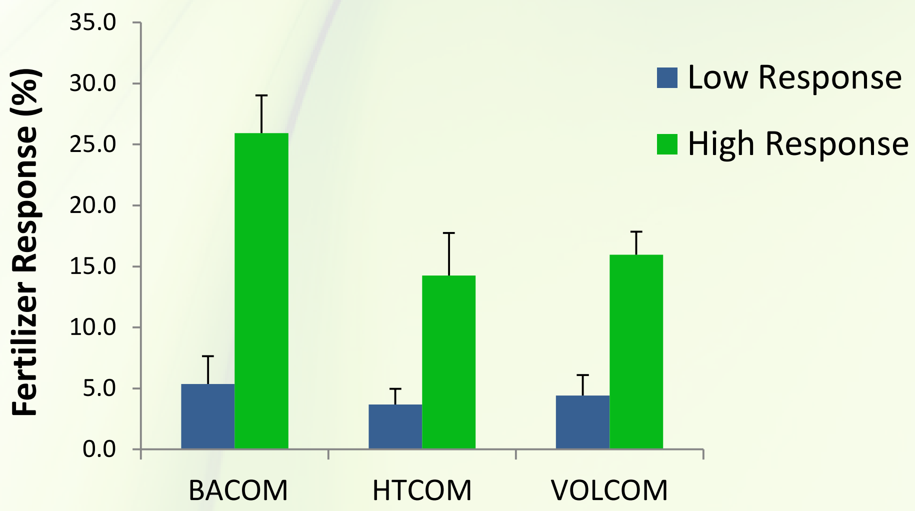
Implementing BRT Models

- Correctly identified responding sites 86% of the time
- Correctly identified non-responding sites 68% of the time
- Basal Area MAI and Forest Floor C:N most important predictors
  - These are measured variables
  - BRT models using only mapped predictors less reliable

Implementing BRT Models

- Average response greatest for Basal Area models
- Height models less precise due to difficulty of measurement
- Volume models rely upon height and thus carry over error





Four Year Response

- Measured for 28 sites
- 3 sites destroyed by ice storms
- Sites that did not respond at two years also did not respond at four years

Four Year Response

- Subtracting out two-year growth:
  - Basal area at 5 sites responded significantly
  - Tree height at 3 sites responded
  - Volume at 2 sites responded
- BRT Models of four-year response may provide different predictor criteria

Timeline for Further Study

- New graduate students taking over project
- Sampling Summer 2013:
  - 28 installations – four-year response
  - 6 installations – six-year response
- Installations are currently being used for 15N study

Questions

Acknowledgements:

- Kim Littke-Hanft
- Rob Harrison
- Dongsen Xue

Appendix I

2013 RFP Template

PROJECT TITLE:
Wood Quality Measures of Trees from SMC/CIPS Paired-Tree Fertilization Projects

PROJECT DESCRIPTION/OBJECTIVES:
Several decades of research by the Regional Forest Nutrition Research Project (RFNRP), Stand Management Cooperative (SMC), other studies of N fertilization of Douglas-fir, have shown that coastal Douglas-fir will respond to 224 Kg N/ha applications on about 2/3 of the stands. If fertilization could be concentrated into the top half of responding stands, the average response could be increased to about 25-30%.The SMC paired-tree (Type V) installations were designed to evaluate the potential for response of 15-25 year-old stands to N fertilization within a given vegetation/geology type and to predict potential response from site and stand variables, allowing landowners to focus fertilization on sites most likely to respond. Following year 6 of growth, a sub-sample of tree pairs was to be selected to assess effects on growth ring wood quality. The Beyond N fertilization trials now managed by CIPS (Center for Intensive Planted-forest Silviculture at OSU) followed a similar design containing both an untreated control and 224 kg/ha of N as urea, but had a primary objective of testing additional fertilization treatments, including three at all 16 installations (calcium as lime, calcium as $CaCl_2$, and phosphorous as monosodium phosphate) and two additional treatments at 10 of the installations (blended fertilizer prescribed by the late George Fenn based on foliar analysis and a multi-nutrient regimes prescribed by Neil Kinsey based on soil chemistry).

