Presentations
SMC Fall Meeting

Schedule (morning)

	STAND MANAGEMENT COOPERATIVE FALL MEETING Wisteria Hall, Washington Arboretum, Seattle, WA September 22, 2016	
	AGENDA	
	BUSINESS MEETING	
8:30	Registration, coffee & rolls	
9:00	Welcome & Introductions	Candace Cahill, outgoing Policy Committee Chair Gareth Waugh, incoming Policy Committee Chair
9:10	Opening Remarks from UW College of the Environment Dean	Lisa Graumlich
9:40	Election of new Policy Committee Vice-Chair	Gareth Waugh, PC Chair, PBTF
9:50	Announcements & Accomplishments ✓ 2016 at a Glance ✓ New Measurement Crew Personnel ✓ NSF CAFS update—funded projects	Eric Turnblom
10:10	Director's Introductory Preface: SMC Budget and Research ✓ Policy Advisory Committee Meeting Summary ✓ Budget Projection and Dues Vote	Eric Turnblom
10:30	**BREAK**	

Schedule (morning)

TECHNICAL SESSION SMC Ongoing Research		
10:50	Overview of Modeling Project	Dave Marshall
10:55	Overview of Wood Quality Project	Eini Lowell
11:00	Overview of Silviculture Project	Eric Turnblom
11:05	Overview of Nutrition Project / Status of Type V's	Kim Littke
11:10	Late-Rotation Fertilization update	Kim Littke
11:30	Yield Performance of SMC Type I, II, and III Installations –$(SMC)^2$ Analysis	Jason Cross
12:00	**LUNCH**	
1:00	**TECHNICAL SESSION (cont.)**	

Schedule (afternoon)

	TECHNICAL SESSION (cont.)	
1:00	PCT Analysis Project Status	Eric Turnblom
1:20	Appraisal of Rotation-age Tree & Stand Characteristics ✓ Tree and log quality ✓ Non-Destructive Testing relationships ✓ Soil Properties ✓ Biomass models ✓ IRC timeline update	 Eric Turnblom Eric Turnblom Kim Littke Maguire / Mainwaring Jason Cross
2:20	Modeling Competition Effects on Tree Growth and Stand Development: Assembly and Exploratory Analysis of a Spatially Explicit Dataset	Jeff Comnick
2:40	**BREAK**	
3:00	NRSIG – DNR Project	Luke Rogers
3:20	Present and Future of VMRC Research	Carlos Gonzales
3:40	2017 Research Plan of attack 1. SMC Ownership Survey Update? 2. Early winter TAC meeting 3. Installation Review Committee 4. Spring meeting date/location 5. Meeting Wrap-up	
4:00	Adjourn	

SMC Accomplishments 2016

- Database
  - Developed set of standard queries to extract data by project (e.g. Type I, Type V); delivered in workshop at Spring Meeting
  - Final stage of linking tables & validating cross-references; expect to have tables linked and validated for GY 2016 update

SMC Accomplishments (cont.)

- Field Measurements Completed (2015 – 2016)
  - Type I Installations
    - Seven (7) Installations received full measurement
    - Nine (9) received RD checks (marked 3 for thinning)
  - Type II installations
    - Two (2) Installations received full measurement
  - Type III Installations
    - Nine (9) installations received full measurement
    - Three (3) plots thinned
  - Type V Installations
    - Twenty six (26) received full measurement

SMC Accomplishments (cont.)

- Tree List Generation Database has five configurations:
  - Fourth major revision (5th version)
    - 5) tgdb4r14: Includes plots from ORGANON modeling database + those Type I/II's established by 2000 (tgdb1r00), AND measurements through 2014 on all Types I/II/III, PLUS (New in 2016) an activated "PCT_STEMS_REMOVED" database schema switch to admit inputting a Pre-Commercial Thinning parameter; rebuilt

SMC Accomplishments (cont.)

- Joint TAC meeting January 2016
- Finalized study plan for "Stand and Tree Reponses to Late-rotation Fertilization"
- Developed two- and four-year response models using linear discriminant analysis for all Type V Paired-tree installations
- Installation Review Committee (IRC) meeting July 2016
- Three Policy Committee Meetings (March, August, September)
- Finalized yield model framework for $(SMC)^2$ Analysis / PYC, both all trees and crop trees- final stage of bootstrapping
- Hired the new SMC Field Marshal Mason Patterson

SMC Accomplishments (cont.)

- Publications
  - Hoibo, O., E. Turnblom. 2016. Modelling vertical profiles of knot characteristics in young coastal U.S. Douglas-fir. **Forest Products Journal**
  - James, J., K. Littke, T. Bonassi, and R. Harrison. 2016. Exchangeable cations in deep forest soils: Separating climate and chemical controls on spatial and vertical distribution and cycling. **Geoderma** 279: 109-121.
  - Littke, K.M., R.B. Harrison, and D. Zabowski. 2016. Determining the Effects of Biogeoclimatic Properties on Different Site Index Systems of Douglas-fir in the Coastal Pacific Northwest. **For. Sci.**
  - Todoroki, C.L. and Lowell, E.C. 201x. Validation of models predicting modulus of elasticity in Douglas-fir trees, boles, and logs. **New Zealand Journal of Forestry Science**

SMC Accomplishments (cont.)

- CAFS Annual Meeting April 26 – 28, 2016, Pensacola, FL
  - **Final**: Understanding Site-Specific Factors Affecting the Nutrient Demands and Response to Fertilizer by Douglas-fir: Harrison et al
  - **Continuation**: Appraising Rotation-age Tree and Stand Characteristics in a 1970's Decadal Cohort of Douglas-fir Plantations in the PNW: Turnblom et al.
  - **New Project**: Stand and Tree Responses to Late-Rotation Fertilization: Turnblom, Cross, Littke, Harrison
  - **Student Poster:** Effects of nitrogen fertilization and thinning treatments on subsurface soil carbon and nitrogen: Gross et al.

SMC Accomplishments (cont.)

- Other Meeting Presentations
  - International Convention Forest Products Society, June 27-29, 2016, Portland, OR, USA. **Impact of Site and Silviculture Practices on non-destructive assessment of wood properties in Douglas-fir**: Lowell, Filipescu, Turnblom, Koppenaal
  - Society for Ecological Restoration 2016 Regional Conference, Symposium: Management impacts on soil organic carbon, hydrology, and biotic communities, April 4-8, 2016. Portland, Oregon. **Forest management impacts on soil carbon: Case studies from wet coastal to dry interior PNW forests** (Invited Presentation): Gross, et al.
  - Society for Ecological Restoration 2016 Regional Conference, April 4-8, 2016. Portland, Oregon. **An assessment of native plant species vigor and survival at an urban restoration site in relation to climate, topography, geology, and soil properties**: Gross.
  - University of Washington School of Environmental and Forest Sciences 13th Annual Graduate Student Symposium, March 4, 2016. Seattle, Washington. **Soil nutrition: Effects of nitrogen fertilization and thinning treatments on subsurface carbon and nitrogen**: Gross et al.

SMC Accomplishments (cont.)

- External Funding
  - $64,200: "Sustainable Biofuels" from USDA
  - $60,000: “CAFS” from NSF I/UCRC program
  - $38,800: “Douglas-fir biomass” from McIntire-Stennis
  - $33,250: “Understanding and Modeling Competition Effects” from NSF I/UCRC FRP
  - ~ $30,000/y to SMC salary “buyback” for Rob Harrison
  - $22,000: “B. Bruce Bare Endowed Chair in Forest Resources” SEFS
  - $20,000: "Organic Retention" from NCASI

SMC Accomplishments (cont.)

- Student Updates
  - Degrees Completed:
    - John Kirby (MS 2016), Matt Norton (MS 2015)
  - Active students
    - Kevin Ceder (PhD), Jason James (PhD), Stephani Michelsen-Correa (PhD) and Marcella Menegale (PhD); Christiana Dietzen (PhD), Kiwoong Lee (PhD), Cole Gross (MS), Amelia Root (MS)
  - Incoming students
    - Fletcher Harvey (MS), Pranjal Dwivedi (MS)

Measurements scheduled 2016-17

Type I

Inst.	Name	Job	Company	Comments
703	Longbell Road	Remark plot 10		Maybe
708	Copper Creek	Full Measurement	Port Blakely	
709	Mill Creek	Full Measurement	Weyerhaeuser	
710	Trail Creek	Full Measurement	Roseburg Lumber	
711	Kitten Knob	Full Measurement	Wash DNR	RD check plot 4
712	Prather Creek	Full Measurement	Weyerhaeuser	
713	Sauk Mt.	Full Measurement	Grandy Lake LLC	RD check plots 4 and 10
714	Mahatta River	Full Measurement	BC	
715	Davie River	Full Measurement	BC	RD check plot 6, mark and thin
716	Quilla Creek	Full Measurement	BC	RD check plot 2, 3, mark and thin
726	Toledo	RD check	Weyerhaeuser	RD check plots 4,8,9
729	Gnat creek	RD check	Oregon Dept. Forest	RD check plots 4 and 6
736	Twin Peaks	Full Measurement	Campbell Group	RD check plot 12
737	Allegany	Full Measurement	Oregon Dept. Forest	RD check plot 2

Type III

Inst.	Name	Job	Company	Comments
910	King Creek	Full Measurement	Hancock	
916	Bobo's bench	Thin	Weyerhaeuser	Mark plot 13
918	Grimm Rd.	Full Measurement	Port Blakely	
924	Mosquito Rocker	Full Measurement	Wash. DNR	
937	Ames Creek	Full Measurement	Cascade Timber	Thin plot 11
938	Grimm Rd.	Full Measurement	Port Blakely	
942	Cat Ballew	Full Measurement	Wash. DNR	Thin plot 11,12,18,24

Measurements scheduled 2016-17

Type IV

Inst.	Name	Job	Company	Comments
601	Donkey Creek	Full Measurement	Rayonier	22 plots
602	Donaldson Creek	Full Measurement	Green Crow	22 plots
603	Crane Creek	Full Measurement	Quinault Indian	22 plots
604	TBD			New WH trials
605	TBD			New WH trials
606	TBD			New WH trials
607	TBD			New WH trials

Type V

Inst.	Name	Job	Company	Comments
883 *	Alderbrook C.C.	Full Measurement	Green Diamond	
884 *	Carson Lake	Full Measurement	Green Diamond	
885 *	Stoner	Full Measurement	Green Diamond	
886 *	Beeville rd. South	Full Measurement	Green Diamond	
887	St. Helen's	Full Measurement	Weyerhaeuser	Dropped
888 *	Fall River Fertilization	Full Measurement	Weyerhaeuser	
889	Deadhorse	Full Measurement	Weyerhaeuser	
890	Ditch creek road	Full Measurement	Hancock	
891	Red Hill	Full Measurement	Roseburg	
892	Castle Rock	Full Measurement	Weyerhaeuser	
893	Frozen Creek	Full Measurement	Roseburg	

* 2016-2017 measurements completed

Measurements scheduled 2016-17

Type VI

Inst.	Name	Job	Company	Comments
751	TBD	Install, Meas., Treat	TBD	
752	TBD	Install, Meas., Treat	TBD	
753	TBD	Install, Meas., Treat	TBD	
754	TBD	Install, Meas., Treat	TBD	
755	TBD	Install, Meas., Treat	TBD	
756	TBD	Install, Meas., Treat	TBD	
757	TBD	Install, Meas., Treat	TBD	
758	TBD	Install, Meas., Treat	TBD	
759	TBD	Install, Meas., Treat	TBD	
760	TBD	Install, Meas., Treat	TBD	
761	TBD	Install, Meas., Treat	TBD	
762	TBD	Install, Meas., Treat	TBD	
763	TBD	Install, Meas., Treat	TBD	
764	TBD	Install, Meas., Treat	TBD	
765	TBD	Install, Meas., Treat	TBD	

Budget Preamble

- We carried over $243,000 into 2016
- We have lost SPI, Plum Creek; BLM has considerably reduced acreage under their new RMP
- Of the 3 approved research projects currently underway
  - Funds for the 2nd Generation western hemlock trials are banked, totaling $51,665 (y1: $3750, y2: $17,515, y3: $17,400, y4: $13,000)
  - Late rotation fertilization project approved: budget evolving ($26,685 for next two years is committed)
  - The Type I Sunset project is in an analyze-report-modify stage; no funds committed to an additional installation this year- as of now none are known to be staged for harvest this year
- Will embark on hiring contractors to take measurements at select installations as Bob has agreed to train Mason and assist in training contract crews in coming year

2016 Income and Expenses

Income	Amount	
Formula Funding	$	623,596
Contracts	$	3,486
Subtotal	$	627,082
In-kind credits	$	(9,840)
Net Cash Contributions	$	617,242
2015 Ending Balance Forward	$	243,031
Total Funds Available	$	860,273
Expenses	**Amount**	
Salaries	$	273,863
Benefits	$	75,237
Travel	$	61,112
Equipment & Supplies &Contracts	$	46,729
Committed Project Funding	$	186,000
Subtotal	$	642,941
Indirect (8% rate while CAFS funded)	$	35,172
Total Direct & Indirect expenses	$	678,113
Research Contracts	$	30,000
Total Expenditures	$	708,113
2016 Ending Balance	$	152,159
Total Funds Available	$	860,273

2017 Dues Projected

Cooperator	Amount
American Forest Mgt.	$ 18,423
Bureau of Land Management	$ 33,067
Campbell Global	$ 24,745
Cascade Timber Consulting	$ 19,152
Green Crow	$ 8,665
Green Diamond Resource	$ 25,234
Hampton Affiliates	$ 17,818
Hancock Forest Management	$ 35,572
Lewis & Clark Tree Farms	$ 19,301
Lone Rock Timber	$ 18,580
ORM Inc	$ 20,891
Oregon Dept. Forestry	$ 41,099
Pacific Denkman	$ 7,340
Port Blakely Tree Farms	$ 19,147
Quinault DNR	$ 9,331
Rayonier Forest Resources	$ 27,628
Roseburg Res.	$ 25,511
Stimson Lumber	$ 20,525
TimberWest-Coast Timberlands	$ 40,974
Washington DNR	$ 54,077
Weyerhaeuser NR	$ 79,514
TOTAL	$ 566,595

If acres > 100,000, dues = $13,501
If acres< 100,000, dues = $ 6,751
+ $0.039242 ac
Dues cap = $80,000

SMC-Related Contributions

Organization	Funds Contributed 2017
BC Ministry of Forestry	$ 68,000
UW faculty salaries (state support tied to mentoring SMC-based student research)	$ 100,000
UW Teaching and Research Assistantships ($33,630/student)	$ 157,052
Total	$ 325,052

2017 Budget Projection

Category	Amount	
2017 Formula Dues	$	566,595
2016 Ending Balance Forward	$	152,159
Total Available Revenue	$	718,754
Salaries	$	291,976
Benefits	$	82,522
Travel	$	61,112
Equipment & Supplies	$	46,729
Committed Project Funding*	$	133,400
Subtotal expenses	$	642,339
Indirect (8% rate while CAFS funded)	$	32,996
Total Direct & Indirect expenses	$	675,335
Field Crew Contracts	$	60,000
Total Expenditures	$	735,335
2017 Ending Balance	$	10,019

*These funds will be held for project commitments.

Vote on dues

- Entertain a motion that we keep the dues the same and monitor our progress on the Type I sunset project, 2nd generation hemlock project, and hiring contract measurement crews through the fall / winter
- Task force to be set up subsequently to examine dues structure and level

SMC Nutrition Report

Fall, 2016 meeting,
Center for Urban Horticulture
University of Washington, Seattle

SMC Nutrition Report, Spring 2016

1) Student/funding updates
2) SMC Type V – Kim Littke
3) SMC late fertilization study - Kim

Funding, new initiatives

- NCASI through 2017 $20K/year, $678K total
- Approx $300K/year equiv. TA/Gessel fellowships
- Partial salary buyback by UW Extension for Rob 3 months per year, about $30K/year to spend on SMC work
- CAFS grant for productivity and response modeling and study of role of deep soils in forest productivity $32,500 total
- Bioenergy grant from USDA, $321K total (2011-2016) finishing

People/Graduate Students

- Graduate Students
  - Christiana Dietzgen, PhD start 2014
  - Jason James, PhD start 2015
  - Cole Gross, MS start 2015
  - Amelia Root, MS start 2015
  - Pranjal Dwivedi, MS start Fall 2016

  - Matt Norton (MS) fishished Spring 2015
  - Stephani Michelsen-Correa (PhD) finishing 2016
  - Marcella Menegale (PhD) finishing 2016

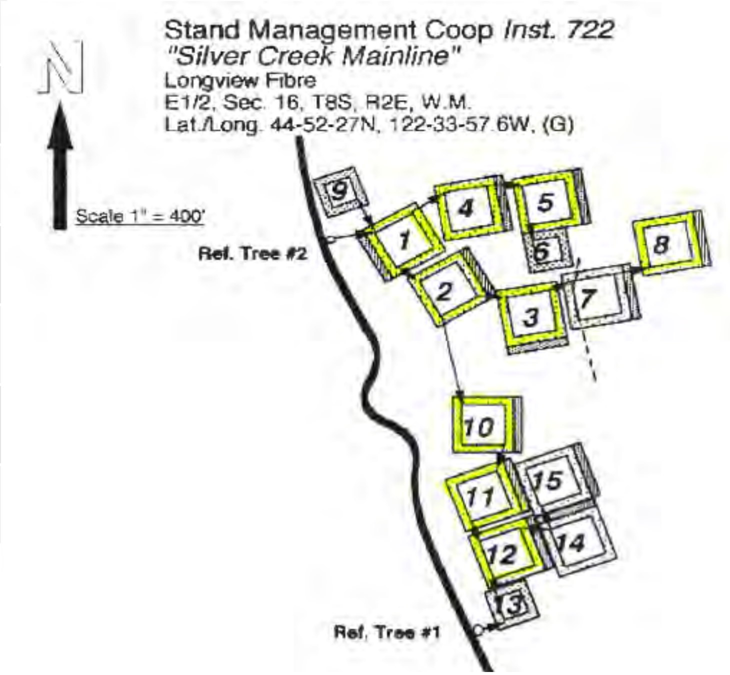
  - Kim Littke, Postdoc

- all salaries currently funded with external funding

Silver Creek Mainline
(SMC Installation 722)
Type 1 Sunset Update

Treatments 1-6 and 13-15 (9 plots total)

Treatment	Initial Stocking	Regime	Installation 722 Plot No.
1	ISPA/4	No Thinning	2
2	ISPA/2	No Thinning	8
3	ISPA/2	Minimal Thinning: RD55-RD35 once (MT)	3
4	ISPA	No Thinning	5
5	ISPA	Minimal Thinning: RD55-RD35 once (MT)	4
6	ISPA	Repeated Thinning: RD55-35, 55-40 and 60-40 (RT)	1
13	ISPA/4	Fertilization with 200 lbs/acre N as urea 5 times (F)	12
14	ISPA/2	Fertilization and Minimal Thinning (F +MT)	11
15	ISPA	Fertilization and Repeated Thinning (F +RT)	10



Possible Comparisons

- Basic Treatments
  - Ho: ISPA = ISPA/2 = ISPA/4
  - Ho: ISPA = ISPA + MT
  - Ho: ISPA/2 = ISPA/2 + MT
- Supplementary Treatments
  - Ho: ISPA/4 vs. ISPA/4 + F
  - Ho: ISPA/2 vs. ISPA/2 + F + MT
  - Ho: ISPA vs. ISPA + F + RT
- Did not sample felled trees for pruned or selection thinning treatments

Sample sizes and data collection

Vegetation plots

- four, circular vegetation sampling sub-plots (0.01 acres)

Soil Sampling

- Three pits dug per plot to minimum of 1 m

Plot data

- stratified by most recent dbh measurements in database (2013) and divided into quintiles

30-tree sample (standing tree) = 6 trees / quintile

- crown width
- tree sonic
- resistograph
- dbh core (2 / tree)

11-tree sub-sample (felled tree) = 2,2,3,2,2 trees per quintile

- Taper
- Hitman – starting with longest merchantable length and working back to shortest length
- Disks cut at 5 locations
  - At 4-in top
  - Half-way between base of crown and 4-in top
  - base of crown (between 40 & 50 ft)
  - 17-ft
  - stump
- LLAD measurments

3-tree Biomass Sample

- *Trees P10, P50 and P90 only:*
  - crown and stem sampling for biomass estimation
  - remove branches and measured all knots by 16-ft log lengths

- *Trees representing the 10th and 90th percentile only:*
  - identify the foliage chemistry
  - measure and sample dead branches

Status

- ✓ Summer/Fall 2016
  - X-ray densitometry on cores and strips
- ✓ Summer 2016
  - ✓ Completed data entry / cleaning of volumetric & weight determinations on disks
  - ✓ Continued examination of treatment differences using available variables
- ✓ Fall 2016
  - ✓ Continuing data extraction / cleaning of resistance value (resi-drill) data

Butt-Log Specific Gravity by Treatment

Treatment Key:

ISPA= Init. Dens. no Thin

I MT= ISPA Thin once

I RT = ISPA Rep. Thin

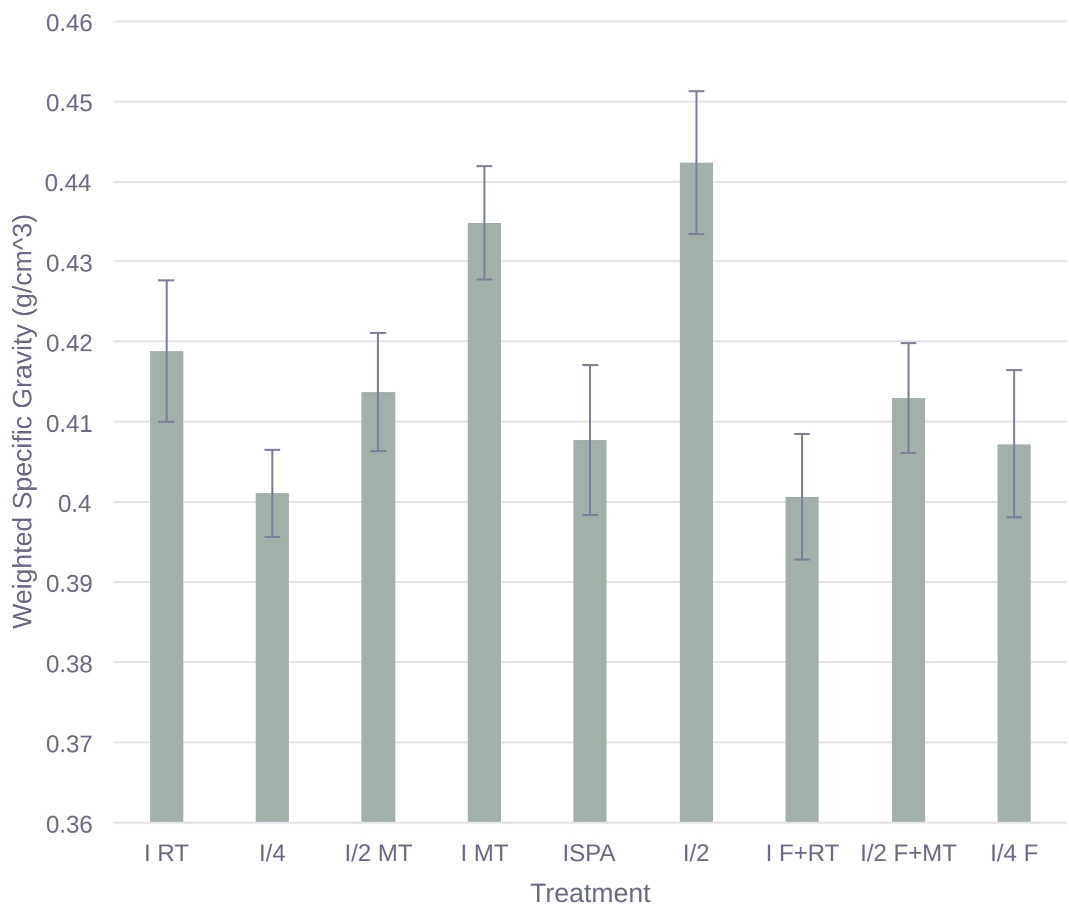
I/2 = ISPA/2 PCT, no CT

I/2 MT= I/2, Thin once

I/4 = ISPA/4 PCT, no CT

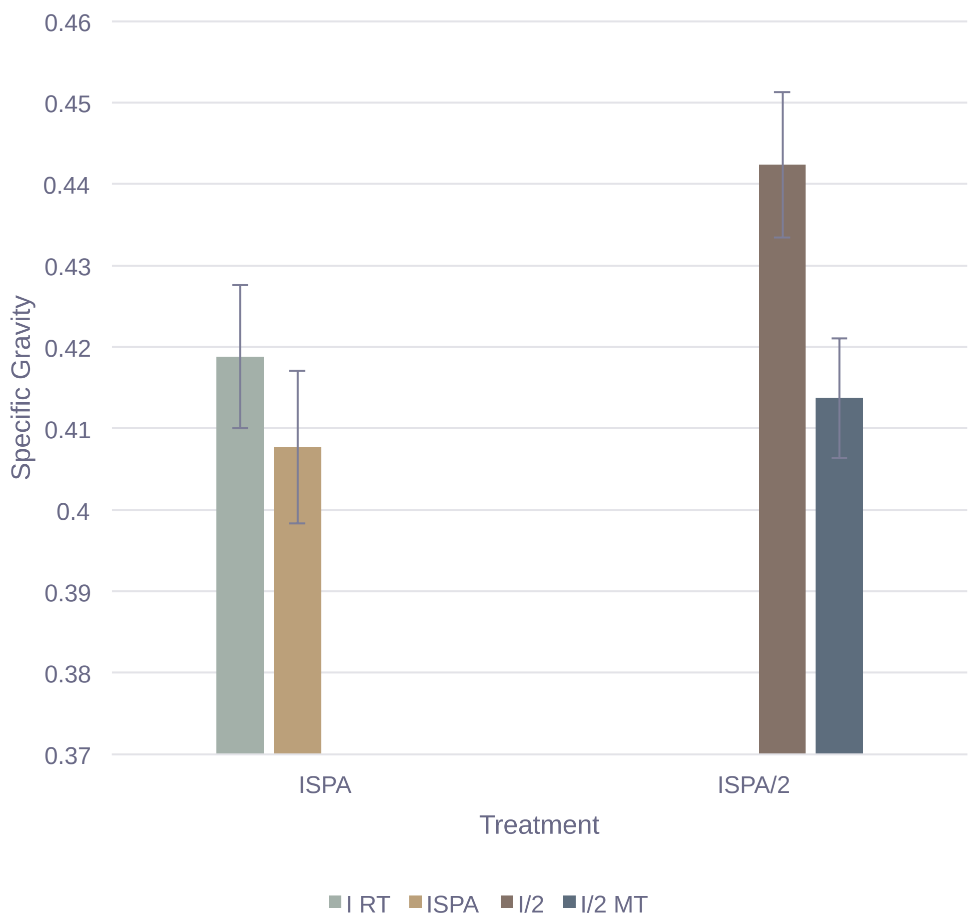
I/4 F = I/4 + Fert.

F = Fert. in all cases



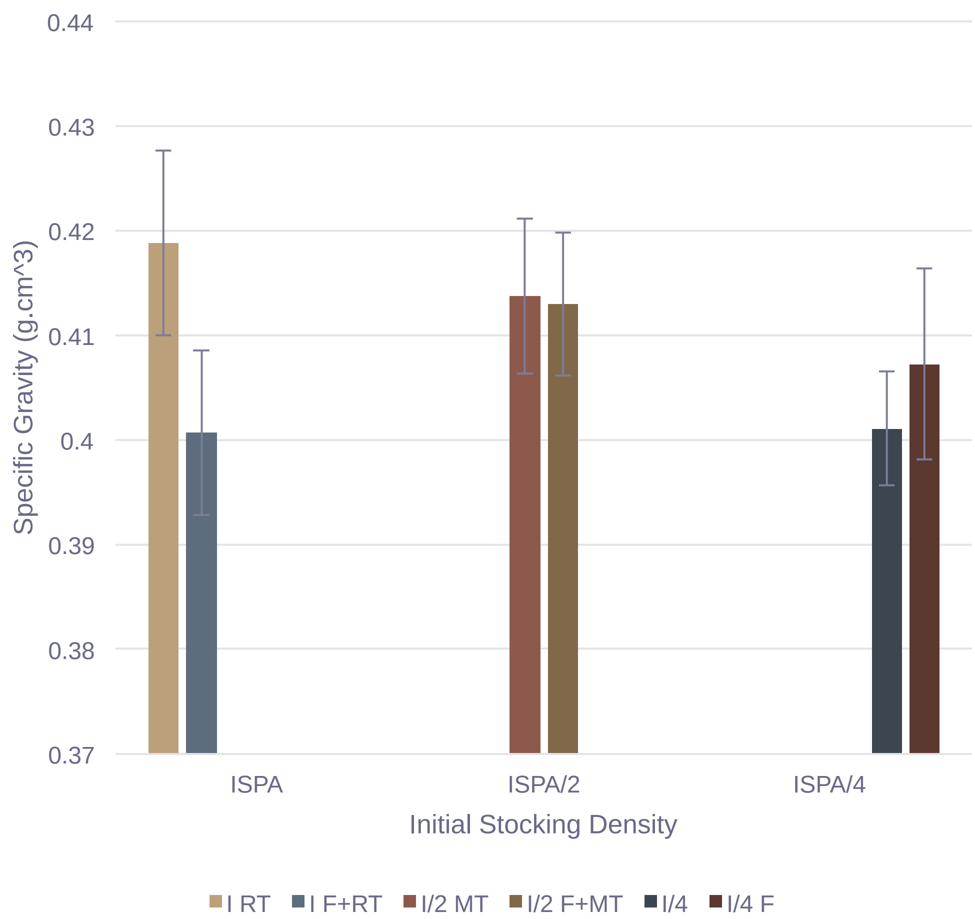
Butt Log SG grouped by Thinning Intensity and Initial Stocking

Treatment Key:
ISPA= Init. Dens. no Thin
I MT= ISPA Thin once
I RT = ISPA Rep. Thin
I/2 = ISPA/2 PCT, no CT
I/2 MT= I/2, Thin once
I/4 = ISPA/4 PCT, no CT
I/4 F = I/4 + Fert.
F = Fert. in all cases

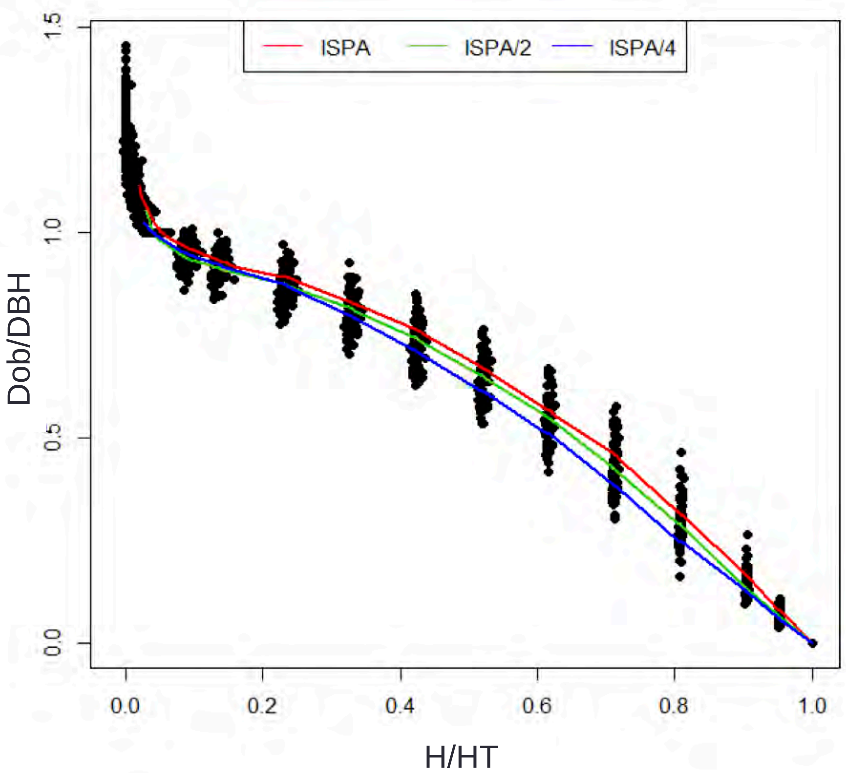


Butt Log SG by Initial Stocking Density, w & w/o fertilization

Treatment Key:
ISPA= Init. Dens. no Thin
I MT= ISPA Thin once
I RT = ISPA Rep. Thin
I/2 = ISPA/2 PCT, no CT
I/2 MT= I/2, Thin once
I/4 = ISPA/4 PCT, no CT
I/4 F = I/4 + Fert.
F = Fert. in all cases

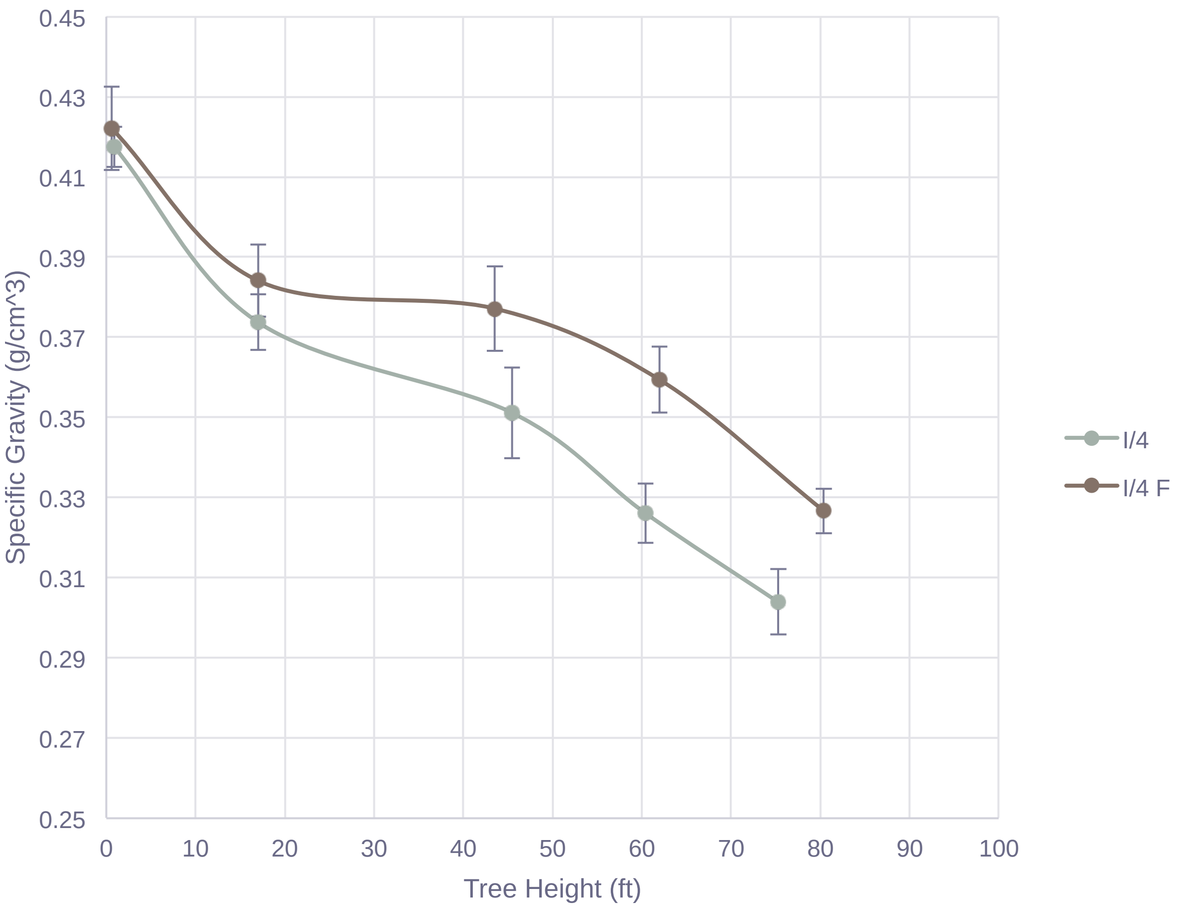


Taper Pattern Among Treatments



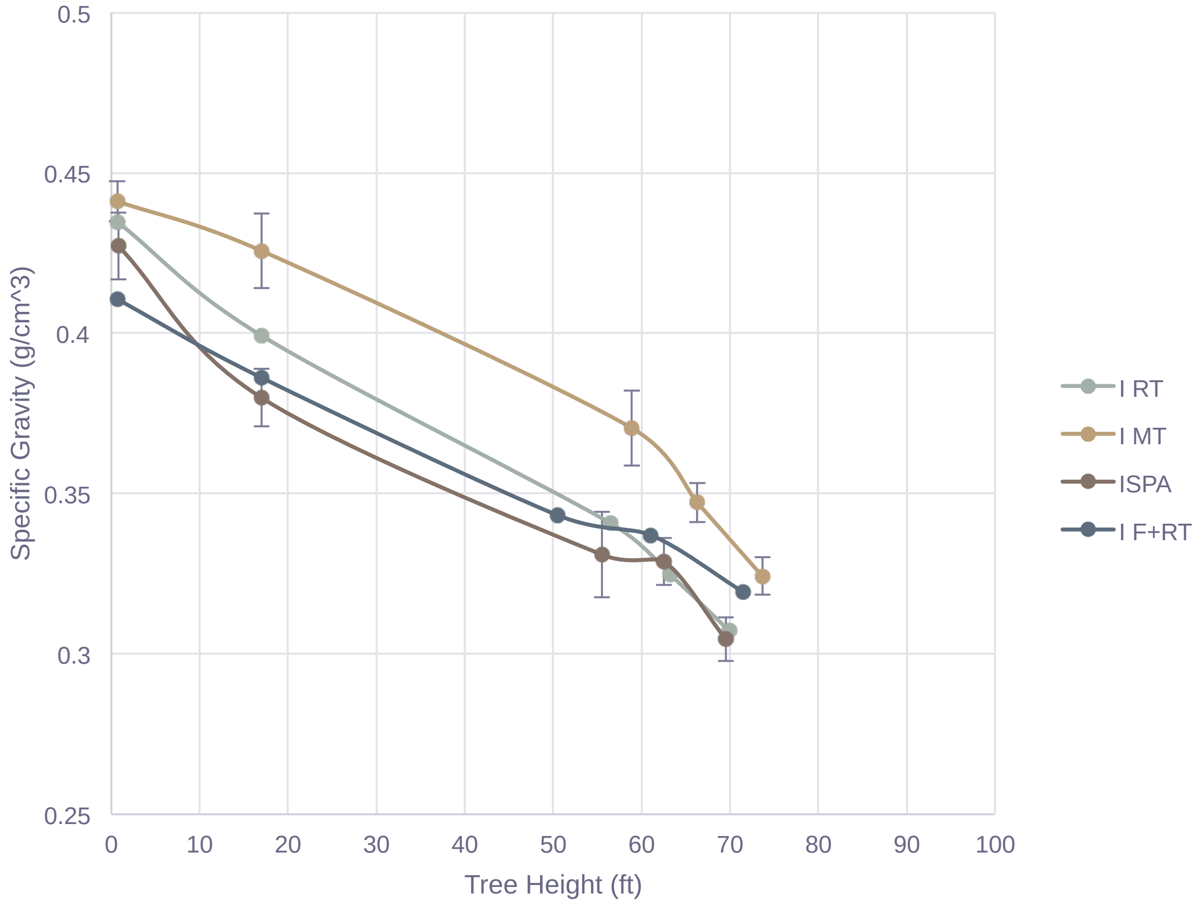
Whole disk SG Along Stem for ISPA/4, variously treated

Treatment Key:
ISPA= Init. Dens. no Thin
I MT= ISPA Thin once
I RT = ISPA Rep. Thin
I/2 = ISPA/2 PCT, no CT
I/2 MT= I/2, Thin once
I/4 = ISPA/4 PCT, no CT
I/4 F = I/4 + Fert.
F = Fert. in all cases



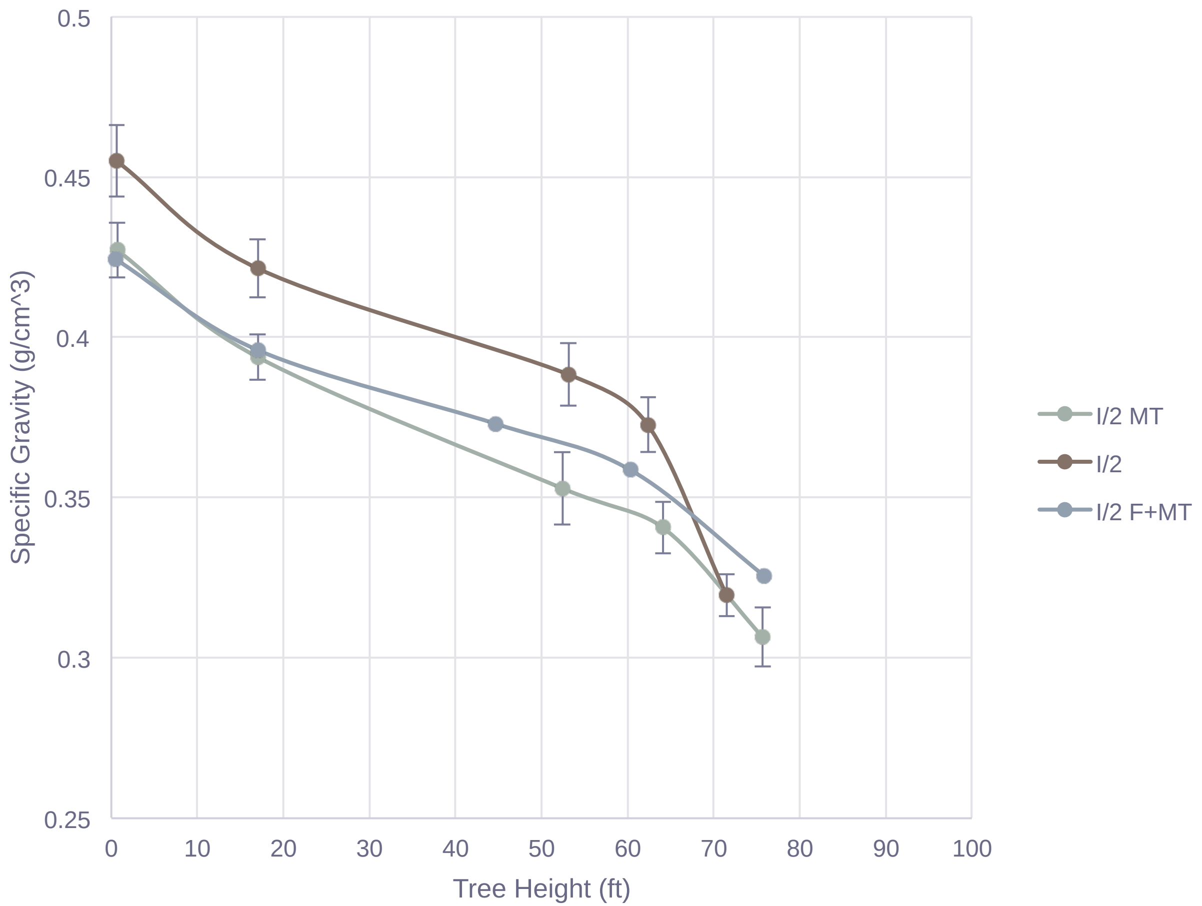
Whole Disk SG for ISPA, variously treated

