# Feedstock Sustainability

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**Northwest Advanced Renewables Alliance (NARA)**


**Greg Johnson**

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| | |
|---|---|
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| Rob Harrison, Kim Littke (UW) | Mike Barber (Univ. of Utah), John Petrie (WSU) |
| John Bailey, Ken Vogler (OSU) | Douglas Maguire, Doug Mainwaring (OSU) |
| Mathew Betts, Jim Rivers (OSU) | Brian Lamb, Vikram Ravi (WSU) |
| Jeff Hatten, Adrian Gallo (OSU) | Todd Morgan, Erik Berg, Eric Simmons (UM) |

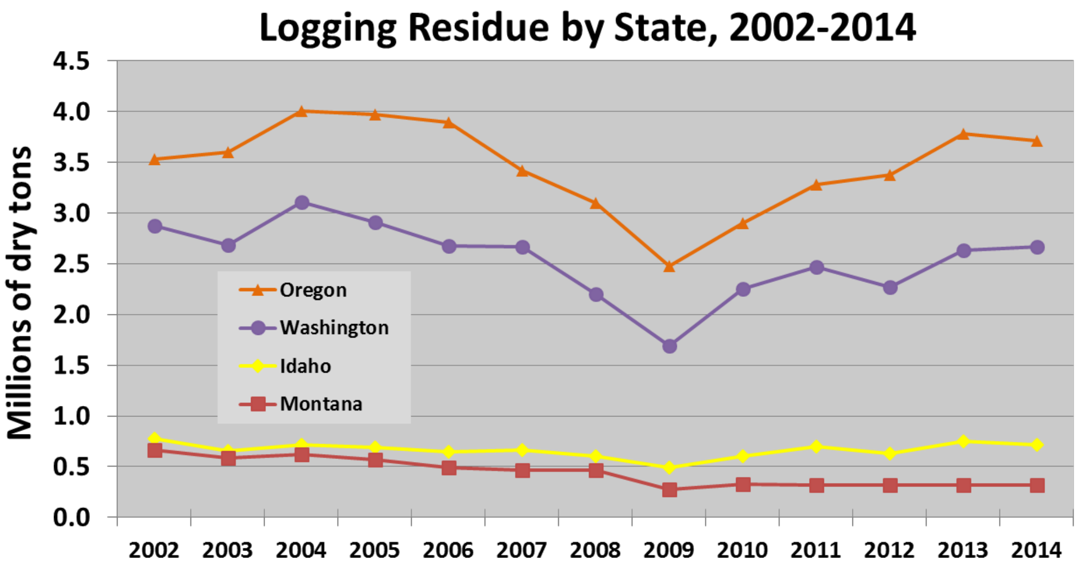
# Feedstock Sustainability Analysis:

- Raw material supply (Morgan, Bailey)
- Economic extraction (Latta)
- Short- and long-term productivity impacts (Holub, Hatten, Harrison, Maguire)
- Water quality impacts (Barber, Petrie)
- Air quality impacts (Lamb, Ravi)
- Wildlife impacts (Betts, Rivers)

# Raw Material Supply (Morgan, et al.)

Developed and shared various data within and across NARA teams and with the public:

- Mill & mill residue data
- Annual harvest data by county and ownership
- Logging characteristics & residue estimates




**Mill census years**:
ID- 2006, 2011
MT- 2004, 2009, 2014
OR- 2008, 2013
WA- 2010, 2012, 2014

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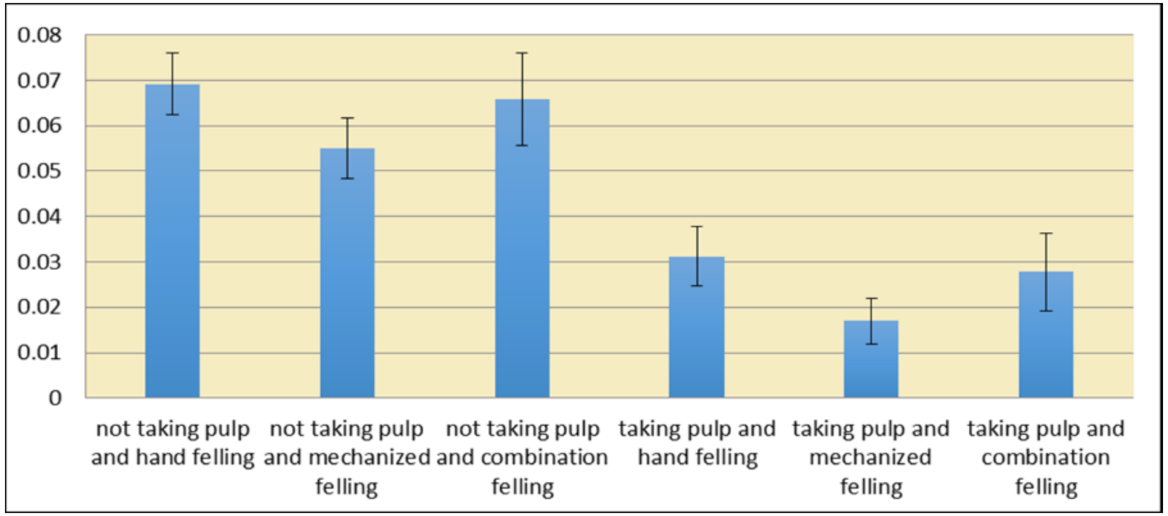
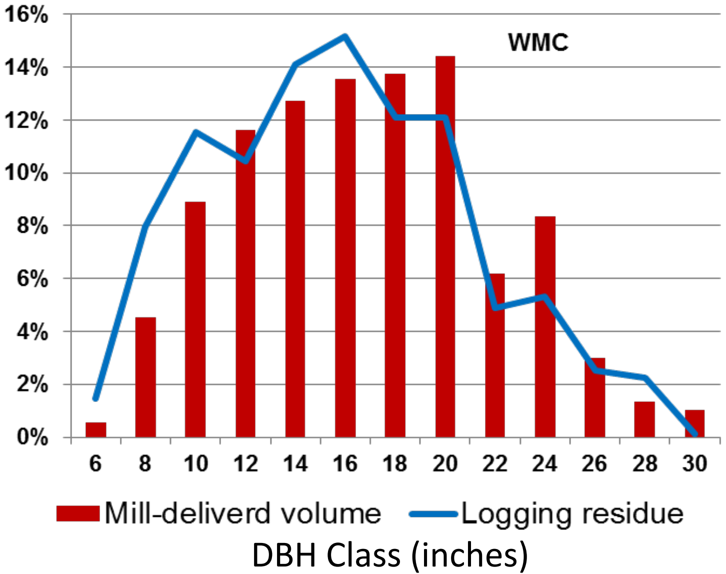
# Raw Material Supply (Morgan, et al.)

## Developed/updated harvest residue data for each state in the NARA region.

- Characterized harvest operations
- Profiled harvest by tree DBH
- Developed residue ratios for calculating residue quantities based on harvest volume, logging methods, and individual tree attributes




