Biophysical responses in soil following intensive biomass removal

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Weyerhaeuser

NARA
Northwest Advanced Renewables Alliance

Outline

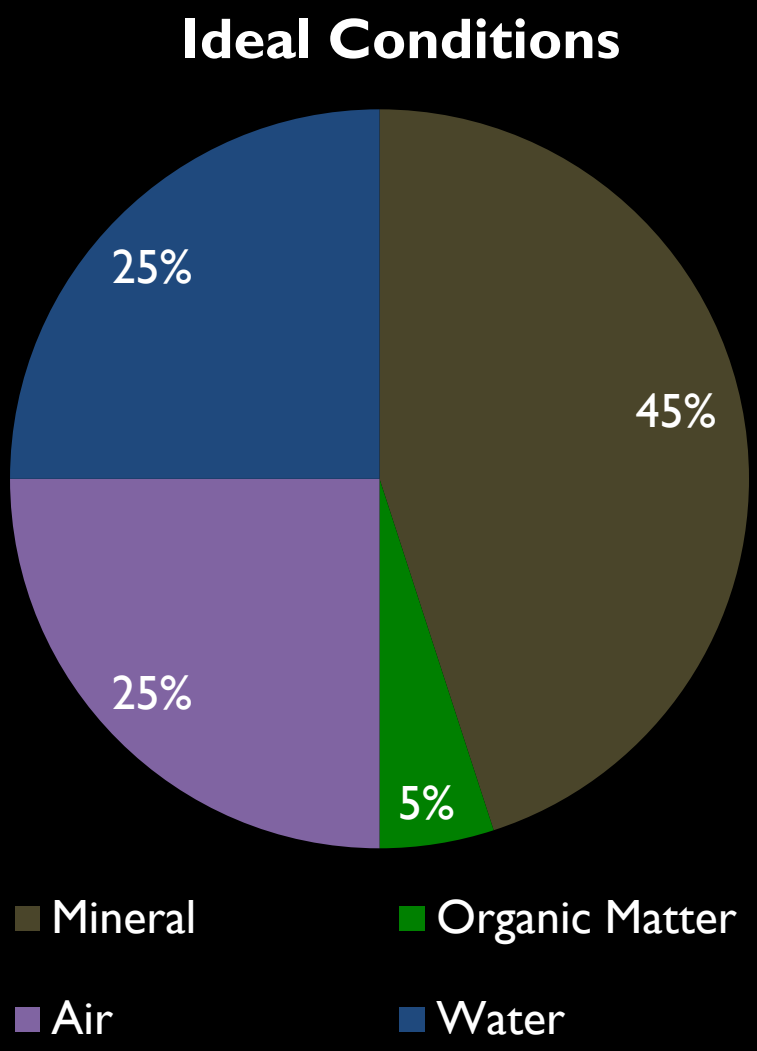
- Background
  - Why focus on soil?
  - Current state of research
- Study Design
  - Hypotheses we aim to address
- Results
  - Soil moisture, temperature, & respiration
- Future Work

Why focus on soil?

Mango Tree: from Biocyclopedia.com

Long-Term Soil Productivity

- LTSP is regulated by
  - Soil organic matter
  - Porosity



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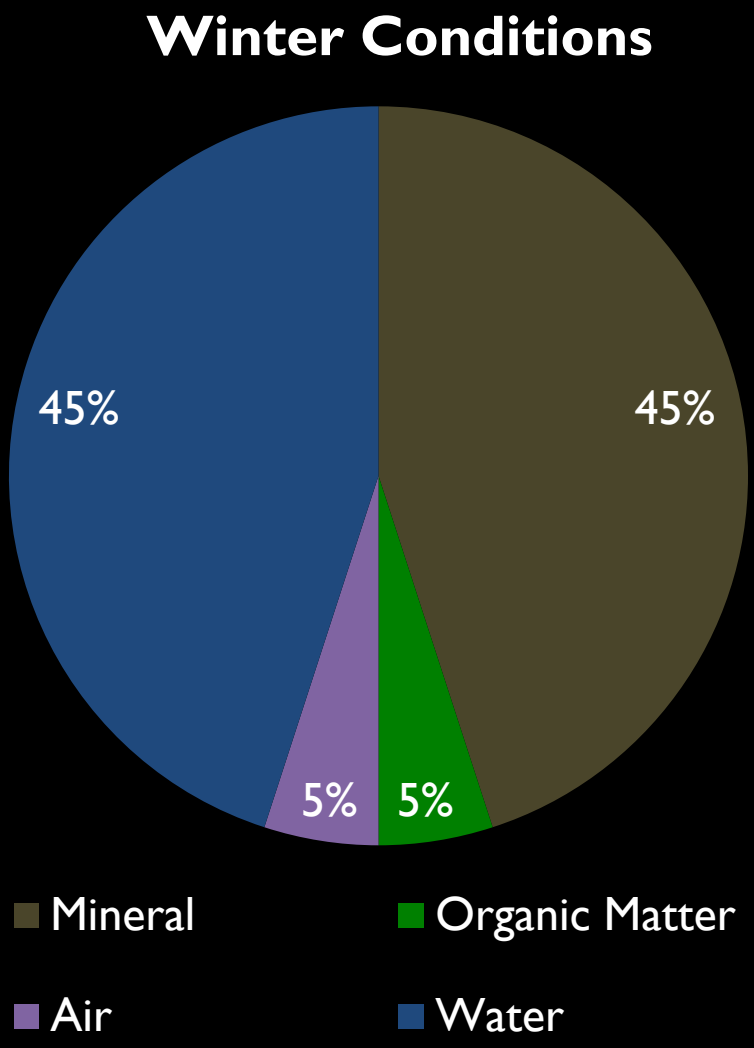

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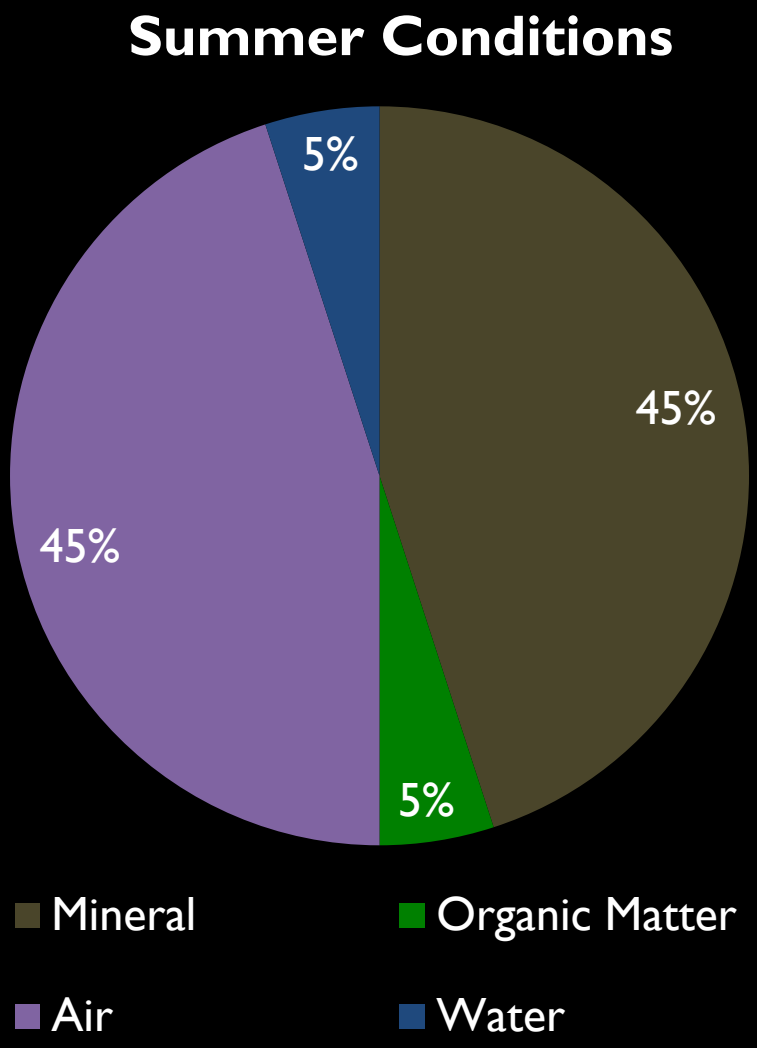

How to **predict** forest productivity?

