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Evaluation of soil for sustained productivity of biofuel feedstock from coastal Douglas-fir plantations

Kim Littke, Rob Harrison, Scott Holub, and Jeff Hatten

May 4, 2016

Northwest Wood-Based Biofuels + Co-Products Conference

COLLABORATION

- **NARA LTSP**
  - UW - Rob Harrison, Marcella Menegale
  - OSU - Jeff Hatten, Adrian Gallo, Jim Rivers, Matt Betts
  - Weyerhaeuser Co. – Scott Holub
- **Fall River, Matlock, and Molalla LTSPs**
  - Weyerhaeuser Co. – Scott Holub
  - Green Diamond Resource Company
  - Port Blakely Tree Farms
  - UW – Christiana Dietzen, Rob Harrison
  - FS – Tim Harrington, Robert Slesak
- **SMC Type V Paired-tree Fertilization Study**
  - UW – Kim Littke, Jason James, Austin Himes, Rob Harrison
- **Stump and Root Decomposition**
  - UW – Matt Norton, Rob Harrison

ENVIRONMENTAL SUSTAINABILITY

Part of NARA's Mission:

... meet the high environmental standards of the Pacific Northwest.

UNDERSTANDING FOREST RESILIENCE TO BIOMASS REMOVALS

Concern:

Removing slash removes nutrients and compacts soil.

Question:

Does slash harvest for biofuel feedstock affect future site growth capacity?

Pathway

SOIL PRODUCTIVITY

- Large range in soil productivity in the coastal Pacific Northwest
- Three distinct soil parent materials
  - Glacial, Igneous, and Sedimentary

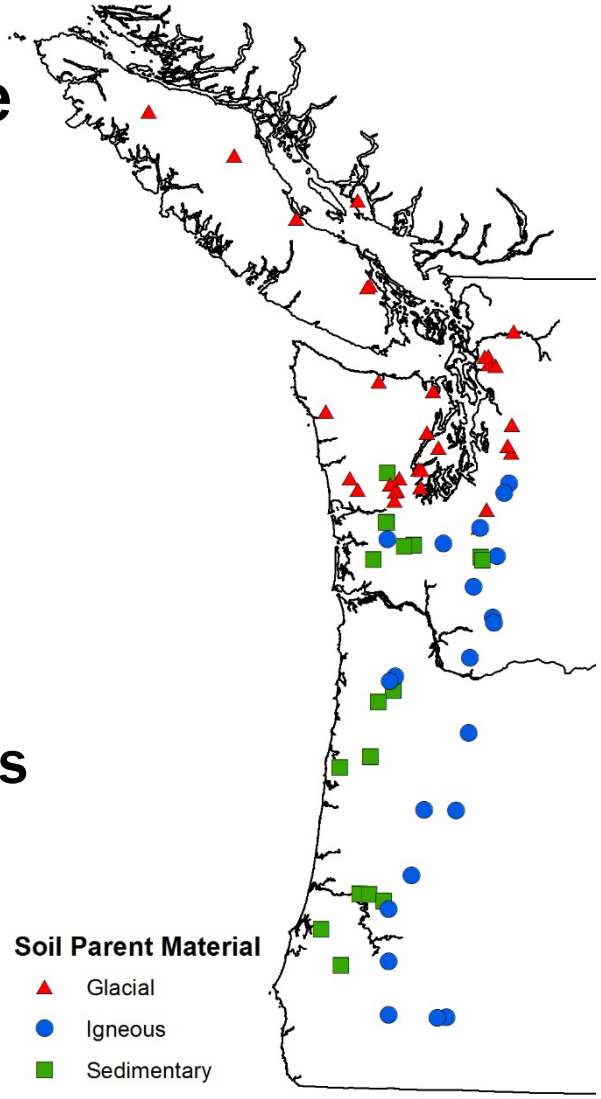
Young → Old soils

Coarse → Fine texture

Poor → High productivity

Low → High soil N contents

- Large effect of soil type on site productivity



SAMPLING

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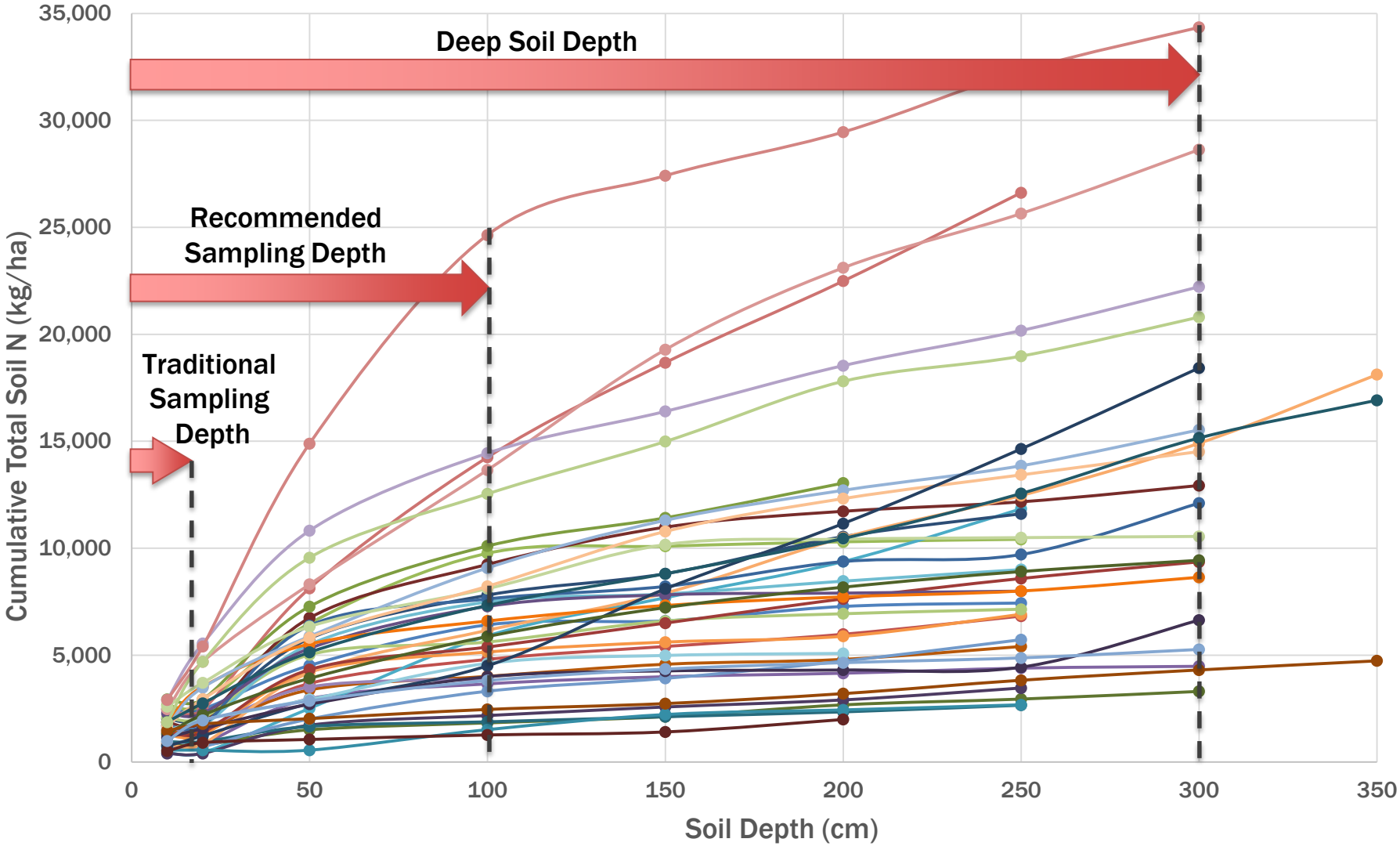
SOIL N CONTENT BY DEPTH