Residue ratios by logging method

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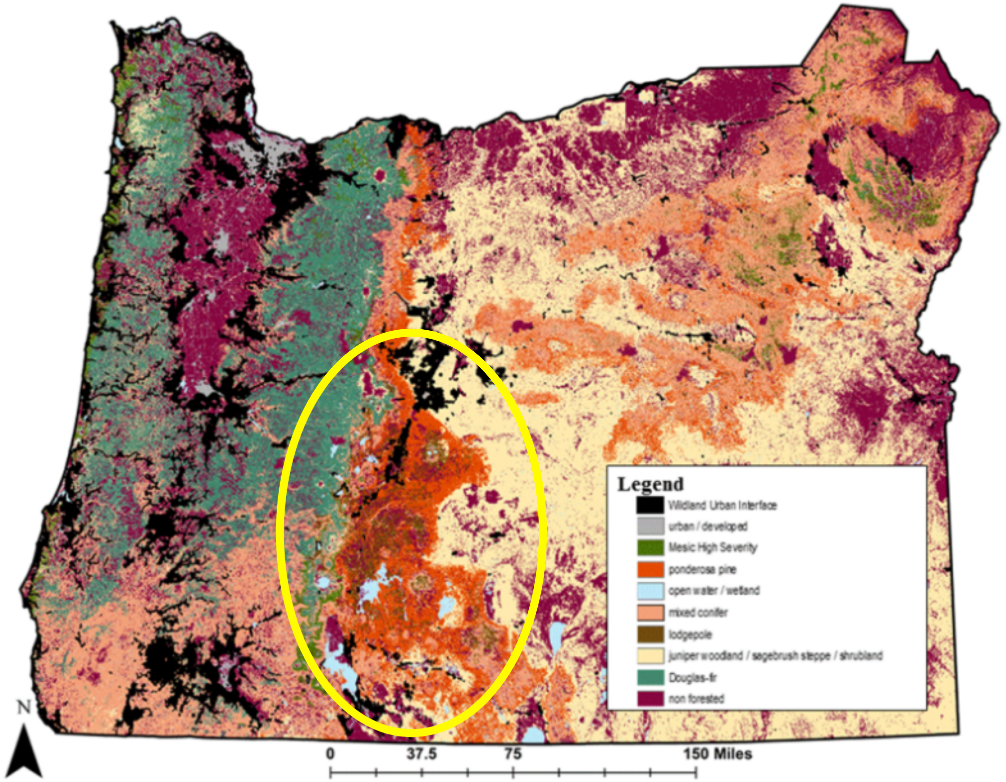
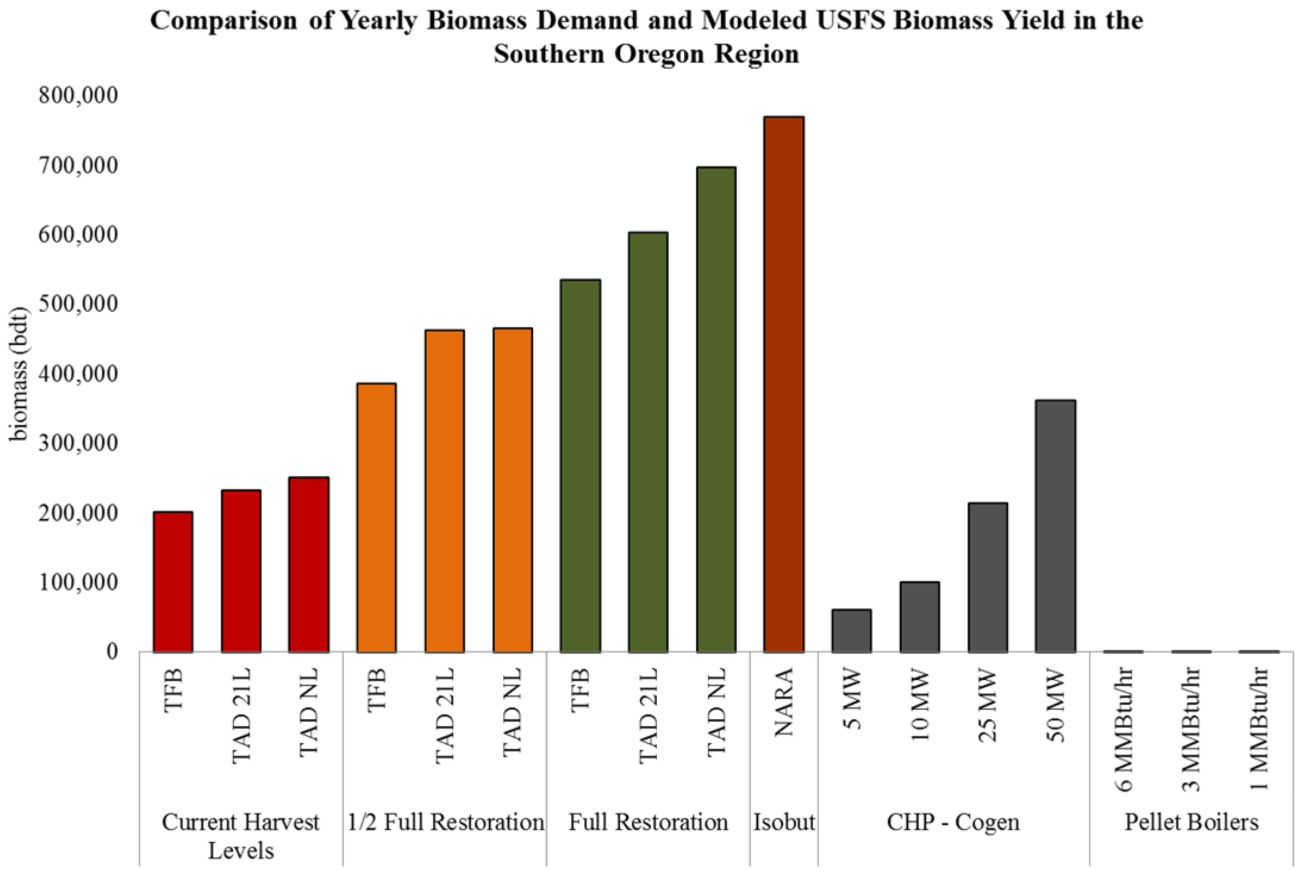
# Raw Material Supply (Bailey, et al.)

## Interior dry-forest biomass availability

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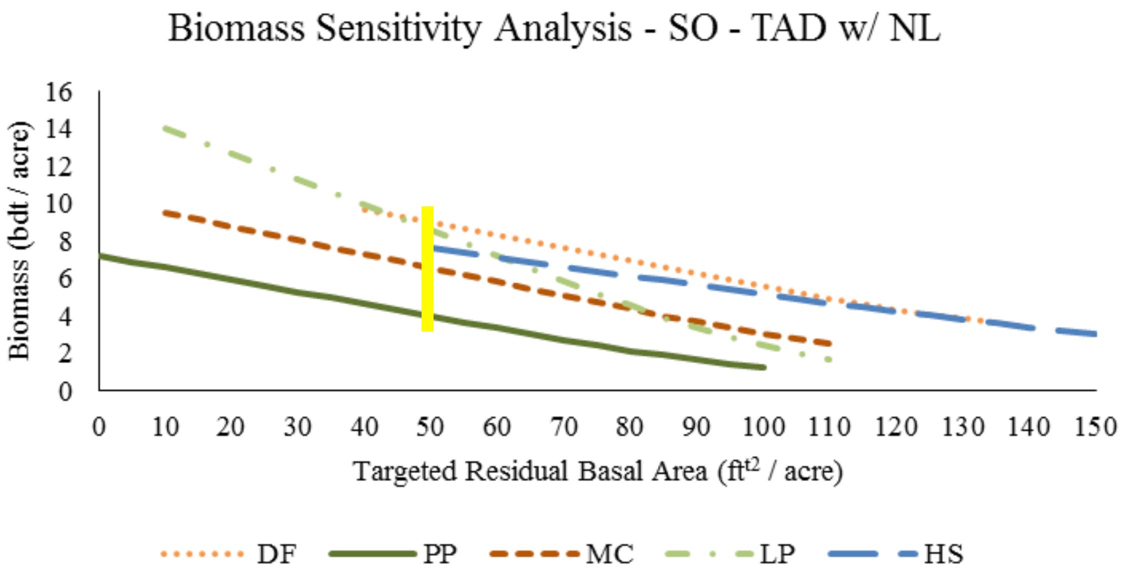