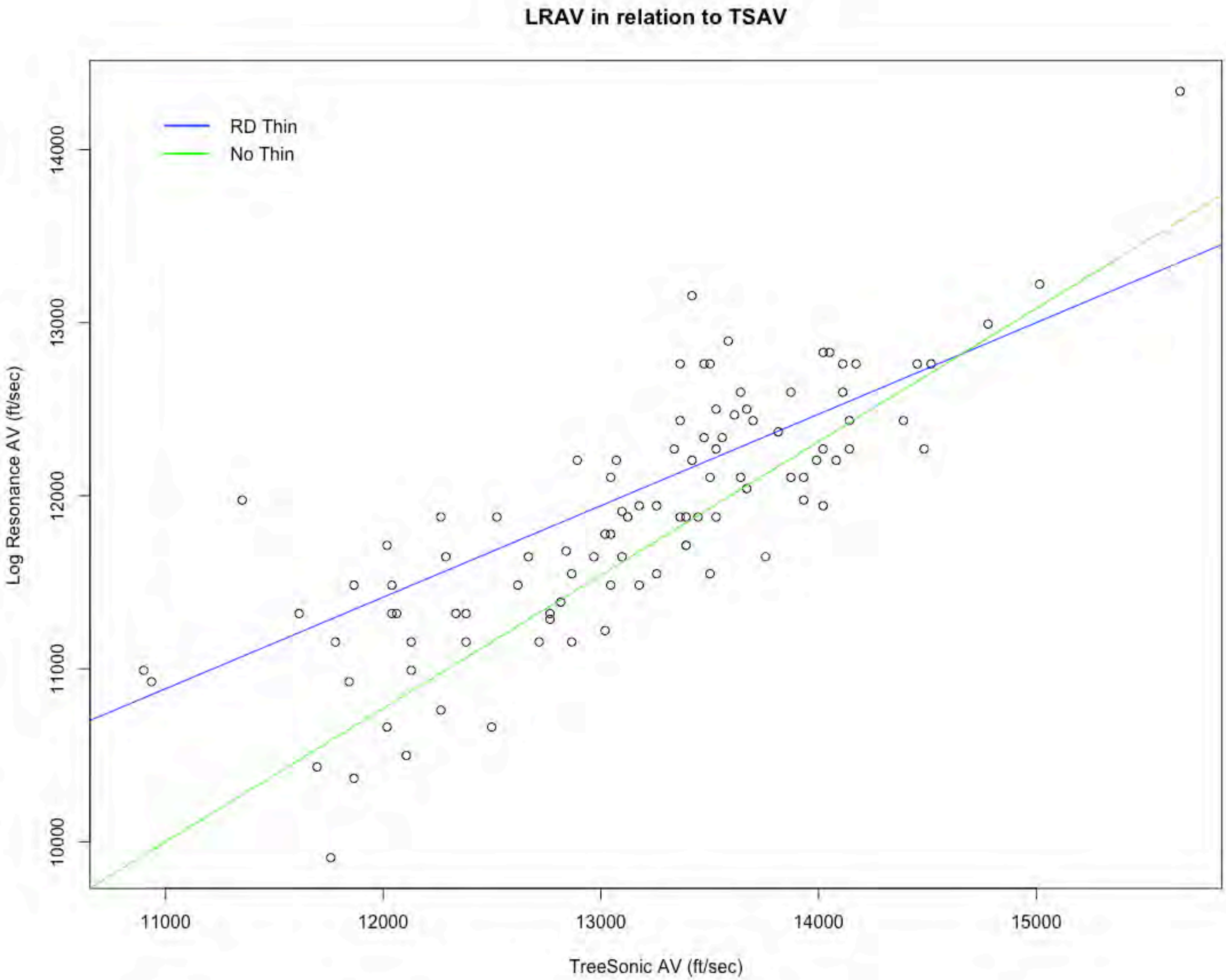
Treatment Key:
ISPA= Init. Dens. no Thin
I MT= ISPA Thin once
I RT = ISPA Rep. Thin
I/2 = ISPA/2 PCT, no CT
I/2 MT= I/2, Thin once
I/4 = ISPA/4 PCT, no CT
I/4 F = I/4 + Fert.
F = Fert. in all cases

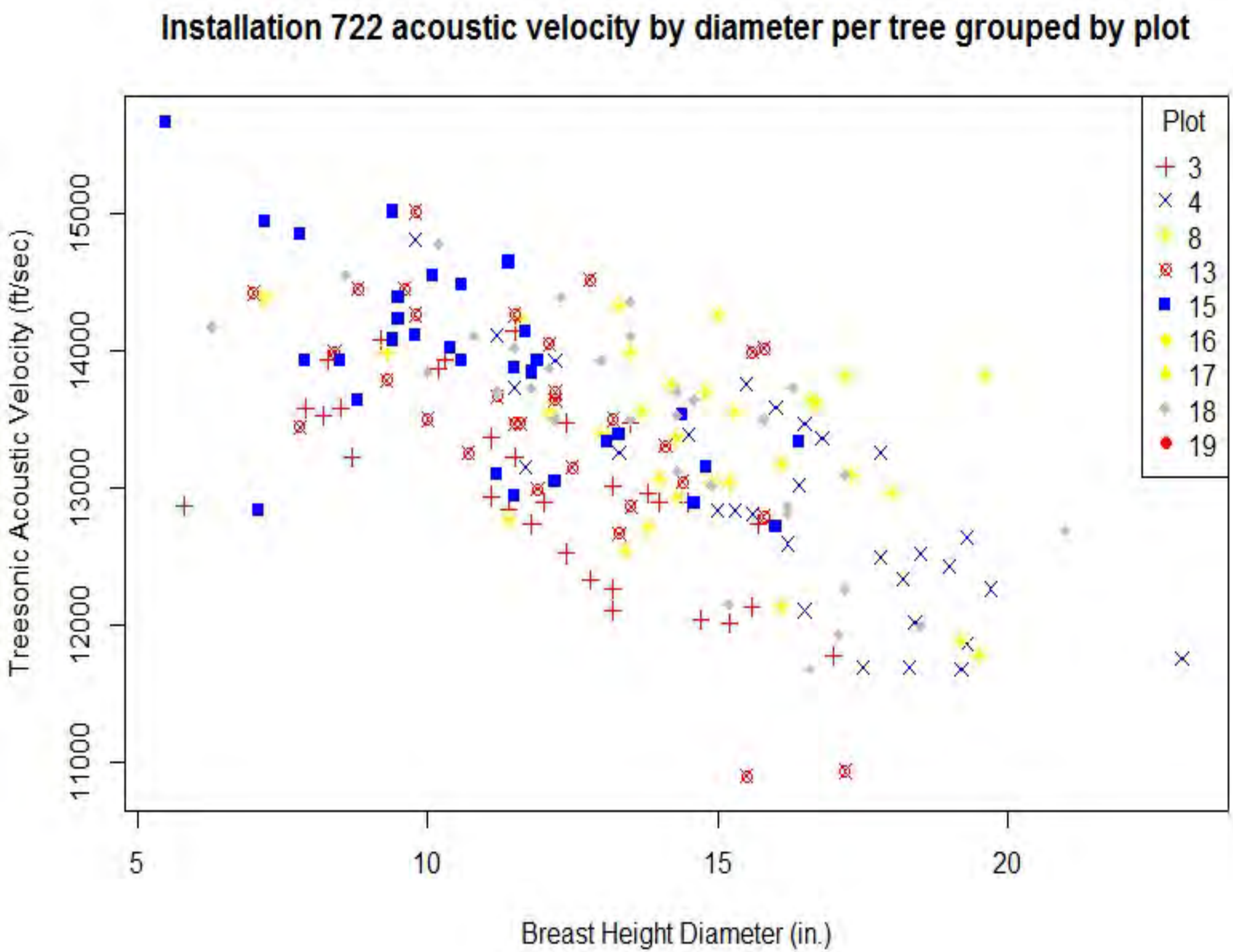


Whole Disk SG for ISPA/2, variously treated

Treatment Key:
ISPA= Init. Dens. no Thin
I MT= ISPA Thin once
I RT = ISPA Rep. Thin
I/2 = ISPA/2 PCT, no CT
I/2 MT= I/2, Thin once
I/4 = ISPA/4 PCT, no CT
I/4 F = I/4 + Fert.
F = Fert. in all cases




LRAV in relation to TSAV
RD Thin
No Thin
Log Resonance AV (ft/sec)
10000
11000
12000
13000
14000
TreeSonic AV (ft/sec)
11000
12000
13000
14000
15000


Installation 722 acoustic velocity by diameter per tree grouped by plot
Treesonic Acoustic Velocity (ft/sec)
11000
12000
13000
14000
15000
Breast Height Diameter (in.)
5
10
15
20
Plot
3
4
8
13
15
16
17
18
19

Results of bootstrap analysis (n=1000): F-test on variance between 6-trees-per-quintile data and resampled quintiles without replacement, by plot with ISPA and Treatment Regimes Code.

Plot	ISPA	Trt	Boot 5/6	Boot 4/6	Boot 3/6	Boot 2/6	Boot 1/6
1	1	RT	1.000	1.000	0.998	0.998	0.991
2	4	NT	1.000	0.999	1.000	1.000	1.000
3	2	MT	0.999	0.990	0.986	0.986	0.975
4	1	MT	0.951	0.893	0.895	0.895	0.885
5	1	NT	1.000	0.999	0.998	0.998	0.997
8	2	NT	1.000	1.000	0.998	0.998	0.994
10	1	F+RT	0.995	0.991	0.981	0.981	0.984
11	2	F+MT	0.999	0.997	0.995	0.995	0.992
12	4	F	1.000	0.999	0.993	0.993	0.981

Notes:

All plots at all resampling intensities matched the 6/6 mean acoustic velocity (not shown).

ISPA/2 and ISPA/4 plots could match mean and variance at a sampling intensity of 1 tree per quintile.

Plot 4 is ISPA with minimal thinning; requiring 5 trees per quintile to match variance. All other ISPA would match at sampling intensity of 1 tree.

Next Steps

- Further analysis
  - Continue optimizing sample sizes
    - TSAV, LRAV
    - X-ray density at breast height
  - Develop plans for orderly sunset
    - Measurement plots
    - Buffers
- Summary Report in Working Paper
- Choose next installation

Nutrition TAC and Current Type V Updates

Kim Littke and Rob Harrison

NARA
Northwest Advanced Renewables Alliance

The Effects of Biomass Removal and Competing Vegetation Control on Douglas-fir Foliar Nutrition in the Pacific Northwest, USA.

A.M. Root, R.B. Harrison, S.M. Holub

Research Objectives:

I. Assess the nutrient status of trees within the treatments.
II. Compare these measured data values against critical values to assist with interpretation of previously collected tree growth data.
III. Use in conjunction with individual tree growth data and site nutrition to assess the effectiveness of plot treatments and to inform on future treatments.

Expectations:

1. The vegetation control treatments will influence foliar nutrition uptake by reducing competition in the plot for soil nutrients.
2. Removal of biomass will lower foliar nutrition levels.
3. Compaction may increase foliar nutrition

Characteristic	Matlock (WA)	Molalla (OR)	Fall River (WA)	Springfield (OR)
Elevation (m)	35	549	334	670-700
Soil series, texture	Grove, very gravelly loamy sand	Kinney, cobbly loam	Boistfort, silt loam	Peavine, silty clay loam
Annual precipitation (cm)	249	174	181	167
Douglas-fir 50 year site index (m)	36	36	41-43	37

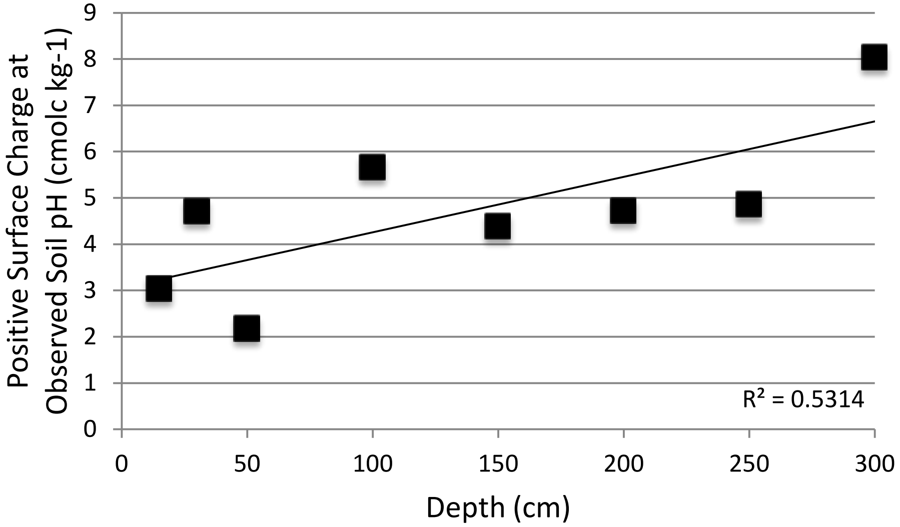
ncasi National Council for Air and Stream Improvement
USDA
University of Washington Stand Management Cooperative

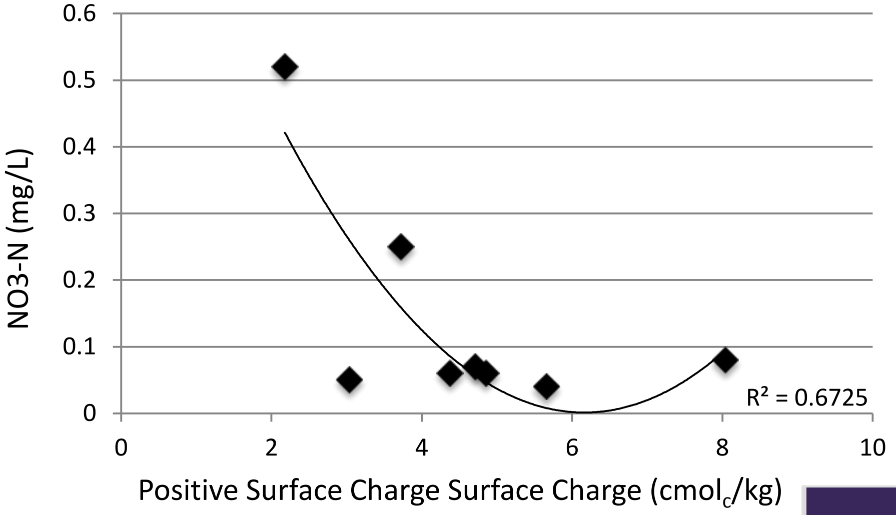
Anion exchange capacity as mechanism for nitrate storage at Fall River

Christiana Dietzen

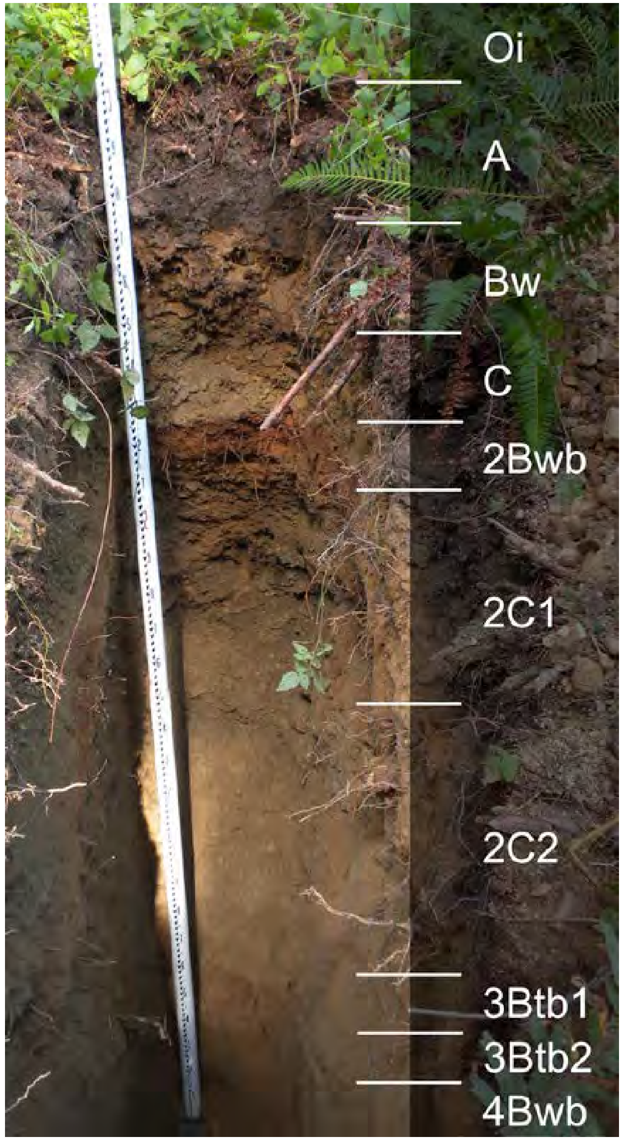
- Currently investigating how soils retain NO_3- and other negatively charged organic compounds in deep soils.
- Preliminary results suggest that anion exchange capacity increases with depth
- There is some correlation between amount of soil positive charge and exchangeable nitrate

Preliminary Results:





Deep Soil Nutrients & Organic Matter – Jason James



Soil Profile at Sauk Mountain to 3.5 m

Analyzed samples to 3+ m depth at 17 additional sites

2 publications:

James, J., Dietzen, C., Furches, J., Harrison, R., 2015. Lessons in Buried Horizons and Pedogenesis from Deep Forest Soils. *Soil Horizons* 56:6.

- [Open Access]

James, J., Littke, K., Bonassi, T., Harrison, R., 2016. Exchangeable cations in deep forest soils: separating climate and chemical controls on spatial and vertical distribution and cycling. *Geoderma* 279: 109-121

- Cycling of Exchangeable Cations at 22 SMC Type V Sites

Type V Status

- Final 6 year measurements happening this fall
  - o 10 installations
- No future measurements planned unless there is interest from the cooperators
- Analyzed 2, 4, and 6 year volume response on available stands
  - o Significant response (p<0.10)
  - o Linear discriminant analysis
  - o Predicted response across the region

Measured Volume Response per Tree

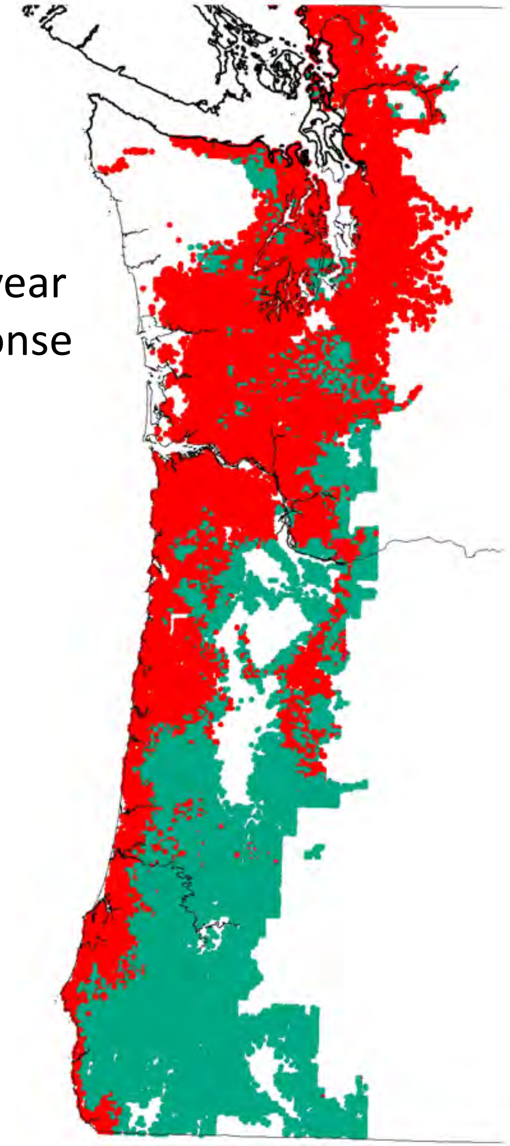
Year	Two-year Response (0-2)	Four-year Response (0-4)	Six-year Response (0-6)
Responders	0.24 ft^3/yr (17%)	0.21 ft^3/yr (17%)	0.20 ft^3/yr (13%)
Average	0.11 ft^3/yr (8%)	0.06 ft^3/yr (5%)	0.02 ft^3/yr (3%)
Total Responding Stands	44% (n=71)	31% (n=65)	30% (n=53)

Linear Discriminant Analysis Models

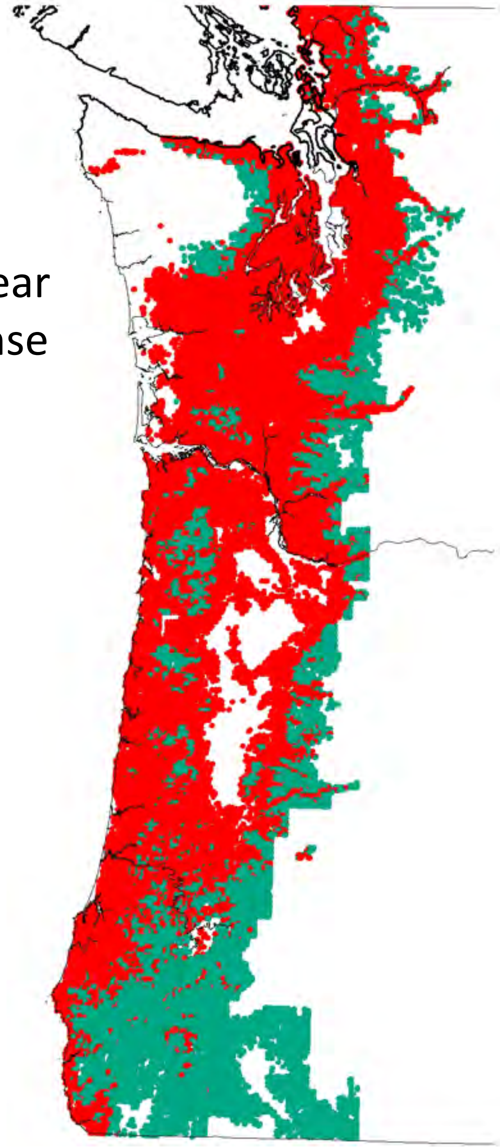
Response	Latitude (°)	Elevation (ft)	Slope (%)	Winter Temp (F)	Spring Temp (F)	September Temp (F)	Precip as Snow (in)	King's Site Index (ft at 50 yr)
Two-year	<46.4	>1,164				>60.1		<138
Four-year	<46.4	>1,309		<39.3	<48.1		>3.2	<139
Six-year		>1,277	>17	<39.3				<138
Average	<46.4	>1,250	>17	<39.3	<48.1	>60.1	>3.2	<138

Projecting Response Models Across the Region

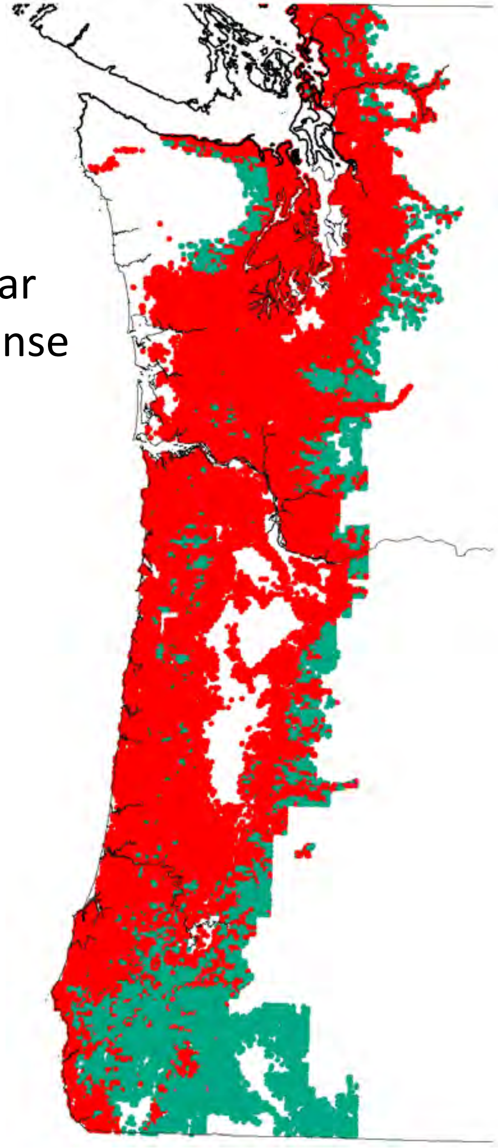
Two-year Response



Four-year Response



Six-year Response



What has the Type V Study accomplished?

- 3 spin-off studies
  - Deep soil nutrients
  - N15 study
  - Harvest residue removal
- 10 journal articles

- Next Steps
  - Analyze all six-year data
  - Publish 2-6 year response using LDA

Questions?

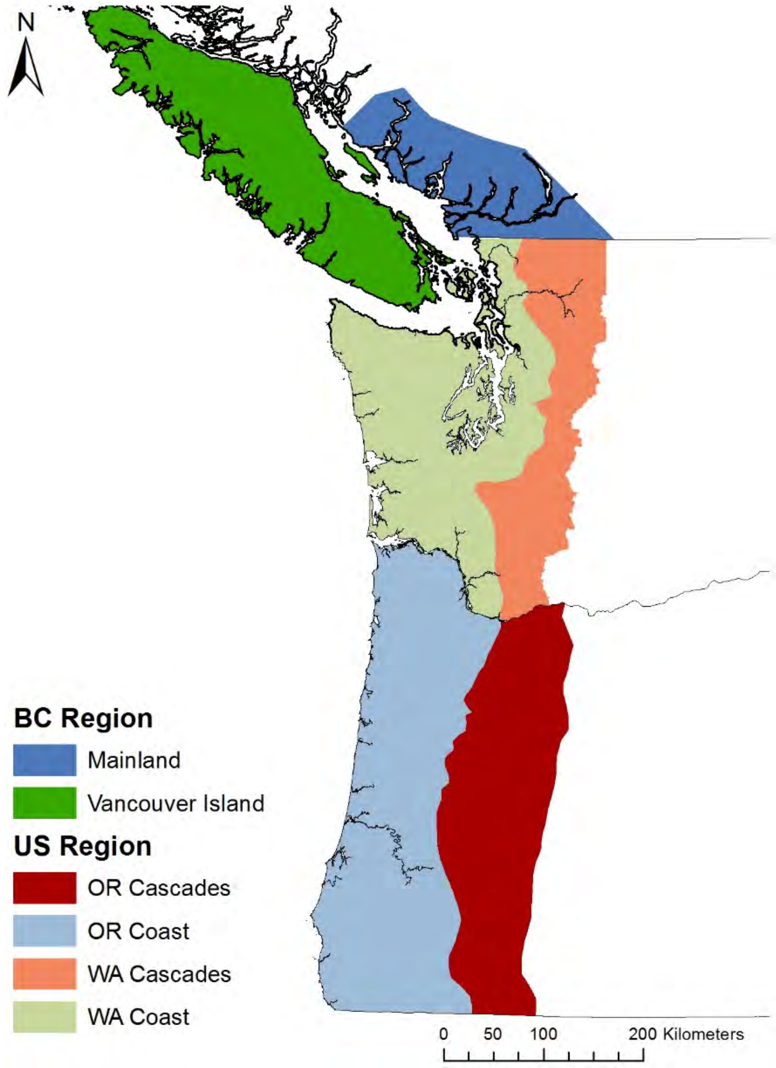
UNIVERSITY of WASHINGTON

Type VI Updates

Kim Littke, Mason Patterson, Eric Turnblom, and Jason Cross

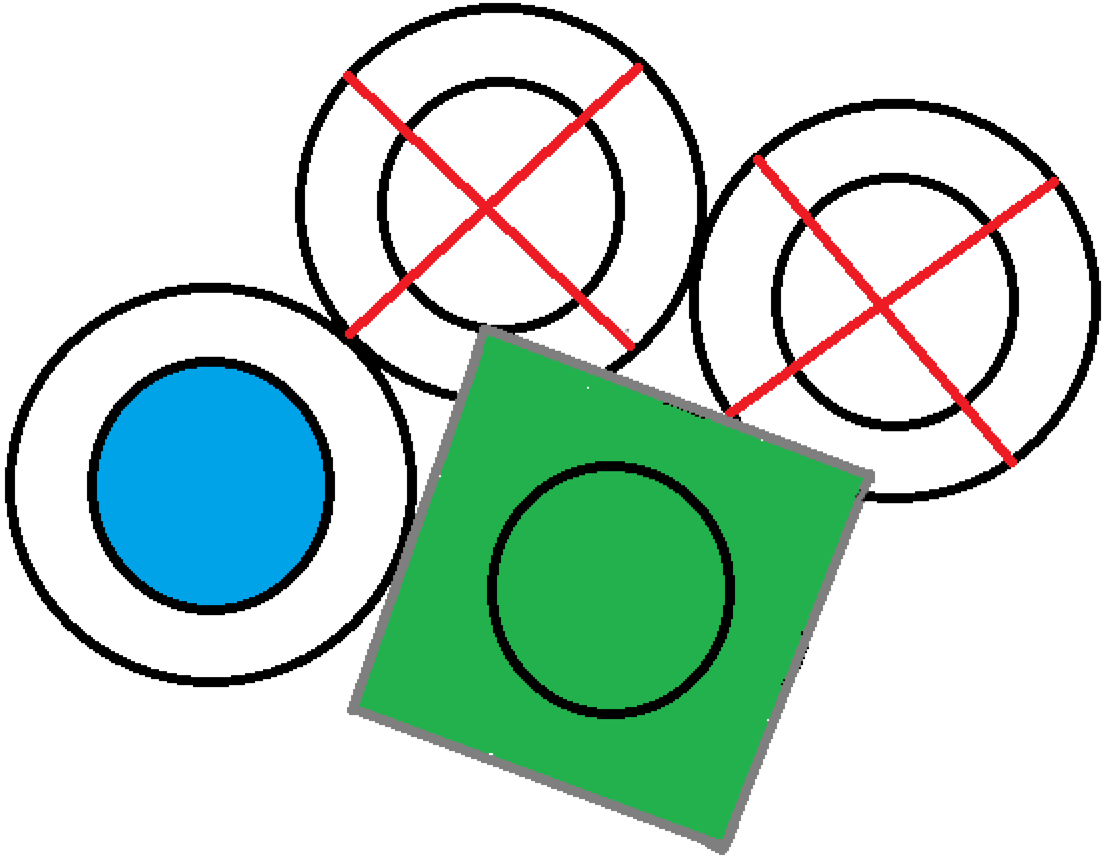
Stand Criteria

- Late-rotation managed Douglas-fir stands in Oregon, Washington, and BC
  - o Four regions in the US and two regions in BC
- Primarily Douglas-fir: 75% of the basal area in Douglas-fir
- Approximately 30 and 50 years total age from planting
  - o ~25-45+ years breast height age
  - o 8-10 years before final harvest
- Stands should not have been fertilized in the past 6 years
- No restriction on past thinning (PCT or CT)
- Uniform area of 15+ acres



Plot Installation

- Stands to become Type VI installations will be chosen at random from all qualifying stands
  - Within 3.38 miles of random Lat/Long coordinates
- Paired fixed-area, circular plots, chosen from four (or five) temporary plots
- Size of plot is dependent on density.
  - For densities ranging from 150-250 TPA - 0.45 ac (0.18 ha)
  - For 251-350 TPA - 0.31 ac (0.126 ha)
  - For greater TPA - 0.20 ac (0.081 ha) plots



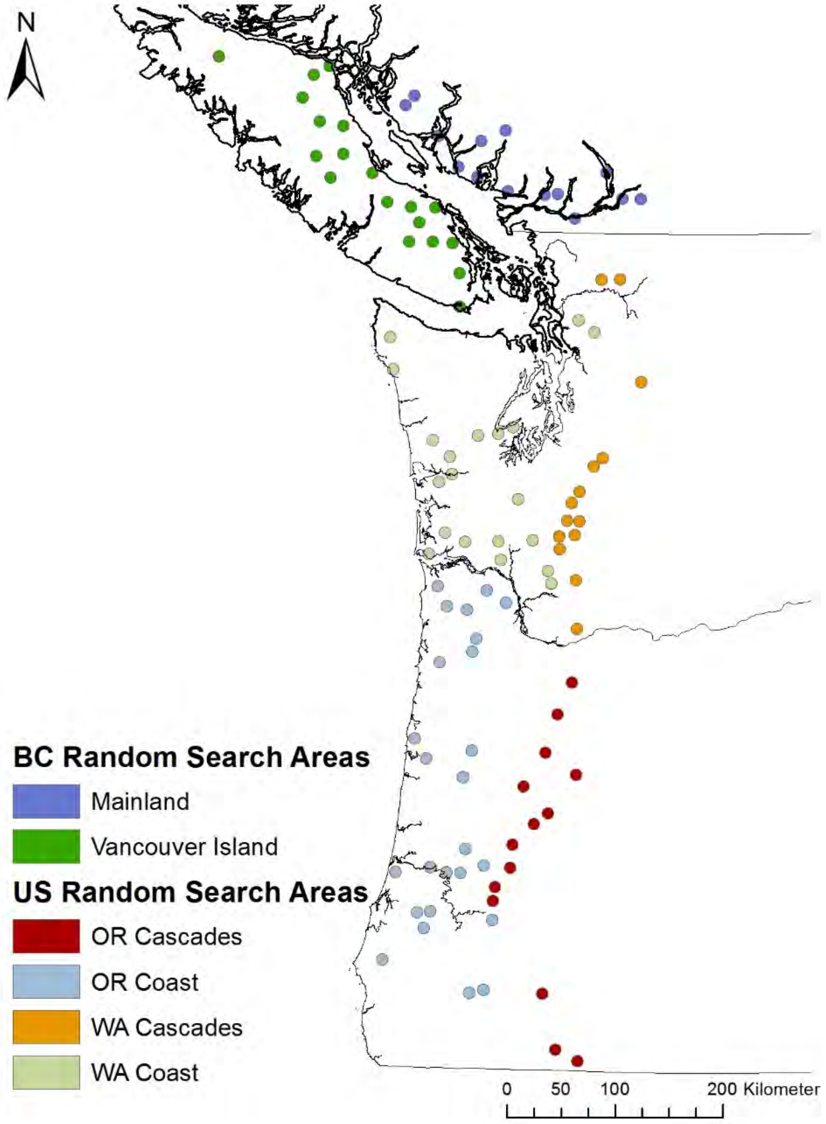
Current Status

US

- Sent out 73 search areas to search for potential stands
- 13/20 cooperators submitted stands
- 59 areas with potential stands
- 14 intersect RFNRP, SMC or Type V installations

BC

- Sent out 33 search areas
- Still searching for potential stands
- 2 intersect Type V installations



Cooperator Areas by Region

Cooperators	Stands	WA Coast	WA Cascades	OR Coast	OR Cascades
American Forest Management	1		1		
Campbell	29	3		2	
Greenwood Resources	1			1	
Green Crow	1	1			
Hancock	85	2	2	3	
Lone Rock	28			7	
Olympic Resource Management	5				
Port Blakely	54	3	4		
Rayonier	11	1			
Roseburg	110			5	1
Stimson	15	3			
Weyerhaeuser	396	11	7	10	10

Proposal for Selecting Areas and Stands

1) Randomly choose a search area for each cooperator
2) Randomly rank that cooperator's stands within that area for inspection
3) Once every cooperator is represented, rank other areas randomly to fill out the 6-9 areas allocated by region
4) Randomly rank stands for inspection within each chosen search area

Example of selection technique showing the randomly chosen stands for inspection per region by area

Region	American	Campbell	Green Crow	Green Diamond	GWR	Hancock	Lone Rock	ORM	Port Blakely	Rayonier	Roseburg	Stimson	Weyerhaeuser
WA Coast		1	1	2		1		1	1	1			2
WA Cascades	1					2			2				1
OR Coast					1	1	1				1	2	3
OR Cascades											1		5

Timeline

Spring 2016	Weyerhaeuser installed two test installations
Fall 2016-Spring 2017	Locate 30 installations
Summer 2017	Establish all installations/Pair plots
Fall 2017	Measure plots
Spring 2018	Fertilize plots
Fall 2019	2-year measurement and interim report
Fall 2021	4-year measurement and interim report
Fall 2023	6-year measurement and interim report
Fall 2025	8-year measurement and final report

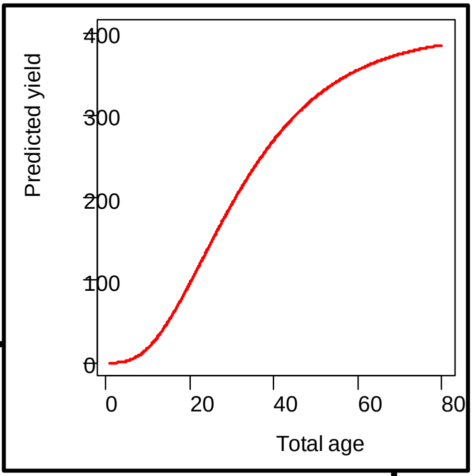
(SMC)^2

Silviculture manipulation consequences in stand management cooperative installations

Maureen C. Kennedy
Eric Turnblom
Jason Cross

SMC Fall Meeting
September 22, 2016

Performance report: Analysis goals



- Predict yield using Chapman-Richards
  - BA, QMD, [TPA], CVT, CV4, CV6, BF4, BF6
- Test differences in yield curves with site characteristics
  - Initial TPA, SI30, species (DF, WH, or Mixed), elevation, latitude, longitude
- Estimate models separately for Type III and for Type I/II combined

Divide into geographic zones

Zone 1: Vancouver Island and Strait of Juan de Fuca

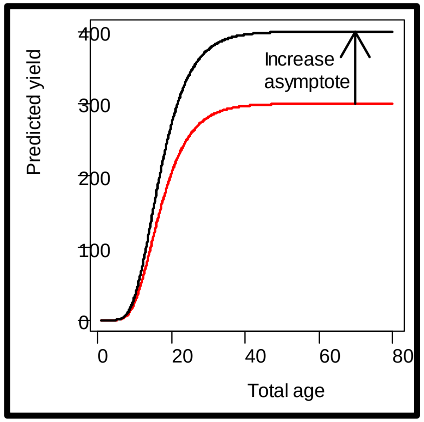
Zone 2: Mainland SW BC, Whatcom and Skagit Counties

Zone 3: "Puget Trough"
E Jefferson, Kitsap, Snohomish, King, Thurston, Pierce, Lewis and E Clallam Counties

Zone 4: "Inland"
Cowlitz, Skamania, Clark Counties, Clackamas, Linn, Marion, E Lane, E Douglas, Jackson counties

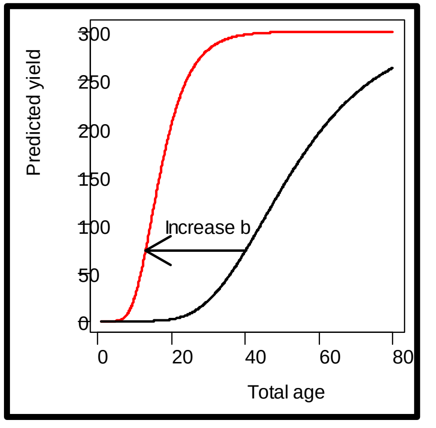
Zone 5: "Coastal"
W Clallam, W Jefferson, Grays Harbor, Pacific, Wahkiakum, Clatsop, Tillamook, Yamhill, Polk, Lincoln, Benton, Columbia, W Lane, W Douglas, Coos, Curry, Josephine

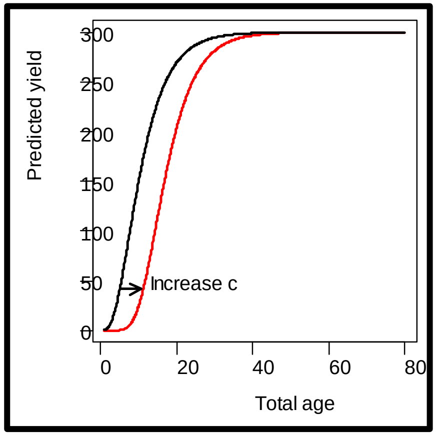
Variables chosen to test a priori



Asymptote (a) ~ (SI30,species,elevation,zone)

Rate parameter (b) ~ (SI30,species,elevation,zone,ISPA,ISPA^2)





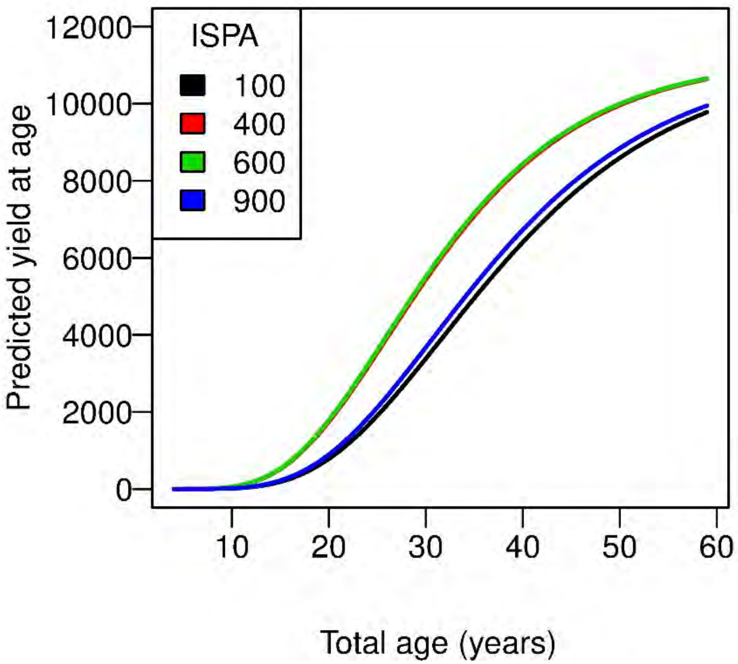
Shape parameter (c) ~ (species)