The proposed work involves characterizing wood quality attributes of annual layers of wood in a simulation modeling context. The objectives of this project are: (1) To test the effect of fertilization with nitrogen on tree and log acoustic velocity, ring width, latewood/earlywood proportion, and latewood and earlywood density; (2) To quantify the effect of nitrogen fertilization on these wood quality attributes; and (3) determine the effect of soil type on high responders.

EXPERIMENTAL PLAN
High responding sites will be stratified by soil type. The number of sites is as follows:

- SMC Type V – high responders: 9 installations stratified by 3 soil type (3 installations/soil type) and spatially separated within constraints of soil type
- CIPS Beyond N - high responders: 2 sites (Vernonia, OR and Sweet Home, OR)

Trees/site:

- 5 tree pairs (5 control trees and 5 treated trees=10 total trees) per installation

Field procedures:
Field work is required to collect samples from both the CIPS Beyond N trials as well as the SMC Type V installations.

Sample trees will be identified from both the SMC Type V Installations and the CIPS Beyond N trial. Acoustic velocity (AV) using the TreeSonic or ST-300 will be measured on standing trees. Trees will be felled, limbed, and bucked to a 4-inch top. The Hitman (HM-200) will be used to measure AV on the merchantable bole. The merchantable bole will then be bucked at the base of the live crown and an HM-200 AV be taken on both the below and above crown base. The below crown base log will be bucked to produce a 16.5 foot log above the stump cut and the HM-200 AV will be measured on this log. Disks will be cut from the stump, at dbh, at the top of the 16.5 foot log, and at the base of live crown. These will be labeled with site, tree number and position within the tree.

A four-foot bolt will be sawn from the small-end of the 16.5 ft log. This will be used for cutting specimens for mechanical properties testing depending on disk processing option selected.

Volumetric specific gravity will be measured for each disk.

A pith to bark 2-inch x disk thickness radial strip will be sawn from the disk and stored for x-ray densitometry.

The 4-ft bolt will be center sawn into a 2-in thick plank. The group of post study rings will be ripped from each edge of the plank and sawn into mechanical property test specimens to test stiffness and tensile strength.

Analysis:
11 installations x 5 tree pairs/installation x 4 disks/tree x y samples/disk (the rind of each disk can be randomly sampled for perhaps 3-4 sections for volumetric SG and x-ray

11 installations x 5 tree pairs/installation x 1 4 ft bolt/tree x 2 edge samples/bolt x 1 specimen for stiffness and 1 specimen for tensile strength. (ideally will get more than one sample/test and maybe enough material for NDT tests)

EXPECTED DELIVERABLE(S): What results, products, models, tools etc. will be produced?

A Master's thesis and report to the SMC documenting both response of wood quality attributes and models for predicting wood quality attributes in response to nitrogen fertilization treatments is planned.

BENEFITS TO SMC MEMBERS:

This work will leverage ongoing research in Type V and CIPS installations and provide additional information that aids SMC members in making land management decisions. Lack of information about wood quality can lead to expensive misallocation of timber to processing facilities whereby products with desired characteristics and value are not obtainable. Furthermore, an inability to routinely collect information about quality as part of monitoring stand development may lead to choices of cultural practices that fail to maintain or improve quality or fail to meet expected future customer needs. AV sampling permits rapid collection of quality data from trees in a stand or sample plot. Knowledge of what wood properties today's products need and an understanding of impacts for merchandising stands along the value chain can be used to match trees with different/desirable attributes to product needs in order to increase value

INVESTIGATOR(S):

Eini Lowell (PNW Research Station and Wood Quality TAC leader), Eric Turnblom (University of Washington and Silviculture TAC Leader), Doug Maguire (Oregon State University and CIPS director), an M.S. graduate student of Dr. Turnblom.

PROJECT TIMELINE & DELIVERY DATES:

Data collection, analysis and modeling fit within the framework of a 2 year program for a Master of Science degree. Work to begin Spring 2013.

Year 1: 2 CIPS sites (20 trees)
Year 2: 5 SMC Type V sites (50 trees)
Year 3: 4 SMC Type V sites (40 trees)

PROJECT BUDGET & SOURCES OF FUNDING:

One graduate student or faculty research assistant could complete this work. There are several alternatives around level of data collection on disk measurement (WinDendro ring [EW/LW] widths only); x-ray specific gravity only; or specific gravity plus additional WQ measures (e.g. microfibril angle, EW/LW proportions, MOE, and wall thickness) and number of disks sampled (1 at dbh (n=110), all 4 (n=440), or any other combination). Five Type V installations would be sampled in late winter 2014 and 4 in late winter 2015.

