Update on wood ash applications to forest soils

NESMC March 2018
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## Bioenergy production in Canada

### Renewable Electric Capacity and Generation in Canada

<table>
<thead>
<tr>
<th>Source</th>
<th>Capacity in MW and %</th>
<th>Generation in GW.h and %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydro</td>
<td>72 861</td>
<td>79 280</td>
</tr>
<tr>
<td>Wind</td>
<td>556</td>
<td>11 071</td>
</tr>
<tr>
<td>Biomass</td>
<td>1 788</td>
<td>2 397</td>
</tr>
<tr>
<td>Solar</td>
<td>17</td>
<td>2 134</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>All renewable sources</td>
<td>75 222</td>
<td>94 882</td>
<td>367 849</td>
<td>421 543</td>
</tr>
<tr>
<td>All sources</td>
<td>122 066</td>
<td>144 525</td>
<td>610 238</td>
<td>646 040</td>
</tr>
</tbody>
</table>


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Potential environmental benefits of recycling wood ash in forests

- nutrient compensation - “recycling of nutrients should be a fundamental principle in sustainable forestry” (Saarsalmi et al., 2001)
- reduction in soil and surface water acidity - amending soils depleted of base cations (Ca, Mg, K) due to acid rain
- fertilization of whole-tree and biomass harvested sites - enhancing forest productivity by raising soil pH
- emulating natural disturbance (END) – mimic some of the effects of wildfire on soil properties
Wood ash utilization

• Currently 2/3 of the wood ash produced in Canada is landfilled - varies by province - 2020 prohibited in Quebec
• ash as a silvicultural tool - accepted management practice in Europe
• social license essential to grow the bio-economy - negative perception of increased utilization
Island Lake Biomass Harvest Experiment

40-year-old jack pine boreal forest
1825 stems/ha, 30 m²/ha
deep glaciofluvial deposit
coarse textured
10 cm forest floor
clearcut full-tree biomass harvest
Harvest - December 2010/January 2011
Grinding - January/February 2011
Plot treatments - July 2011
Site preparation - September 2011
Ash application - October 2011
Tree plant - May 2012
Island Lake – site Ca post ash application

Island Lake post-treatment Ca retention

- Unharvested
- Tree length
- Full tree
- Stumped
- Bladed
- Ash50
- Ash100
- Ash200
- Ash400

Ca retention (kg ha⁻¹)

Legend:
- Mineral soil 30-100 cm
- DWD below
- Harvest slash
- Mineral soil 0-30 cm
- Stump
- Organic
- DWD above
- Wood ash
- Standing biomass
Soil pH

- control = full-tree = Ash 0
- increase in forest floor pH 1 year after application at the highest application rate and maintained at 3 years after application
- no increase in mineral soil pH
• different bacterial communities in Control, Ash, and Fire plots, but no effect of increasing ash addition rate
• no effect of Ash on fungal soil community composition, but significant Fire effect

Soil fauna - nematodes

• nematode community composition is an important biological indicator of soil quality
• no effect of ash on nematode community using morphological characteristics (richness, abundance, diversity), trait-based indices or molecular techniques

Exchangeable cations 20 months after ash application

- pH values of bulk soils can be a misleading indicator for the actual extreme conditions
- authors recommend using microscale depth increments and a shorter temporal scale to avoid an underestimation of effects
Beech bark disease
Add Wood ash

Mixed beech/maple stand

BBD Infestation

Beech die or decline

Low substrate Ca

CaO < 0.1%

Low-Ca forest floor

Beech reproduction

Beech dominant

Regional Soil Acidification

Local FF acidification continues

High substrate Ca

CaO > 0.1%

Maple pumping of subsoil Ca

Maple growth and reproduction

High-Ca forest floor

Maple dominant

Local FF acidification moderated

Porridge Lake Ash Trial

- beech thickets, reduced soil pH and base cation status, stagnation of forest productivity
- wood ash applications as a silvicultural tool in combination with vegetation control to promote maple/birch competitiveness
- beech control, ash application planned for 2018
# Ash chemistry

<table>
<thead>
<tr>
<th></th>
<th>Fly ash (g kg⁻¹)</th>
<th>Bottom ash (g kg⁻¹)</th>
<th>Wildfire ash (g kg⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon</td>
<td>180.9</td>
<td>203.6</td>
<td>282.5</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>1.7</td>
<td>0.9</td>
<td>8.6</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>6.3</td>
<td>4.9</td>
<td>3.0</td>
</tr>
<tr>
<td>Calcium</td>
<td>153.5</td>
<td>103.7</td>
<td>159.5</td>
</tr>
<tr>
<td>Magnesium</td>
<td>14.6</td>
<td>11.8</td>
<td>15.8</td>
</tr>
<tr>
<td>Potassium</td>
<td>33.1</td>
<td>24.1</td>
<td>23.8</td>
</tr>
</tbody>
</table>
More soil C is retained after ash applications than after wildfires.
More soil N is retained after ash applications than after wildfires.
...is increased much more by applications of ash
...tends to increase in the mineral soil following wildfires and ash applications.
AshNet

What is AshNet?

AshNet is a network of scientists, foresters, industry and government (federal and provincial) representatives who are actively investigating the potential for reducing waste and improving forest health by applying wood ash from bioenergy production to forest soils.

AshNet is funded by the Program of Energy Research and Development (PERD).

Why study wood ash?

When trees are cut and processed for timber or pulp and paper production, branches, bark and other small pieces of wood are removed from the tree stems. This woody material is often burned for energy in industrial or commercial boilers. It is common for the remaining ash to be treated as waste and sent to the landfill. Yet, wood ash is rich in nutrients. By applying it to forest soils, wood ash could provide several benefits for the forest and reduce landfill usage.

The application of wood ash, also called bioenergy ash, to forest soils is not a common practice in Canadian forestry.

About this online resource

The information you'll find on the AshNet project webpages site has been researched, written and developed by AshNet members, who also help coordinate original research about the effects of soil applications of wood ash on tree growth and forest ecology.
Canadian Wood Ash Chemistry Database

This database contains information on the chemical composition of wood ashes sampled from 17 Canadian biomass boilers. The goal of the database is to provide information about the levels and variation in the element concentrations of fly and bottom ashes formed during the combustion of woody biomass, and how they compare with the trace element limits established by the Canadian Council of Ministers of the Environment (CCME) noted in Hannam et al. Regulations and guidelines for the use of wood ash as a soil amendment in Canadian forests (2016).

The database includes the results of chemical analyses of wood ashes collected from 17 boilers: 10 pulp and paper mills and seven bioenergy co-generation facilities. At seven of these facilities, separate samples of bottom and fly ash were collected for analysis. The data presented in the tables and figures below summarize the chemistries of 16 bottom ash samples and nine fly ash samples.

If you have wood ash chemistry data that you can contribute to this database, or ash samples that we could analyze to add new data, please contact Paul Hazlett.

Figure 1. pH, carbon and nutrient concentrations of Canadian fly and bottom wood ashes in grams per kilogram (g kg⁻¹). Data represent mean and standard deviation.

http://www.nrcan.gc.ca/forests/research-centres/glfc/ashnet/20288
AshNet Sites

Canadian National Vegetation Classification.
NRCan, CFS, Sault Ste. Marie, ON.
Thank you

Wood ash as a soil amendment in Canadian forests: what are the barriers to utilization?

K.D. Hannam, L. Venier, D. Allen, C. Deschamps, E. Hope, M. Jull, M. Kwiaton, D. McKenney, P.M. Rutherford, and P.W. Hazlett


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