- Organic Matter
  - Stem only, Whole tree, & Whole tree + Forest floor.
- Compaction
  - No compaction, Moderate compaction, & Heavy Compaction

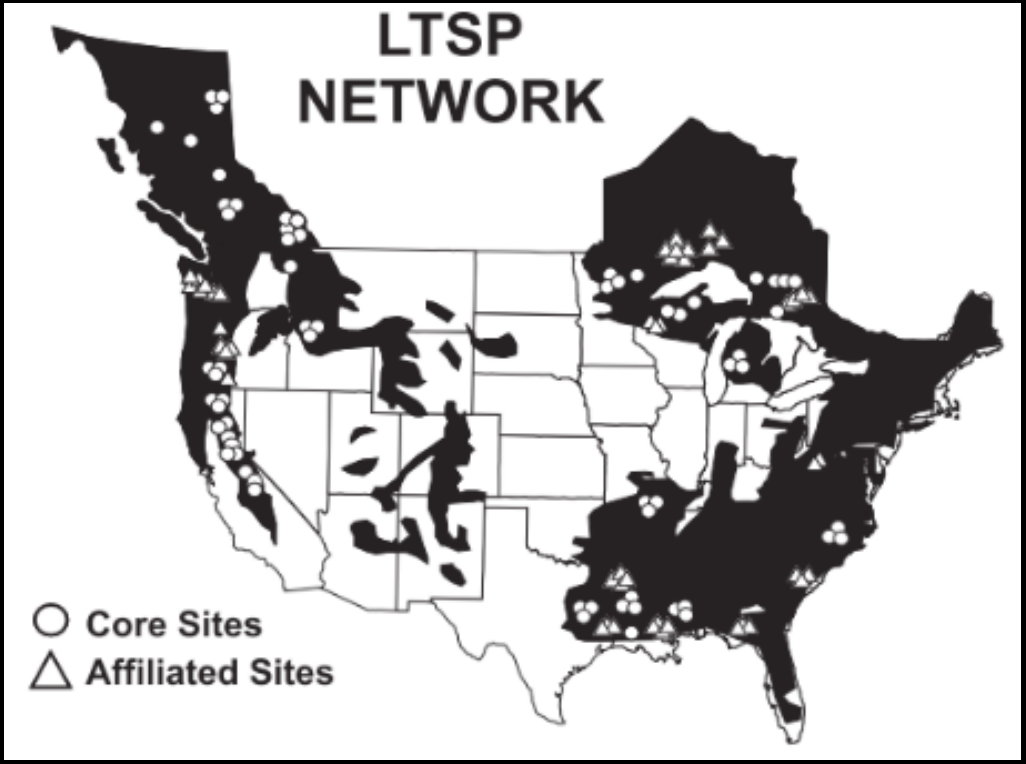

Fig.2 - Shaded areas represents forests capable of producing 1.4 m^3 of wood, per hectare annually

Powers, R. 2006. Long-term soil Productivity: genesis of the concept and principles behind the program. Canadian Journal of Forest Research. 36:519-528.

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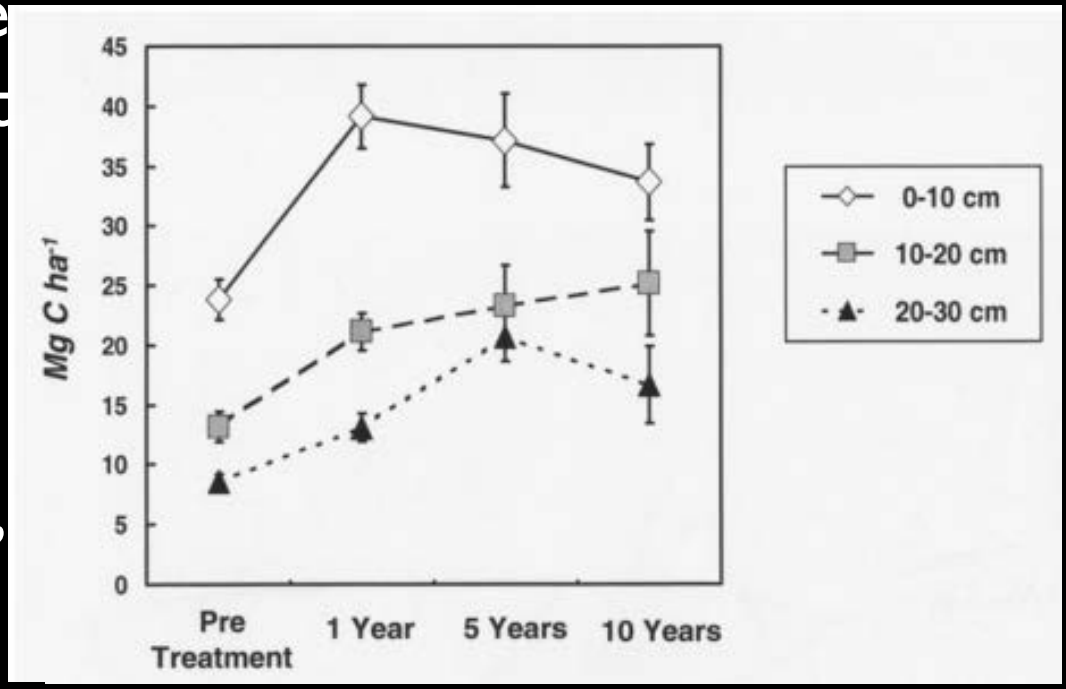
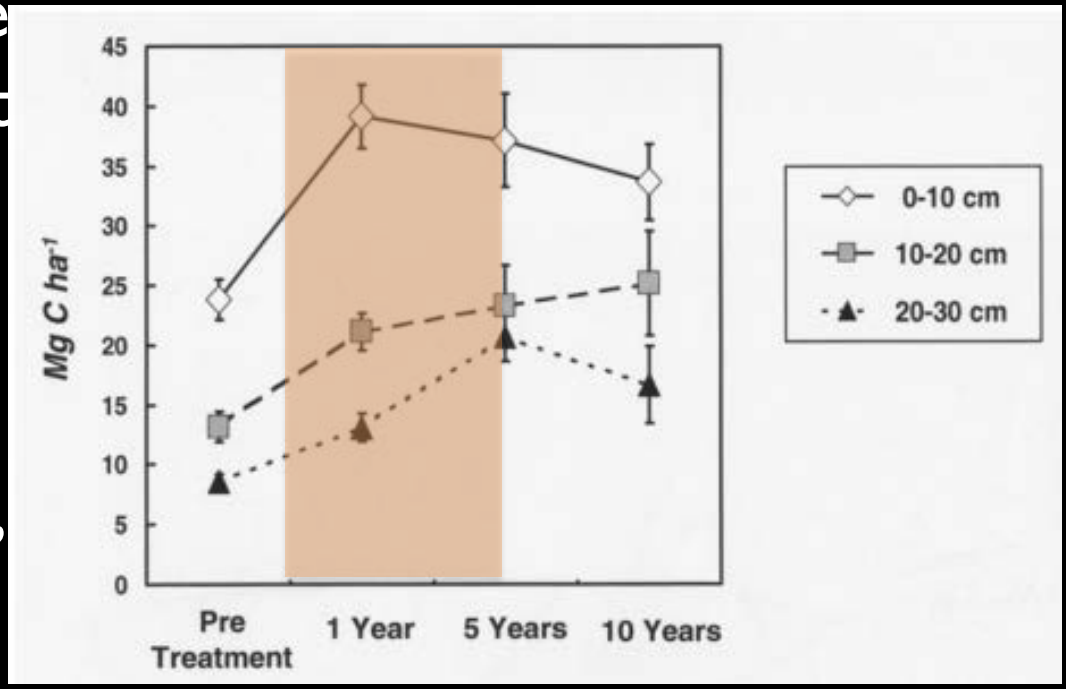


Fig 5. Quantity of fine fraction SOC stored at three depths before and after the OM_1 treatment. Vertical bars = one SE of the mean

Powers, R., A. Scott, F. Sanchez, R. Voldseth, D. Page-Dumerose, J. Elioff, and D. Stone. 2005. The North American long-term soil productivity experiment: findings from the first decade of research. Forest Ecology and Management. 220:31–50.

How to **predict** forest productivity?