Several options are as follows (low and high end). There likely would be an opportunity to reduce graduate student cost to $18,000/year.

Option A: Breast Height Specific Gravity only

Cost Item	Year 1	Year 2	Year 3
Graduate student (E. Turnblom advisor)		$30,000[a]	$30,000
Tree felling/limbing/bucking/disk cutting	OSU/SMC in-kind	SMC in-kind?	SMC in-kind?
X-ray densitometry breast height only ($50/strip Weyerhaeuser)	$1,000	$2,500	$2,000
Sample prep and testing mechanical properties (FPL)		$15,000	
TOTAL COST [$80,500]	$1,000	$47,500	$32,000

Option B: All four disk locations (stump, bh, top of first 16 ft log, base of live crown) specific gravity only

Cost Item	Year 1	Year 2	Year 3
Graduate student (E. Turnblom advisor)		$30,000	$30,000
Tree felling/limbing/bucking/disk cutting	OSU/SMC in-kind	SMC in-kind?	SMC in-kind?
X-ray densitometry all disks ($50/strip Weyerhaeuser)	$4,000	$10,000	$8,000
Sample prep and testing mechanical properties (FPL)		$15,000	
TOTAL COST [$97,000]	$4,000	$55,000	$38,000

Option C: Breast height intensive WQ measures

Cost Item	Year 1	Year 2	Year 3
Graduate student (E. Turnblom advisor)		$30,000	$30,000
Tree felling/limbing/bucking/disk cutting	OSU/SMC in-kind	SMC in-kind?	SMC in-kind?
Intensive WQ data on bh disks ($100/strip Weyerhaeuser or SilvaScan)	$2,000	$5,000	$4,000
TOTAL COST [$71,000]	$2,000	$35,000	$34,000

Option D: All four disk locations (stump, bh, top of first 16 ft log, base of live crown) intensive WQ measures

Cost Item	Year 1	Year 2	Year 3
Graduate student (E. Turnblom advisor)		$30,000	$30,000
Tree felling/limbing/bucking/disk cutting	OSU/SMC in-kind	SMC in-kind?	SMC in-kind?
Intensive WQ data, all disks ($100/strip Weyerhaeuser or SilvaScan)	$8,000	$20,000	$16,000
TOTAL COST [$104,000]	$8,000	$50,000	$46,000

Option E: Two disk locations (bh and base of live crown) intensive WQ measures

Cost Item	Year 1	Year 2	Year 3
Graduate student (E. Turnblom advisor)		$30,000	$30,000
Tree felling/limbing/bucking/disk cutting	OSU/SMC in-kind	SMC in-kind?	SMC in-kind?
Intensive WQ data, all disks ($100/strip Weyerhaeuser or SilvaScan)	$4,000	$10,000	$8,000
TOTAL COST [$82,000]	$4,000	$40,000	$38,000

Option F: Windendro only (ring widths, EW/LW percents)

Cost Item	Year 1	Year 2	Year 3
Graduate student (E. Turnblom advisor)		$30,000	$30,000
Tree felling/limbing/bucking/disk cutting	OSU/SMC in-kind	SMC in-kind	SMC in-kind
WinDendro analysis by grad student		$0	$0
Sample prep and testing mechanical properties (FPL)		$15,000	
TOTAL COST [$75,000]	$0	$45,000	$30,000

[a] Graduate student: $30,000/year for 2 years = $60,000
(2/4 of research assistantship and 1 summer quarter of hourly support with external University funds cover fourth quarter) Possibility of reducing this to $18,000/year through swapping TA for RA funding sources

Tree felling/limbing/bucking/disk cutting and preparation: N sites x N trees
(some donated from SMC members?)

