Soil Nitrate & Phenols in Mountain Pine Beetle-killed Forests

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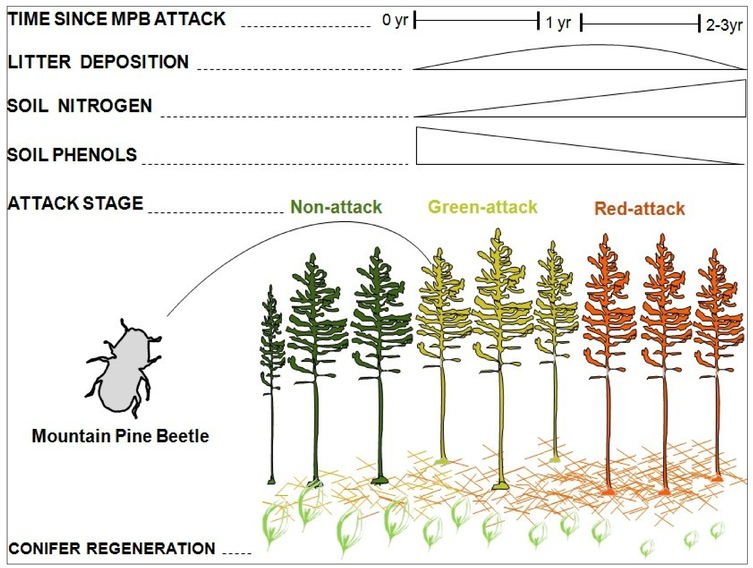
BACKGROUND

- Outbreaks of the mountain pine beetle (MPB) cause extensive overstory tree mortality which triggers a cascade of interlinked effects manifesting in soil nutrient and chemical legacies (Fig. 1).
- Nutrient legacies are influenced by the balance between inputs (e.g., litter quantity, quality, and decomposition) and losses (e.g., vegetative immobilization and hydrological export).
- Phenolic compounds (e.g., tannins) are a broad class of plant secondary metabolites that inhibit nitrification and thus regulate keys aspects of N cycling.
- Soil nitrate and phenols are influential factors in seeding regeneration and succession; therefore, a better understanding of their dynamics will help to predict short- and long-term impacts of MPB outbreaks on recovery outcomes for intensively or minimally managed stands.

Fig. 1 Hypothesized above- & below-ground changes associated with various stages of MPB attack.



OBJECTIVES

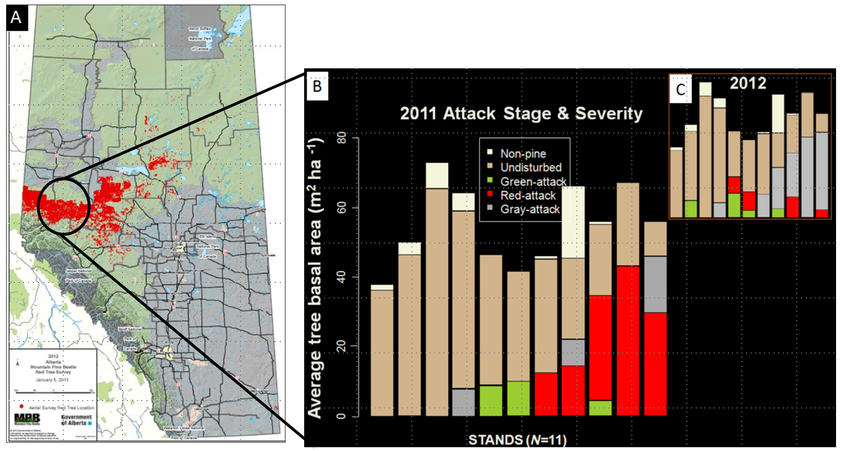
We sought to determine the strength, direction, and magnitude of the relationships between levels of beetle kill and:

1. Pine needlefall & nutrient chemistry
2. Soil bioavailable nutrient supply
3. Total mineral soil phenols

METHODS

- In 2011 & 2012 , we surveyed site conditions associated with a gradient of beetle kill (0–82% basal area $m^2\ ha^{-1}$) (Fig. 2).
- We sampled pine needlefall rates and macro nutrient chemistry.
- We measured the supply rates of soil nutrients (i.e., macro & micro) using PRS™ probes and moisture using a handheld theta probe.
- We calculated total mineral soil phenols from soil samples in 2012.
- Single linear regressions were used to determine the nature of relationships of beetle kill to the chemistry of needle litter and soils.

