

Does Root Carbon from Harvested Trees Replace Mineral Carbon?

Effects of LTSP Treatments in a Western Oregon Douglas-fir Forest

Adrian Gallo

galloa@oregonstate.edu

Jeff Hatten

Scott Holub

Kate Lajtha



Weyerhaeuser



NARA

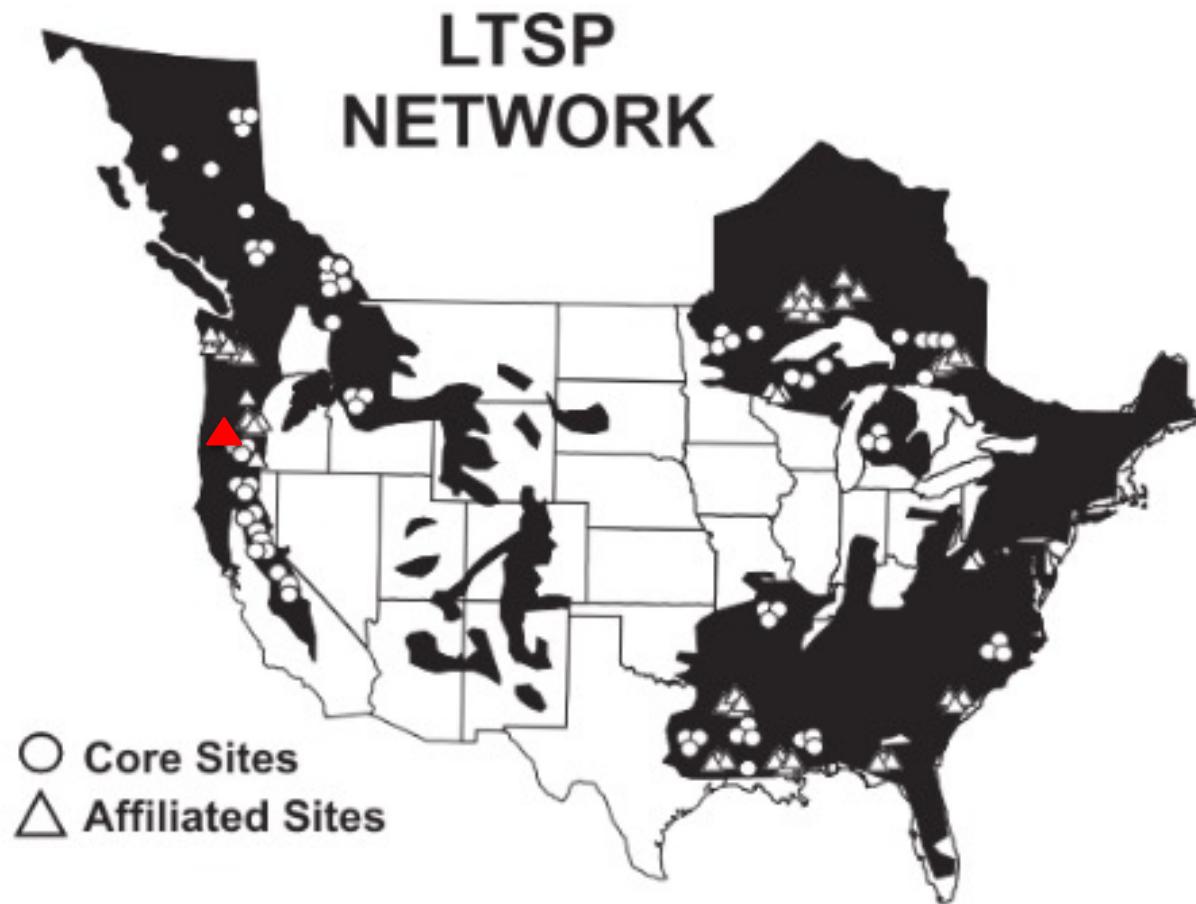
Northwest Advanced Renewables Alliance

How to understand forest management impacts?

Long-Term Soil Productivity (LTSP)

- Organic Matter
 - Biomass
- Compaction
 - Bulk Density

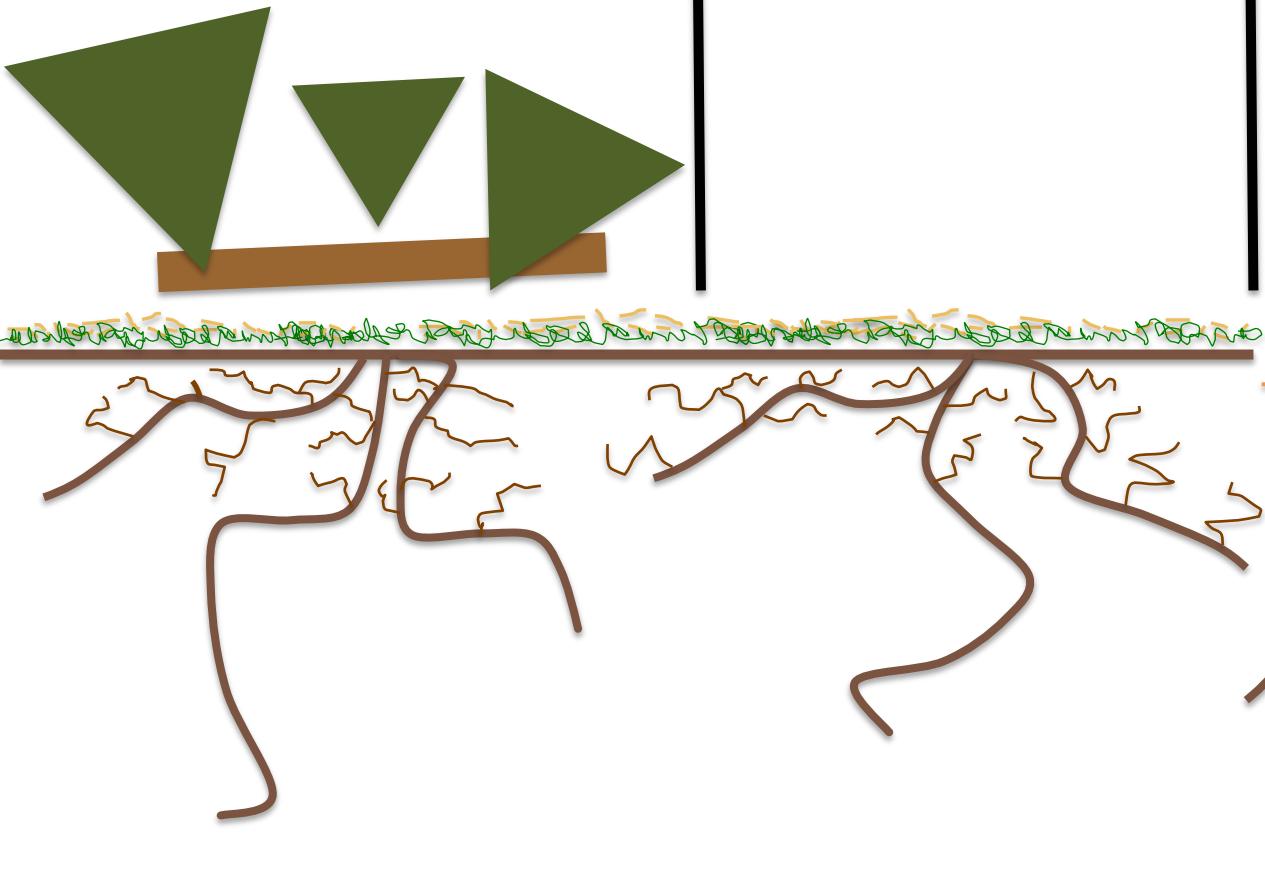
▲ Oregon Study



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

**Bole Only
(BOC)**

\sim 150 Mg-C/ha



**Total Tree
(TTC)**

\sim 50 Mg-C/ha

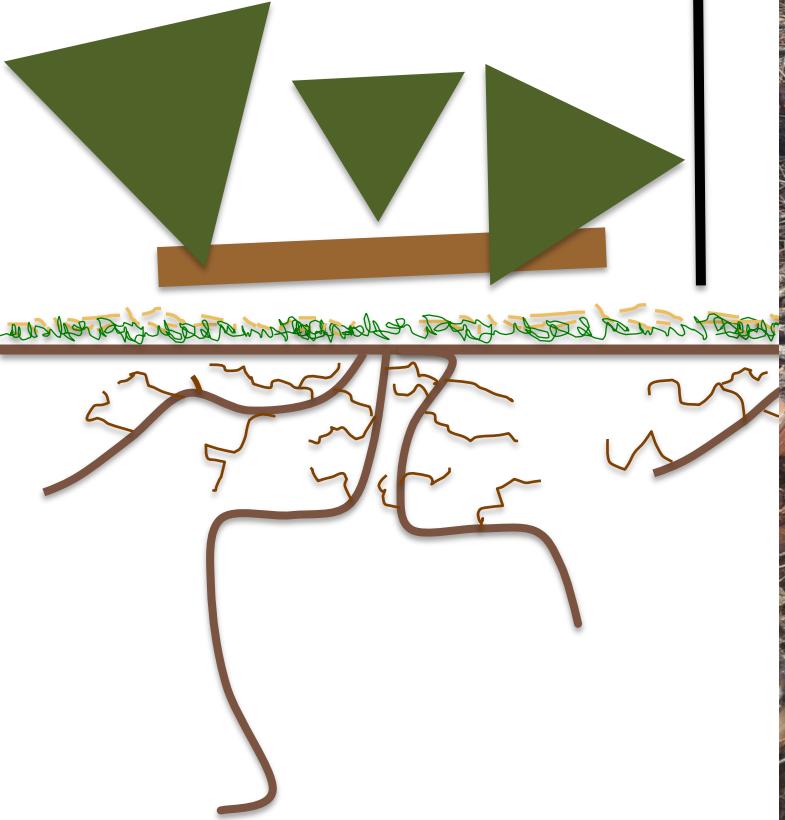
**Total Tree +
Forest Floor
Removal
(FFC)**

<5 Mg-C/ha



Bole Only (BOC)

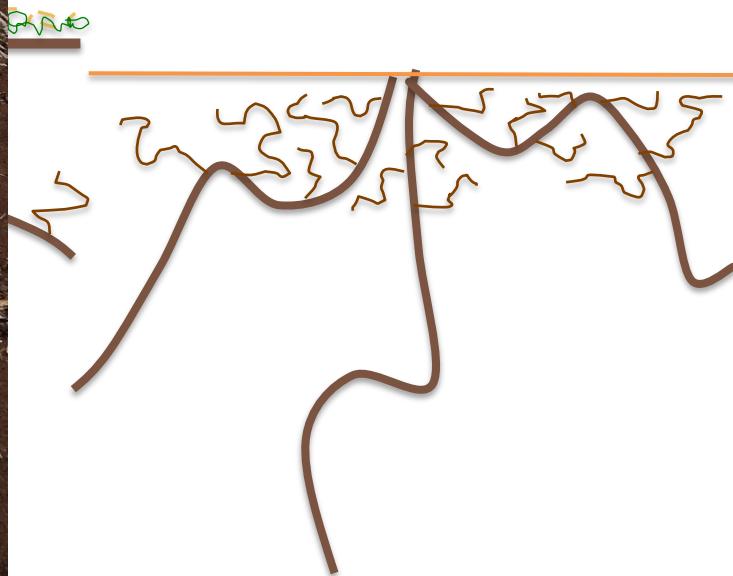
~ 150 Mg-C/ha





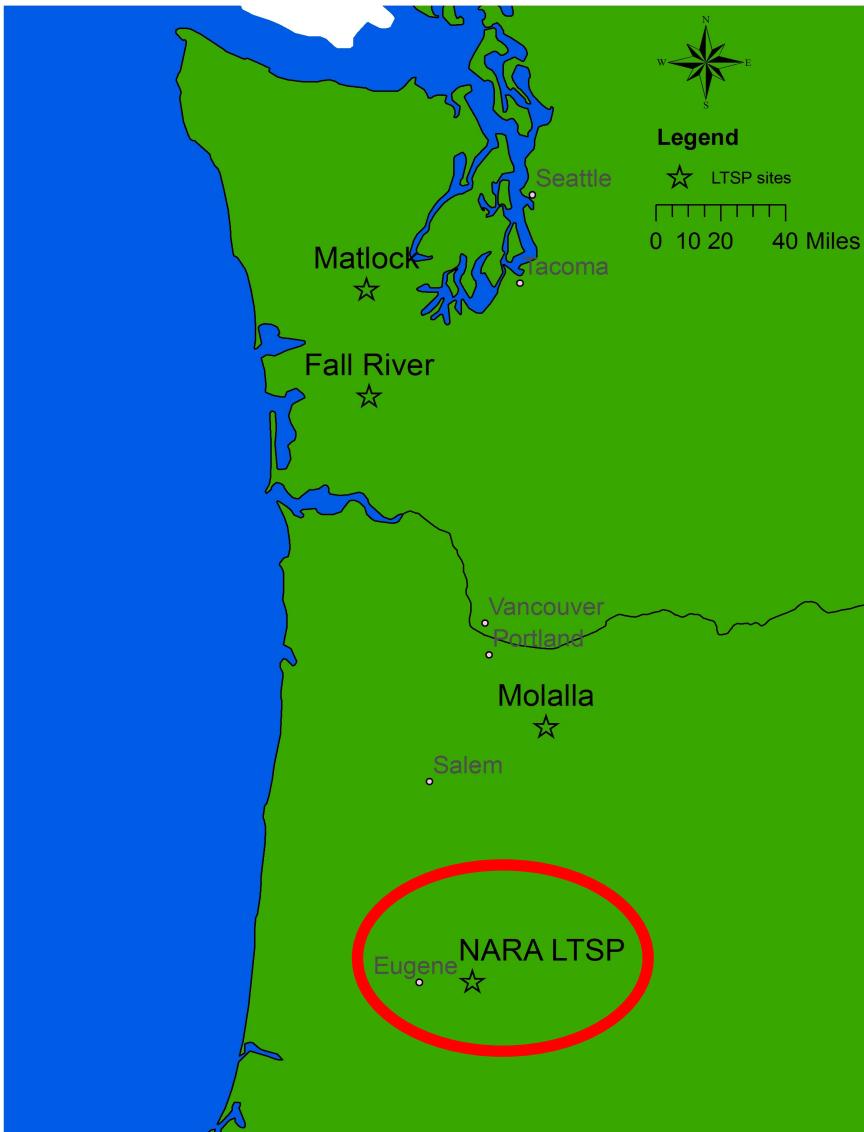
Total Tree +
Forest Floor
Removal
(FFC)