James et al. 2013

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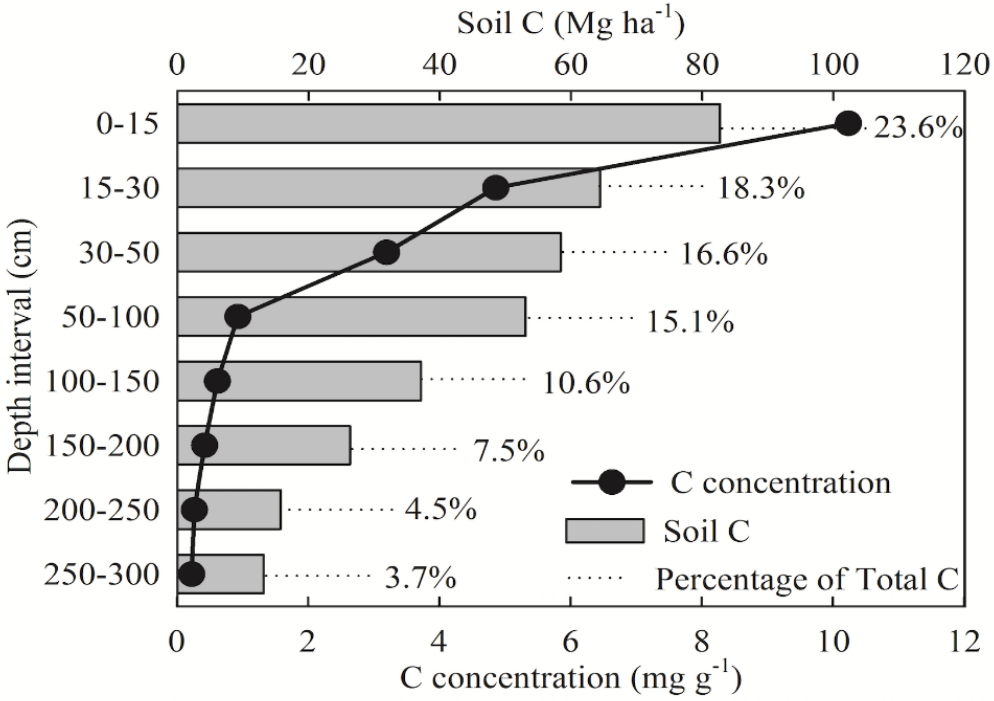
DEEP SOIL CARBON AT FALL RIVER LTSP



- Carbon and N ratios are similar throughout the profile
- Fall River is an extremely high productivity soil
- Nutrients by depth
  - 0-15 cm – 23%
  - 15-100 – 50%
  - 100-300 – 27%

Dietzen in review

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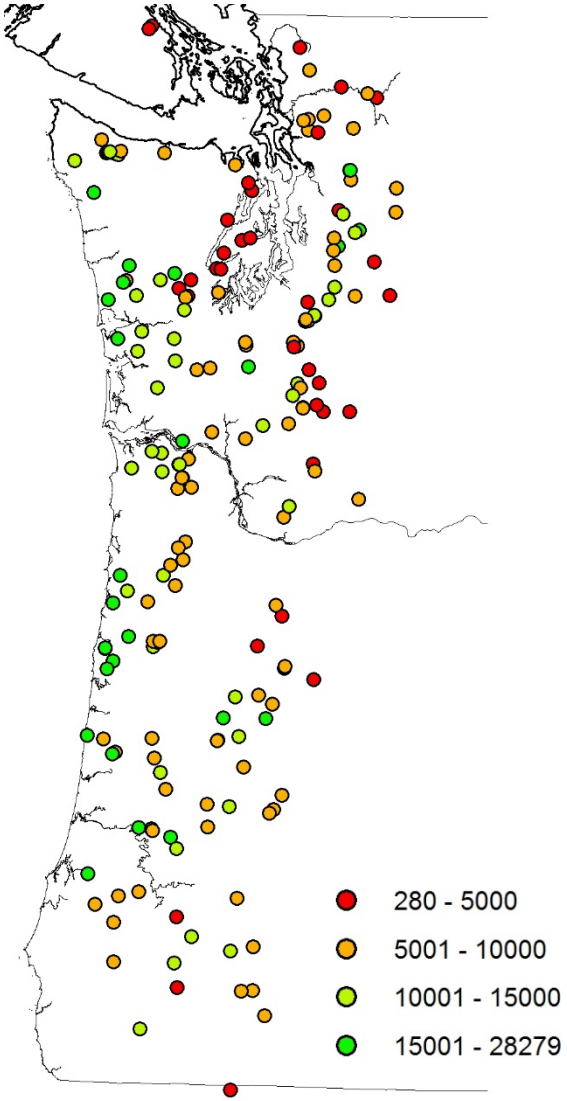
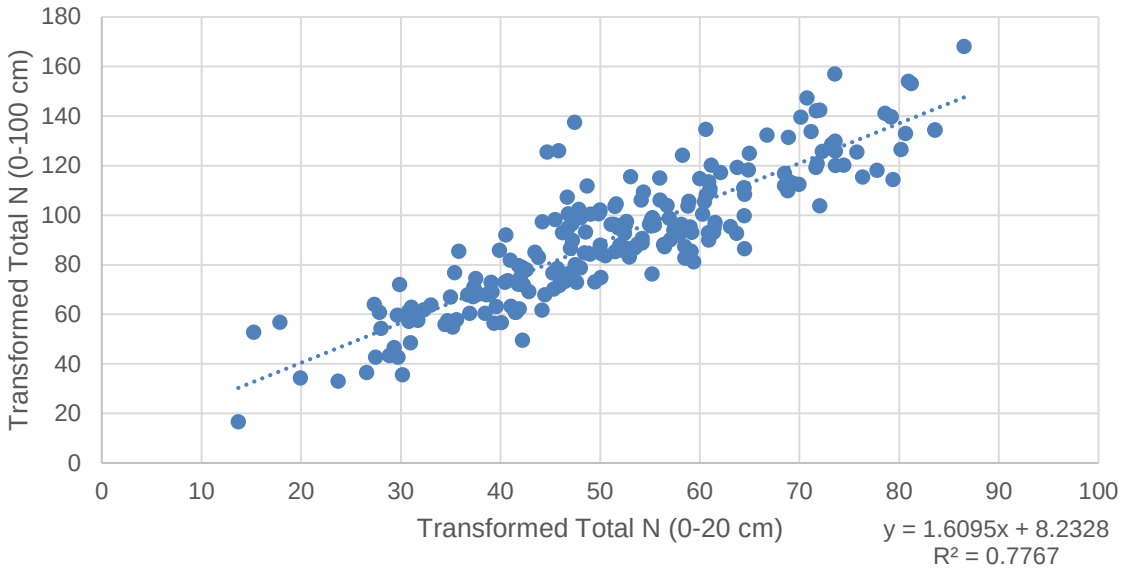
RANGES OF SOIL N CONTENTS





- Large measured variation in soil nutrition (N) in the region
- Forest Inventory and Analysis (FIA) program measured to 20 cm
- 28-92% of soil N below 20 cm
- We can use the associations between shallow and deep soil to estimate deep N on FIA plots