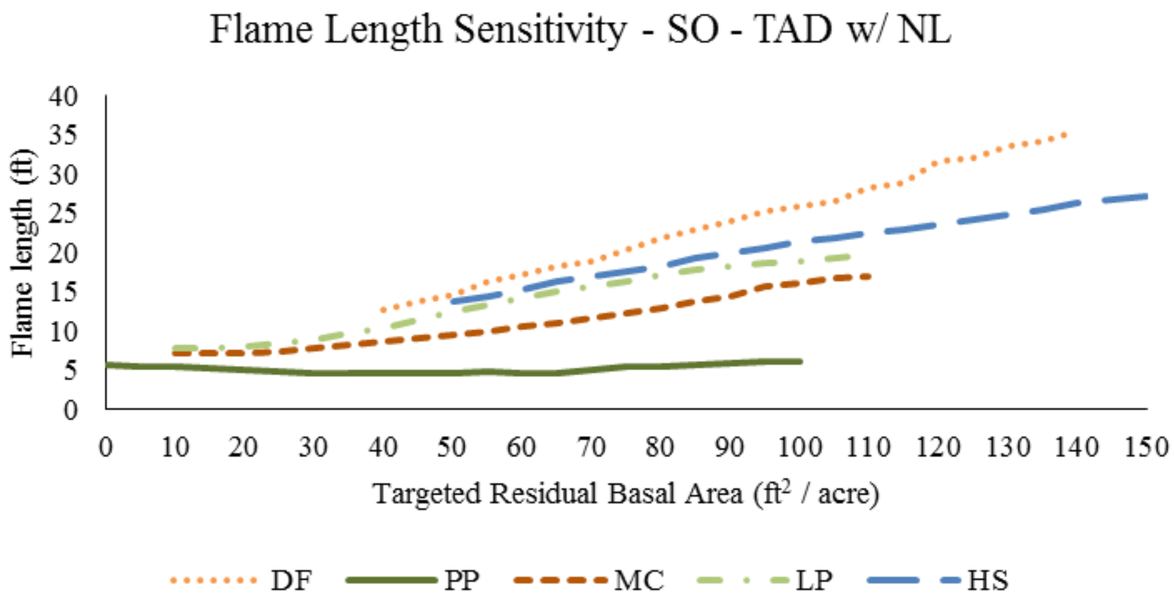


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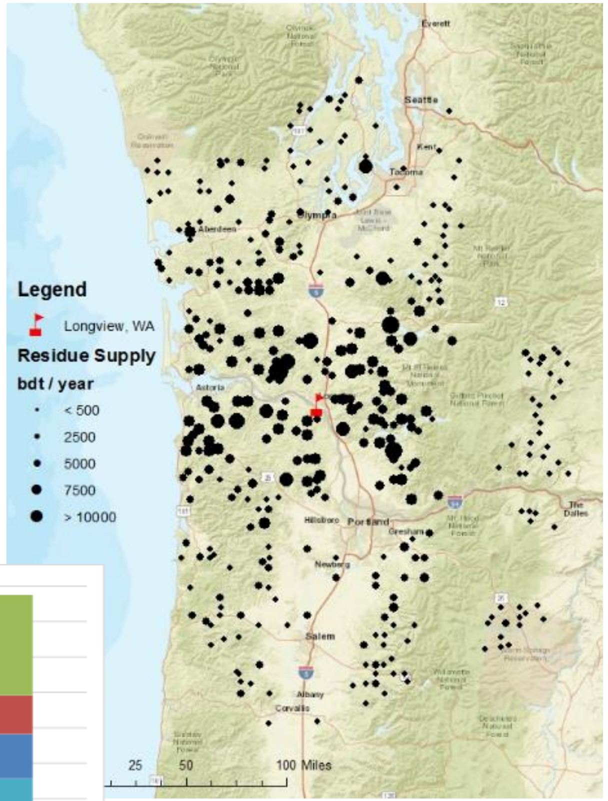
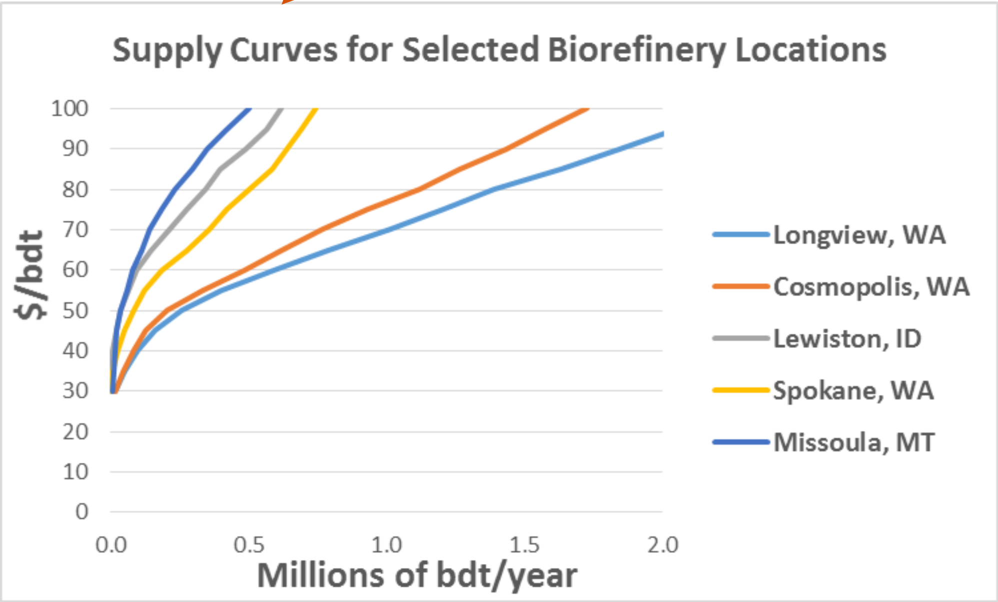
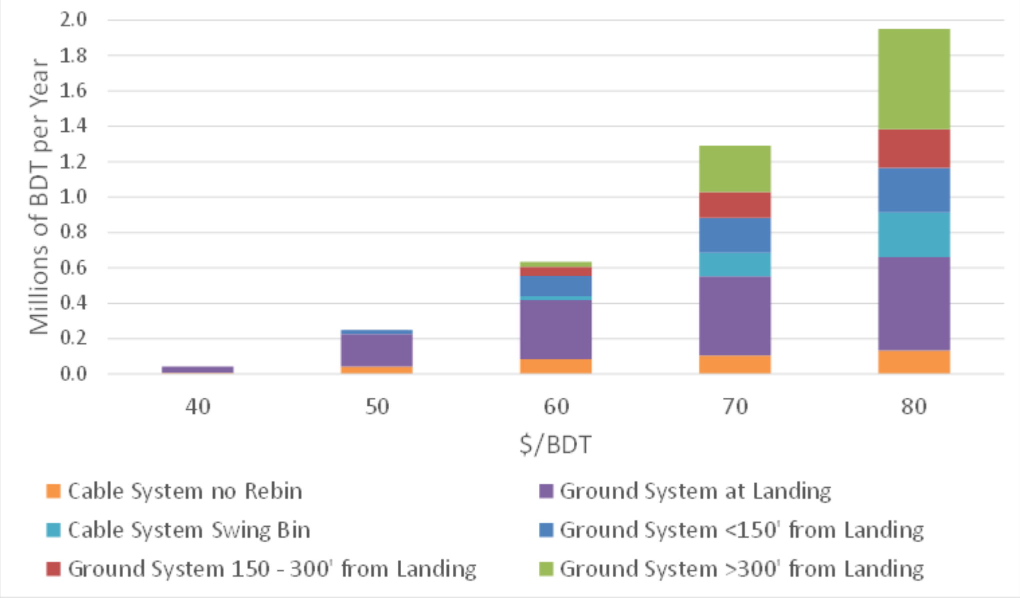
# Economic Extraction (Latta, et al.)