<5 Mg-C/ha



Location, Treatments, & Climate

Figure courtesy of Scott Holub – Weyerhaeuser



DESCRIPTION	TREATMENT ID
Unharvested Forest Reference	REF
Bole Only Harvest +compaction	BOC
Total Tree Harvest +compaction	TTC
TT & Forest Floor Removal +compaction	FFC

2012 Pre-harvest soil sampled

2013 Treatments applied, soil sampled

2015 Two-year post soil sampled

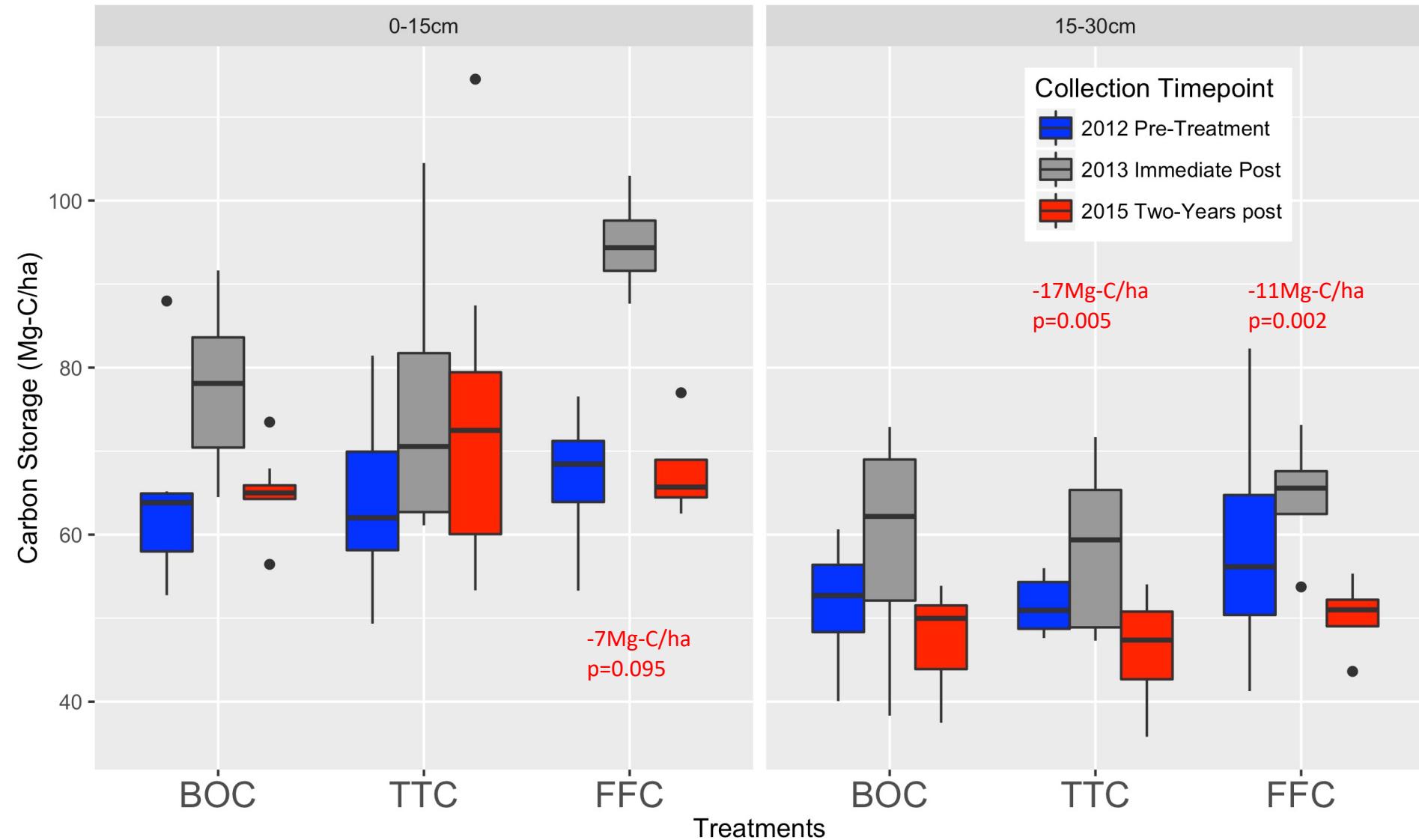
+Herbicide for understory cover <20%

MAT=11.4°C, MAP=140cm (rain only)

Fine-loamy, isotic, mesic Andic Humudepts

Clay loam texture 0-100cm

Total Carbon Stores by Depth



Average Daily Soil Temperature 2014-2015

Average Temperature

FFC vs BOC

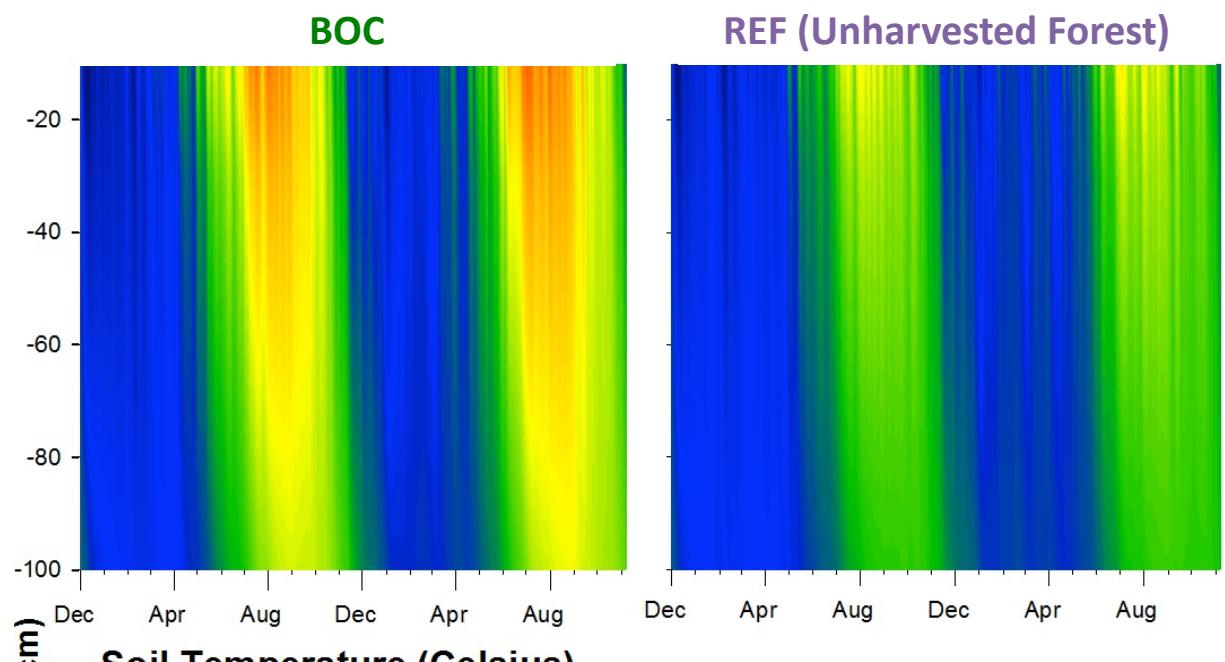
(Effect of Forest Floor Removal)

@10cm = +2.7°C

@20cm = +2.5°C

@30cm = +1.2°C

@100cm = +0.95°C



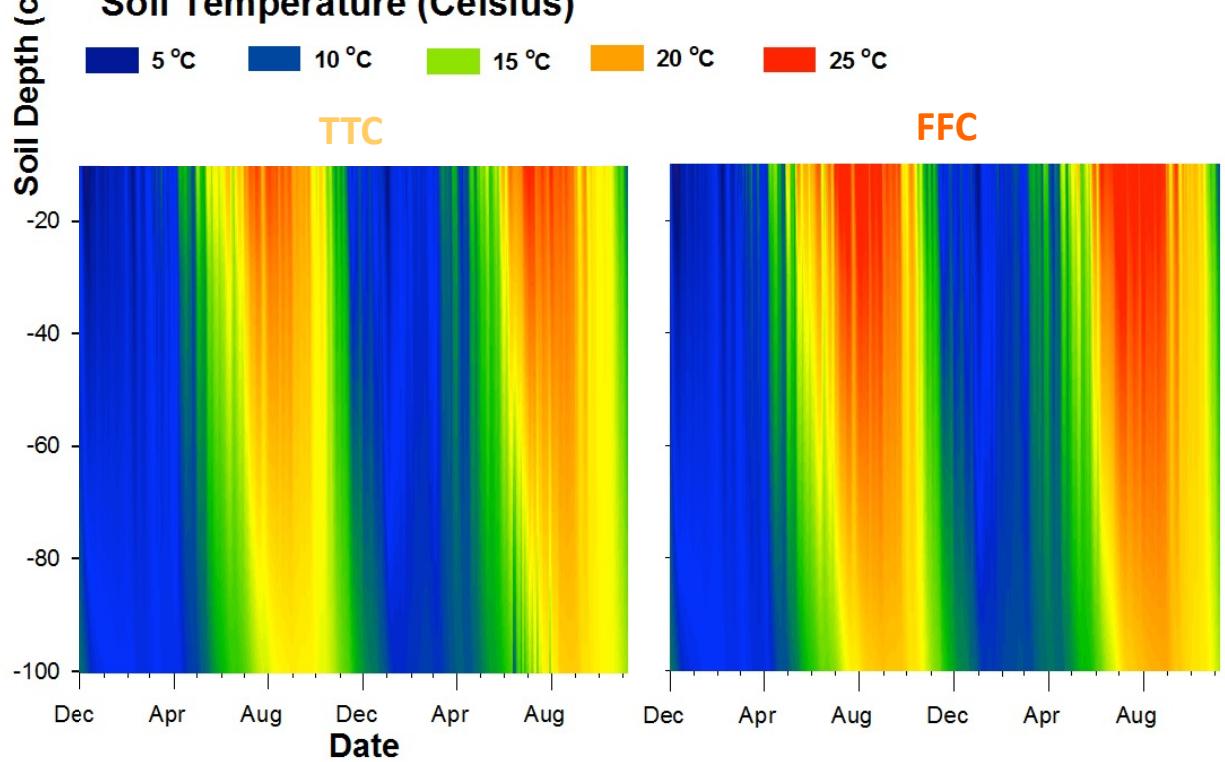
Maximum Temperature

FFC vs BOC

(Effect of Forest Floor Removal)