X-ray densitometry: n samples x $50/sample
(contract with Weyerhaeuser Tech Center)

SG, MFA, EW/LW, MOE: n samples x $100/sample
(contract with Weyerhaeuser Tech Center)

Mechanical property sample preparation:
(contract with Forest Products Laboratory)

In kind personnel:
Doug Maguire (CIPS) 10%
Andy Bluhm (CIPS) 5 %
Doug Mainwaring (CIPS) 5%
Eini Lowell (PNW) 5%
SMC field crew assistance (16 days)
SMC Type V installation owners
FPL - $15,000

SUBMITTER(s) NAME, ORGANIZATION AND CONTACT INFORMATION

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1. **PROJECT TITLE:**
Stand and tree response to varying timing and intensity of Pre-Commercial Thinning

2. **PROJECT DESCRIPTION/OBJECTIVES:**
It might be said that the goal of silviculture is to choose suitable sites upon which to arrange trees so as to give them an appropriate amount of growing space at each stage of their development for an identified desirable outcome or stand goal. The most direct method available for giving trees a suitable amount of growing space at each stage of development is through various stand tending techniques, including initial planting density, subsequent spacing (pre-commercial thinning, or PCT), and / or other intermediate cuttings or thinnings. To this end, silviculturists and forest managers usually wish to use prescriptions giving high value production outcomes at lowest possible cost. With time, SMC membership has become more complex, which has led to an emerging mixture of economic and ecologic objectives. Stand prescriptions are sought not only to maximize timber volume or value, but in some instances may even place a higher priority on non-traditional goals such as long live crowns or large branches for enhancing particular habitat values than has been placed in the past. The proposed project aims to:

1) Analyze relevant data in the SMC Database to describe stand yields in response to different timings and intensities of pre-commercial thinning on different sites;

2) Provide stand and stock tables (stand structure) expected under the various treatment regimes;

   2a) Conduct a generic financial analysis, such as net present value, or financial maturity analysis (optional);

3) Illuminate (describe) how resultant stand structures may meet different stand goals and objectives, including their impacts on wood quality;

4) Provide a comparison between how well the assumptions made in setting up Type I installations are supported by Type III results.

3. **ANALYTICAL PLAN:**
The relevant data to be used in achieving the above-stated objectives are those collected from the Type I and III Douglas-fir Silviculture Project Installations. The Type I installations were established in planted stands between the ages of 5 and 17 (40% of stands between 5 and 10 yr, 60% between 11 and 17). At establishment, several plots within each installation were spaced (PCT'd) to leave one-half and one-fourth of initial stems per acre, thus representing three levels of pre-commercial thinning: none, 50% and 75%. Since initial number of stems per acre spans a significant range (300 to 700), a fairly rich mosaic of conditions represented by various combinations of initial density, PCT intensity, as well as site index and timing of entry (though a somewhat narrower range for the latter two attributes) are available for analysis. Several of the plots receiving initial spacing have also received subsequent commercial thinning, which will be useful for comparison.

The Type III Douglas-fir installations were actually planted under the auspices of SMC and represent widely ranging initial densities (100 to ~ 1000 stems per acre) over a somewhat narrower range of site indexes than the Type I's (Type IIIs on average are higher productivity sites). The Type III auxiliary thinning regimes (applied in the three densest plots only) are comprised of a timing factor (early / late) and an intensity factor (light / heavy). Timing is regulated by Relative Spacing (RS); early thinning is triggered by an RS of 0.27, while late is triggered by an RS of 0.17. Light thinning is represented by an average residual density of 67% of initial stems per acre, while heavy thinning is represented by about 45 to 50% of initial stems per acre. Pre-commercial thinnings occurred at ages ranging from about 8 to 21 yr.

Analysis for objective 1. Given the more or less continuous nature of the resultant treatments (combinations of initial stand density, spacing intensity, age of entry, site index, and other covariates, such as slope, aspect, elevation), a regression model approach is suitable. Multiple linear and non-linear model forms will be explored, the best form being chosen on the basis of fit statistics (p-value, mean residual, mean absolute deviation, residual variance, AIC). Manipulated factors defining treatments will be considered as fixed effects, as will site index, slope, aspect, and elevation; factors such as installation, experimentally uncontrolled and / or other indeterminate factors that may arise during analysis will be considered as random effects, resulting in a mixed model approach. Yields will be reported in five-year increments (10, 15, 20, …) through age 45 for useful combinations (defined in close collaboration with the Silviculture TAC) of input variables (site index, initial density, age of entry, PCT intensity). Statistical uncertainty will be expressed as a percentage of estimated (or model-predicted) yield at each reported age.