Bootstrap to eliminate non-significant predictors

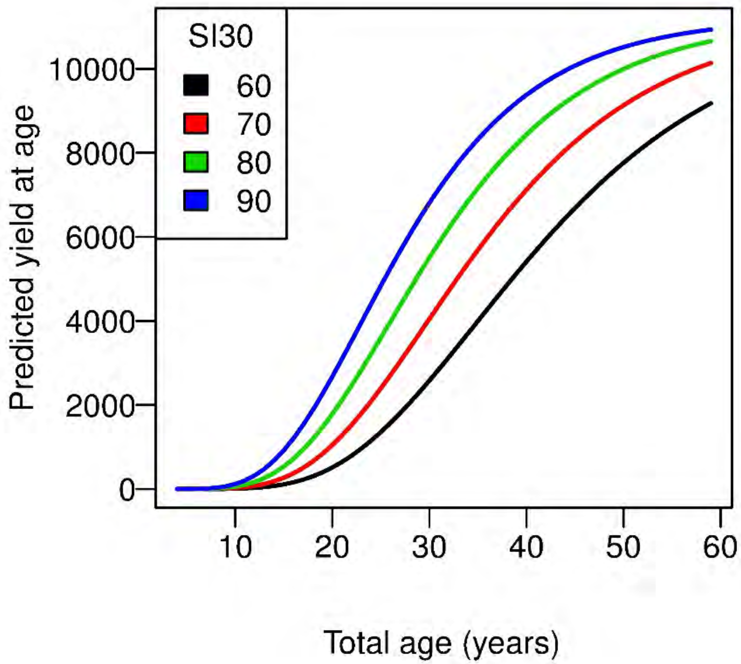
Douglas-fir, Site Index (30) = 80
Elevation = 1000, zone = Puget Trough

Example final model: cubic foot volume (top) (r^2=0.93)

Varying initial stems per acre



Varying site index

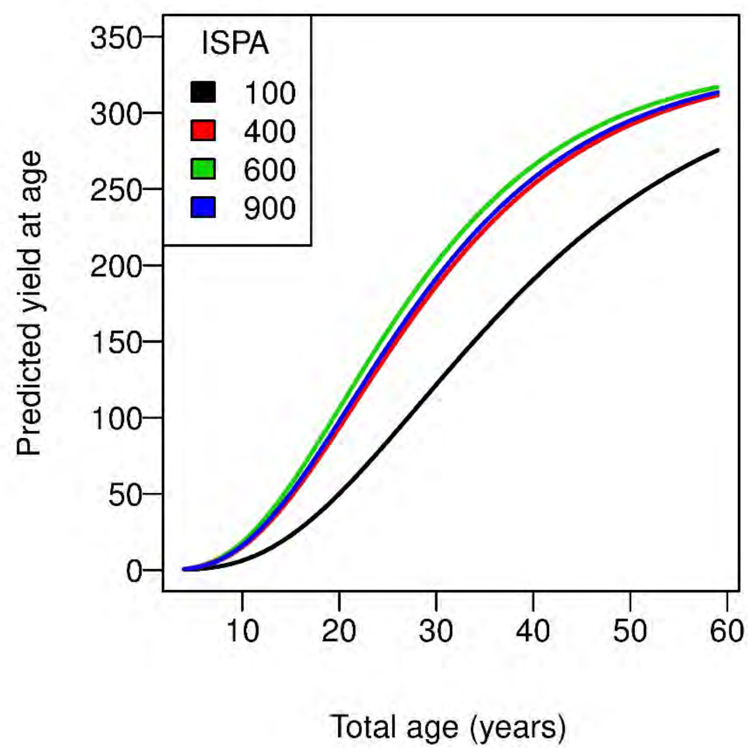


BA and QMD fitted simultaneously with TPA

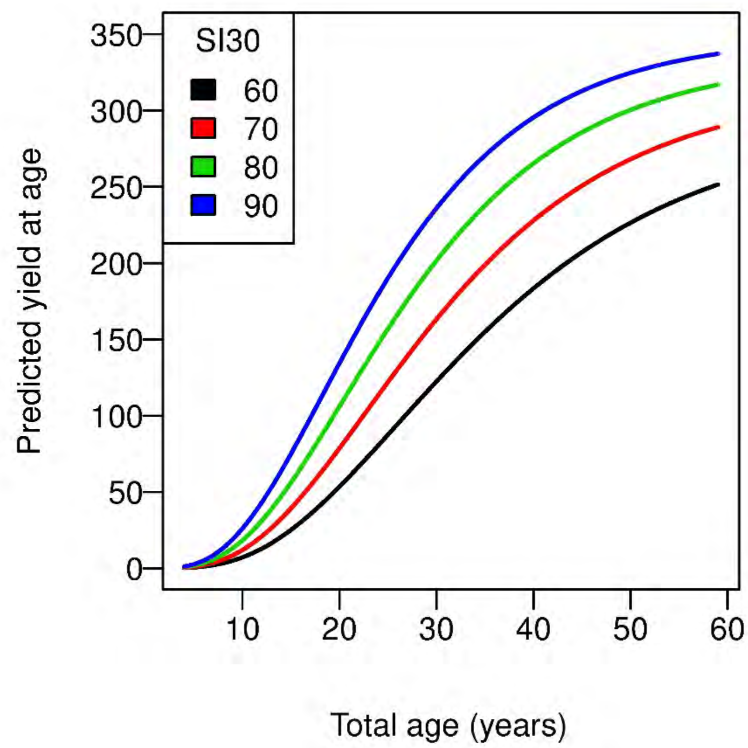
- Solved issue in estimating asymptotic yield
  - Fit asymptotic yield to SI30, separately for BA and QMD, using McArdle & Meyer yield tables
- Reverse-weighted TPA with age (issues in ingrowth with Type I/II installations)
- Ensured that weights for each of the three variables standardized to equal weighting
- Fits of the full model completed, currently running bootstrap model reductions

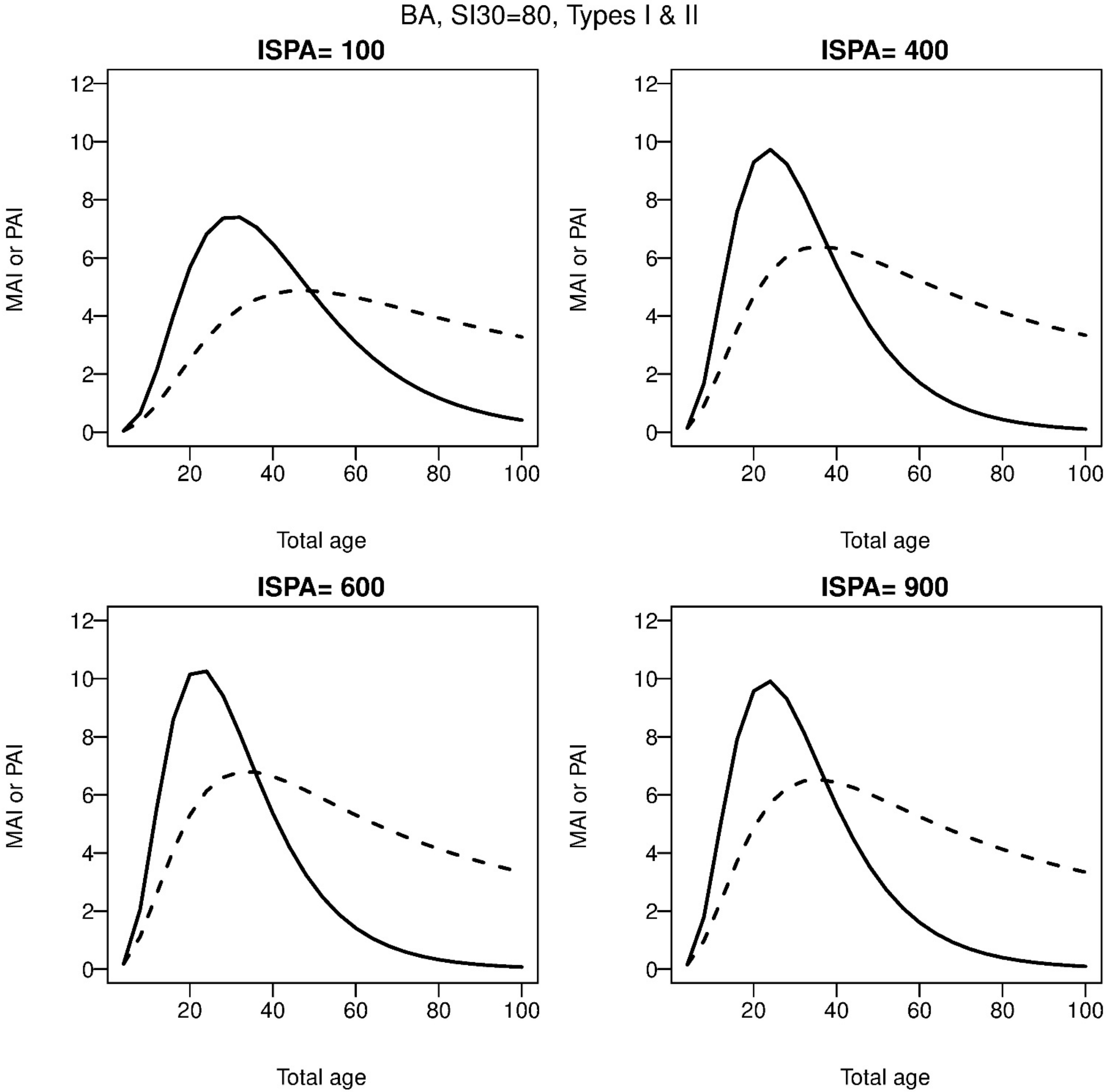
BA predicted yields (unreduced) Type I/II installations (r^2=0.89)

Varying initial stems per acre



Varying site index

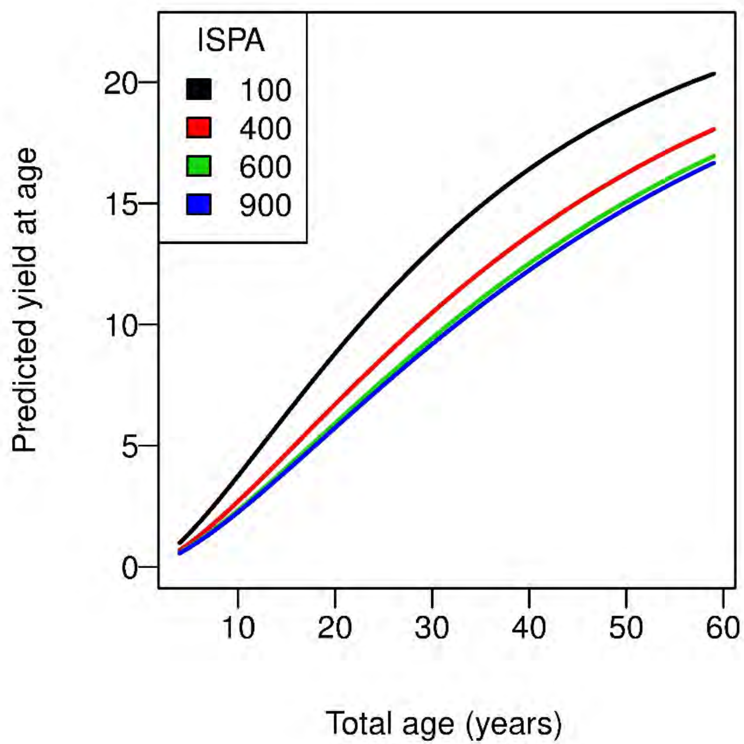




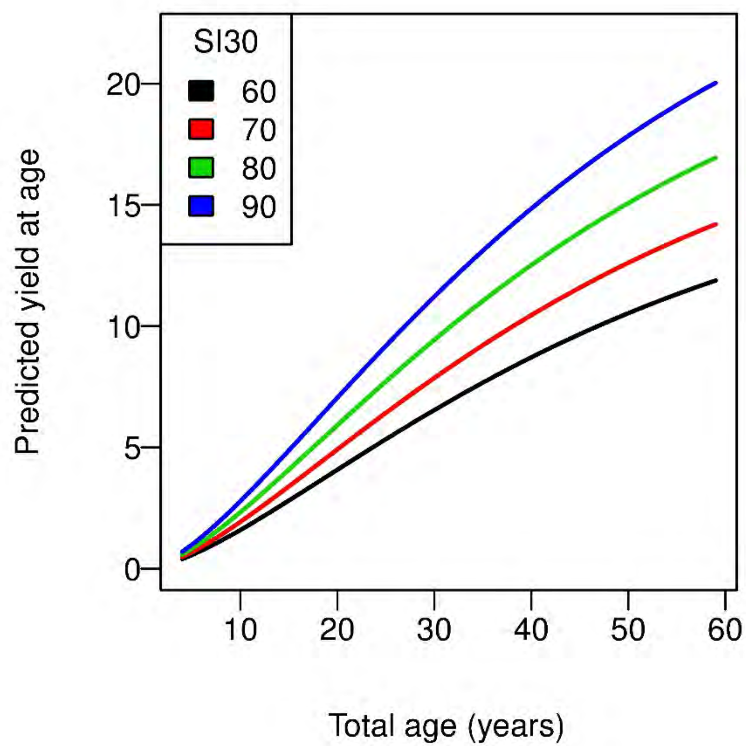
BA, SI30=80, Types I & II
ISPA= 100
ISPA= 400
ISPA= 600
ISPA= 900
MAI or PAI
Total age
0
2
4
6
8
10
12
20
40
60
80
100

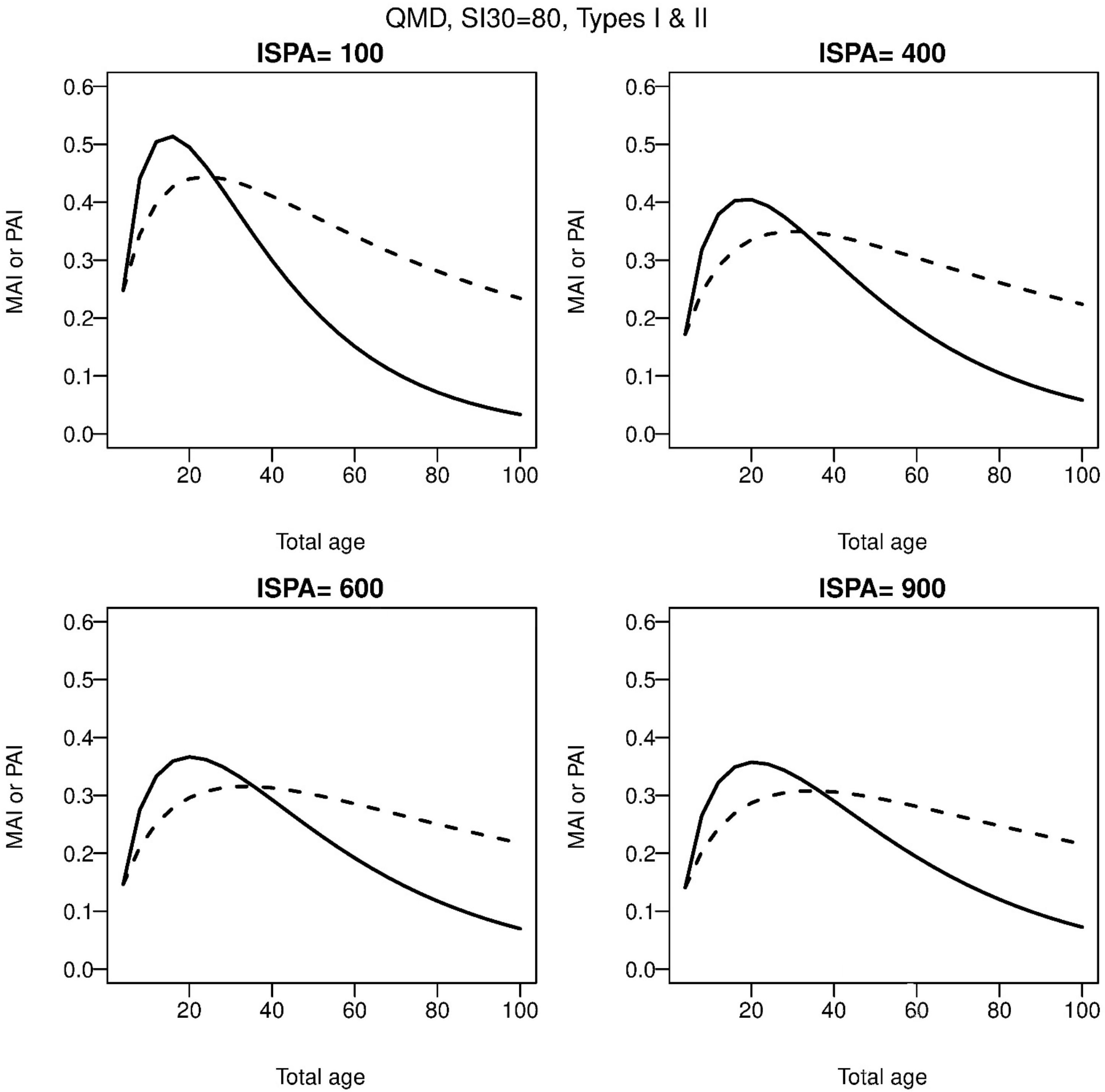
QMD predicted yields (unreduced) Type I/II installations (r^2=0.88)

Varying initial stems per acre



Varying site index



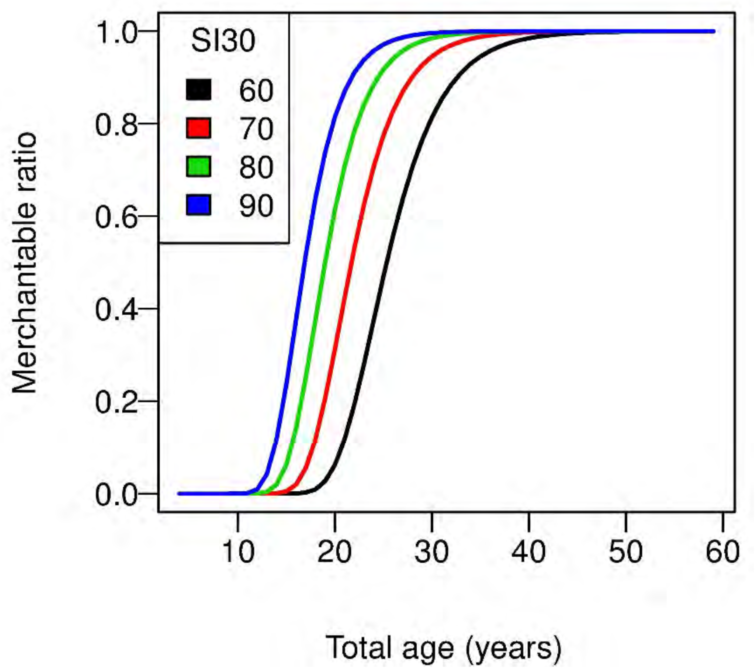

QMD, SI30=80, Types I & II
ISPA= 100
ISPA= 400
ISPA= 600
ISPA= 900
MAI or PAI
Total age
0.0
0.1
0.2
0.3
0.4
0.5
0.6
20
40
60
80
100

Fitting crop yield

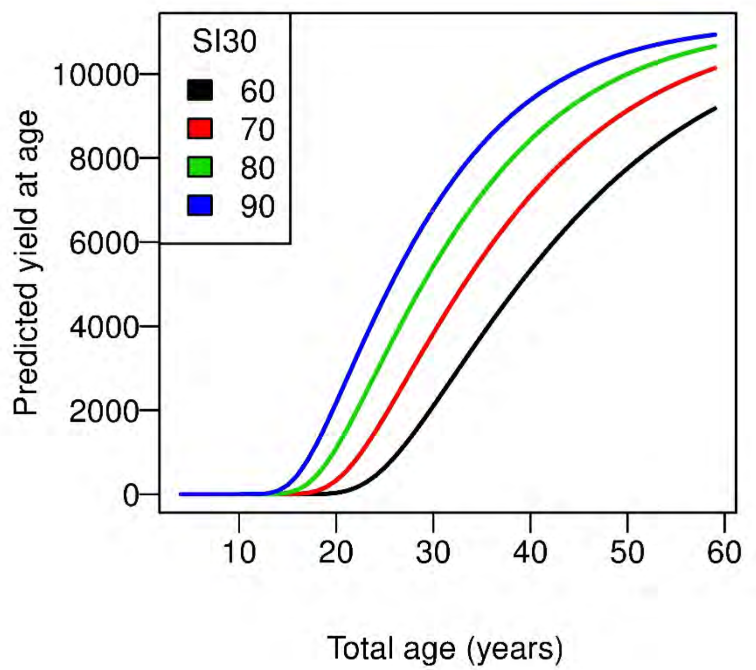
- Crop yields for cubic foot volume and board foot yields
- Model merchantable ratio of crop trees relative to total yield variable
  - A ratio between 0 and 1.
  - e.g., CVTcrop/CVT
- Use same modeling framework as for total yield, but fix asymptote at 1
- Apply predicted merchantable ratios to predicted total yield
- First fits give R^2 for crop variables commensurate with those for total yield.

Example crop yield: Cubic foot volume (4 in top); (r^2=0.93)

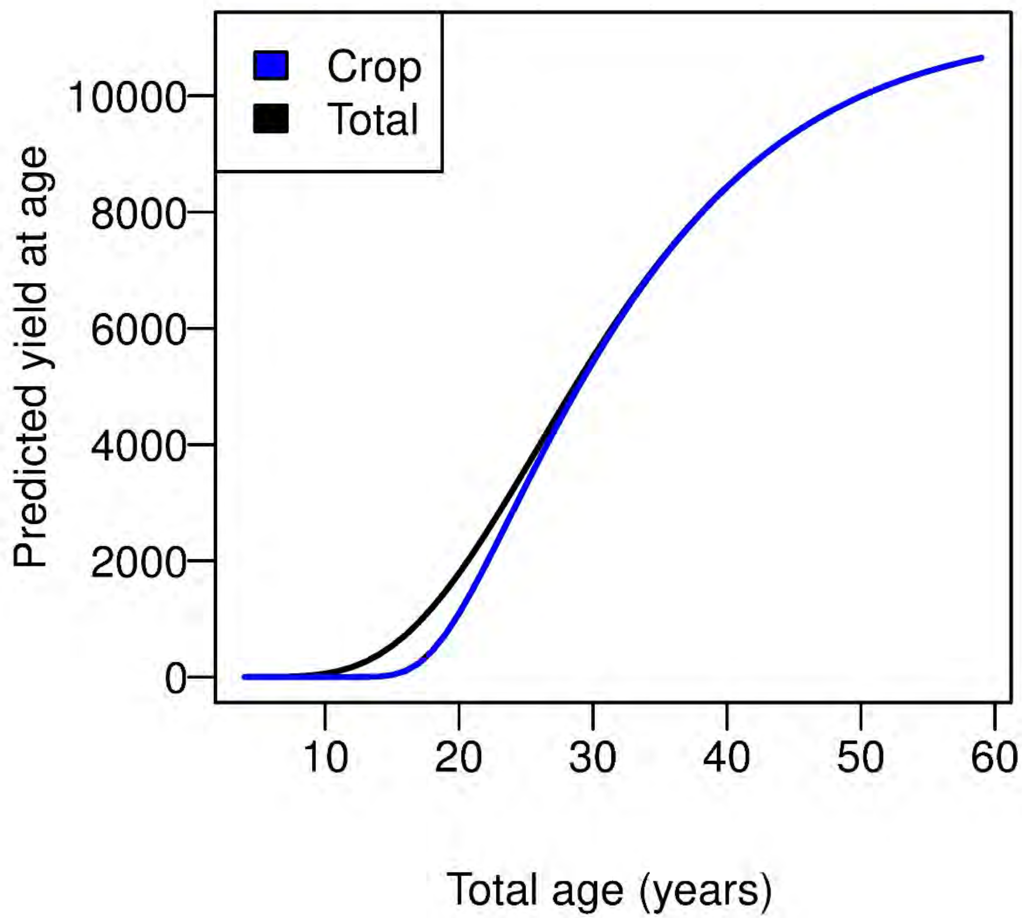
Merchantable ratio with SI30



CV4 crop trees (mr*CV4)



Compare total yield to crop yield: Cubic foot volume (4 in top)



Conclusions & Next Steps

- We recommend limiting predictions to within observed age ranges (<60 years Type I/II, < 30 years Type III's)
- BA and QMD models are now included
- Finalizing coding of Plantation Yield Calculator: how to let users select among options in an intuitive manner without being overloaded.
- Next challenge—add the effect of treatments:
  - PCT stands
  - Fertilization
  - RD thinnings

PCT Analysis

Eric C. Turnblom

Spring Policy Meeting 19 April 2016

PCT Analysis

- Rationale
- Objectives
- Experimental Plan
- Results
- Final Steps

Rationale

- SMC members seek to maximize timber volume & value, but also place some degree of priority on less conventional stand attributes such as:
  - Live Crown Length
  - Branch / Knot Size
  - Other habitat values
- The impacts of timing / intensity of PCT on these attributes are not well understood / publicized

Experimental Plan

- Objective 1: Describe Stand yield
  - QMD, BA, TPA, CVT, CV4 & BF4, CV6 & BF6
  - Late-rotation & At-rotation
- Objective 2: Provide stand / stock tables (stand structure) expected under different PCT regimes
  - Implementing Treelist Generation Database (TGDB)
    - Inputs are:
      - Thinned flag & thinning specs (percent of stems removed, pre-thin TPA and BA, years since thinning and number of thinnings
      - Stand origin (planted/natural), Stand type (spp mix), SI50, Total age, QMD, TPA, Thinning specs if thinned (including during

Experimental Plan

- Use existing SMC data –
  - Type I data
    - Two levels of spacing (ISPA/2, /4)
    - Two types of spacing (systematic, select best trees)
    - Applied at different ages
    - Twenty-nine (29) Type I installations were available for analysis, 12 contained auxiliary "Best Tree Selection" (BST) plots
    - ISPA ranged from 250 to 700; age at PCT from 5 to 17 yr; 30-yr SI ranged from 40 to 90 ft

Experimental Plan

- Use existing SMC data –
  - Type III data
    - PCT is combination of two factors
      - Timing: early / late
      - Intensity: light / heavy

Expected Deliverables

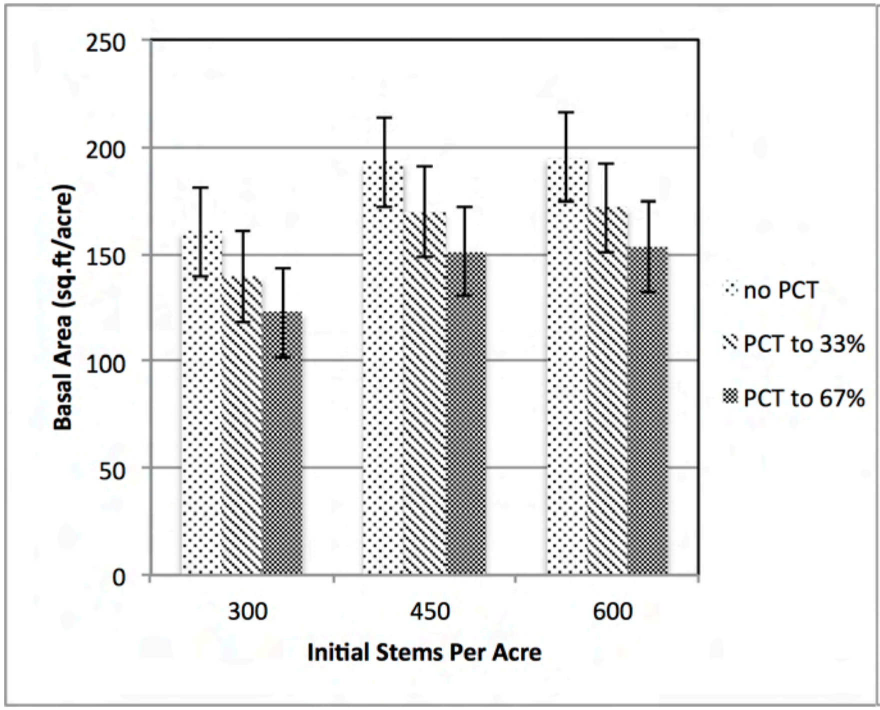
- Models describing yields in stands with & w/o PCT across sites, densities, timings in SMC Working Paper
- Mechanism to deliver tree lists corresponding to defined reporting ages and useful combinations of input variables

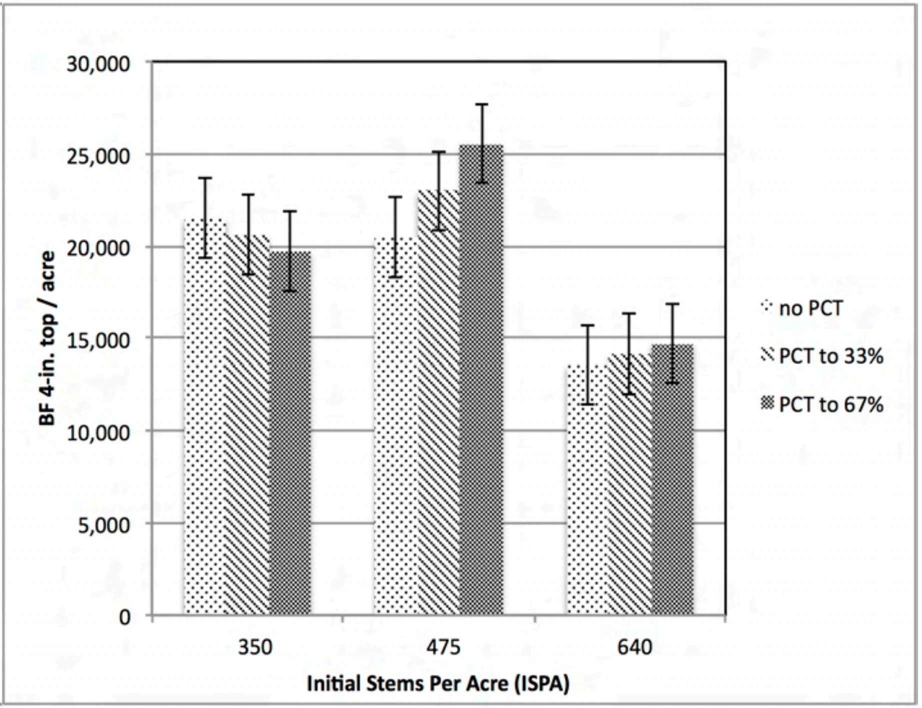
Results

- Yield Responses in Type I installations
- A multiple linear regression approach was used to analyze “late rotation” yield responses to PCT
  - Total stand ages greater than 30 yr from seed
  - Independent variables used:-
    - ISPA, percent stems removed (PRM), SI30, Elev, Tot. Age, Age at PCT, PCT type, Latitude, Longitude – their interactions
    - This made 163 observations available for analysis

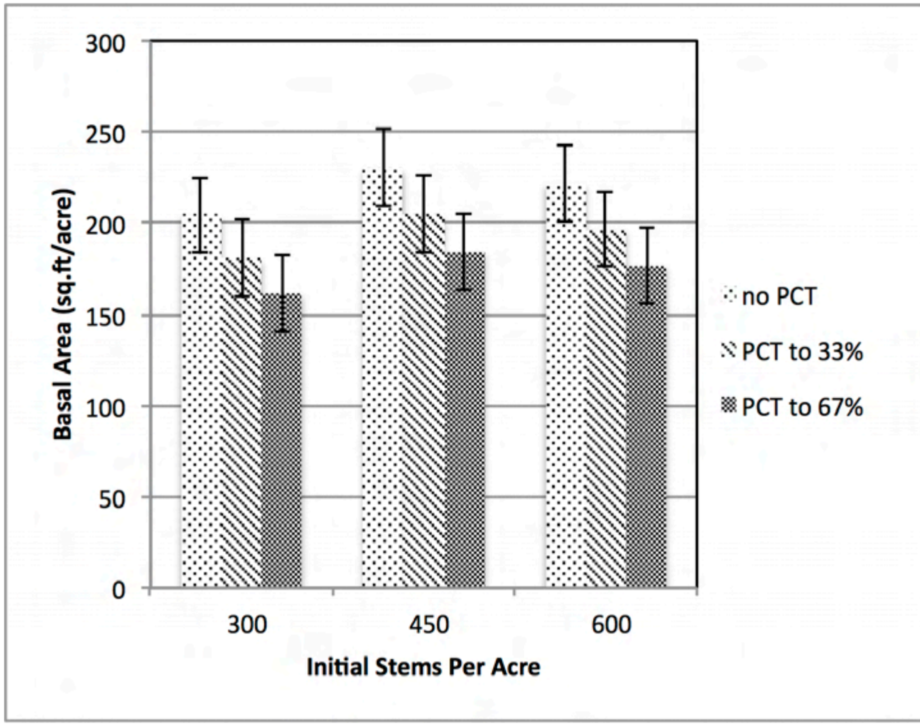
Stand Management Cooperative

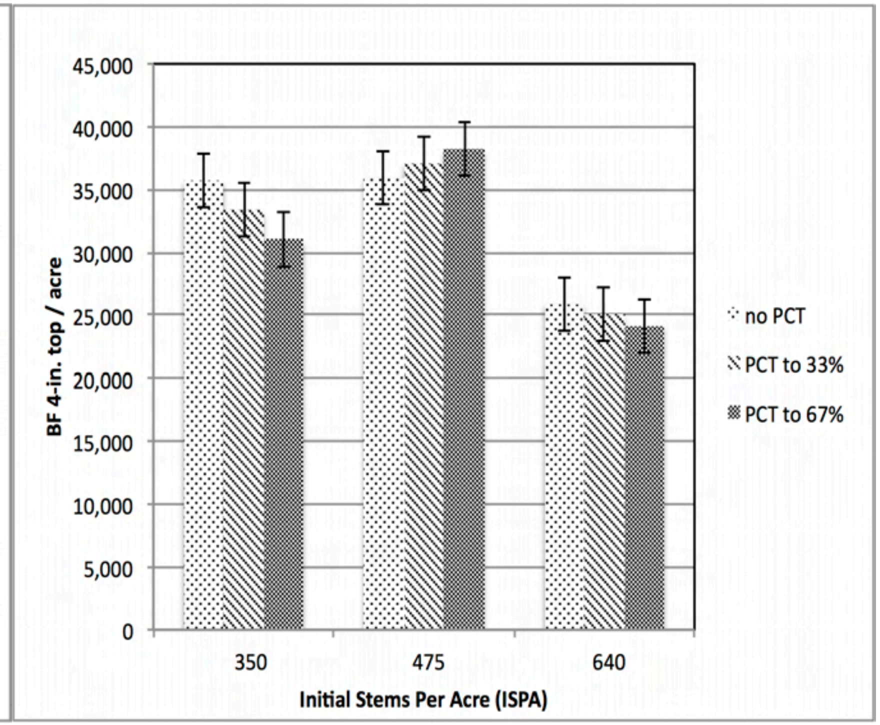
Age 35 Yields, SI30 = 70 by density by PCT intensity (age 10)





Age 35 Yields, SI30 = 70 by density by PCT intensity (age 10)





Stand Management Cooperative

Member Benefits

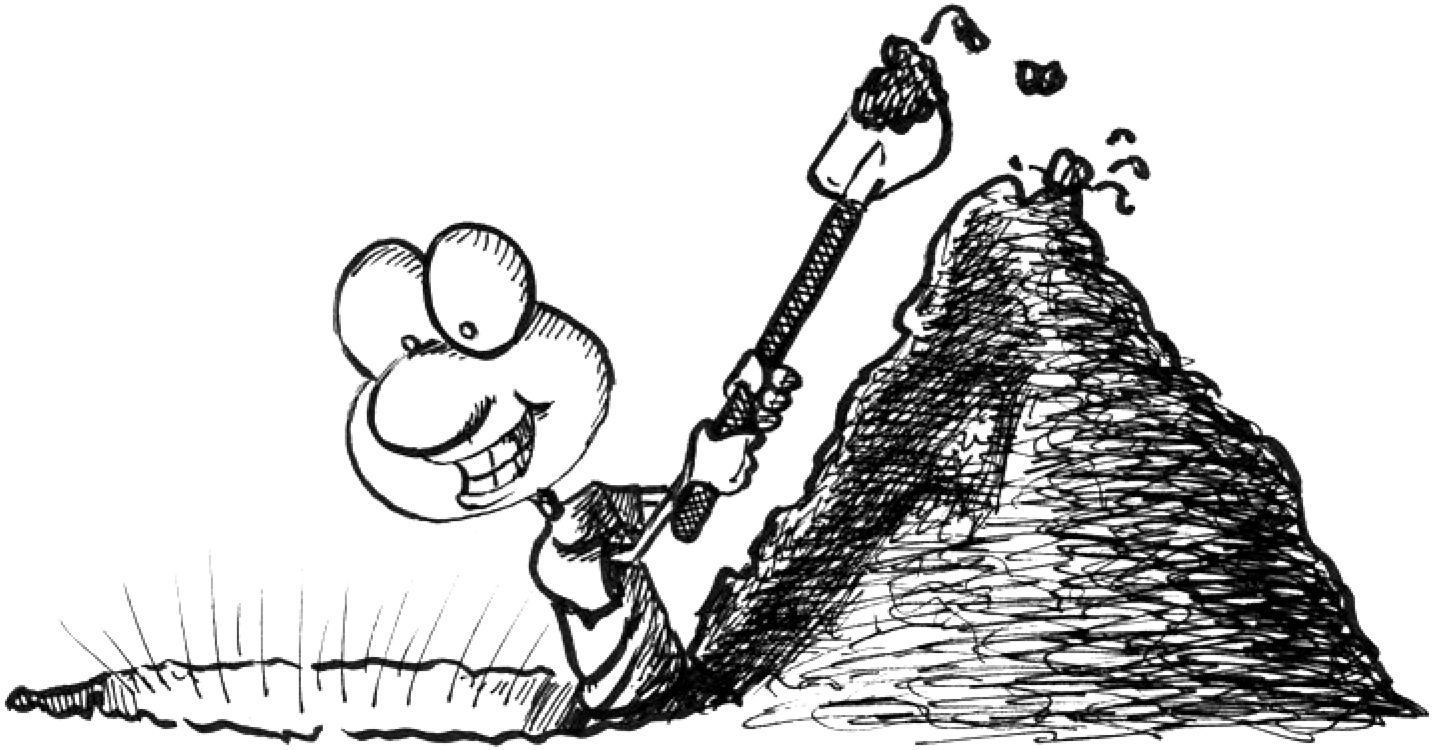
- Better understanding of how stands with given characteristics could be most profitably managed for the mix of materials that might be produced
- Resulting whole stand models will provide independent corroboration of growth modeling work

Final Steps

- Write up Type I ‘late-rotation yield results in first Working Paper
- Write up Type I ‘at-rotation’ yield results in second Working Paper
- Repeat for Type III installations
- Link to PYC

Effects of Nitrogen Fertilization and Thinning Treatments on Subsurface Soil Carbon and Nitrogen

Cole D. Gross, Jason N. James, Robert B. Harrison



Purpose

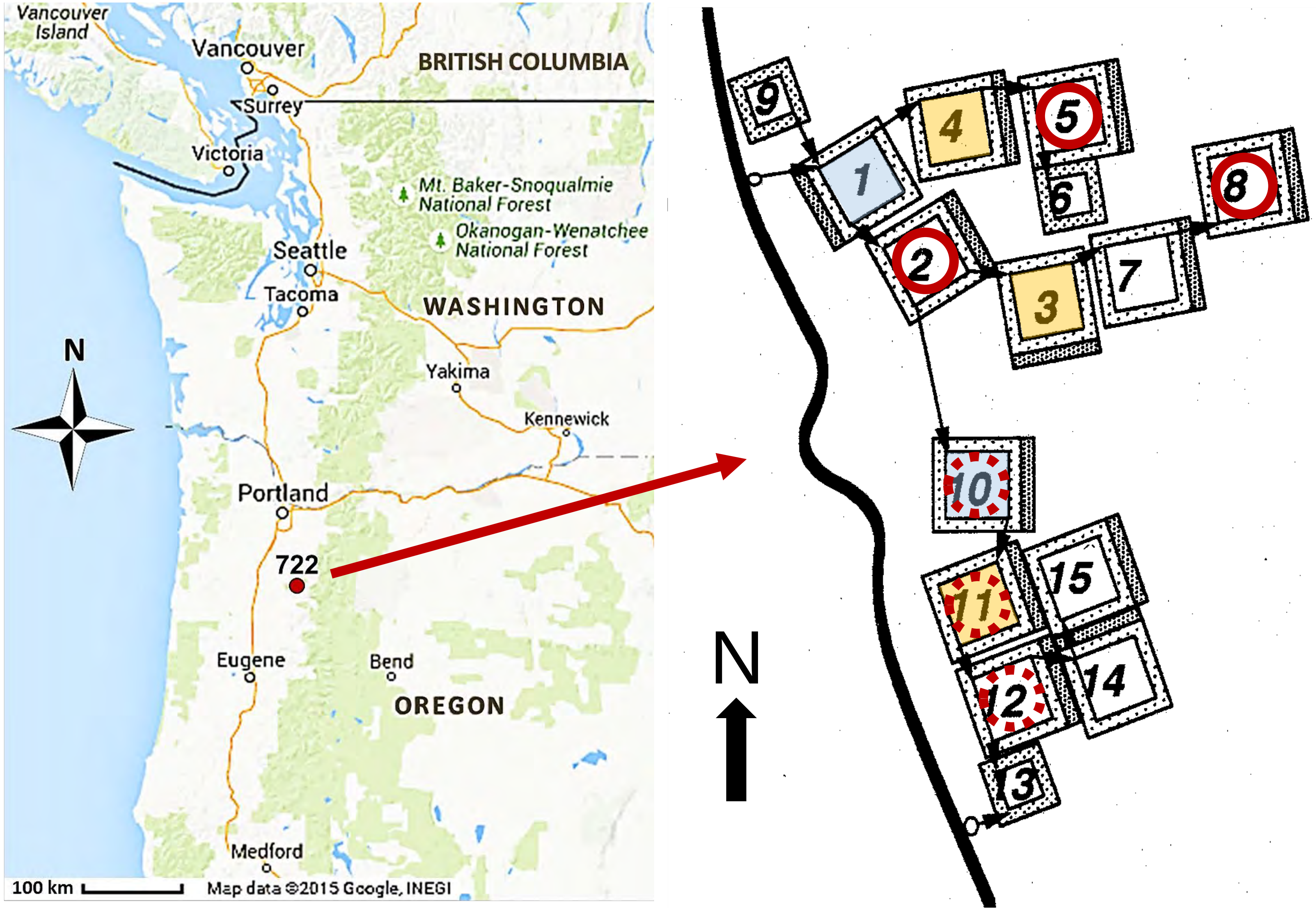
Provide data for regional responses of soil C and N by depth to fertilization and thinning treatments