@10cm = +5.5°C

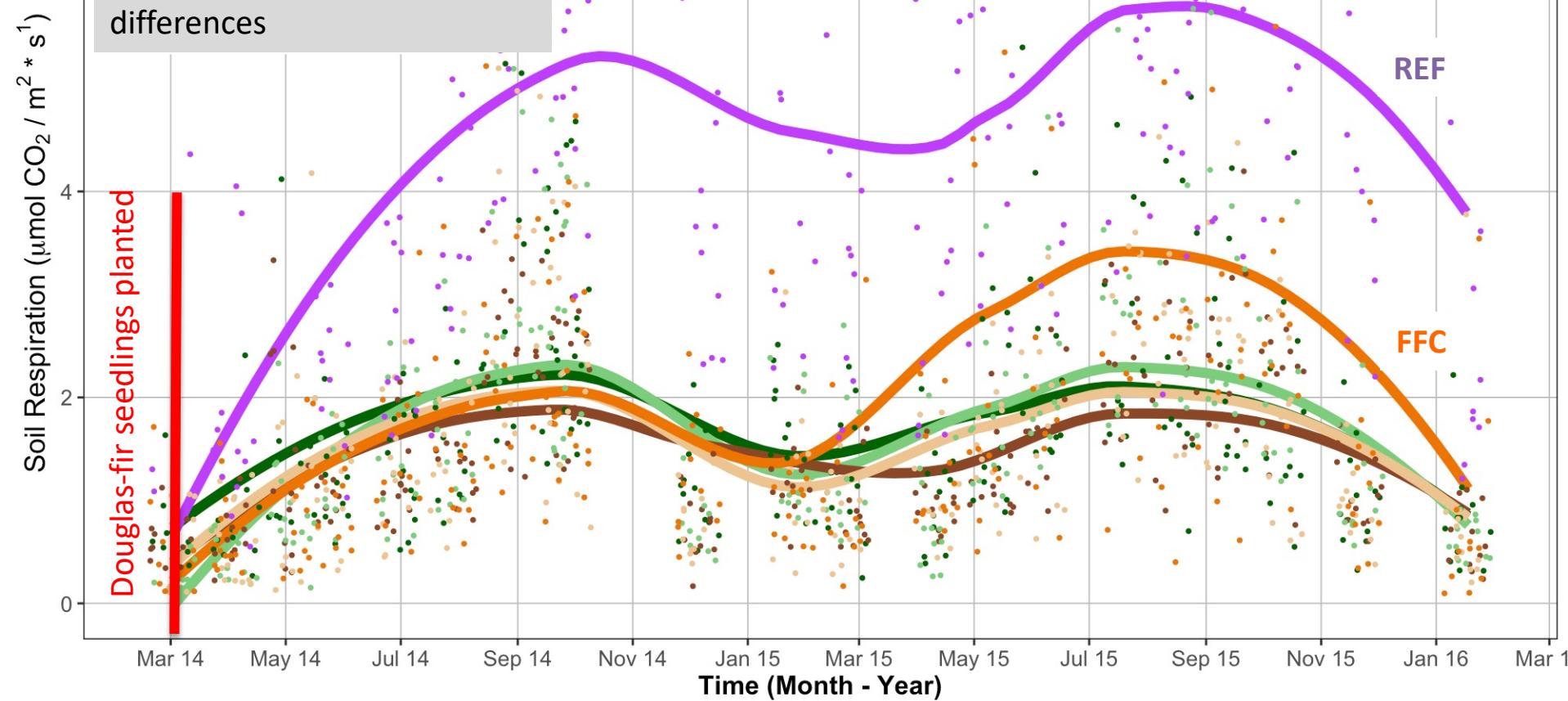
@100cm = + 2.9°C



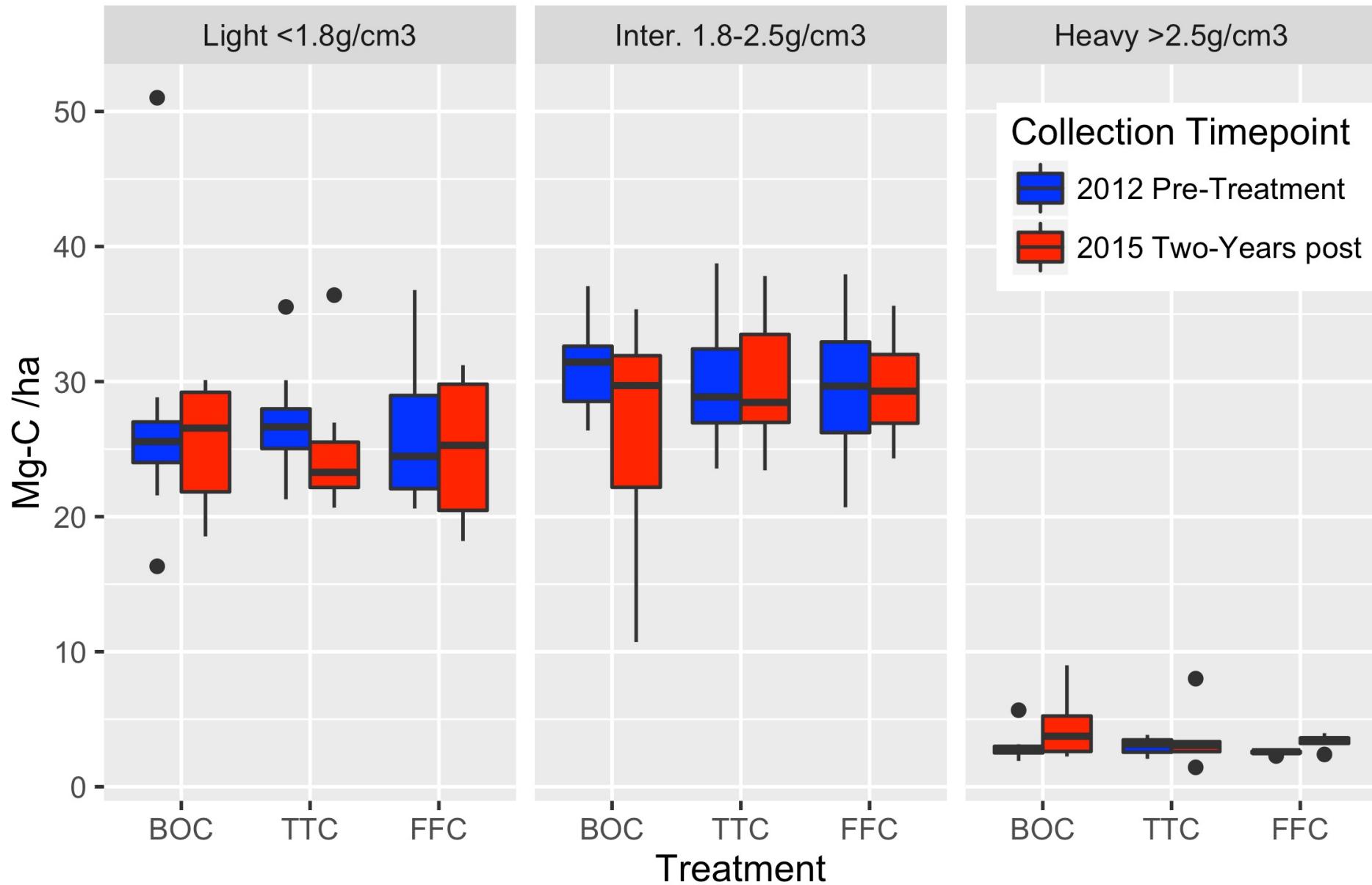
Bulk Soil Respiration Time Series

Bulk Soil Respiration with Organic Matter & Compaction Manipulations

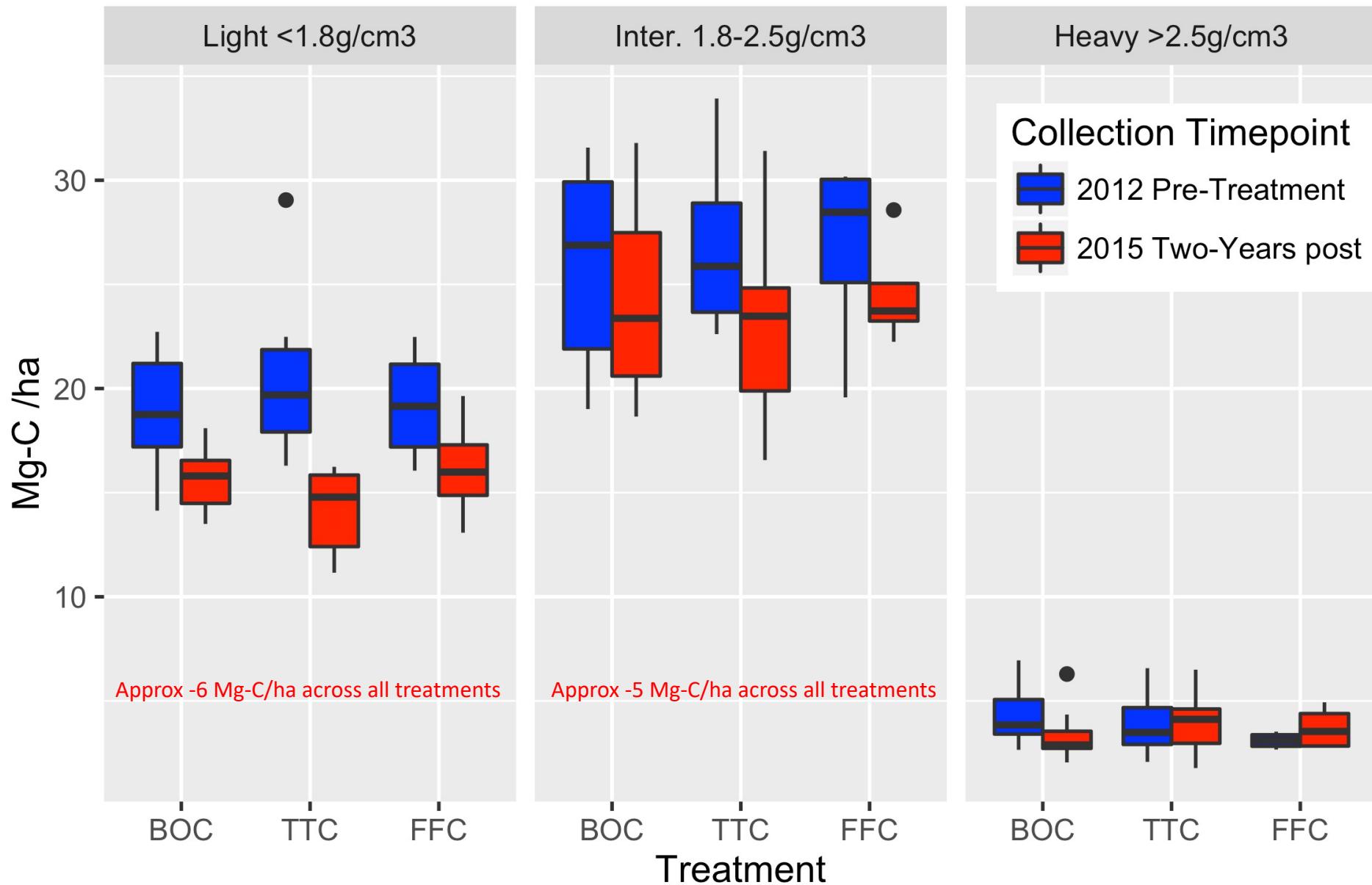
→ Li-COR 8100A infrared gas analyzer monthly for 2-yrs
→ Disturbance from harvest overshadow treatment differences

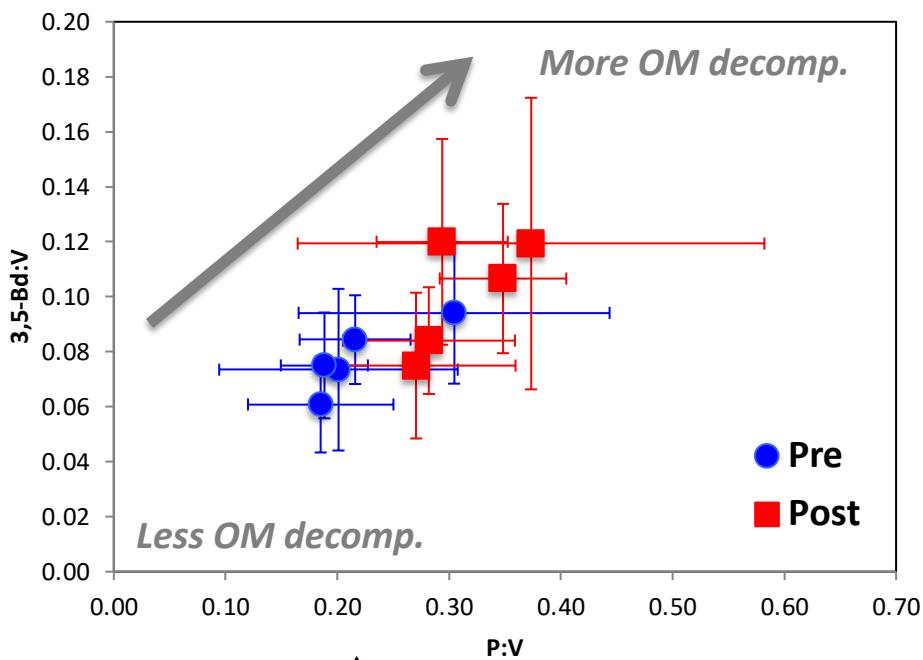


C-storage per Fraction (0-15cm)



C-storage per Fraction (15-30cm)