Analysis for objective 2. Stand tables (tree lists) for each actual combination of input variables represented in the SMC database will be summarized using the methods of Gehringer and Turnblom (2004). Statistical uncertainty will be reported on the basis of mis-matched (non-overlapping) proportions of smoothed, actual tree size distributions and smoothed, generated (i.e., predicted) tree size distributions. Stand tables corresponding to the useful combinations of input variables identified during analysis for objective 1 at reported ages will then be generated according to the best method in Gehringer and Turnblom (2013). Stock tables will be derived from the stand tables using applicable volume and taper equations that are used currently in creation of SMC Plot Summary Reports. One possible weakness to this approach is that methods for using random factors in the stand table generation technique have not been fully worked out, however, as part of this investigation, methods to either account for, or obviate this apparent need will be examined.

> Analysis for optional objective 2a. Working in close collaboration with the Silviculture TAC, a single method of financial analysis will be chosen providing a satisfactory level of consensus, as well as setting a fixed fiscal or calendar year upon which to base prices. Statistical uncertainty will be derived from uncertainty in yield, established during the yield analysis (objectives 1, 2), and expressed in percentage of estimated financial yield.

Analysis for objective 3. Largest Limb Diameter in the Breast-Height region (LLDBH), a measurement made routinely as part of the SMC measurement protocol will be used as an index to wood quality. Briggs, et al. (2008) showed that in unthinned stands this measurement is well correlated with LLAD (Largest-Limb Average Diameter) of the butt log. LLAD is an industry standard index to log quality, itself an indicator of contained lumber quality. One possible weakness to using this approach is that the relationship between LLDBH and LLAD is probably different for stands that have been PCT'd compared with those that have not been in the case when the PCT occurs prior to breast-height branch death. None-the-less, the best extant models will be employed (Briggs, et al. 2008; Briggs, et al. 2010; Bryce 2012) for predicting LLDBH for the trees in stand tables generated during the analysis for objective 2. Analysis conducted as part of this objective will include estimates for live crown ratio, as well as other tree attributes deemed desirable by the Silviculture TAC for assessing how treatment outcomes may or may not meet their respective stand goals. Statistical uncertainty will be expressed as a percentage of estimated (or model-predicted) average LLDBH, LCR, etc., at each reported age for each identified, useful combination of input variables.

Analysis for objective 4. There is some evidence to suggest that even when stands are PCT'd very young to a particular residual density, subsequent stand development is not exactly the same as compared with stands planted to the same density as the residual PCT'd density. To assess whether the original assumption holds for Type I's being PCT'd "before substantial inter-tree competition has occurred," and that Type Is would match what is expected from Type III installations planted to a similar density, actual yields for PCT'd Type I installations will be plotted against estimated (or model-predicted) yields for matching planted density Type IIIs. Residual variation (lack of agreement between Type I yields and Type III yields) will be compared with the Mean Squared Error for the Type III model equation to assess the magnitude of "excess" variation using a likelihood ratio, or F-test. Analogously, Type I ISPA plots will be tested against their Type III counterparts (same site index, initial density, age) to assess how well they are tracking over time.

The intent of these analyses are to expose what the SMC Silviculture Installations can tell us with respect to precommercial thinning, so augmenting the SMC database with other data sources is not anticipated at this time.

No additional fieldwork is anticipated as part of this project at this time. When results are in, the need for additional measurements to establish the relationship between LLAD and LLDBH on butt logs in stands PCT'd prior to breast-height branch death should be evaluated.

4. **EXPECTED DELIVERABLE(S):**
Models describing yields per acre (cubic feet incl. top, cubic feet to 4" and 6" top, and board foot to 4" and 6" top) in Type I and III installations, including stands that were PCT'd, as well as those that were not will be fully documented in an SMC Working Paper, along with the methods used to derive them with examples of how they may be implemented. This report will also contain findings for Type I & III developmental agreement, or lack thereof.