- Organic Matter
  - Stem only, Whole tree & Whole tree + Forest floor.
- Compaction
  - No compaction, Moderate compaction, & Heavy Compaction
- Soil C Paradox:
  - Rapid respiration of residual organic matter
  - Root decomposition



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Hypotheses

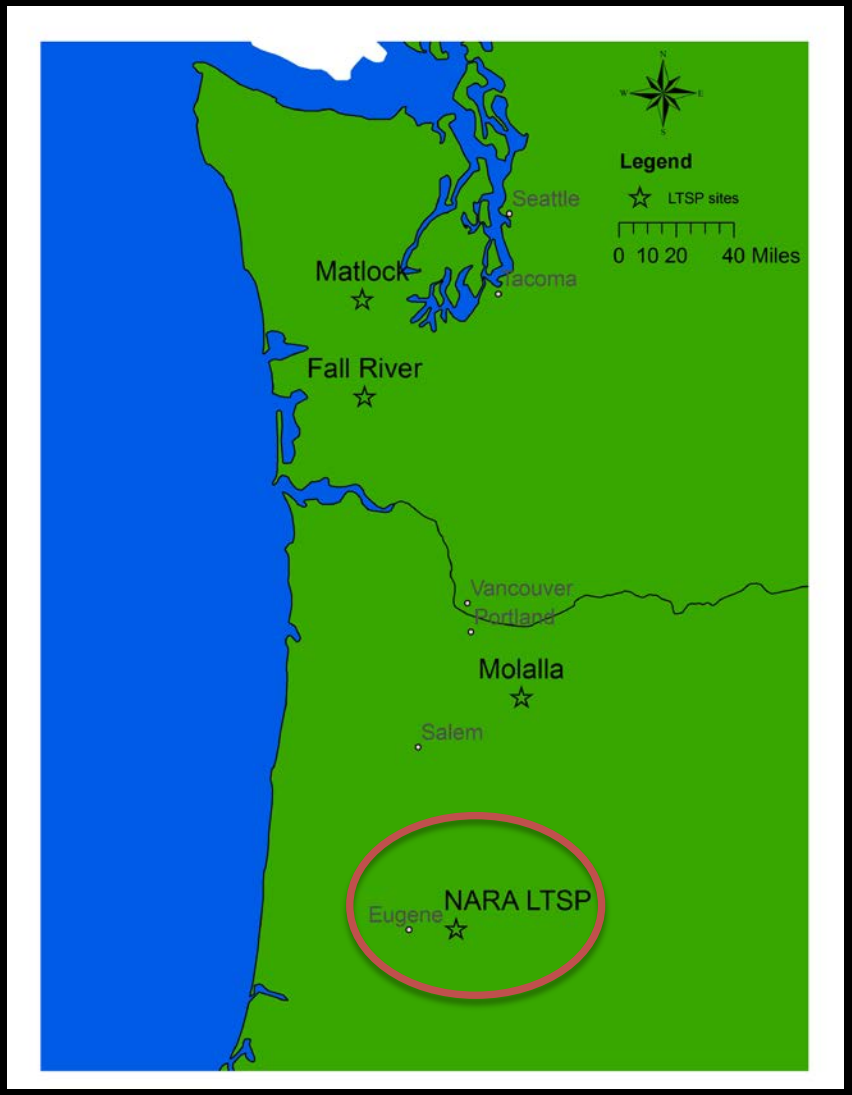
? Direct solar radiation and direct rain on the soil surface will increase soil temperature and moisture throughout the profile.

? This may promote a favorable environment for microbial activity leading to increased heterotrophic respiration.

? Eventually, mineralizing more nutrients for plant uptake producing an apparent resilience in tree growth following intensive biomass removals.

Location & Timeline

Figure courtesy of Scott Holub – Weyerhaeuser



2012 – Sites identified and pre-harvest measurements taken

2013 – Treatments applied, post-harvest measurements, instrumented for weather data, soil water collections, gas analysis, and fenced for deer

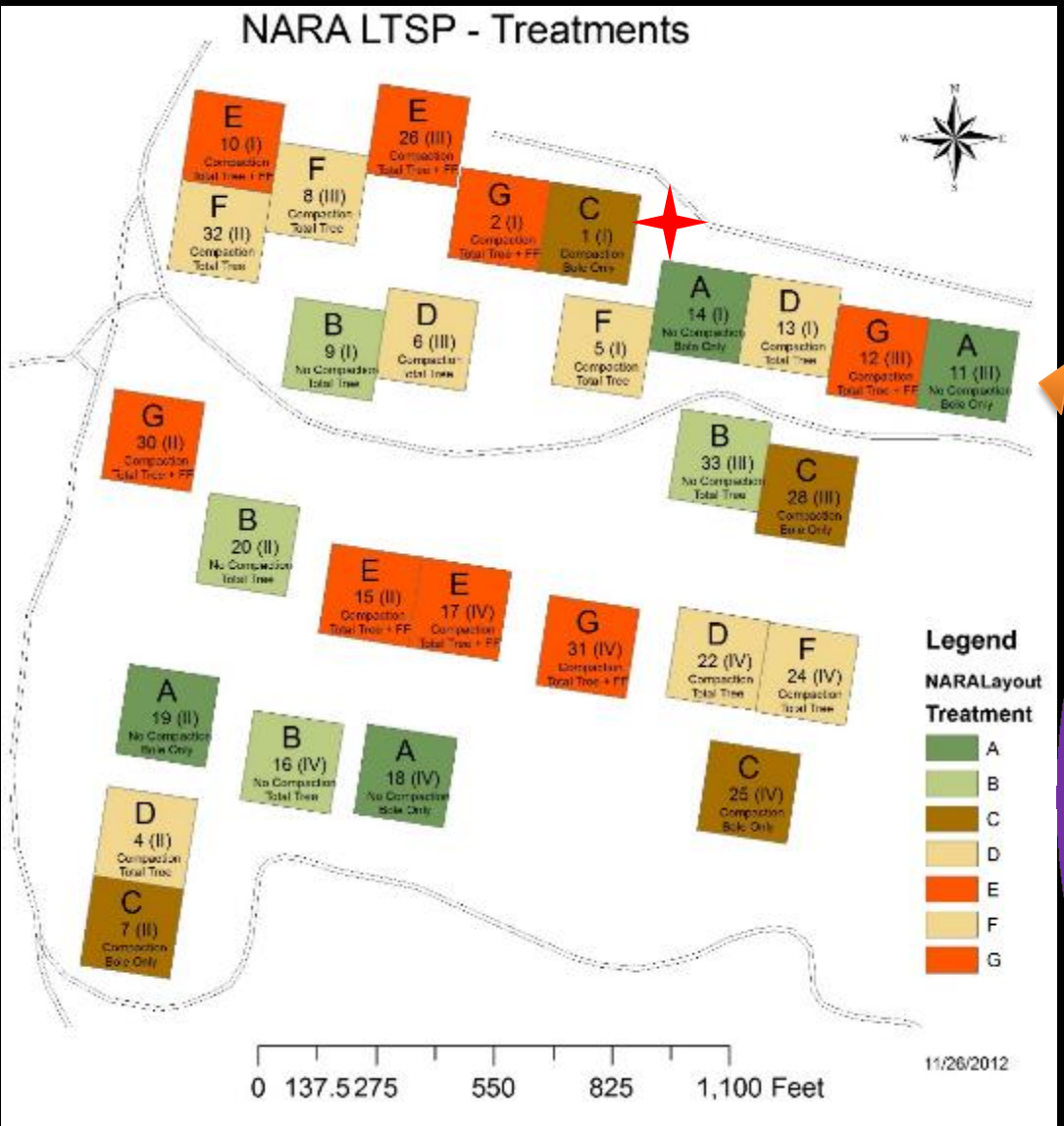
2014 – Seedlings planted with initial tree measurements

2015 – Second year tree measurements, continuing soil observations

Graduate (never)?