Littke et al. 2011; Holub et al. 2011; James et al. 2015

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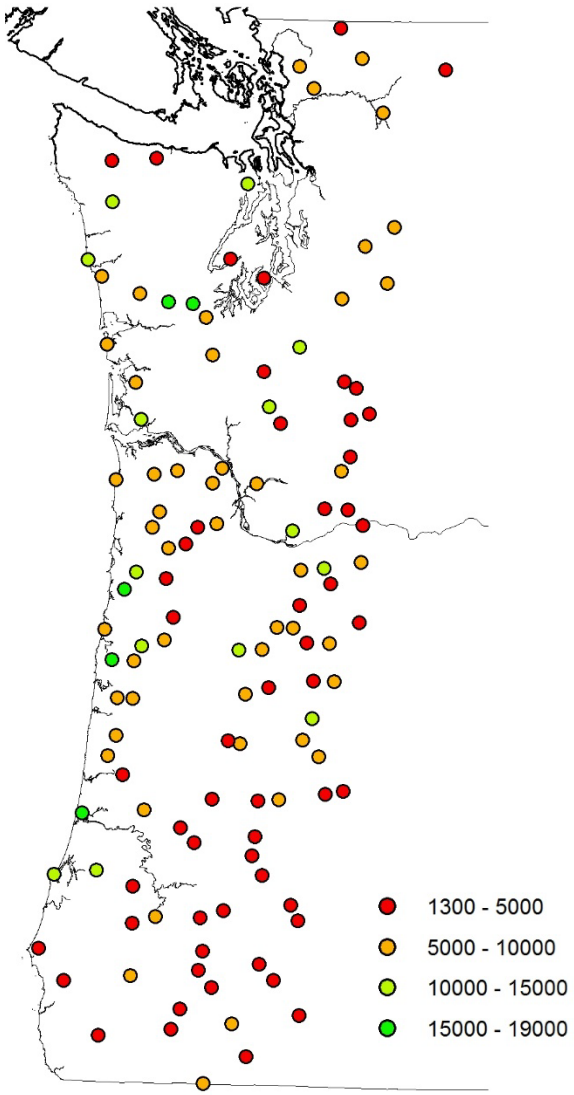
FIA SOIL DATA



- Expanded FIA data from 20 cm to 100 cm
- However, estimated N relationships don't follow spatial relationships of measured data
- Supports more examination of deep soil nutrients

Littke et al. 2011; Holub et al. 2011; James et al. 2015

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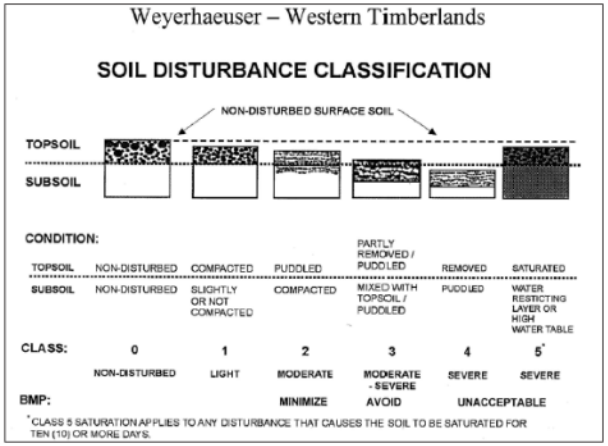
HARVESTING IMPACTS ON LONG-TERM SOIL PRODUCTIVITY

- Harvest



- Compaction/Disturbance

- OM removal

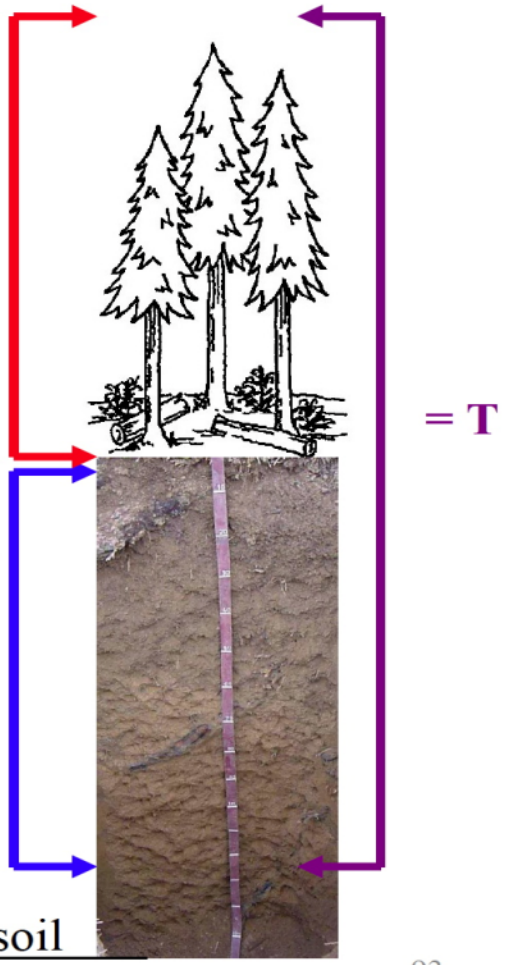
Nitrogen Risk Ratings - Generalized Concept

Proportion of site N pool removed:

Increasing risk (after Evans, 1999)

Low	Serious	Imminent decline
0.1	0.3	0.5

A =



= T

Bole-only removal = 0.05 (5%) [Johnson et al. 1982]

Total-tree removal = 0.10 (10%) [Johnson et al. 1982]

S =

Fall River: Total-tree plus forest floor removal = 0.09

Boistfort soil

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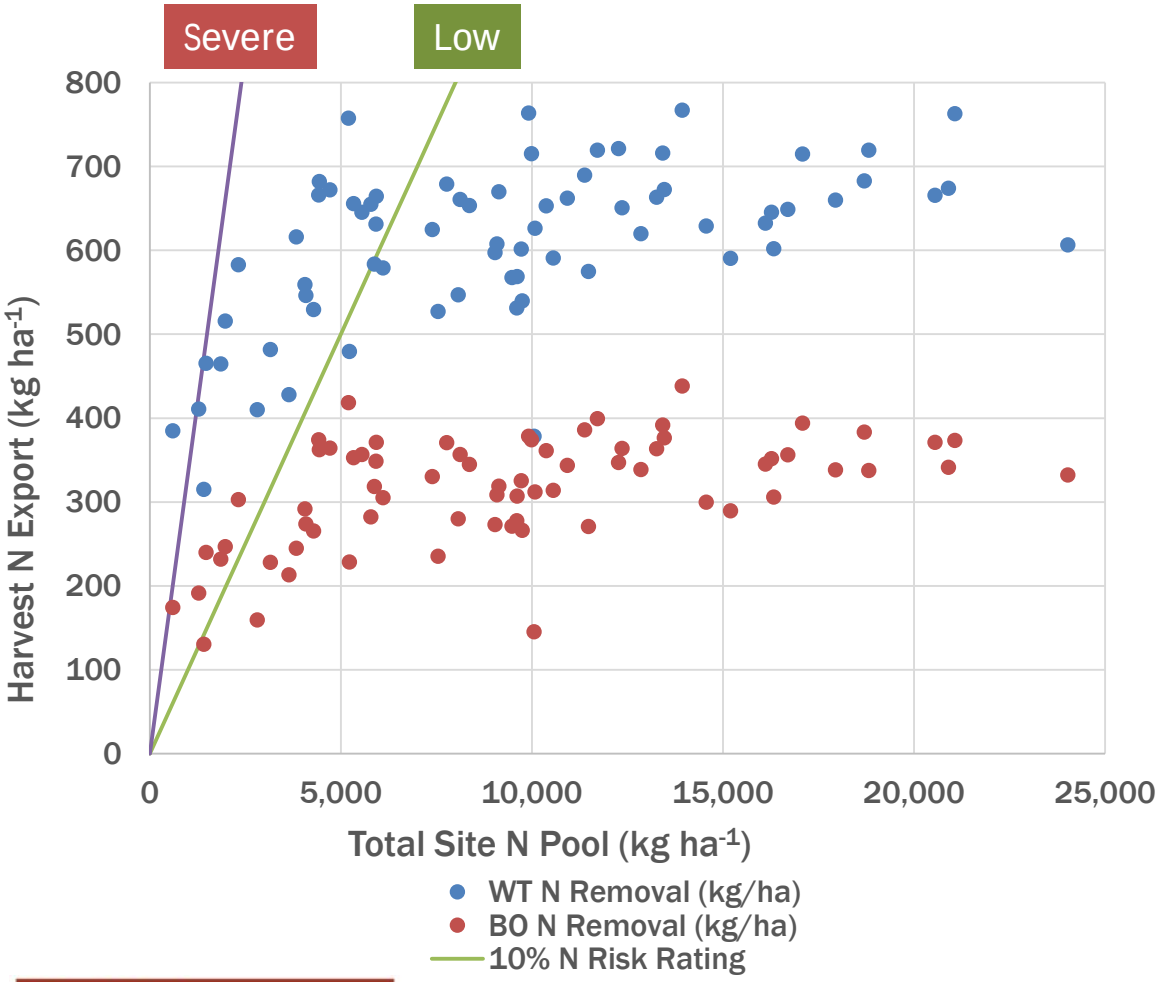
EFFECT OF HARVEST ON N RISK RATINGS



