The Effects of In-Bush Chipper Debris on Leachate Chemistry, Tree Seedling Survival and Growth, and Soil Microclimate

Dave Morris[1], Martin Kwiaton[1], Emile Koste[2], Kristian Johnson[2], Sally Krigstin[2] and Suzanne Wetzel[3]

[1] Ministry of Natural Resources and Forestry – Centre for Northern Forest Ecosystem Research

[2] University of Toronto – Faculty of Forestry

[3] Canadian Forest Service – Canadian Wood Fibre Centre

Background:

In-bush chipping operations have become a common practice across Ontario's boreal forest, i.e. ~ 3.8 million m^3 of white chips have been produced annually in northwestern Ontario alone. Poor regeneration has been noted through provincial surveys and Independent Forest Audits, heightening concerns regarding the potential loss of productive land. A series of simple experiments were conducted between 2012 – 2016 to investigate the potential causes for this poor regeneration. Suggested causes have included:

1. Production of leachate (higher in phenolic compounds) impeding seed germination and reducing seedling vigor and growth.
2. Physical barrier to seedling root penetration into a suitable rooting medium.
3. Altered soil microclimate conditions that also result in poor seedling survival and growth.

Leachate Production: volumes and phenolic concentrations

In 2012, 3 replicate debris piles were instrumented with 5 buchner funnels inserted beneath the chipper debris in both Fresh (1 year old) and older/decomposing (8 year old) piles. Leachate and incoming rainfall were collected after each rainfall event for 2 years (17 events). Collected volumes were recorded, and subsamples filtered and analyzed for total phenolic concentrations (Folin-Denis reagent method).

Results:

Fig. 1. Leachate regression

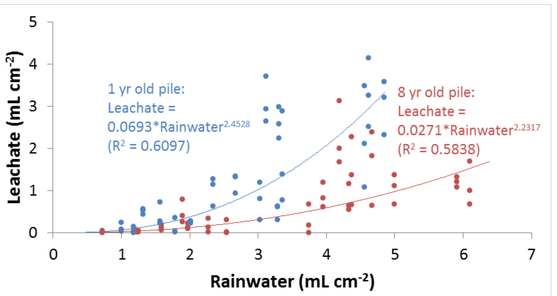


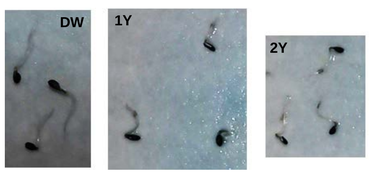
Table 1. Total phenolic concentration in leachate

Sample	Concentration (ppm)
Distilled Water	0
Rainwater	2.03
1 yr old pile	26.58
2 yr old pile	13.38
3 yr old pile	19.71
9 yr old pile	14.75

- The hydrophobic nature of the fresh chipper debris generated increasingly greater volumes of leachate per unit of incoming rainwater compared to the more hydrophilic, partially decomposed debris (Fig. 1)
- Total phenolic concentrations was highest in the leachate originating from the fresh (1-yr-old) piles compared to the older (8-yr-old) piles. However, concentrations remained high across all age classes compared to incoming rainwater (Table 1).

Does chipper debris leachate impede conifer seed germination?

One hundred *Picea mariana* (black spruce) seeds were germinated with one-year-old pile extract (1Y), two-year-old pile extract (2Y) and distilled water (DW) as a control. Seeds were incubated for 7 days at 25^{0}C and measured for emergence, root length, and vigour (i.e., based on the degree of cotyledon development).



Results:

Table 2. Seed germination results

Sample Trial	Concentration (ppm)	Total Mass of Phenols (mg)	Mean Root Length (cm)	Emergence Rate (%)	Percent Low Vigour
DW	0	0	0.56	98	7
1Y	153.2	0.012	0.32	99	18
2Y	196.9	0.016	0.45	97	8

- Seed emergence rate was high (>96%) across all extract treatments, however root lengths were significantly shorter for the 1-yr-old and 2-yr-old extract treatments with higher number of developing germinants with low vigour in the 1-yr-old extract treatment (Table 2).

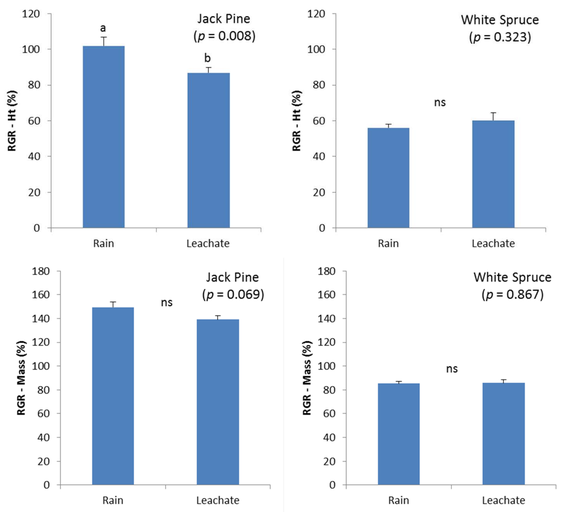
Does chipper debris leachate affect seedling growth (16-week seedling greenhouse trial)?