Study Site & Methods

- Douglas-fir plantation
- Established in 1989
- Three random pits/plot
- Soil sampled by depth to 1.5 m
- Methods for soil bulk density:
  - Clod
  - Corer
  - Volumetric

Stand Management Coop *Inst.* 722 “Silver Creek Mainline”

Lat./Long. N 44.88, W 122.57



0.2-ha plots

9.3-m buffer strip

9.3-m additional buffer strip

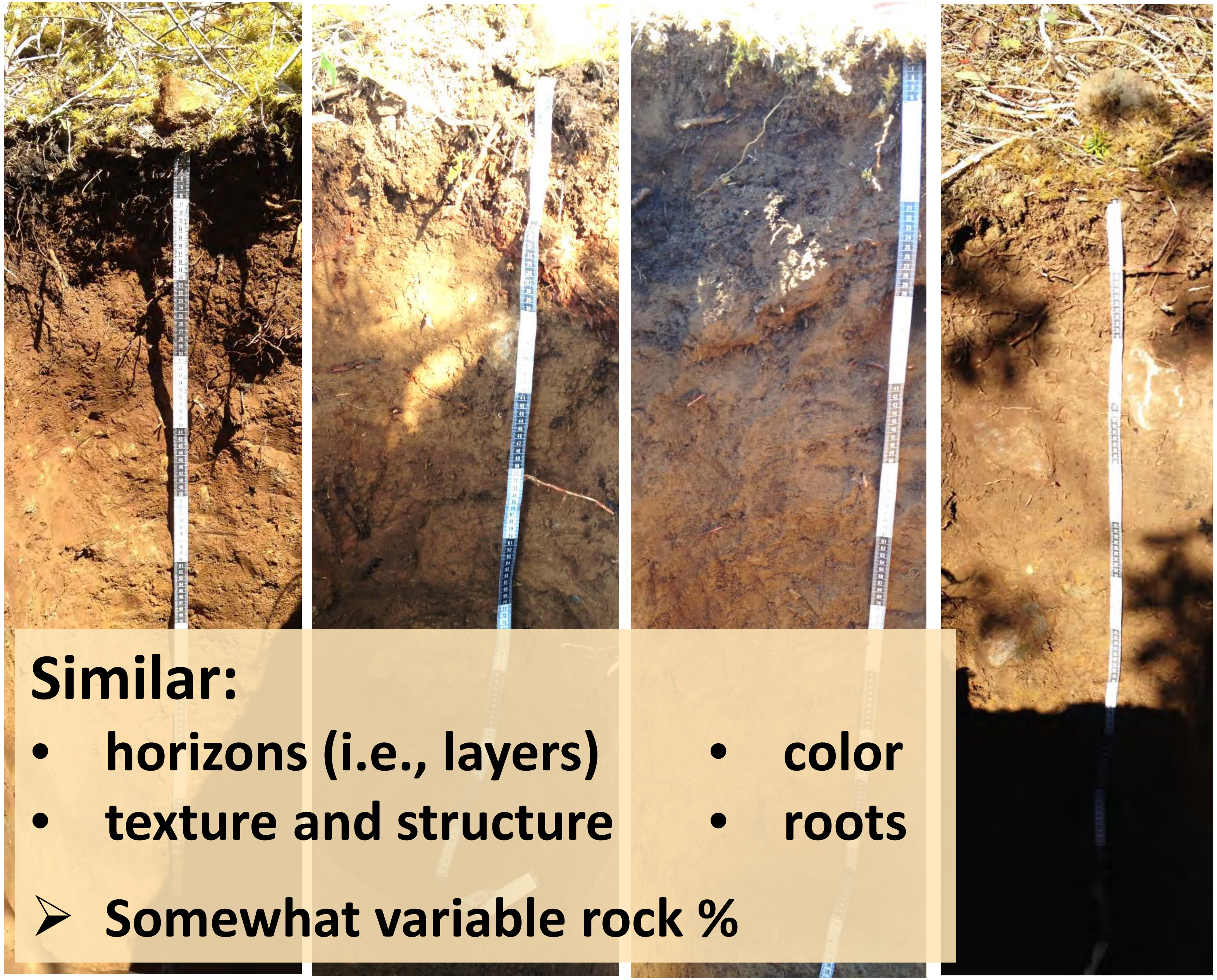
Control plots

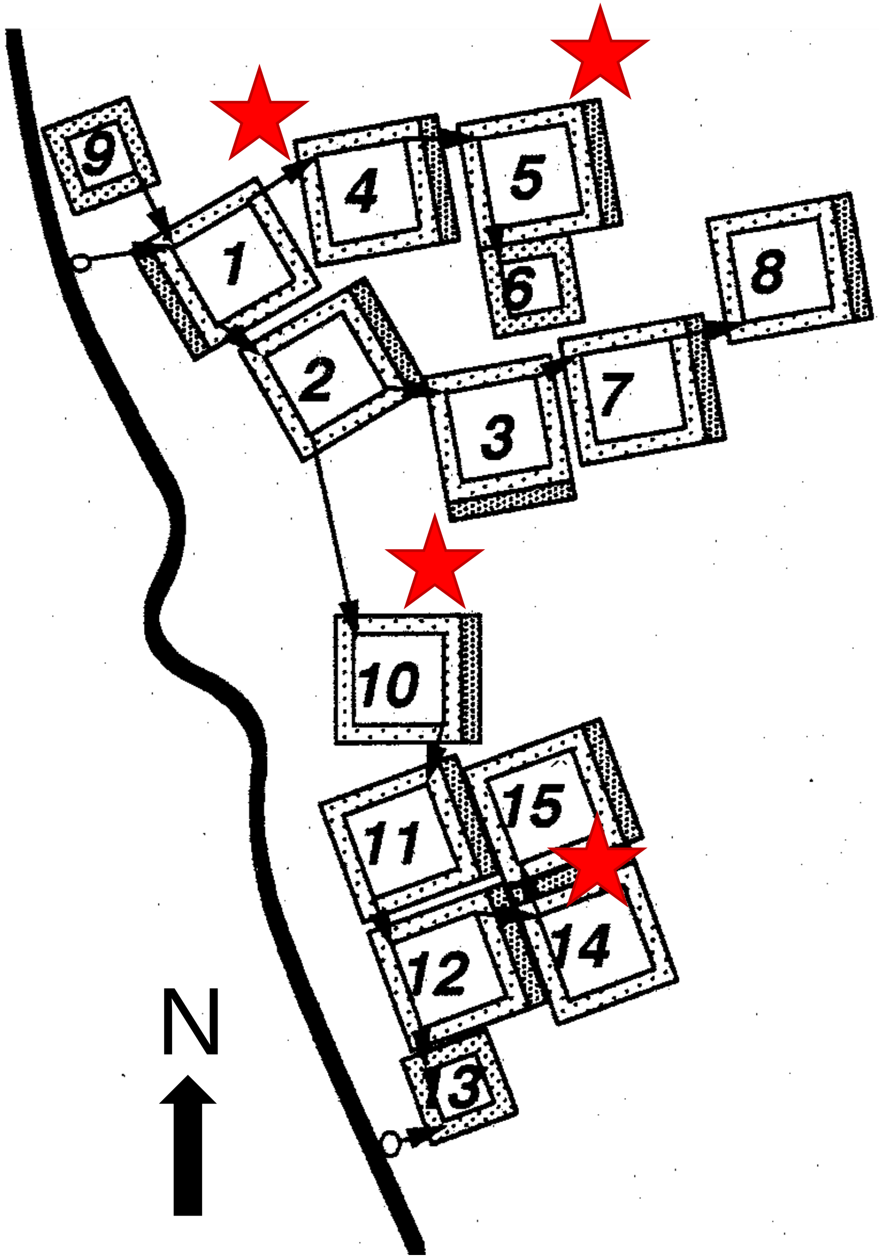
N fertilizer applied at rate of 224 kg N ha^{-1} as urea in 1989, 1993, 1997, 2001, and 2005

Repeated thinning

Minimal thinning

Assumption of Soil Uniformity at the Site Prior to Treatment





Similar:
- horizons (i.e., layers)
- texture and structure
- color
- roots

➢ Somewhat variable rock %

Climate
- Precipitation
- Temperature

Amount of **TIME** parent materials have been exposed to soil-forming processes.

Organisms
- i.e., biota
  - Vegetation
  - Microbes
  - Soil animals
  - Humans

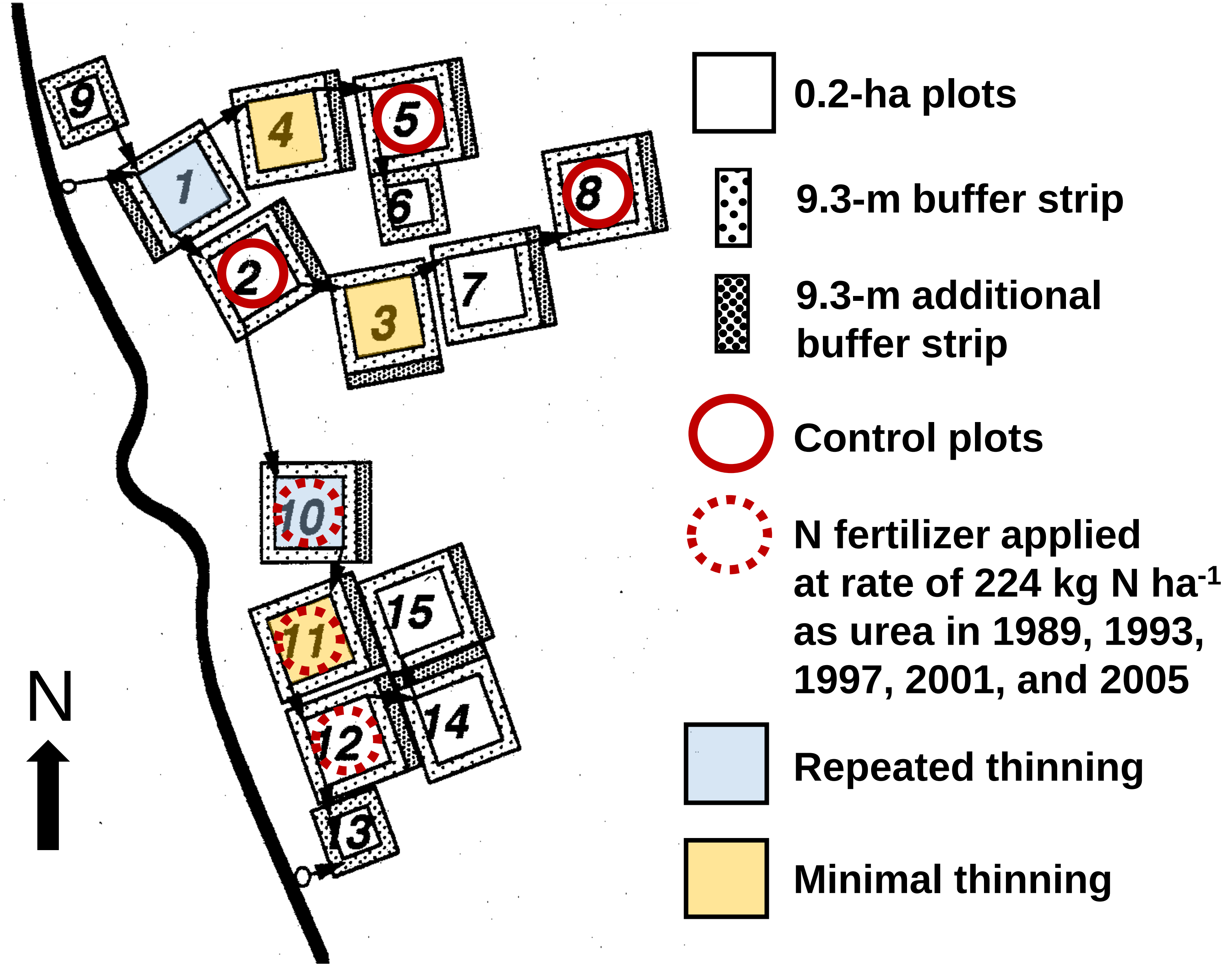
Variables in Addition to Plot Treatment?

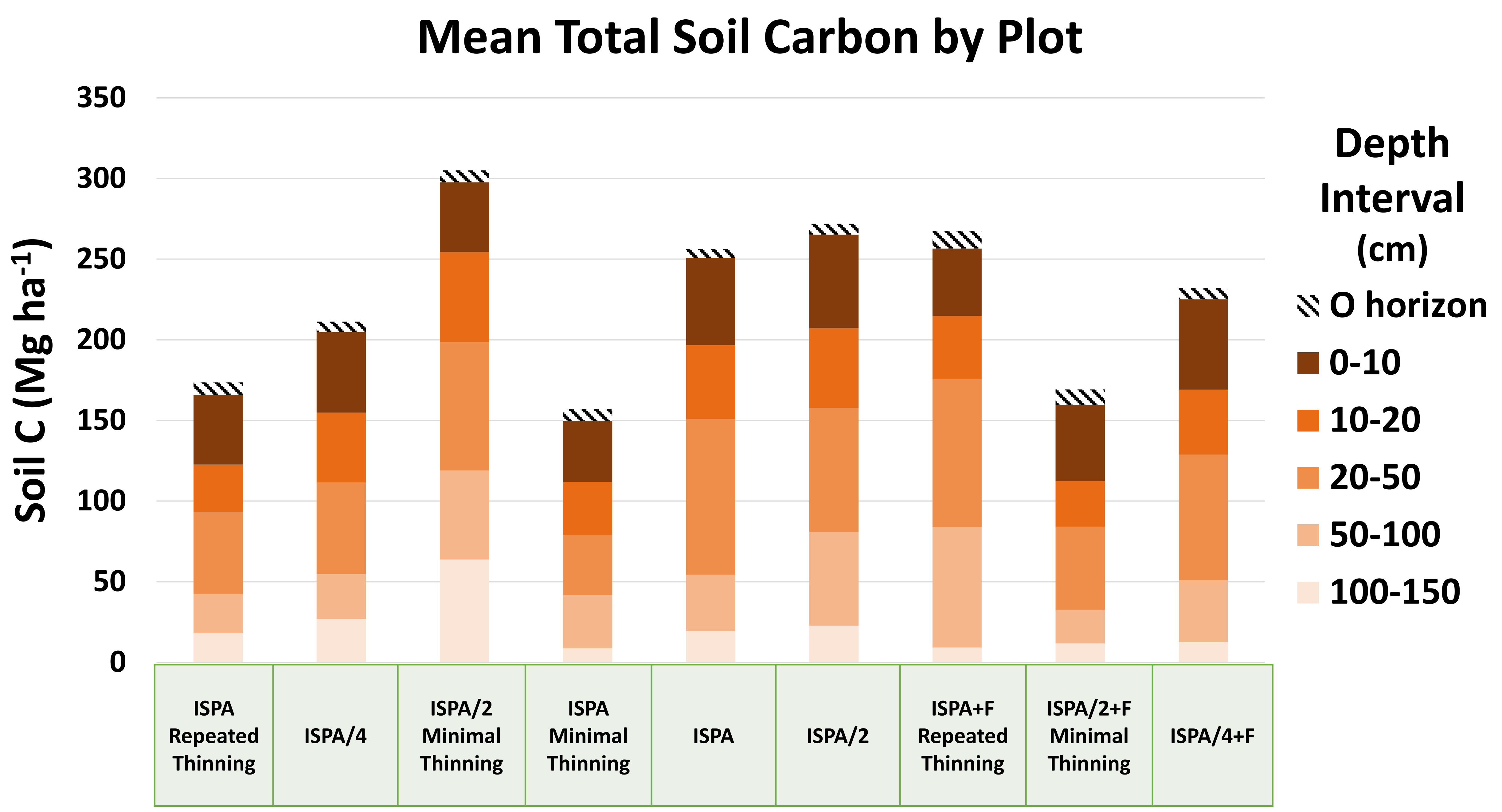
Parent Materials
- Geologic or organic precursors to soil

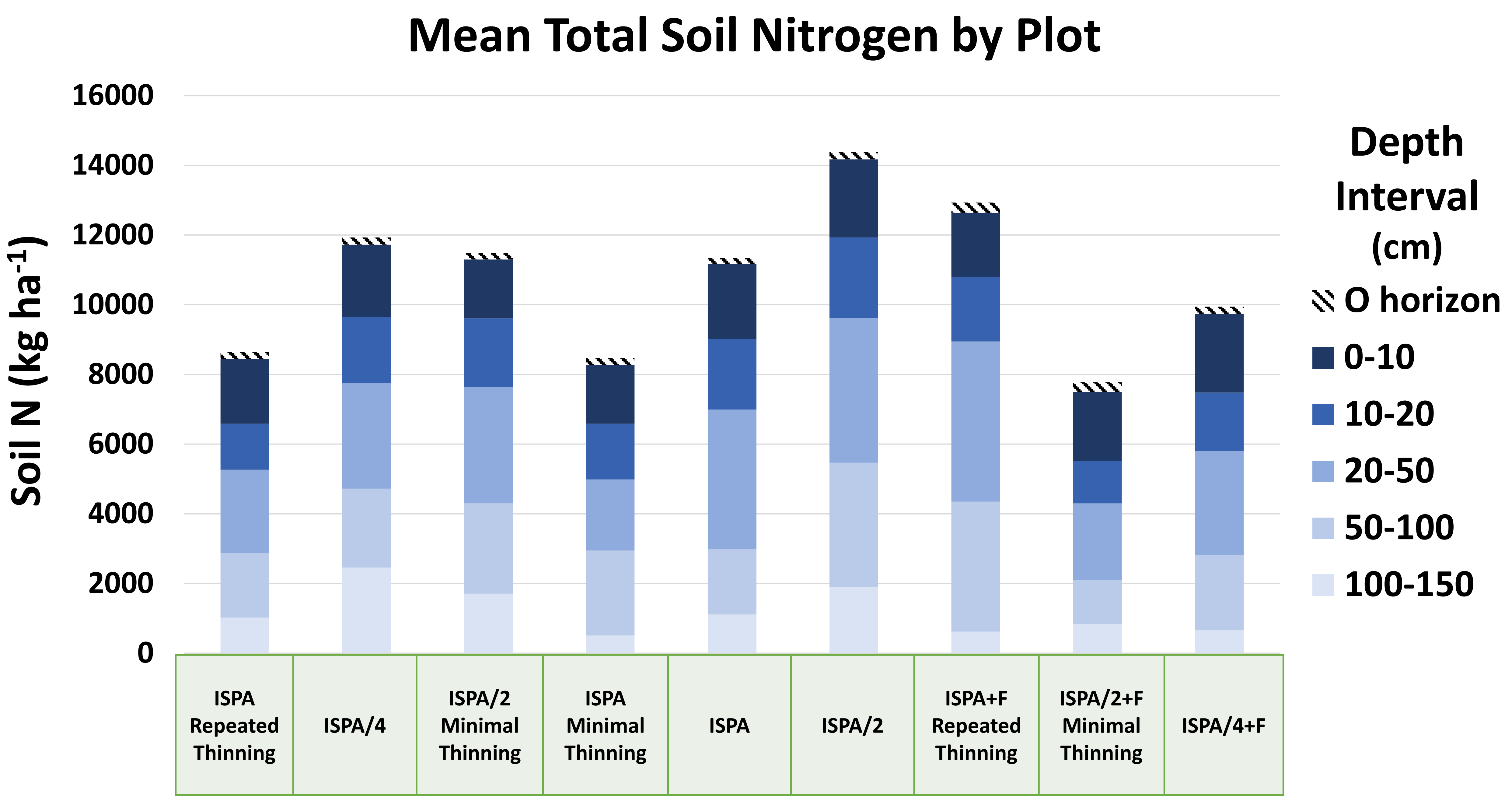
Relief
- i.e., topography
  - Slope
  - Aspect
  - Landscape position

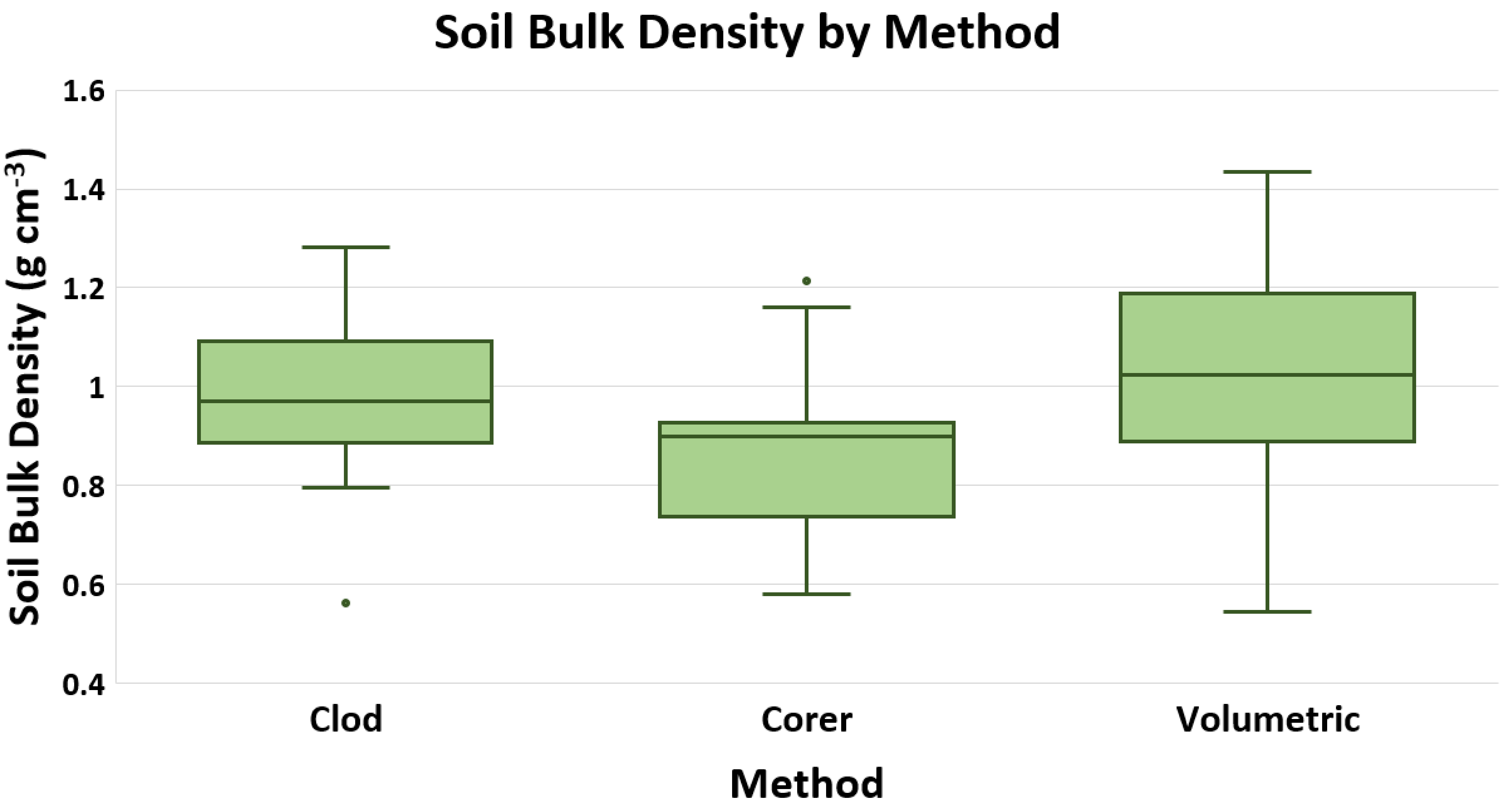
Variables in Addition to Plot Treatment?

PLOT	SLOPE (%)	ASPECT (°)
1	12	222
2	0	0
3	28	242
4	17	274
5	13	353
8	0	0
10	15	255
11	15	236
12	15	203




Mean Total Soil Carbon by Plot
Soil C (Mg ha-1)
350
300
250
200
150
100
50
0
ISPA Repeated Thinning
ISPA/4
ISPA/2 Minimal Thinning
ISPA Minimal Thinning
ISPA
ISPA/2
ISPA+F Repeated Thinning
ISPA/2+F Minimal Thinning
ISPA/4+F
Depth Interval (cm)
O horizon
0-10
10-20
20-50
50-100
100-150


Mean Total Soil Nitrogen by Plot
Soil N (kg ha-1)
16000
14000
12000
10000
8000
6000
4000
2000
0
Depth Interval (cm)
O horizon
0-10
10-20
20-50
50-100
100-150
ISPA Repeated Thinning
ISPA/4
ISPA/2 Minimal Thinning
ISPA Minimal Thinning
ISPA
ISPA/2
ISPA+F Repeated Thinning
ISPA/2+F Minimal Thinning
ISPA/4+F



Soil Bulk Density by Method
Soil Bulk Density (g cm-3)
1.6
1.4
1.2
1
0.8
0.6
0.4
Clod
Corer
Volumetric
Method

Results

Initial statistical analysis:

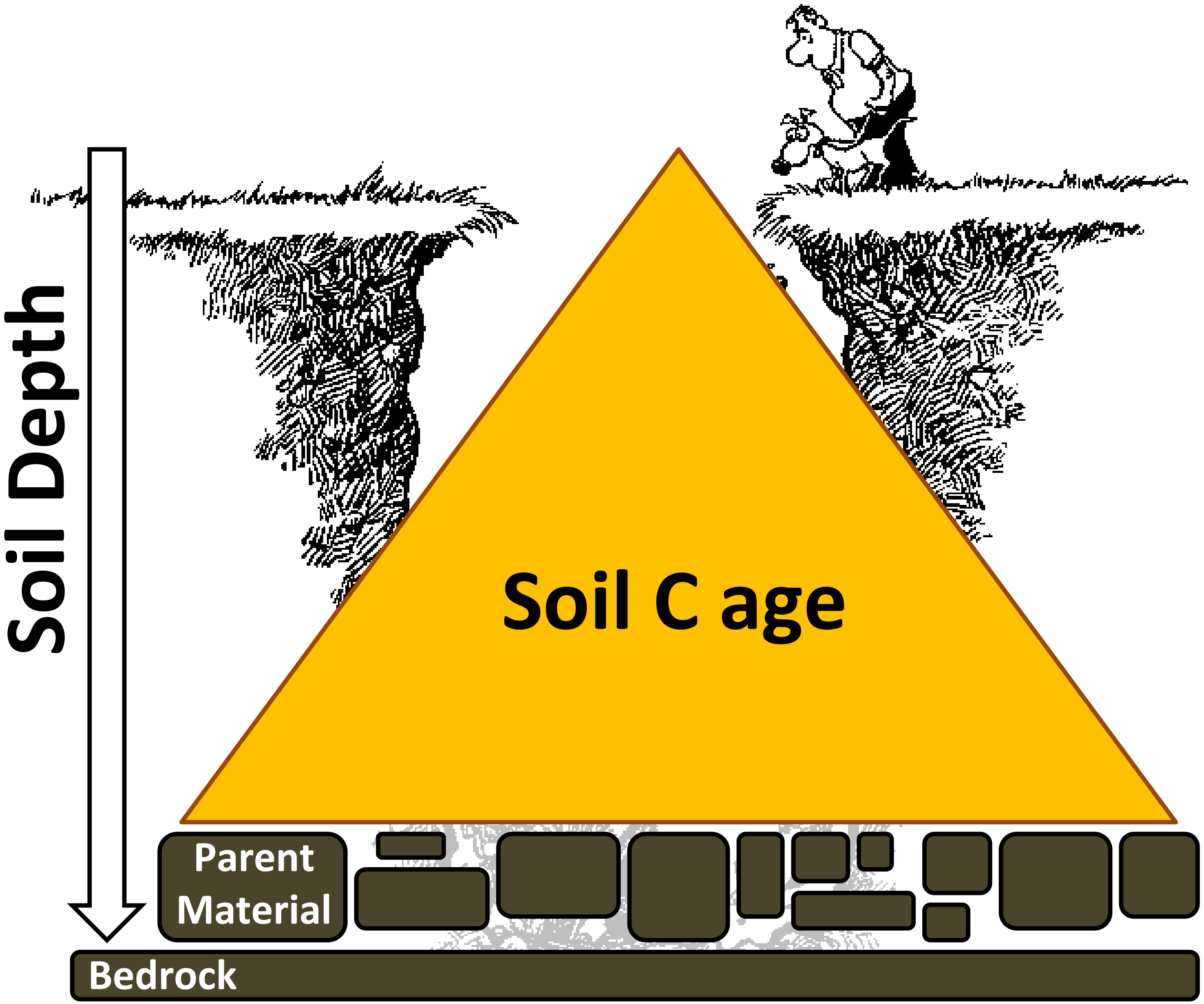
- NO significant effect of treatment on soil C and N
- NO significant effect of slope or aspect on soil C and N
- Over 50 percent of soil C and N is below a depth of 20 cm
- NO significant effect of method on soil bulk density measurement

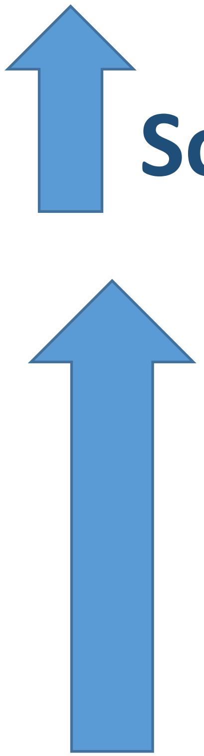
ISPA Repeated Thinning	ISPA/4	ISPA/2 Minimal Thinning	ISPA Minimal Thinning	ISPA	ISPA/2	ISPA+F Repeated Thinning	ISPA/2+F Minimal Thinning	ISPA/4+F

Conclusions

- **Substantial additions of N as urea over 16 years to fertilized plots did not significantly affect soil C or N**
- **Thinning regimes (+,- N fertilizer) did not significantly affect soil nutrients**
- **Subsoil (below 20 cm) contains substantial and biologically available C and N stocks**
- **Clod, corer, and volumetric methods for measuring soil bulk density are statistically equivalent**

Directions for Future Research





- Soil N
- Soil structure
- Nutrient and water retention
- Productivity

➢ **Increasing soil C in subsoil may result in a more long-term increase**

Tipping et al. (2012); Kaiser & Zech (2000)

Acknowledgements

Stand Management Cooperative
SILVICULTURE ▪ NUTRITION
WOOD QUALITY ▪ MODELING

School of Environmental and Forest Sciences
UNIVERSITY of WASHINGTON
College of the Environment

Weyerhaeuser

NSF

CAFS

References

Kaiser, K. and W. Zech. 2000. Dissolved organic matter sorption by mineral constituents of subsoil clay fractions. J. Plant Nutr. Soil Sci. 163:531-535.

Kalbitz, K., S. Solinger, J.-H. Park, B. Michalzik and E. Matzner. 2000. Controls on the dynamics of dissolved organic matter in soils: a review. Soil Sci. 165(4):277-304.

Lehmann, J. and M. Kleber. 2015. The contentious nature of soil organic matter. Nature 528:60-68.

Tipping, E., P.M. Chamberlain, M. Fröberg, P.J. Hanson and P.M. Jardine. 2012. Simulation of carbon cycling, including dissolved organic carbon transport, in forest soil locally enriched with 14C. Biogeochemistry 108:91-107.

Photos/Art

Slides 1,21: http://www.avaya.com/blogs/assets_c/2013/04/digging_deeper_2-thumb-768x459-864.jpg

Slide 6: http://www.ejuicesuperstore.com/product-p/j-mv-trav-jungle.htm. https://areyouhavingabubble.wordpress.com/tag/sonoran-desert/.
https://upload.wikimedia.org/wikipedia/commons/4/4d/Shola_tadiandamol.jpg.
https://www.tripadvisor.com/Attraction_Review-g143048-d527222-Reviews-Alluvial_Fan-Rocky_Mountain_National_Park_Colorado.html.
https://en.wikipedia.org/wiki/Aspect_(geography).

Slide 18: http://john-barton.com/wp-content/uploads/2013/11/Digging-this-hole.jpeg

Biomass Models
D. Maguire / D. Mainwaring

				HARVEST DATE			
IID	NAME	LANDOWNER	SPECIES	2012 est	2015 est	2016 est	FLEX?
701	Mason Lake	Green Diamond Resource Company	DF	2023			
702	Adam River	BCMF/Mac. Bloedel LTD.	WH	2042		2042	
703	Longbell Road	Washington State DNR	DF	2037		checking	not likely
704	Ostrander Road	Longview Fibre Company	DF	2015		harvested	
705	East Twin Creek	? Via Hancock	DF	2025			
706	B & U Plantation	Weyerhaeuser Company	DF	2025			
707	Rupert Main	BCMF/Fletcher Challenge	WH	2060		2060	
708	Copper Creek	Port Blakely Tree Farms	DF	2037			
709	Mill Cr. Mainline	Weyerhaeuser Company	DF	2026			
710	Trail Creek	Roseburg Lumber	DF	2021		2024	not prior
711	Kitten Knob	Washington State DNR	DF	2040		checking	not likely
712	Prather Creek	Willamette Industries	DF	2034			
713	Sauk Mountain	Arbor Pacific / Grandy Lake	DF	2024	2024		
714	Mahatta River	BCMF/Fletcher Challenge	WH	2055		2055	
715	Davie River	BCMF/Mac. Bloedel LTD.	WH	2032		2032	
716	Quilla Creek	BCMF/CP Forest Products	DF	2036		2036	
717	Grant Creek # 1	Willamette Industries	DF	2032			
718	Roaring River 100-REV	Willamette Industries	DF	2030			
719	A-1510 Road	Washington State DNR	WH	2037	2025	checking	not likely
720	Horton	Bureau of Land Management	DF	2026	2026		
722	Silver Creek Mainline	Longview Fibre Company	DF	2023	2023	harvested	
723	Formader Ridge	USDA Forest Service (NFS)	DF	2048			
724	Vedder Mountain	B.C. Ministry of Forests	DF	2035	2027	2024	
725	Sandy Shore	Pope Resources	DF	2026			
726	Toledo	Plum Creek Timber	DF	2030	2030		
727	American Mill	Rayonier Timberlands	WH	2023			
728	LaPush	Rayonier Timberlands	WH	2020			
729	Gnat Creek	Oregon Dept. of Forestry	DF	2026	2026		
730	Big River	Cavenham Forest Industries	WH	2016	2016	harvested	
731	Dingle 4	USDA Forest Service (NFS)	DF	2050			
732	100-Lens East	BCMF/CP Forest Products	DF	2024		2024	
733	Stowe Creek	BCMF/Mac. Bloedel LTD.	DF	2045	2035	2045	
734	Upper Canada Creek	Hampton Tree Farms	DF	2030		2030	Yes
735	Rayonier Sort Yard	Publishers Paper	DF	2017		2025	
736	Twin Peaks	Campbell Global via Hancock	DF	2025		checking	
737	Allegany	Oregon Dept. of Forestry	DF	2029	2029		
738	Grave Creek Burn	Campbell Global via Hancock	DF	2035		checking	
739	Silver Panther II	Rayonier Timberlands via Campbell	DF	2023			

Notes:

3 Type I installations harvested.

Based on limited responses from 2015 and 2016 survey, best bet(s) for next retirement is/are 735 and 728.

Plan to attend!

Symposium on Systems Analysis in Forest Resources

August 27-31, 2017

The Symposium on Systems Analysis in Forest Resources (SSAFR) is an international gathering that has been held every two or more years since 1975, will be held in August 2017 near Seattle, WA. Past symposia brought together decision scientists from around the world who studied forest systems with the goal of making better management and policy decisions. Common topics included harvest scheduling, spatial reserve design, wildfre management, wildlife management, invasive pest detection and control, forest ecosystem services, supply chain optimization for biofuel and timber and non-timber forest economics. The overarching link across these topics has been the use of operations research and decision theory to inform on-the-ground management as well as forest policy. The 2017 SSAFR is going to be unique in that it will bring together two traditionally disconnected disciplines both working on forest decision support systems: the remote sensing/geospatial informatics community and operations researchers. The former group is concerned with how to best collect and process data on forests and other resources, whereas the latter tries to optimize resource management given whatever data is available. Despite the obvious feedback between the two groups, so far they have generally operated separately from each other. In this symposium, we seek to study such questions as how to streamline data collection protocols of competing forest management objectives.

SSAFR 2017

August 27-30, 2017

Clearwater Resort

Suquamish, Washington

(near Seattle)

IMPORTANT DATES

1 Oct 2016 - Call for Abstracts

15 Nov 2017 - Registration opens

1 Jan 2017 - Submission deadline

1 Feb 2017 - Decision notifcation

15 May 2017 - Early bird fee deadline

15 Jul 2017 - Hotel reservation deadline

27 Aug 2017 - SSAFR 2017 opens

Modeling Competition Effects on Tree Growth and Stand Development: Assembly and Exploratory Analysis of a Spatially Explicit Dataset

Jeff Comnick

Modeling Competition Effects on Tree Growth and Stand Development: Assembly and Exploratory Analysis of a Spatially Explicit Dataset

Eric Turnblom

Jeff Comnick

NSF Fundamental Research Program Project Justification

Components of tree growth	Represented mathematically by
Present size and vigor from past growth environment and genetics	Initial size/age in the growth model
Micro-environmental and genetic influences	Ratio of subject tree attribute to mean or max attribute in the stand
General competition environment	Stand density (e.g. basal area per acre)
Average growth potential modified by neighbors	Competition index of hierarchical position in the stand or distance to/number of neighbors

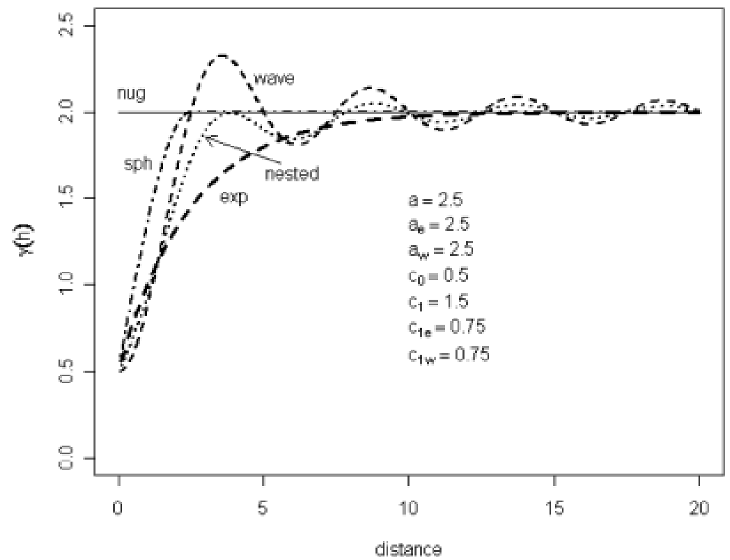
- Effects are confounded and highly interactive over long time periods: difficult to separate
- Critiques of existing competition indices:
  - Static, low predictive power, confounded with size and age, strongly influenced by sampling design, not sensitive to spatial patterns, and limited representation of below ground processes

NSF Fundamental Research Program Project Hypotheses

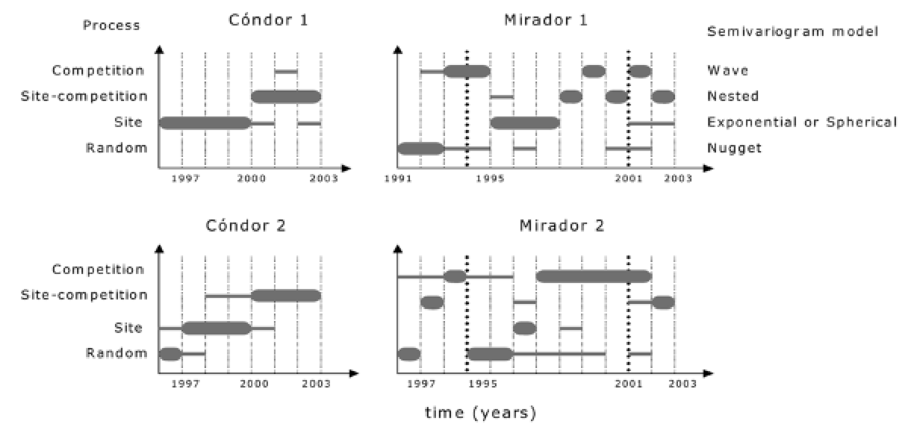
1. Does the incorporation of spatially explicit information improve predictions when compared to spatially implicit measures of competition?
2. When are competition effects first exhibited in above-ground characteristics of trees in forest stands?
3. Can microsite and tree competition processes be separated in plot measurement data?
4. Does genetic variability of trees in stands alter competition relationships?
5. How do climatic influences affect competition, and hence mortality, relationships?
6. Can predictive ability of competition measures be improved through better incorporation of experimental results and theory?

Analysis Context: Spatial

Fajardo, A. and E.J.B. McIntire. 2007. Distinguishing microsite and competition processes in tree growth dynamics: an a priori special modeling approach. Am. Nat. 169:647-661.



Variogram Model	Represents	Justification
Wave	Competition	Dampens with distance
Exponential	Microsite	Positive spatial autocorrelation continuity
Spherical	Microsite	Positive spatial autocorrelation continuity
Nested	Competition and Microsite	
Nugget	Lack of spatial autocorrelcation	



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Analysis Context: Weather

- Hill, Andrew D. 2008 "Improving diameter growth prediction of Douglas-fir in Eastern Washington state, USA, by incorporating temperature and precipitation", PhD Dissertation, College of Forest Resources, University of Washington, Seattle, WA. 213 pp.