- Much larger removal from WT harvest
- Many stands with <low N risk ratings
- WT harvest results in more stands with low-severe N risk ratings
- Only one stand with severe N removal risk

Himes et al. 2013

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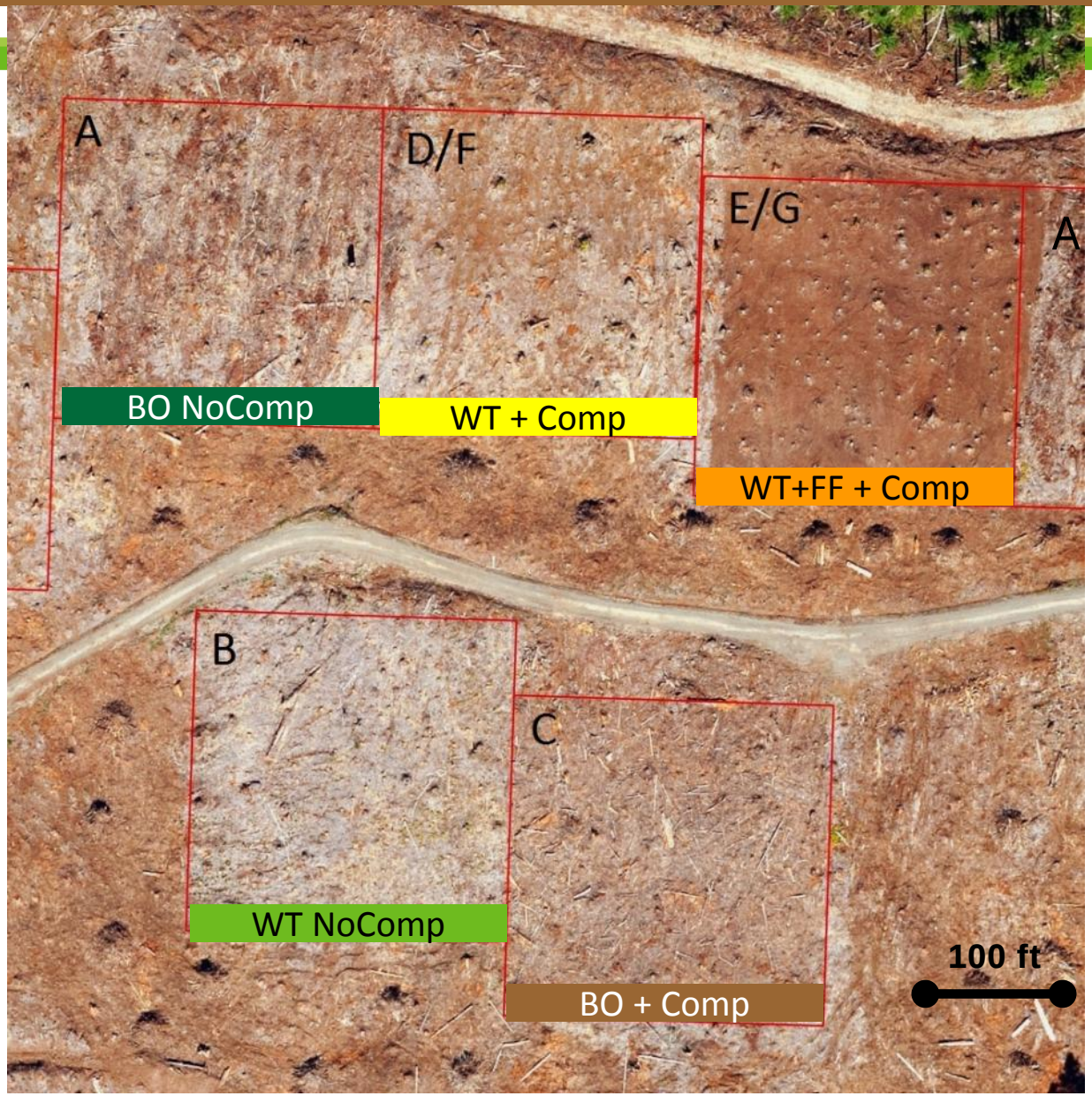
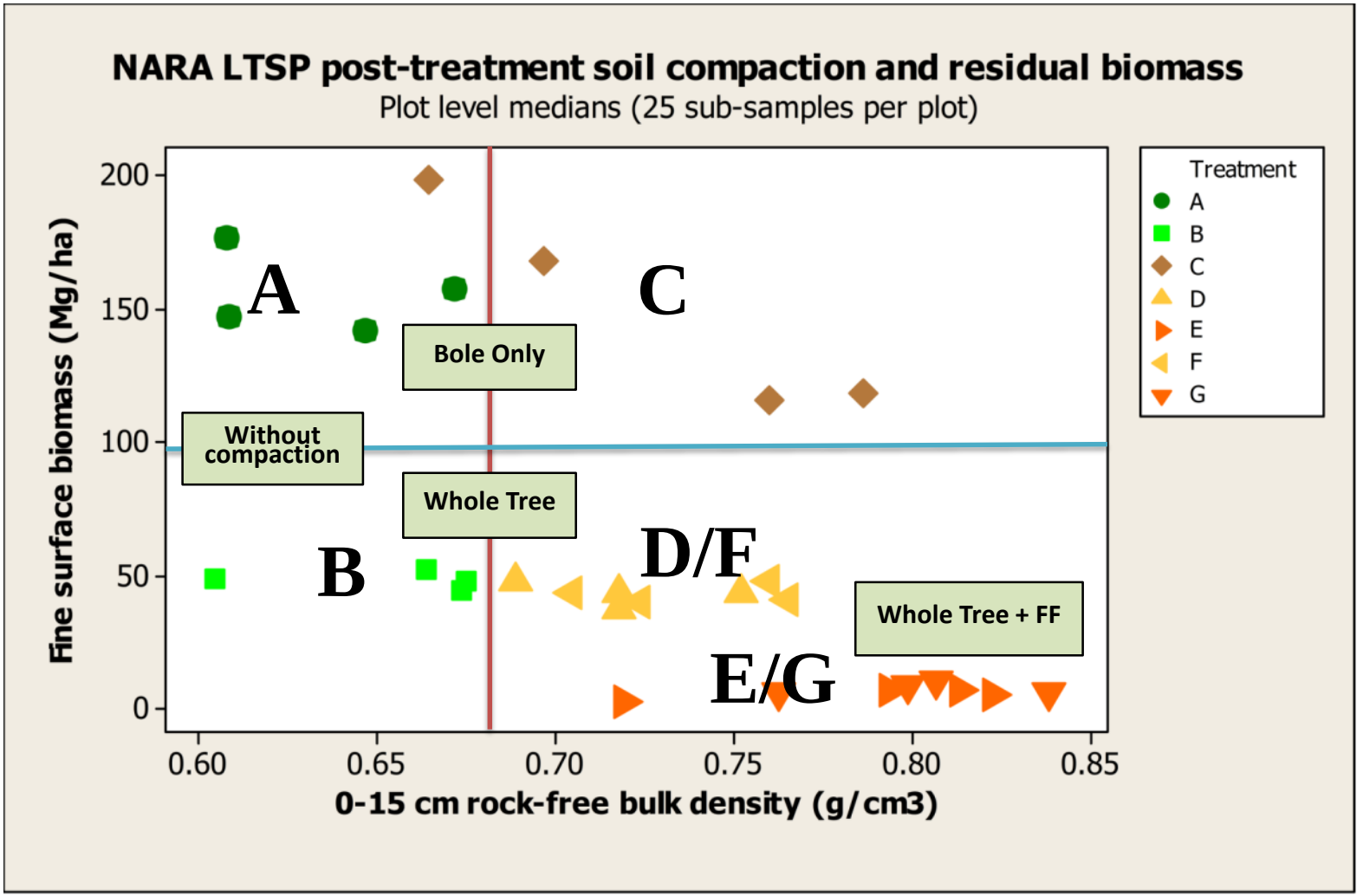
NARA POST-TREATMENT AERIAL PHOTO