## Flexible econometric model was developed:

1. Allocate regional harvest for traditional forest products (lumber, plywood, pulp, etc.)
2. Determine cost of collecting and transporting residues to potential facility
   - Incorporate NARA supply logistics team findings
   - Potential cost varies by size and location of facility
     - West of Cascades cheaper than Inland
   - Intensity of recovery varies by distance from facility
     - Lower transportation costs of nearby harvests allow collection farther from landings

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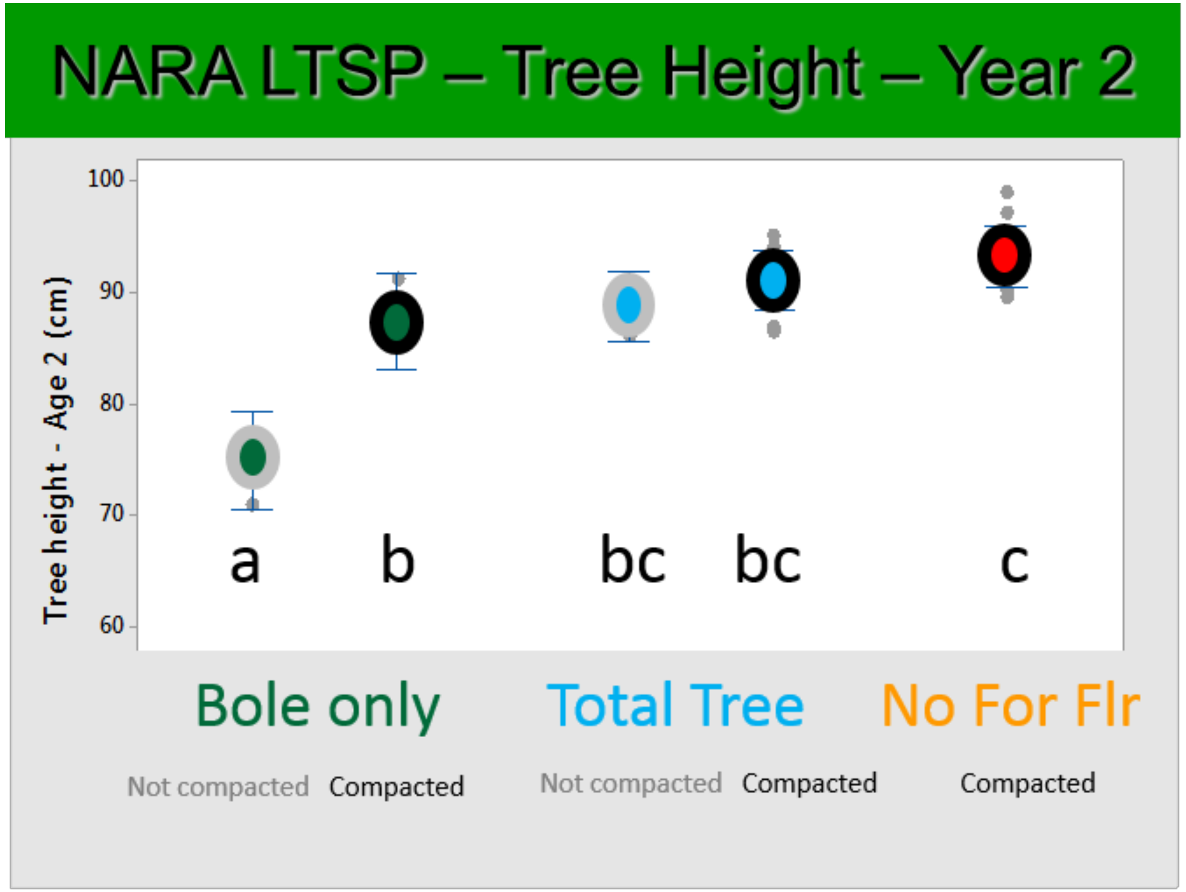
# Short- and Long-term Productivity Impacts (Holub, et al.)

Established a west-side Long-term Site Productivity (LTSP) study in Oregon to assess the impact of varying intensities of biomass harvesting.


Results: Site Established. After two years of growth, more removal yielded bigger trees because of warmer soil.

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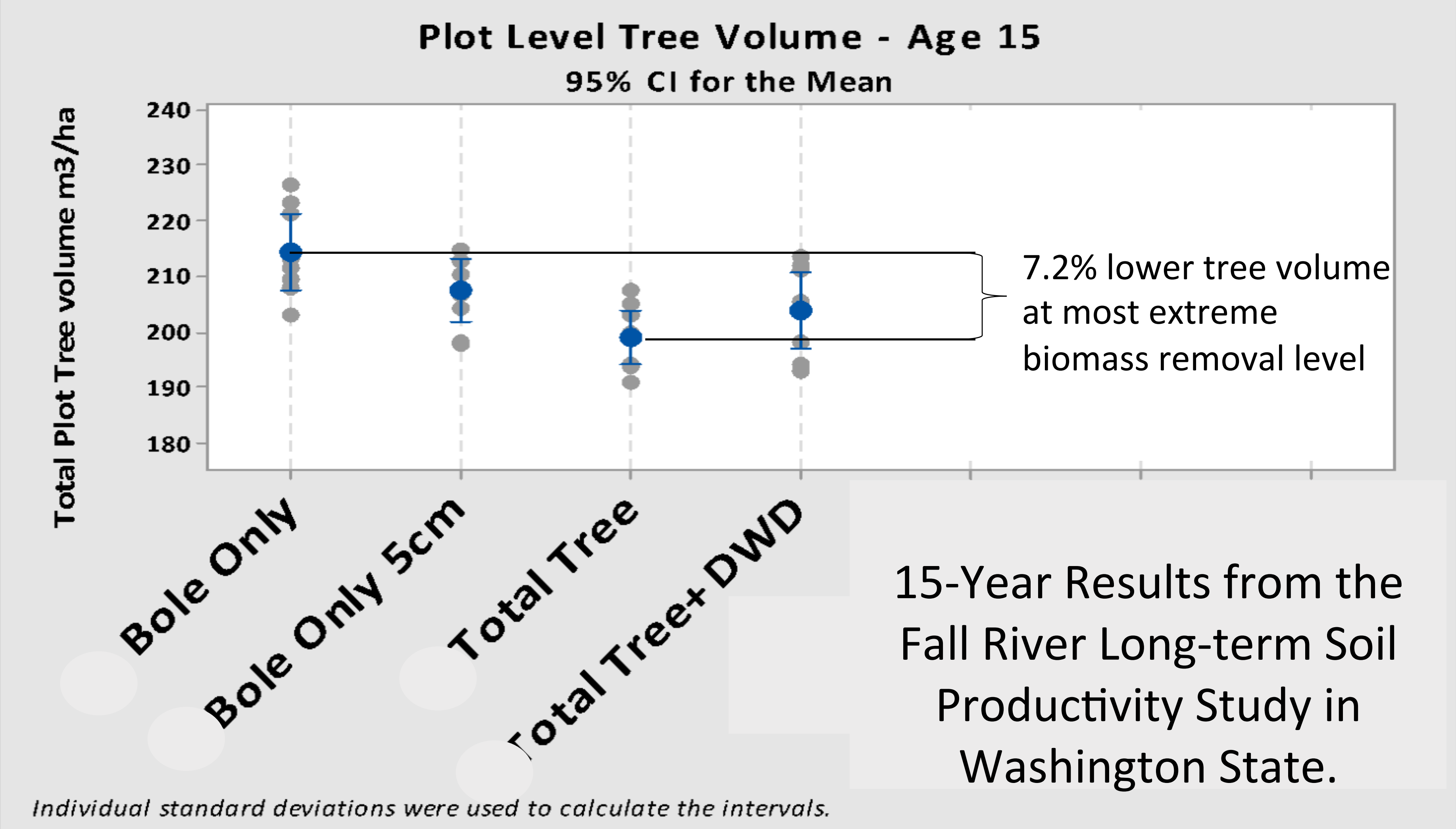
# Short- and Long-term Productivity Impacts (Holub, et al.)

Leveraged an existing west-side Long-term Site Productivity (LTSP) study in Washington.

Results from Oregon are tracking early data from the Washington site.




15-Year Results from the Fall River Long-term Soil Productivity Study in Washington State.