- Dr. Terrance Ye, OSU, NTIC - most important climate variables to the adaptation of Douglas-fir to PNW environments (from St. Clair et al. (2005)):
  1. minimum temperatures in the winter months
  2. dates of first spring and last fall frost
  3. precipitation and maximum temperature in the summer months

- Dr. Kevin Ford, Forest Service Post-doc - Climatic Water Balance Variables with FIA plots

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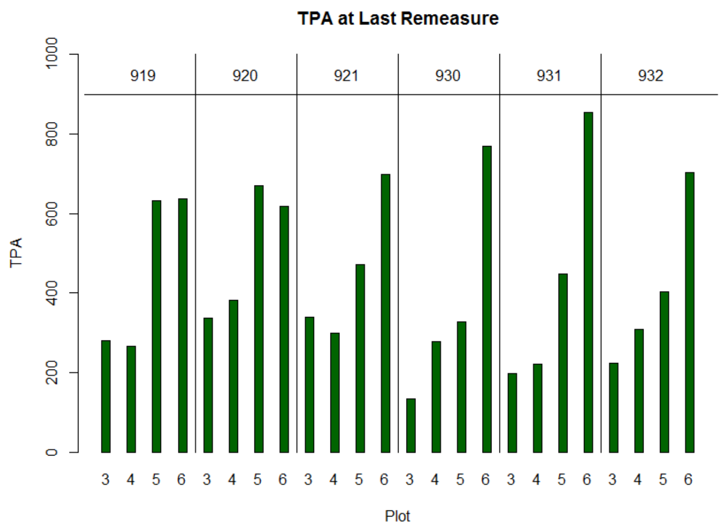
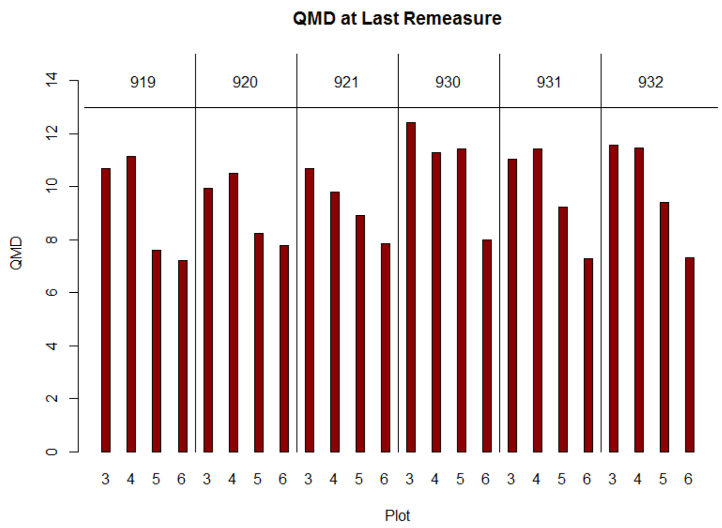
Analysis Data Set

- 4 Plots on each of Installations 819, 820, 821, 830, 831, 832 were stem mapped in summer 2011
- Forks and East Humptulips Installations on west side of Olympic Peninsula
- Plant 300, 440, 680, and 1210
- Pure DF, Pure WH, 50/50 Mix
- 8 – 11 measurements between 1992/1993 and 2014/2015
- 16,200 observations

- Additional stem maps: raw data for plots on 704, 705, 708, 713, 719, 723, 725, 736, 803, 805, 807

- Validation data set from SE





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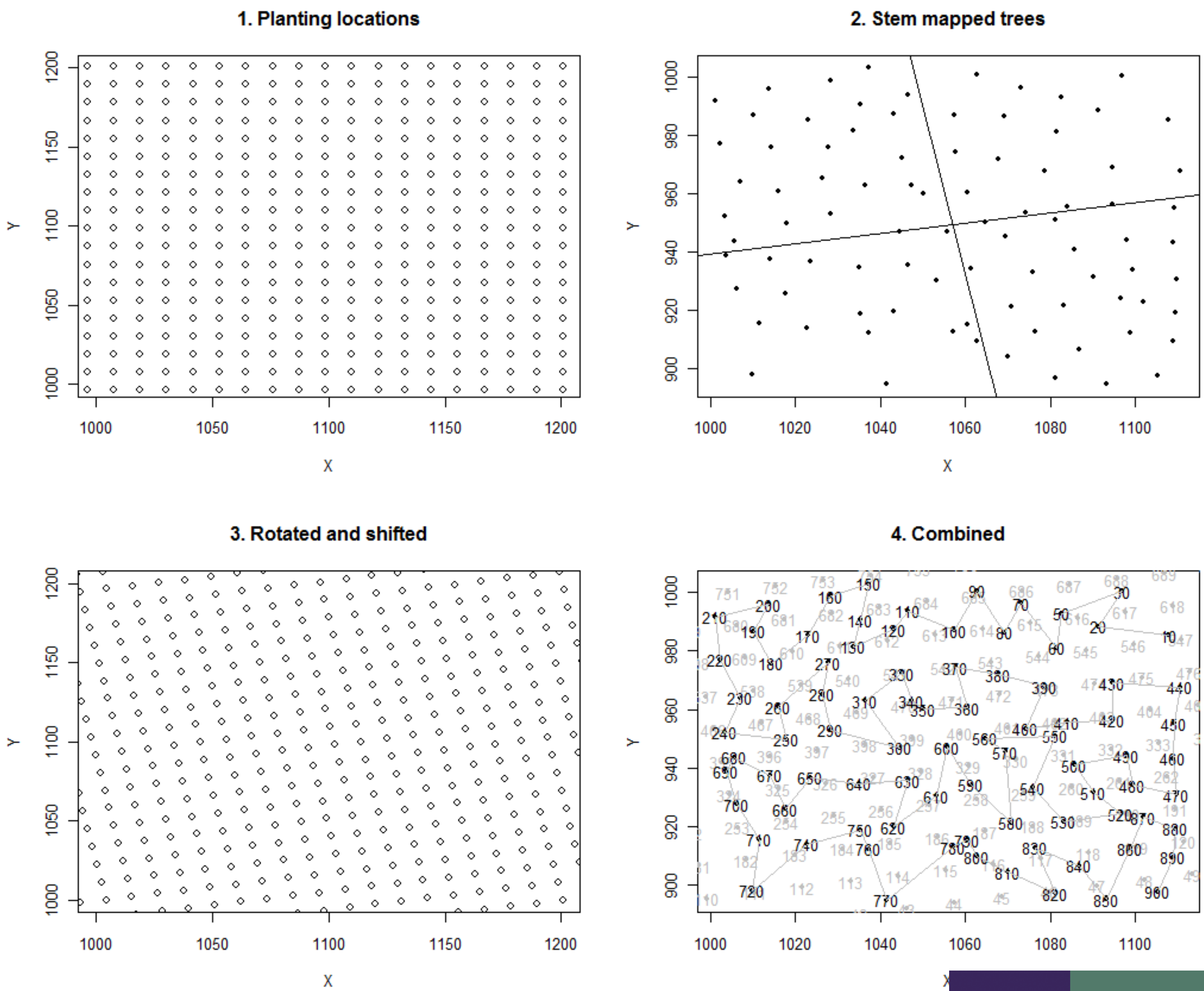
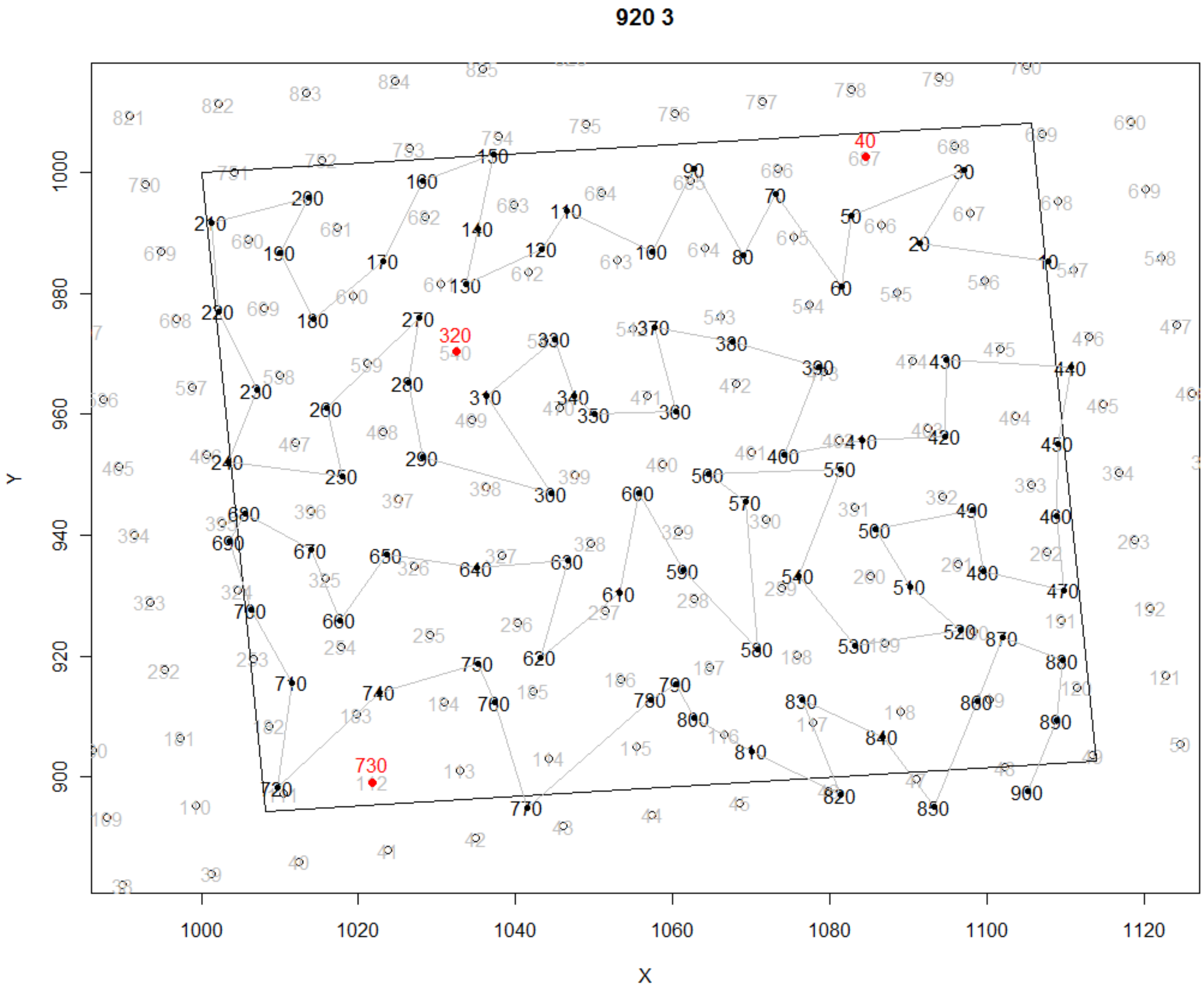
Stem Mapping

- 3 person crews: criterion laser range finder, target, data entry
- Back shot was taken from a plot corner to the first point
- All trees that could be seen from the first point were shot (distance and azimuth)
- Shoot to additional points, shoot all visible trees from each point, repeat…
- All plot corners were shot… usually
- In the office, distance and azimuth were converted to arbitrary XY coordinates

Locating Dead Trees

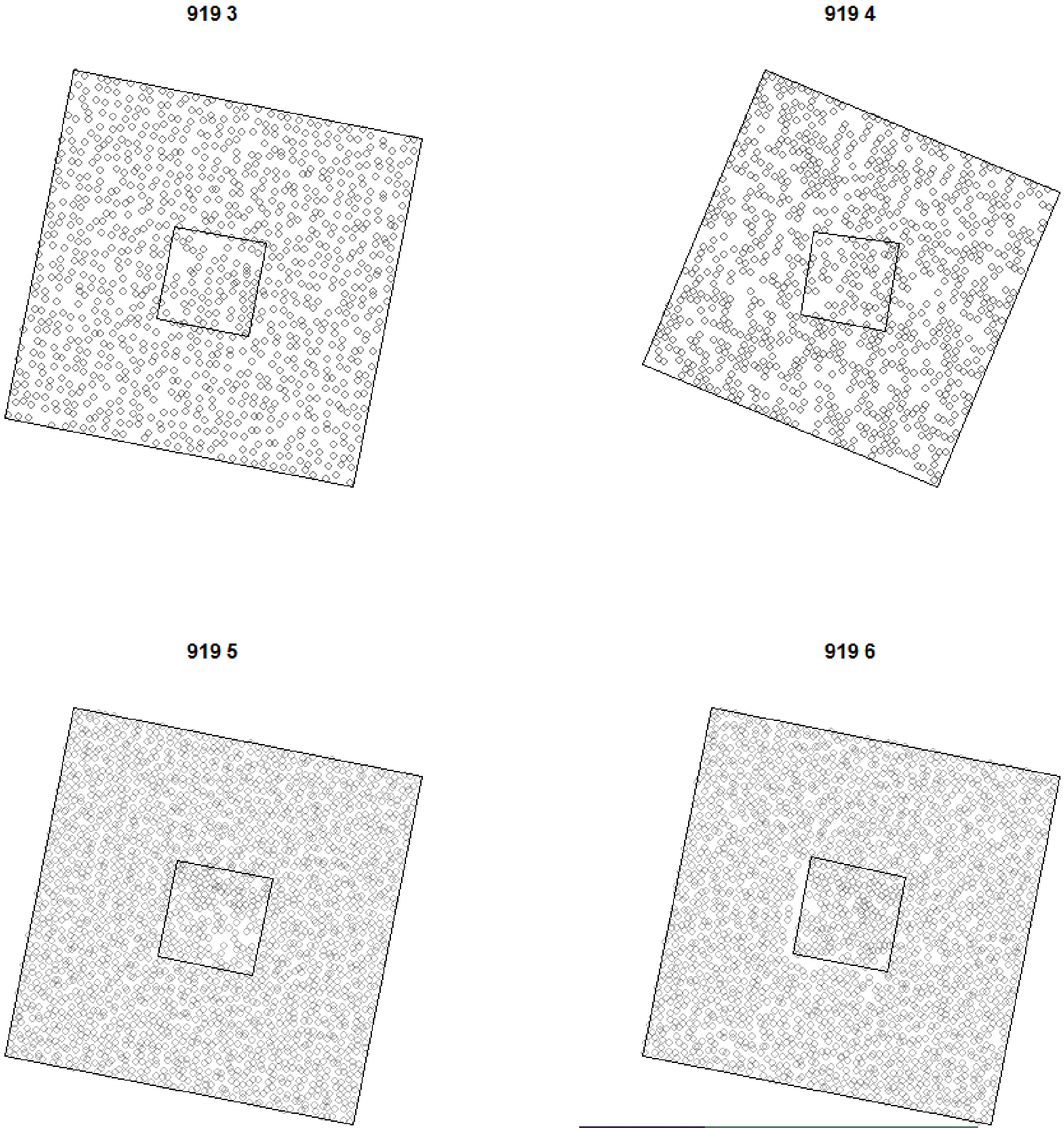


Locating Dead Trees



Generating Buffer Trees

- Used spatstat.R package to simulate buffer trees:
    1. Create planting grid from spacing
    2. Rotate and shift to minimize squared distance from stem mapped trees
    3. Periodify in 8 “cardinal” directions
    4. Jitter to add random variation
    5. Thin to add random gaps
- Simulated locations were then randomly assigned attributes from plot trees



Refitting Organon to Analysis Data Set

$$DG \sim e^{(DBH + DBH^2 + SI + LCR + BAL + BAA)}$$

Where:

$DG = \text{DBH Growth} + .15$

$DBH = \ln(DBH + 1)$

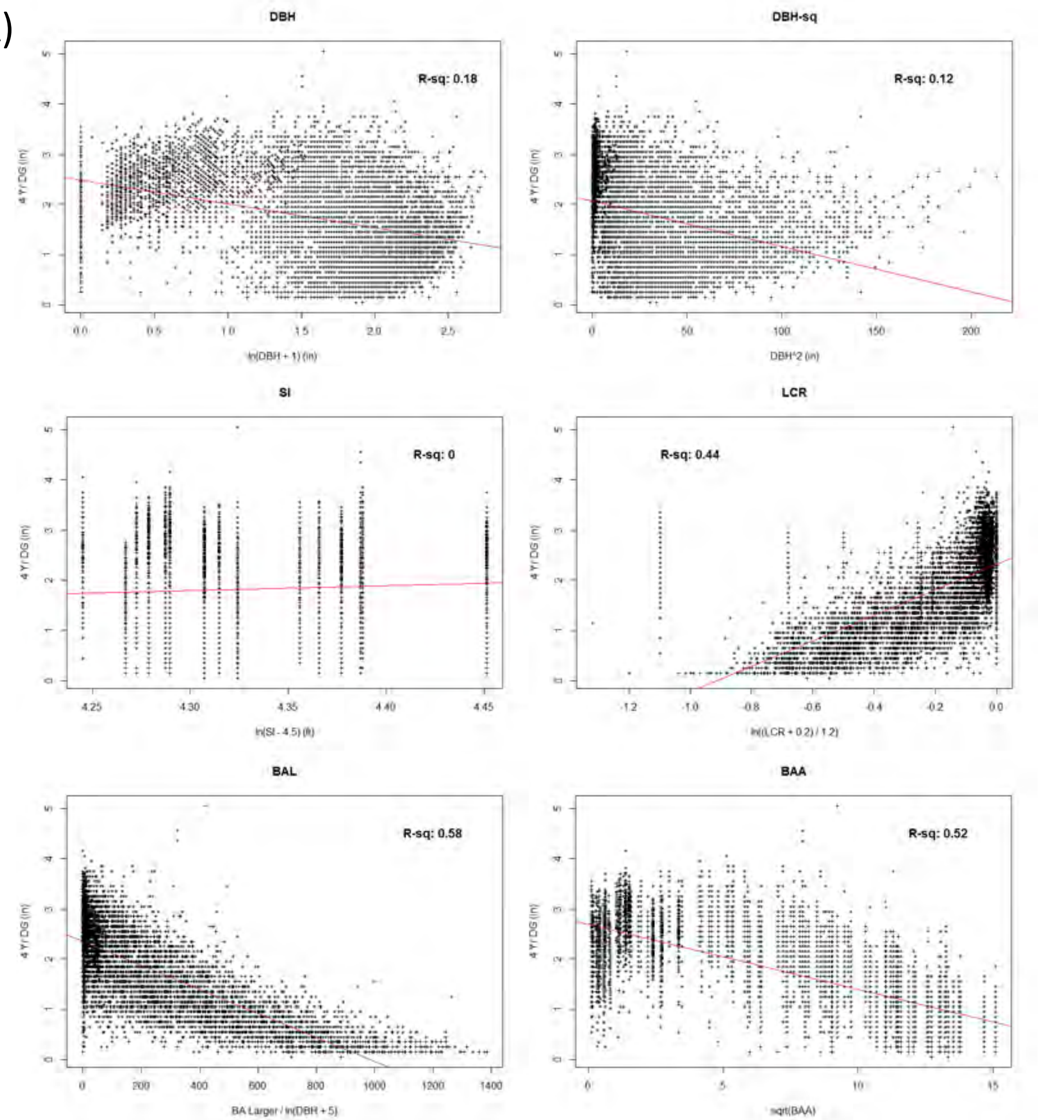
$DBH^2 = DBH^2$

$SI = \ln(SI - 4.5)$

$LCR = \ln((LCR + 0.2) / 1.2)$

$BAL = \text{BA Larger} / \ln(DBH + 5)$

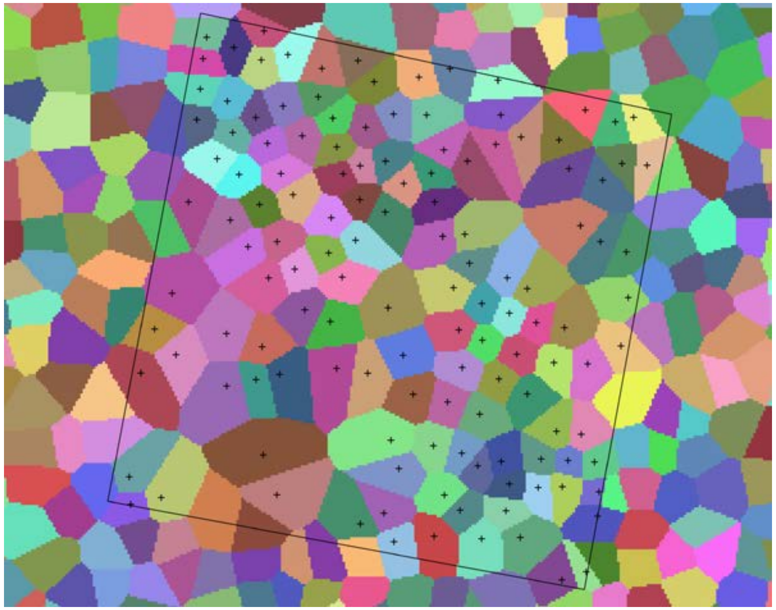
$BAA = BAA^{1/2}$



	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	-3.08E+00	1.89E-01	-16.304	< 2E-16	***
DBH	7.28E-01	1.14E-02	63.751	< 2E-16	***
DBH^2	-1.35E-03	1.70E-04	-7.965	1.77E-15	***
SI	8.53E-01	4.31E-02	19.774	< 2E-16	***
LCR	3.83E-01	2.33E-02	16.44	< 2E-16	***
BAL	-7.32E-04	2.04E-05	-35.841	< 2E-16	***
BAA	-1.35E-01	2.48E-03	-54.474	< 2E-16	***

$R^2 = .7148$

Local Measures of Competition: Dirichlet Polygons



- Thiessen, Voronoi
- Polygon identifies all areas closer to a tree than any other tree
- Utility has been studied many times
- Thought to represent growing space
- Weighted polygons have been studied less frequently (hard to do)
- Approximated using raster-style least cost path analysis
- Implemented in Python NumPy matrix
- Weights determined by: BA, Ht, and D2H
- Impedence (or weight):
  - Distance^2 / Attribute

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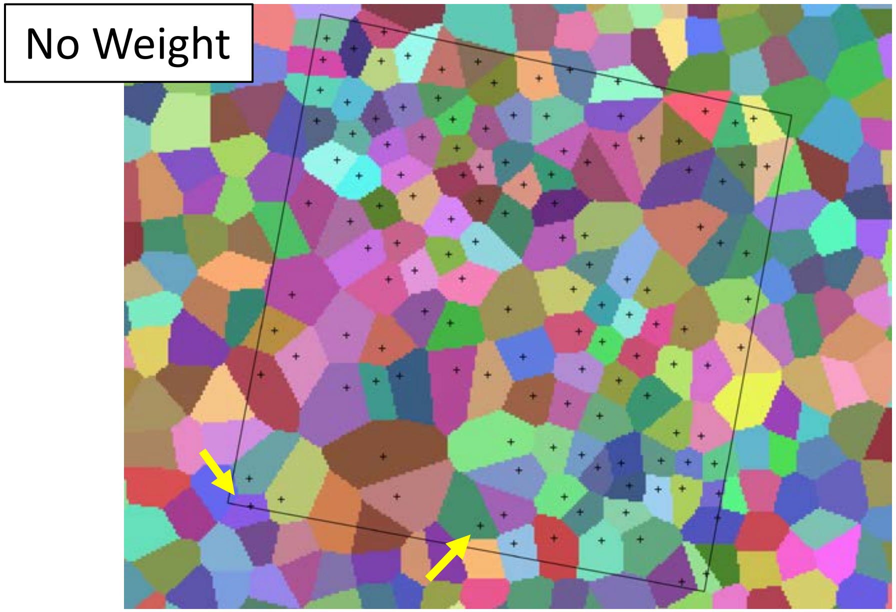
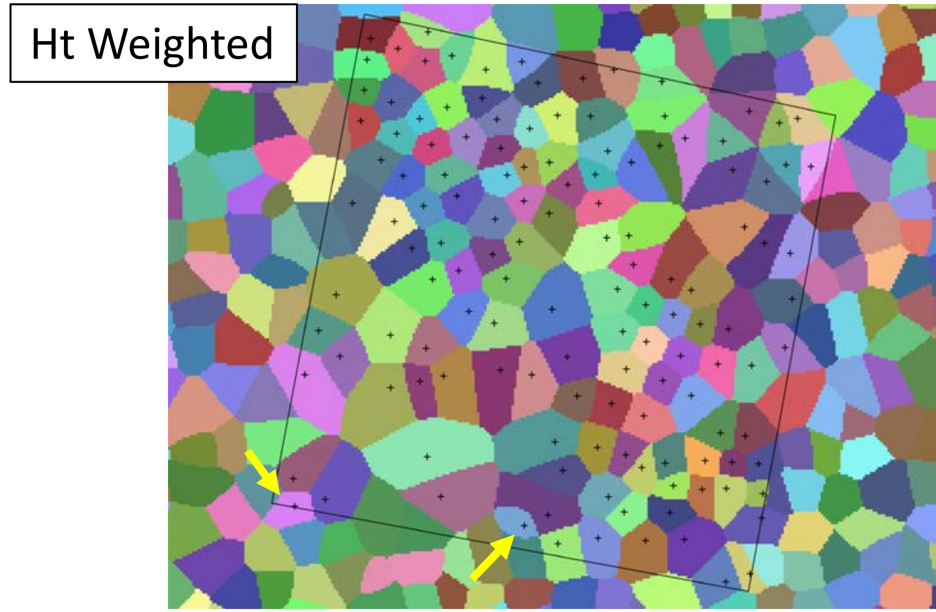
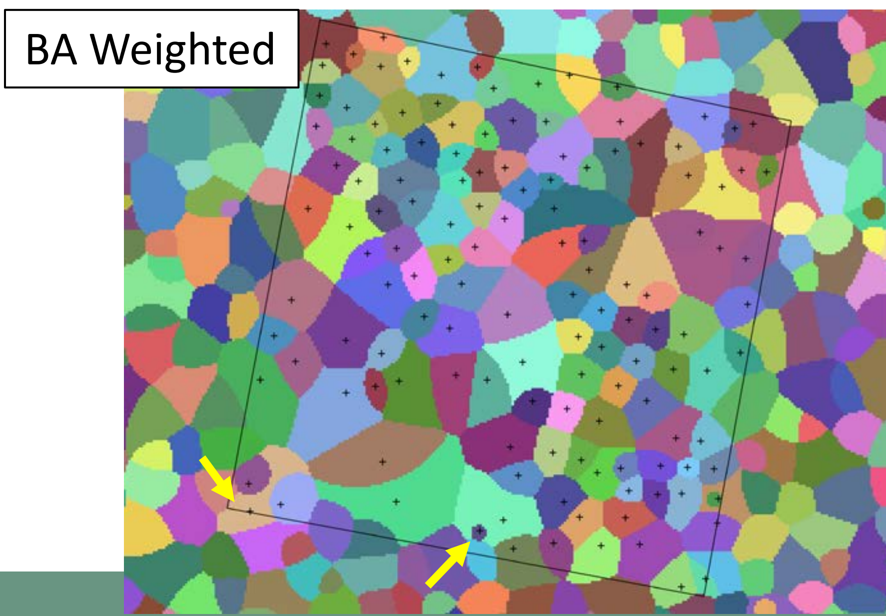
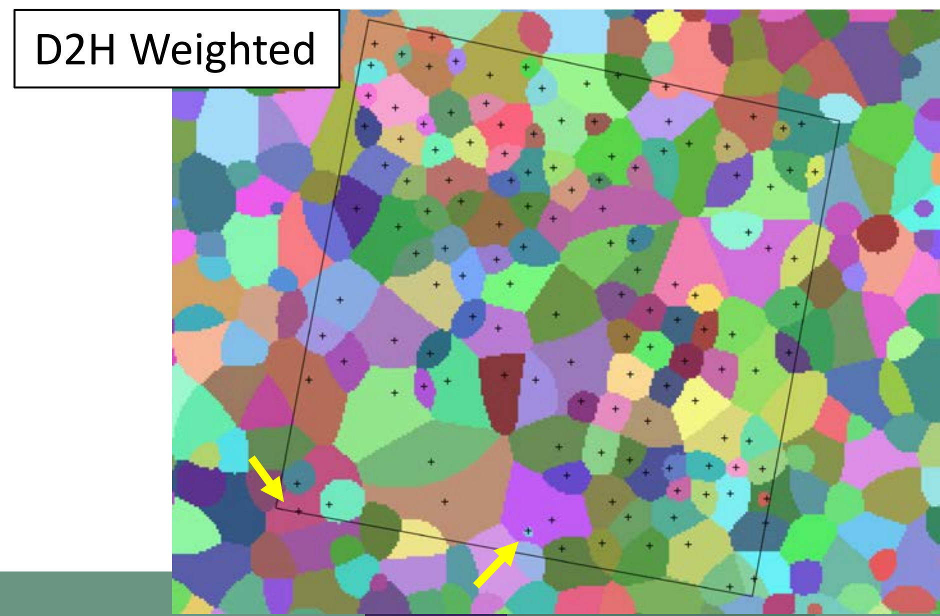
Local Measures of Competition: Dirichlet Polygons (919 6 2015)



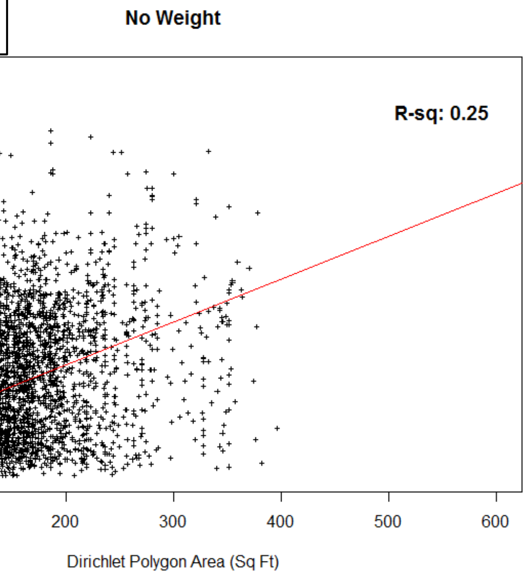




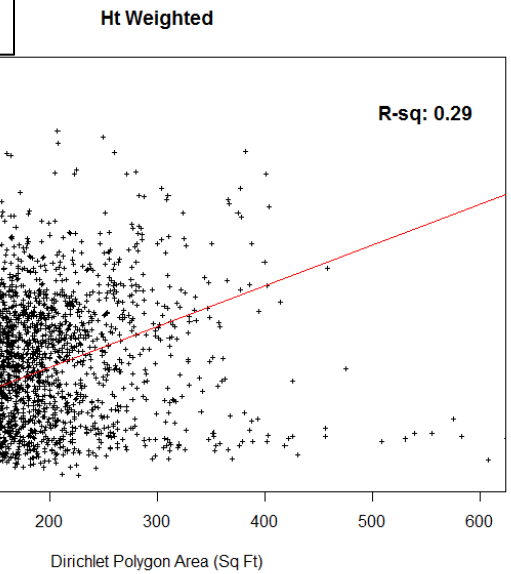


Local Measures of Competition: Dirichlet Polygons

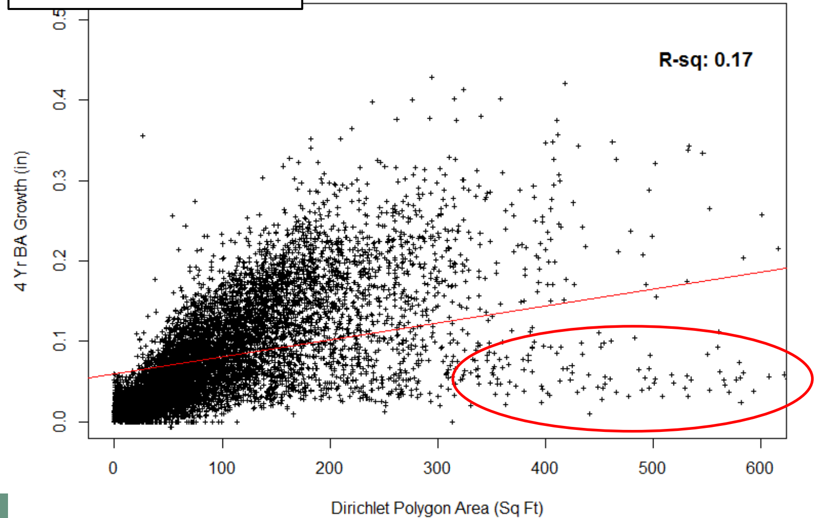
No Weight



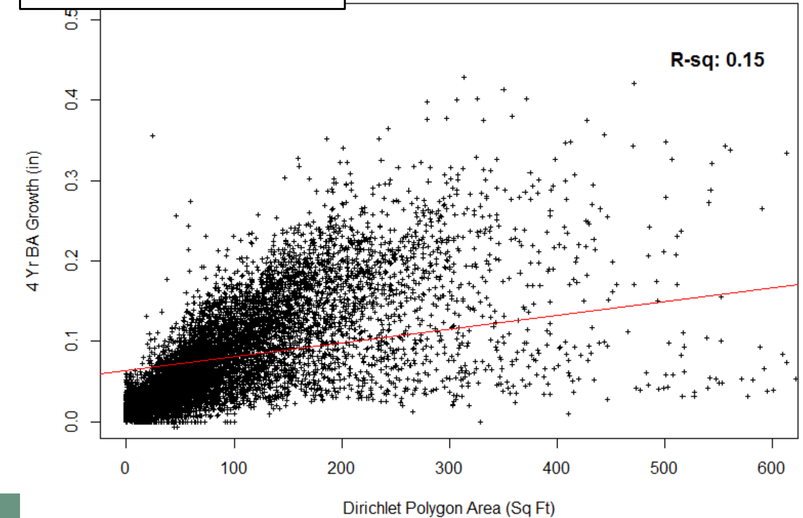
Ht Weighted



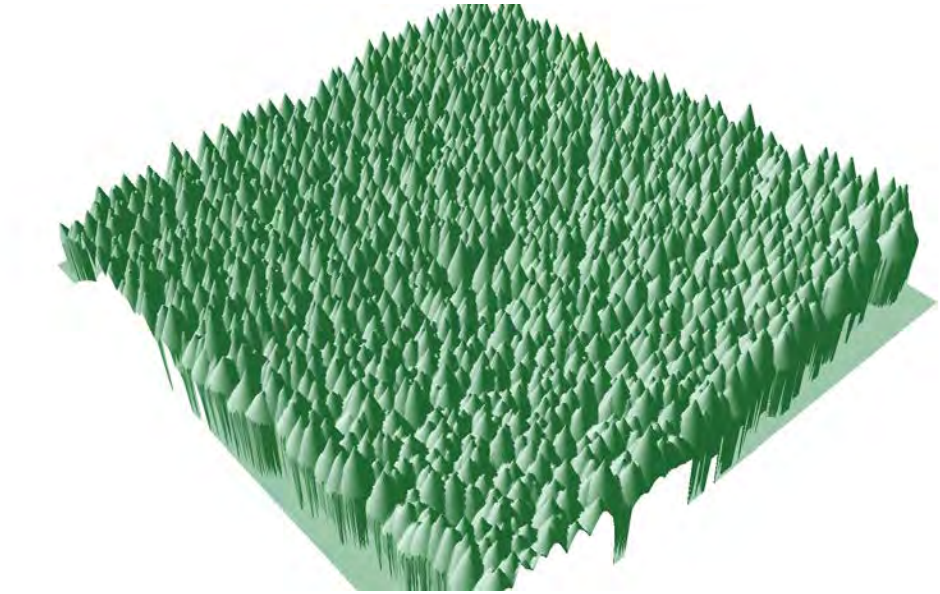
BA Weighted



D2H Weighted



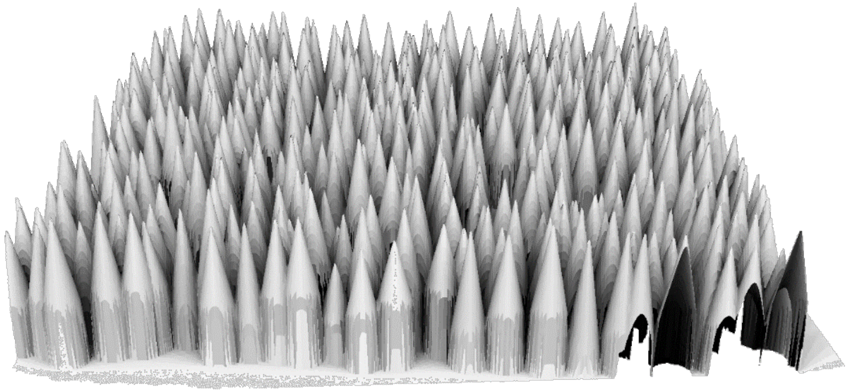
Local Measures of Competition: Solar Insolation



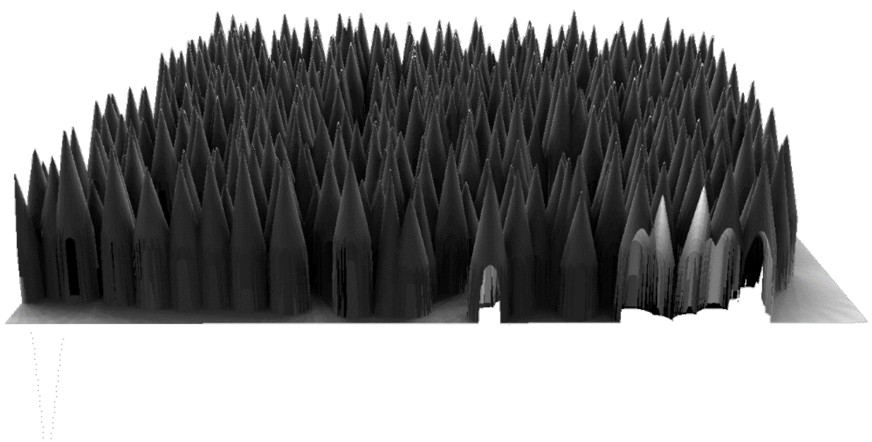
- Model light environment directly:
  - Solar Radiation Tool in ArcGIS Spatial Analyst
  - Crown Surface as Digital Elevation Model
- Calculates solar energy over a time period for every cell in the DEM
- Hemispherical viewshed algorithm, with direct and diffuse radiation, the solar constant, angle of incidence, etc…
- Crowns defined by tree height, LCR, largest crown width
- Crown profile model from Hann, 1999

Local Measures of Competition: Solar Insolation (930 3 2014)

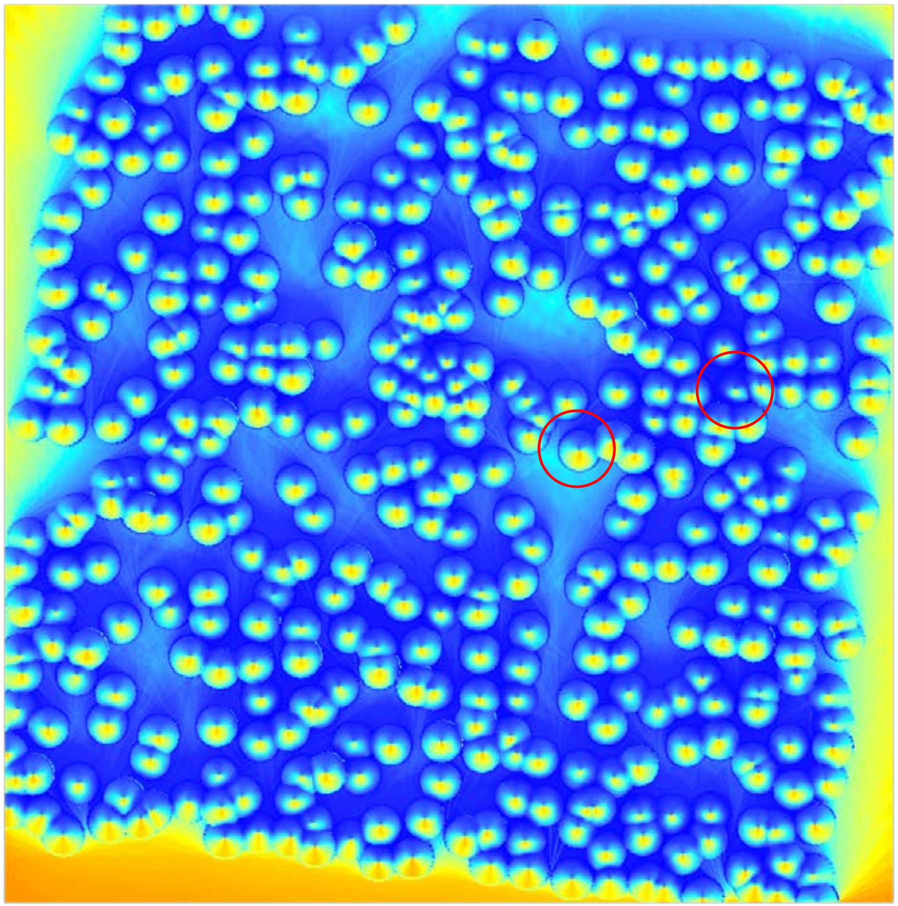
From South



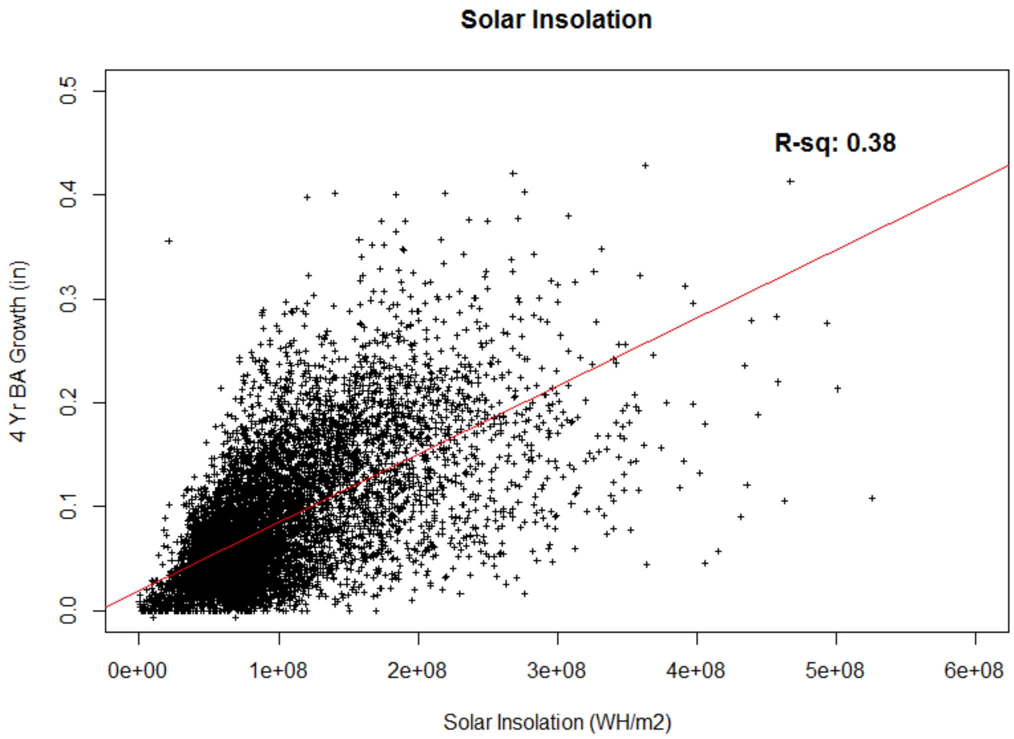
From North



From Overhead



Local Measures of Competition: Solar Insolation



- Requires Ht, LCR, LCW, which are correlated with DBH
- Not as strong a correlation with growth as BAL
- Explicitly describes part of the light environment
- CACTOS CC66 – crown area at 66% of a subject tree's height – reflects how density affects the photosynthetic portion of the crown (Krumland and Wensel 1981)