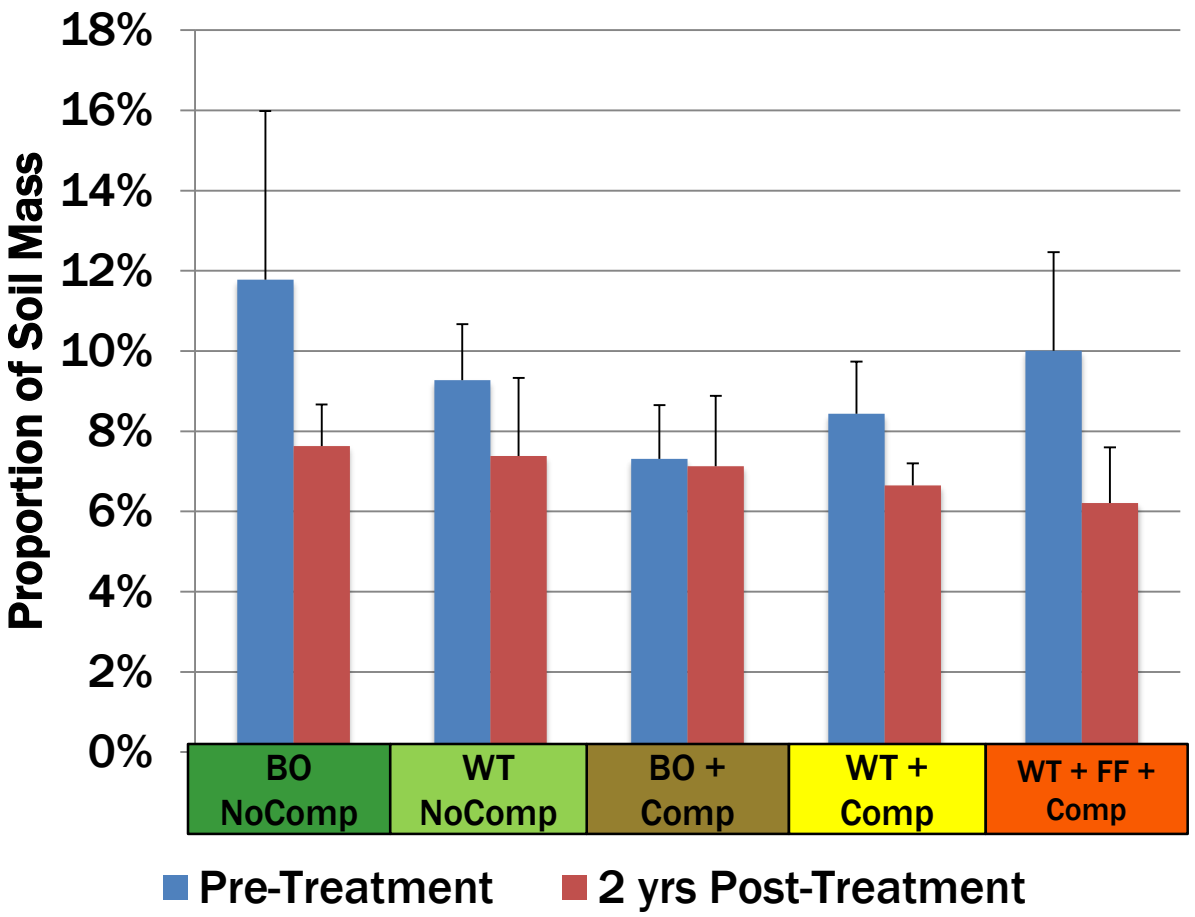
Also:
Un-harvested
Reference
Stand

Photo taken September 2013 – Post treatment

NARA POST-TREATMENT CONDITIONS



PARTIALLY DECOMPOSED ORGANIC MATTER



- NARA LTSP
- Organic matter decreases in all treatments
- Removal of forest floor decreased soil organic matter
- Standard protocol (BO NoComp) likely had more soil leaching

Hatten et al. (OSU)

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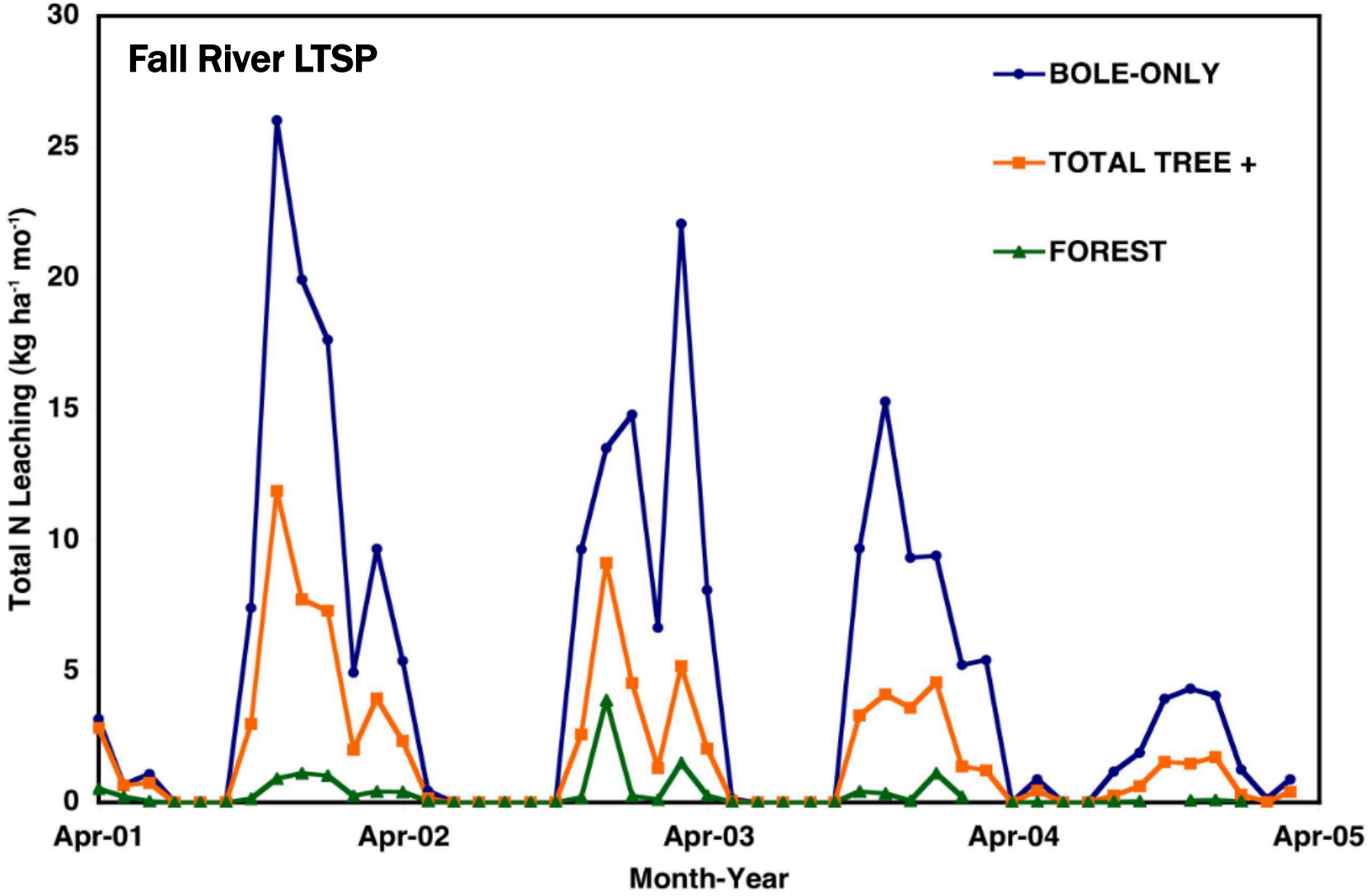
N LEACHING AFTER HARVEST