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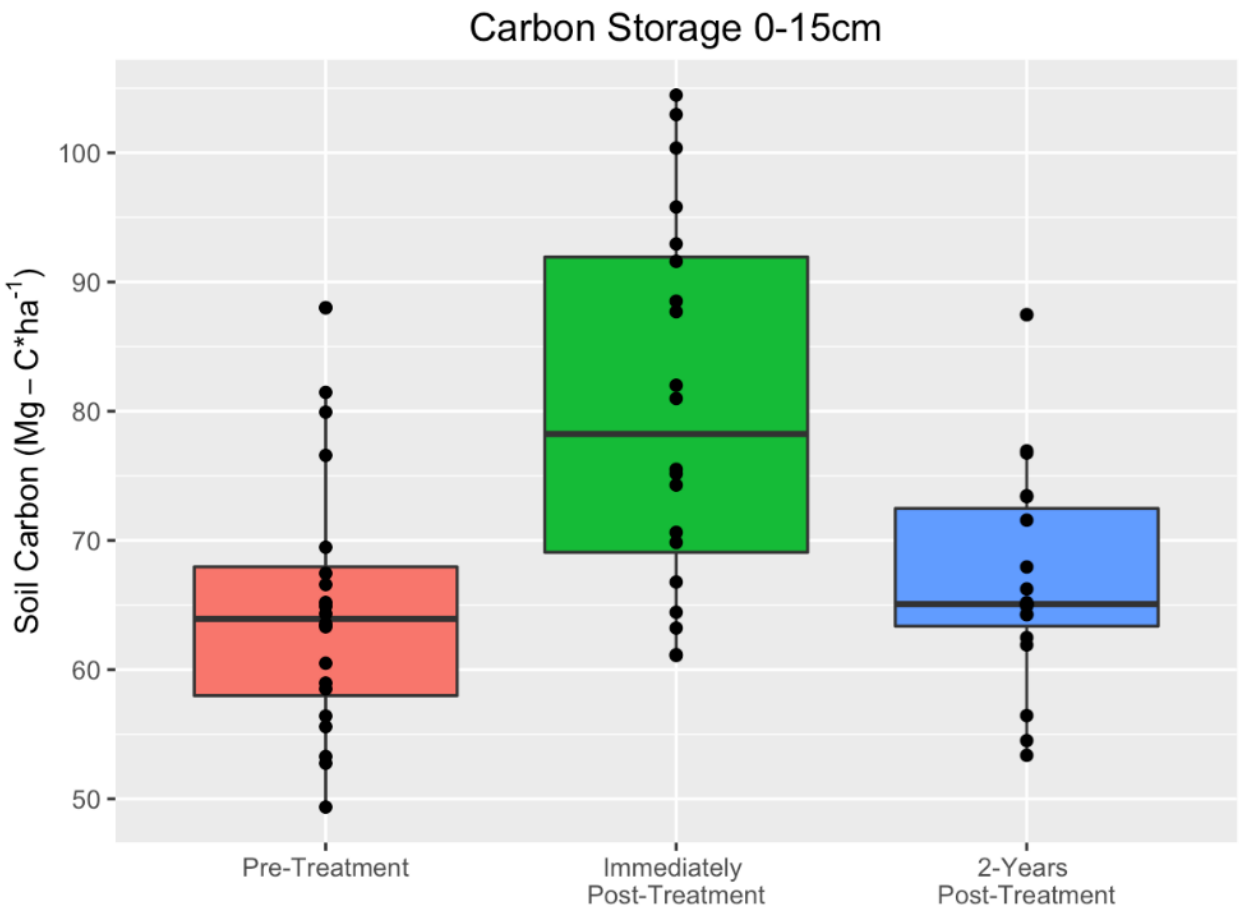
# Short- and Long-term Productivity Impacts (Hatten, et al.)

## Soil Carbon was not affected by biomass harvesting perhaps due to residual roots

- Organic matter removal and compaction treatments had no effect on soil carbon content.
- **Carbon content increased** significantly after harvest and application of treatments
- C:N ratio increased across all treatments (even those with no forest floor or slash) after harvest/application of treatments suggesting that residual roots roots are playing a mitigating role in buffering the C losses and the sustainability of biomass harvesting

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# Short- and Long-term Productivity Impacts (Hatten, et al.)

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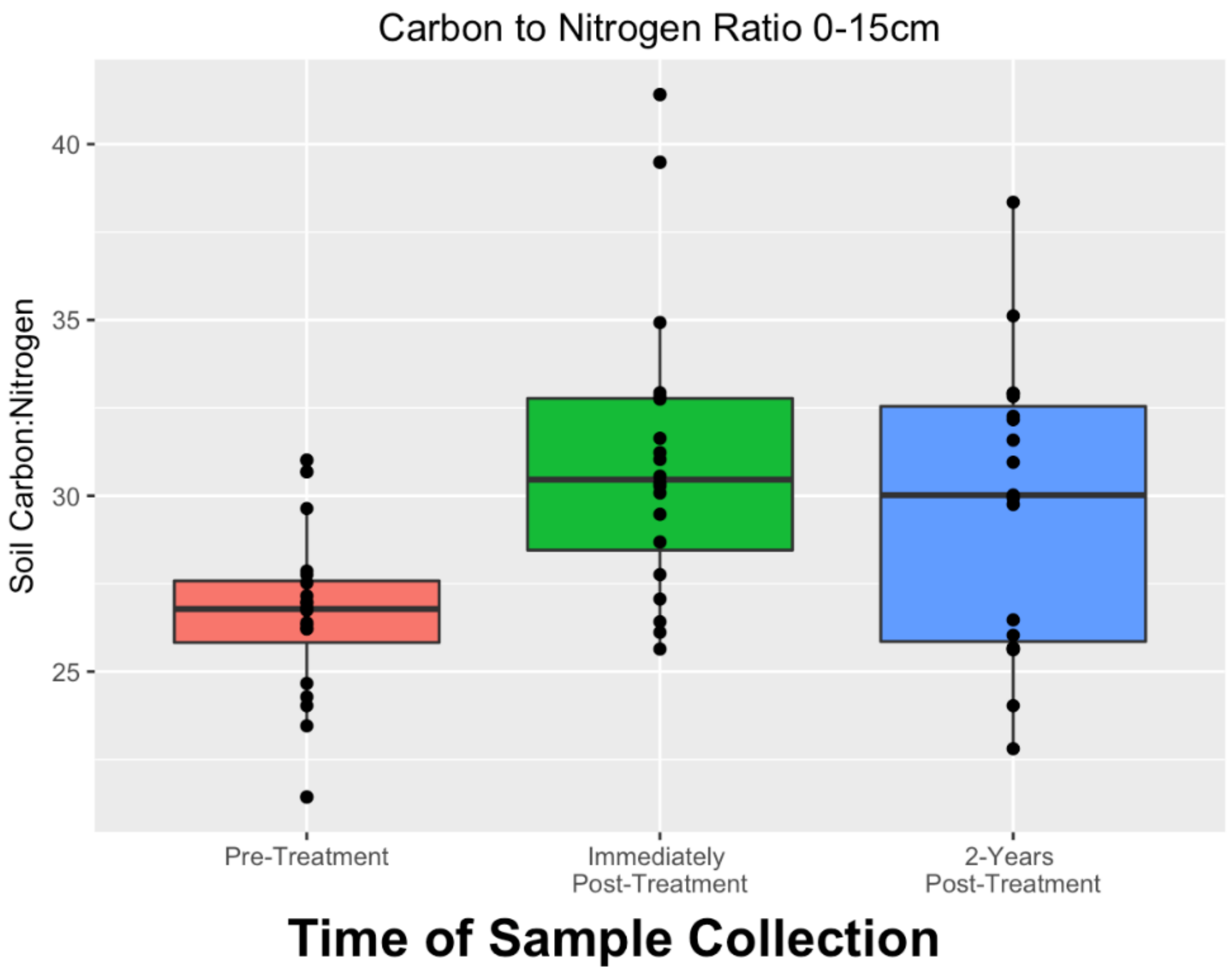