2070 – Harvest and re-implement treatments

Plot Layout



	No Compaction	Compaction	
Bole Only	A	C	Untreated Forest
Total Tree	B	D, F*	
Total Tree + Forest Floor	Not Conducted	E, G*	

H (I) Untreated Forest

H (II) Untreated Forest

H (III) Untreated Forest

H (IV) Untreated Forest

1 acre *treatment* plots (32)

Weather stations (2)

	No Compaction	Compaction	
Bole Only	A	C	Untreated Forest
Total Tree	B	D, F*	
Total Tree + Forest Floor	Not Conducted	E, G*	

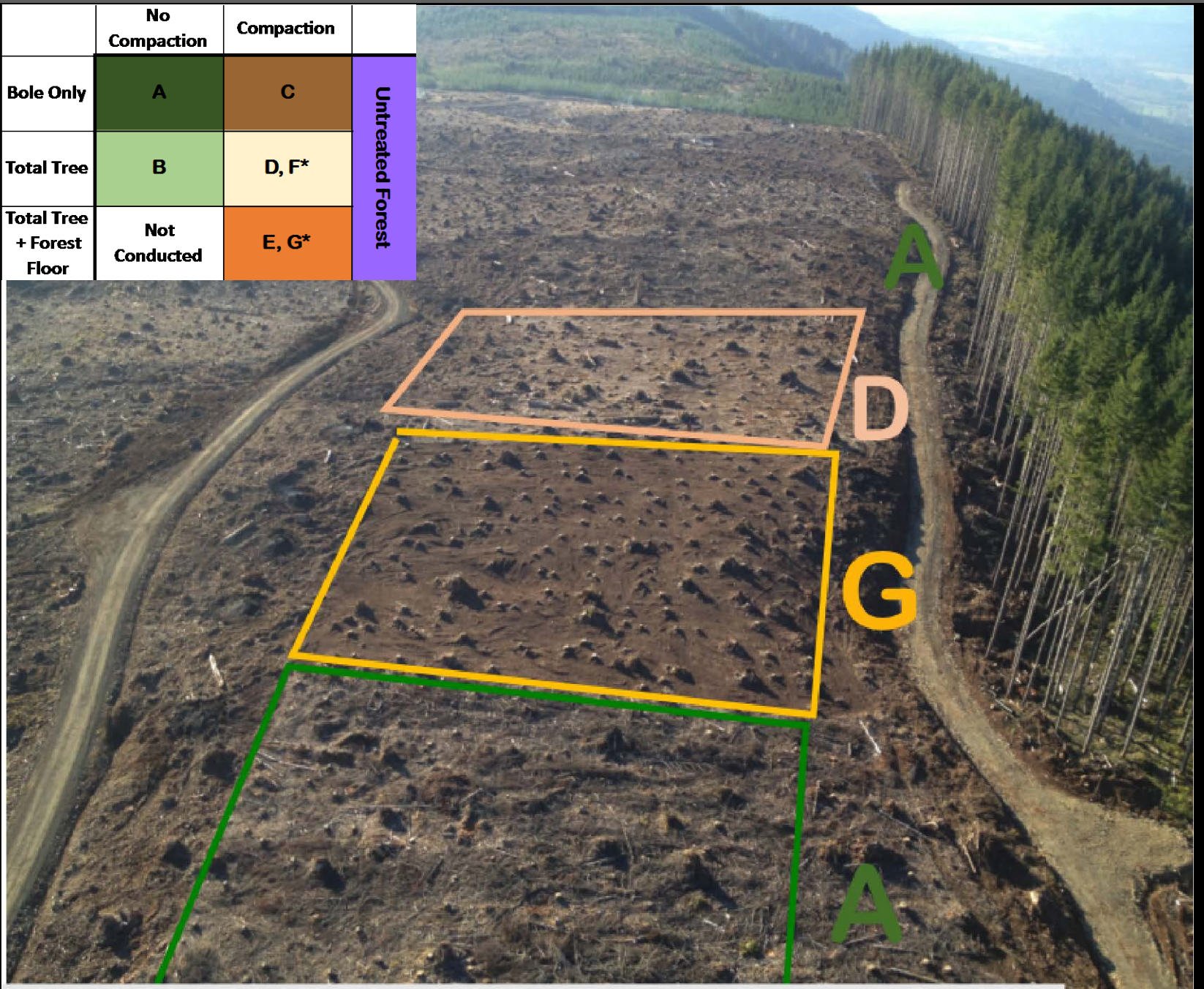


Photo taken summer 2013, courtesy of Scott Holub – Weyerhaeuser.

Methods: Instrumentation

Decagon

Soil temp/VWC @ 10, 20, 30, 100 cm
Air temp and RH @ +15cm above mineral
1 per plot measured every hour

A H O

A, H, O = three different sources of CO2
Measured with an infrared gas analyzer (LiCOR 8100A)
3 per **plot** measured monthly

LYS

Zero-tension lysimeters *beneath* O-horizon
2 per **plot** collected after ~25cm rain

TRF

Throughfall collectors *above* the O-horizon
1 per **block** collected after ~25cm rain