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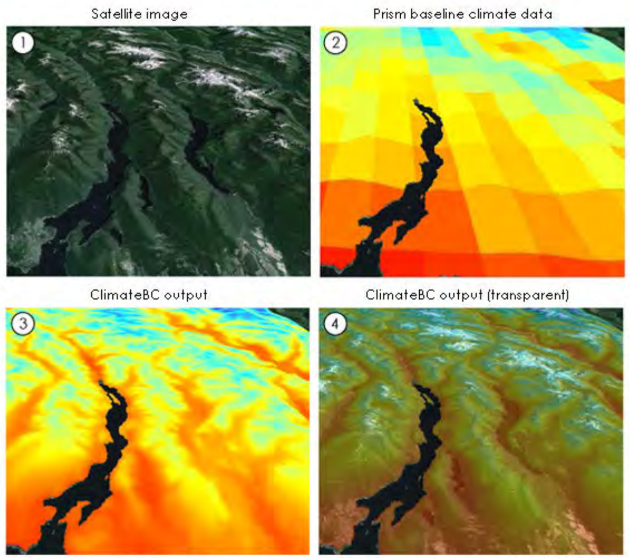
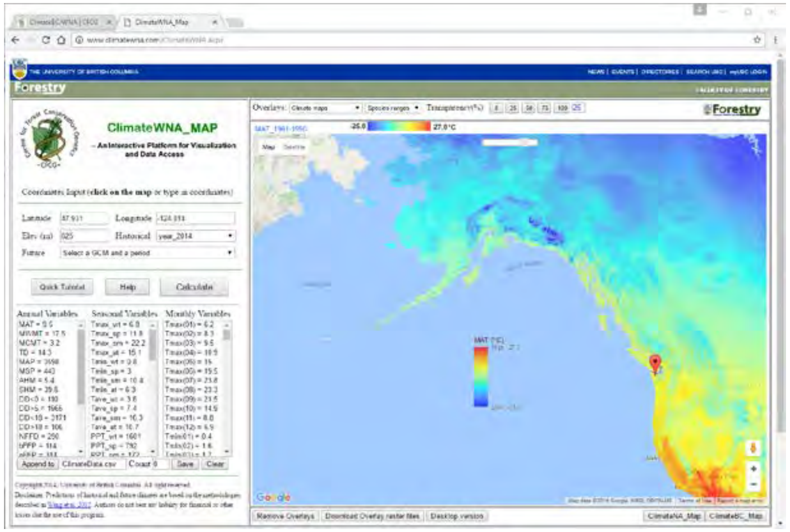
Weather

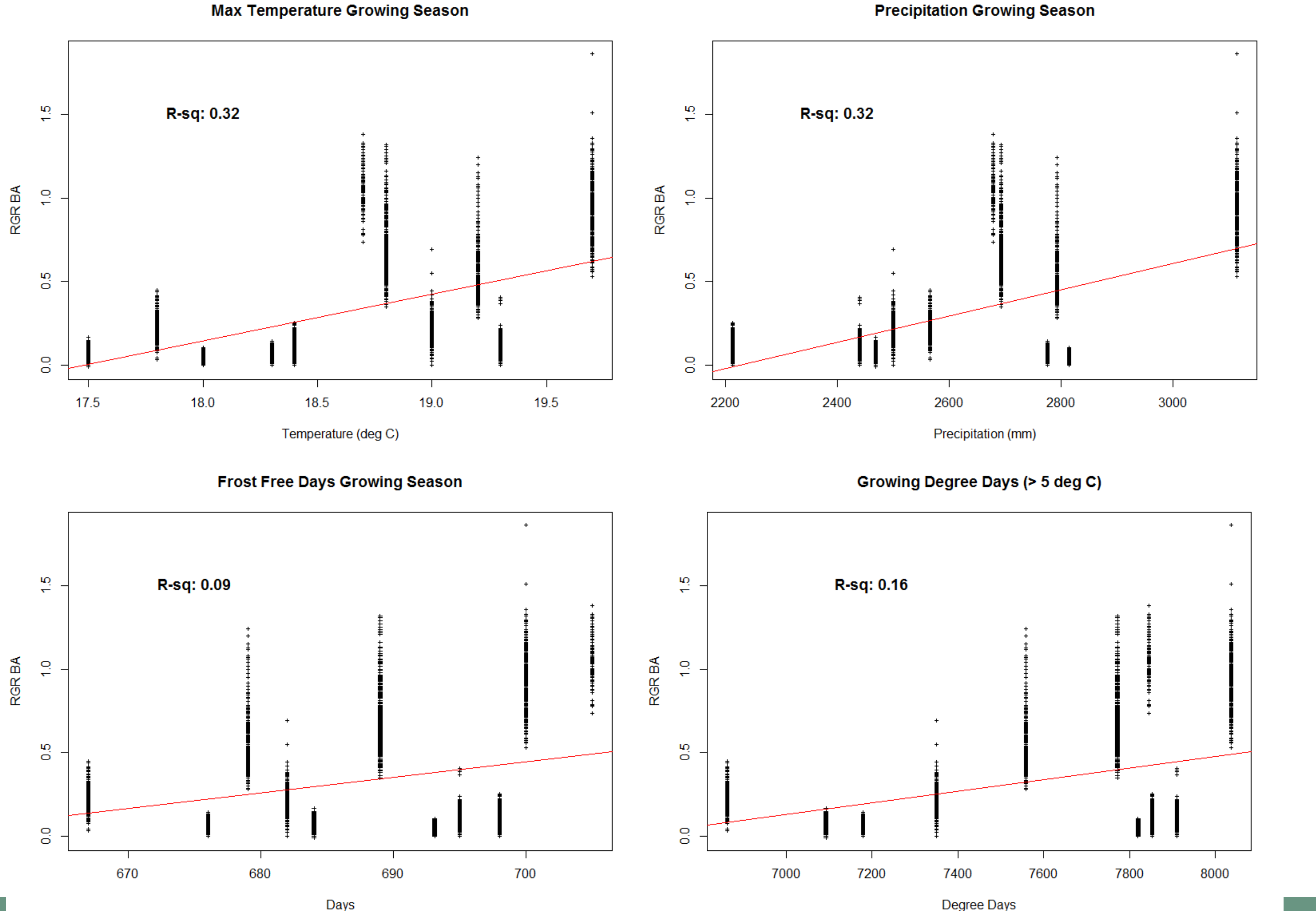
- ClimateWNA (Western North America) from UBC Centre for Forest Conservation Genetics
- Uses a combination of bilinear interpolation and elevation adjustment to downscale PRISM baseline climate data (1961-1990 normals) into scale-free point data
- Annual, Seasonal, and Monthly Variables:
  - Mean, Min, Max Temp, Precip
  - Degree-days (chilling, growing, heating, cooling)
  - Frost free days
  - First and last freezing day
  - Hargreaves moisture deficit
  - Relative humidity
  - Solar radiation



Effect of downscaling on the baseline data

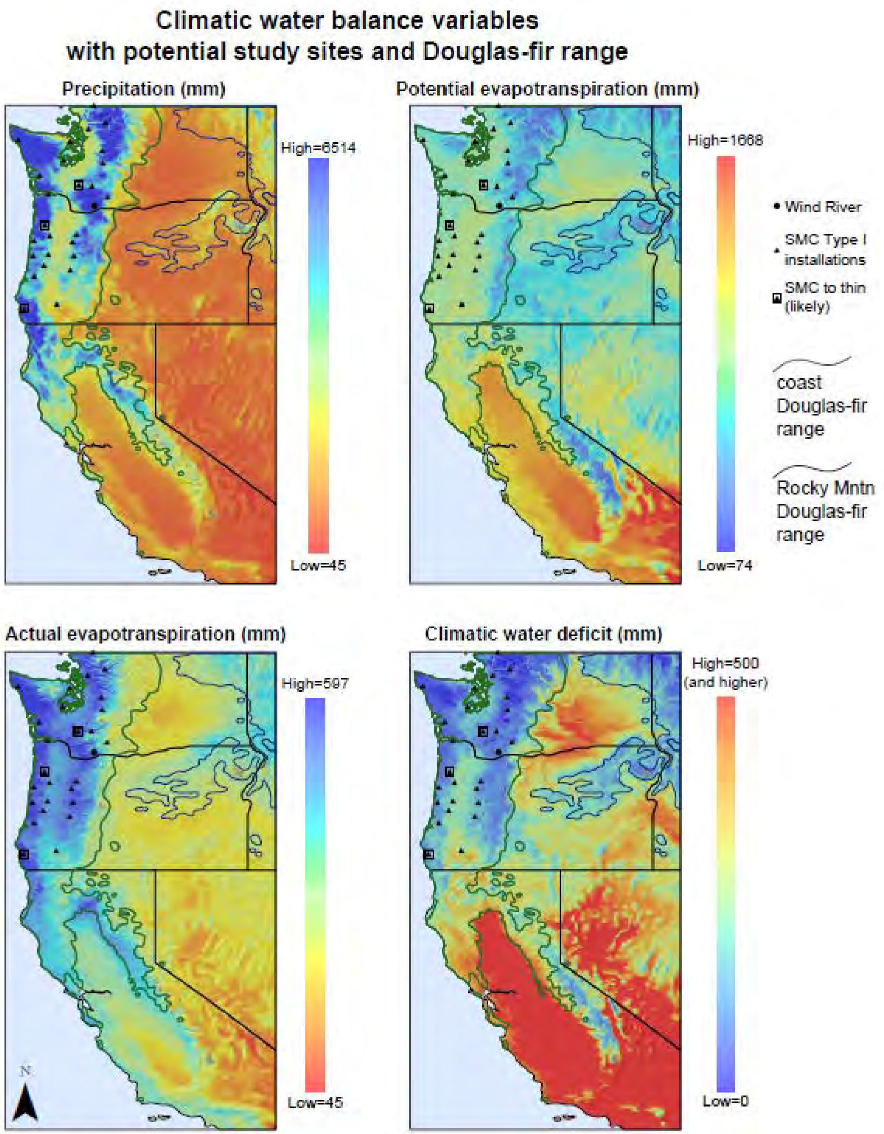


Weather


Max Temperature Growing Season
R-sq: 0.32
RGR BA
Temperature (deg C)
0.0
0.5
1.0
1.5
17.5
18.0
18.5
19.0
19.5
Precipitation Growing Season
R-sq: 0.32
RGR BA
Precipitation (mm)
2200
2400
2600
2800
3000
Frost Free Days Growing Season
R-sq: 0.09
RGR BA
Days
670
680
690
700
Growing Degree Days (> 5 deg C)
R-sq: 0.16
RGR BA
Degree Days
7000
7200
7400
7600
7800
8000

Weather

- Climatic Water Balance Variables:
  - Indicators of availability of energy and water for plant growth
  - Indexed to standard vegetation cover
  - PET: Potential evapotranspiration if unlimited water were available
  - Water availability: Water supply from seasonal dynamics of temperature, precipitation, insolation, snowpack, and soil moisture
  - AET: Actual evapotranspiration, min of PET and water availability - an indicator of the climatic favorability of a location for growth
  - Climatic Water Deficit: PET - AET



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Variables

Tree
- Spp
- DBH
- Ht
- LCR
- LCW

Stand Per Acre
- TPA
- QMD
- BA
- RD

Non-Spatial Measures of Growing Space and Competition
- BAL
- CC66

Spatial Measures of Growing Space and Competition
- Dirichlet No Wt
- Dirichlet BA Wtd
- Dirichlet Ht Wtd
- Dirichlet D2H Wtd
- Solar Insolation
- Solar Insolation GS
- Solar Insolation DS

Weather
- Temperature
- Precipitation
- Frost Free Days
- Degree Days
- PET
- AET
- Water Deficit

NRSIG – DNR Project
Luke Rogers

Precision Forestry Cooperative Synergistic Projects

Luke Rogers, Research Scientist
Natural Resources Spatial Informatics Group
School of Environmental and Forest Sciences

W NRSIG

Overview

- Inventory Sampling Design & WETSAG Riparian Monitoring
- CMER Stream Typing Model
- Ecology Wetland Mapping
- Waste 2 Wisdom

Inventory Sampling Design and RSAG Riparian Monitoring

Andrew Cooke

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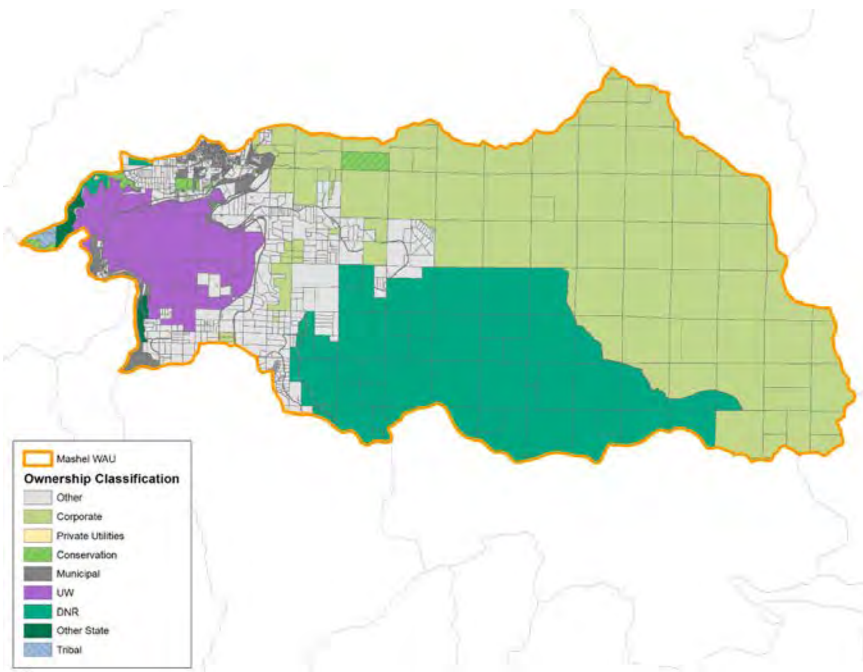
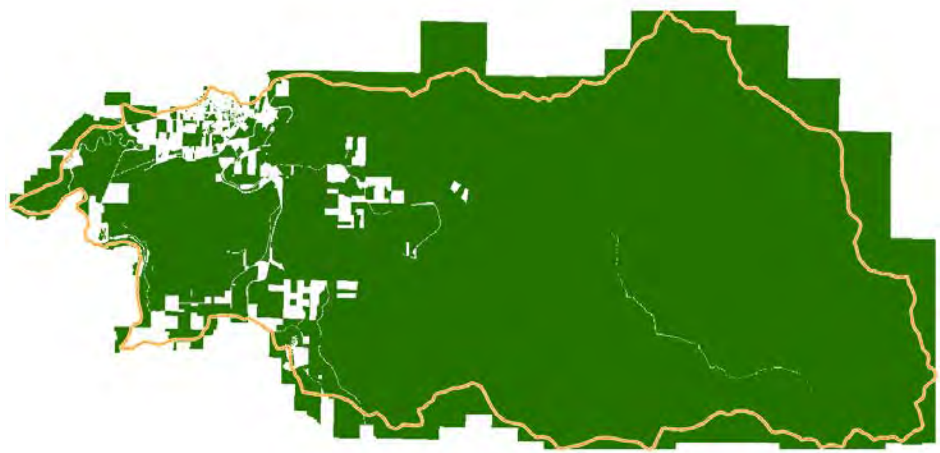
Limiting Plot Locations on Landscape

Resource Lands (DOR land use code 80 or above; WAC 458-53-030)





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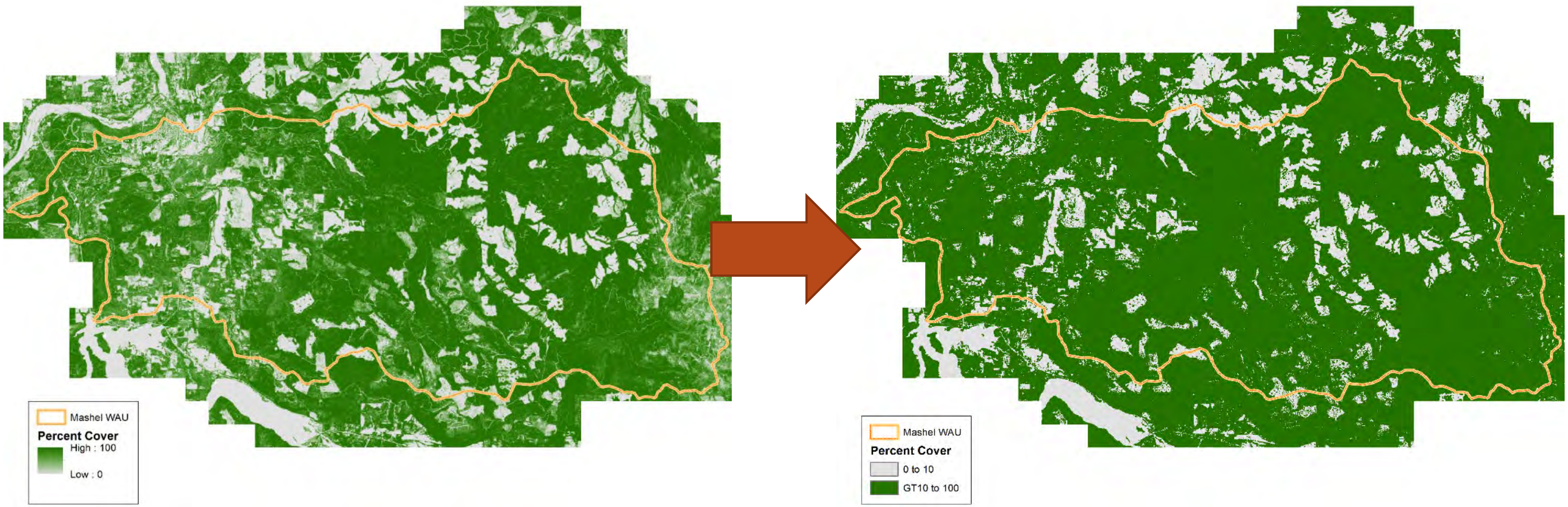
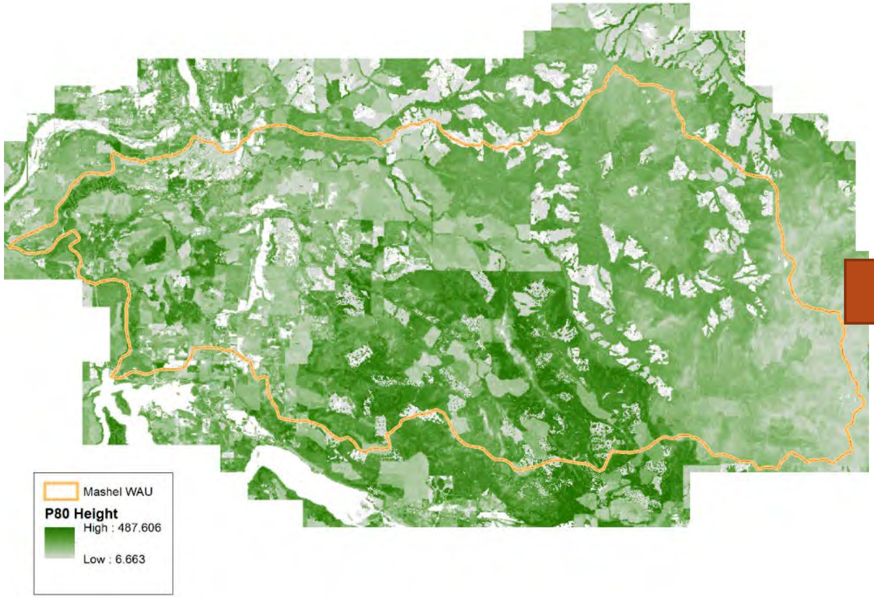
Limiting Plot Locations on Landscape

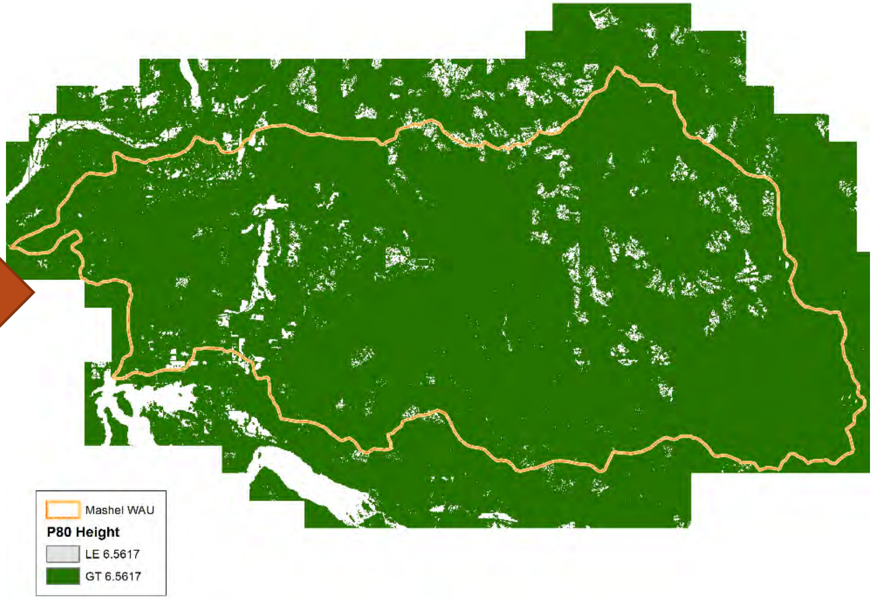
LIDAR Percent Cover (10% or more)



Limiting Plot Locations on Landscape

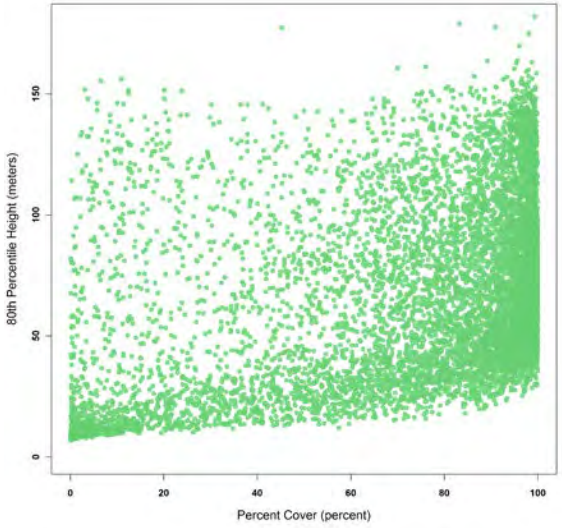
LIDAR P80 Height (2m or higher)



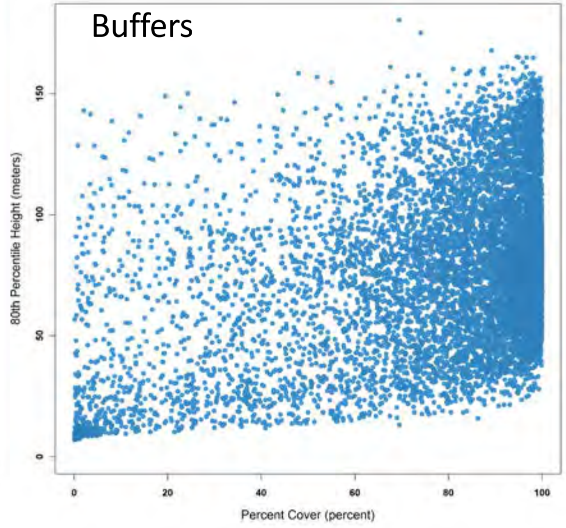


W NRSIG

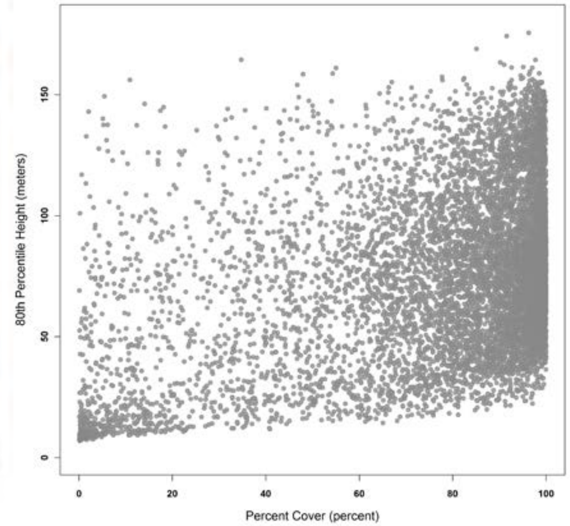
Set 1: Entire Watershed



Set 2: Forest Practice Buffers



Set 3: 1500ft Buffers



	P80		Cover	
	mean	sd	mean	sd
SET1	67.1	35.7	74.8	30.7
SET2	77.3	33.4	79.9	25.6
SET3	75.0	33.2	79.6	26.5

Comparison of 80th percentile height and percent cover for the 3 buffer rule sets

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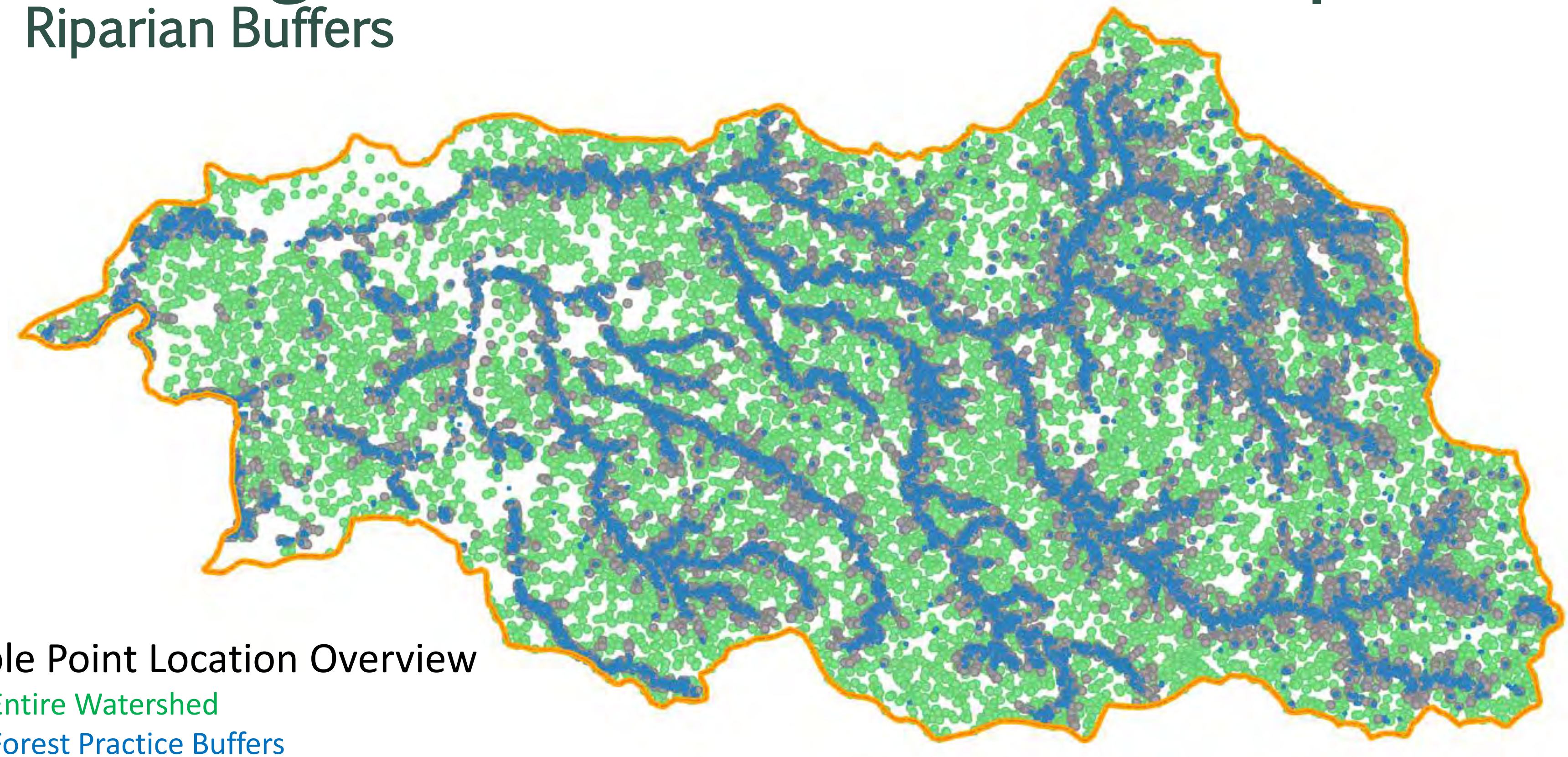
Limiting Plot Locations on Landscape
Riparian Buffers



Sample Point Location Overview

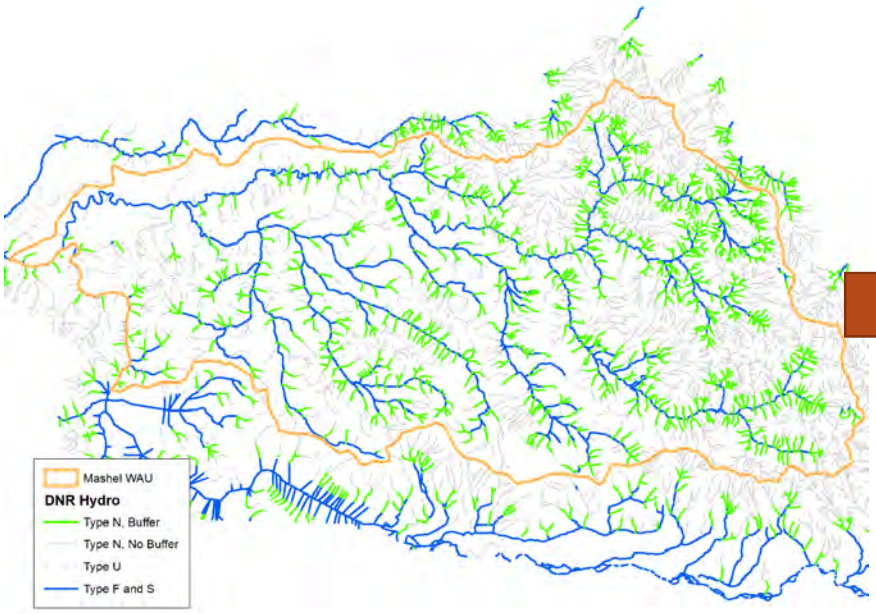
Set 1: Entire Watershed

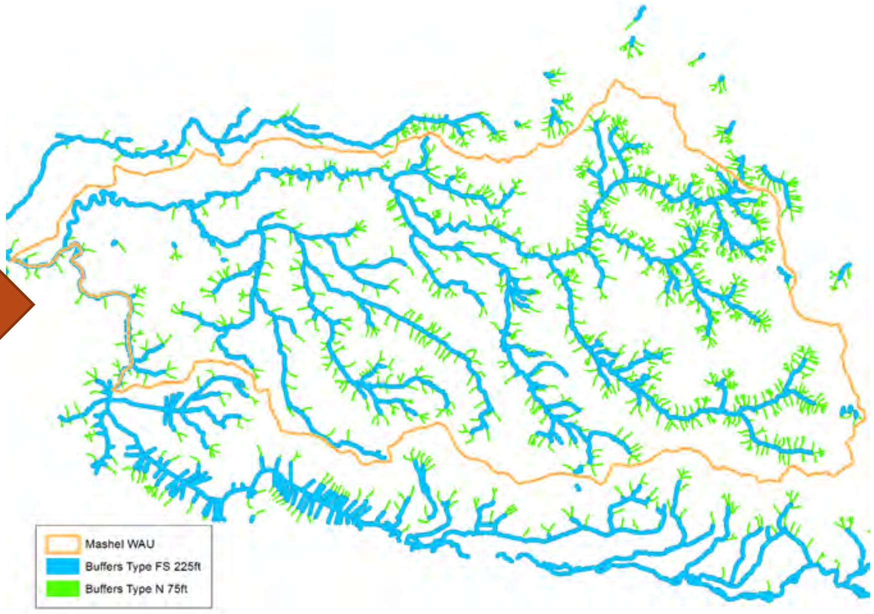
Set 2: Forest Practice Buffers

Set 3: 1500 ft. Buffers

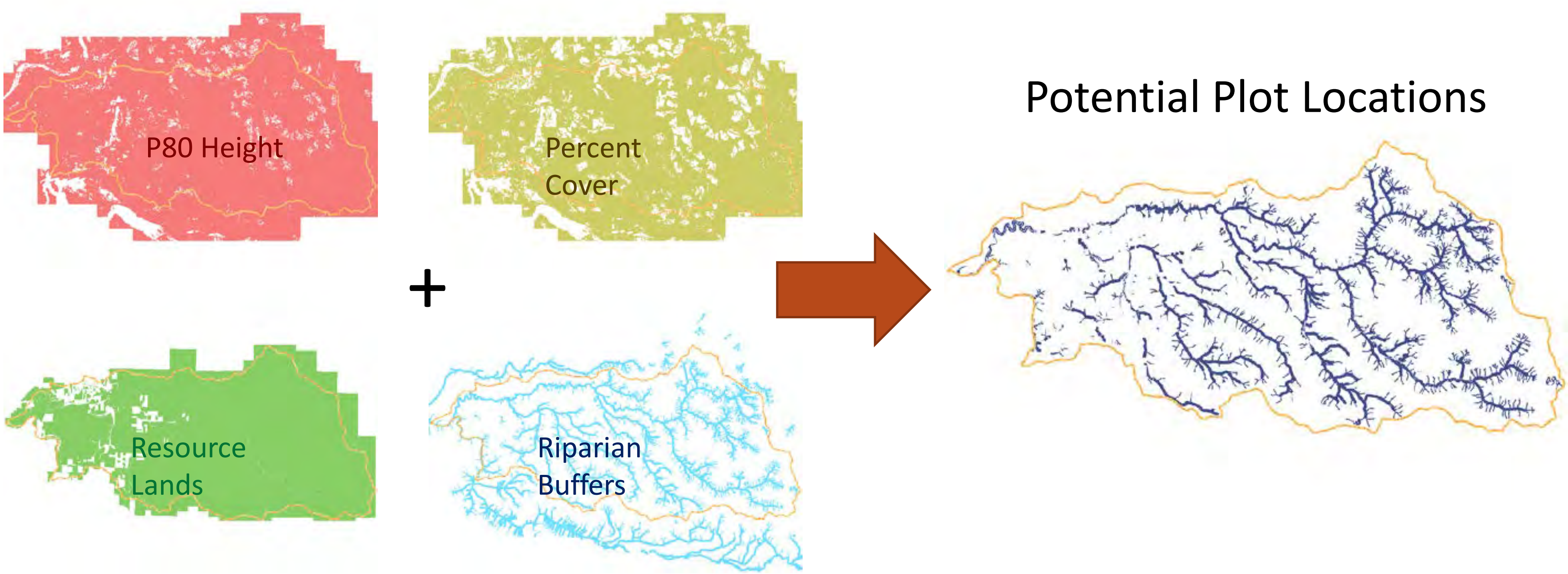
Limiting Plot Locations on Landscape

Riparian Buffers (Type F and S; 1500 ft up all type N streams)



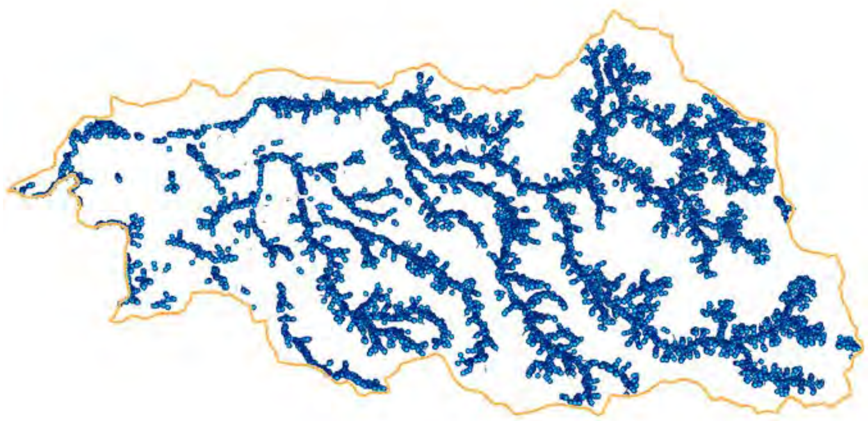


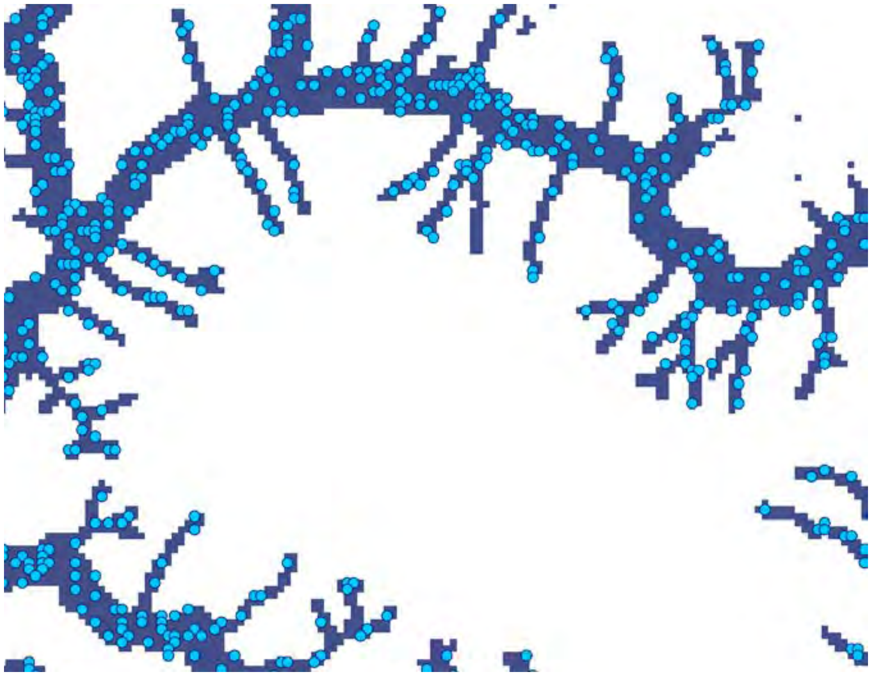
Limiting Plot Locations on Landscape
Combining



Sample Points for Principal Components Analysis

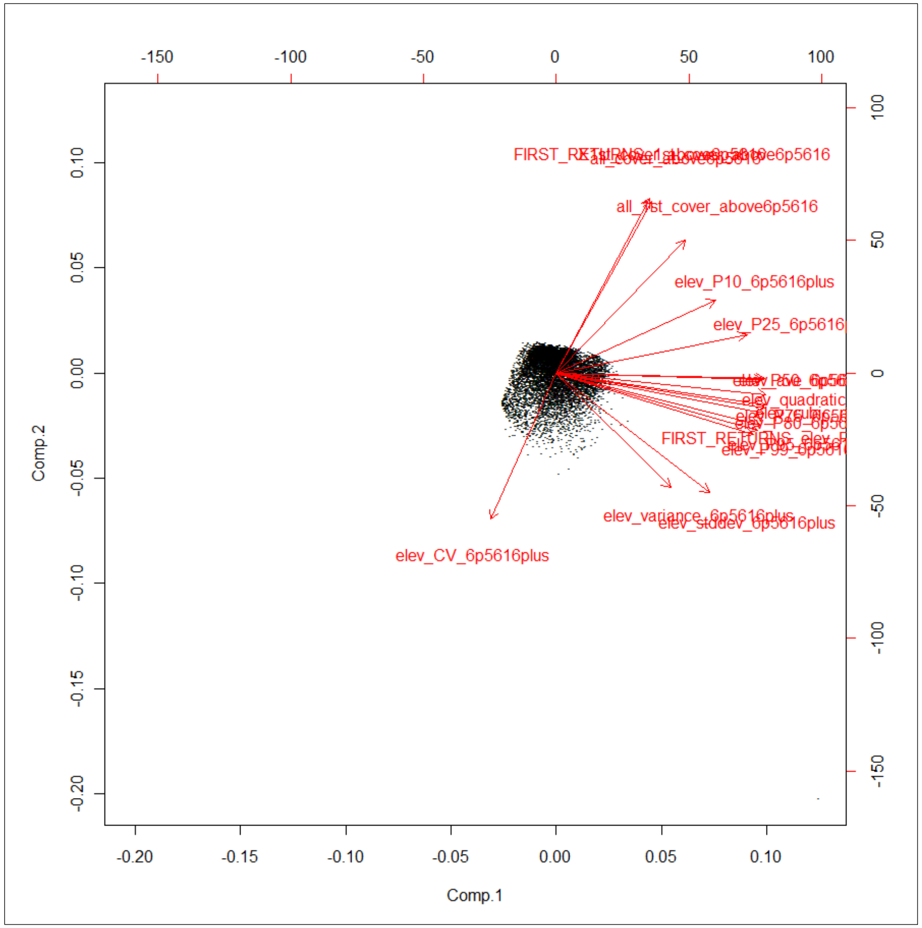
10k points sampled randomly from potential plot location area