A 16-week greenhouse trial was conducted to examine the effect of three factors on survival and growth (height, biomass, shoot:root ratio):

- Tree Species: jack pine (Pj), white spruce (Sw)
- Soil Type: Sand, Loam, Clay
- Watering Medium: Rainwater, Leachate (1-yr-old pile)
- 5 reps per treatment combination

Results:

Fig. 2. Seedling growth response



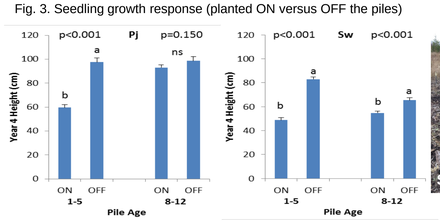
- Watering with leachate did have a negative effect (p=0.008) on the relative height growth rate of jack pine, but did not affect white spruce growth parameters.
- The negative growth effects by the jack pine seedlings were not dependent on soil type.

Can these piles be successfully planted (outplanting trial)?

In 2013, each of the 6 debris piles used in the leachate study were planted with 50 white spruce and 50 jack pine seedlings as a split plot design. Additional plots were also planted in the harvested cut block adjacent to the chipper debris piles. Seedling survival, health/vigour, and growth (total height and ground level diameter) were measured for 4 years.

Results:

Fig. 3. Seedling growth response (planted ON versus OFF the piles)



- Although survival and health parameters were comparable between seedlings planted ON or OFF the debris piles, total height was significantly lower for seedlings planted ON the piles, particularly for the fresh (1-yr-old) piles for both species.

How does the presence of chipper debris alter soil microclimate profiles?

As part of the leachate field trial, 2 microclimate stations were installed at each pile to monitor and compare soil temperature and soil moisture under versus away from debris piles.

Results:

Fig. 4. Soil temperature and moisture profiles comparing microclimate collections under versus away from debris piles

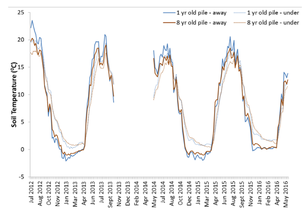
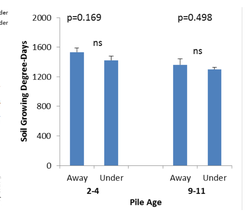


Fig. 5. Soil Growing Degree Days



- Diurnal (greater daily fluctuations away from the piles in soil temperature) and seasonal patterns (delayed spring warm up and extended warm soil period in the fall under the piles) differed when comparing under vs. away from the debris piles (Fig. 4).
- However, growing season (May to Oct) soil GDDs did not differ based on location (Fig. 5). Lower overall soil GDD in the older debris piles/harvest blocks can be attributed to the shading effect of the developing tree canopies.
- Soil moisture levels remained higher under the debris piles throughout the growing seasons, and were slightly higher under the older (8-yr-old) piles (Fig. 4).

Take-home Messages from the Experimental Trials:

- The combination of high leachate volumes and elevated phenolic concentrations produce a considerable amount of phenolic-rich leachate from fresh chipper debris piles. Although volumes and concentrations are lower from older piles, concentrations remain elevated compared to incoming rainfall.
- High phenolic concentrations did reduce root lengths and reduced vigour in germinating black spruce seed.
- Based on the greenhouse pot study, watering with phenolic-rich leachate did reduce relative growth rates (jack pine only).
- Reduced 4th year growth and seedling health (both jack pine and white spruce) were experienced by seedlings planted directly in the debris piles, with this reduction more noticeable on the fresh piles; likely due to the influence of poor planting medium, high phenolic concentrations in leachate, and altered soil microclimate conditions.

Forest Management Actions:

Running concurrent to the experimental trials (2012-2014), a region-wide chipper debris technical working group, comprised of industry and government foresters, forest policy advisors, logging contractors, science and fire specialists, participated in a series of workshops, field tours, and operational trials with the aim of developing Standard Operating Procedures (SOPs) that will greatly improve regenerations success on these chipper debris piles (i.e., similar stocking and densities of desired tree species compared to in-block numbers). SOPs now include:

- Harvest contractors to maximize grapple skidder carry bag, leaving small, manageable debris piles throughout the block.
- After chipping is completed, remaining roadside debris spreading evenly to <20 cm deep.
- Site preparation with power disc trenchers exposing mineral soil. Deeper piles (+30 cm) will require double passes. Trench along the slope to improve water and air drainage.

Information Report (MNRF Info Rep IR-04) available that provides full details on chipper debris working group activities – see author (email: dave.m.morris@ontario.ca)


Grapple skidder carrying back chipper debris


Power disc trenching through a chipper debris pile