A mechanism to deliver tree lists corresponding to defined reporting ages and useful combinations of input variables as designed with TAC input. This could be in the form of an auxiliary Tree List Generation Database (Gehringer and Turnblom 2004) accessible through software applications, or via a web browser. This mechanism will be the principal driver behind generating the estimated (or model-predicted) stand structures that cooperators may use to decide if any particular treatment or treatment regime as it has been implemented in SMC trials will suit their stand objectives.

Optional deliverable (objective 2a): Oral presentation at Spring 2015 SMC Policy committee meeting detailing financial analysis findings and an SMC Working Paper detailing same.

5. **BENEFITS TO SMC MEMBERS:**
Information of this type is expected to help some SMC members improve their "bottom line." This will occur mainly though better understanding of how stands with given characteristics could be most profitably managed for the materials the stand might produce. The results will provide members with a more informed answer not only to the question of what PCT specifications are needed to produce a desired product mix over a rotation, but in addition, are anticipated to provide a better answer to the question of what PCT specifications are needed to produce a particular stand structure.

Members will also benefit from the results of this proposed analysis, because it dovetails with the work on modeling re-spacing effects that Maguire and Hann are currently conducting (Maguire 2013). As a component of updating the fertilization and thinning modules of ORGANON, Maguire and Hann are building individual tree volume increment models employing the "potential growth x growth modifier" framework that will isolate effects purely due to thinning, purely due to fertilization, and purely due to re-spacing (the so-called ISPA/2 and /4 treatments). They expect yet to investigate several characteristics about the re-spacing effect, such as whether or not it impacts estimates of site index, and whether or not it is the same or different from the pure thinning effect, within this growth modeling context. Maguire and Turnblom agreed that having whole-stand yield estimates (work proposed herein) provides a very useful benchmark for the growth models that result from Maguire and Hann's work. This paradigm was used to benchmark Swiss Needle Cast growth modifiers for ORGANON; a subsequent yield analysis provided the means to improve both prediction systems (both growth and yield), as well as achieving the singular benefits of each separate analysis.

6. **INVESTIGATOR(S):**
Principal Investigator will be Eric C. Turnblom, Silviculture Project Lead, Stand Management Cooperative (current Curriculum Vitae attached), one (post-MS) professional staff analyst (likely candidate is Jeff Comnick), and one MS student analyst to be named.

7. **PROJECT TIMELINE & DELIVERY DATES:**

Period	Activity
June 2013 – November 2013:	Begin analysis for objective 1. Meet with TAC to define useful combinations of input variables. Oral progress report delivered at SMC Fall Policy Cmte. Mtg. Begin conducting analysis for objective 4. First interim report issued end of year.
December 2013 – May 2014:	Finalize analysis for objective 4. Conduct analysis for objective 2. Begin exploring options for wood quality index prediction. Meet with TAC to finalize useful tree and stand metrics needed to assess degree of success in meeting a particular stand goal, as well as choose financial analysis method and fix pricing year. Oral progress report delivered at Spring SMC Policy Cmte. Mtg. Second interim report issued and "Beta" version of tree list generation mechanism available for testing by end of 2nd quarter 2014.
(Optional) June 2014 – June 2015:	Conduct analysis for objective 2a. Meet with TAC as needed.
June 2014 – November 2014:	Conduct and finalize analysis for objective 3. Oral progress report delivered at SMC Fall Policy Cmte. Mtg. Third interim report issued in 4th quarter.
December 2014 – March 2015:	Compile results / reports into SMC Working Paper(s). Submit publishable material to appropriate refereed journals.

8. **PROJECT BUDGET & SOURCES OF FUNDING:**
The Principal Investigator, one professional staff analyst, and one graduate student could complete this work. Requested funding covers salaries of the to-be-named post-MS professional staff analyst and graduate student assistant, and computer and software purchases and upgrades.

Cost Item	Year 1	Year 2	All Years
Professional Staff Analyst	$17,500	$8,750	$26,250
Computer, supplies, software upgrades	$2,000	$200	$2,200
TOTAL COST	$19,500	$8,950	$28,450

Optional objective 2a.