½ acre measurement plot

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Methods: Instrumentation

Treatment A

Treatment E

Untreated forest stand

Hypotheses

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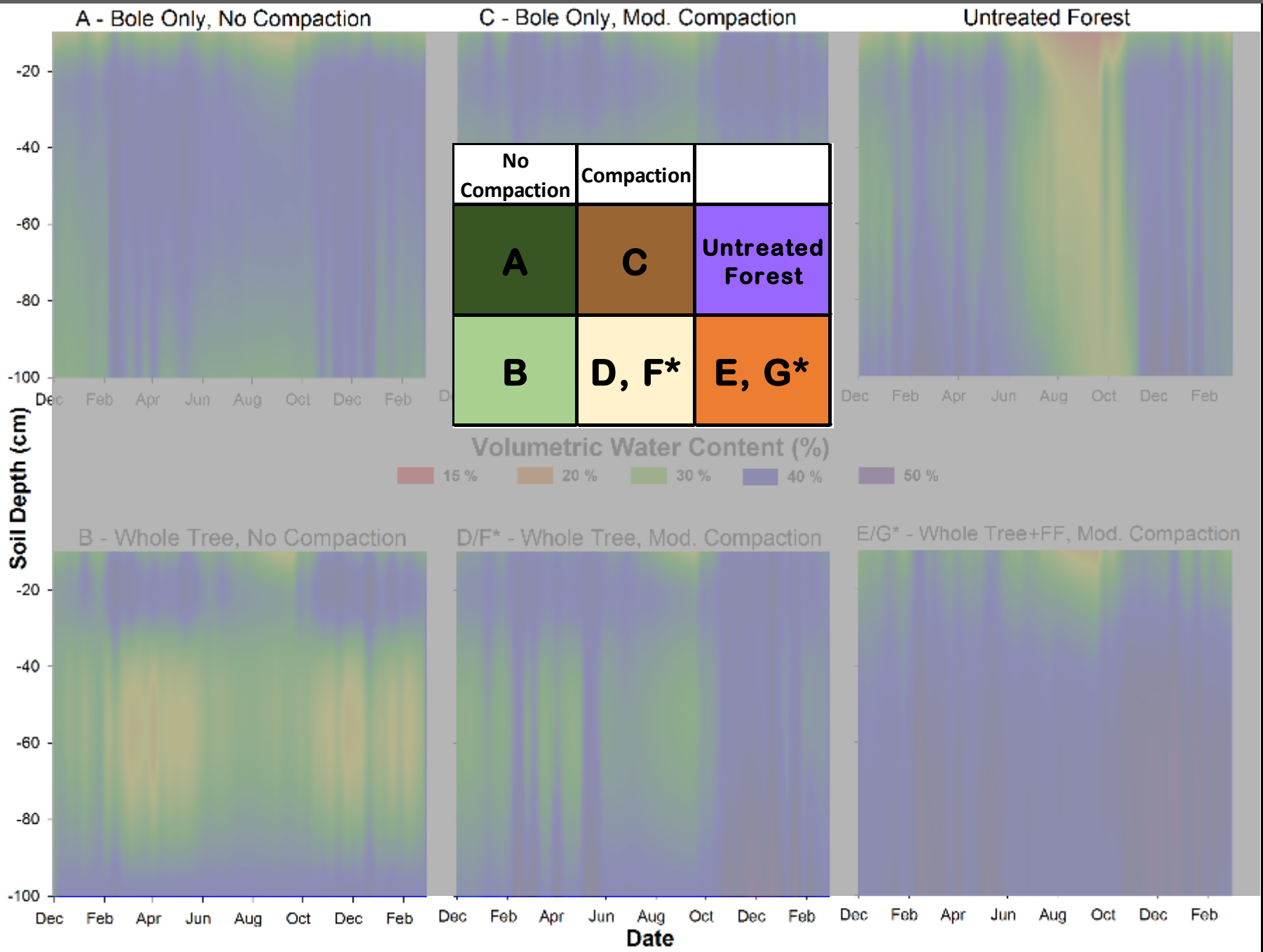
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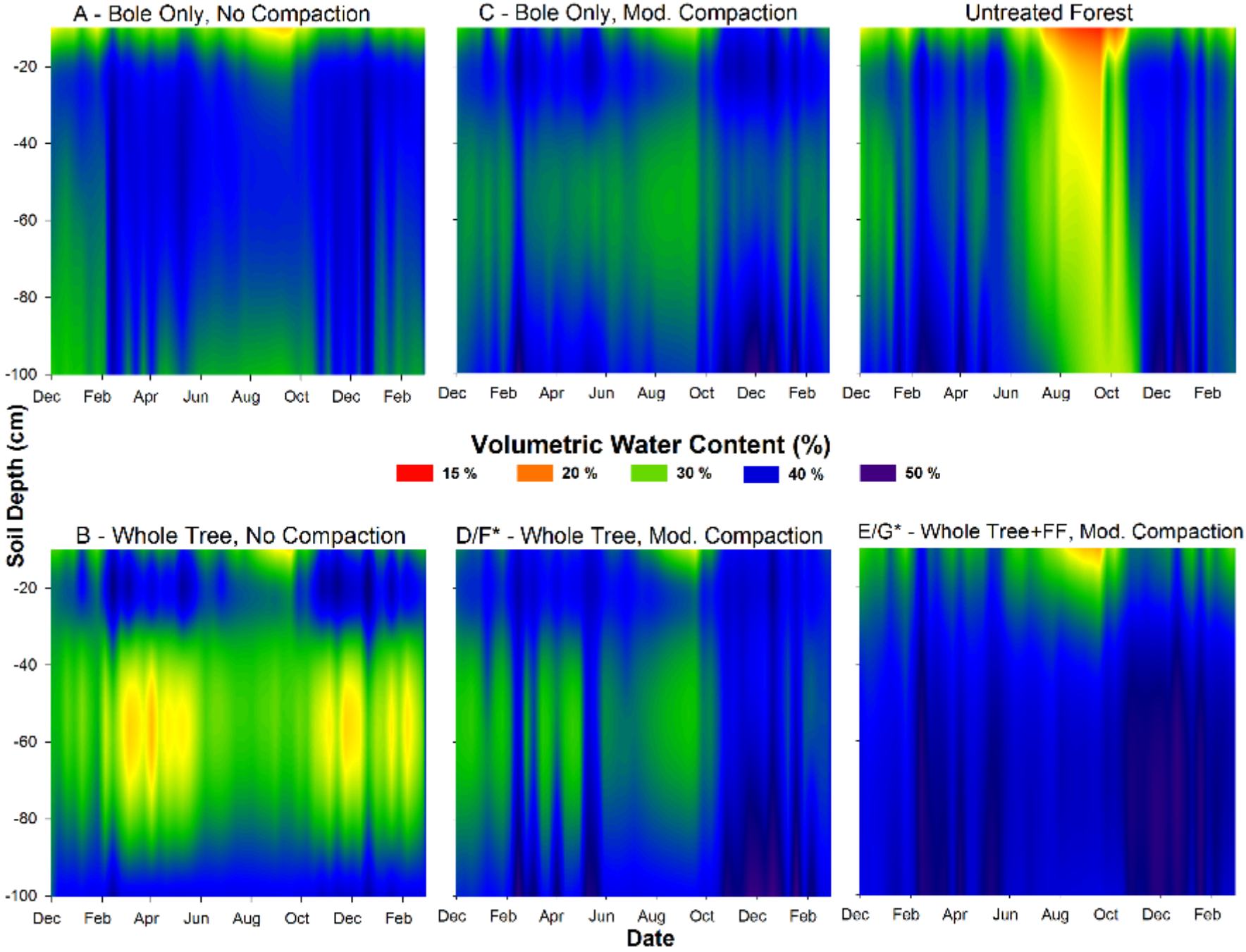
C - Bole Only, Mod. Compaction
Untreated Forest
B - Whole Tree, No Compaction
D/F* - Whole Tree, Mod. Compaction
E/G* - Whole Tree+FF, Mod. Compaction
No Compaction
Compaction
A
C
Untreated Forest
B
D, F*
E, G*
Volumetric Water Content (%)
15 %
20 %
30 %
40 %
50 %
Soil Depth (cm)
-20
-40
-60
-80
-100
Dec
Feb
Apr
Jun
Aug
Oct
Dec
Feb
Date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Soil Depth (cm)
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-40
-60
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-100
Dec Feb Apr Jun Aug Oct Dec Feb
Volumetric Water Content (%)
15 %
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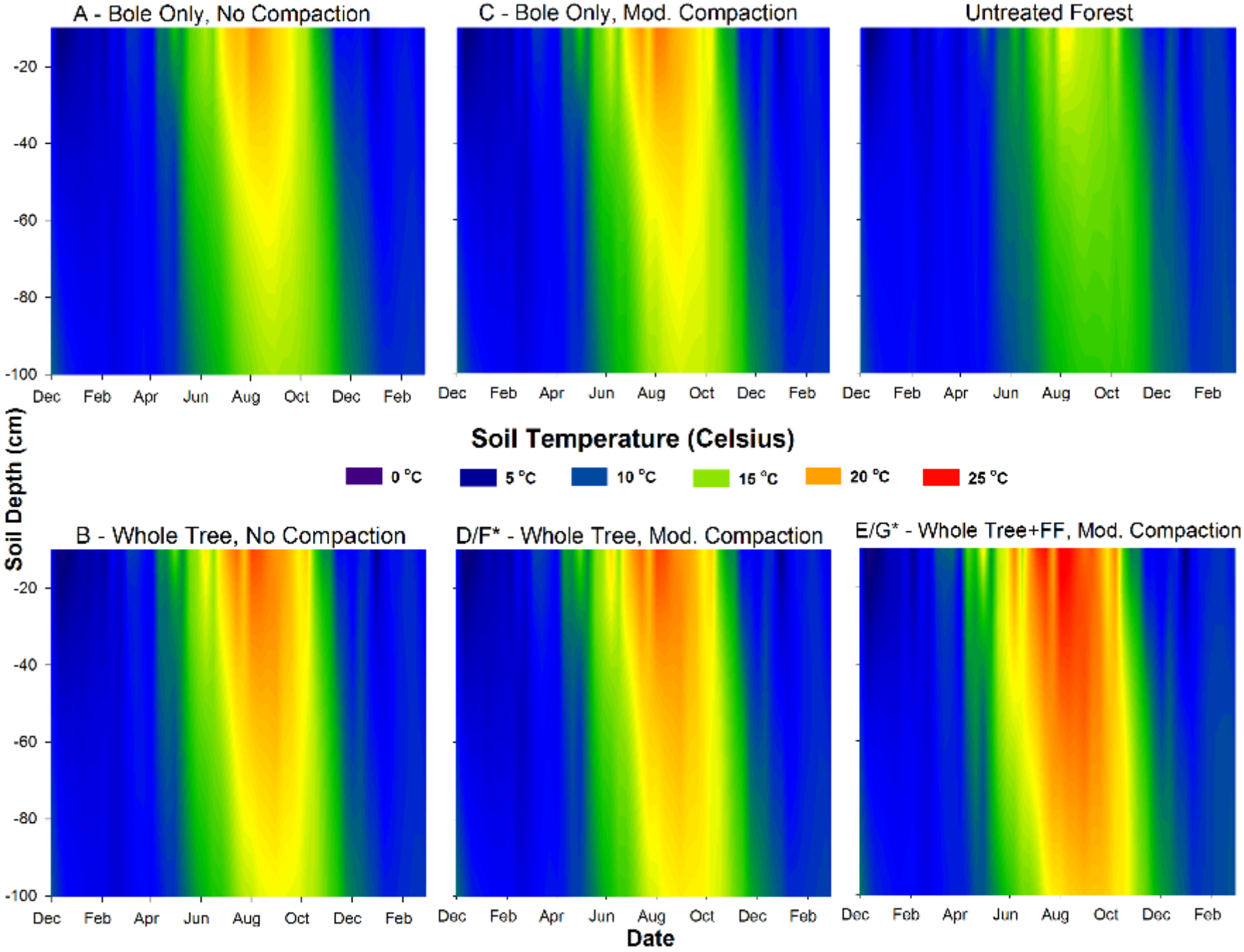
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Soil Depth (cm)
-20
-40
-60
-80
-100
Dec
Feb
Apr
Jun
Aug
Oct
Dec
Feb
Soil Temperature (Celsius)
0 °C
5 °C
10 °C
15 °C
20 °C
25 °C
Date

Hypotheses

Direct solar radiation and direct rain on the soil surface will increase soil temperature and moisture throughout the profile.