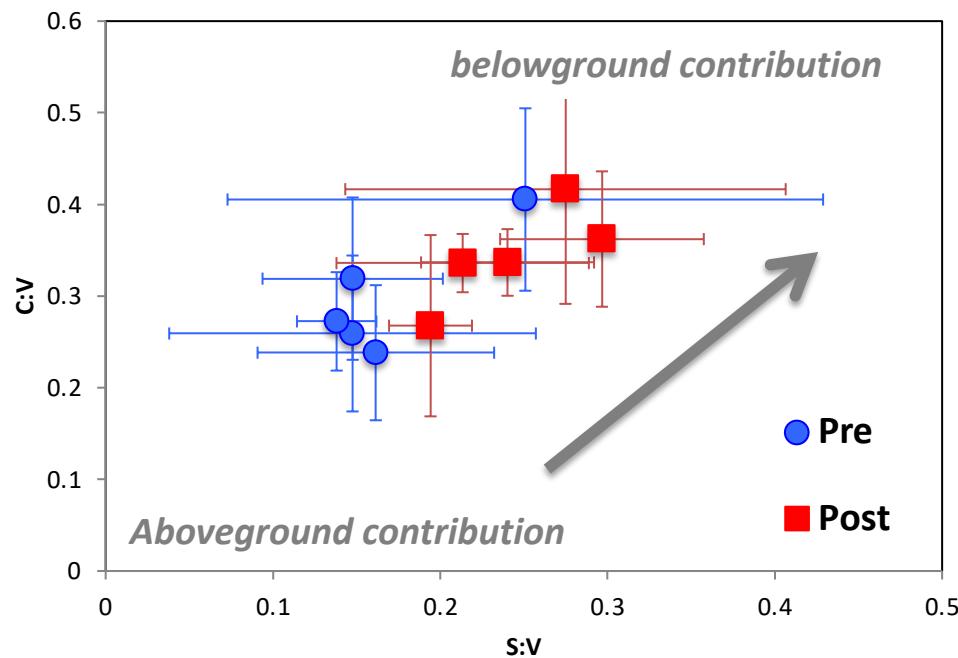


Increasing levels of organic matter decomposition

Soil-C has a higher contribution from belowground (**root**) components for all treatments

Cupric Oxidation Method

- Provides estimates of plant & microbial degradation products
- All axes normalized to Vanillin
- Bulk soils
- Each point = avg of 4 replicates within each treatment



Conclusions

What didn't change?

- > Bulk soil carbon 0-15cm
- > Soil respiration (in year 1)

What DID change?

- > Soil Temp ↑ with ↑ OM removals
- > Soil-C in density fractions 15-30cm
- > Light & inter. fraction C-stores **-5Mg C/ha** each after 2yrs

Source of Carbon?

- > More SOM decomposition with belowground contributions
- > Evidence of **fine** root-C buffering OM removals
- > Study infancy (3yrs old)



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Questions?

Adrian Gallo

galloa@oregonstate.edu

@Gallo_Rocks

Jeff Hatten* & Kate Lajtha*

OSU Forest Soils Lab Group

Yvan Alleau

Brett Morissette

Weyerhaeuser Company

Scott Holub*

Nathan Meehan

Greg Johnson

Funding Agency

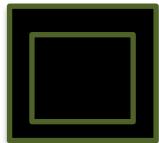
NARA is led by Washington State University and is supported through the USDA Competitive Grant # 2011-68005-30416



Extra Slides

- Continue if you dare....

Plot Layout



1 acre treatment plot and
½ acre measurement plot.



Weather Stations



Treatment Design

ORGANIC MATTER REMOVALS	COMPACTI	
	No Compaction	Compaction (C)
Unharvested Forest Reference (REF)	REF	<i>Not Conducted</i>
Bole Only Harvest (BO)	BO	BOC
Total Tree Harvest (TT)	TT	TTC
TT + Forest Floor Removal (TPP)	<i>Not Conducted</i>	TPP

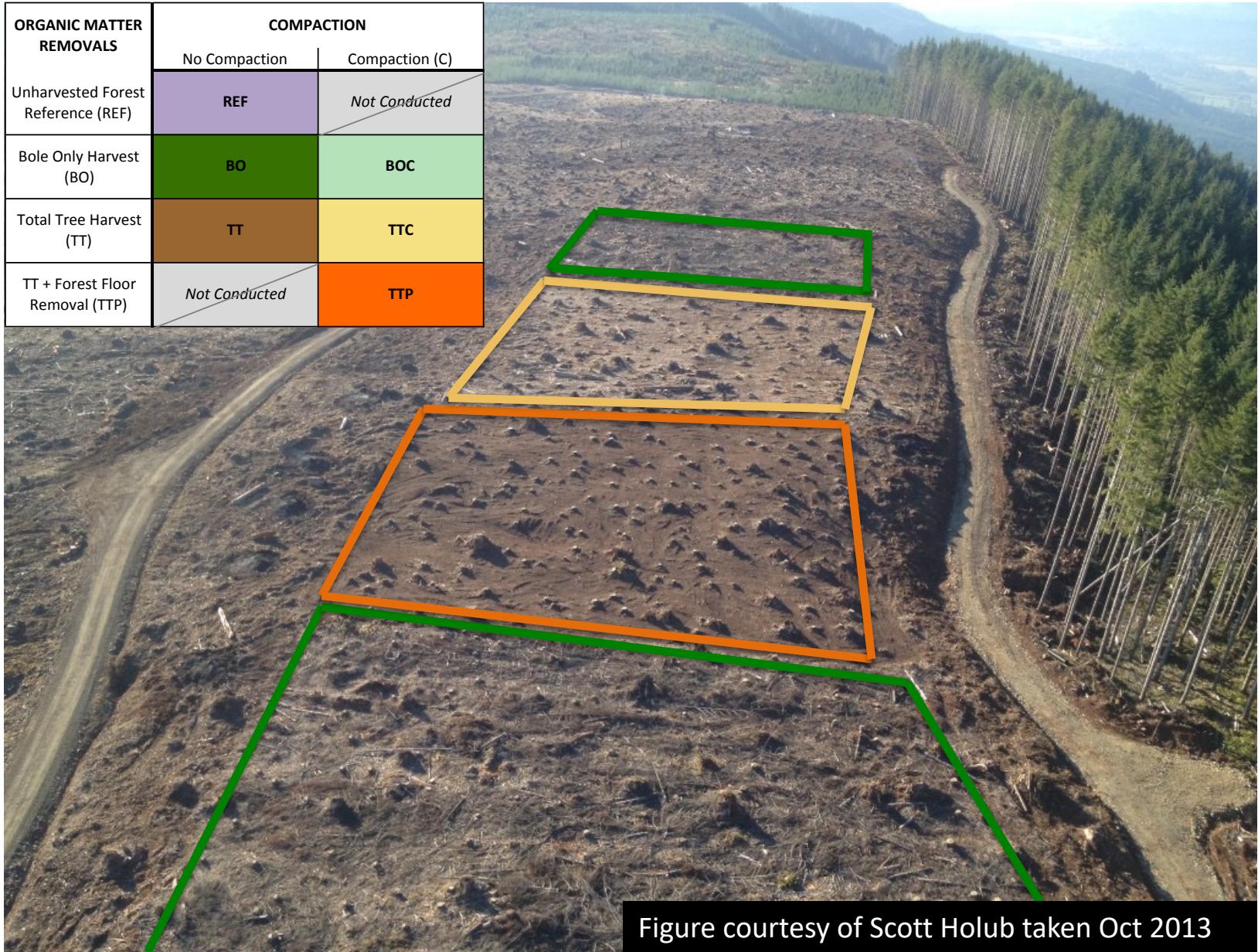


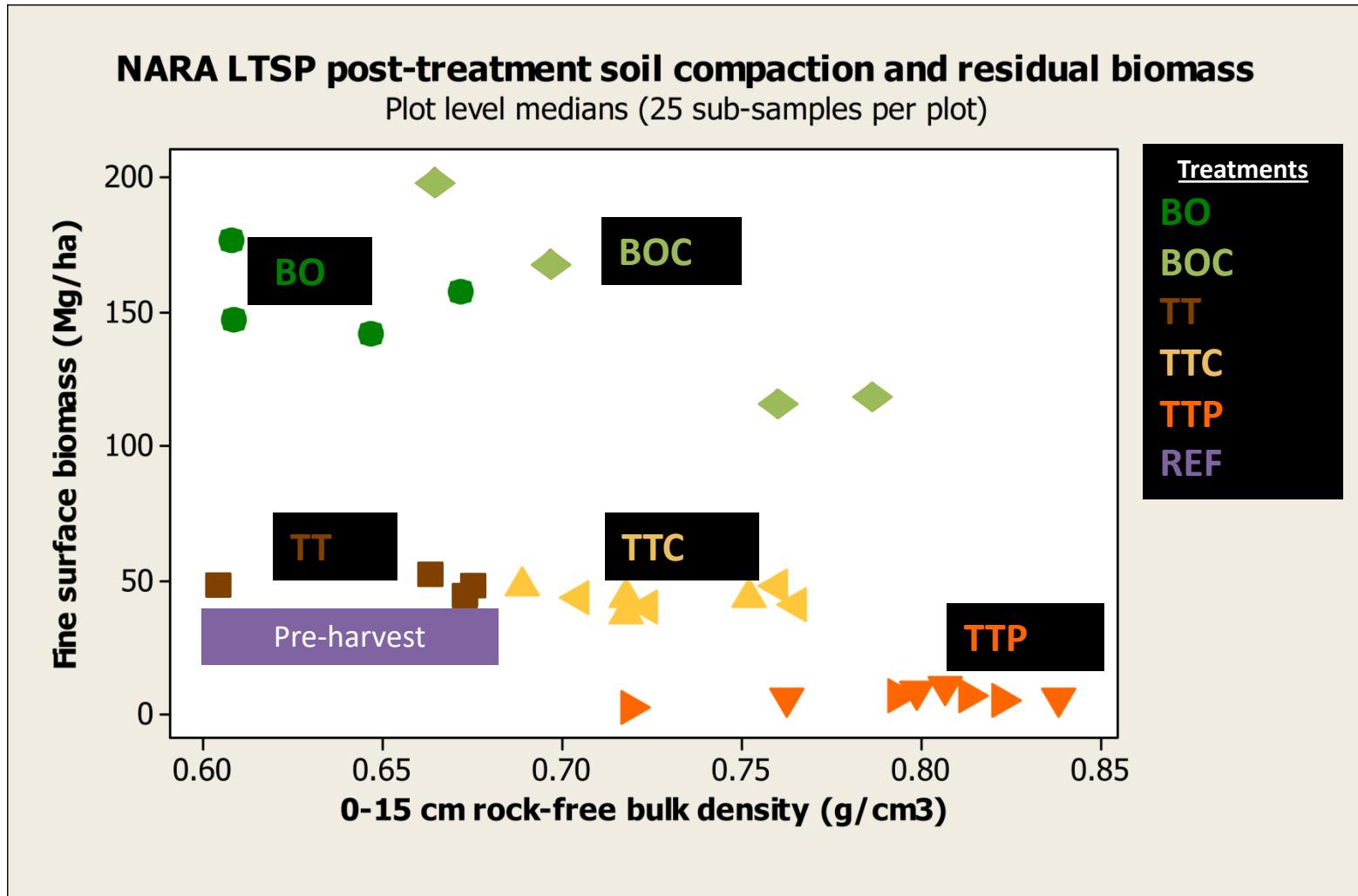
Figure courtesy of Scott Holub taken Oct 2013

Treatment Implementation

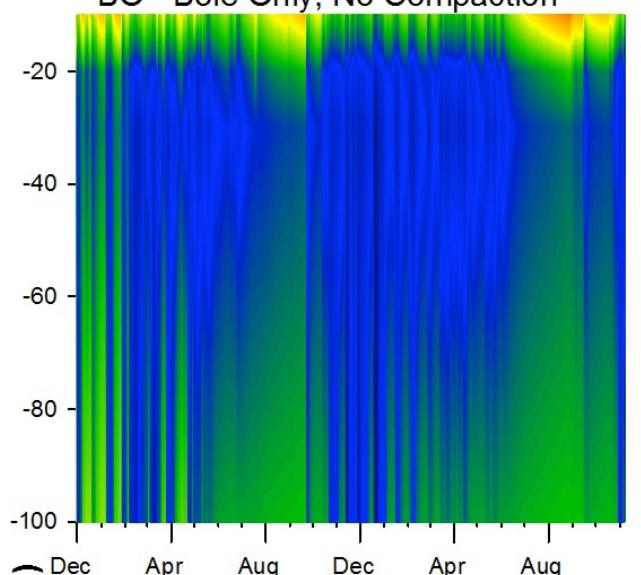
BOC & TTC +15% BD

FFC +23% BD

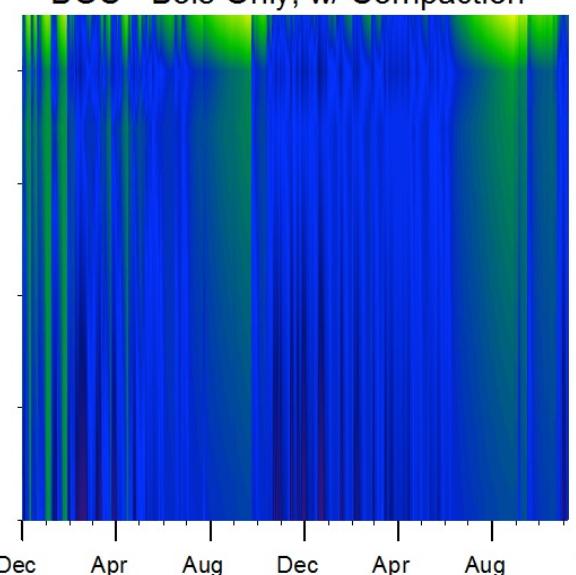
Figure courtesy of Scott Holub – Weyerhaeuser