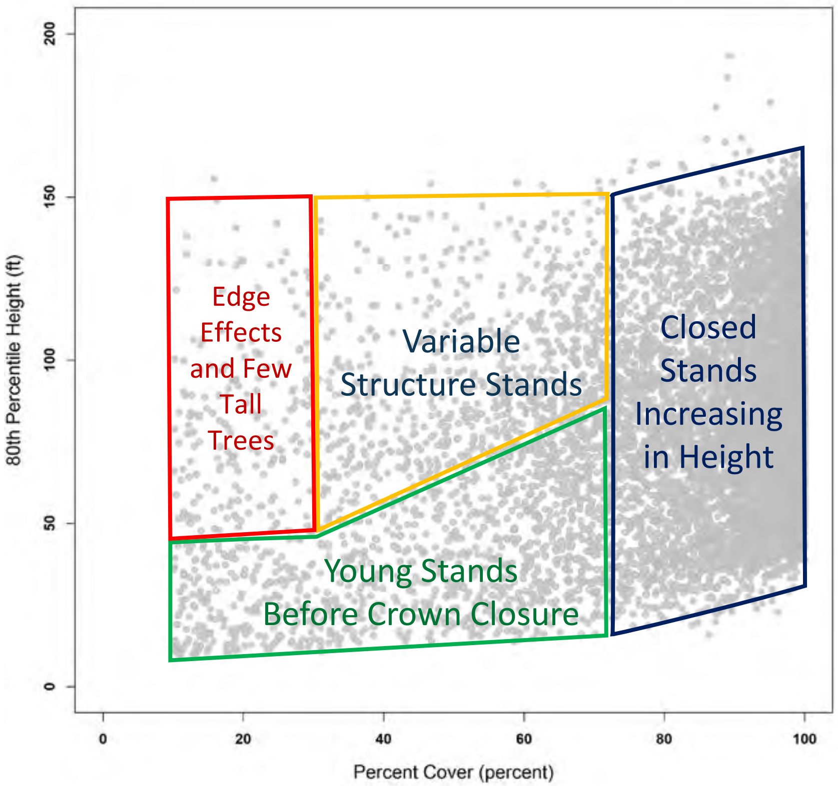


Principal Components Analysis

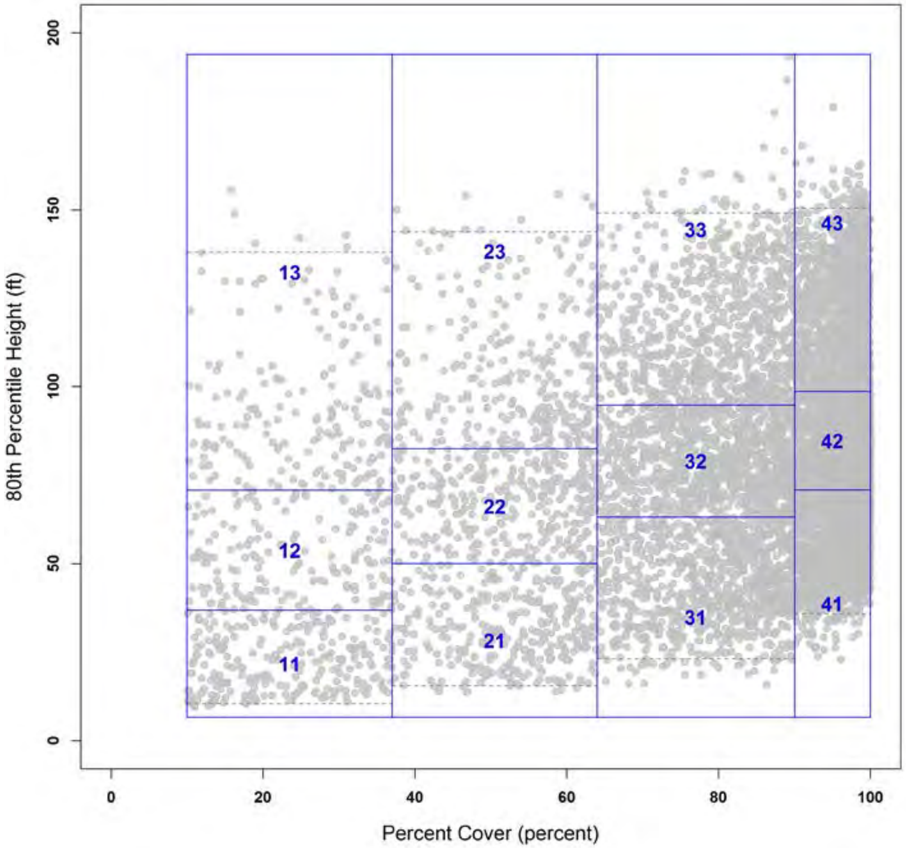
Importance of components:			
	Comp.1	Comp.2	Comp.3
Standard deviation	3.42	1.99	1.26
Proportion of variance	0.65	0.22	0.09
Cumulative Proportion	0.65	0.87	0.96
	Comp.1	Comp.2	Comp.3
1st_cover_above6p5616	0.13	0.41	0.28
all_1st_cover_above6p5616	0.18	0.32	0.32
all_cover_above6p5616	0.13	0.41	0.24
elev_ave_6p5616plus	0.29	-0.01	-0.14
elev_cubic_mean	0.29	-0.08	-0.05
elev_CV_6p5616plus	-0.09	-0.35	0.44
elev_P10_6p5616plus	0.22	0.17	-0.39
elev_P25_6p5616plus	0.26	0.09	-0.29
elev_P50_6p5616plus	0.28	-0.01	-0.13
elev_P75_6p5616plus	0.29	-0.08	-0.03
elev_P80_6p5616plus	0.29	-0.10	-0.01
elev_P95_6p5616plus	0.28	-0.14	0.06
elev_P99_6p5616plus	0.27	-0.14	0.09
elev_quadratic_mean	0.29	-0.05	-0.08
elev_stddev_6p5616plus	0.21	-0.28	0.31
elev_variance_6p5616plus	0.16	-0.27	0.31
FIRST_RETURNS_1st_cover_above6p5616	0.13	0.41	0.28
FIRST_RETURNS_elev_P90_6p5616plus	0.28	-0.12	0.05



Description of Stand Structures in Sample

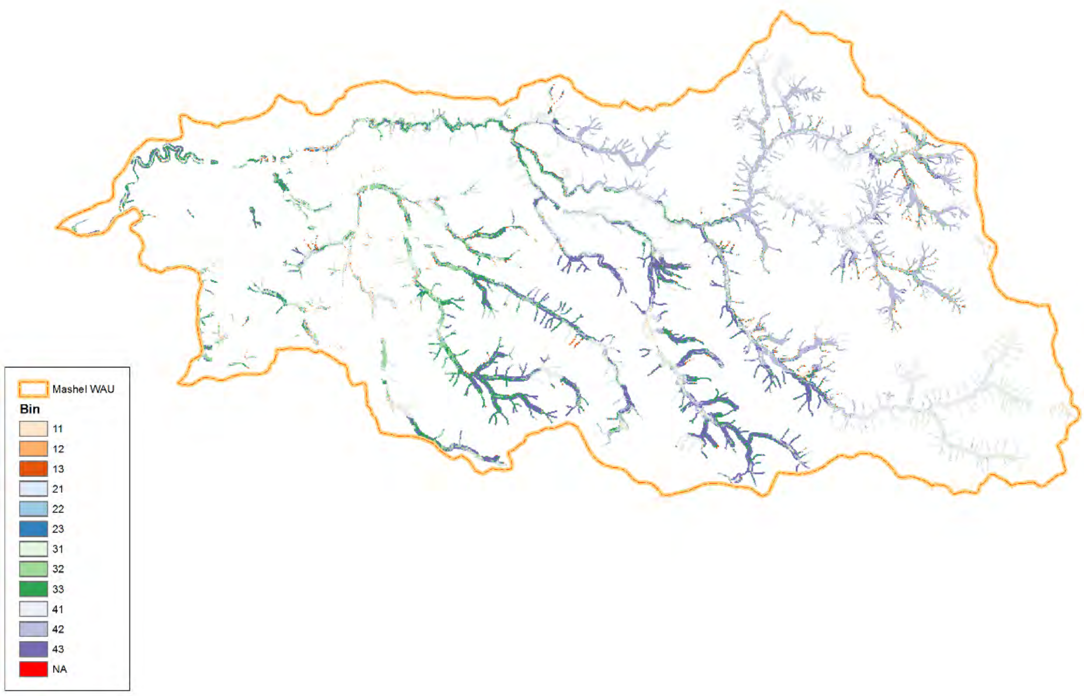


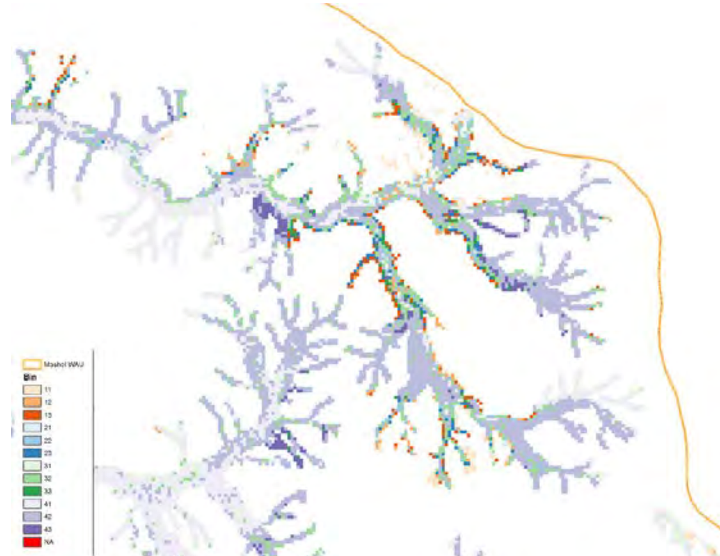
Bins



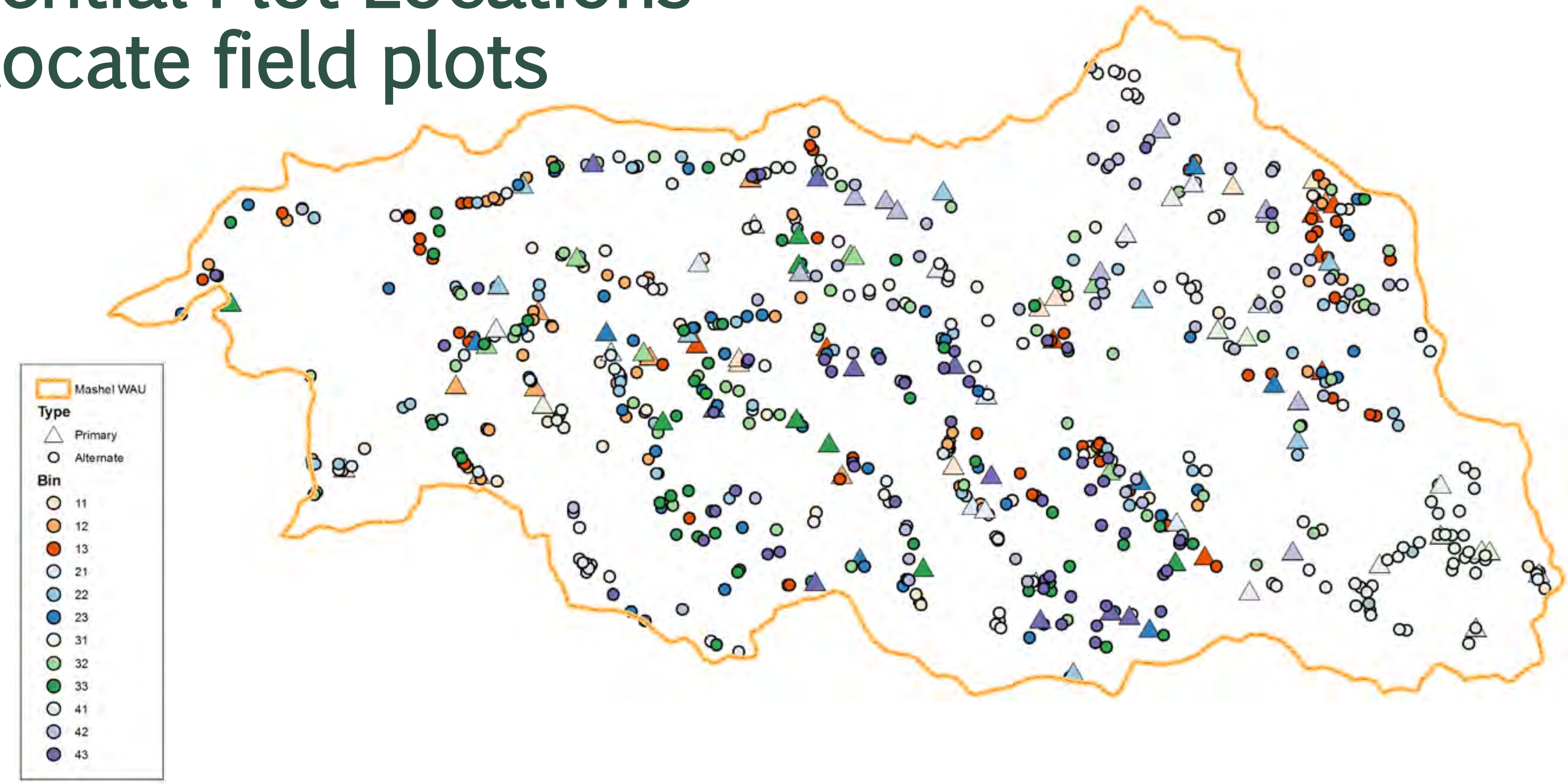
bin	pc_min	pc_max	ht_min	ht_max	percent
11	10	37	6.6	36.9	2%
12	10	37	36.9	70.8	2%
13	10	37	70.8	max	2%
21	37	64	6.6	50.1	3%
22	37	64	50.1	82.5	3%
23	37	64	82.5	max	3%
31	64	90	6.6	63.2	10%
32	64	90	63.2	94.9	10%
33	64	90	94.9	max	9%
41	90	100	6.6	70.9	19%
42	90	100	70.9	98.7	22%
43	90	100	98.7	max	15%

Assign Bins to All Potential Sample Areas





Randomly Sample from Potential Plot Locations to locate field plots



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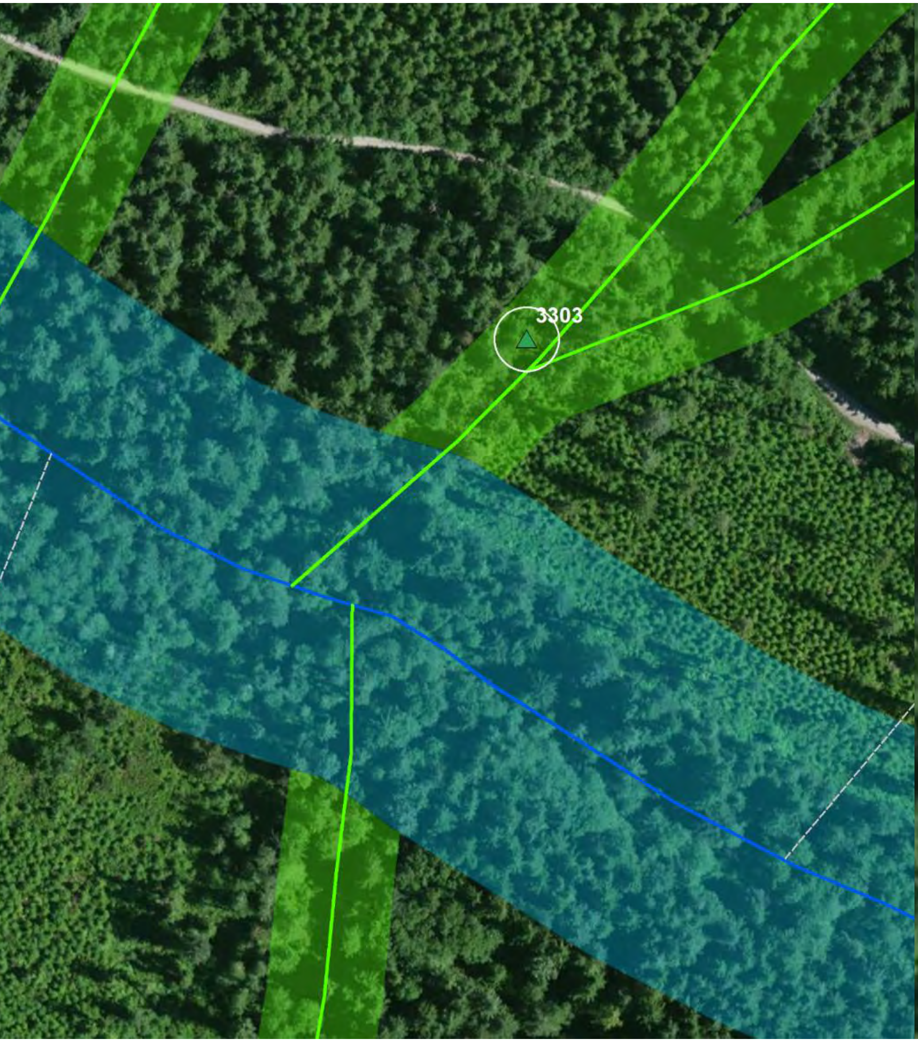
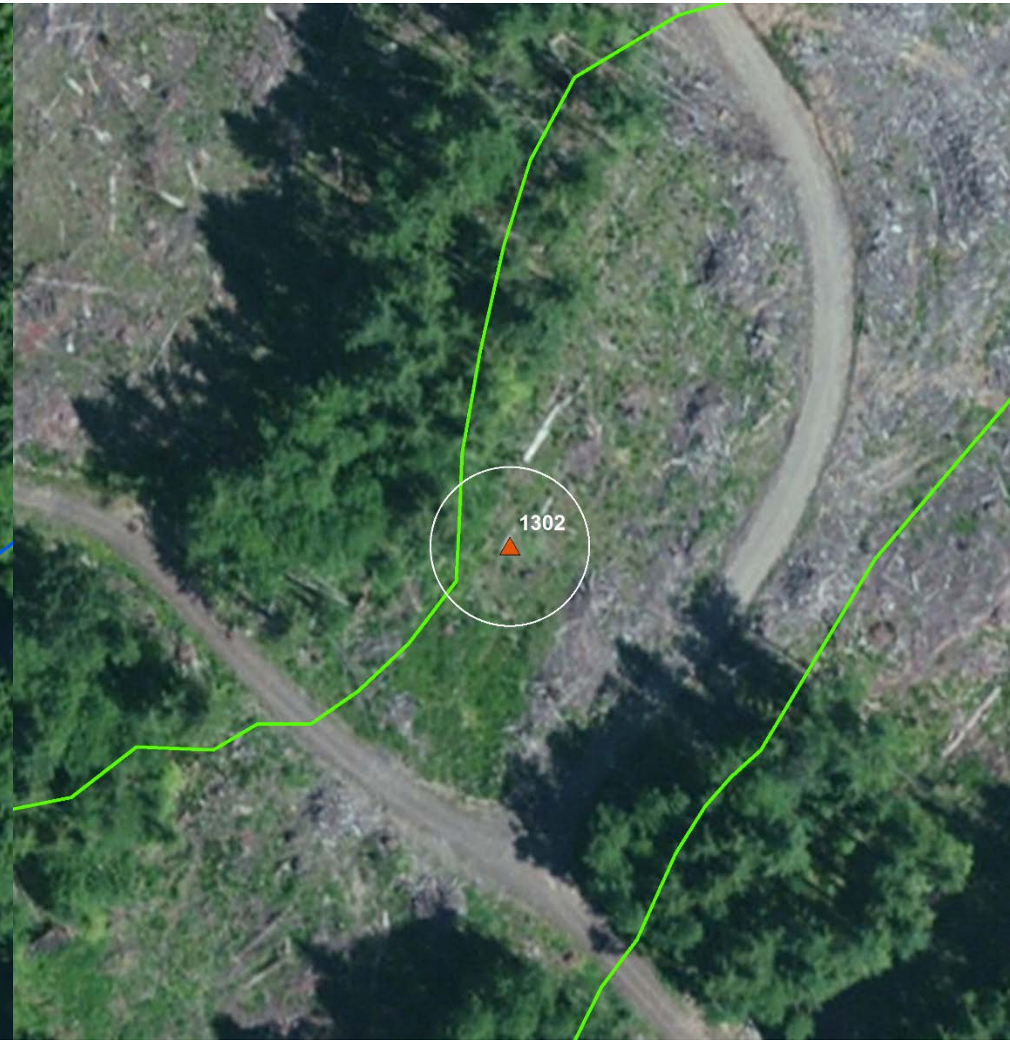


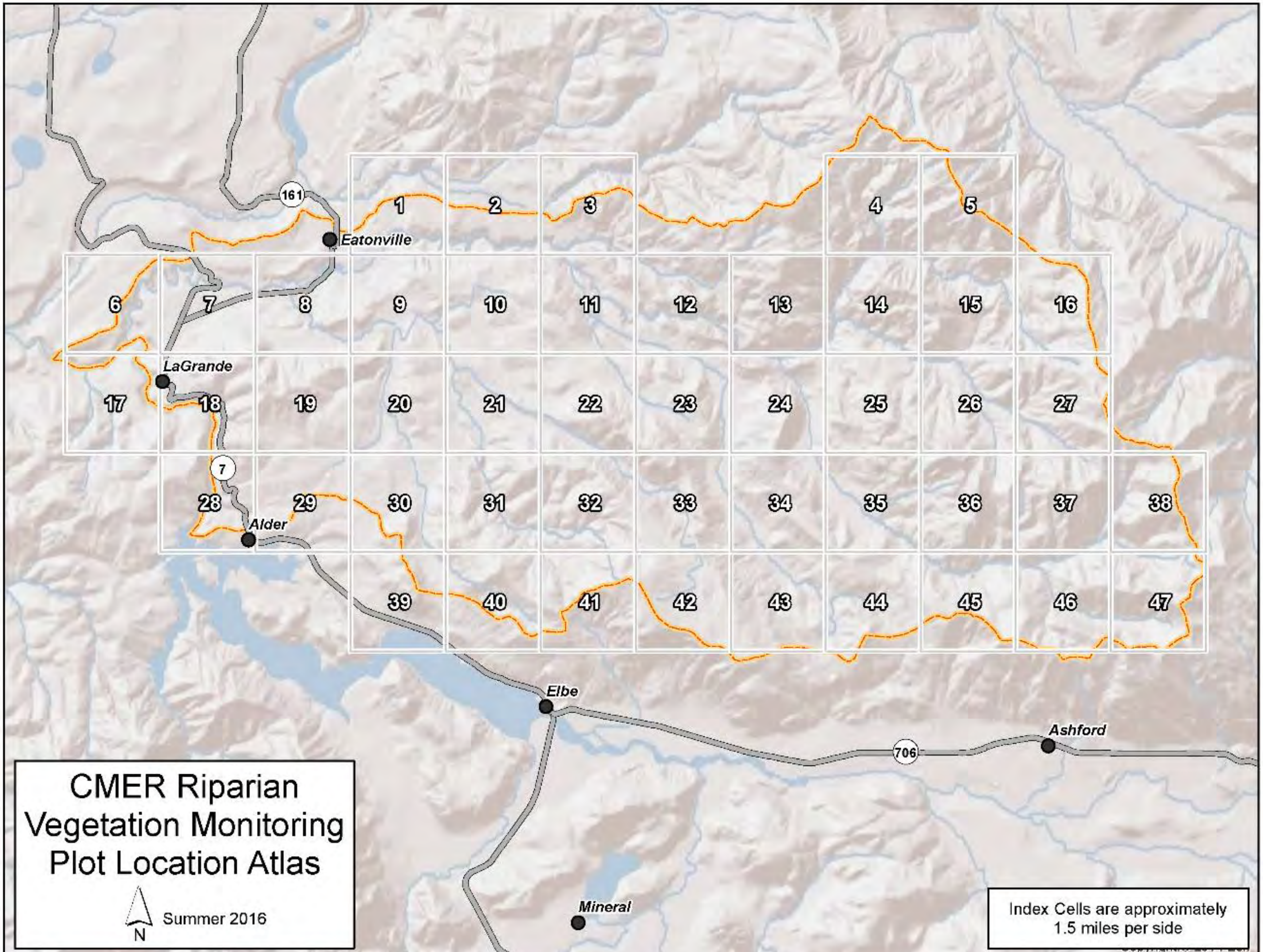
W NRSIG


2104

2104



NRSIG


CMER Riparian
Vegetation Monitoring
Plot Location Atlas
N
Summer 2016
Index Cells are approximately
1.5 miles per side
Eatonville
LaGrande
Alder
Elbe
Ashford
Mineral
161
7
706
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
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19
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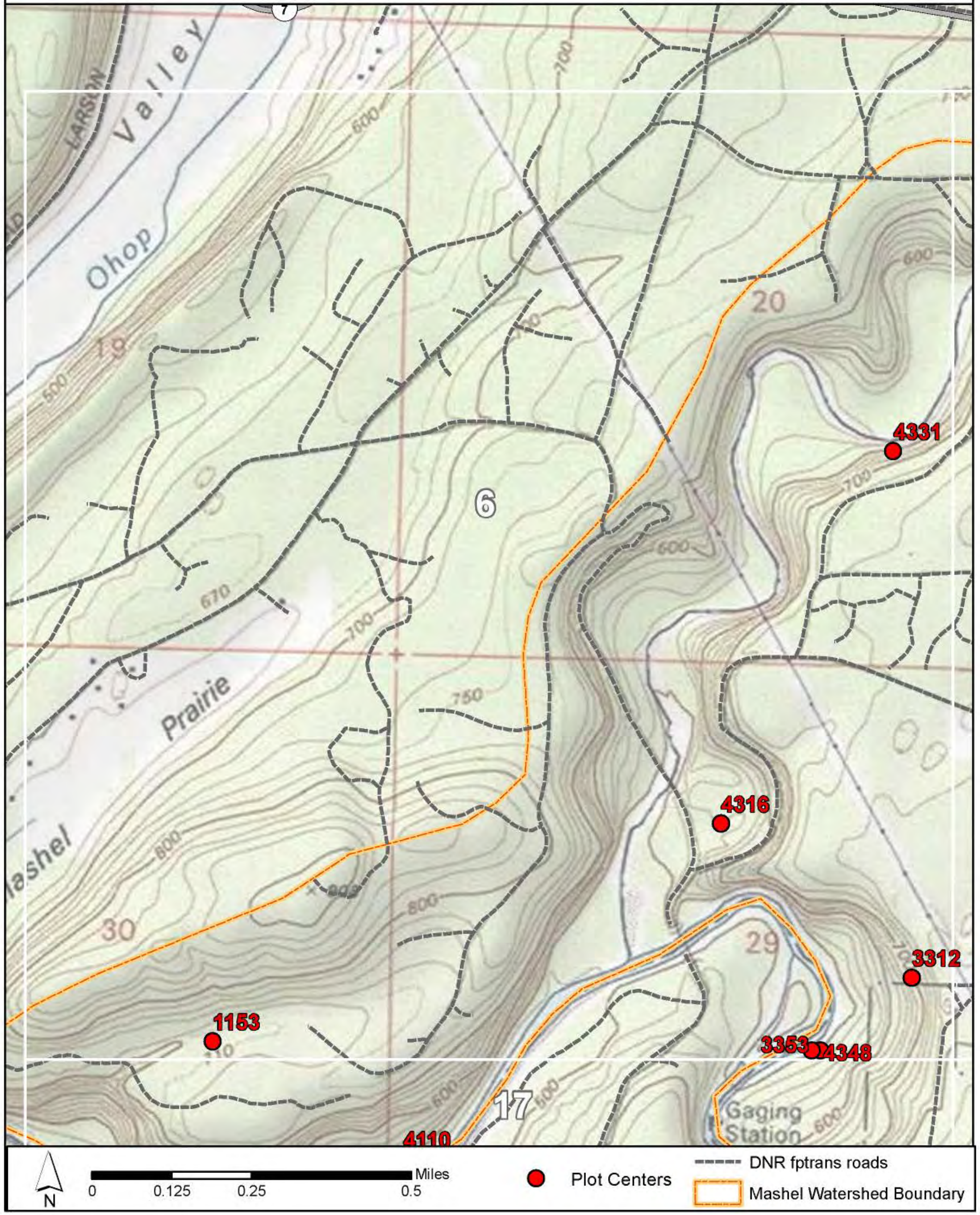
47

Map Index 6


Valley
Ohop
Prairie
Mashel
LARSON
19
20
6
30
29
17
Gaging Station
4331
4316
3312
1153
3353
4348
4110
0
0.125
0.25
0.5
Miles
N
Plot Centers
DNR fptrans roads
Mashel Watershed Boundary

Plot: 1153

Map Index: 6
Bin: 11 27 of29
Plot: 27 of 463

coordinates are in WA State Plane South, NAD83 HARN, feet

N

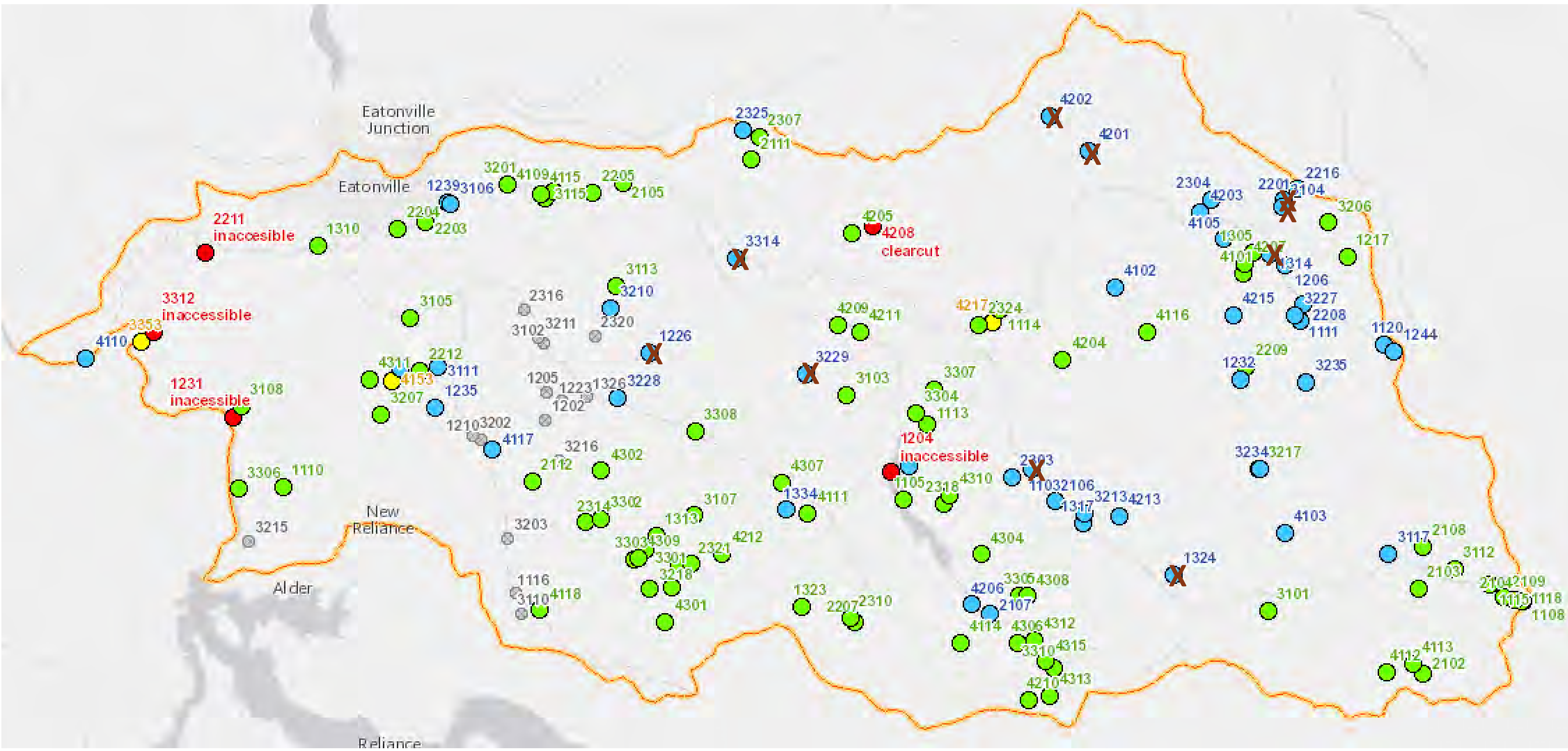
Plot Center X: 1178550
Y: 555150

0 100 200 400 Feet

white grid squares are 300 feet

Field work status

as of August 26



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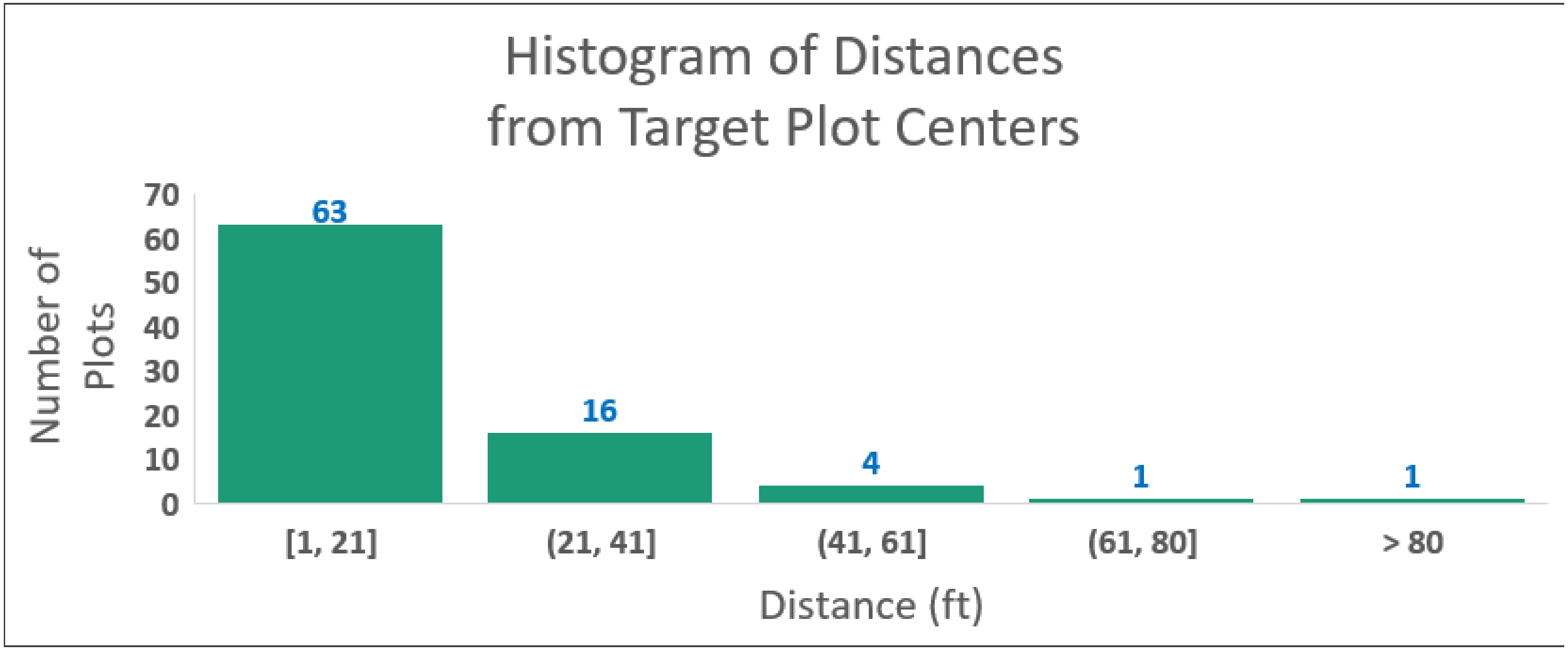
Navigation Accuracy

as of August 26



Reprocessing LIDAR and recalculating bins

Reprocessing LIDAR and recalculating bins

- True plot centers are not exactly at the intended plot centers
- Reprocess the LIDAR centered on each GPS position
- This will give us slightly different bin distributions

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CMER Stream Typing Model

Luke Rogers

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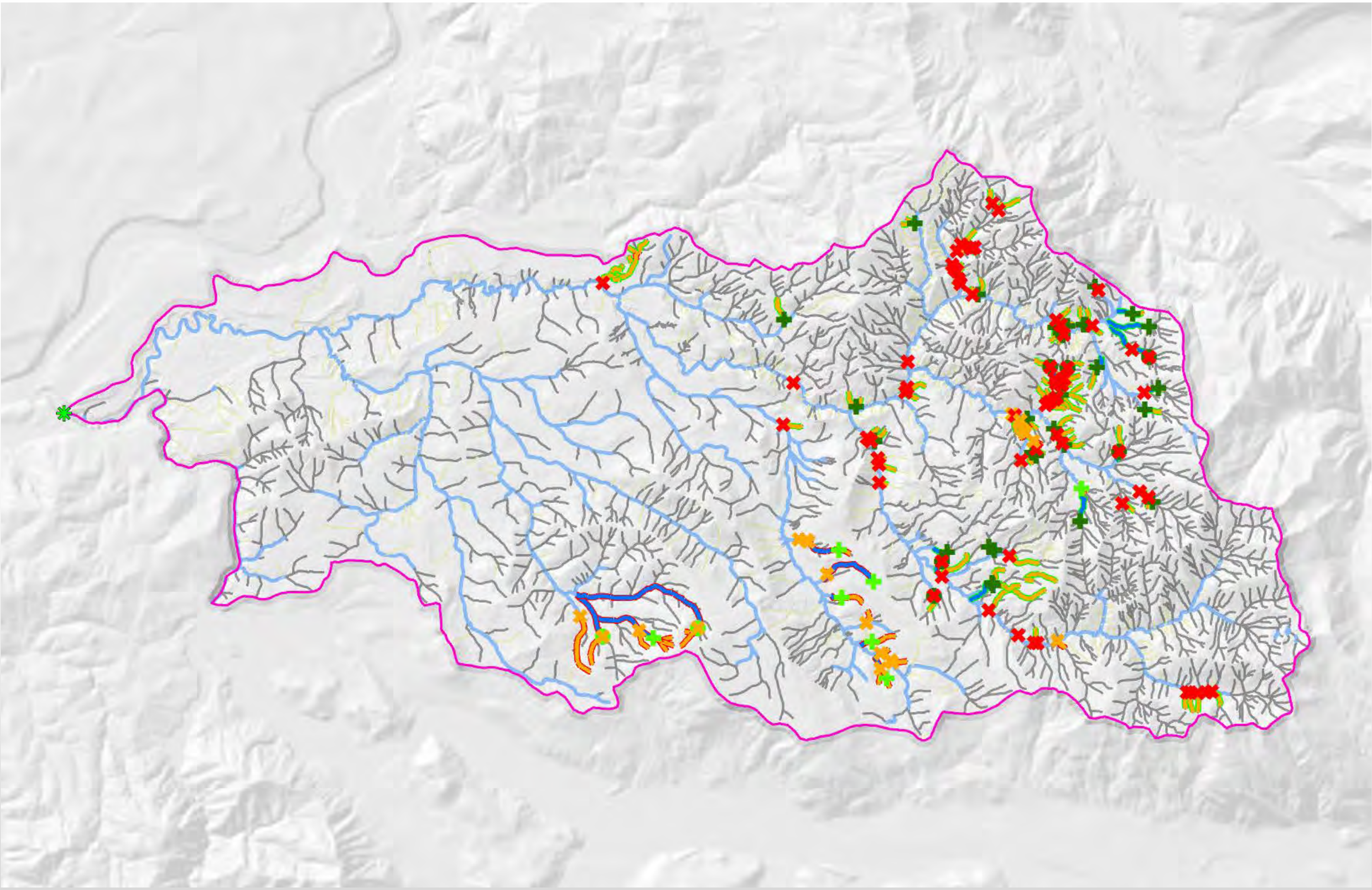
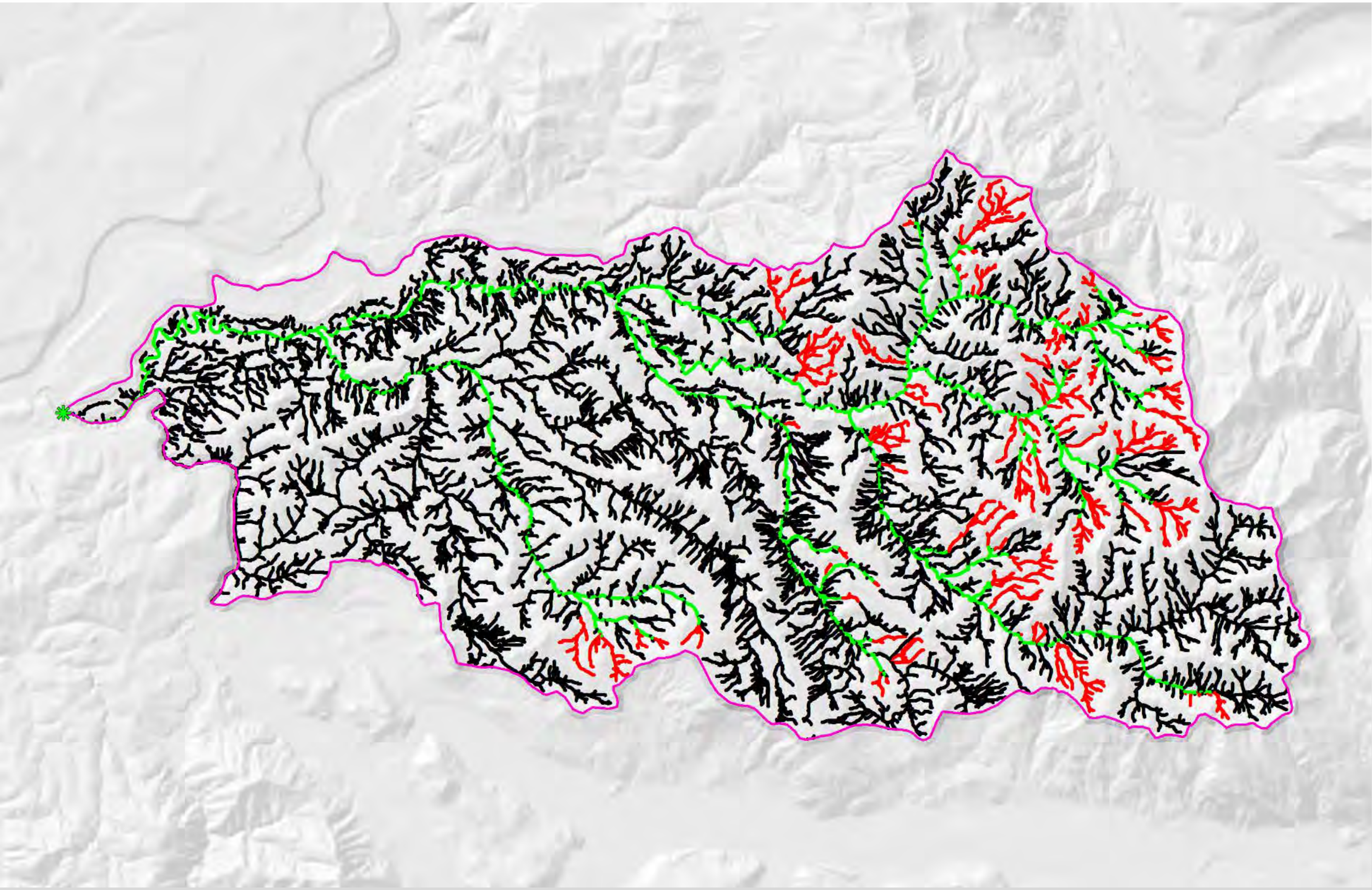
Mashel Field Data



Mashel Validation Data



Mashel Results

Logistic Model

DEM	Correct	Over	Under
LIDAR			
3	87.96%	0.85%	11.18%
10	86.22%	0.02%	13.76%
30	81.95%	0.04%	18.01%
USGS			
30	85.25%	0.11%	14.64%

Stopping Rule

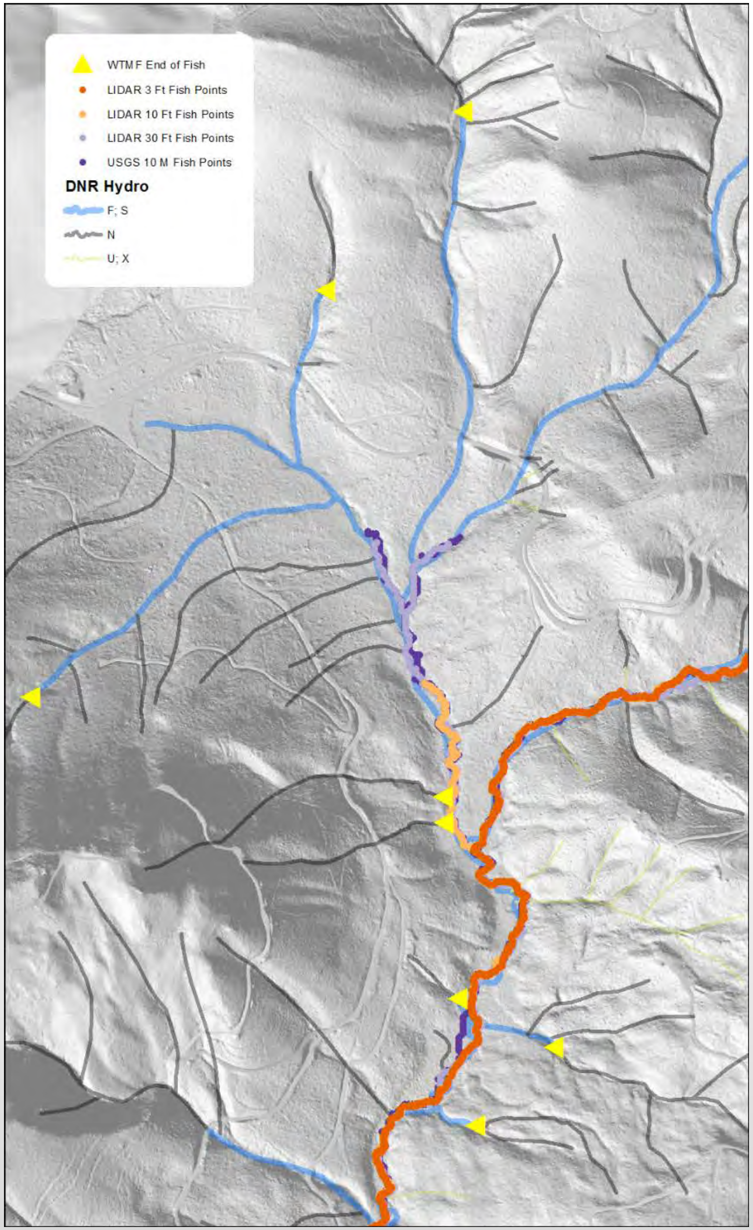
DEM	Correct	Over	Under
LIDAR			
3	88.80%	1.47%	9.73%
10	88.18%	0.10%	11.73%
30	83.56%	0.06%	16.38%
USGS			
30	87.67%	0.12%	12.21%

Stream Type	Field Verification Method	# WTMF
Fish	Biological	36
Non-Fish	Biological	66
Fish	Physical	9
Non-Fish	Physical	20

Mashel Results

Error Distances

DEM	Error Distance	Absolute Error Distance	Average Error Distance
LIDAR			
3	60,938	64,944	984
10	82,944	84,044	1,184
30	86,580	87,274	1,015
USGS			
30	81,508	83,112	966



Ecology Wetland Mapping

Luke Rogers, Andrew Cooke, Jeff Comnick

W NRSIG

Factsheet # 23

Using LiDAR and Object Based Image Analysis (OBIA) to map wetlands in Mt. Rainier National Park

This research was funded by a grant to Dr. Moskal through the USDA Forest Service MacIntire Stennis Program

UW
Understanding multiscale dynamics of landscape change through the application of remote sensing & GIS
Remote Sensing & Geospatial Analysis Laboratory

Figure 1. 3-D image of wetlands using LiDAR data

Summary: The combination of LiDAR and Object based image analysis (OBIA) provides a cost-effective approach to map wetlands across large spatial extents. LiDAR removes problems associated with tree canopy and topography while OBIA provides the ability to automate the wetland classification process.