Fig. 2 Distribution of MPB outbreaks relative to the study area, (a); 2011,(b), and 2012,(c), attack severity in study area (Courtesy: ASRD, 2012).



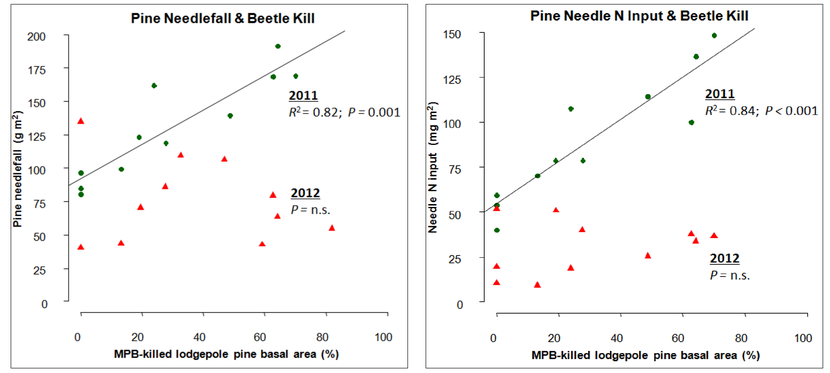
RESULTS

- Pine needlefall was positively related to MPB-killed basal area 2-3 yrs after peak infestation but not after 3-4yrs (Fig. 3).
- Needle nitrogen was positively related to MPB-killed basal area 2-4 yrs after peak infestation (Fig 4.)
- Elevated needle deposition and nitrogen concentration compounded observed levels of needle N input, which were positively related to beetle kill 2-3 yrs after peak infestation, but not after 3-4 yrs, due to declining needlefall (Fig. 3).
- Soil moisture was positively related to beetle kill 2-3 yrs after peak infestation, but re-stabilized after 3-4 yrs, showing no trend.

REFERENCES

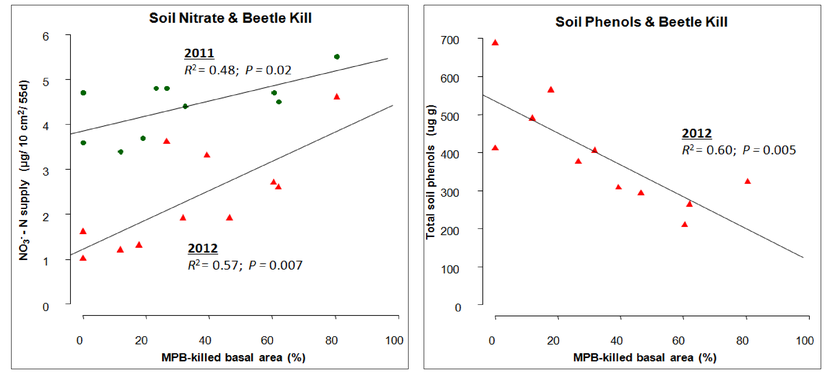
- Griffin et. al. 2011. *Forest Ecol. & Mgt.* 261: 1077–1089.
- Clow et. al. 2012. *J. Soil Chem.*
- Wulder. et. al. 2006 *Remote Sen. Env.*

Fig. 3 Pine needlefall, (a), and nitrogen concentration, (b).



- Soil nitrate was positively related to beetle kill 2-4 yrs after peak infestation, but declined significantly after roughly 3 yrs (Fig. 4).
- Total mineral soil phenols were inversely related to beetle kill (Fig. 4) and nitrate supply 3-4 years after peak infestation.

Fig. 4 Soil nitrate supply, (a), and phenols, (b).



IMPLICATIONS

- Effects of outbreak on soil moisture may be more transient than effects on soil nitrate supply.
- Within a phenol-reduced soil environment, increased rates of nitrification may accelerate litter mineralization; nitrate is likely to become the dominant form of nitrogen in plant nutrition.
- Soils will likely have higher moisture and nitrate supply rates between 2-4 years post outbreak, and possibly accelerated rates of needle litter mineralization; increased light may compound these paralleled effects and induce a positive growth response in existing and regenerating vegetation.