Strahm et al. 2005

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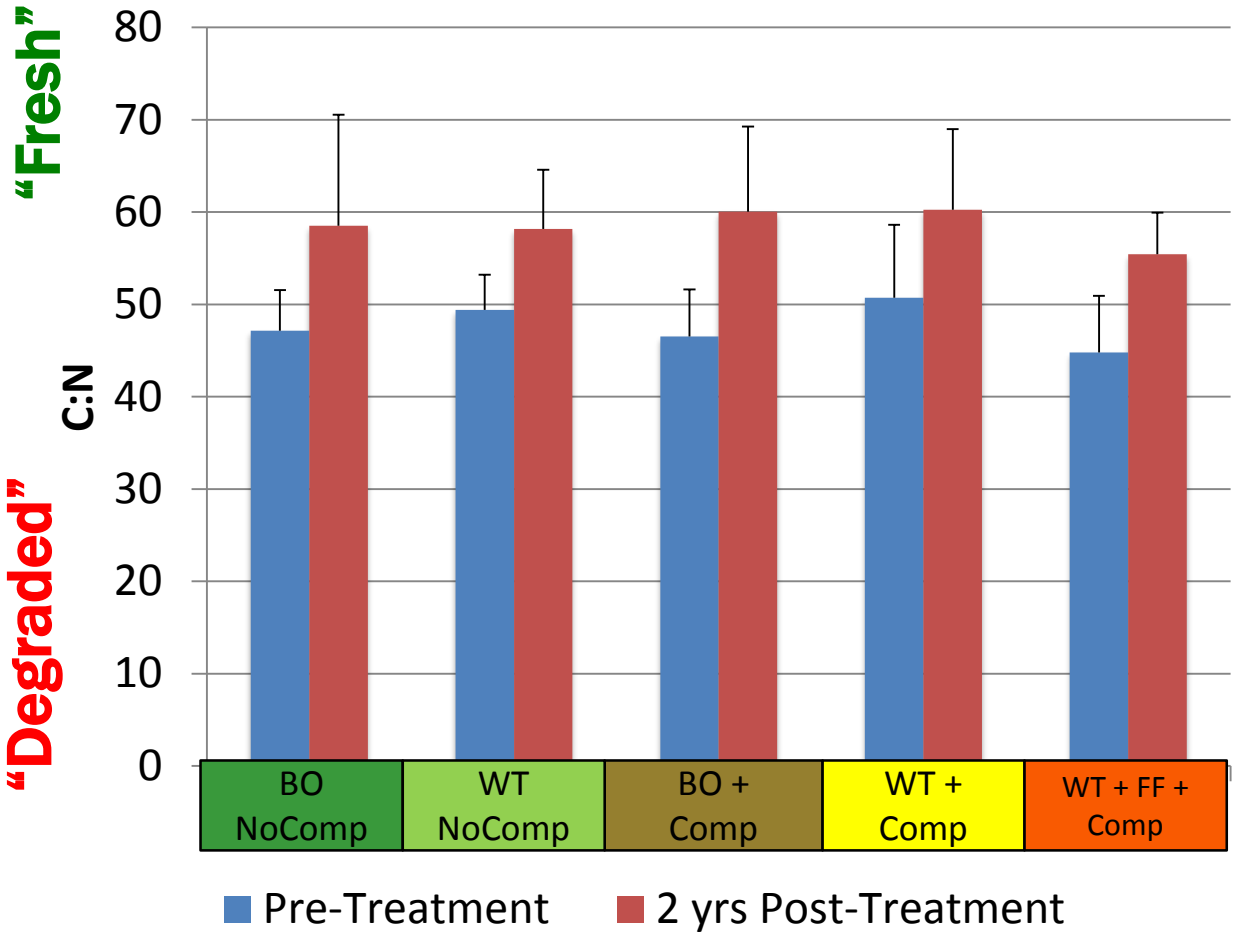
CARBON TO NITROGEN RATIO



- Increasing C:N ratio indicates an addition of fresh organic matter
- Organic matter coming from roots and stumps
  - Only common source between treatments

Hatten et al. (OSU)

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ROOT AND STUMP DECOMPOSITION

Examples of Stump Ages: A: 1 year; B: 4 years; C: 8 years; D: 15 years

- The rate of Douglas-fir stump decay per year is faster than other coarse woody debris
- The factors that determine decay are hard to predict beyond age
- Stumps could hold as much as 3 Mg of carbon in Washington private forests

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Matt Norton M.S.

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EFFECTS OF HARVESTING BIOMASS ON TREE GROWTH

- Intensive management impacts future tree growth
- Soil types will respond to harvesting differently
  - Soil texture, nutrients, compaction issues, water holding capacity