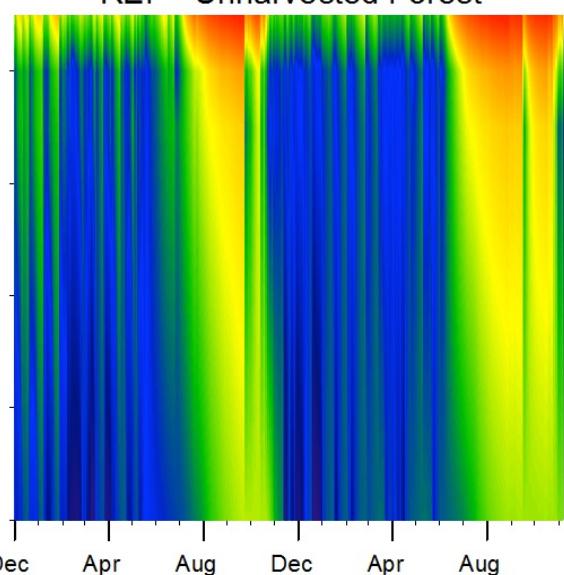
BO - Bole Only, No Compaction



BOC - Bole Only, w/ Compaction



REF - Unharvested Forest



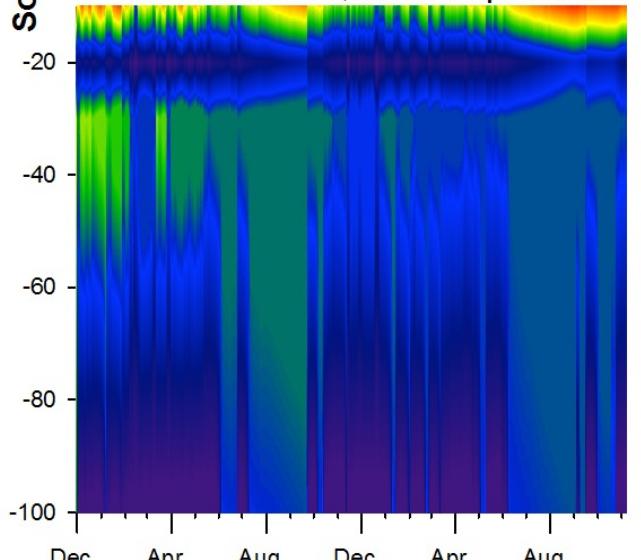
Volumetric Water Content (%)

15 % 20 % 30 % 40 %

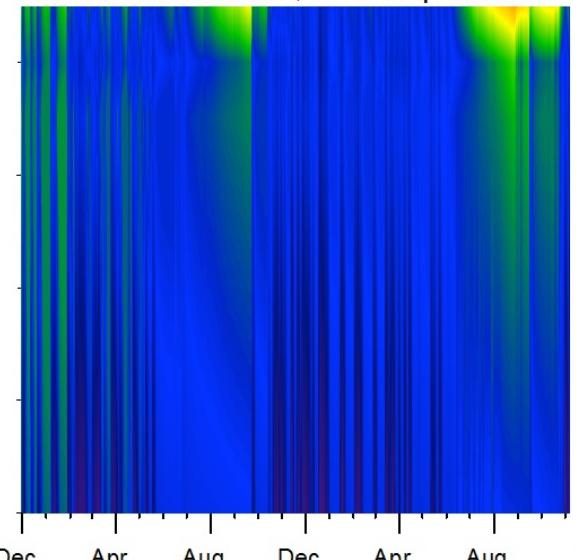
50 %

Soil Depth (cm)

