Implications of Salvage Logging on Soil Organic Matter Physico-Chemical Protection and Ecosystem Carbon Stocks in Pine Beetle Infested Lodgepole Pine Forests

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Introduction

- Mountain pine beetle (MPB) affected over 7 million ha of forest, primarily lodgepole pine (*Pinus contorta*), in western North America over the 1st decade of the 21st century[1].
- Salvage logging increased in response to the high overstory mortality and as a result logging residue management has become an issue of concern[2].
- Physico-chemical protection of carbon (C) and nitrogen (N) in soil occurs through the formation of bonds between simple, microbially processed organic matter (OM) compounds and the mineral matrix.
- Impacts of salvage logging and residue management practices on soil C and N stocks, particularly on physico-chemical protection, and productivity are not known. Fractionating soil OM into component pools will provide a better understanding of potential long-term implications of management, by revealing changes in soil C and N stocks that may not be detectable by analyzing the bulk soil.
- Quantifying such changes associated with logging residue retention levels is critical as salvage logging and use of logging residues is of interest to the bioenergy industry.

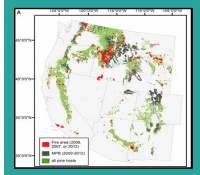
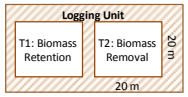


Image 1. (left) Distribution and extent of the MPB outbreak in the western US (from Hart et al. 2015).

Image 2. (left) Lodgepole dominant stand, with high overstory mortality due to MPB, and regenerating lodgepole and aspen in a logged unit.

Approach



4 Sites (Fraser Experimental Forest, Gore, State Forest, & Willow Creek) × **3 Units** (or blocks) per site

12 independent reps per treatment

3 Treatments:

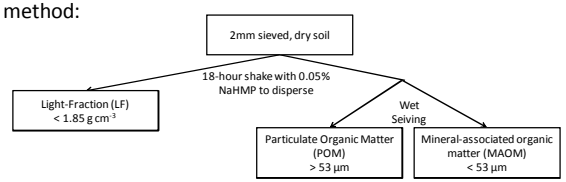
Biomass Retention (lop-and-scatter)

Biomass Removal (whole tree)

Control (unlogged)

Soil Analysis

- Collected Sept-Oct. 2015
- 6 soil cores 0-10 cm were taken per treatment plot and composited at the plot level
- Bulk soils were 2mm sieved, dried, ground and analyzed for %C, %N, $\Delta^{13}C$, and $\Delta^{15}N$ on the EA-IRMS.
- A representative subsample was fractionated by the following method:



- Samples were run on the EA-IRMS to measure %C, %N, $\delta^{13}C$, and $\delta^{15}N$

Research Questions and Hypotheses

***Q1*: Does salvage logging MPB-killed stands result in significant differences in soil C and N stocks and protection?**

H1a: We anticipate no net losses of soil C and N stocks 6 years after salvage logging.

- MPB-induced mortality had decreased new soil C inputs years prior to logging.
- Logging stimulated the sub-canopy, understory and regeneration allowing for new soil C inputs.

H1b: We anticipate increased soil organo-mineral protection 6 years after salvage logging.

- Changes in abiotic conditions and fresh litter inputs may stimulate microbial processing and new mineral-associated organic matter formation (MAOM).

***Q2*: Does level of logging residue retention following salvage logging result in significant differences in soil C and N stocks and protection?**

H2a: Changes anticipated *relative to unharvested, control* due to differences in quantity and quality of inputs:

Treatment	Inputs	LF	POM	MAOM
Logged + residue *removal*	Mostly needles	↓	↓	↑
Logged + residue *retention*	Boles, branches, and needles	↑	↑	No change

H2b: Logging with residue removal will have the greatest organo-mineral protection.

Initial Results

Table 1. Average (sd) of pH (n=12 per site) and soil texture (% sand, silt, and clay) (n=3 per site, measured only in the control unit of each block).

	Sites:			
	Fraser	*Gore*	*State Forest*	*Willow Creek*
pH	5.47 (0.28)	5.51 (0.30)	5.58 (0.28)	5.43 (0.40)
% sand	44 (25)	63 (22)	65 (16)	63 (22)
% silt	39 (14)	28 (16)	29 (14)	25 (16)
% clay	17 (12)	8 (7)	5 (3)	12 (7)

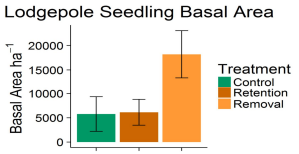


Fig. 2. Basal area per hectare of all lodgepole seedlings

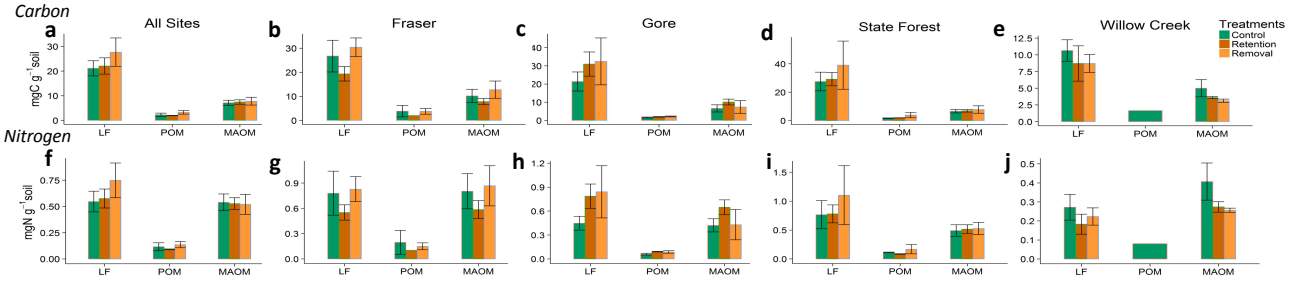


Fig. 3. C (a-e) and N (f-j) content averaged across all sites (a & f) and at each site (b-e & g-j) in each of the SOM fractions.

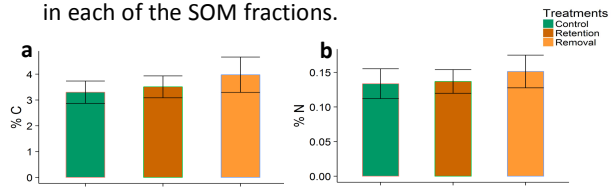


Fig. 4. %C (a) and %N (b) of bulk soil samples

Initial Discussion and Conclusions:

- Salvage logging beetle-killed lodgepole in CO does not appear to have a significant impact on bulk C and N stocks (**Fig. 4)(Q1. H1a)**
- Responses of the changes in C and N fractions in response to the treatments were highly variable **(Fig. 3)(Q2, H2a)**
- Site seemed to be more important than treatment in determining organo-mineral protection **(Fig. 3)(Q1, H1b, Q2, H2b)**
- We anticipate that texture is going to be critical for explaining site variability than response to treatment **(Table 1)**

Acknowledgements:
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References:
[1] Hart et al., 2015 *PNAS*
[2] Miller, 2015 *Science you can Use, USFS*

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