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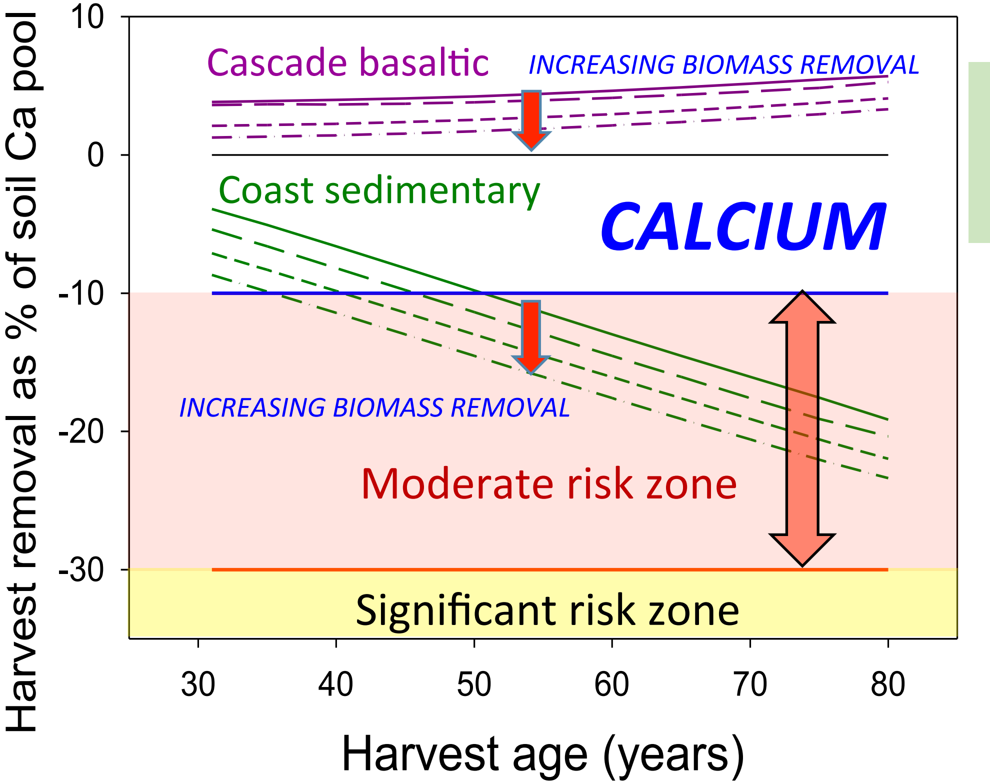
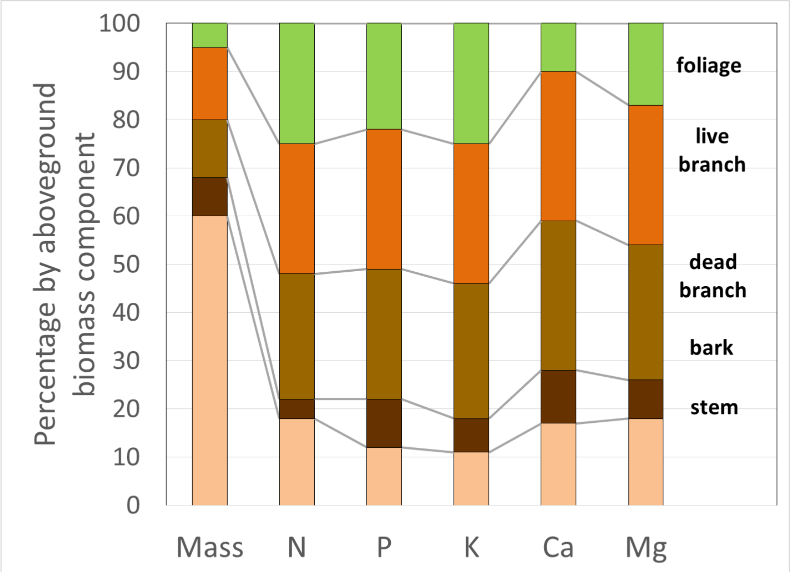
# Long-term Productivity Impacts (Maguire, et al.)

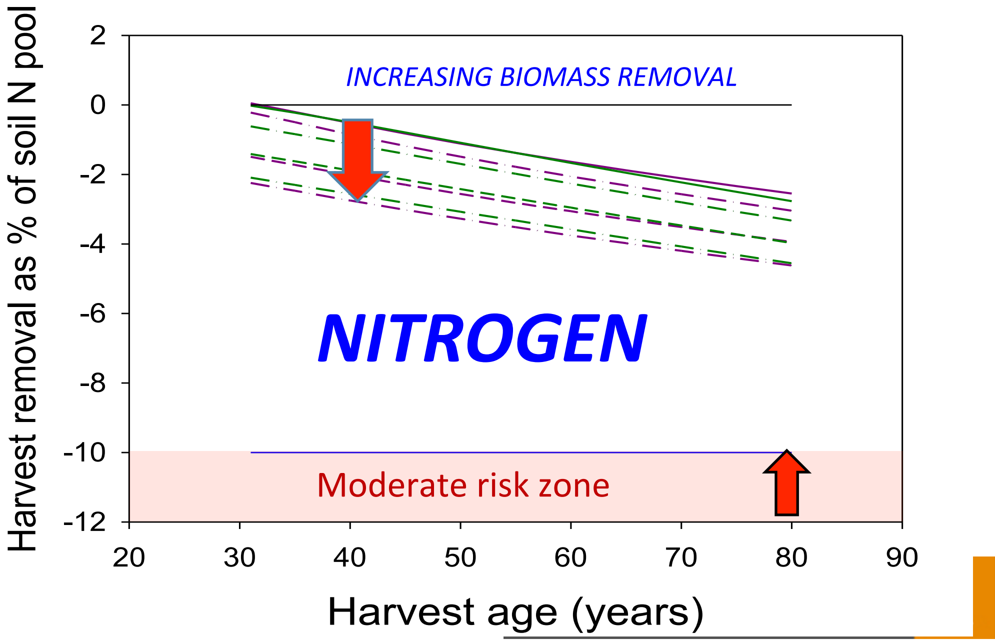
## Do net nutrient removals under alternative harvest intensities diminish site productivity?

- Using Evans Stability Ratio (harvest removal as a percent of nutrient pool):
  - Low risk for depleting Nitrogen (assuming no slash burning) under all removal scenarios
  - Moderate risk for Calcium on Coast Sedimentary soils and low risk on Cascade basaltic soils.



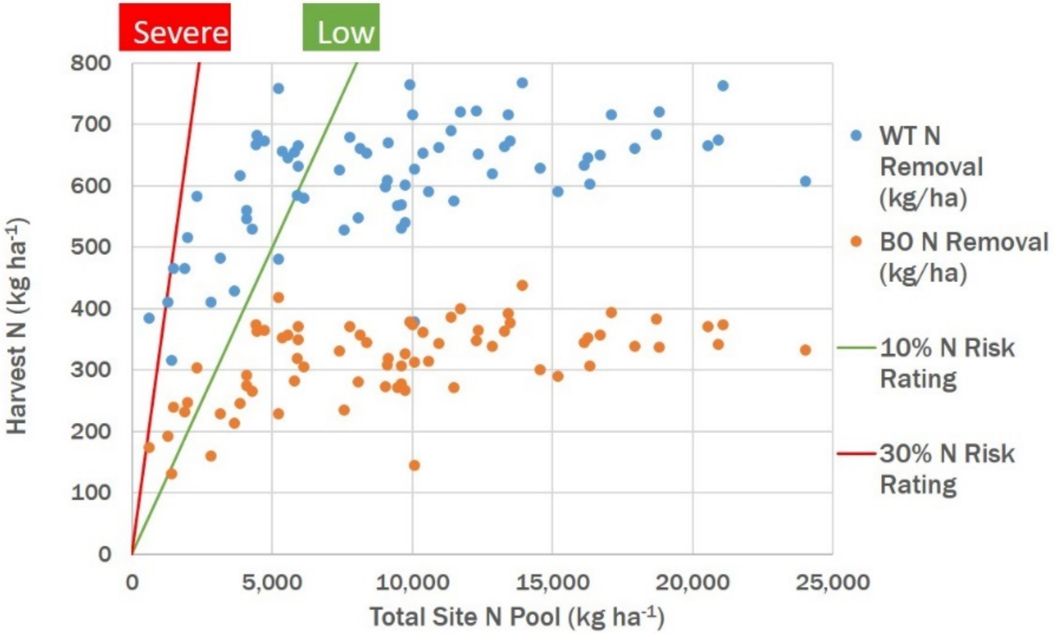

| | |
|---|---|
| BO: | Bole only removal |
| MERCH: | Bole >12.5 cm DIB + 50% of crown removed |
| NARA: | Bole + 67% of crown contents removed |
| WT: | Whole tree removal |