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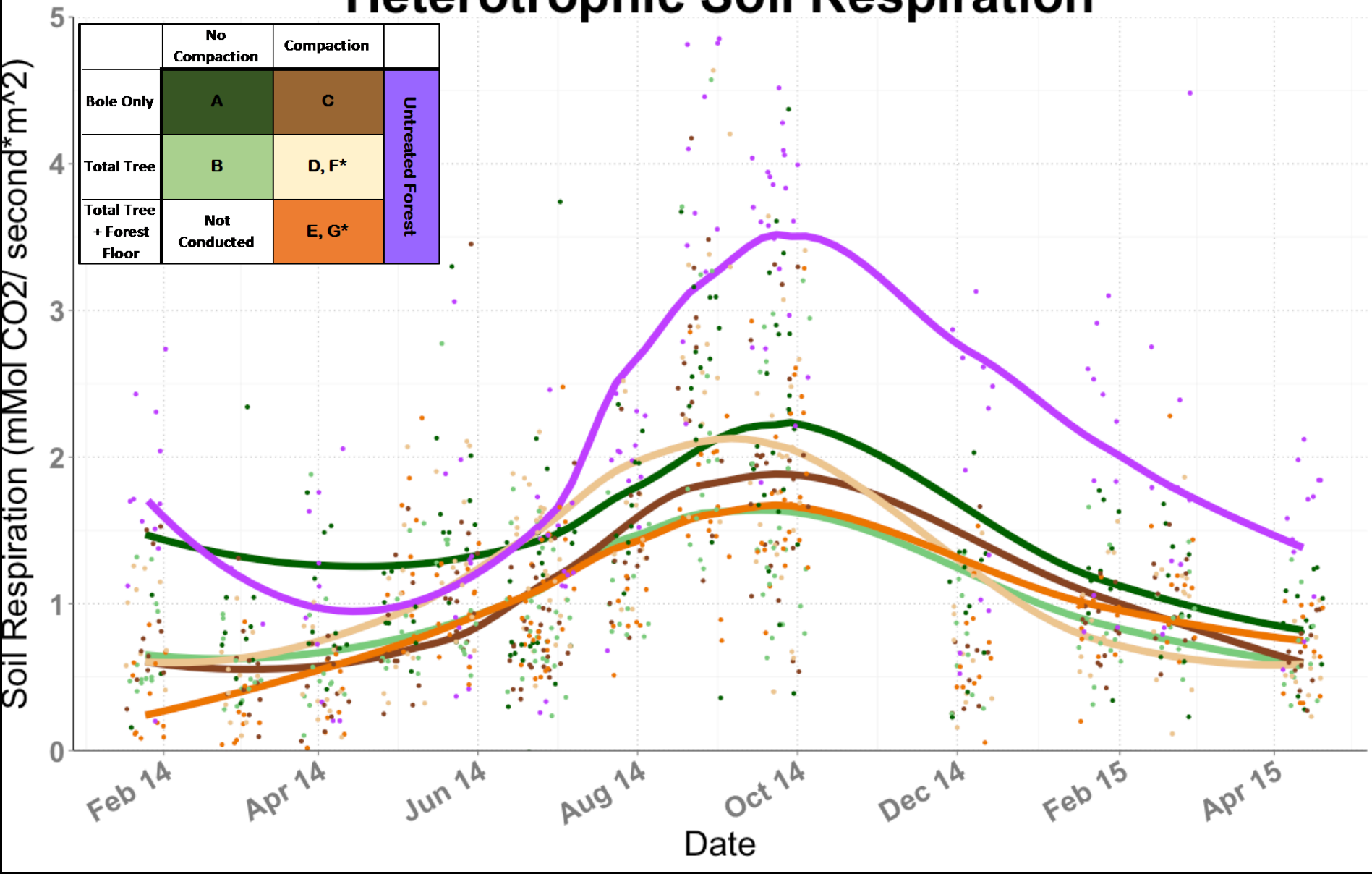
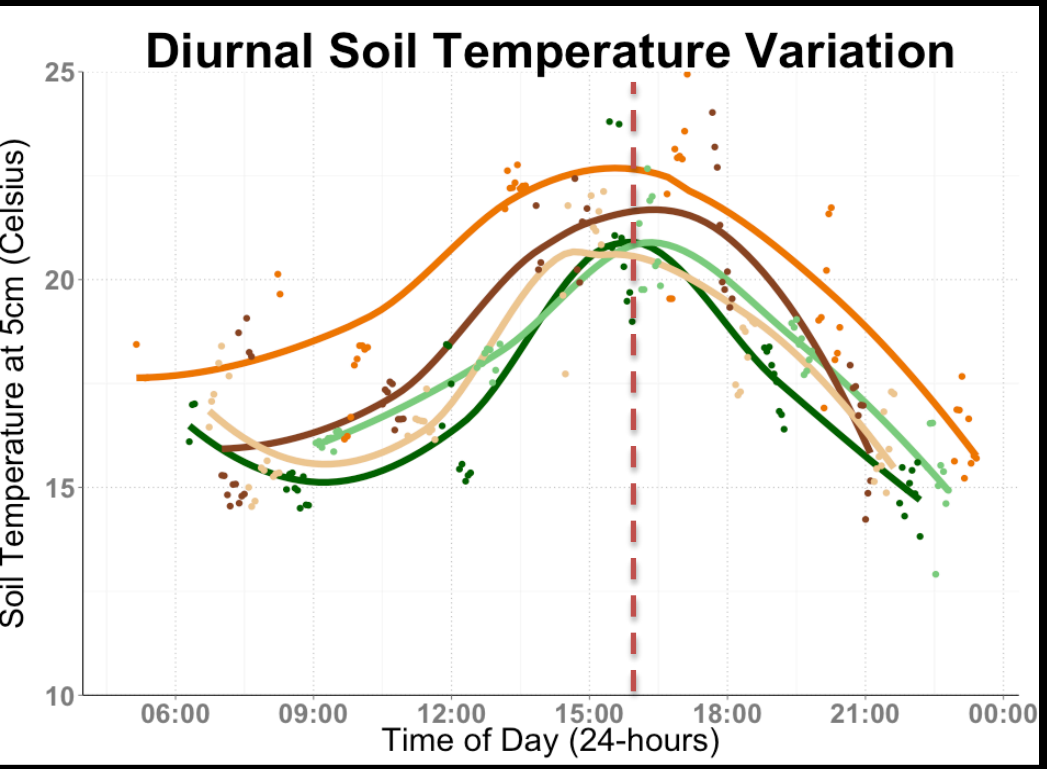
Heterotrophic Soil Respiration

	No Compaction	Compaction	
Bole Only	A	C	Untreated Forest
Total Tree	B	D, F*	
Total Tree + Forest Floor	Not Conducted	E, G*	