LiDAR: LiDAR is an active remote sensor that penetrates the canopy and therefore removes any shadowing or blocking effects. We used four LiDAR derived data products; canopy surface model, ground model, LiDAR intensity image, and a slope index. Figure 1 is an example of a LiDAR point cloud colored using an aerial image.

Object based image analysis: OBIA mimics the way that humans recognize patterns. OBIA **detects** patterns within multiple data input layers, **segments** these patterns at a user defined scale and **classifies** these segments through the development of a ruleset. We used Trimble eCognition software for our analysis.

Study Area

Mt. Rainier National Park

Figure 2. The study area is located in Paradise Meadows in Mt. Rainier National Park

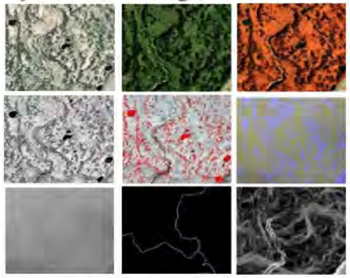
Methods

One of the strengths of OBIA is that it allows the analyst to use multiple data input layers. (Figure 3a), However, we ran the segmentation only on the LiDAR data layers (Figure 3b).We chose from hundreds of classification features (i.e. color, shape, size) to develop our classification ruleset (Figure 3c). We mapped significantly more wetlands than had been previously detected in other wetland inventories (Figure 3d).

Input Data Layers:

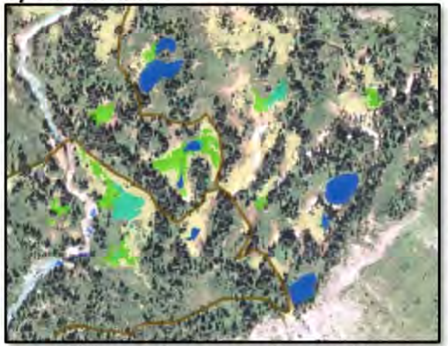
- 2006 aerial imagery
- 2009 aerial imagery
- Lidar intensity
- Lidar intensity below 2 meters
- Surface model
- Ground model
- Roads layer
- Trails layer
- Slope index

A) Pre-Processing



B) Segmentation

C) Classification



D) Results

Accuracy Assessment:

21/25 = 84% using amphibian dataset from Mt. Rainier National Park

61/64 = 95.31% using USFWS National Wetland Inventory

Figure 3. OBIA process. Pre-processing of input data (a), example of segmentation of data (b), example of classification of wetlands (c), & results using available datasets from Mt. Rainier and the National Wetland Inventory

THE ISSUE: A repeatable cost-effective approach to map wetlands over large spatial extents is needed. However, complex topography and tree canopy obscures wetlands and causes shadows, which makes wetland classification using traditional remote sensing methods infeasible.

THE KEY QUESTIONS:

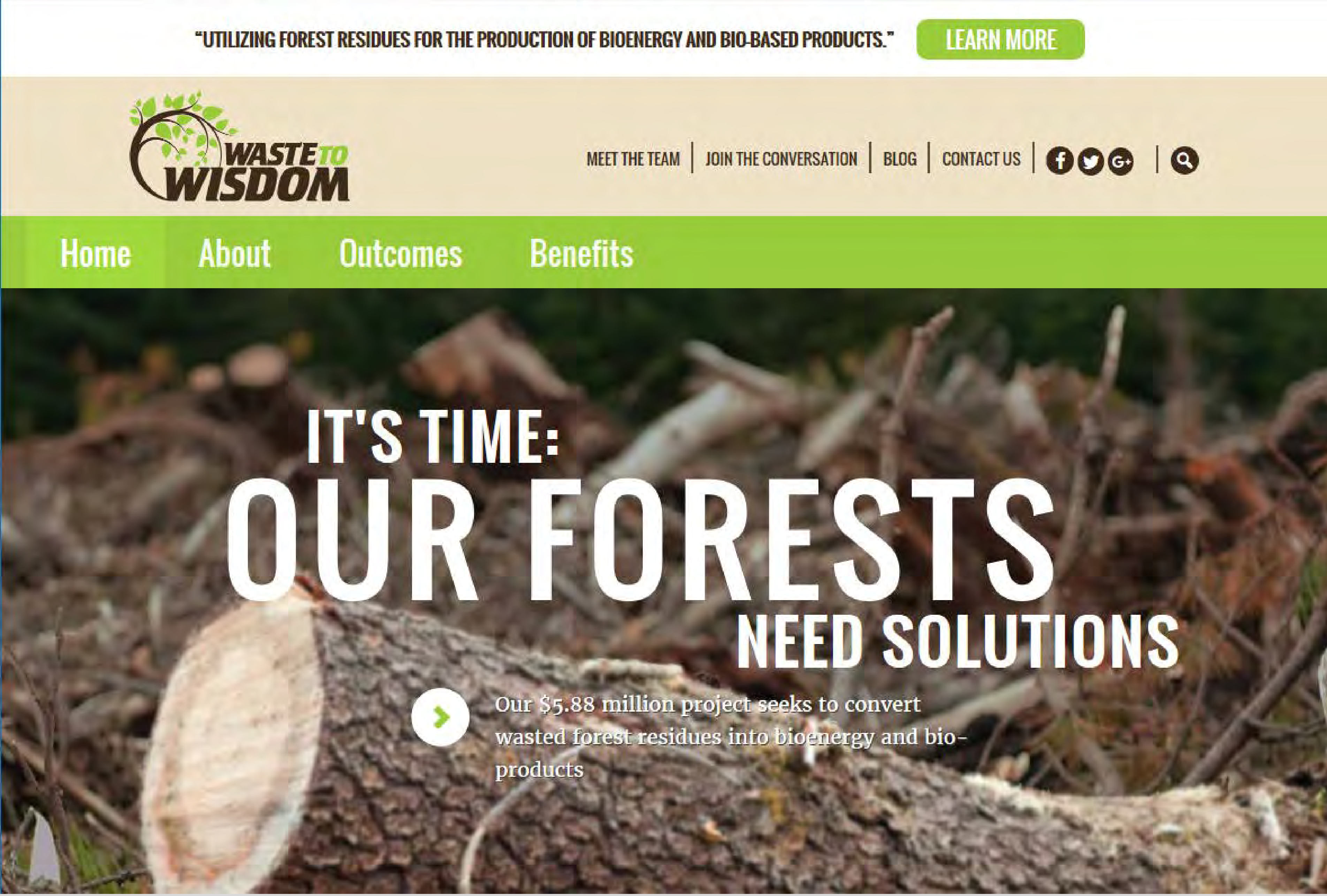
Can the use of LiDAR remove problems associated with trees and topography in the classification of wetlands?

Citation: Halabisky, M., and L.M. Moskal., 2012. Using LiDAR and object based image analysis to map wetlands in Mt. Rainier National Park. Factsheet # 23. Remote Sensing and Geospatial Application Laboratory, University of Washington, Seattle, WA. Digital version of the fact sheet can be downloaded at: http://dept.washington.edu/rsgal/

Waste 2 Wisdom

Jeff Comnick

NRSIG


"UTILIZING FOREST RESIDUES FOR THE PRODUCTION OF BIOENERGY AND BIO-BASED PRODUCTS."
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MEET THE TEAM
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Outcomes
Benefits
IT'S TIME:
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NEED SOLUTIONS
Our $5.88 million project seeks to convert wasted forest residues into bioenergy and bio-products

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Thank You

Luke Rogers

Research Scientist

lwrogers@uw.edu

Precision Forestry Cooperative
School of Environmental and Forest Sciences
College of the Environment, University of Washington
355 Bloedel Hall
Box 352100
Seattle, WA 98195-2100
(206) 543-7418

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Vegetation Management Research Cooperative

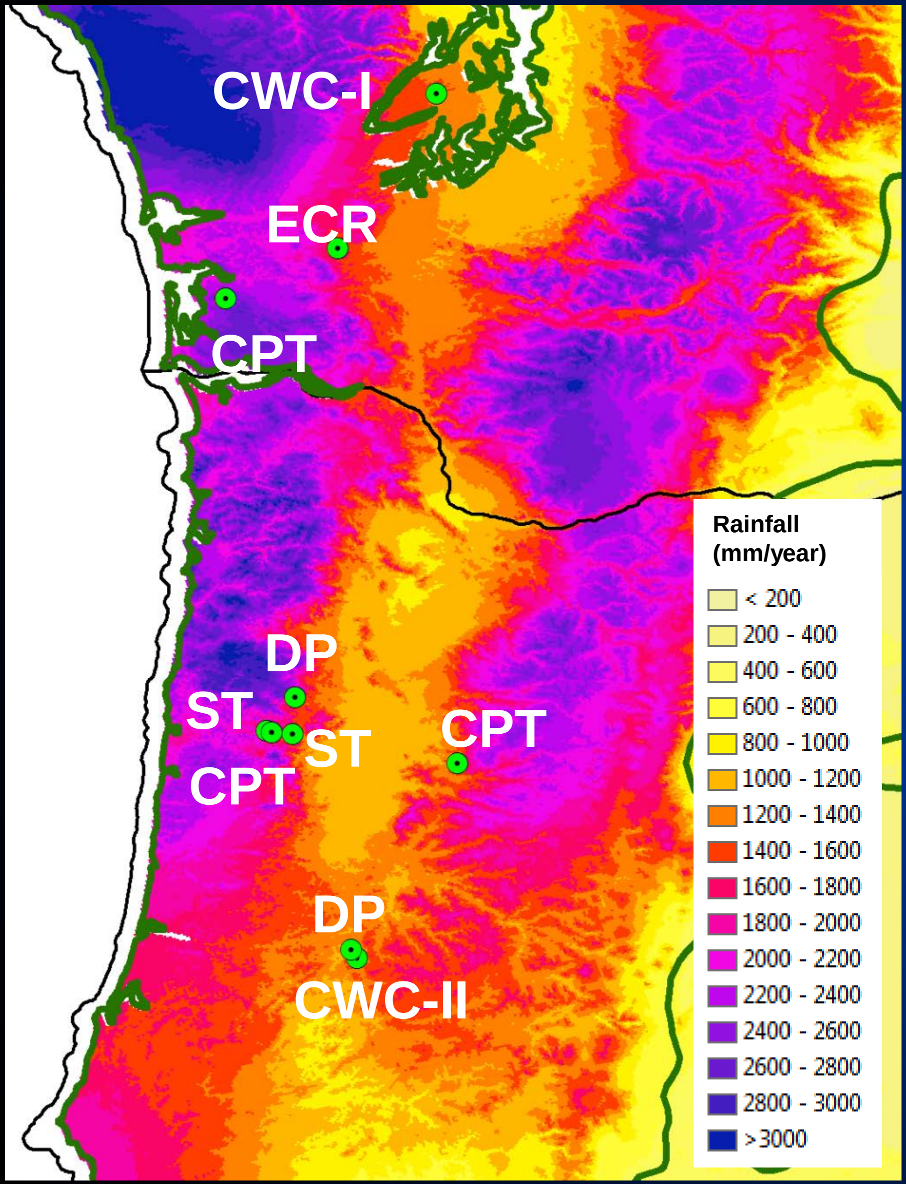
Carlos Gonzalez-Benecke

VMRC - Mission

- **Conduct applied reforestation research with an emphasis on operational vegetation management.**

- **Promote reforestation success such that survival, wood-crop biomass and growth are maximized while protecting public resources.**

VMRC – Ongoing Studies



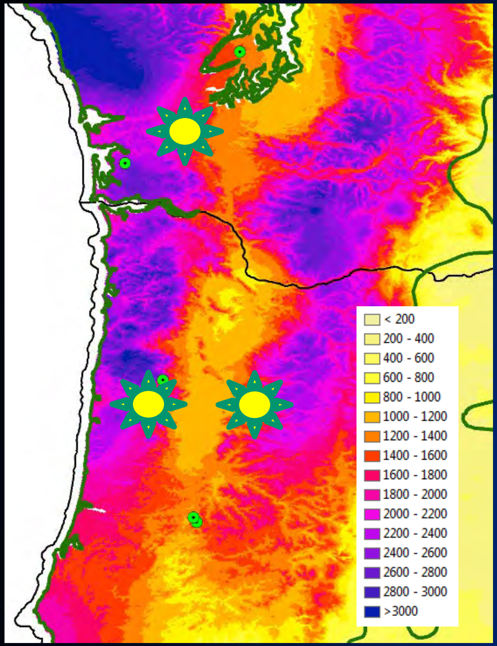
- **13 Members**
- **10 ongoing studies**
- **69 acres**
- **448 plots**
- **17,832 measurement trees**
- **Planted year: 2000 – 2012**

Full Members of the Vegetation Management Research Cooperative
Bureau of Land Management
Campbell Global, LLC
Cascade Timber Consulting
Green Diamond Resource Company
Hancock Forest Management, Inc.
Lone Rock Timber Co.
Olympic Resource Management
Oregon Department of Forestry
Oregon State University
Plum Creek Timber Co. Inc.
Rayonier Inc.
Roseburg Resources Co.
Starker Forests, Inc.
Washington Department of Natural Resources

Supporting Members
Dow Agro Sciences, LLC

VMRC – Results Examples

Integrated Analysis: VM Effects on Stand Canopy Dynamics

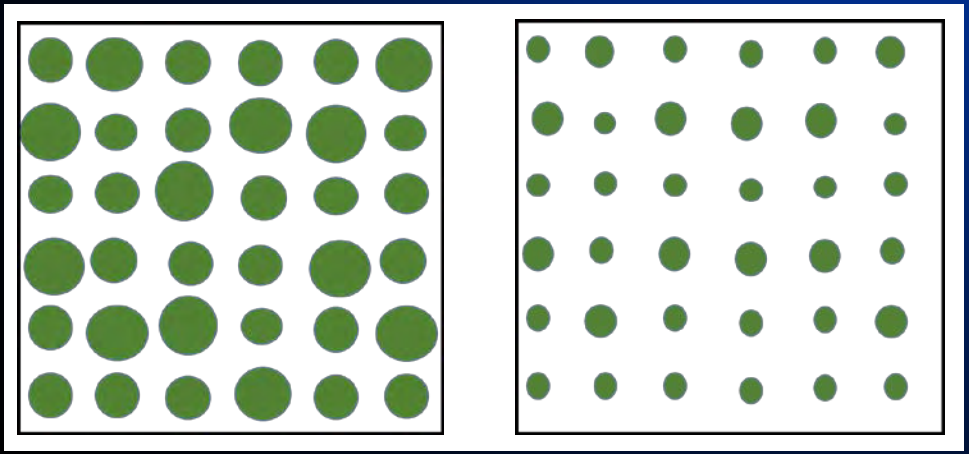


Studies measured:

- CPT01 (Starker Forests)
- CPT02 (Cascade Timber)
- ECR01 (WDNR)

Age of measurement: 1, 2, 3, 4, 5, 7 and 8

CAR = 0.6 CAR = 0.2

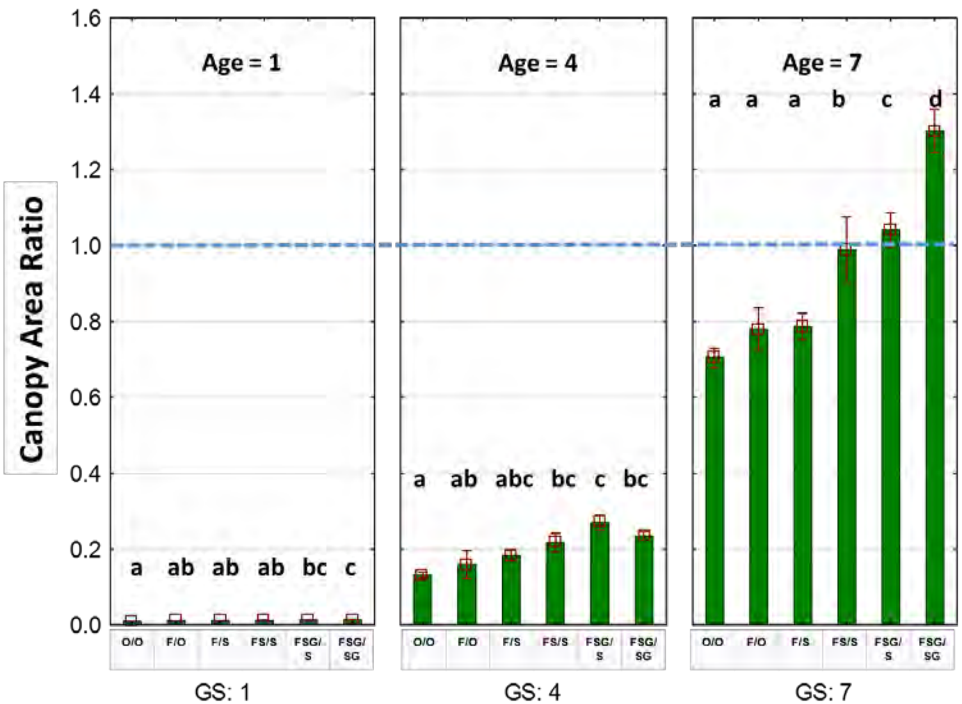


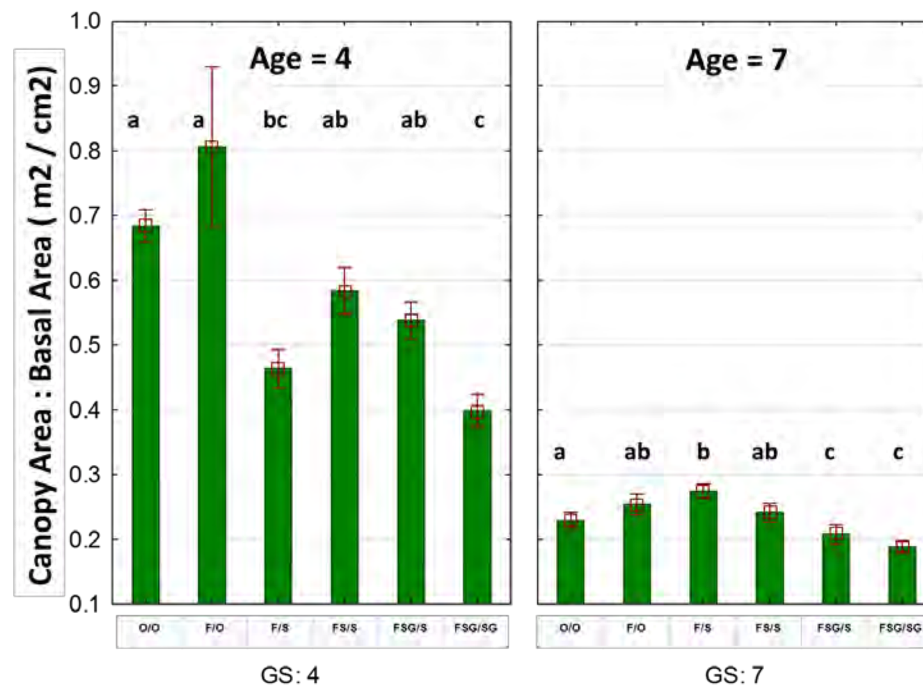
$$\text{CAR} = \frac{\sum \text{CA}i}{\text{plot area}}$$

VMRC – Results Examples

Integrated Analysis: VM Effects on Stand Canopy Dynamics

ECR01 (WDNR)



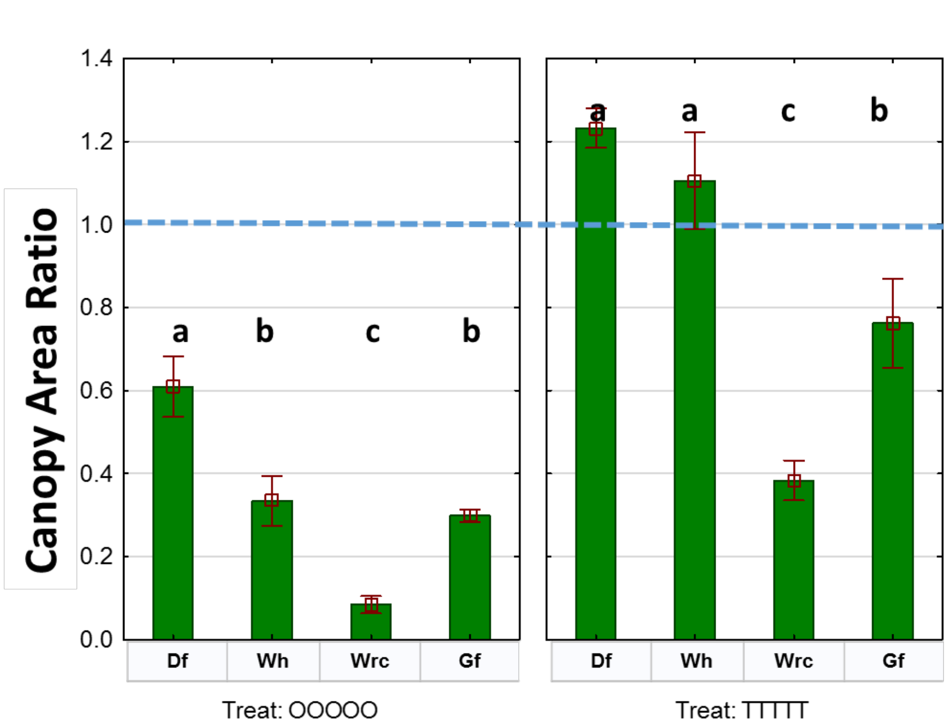


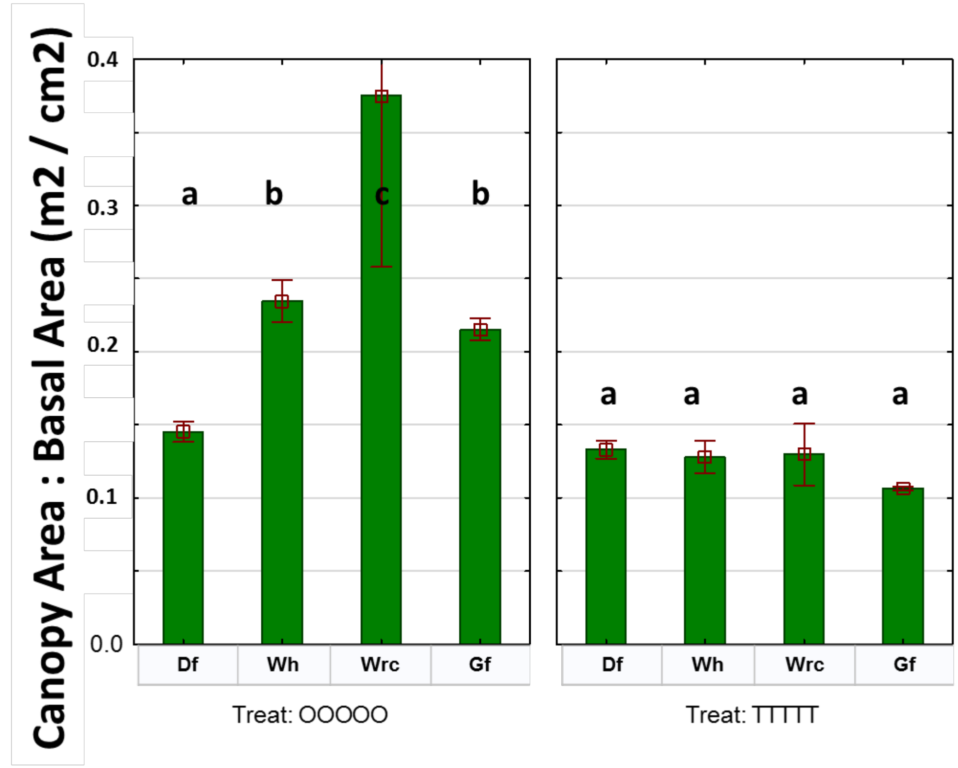
	2005	2006		2007	
Treat	Fall SP	SR	E-SR	SR	E-SR
O/O	O	O	O	O	O
F/O	SP	O	O	O	O
F/S	SP	O	O	T	O
FS/S	SP	T	O	T	O
FSG/S	SP	T	T	T	O
FSG/SG	SP	T	T	T	T

VMRC – Results Examples

Integrated Analysis: VM Effects on Stand Canopy Dynamics

CPT01 (Starker Forests)



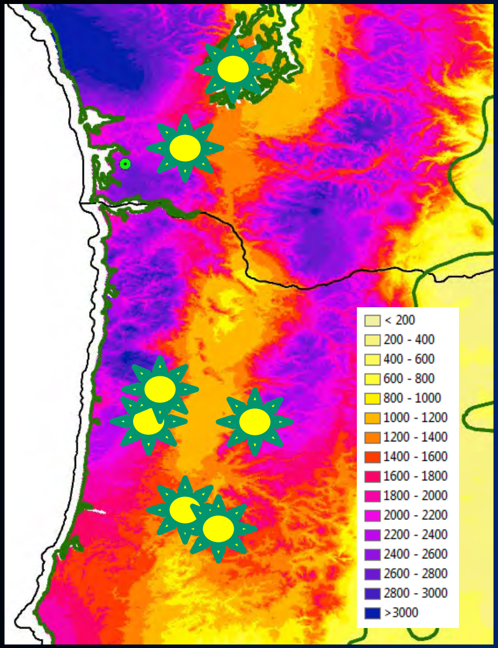


Age = 8

Treat	Fall SP	SR1	SR2	SR3	SR4	SR5
OOOOO	SP	O	O	O	O	O
TOOOO	SP	T	O	O	O	O
TTOOO	SP	T	T	O	O	O
TTTOO	SP	T	T	T	O	O
TTTTO	SP	T	T	T	T	O
TTTTT	SP	T	T	T	T	T
OTTTT	SP	O	T	T	T	T
OOTTT	SP	O	O	T	T	T

VMRC – Results Examples

Integrated Analysis: VM Effects on Vegetation Community Dynamics



CW101 (ORM)

ECR01 (WDNR)

CPT01 (Starker)
DPS01 (Starker)
CPT02 (Cascade Timber)

DPS02 (Hancock F. M.)

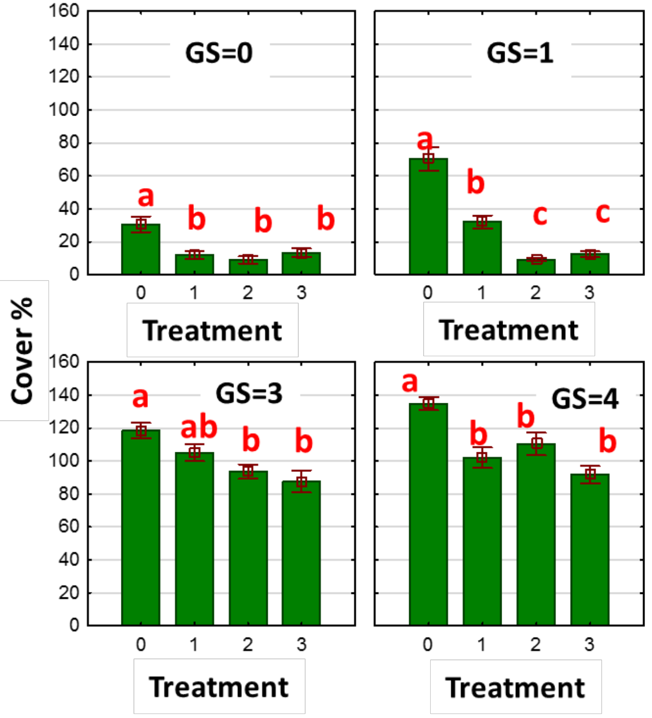
CW201 (Lone Rock Timber Co.)

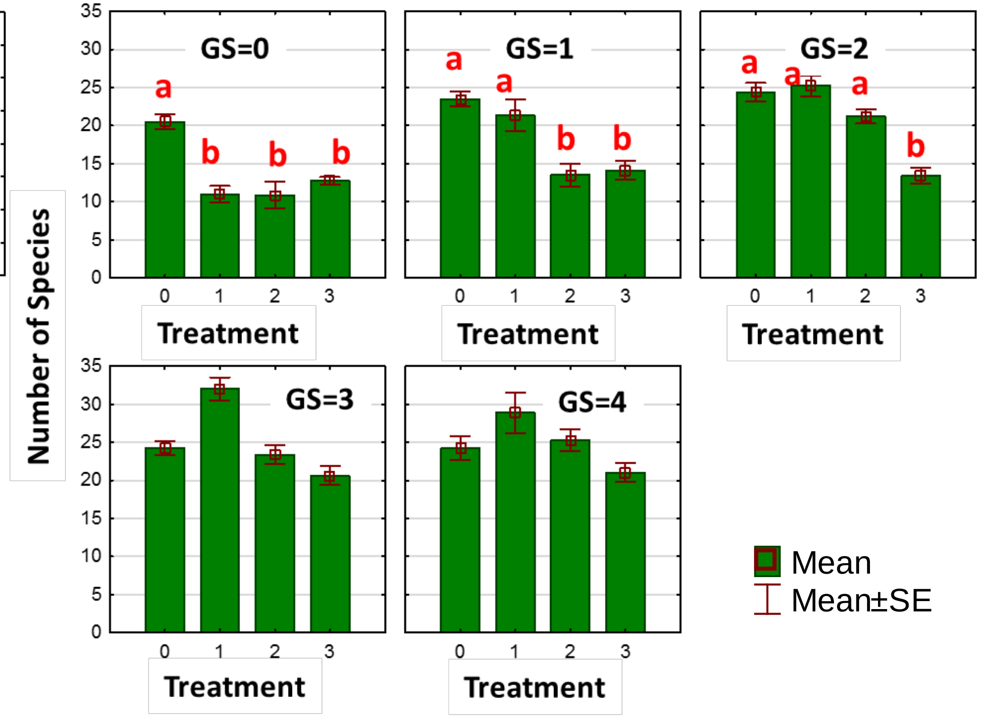
On each study selected treatments with:

- **Control : No Vegetation Management**
- **FSP : Only Fall Site Preparation**
- **FSP + SR1 : Fall Site Preparation + Spring Release Year 1**
- **FSP + SR1 + SR2: Fall Site Preparation + Spring Release Year 1 + Spring Release Year 2**

VMRC – Results Examples

Integrated Analysis: VM Effects on Vegetation Community Dynamics





Total Vegetation

Treatments
0 : Control
1 : FSP
2 : FSP + SR1
3 : FSP + SR1 + SR2

VMRC – Results Examples

Integrated Analysis: VM Effects on Vegetation Community Dynamics

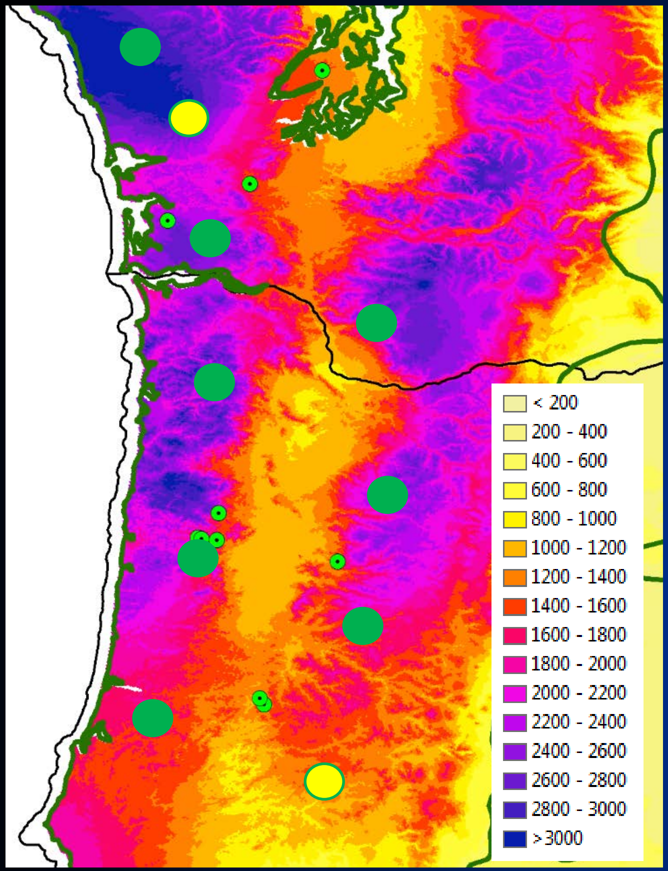
Growing Season when species Cover% is recovered (equals to control)

Habit	Cover % of Control at GS=4 yrs.	FSP	FSP + SR1	FSP + SR1 + SR2
Forb	22	1	2	3
Fern	23	>4	>4	>4
Graminoid	20	1	3	4
Shrub	22	>4	>4	>4
Tree	7	1	2	2
V/S	38	>4	>4	>4
Total	**132**	**>4**	**>4**	**>4**

Growing Season when species richness is recovered (equals to control)

Habit	Number of spp of Control at GS=4 yrs.	FSP	FSP + SR1	FSP + SR1 + SR2
Forb	15	1	2	3
Fern	1-2	-	-	-
Graminoid	2	1	2	4
Shrub	3	-	-	-
Tree	2	-	-	-
V/S	2	3	3	3
Total	**25**	**1**	**2**	**3**

VMRC - New Project



Develop a Decision Support System

"Assessing Interactions between Soil, Climate and Vegetation Management Treatments for PNW Conifer Plantations"

Treatment Type	Fall site Preparation	Spring Release Growing Season 1	Spring Release Growing Season 2
1 (000)	0	0	0
2 (010)	0	1	0
3 (001)	0	0	1
4 (011)	0	1	1
5 (100)	1	0	0
6 (101)	1	0	1
7 (110)	1	1	0
8 (111)	1	1	1

- Tier I : 2 sites for Douglas-fir (wet, dry), 1 site for Western Hemlock; 4 replicates; tree and vegetation dynamics; tree and vegetation biomass sampling; weather; soil moisture; nutrient use; ecophysiology (stomatal conductance, xylem water potential, transpiration, soil respiration).

- Tier II : +8 sites (from WA to South OR); 1 replicate ; tree and vegetation dynamics; weather.

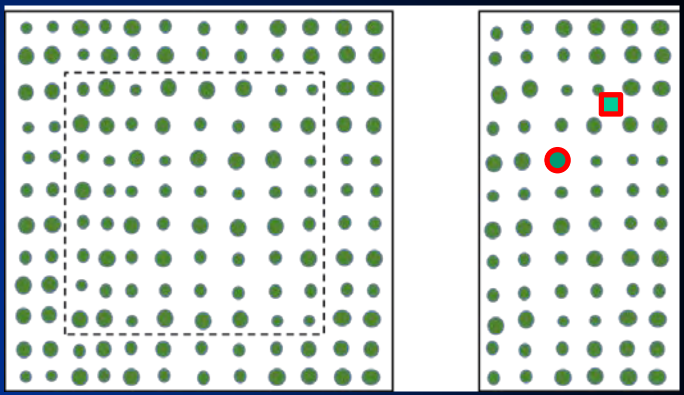
Sites selected: Tier I: Hancock Forest Management (Western Hemlock)
Tier II: OSU College Forest (Douglas-fir)
Tier II: Cascade Timber Resources (Douglas-fir)

Factorial Combinations of Vegetation Control

Number of Treatments: 8
Replicates per site: 4
Total Plots: 32
Measurement Plot: 8 x 8 trees (64 trees = 0.15 ac)
Buffer: 2 trees
Total Plot = 12 x 12 trees (144 trees = 0.29 ac)

+ Extra plot with 000 and 111
for biomass sampling

Example of plot layout



Example of block layout

Biomass	000	011	100	001
Biomass	010	110	101	111

Seasonal Sampling

Table 3. Monthly activities during the first 3 years on selected plots for Tier I study sites:

Activity	March	April	May	June	July	Aug	Sept	Oct	Nov
Seedlings diameter and height*	■		■		■		■		
Vegetation biomass and cover*	■		■		■		■		
Seedling biomass and SNA**									■
Nutrient concentration**									■
Soil moisture*	■	■	■	■	■	■	■	■	■

*: Only on two selected plots (000 and 111)
**: Only on two biomass plots

New Project

Table 5. Proposed site deployment strategy over the next 4 years.

	2017	2018	2019	2020	Total
Tier I DF		1	1		2
Tier I WH	1				1
Tier II DF	2	1	2	3	8
Tier II WH		1	1	1	3

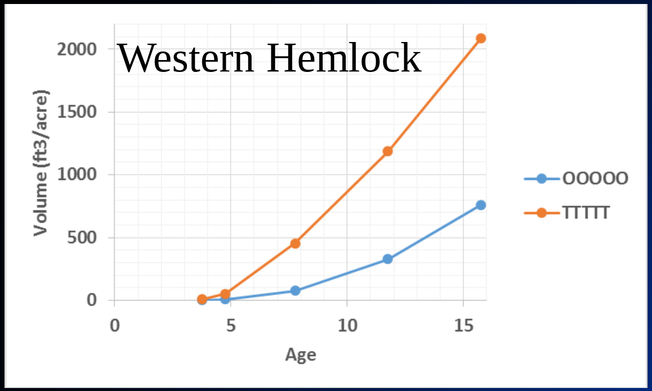
The data from all of the experimental sites will be pooled into a large database and used for region wide modelling analysis.

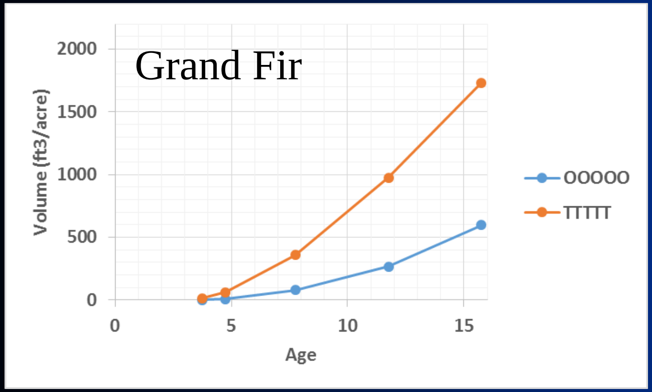
Outcomes:
Develop a process based model for the whole forest system (crop trees plus competing vegetation) to predict productivity and survival under different management and site conditions.

- Quantify and predict the effect of environmental changes on the ecophysiology and productivity of recently established DF and WH plantations interacting with competitive vegetation.
- Characterize dynamics of tree and competing vegetation demands for nutrients and water.

Current Projects

Beyond DBH and Height





"Assessments of Carbon Stock and Net Primary Productivity Responses of Four Coniferous Species on Long-term Vegetation Management Studies in the PNW"

On a 16 year-old VMRC study that includes 4 crop species (DF, WH, WRC and GF), we are measuring litterfall, tree biomass, understory biomass, forest floor and soil organic matter in two contrasting VM treatments.

Future Projects

1. G x E Interactions
   - Site-Specific Interactions of Genetics, Site and Regeneration Treatments (Vegetation Control, Planting Density, Fertilization, Mech. Site Prep.)

2. Sustainability of regeneration treatments
   - Long-term effects on water and nutrient dynamics
   - Long-term effects on biodiversity

3. Mid-rotation Vegetation Management
   - Associated to Thinning
   - Pre-Harvest

4. Stock-type x VM Interactions: Include other species (WH / WRC)

5. Ecophysiological Modeling:
   - 3-PG for young stands including the effects of VM tretments on trees and competing vegetation dynamics.

6. Operational/Specific studies: Test new herbicides (Cleantraxx)