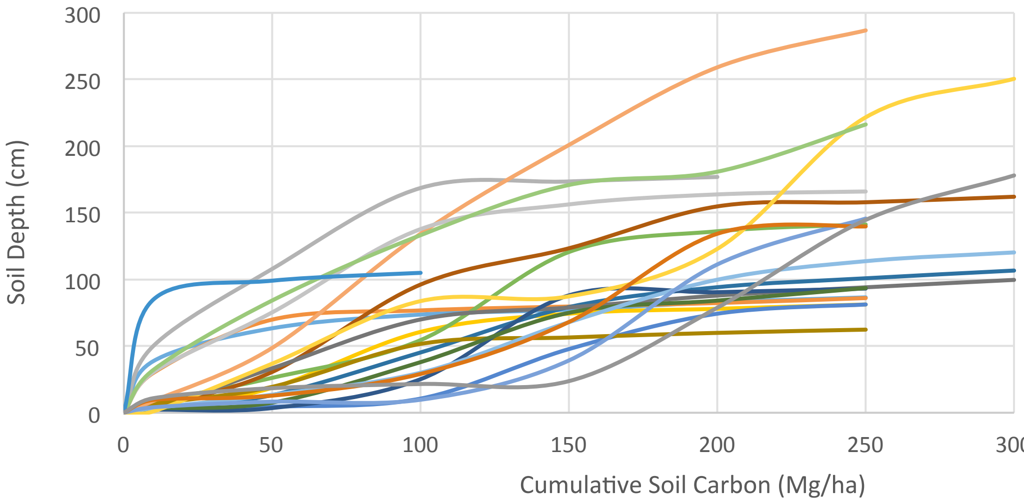
# Long-term Productivity Impacts (Harrison, et al.)

## Do net nutrient removals under alternative harvest intensities diminish site productivity?

- Austin Himes and others analyzed the potential productivity impact of increased removal of N on intensively-managed Douglas-fir plantations
- Jason James and others determined the amount and nature of carbon in deep soils of intensively-managed PNW forest plantations
- Matt Norton and others developed a relationship between stump C content and time since cutting for the C life-cycle analysis.





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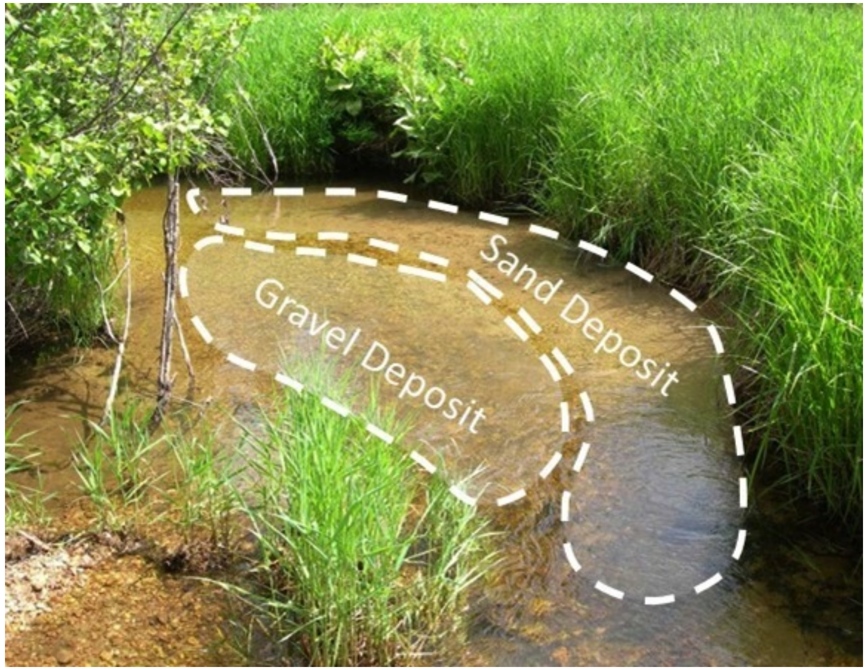
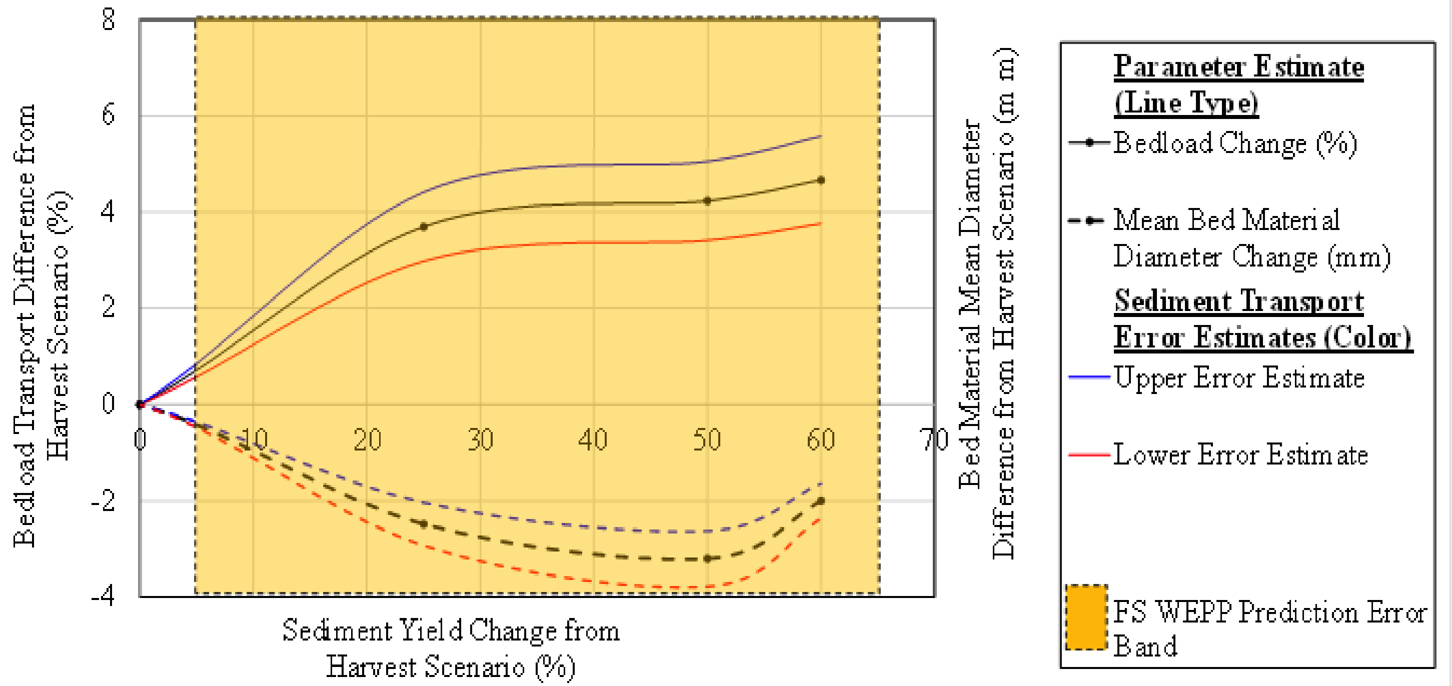
# Water Related Impacts (Barber, Petrie)