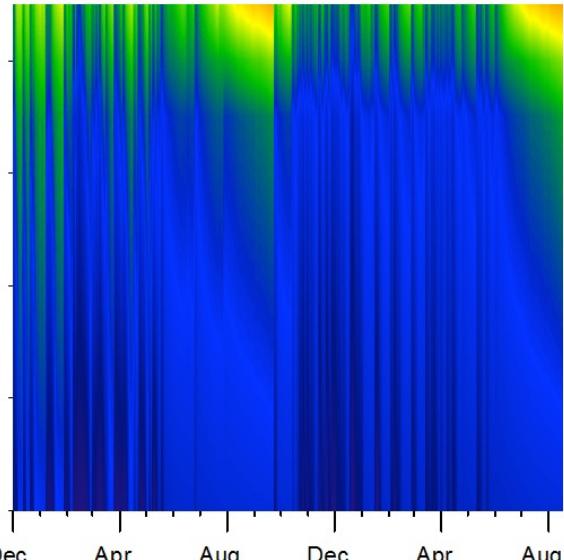
TT - Total Tree, No Compaction



TTC - Total Tree, w/ Compaction

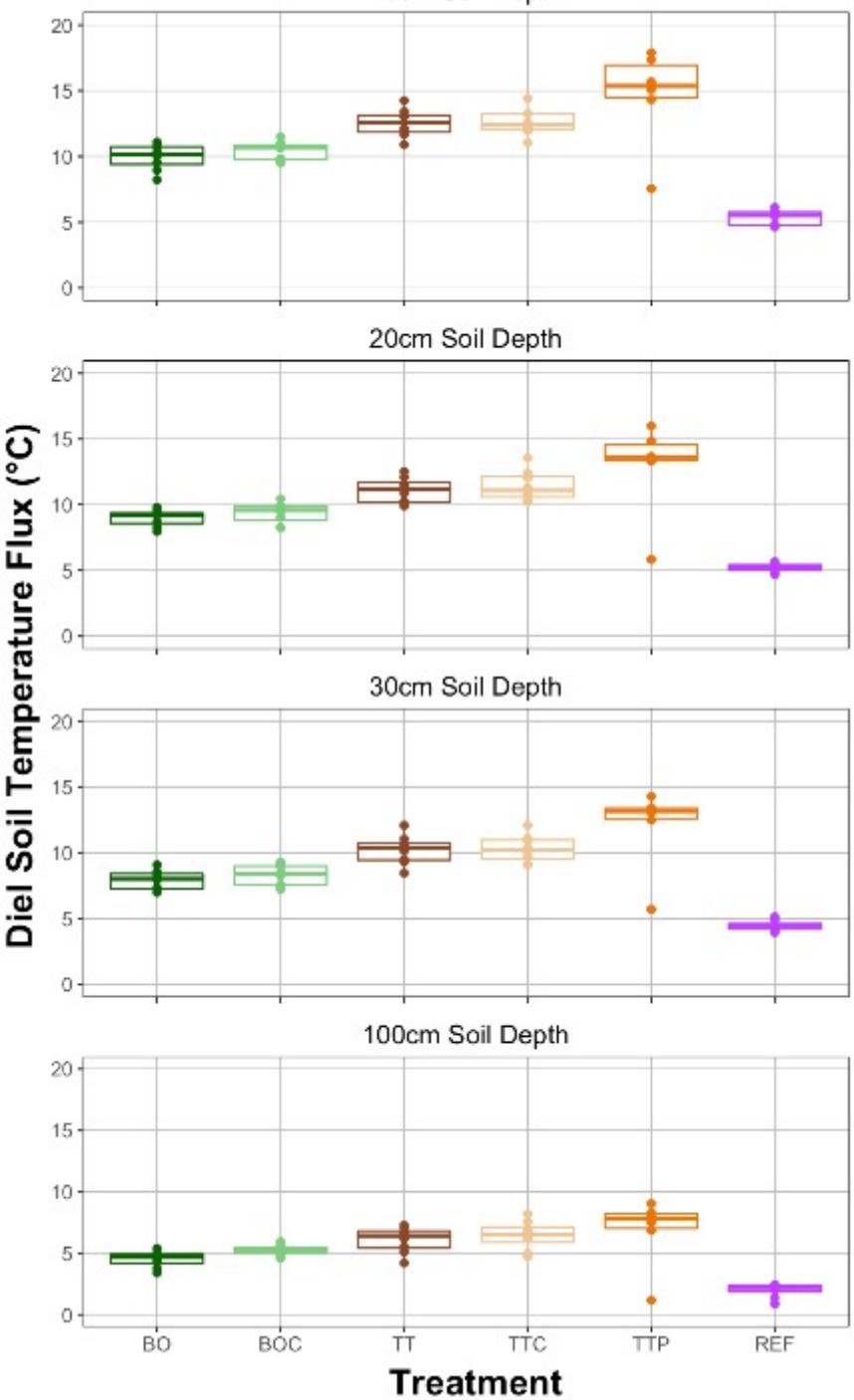


TTP - Total Tree + FF, w/ Compaction

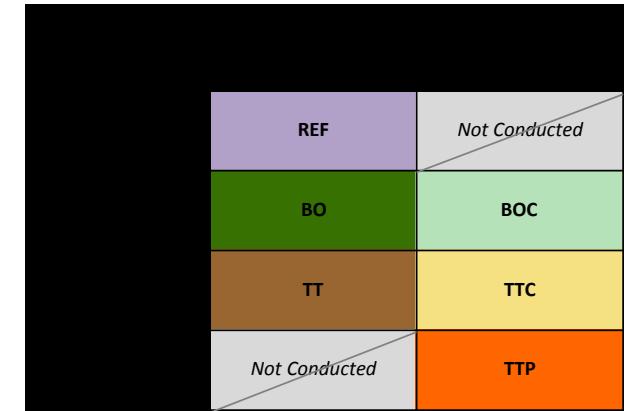


Date

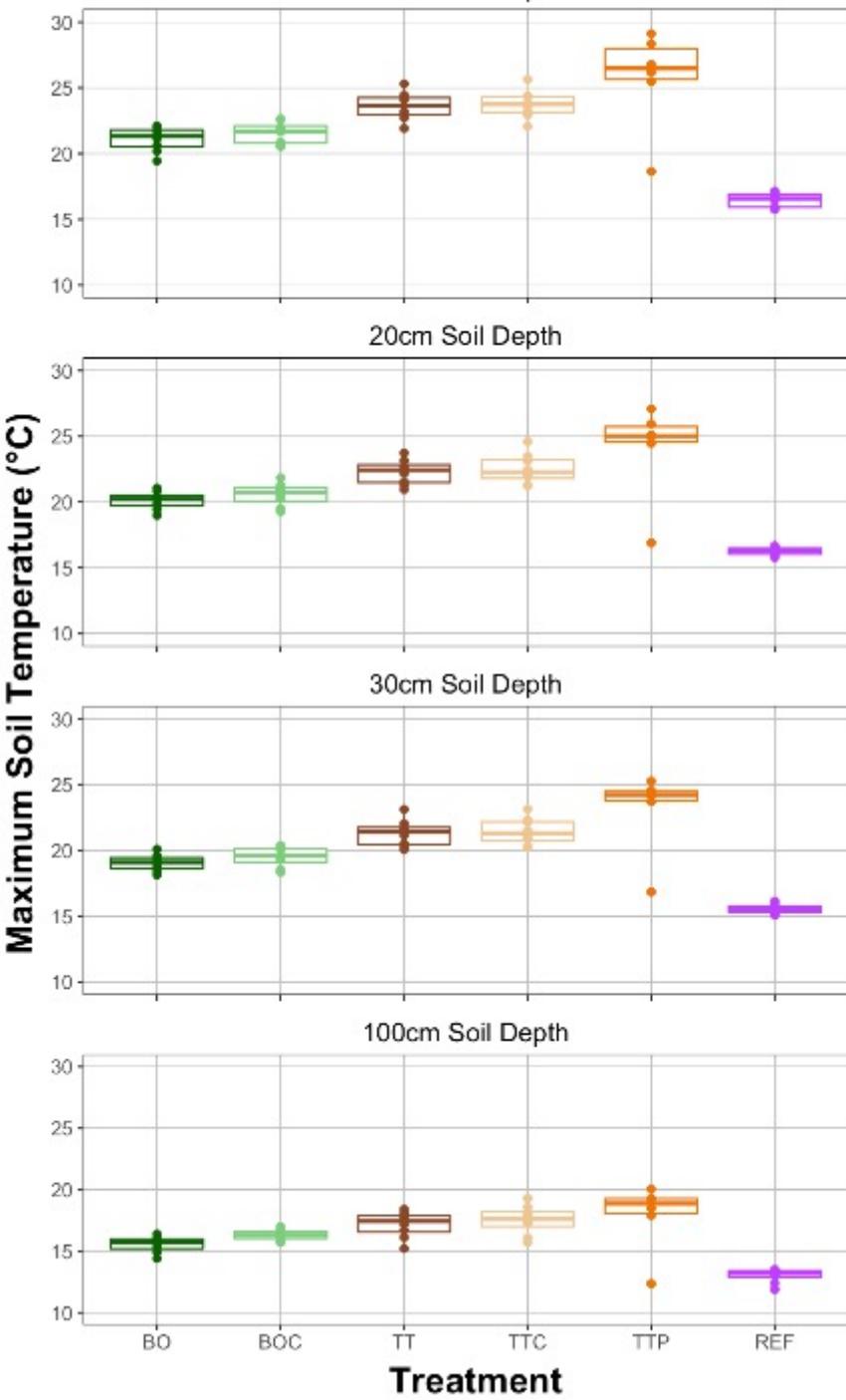
Diel Soil Temperature



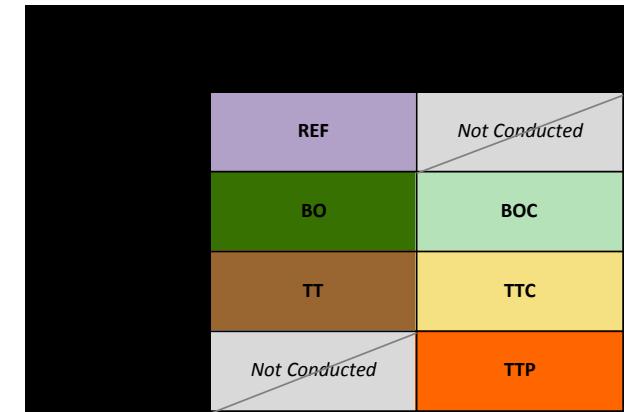
- > All treatments experienced $\pm 10^{\circ}\text{C}$ within a single day at 10cm
- > 6-8°C = seasonal transitions from winter-spring or autumn-summer @100cm
- > Harvesting increases diel flux +2°C @100cm



Maximum Soil Temperature

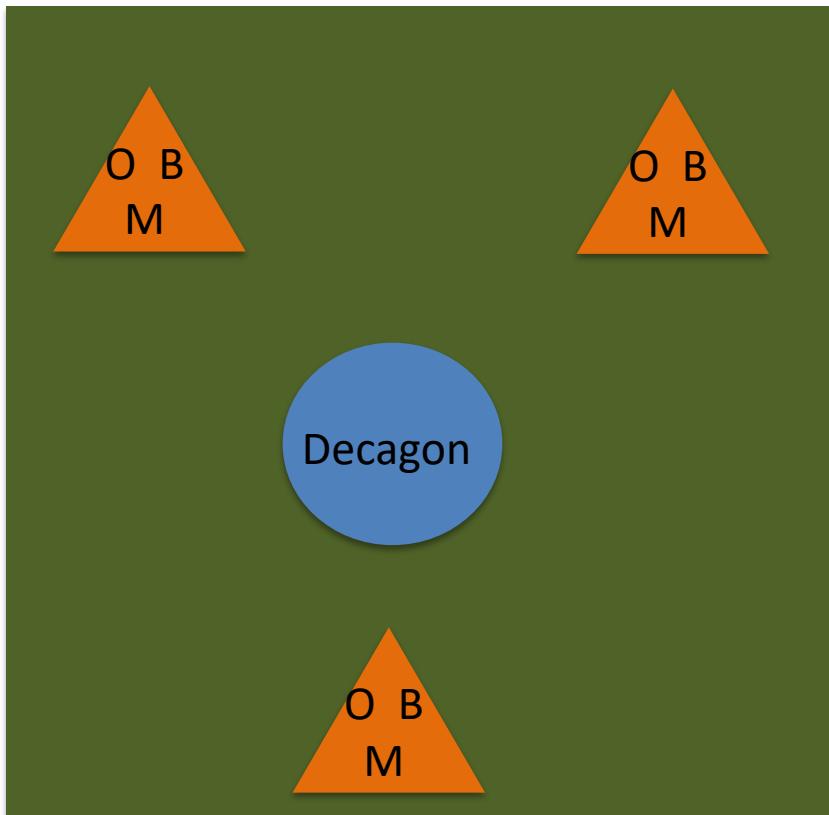


- > 25°C = Optimal root growth temperature for Douglas-fir (Lopushinsky, 1990)
- > Increasing organic matter removal = higher maximum soil temperatures at all depths
- > Compaction had no appreciable effect on soil temperature characteristics



Sources of CO₂

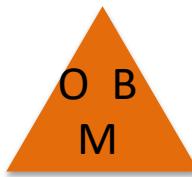
½ acre measurement plot



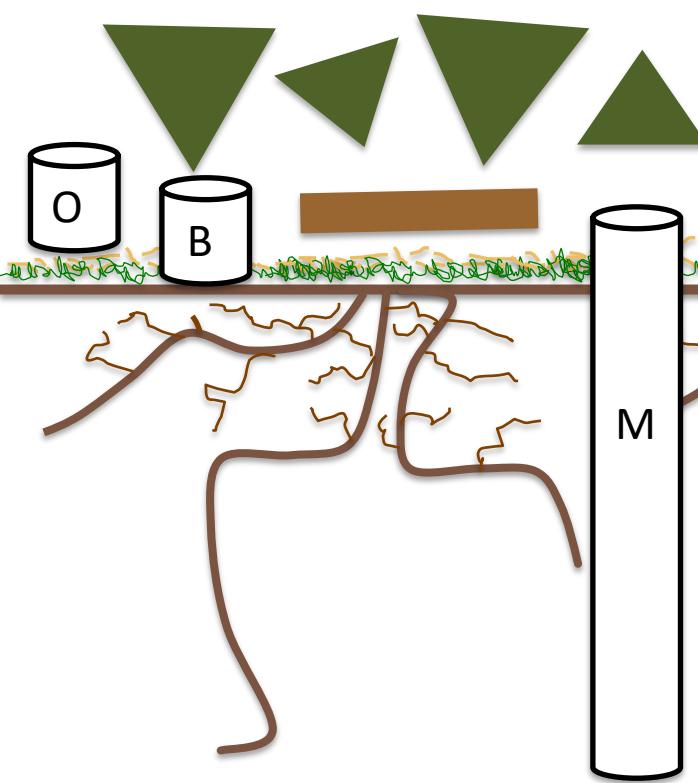
Soil moisture and temperature sensors installed at 10, 20, 30, 100cm depth



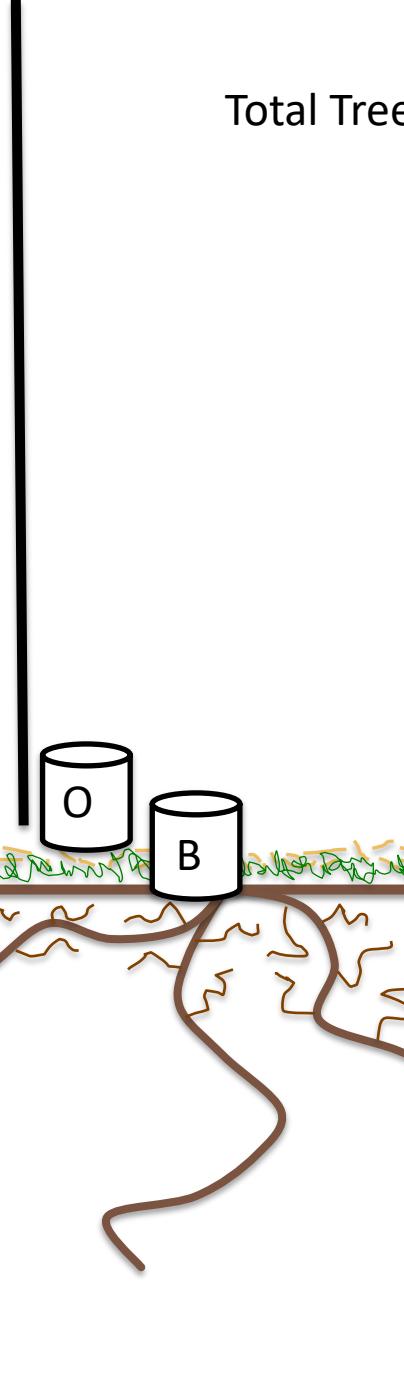
Soil respiration nest that includes O-horizon, Bulk, and Microbial sources of CO₂