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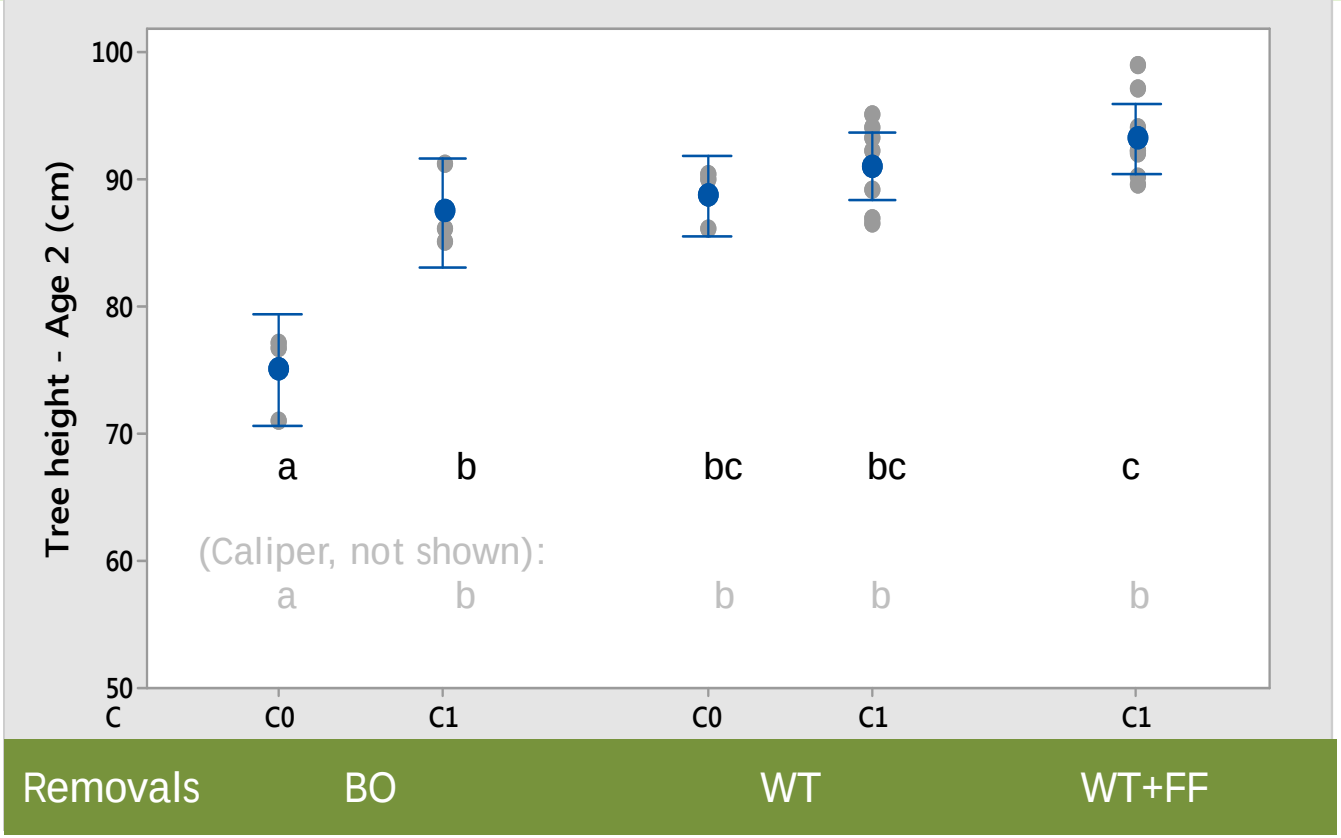
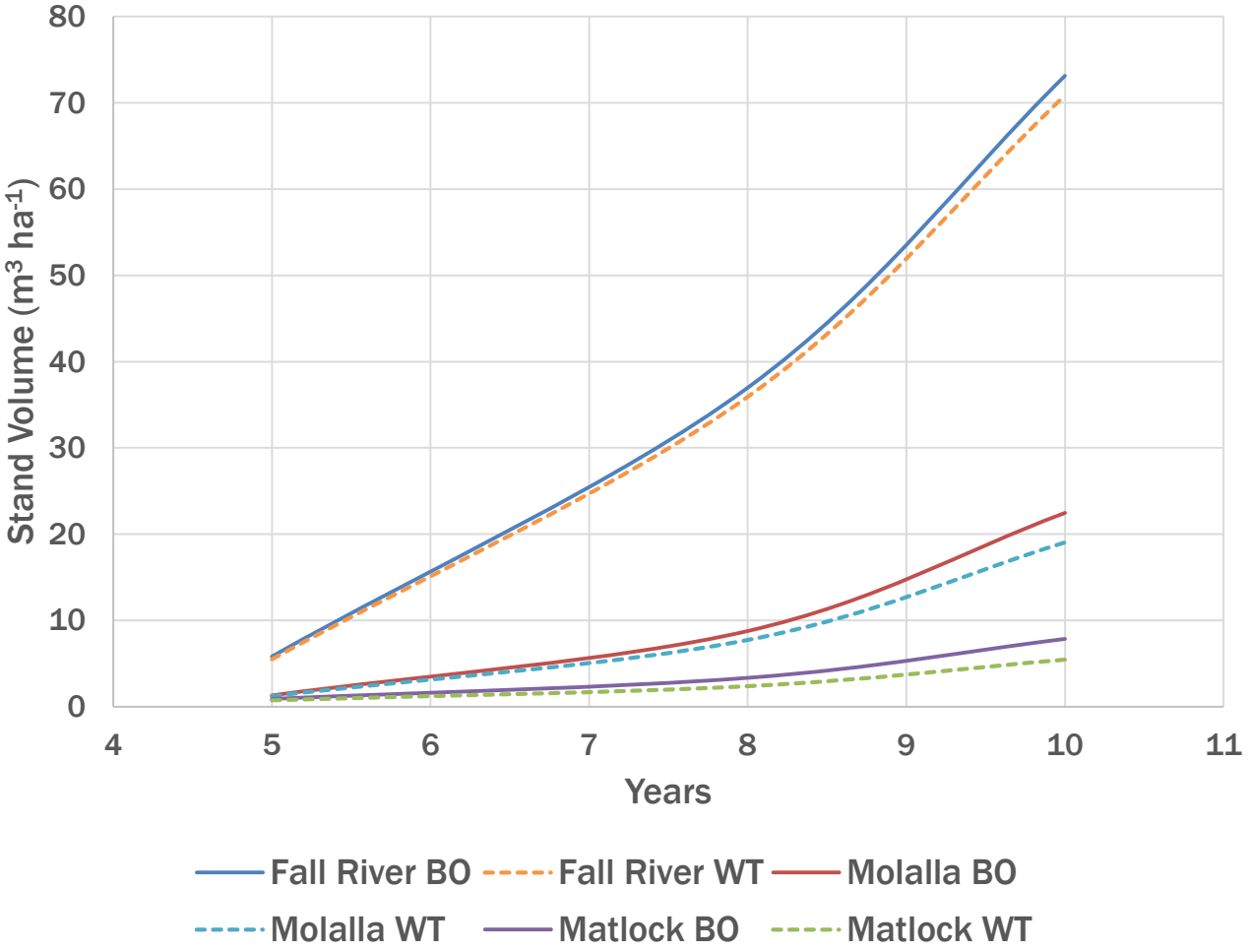
NARA LTSP TWO-YEAR HEIGHT



- **Statistical differences, least impacted doing worse.**
- **Probably related to temperature. Less OM = warmer**

BIOMASS REMOVAL EFFECTS ON VOLUME YEARS 5-10



- More differences due to site productivity than whole tree removal
- Greater effect of tree removal at lower productivity sites