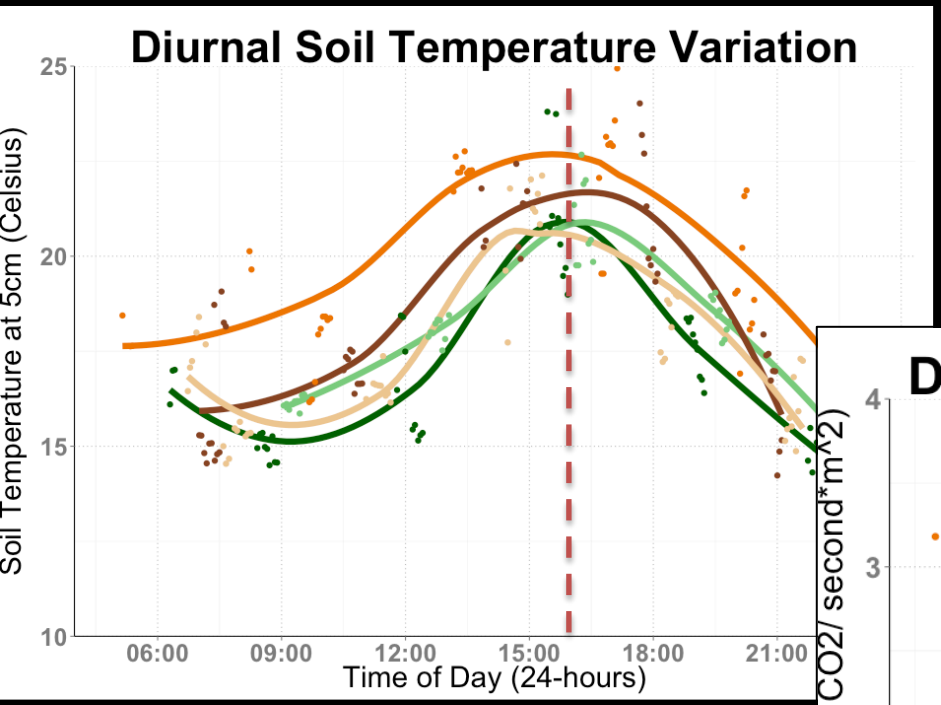


Daily Soil Respiration



Treatments	
A	Bole only, No Comp.
B	Total Tree, No Comp.
C	Bole only, Comp.
D, F*	Total Tree, Comp.
E, G*	Total Tree+FF, Comp.

Daily Soil Respiration



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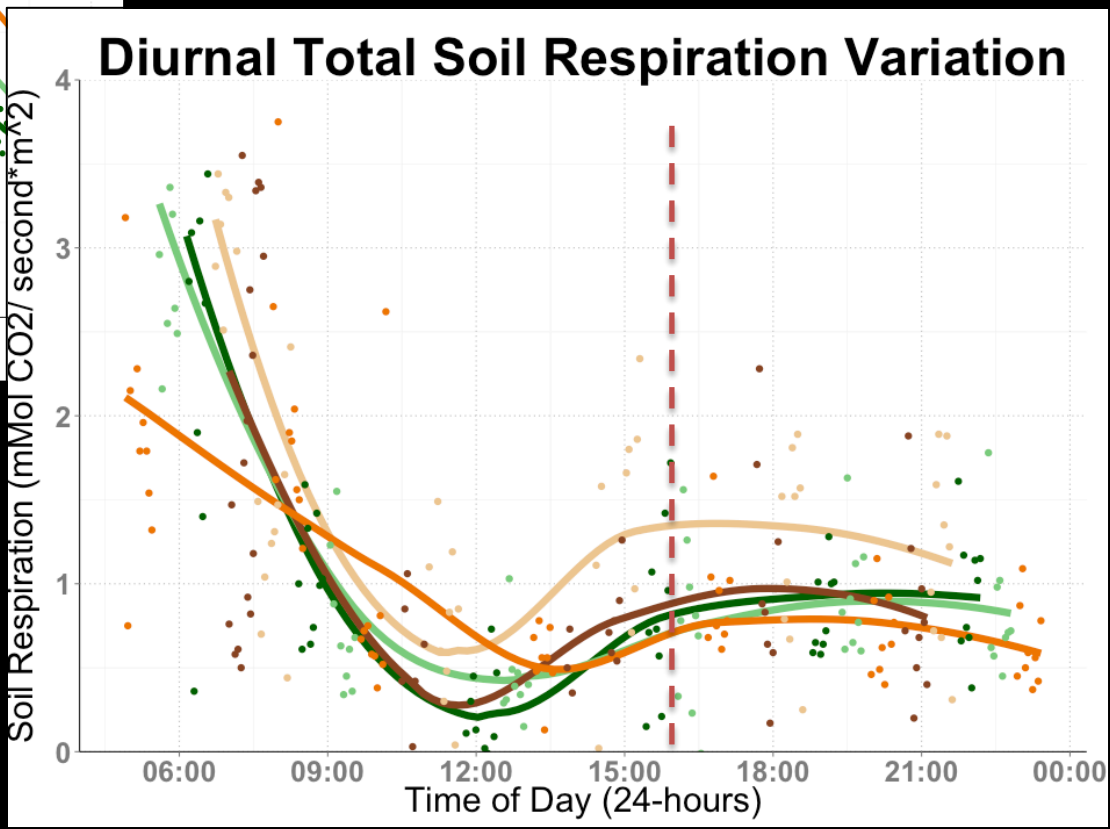

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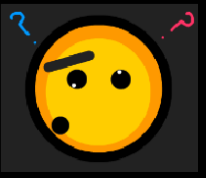

This may promote a favorable environment for microbial activity leading to increased heterotrophic respiration.

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What do we know so far?

1. Less OM = higher soil temperatures
2. Less OM = higher soil moistures
   - OM removals > compaction
3. Questions over time are *messy*
   - Summer months have all the "action"

Ongoing Analysis

1. A robust statistical data analysis of CO_2
2. H_2O Collections
3. Soil Nutrients
   - Stable Isotopes
     Greater microbial processing?
   - Biomarkers
     Source of the organic matter?

Questions?

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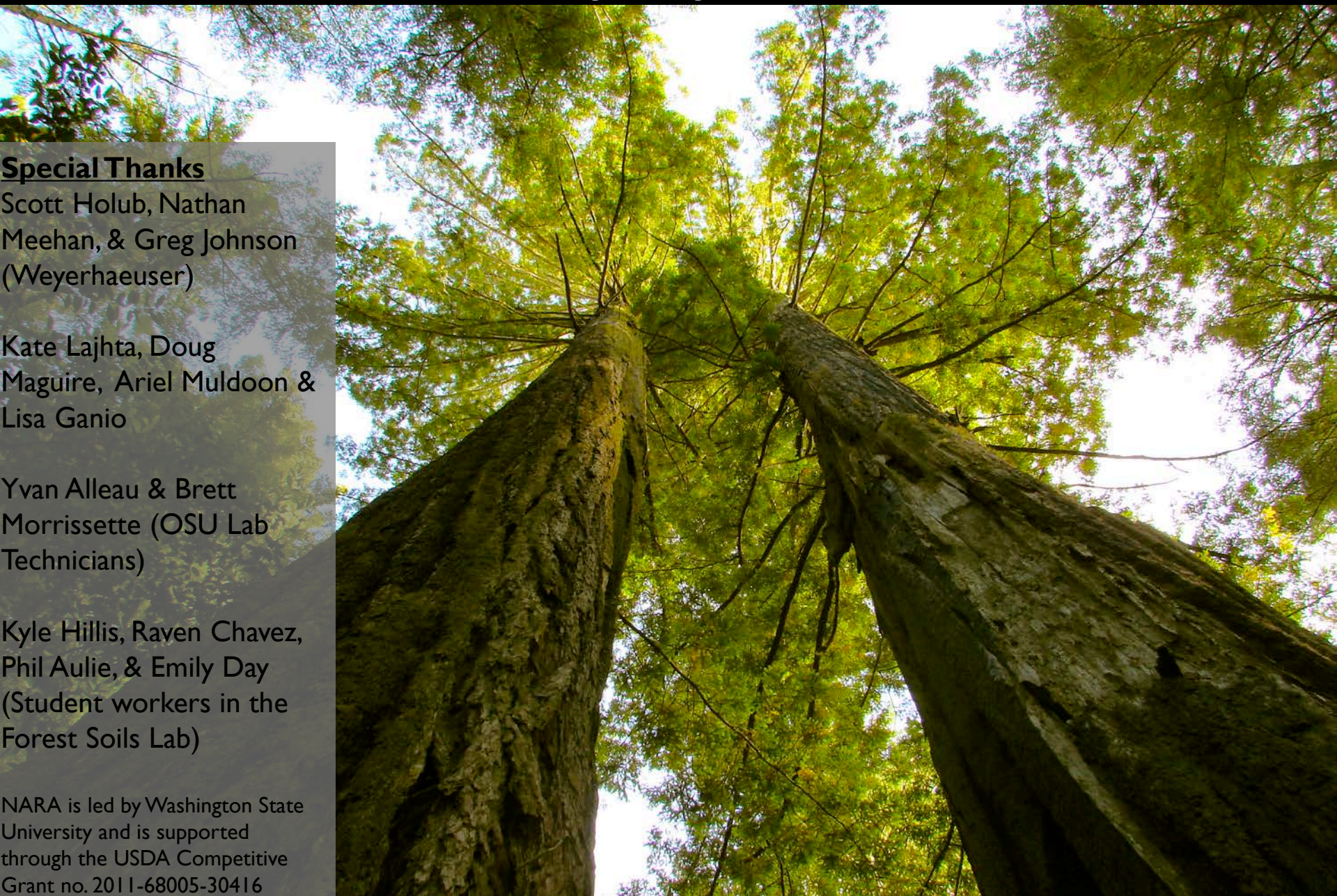