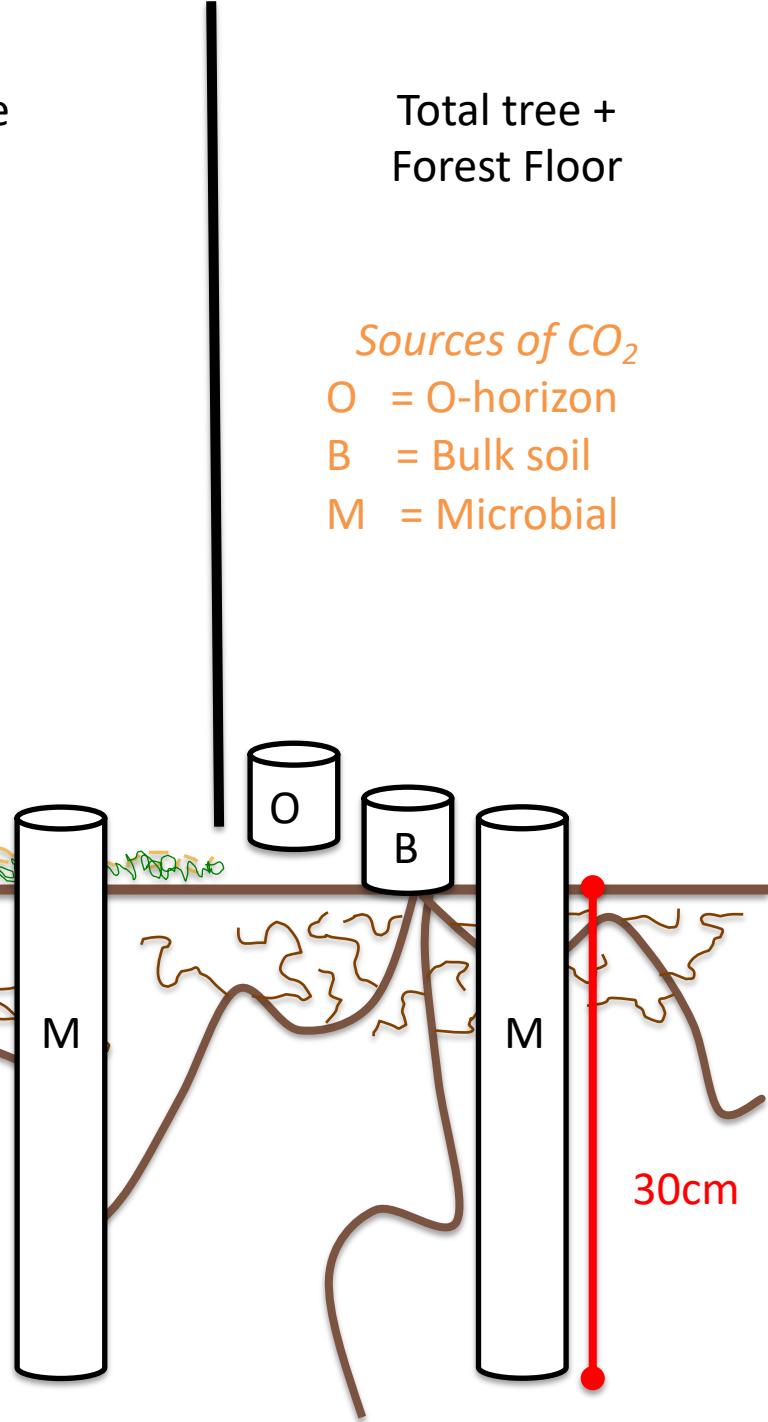
Bole Only



Total Tree



Total tree +
Forest Floor



Sources of CO₂

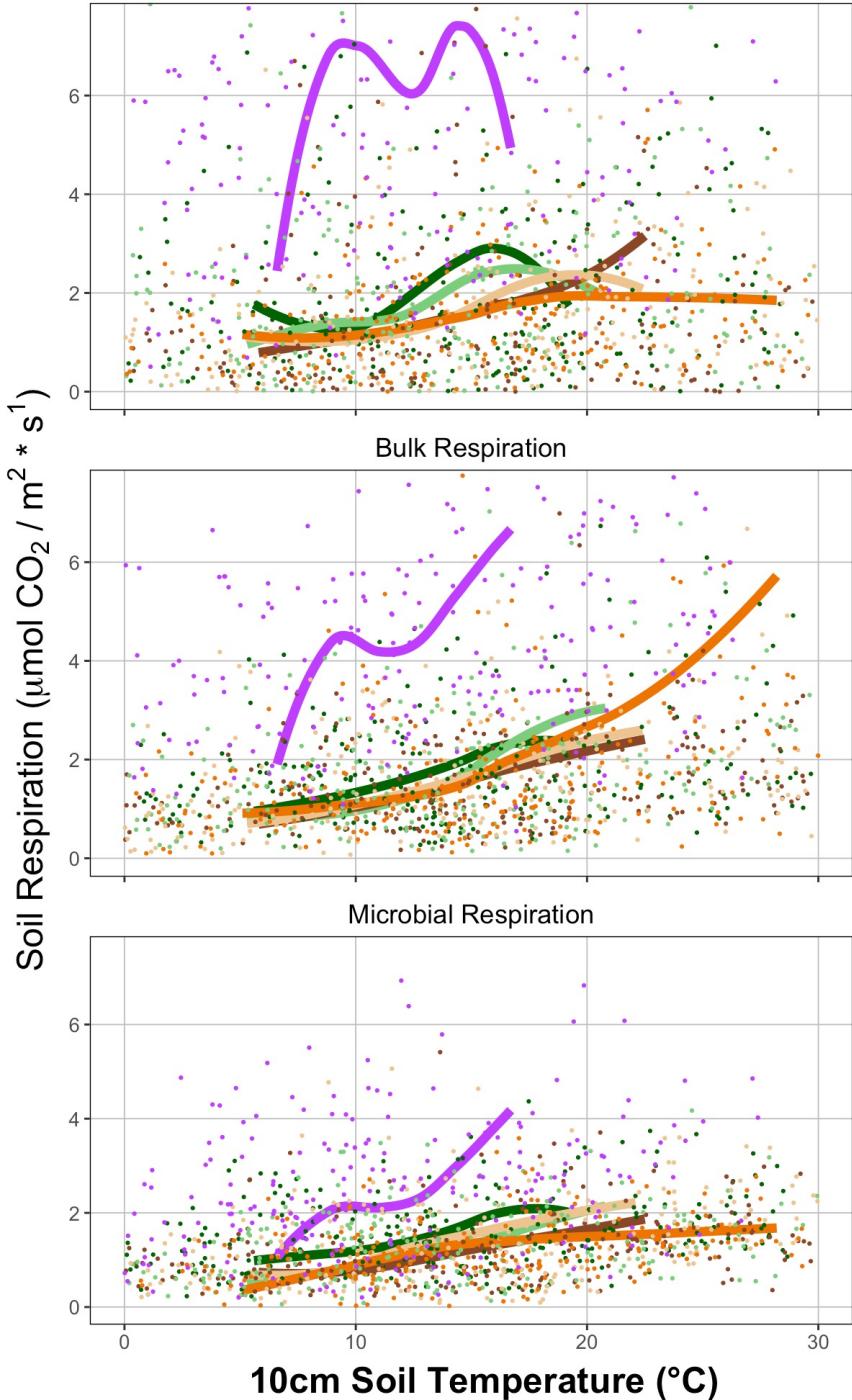
O = O-horizon

B = Bulk soil

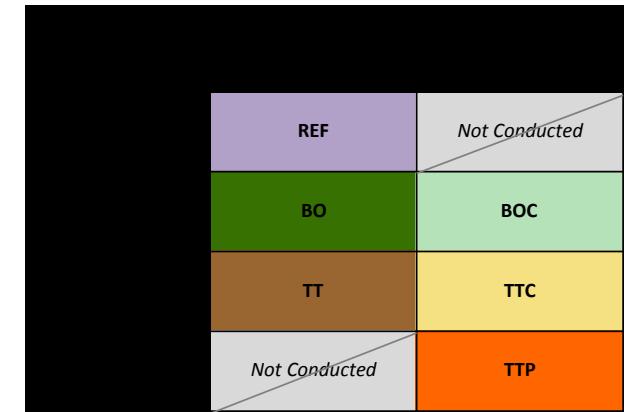
M = Microbial



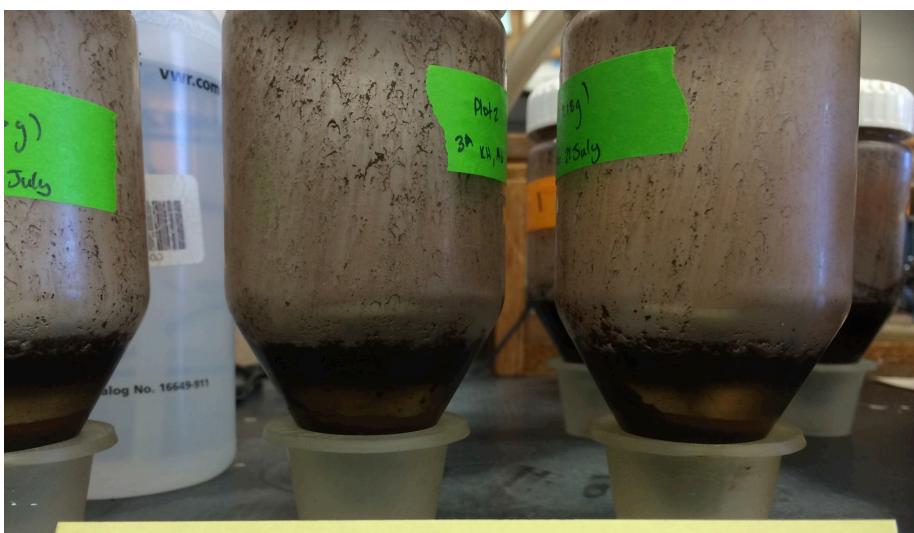
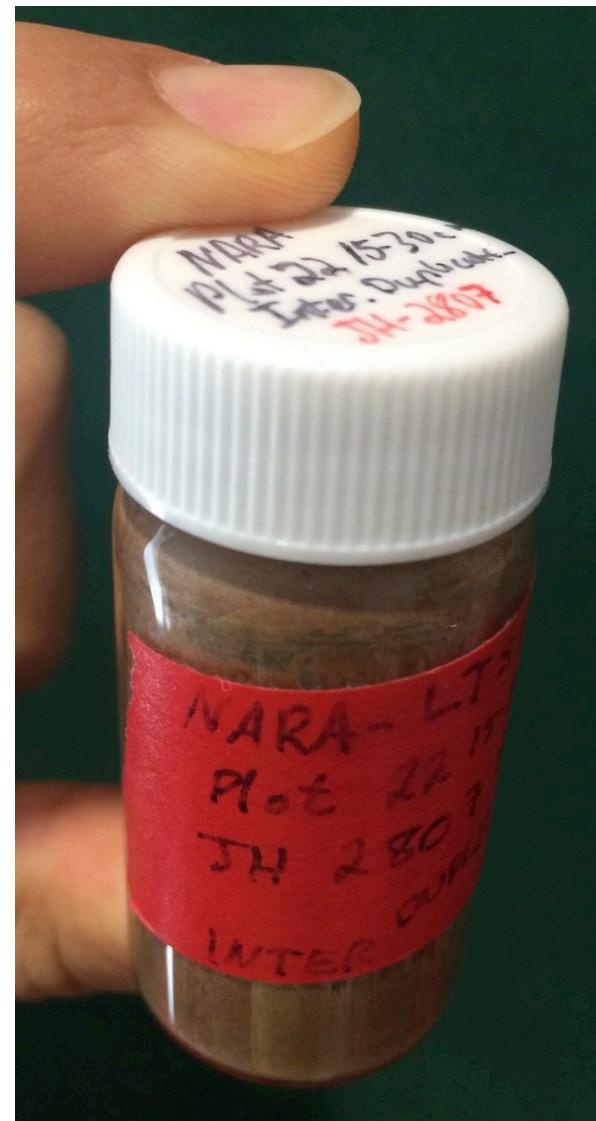
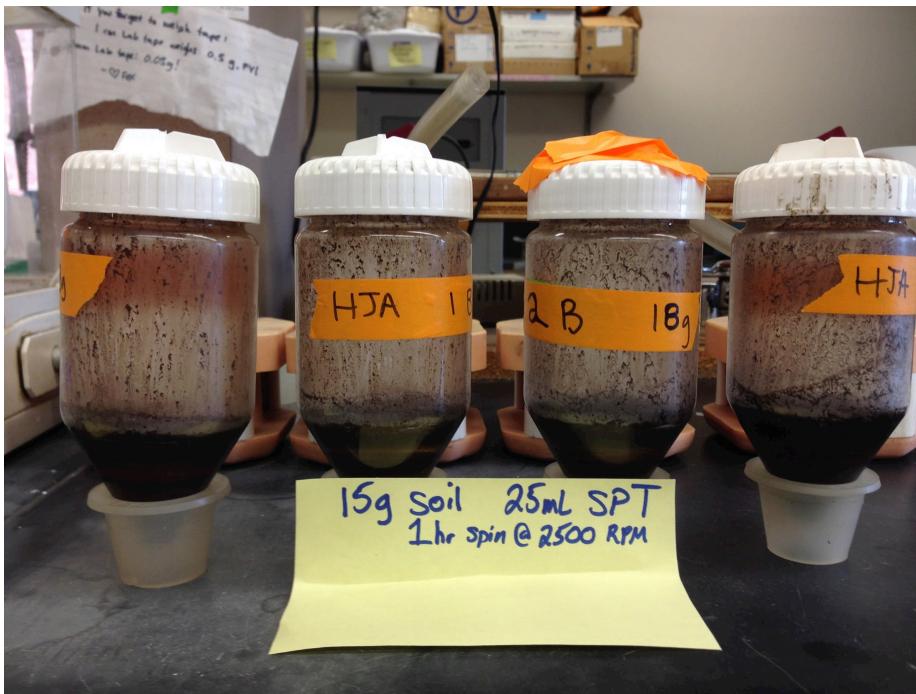
Soil Respiration by Source + Temperature



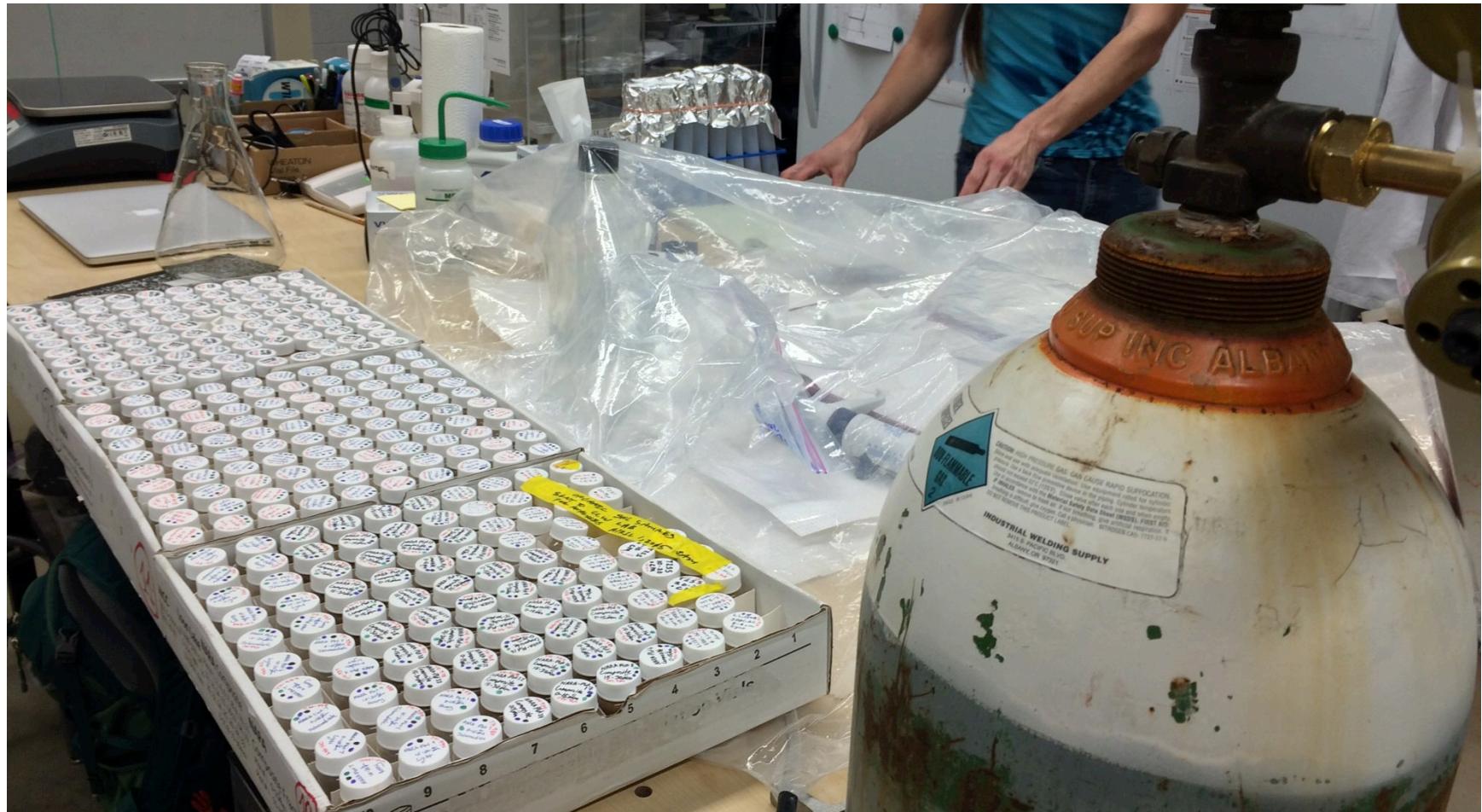
- > TTP treatments have longer tails due to higher observed temperatures
- > Limited evidence for an interaction between temperature and treatments
- > Poor relationship between treatment
- > O-horizon reaches peak $\sim 15^{\circ}\text{C}$