Grad. Student Asst. (E. Turnblom advisor)	$6,000	$13,000	$19,000

The Professional Staff analyst is needed in the first year (1.0 FTE for three months) to perform yield analyses in PCT'd stands and to assist Turnblom in developing and testing SMC database summarization methods for objective 2; needed in second year to assist with pulling together extant branch models, finalizing analyses, and report writing. Funding for the GSA is expected to come from Teaching Assistantship (TA) positions during their first Academic Year, so in the first year, only summer funding is requested; in the second year, support is again expected to come from TA positions for two quarters, however in their final quarter, full Research Assistantship funding is requested to ensure timely conclusion to the work without the distraction of a TA position. One new computer purchase with software is requested in year 1, with allowance for purchase of supplies in year 1 and software upgrades in year 2.

9. **SUBMITTER(s) NAME, ORGANIZATION AND CONTACT INFORMATION:**
Eric C. Turnblom, Stand Management Cooperative, School of Environmental and Forest Sciences, University of Washington, BOX 352100, Seattle, WA 98195-2100. Phone: 206-543-2762. Email: ect@uw.edu.

10. **RELEVANT REFERENCES:**
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Turnblom, E. and B. Gonyea. 2011. Silviculture Project installation review summary. SMC Installation Review Committee Report No. 1, Stand Management Co-op, University of Washington, Seattle, WA 98195. 18 p.

Appendix K

2012-2013 SMC Field Season
Field Measurements

Type I					
Inst.	Inst. Name	Job	Date	Status	Comments
703	Longbell Road	Rd check plot 4,10	10/1/2012	Finished	Plot 4 RD 54.5., marked Plot 10 RD 53.2, wait
704	Ostrander Road	RD check plot 3, 9		Drop	Plot 3 likely, 9 not likely (logging site in 2015)
708	Copper Creek	Full Measurement	2/15/2013	Finished	
		RD check plots 3,4,7,9			Plot 3 RD 53.3 marked, Plot 4 54.3, marked
					Plot 7 RD 55.3 marked, Plot 8 55.6, marked
709	Mill Creek Mainline	Full Measurement	1/17/2013	Finished	
		RD check plots 4,5			Plot 4 RD 54.5, marked Plot 5 RD 50.4, marked
710	Trail Creek	Full Measurement	2/21/2013	Finished	
711	Kitten Knob	Full Measurement	2/1/2013	Finished	
		RD check plot 2			Plot 2 not likely
712	Prather Creek	Full Measurement	2/28/2013	Finished	
		RD check plot 1			Plot 1 RD 56.2, marked
713	Sauk Mt.	Full Measurement	1/25/2013	Finished	
714	Mahatta River	Full Measurement	11/10/2012	Finished	
		RD check plots 3,5			Plot 3 RD 73.5, thinned Plot 5 RD 73..1, thinned
715	Davie River	Full Measurement	11/20/2012	Finished	
716	Quilla Creek	Full Measurement	11/25/2012	Finished	
		RD check plot 3			Plot 3 RD 53.8, wait
726	Toledo	RD check plot 1,8	1/15/2013	Finished	Plot 1 RD 49.1, wait
729	Gnat Creek	RD check plot 1, 4	10/1/2012	Finished	Plot 1 RD 54.0, wait Plot 4 RD 52.4, wait
731	Dingle 4	Rd check plot 4			
734	Upper Canada Creek	RD check plot 5	1/18/2013	Finished	Plot 5 RD 53.9, wait
736	Twin Peaks	Full Measurement	4/19/2013	Finished	
		RD check plot 8			Plot 8 not likely
737	Allegany	Full Measurement	2/7/2013	Finished	
		RD check plot 2			RD 52.5, wait

*Gray Highlighted installations in BC and Canadians will do

Appendix K

2012-2013 SMC Field Season
Field Measurements

Type III					
Inst.	Inst. Name	Job	Date	Status	Comments
910	King Creek	Full Measurement	2/11/2013	Finished	Thin plot 10
918	Grimm Road A	Full Measurement	5/7/2013	Finished	
924	Mosquito Rocker	Full Measurement	1/31/2013	Finished	
932	Forks #3	Thin plot 11, 18	4/1/2013	Finished	
937	Ames Creek	Full Measurement	5/1/2013	Finished	Prune 7,8,9 (Didn't need 3rd lift)
938	Grimm Road B	Full Measurement	5/8/2013	Finished	
942	Cat Ballew	Full Measurement	4/25/2013	Finished	Prune 7,8,9,13,14,15,20,21 Thin 10,11,12,24