- Short-term sustainability metric
  - biomass removal from field does not have any detrimental impact on the short-term flux of nutrient populations and microbial ecology
- Sediment erosion from harvested areas
  - Field sites in Oregon did not experience increased surface erosion as a result of woody biomass removal so calibration of WEPP was not possible
  - Theoretical application over predicted sediment erosion
  - Site-specific work is needed to improve hillslope sediment and runoff predictions from watersheds impacted by biomass removal
- Water budget
  - Site infiltration versus evaporation are extremely variable but there appears to be small differences between treatment options
  - Analyses continuing to determine if differences are statistically significant



# Water Related Impacts (Barber, Petrie)

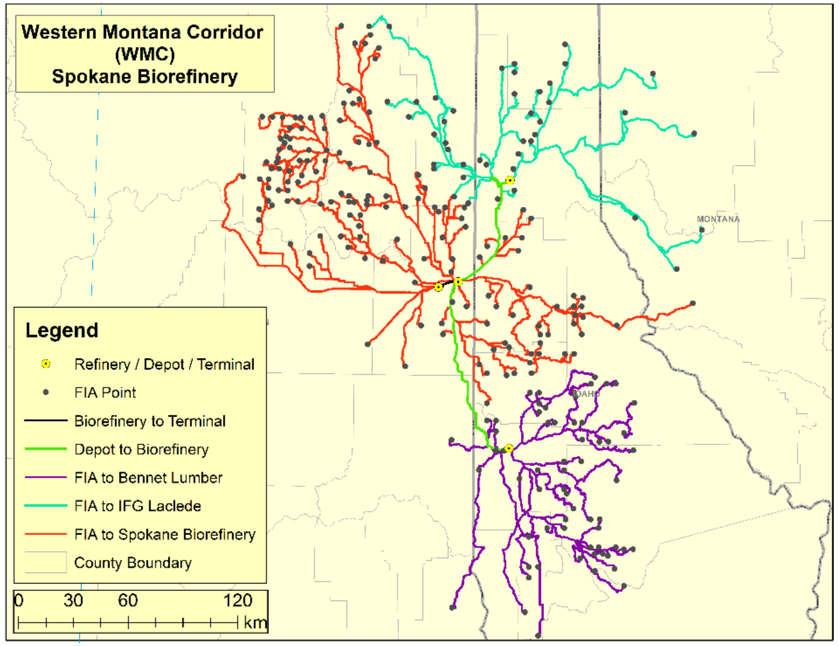
- Stream channel processes
  - Numerical models predict an increase in the transport of coarse sediment in streams impacted by biomass removal
  - Limited information on inputs of water and sediment from hillslopes leads to high uncertainty
  - Site-specific work is needed to reduce uncertainty and improve channel response predictions
  - Analyses continuing to quantify long term effects on channel form

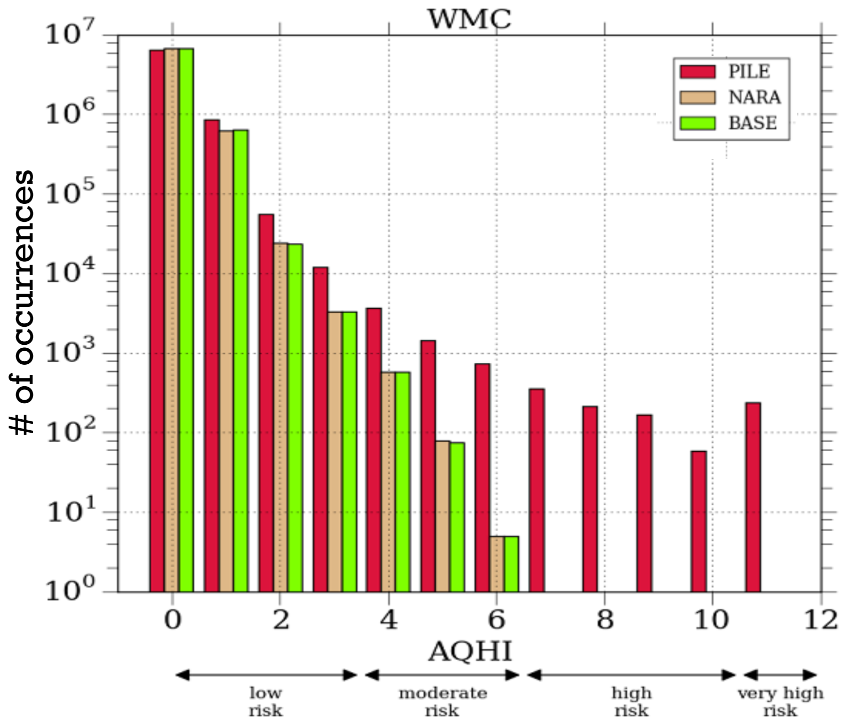


# Air Quality Impacts (Lamb, Ravi)

## Air Quality Impacts from a NARA Biorefinery Supply Chain are offset by Improvements due to Reduced Slash Pile Burns

- We used an advanced air quality modeling system to assess impacts from a potential NARA biorefinery and supply chain located in western WA or eastern WA for a summer and a late fall/winter period
- We found that the impact of feedstock harvesting and transportation are negligible for ozone and $PM_{2.5}$ in each area
- We also found that biorefinery emissions produce only a 1 to 2 ppb increase in ozone and less than 1 $\mu g/m^3$ increase in $PM_{2.5}$ levels in each area
- These impacts are more than offset by substantial improvements in $PM_{2.5}$ levels when slash pile burning is reduced by the harvesting of logging residues.
- Overall, the air quality health index is significantly improved for each region (due to avoided slash pile burning) and doesn't deteriorate in presence of biorefinery emissions



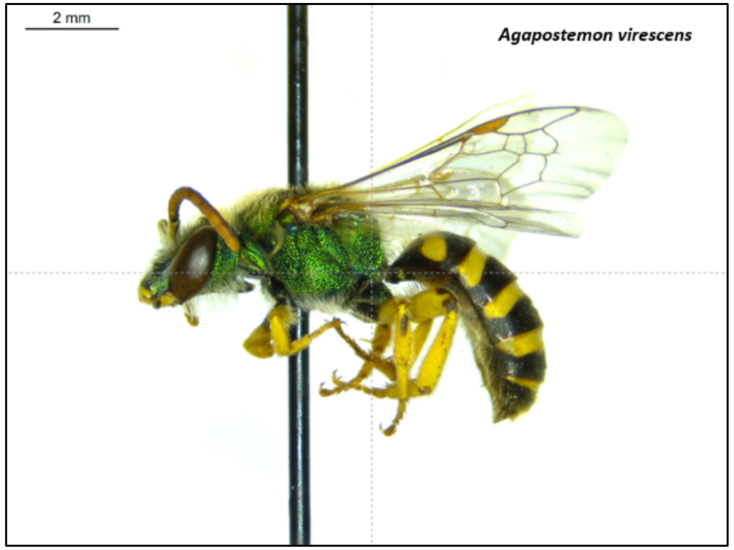
# Wildlife Impacts (Betts, et al.)

## Slash amount is not associated with post-fledging bird survival

We did not detect associations between daily survival rate and slash cover ($\beta$ = 0.00 [95% CI: 0.00, 0.00, $X^2$ = 0.13, $P$ = 0.717). Similarly, we found no effect of slash cover ($\beta$ = -0.06 [95% CI: -0.38, 0.25], hazard ratio = 0.94 [95% CI: 0.69, 1.28], $X^2$ = 0.16, $P$ = 0.690) on sparrow post-fledging survival.

## Biomass harvest and pollinators (preliminary results)

- 62 bee species identified comprising >7500 individuals
- >33% of captures were of a single ground-nesting species (*Agapostemon virescens*)




- Much greater bee species richness and abundance in second year of study (2015)
- Treatment effects detected only for species richness when comparing treatments at ends of disturbance gradient (bole removed vs. forest floor removed)