Special Thanks

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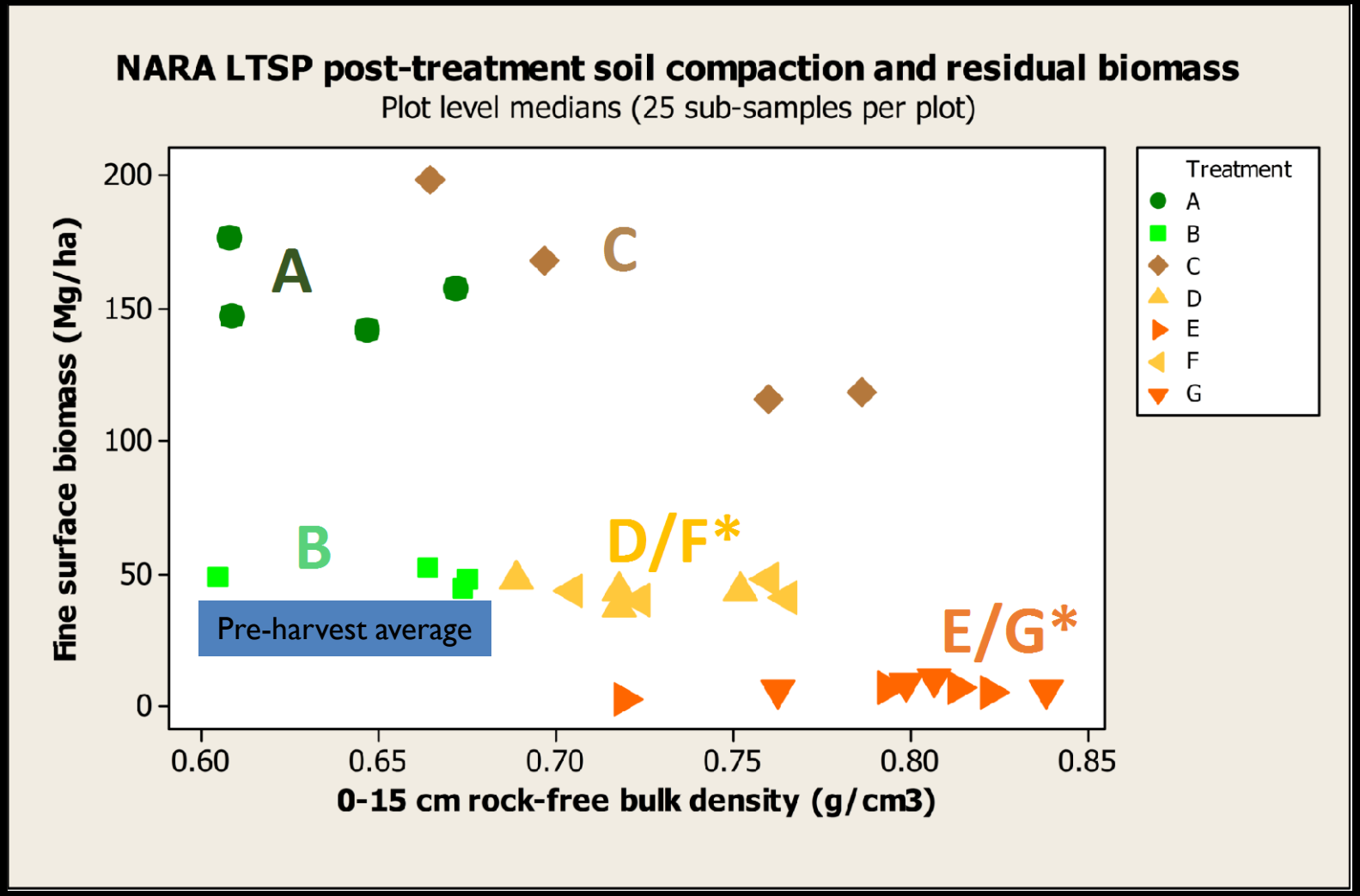
Methods: Treatment implementation

Figure courtesy of Scott Holub – Weyerhaeuser



Plot Layout

1 acre treatment plot and
½ acre measurement plot.

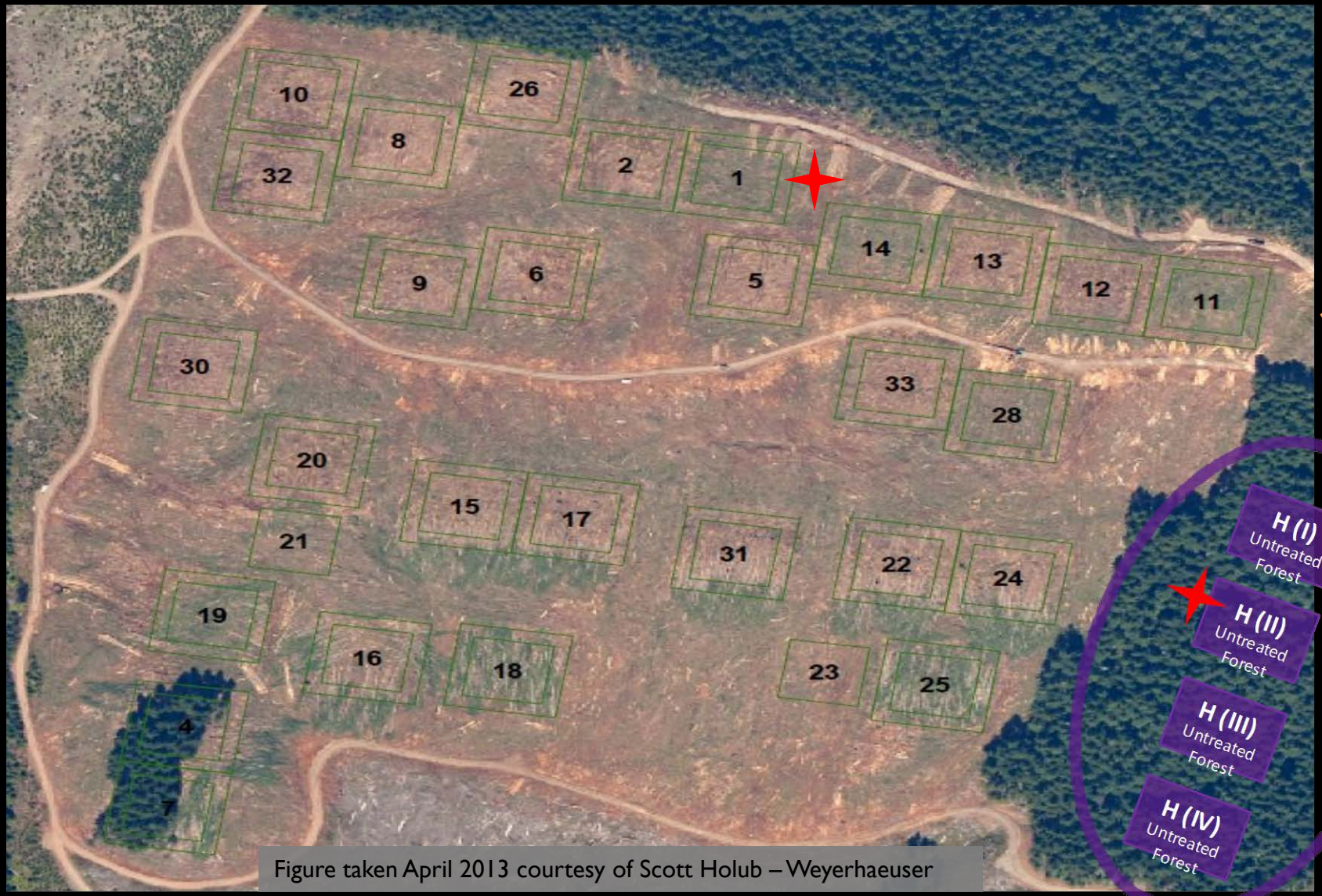


Figure taken April 2013 courtesy of Scott Holub – Weyerhaeuser