Type IV					
Inst.	Inst. Name	Job	Date	Status	Comments
601	Donkey Creek 2	Full measurement	1/30/2013	Finished	UW measures this year
602	Donaldson Creek	Full measurement	2/13/2013	Finished	UW measures this year
603	Crane Creek 2	Full measurement	3/20/2013	Finished	UW measures this year

Type IV					
Inst.	Inst. Name	Job	Date	Status	Comments
827	Nestucca	Full Measurement	11/30/2012	Finished	Collect Weather data
828	Bunker Creek	Full Measurement	12/19/2012	Finished	Collect Weather data
829	Grants Pass	Full Measurement	12/18/2012	Finished	Collect Weather data
830	Weikswoods Flat	Full Measurement	12/19/2012	Dropped	Collect Weather data, Ice storm damage
831	Rancho Ranchera PP	Full Measurement	10/30/2012	Finished	Collect Weather data
832	Clarke Creek PP	Full Measurement	10/31/2012	Finished	Collect Weather data
833	Clarke Creek DF	Full Measurement	10/30/2012	Finished	Collect Weather data
834	Dudley	Full Measurement	10/30/2012	Finished	Collect Weather data
835	Weikswoods Slope	Full Measurement	12/19/2012	Dropped	Collect Weather data, Ice Storm damage
836	Rabbit Creek	Full Measurement	12/13/2012	Finished	Collect Weather data
837	Mill Creek #2	Full Measurement	12/13/2012	Finished	Collect Weather data
838	Star Lake	Full Measurement	12/13/2012	Finished	Collect Weather data
839	Russel Ranch	Full Measurement	12/7/2012	Finished	Collect Weather data

Appendix K

2012-2013 SMC Field Season
Field Measurements

Type IV

Inst.	Inst. Name	Job	Date	Status	Comments
840	Coyote Ridge	Full Measurement	11/16/2012	Finished	Collect Weather data
841	Cascadia Tree Farm	Full Measurement	11/29/2012	Finished	Collect Weather data
842	Scott Mountain	Full Measurement	11/29/2012	Finished	Collect Weather data
843	DeVore Mountain	Full Measurement	11/28/2012	Finished	Collect Weather data
844	Brush Creek	Full Measurement	11/28/2012	Finished	Collect Weather data
845	Hanes Ranch	Full Measurement	11/28/2012	Finished	Collect Weather data
846	Armstron-Janicki	Full Measurement	12/26/2012	Finished	Collect Weather data
847	Victoria	Full Measurement	12/26/2012	Finished	Collect Weather data
848	McKinely	Full Measurement	12/26/2012	Finished	Collect Weather data
849	Pender Harbor	Full Measurement	11/1/2012	Finished	Collect Weather data
850	Steel Creek	Full Measurement	11/2/2012	Finished	Collect Weather data
851	Upper Campbell	Full Measurement	11/3/2013	Finished	Collect Weather data
852	Fanny Bay	Full Measurement	1/11/1900	Finished	Collect Weather data
853	Copper Canyon 1	Full Measurement	1/15/1900	Finished	Collect Weather data
883	Alderbrook C.C.	Full Measurement	1/11/1900	Finished	Foliage, Core, Weather data
884	Carson Lake	Full Measurement	1/22/1900	Finished	Foliage, Core, Weather data
885	Stoner	Full Measurement	1/12/1900	Finished	Foliage, Core, Weather data
886	Beeville rd. South	Full Measurement	12/12/2012	Finished	Foliage, Core, Weather data
887	St. Helen's	Full Measurement	11/26/2012	Finished	Foliage, Core, Weather data
888	Fall River Fertilization	Full Measurement	12/19/2012	Finished	Foliage, Core, Weather data
889	Deadhorse	Full Measurement	11/27/2012	Finished	Foliage, Core, Weather data
890	Ditch creek road	Full Measurement	10/31/2012	Finished	Foliage, Core, Weather data
891	Red Hill	Full Measurement	11/1/2012	Finished	Foliage, Core, Weather data
892	Castle Rock	Full Measurement	11/02/12	Finished	Foliage, Core, Weather data
893	Frozen Creek	Full Measurement	11/1/2012	Finished	Foliage, Core, Weather data