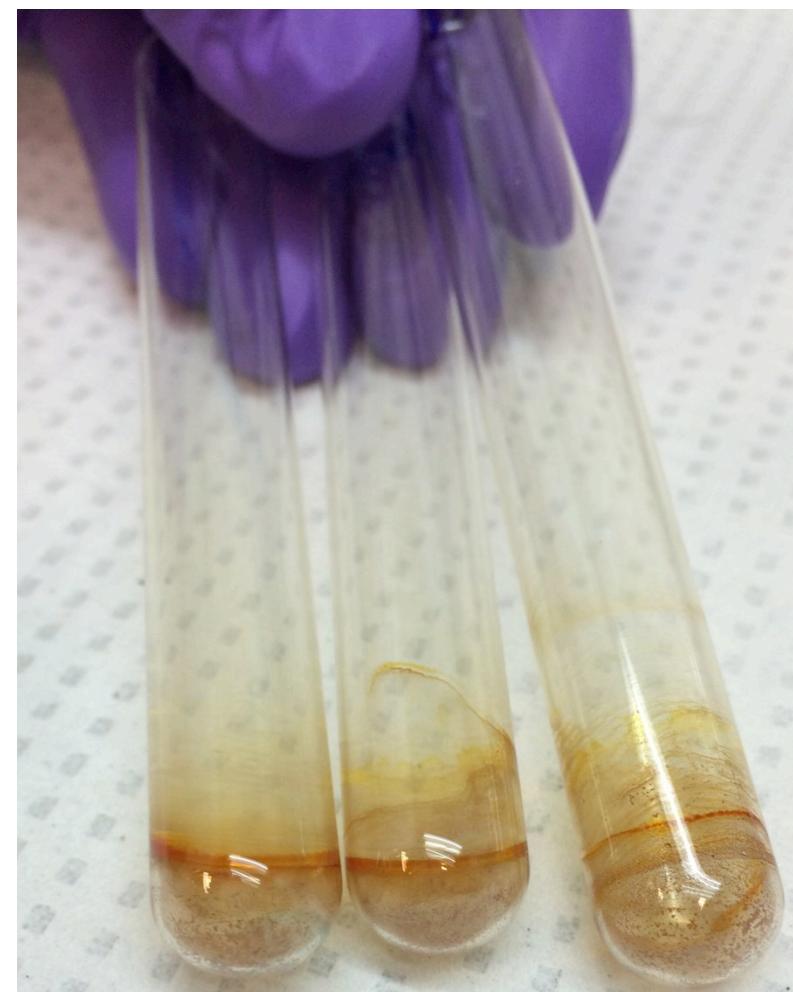
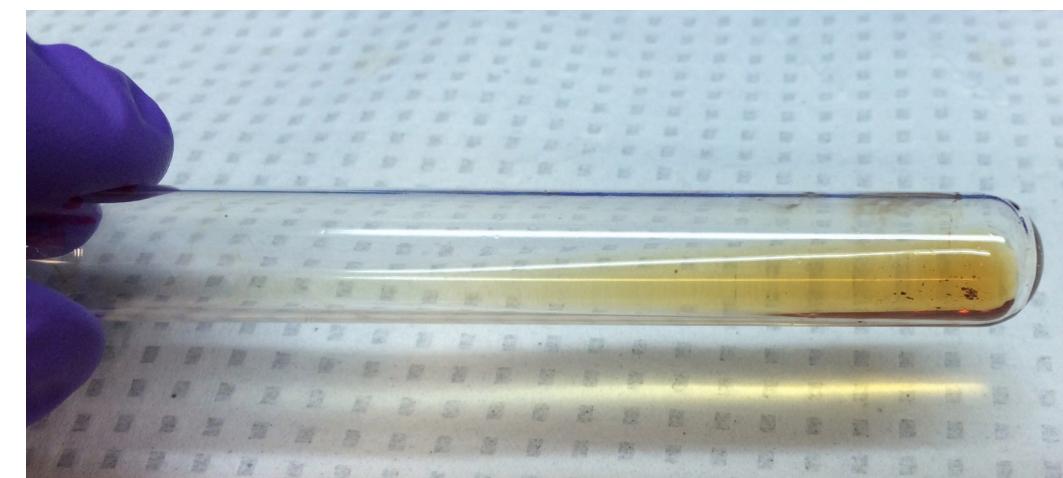




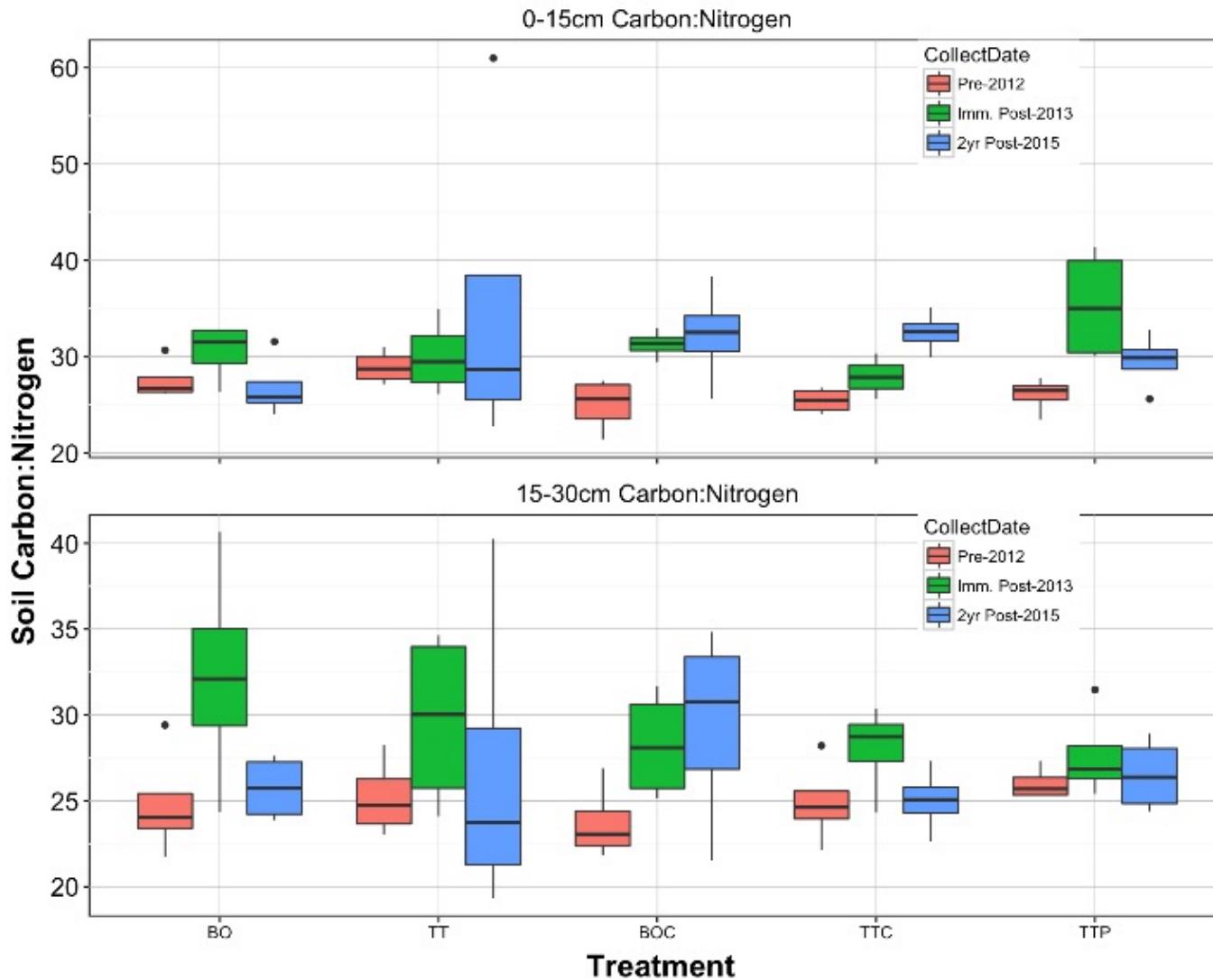


7g soil 20mL SPT
1hr spin @ 2500RPM

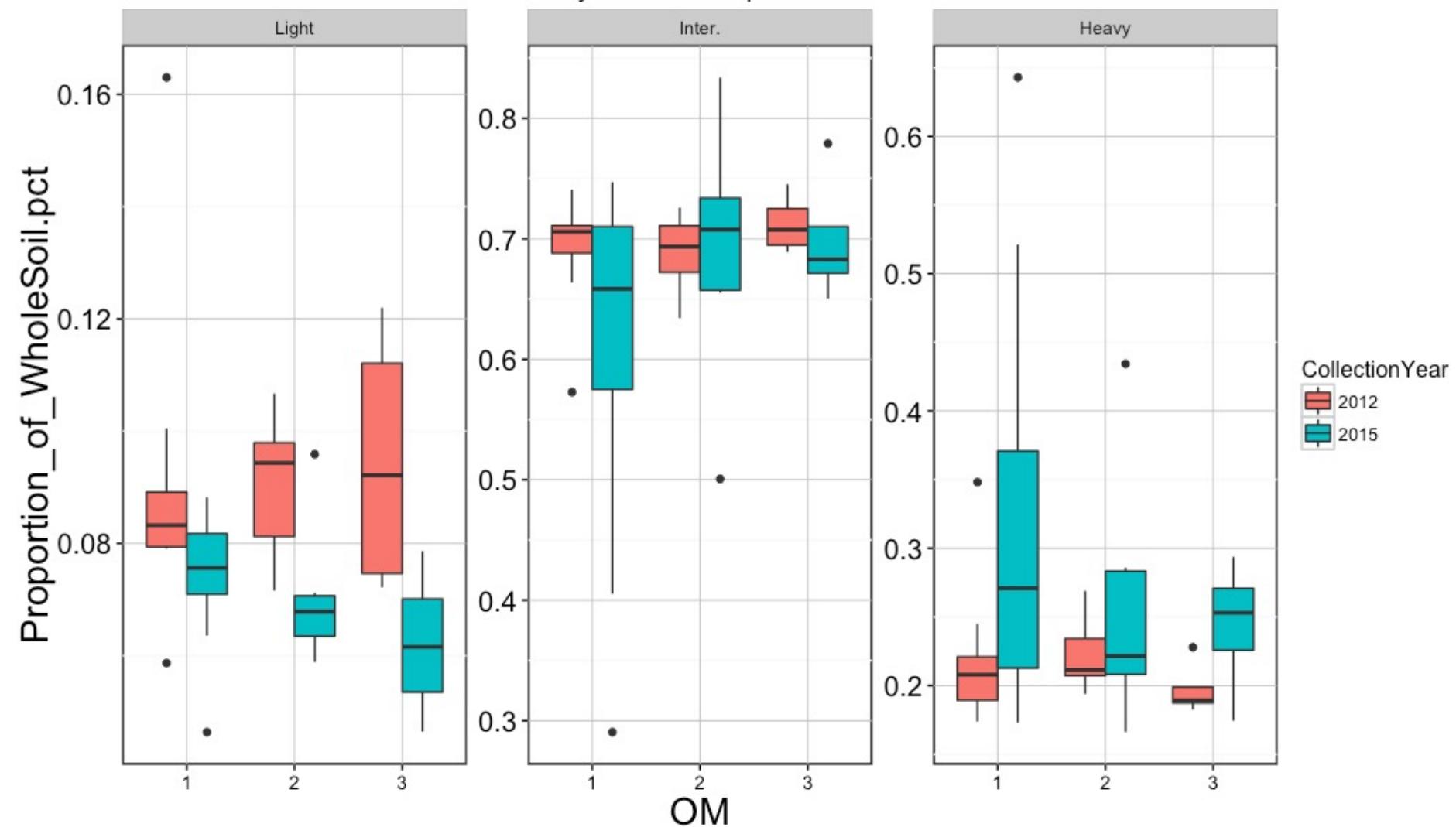




Carbon:Nitrogen Ratios



0-15cm Density Fraction Proportion of Whole Soil



15-30cm Density Fraction Proportion of Whole Soil