Holub et al. 2013 and Slesak et al. 2016

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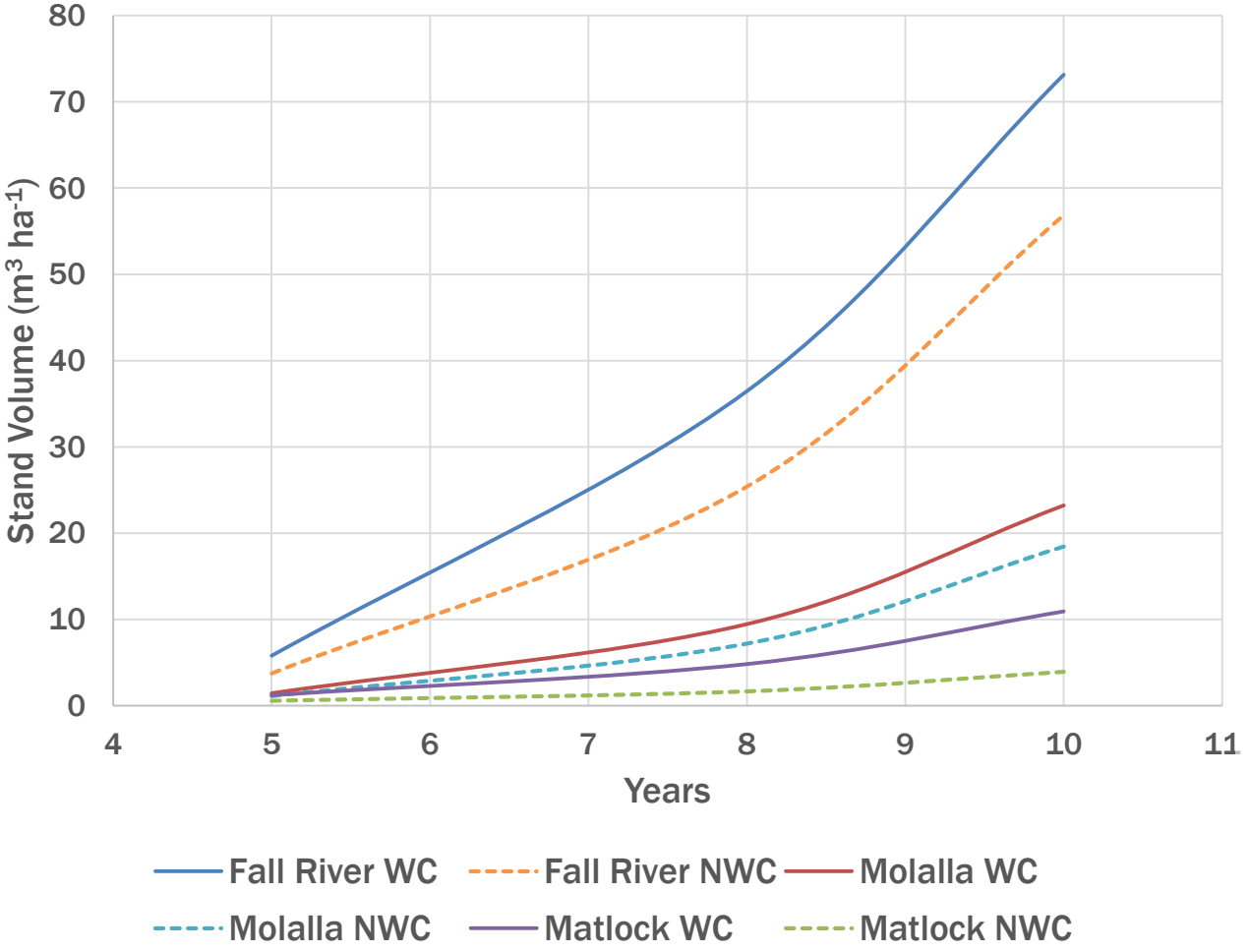
WEED CONTROL EFFECTS ON VOLUME YEARS 5-10



- Greatest effect on growth due to weed control (WC)
- No weed control (NWC) decreases productivity more than whole tree harvests

Holub et al. 2013 and Slesak et al. 2016

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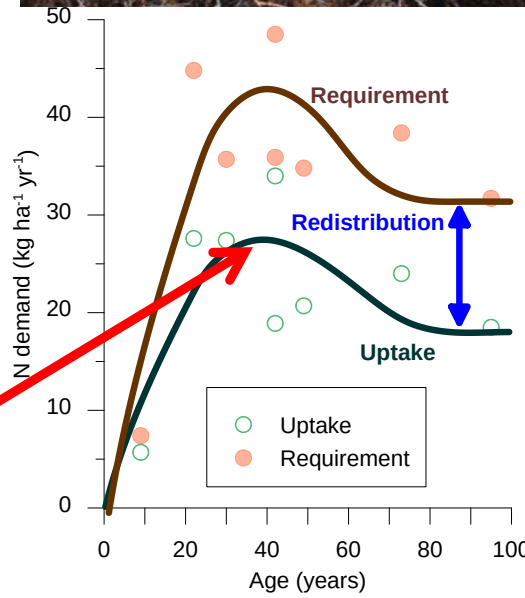
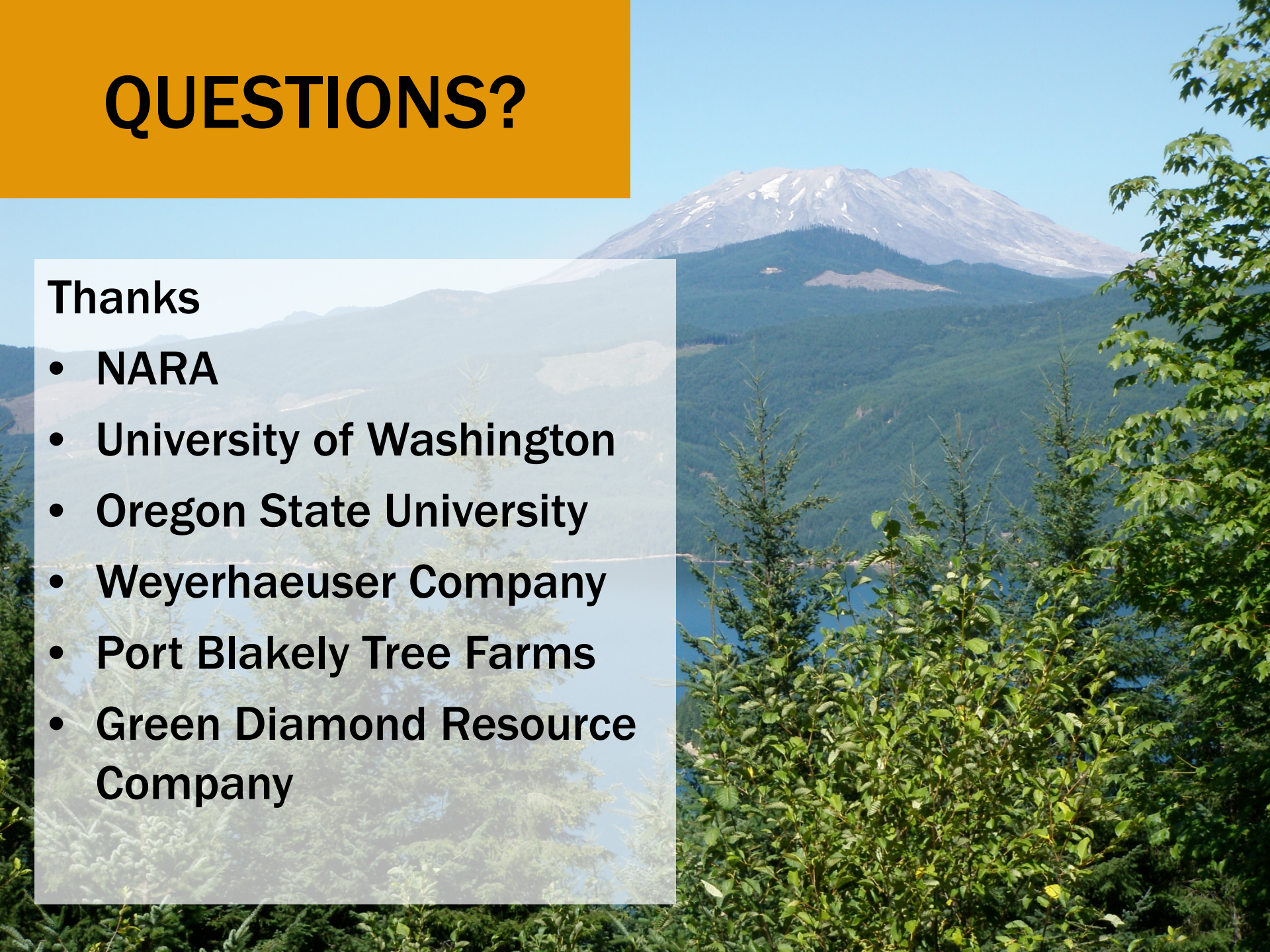
PROPOSED MECHANISMS OF PRODUCTIVITY RESILIENCE

- Very little effect of whole tree harvests on site productivity
  - Except for the poorest soils
- Increase or compensation for loss of available nutrients
  - Decomposing roots and stumps
  - Change in soil temperature/moisture regime
    - Increasing mineralization rates and available nutrients
  - Change in soil microbial or fungal community
- Improved soil water supply
  - Less O-horizon interception (particularly low intensity rainfall)
- Majority of sites have not reached canopy closure yet (when nutrient limitations may be strongest)



QUESTIONS?



Thanks

- NARA
- University of Washington
- Oregon State University
- Weyerhaeuser Company
- Port Blakely Tree Farms
- Green Diamond Resource Company