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Update on wood ash applications to forest soils

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Paul Hazlett
Canadian Forest Service
Sault Ste. Marie, Ontario, Canada

Canada

Bioenergy production in Canada

Renewable Electric Capacity and Generation in Canada	Capacity in MW and %		Generation in GW.h and %	
	2005	2015	2005	2015
Hydro	72 861	79 280	358 520	376 909
	60%	55%	59%	58%
Wind	556	11 071	1 454	28 526
	0.5%	8%	0.2%	4%
Biomass	1 788	2 397	7 875	13 107
	1%	2%	1%	2%
Solar	17	2 134	0	3 001
	0.01%	1%	0%	0.5%
All renewable sources	75 222	94 882	367 849	421 543
	62%	66%	60%	65%
All sources	122 066	144 525	610 238	646 040

National Energy Board. 2016.

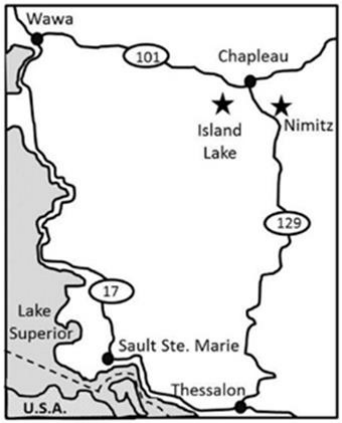
Potential environmental benefits of recycling wood ash in forests

- 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

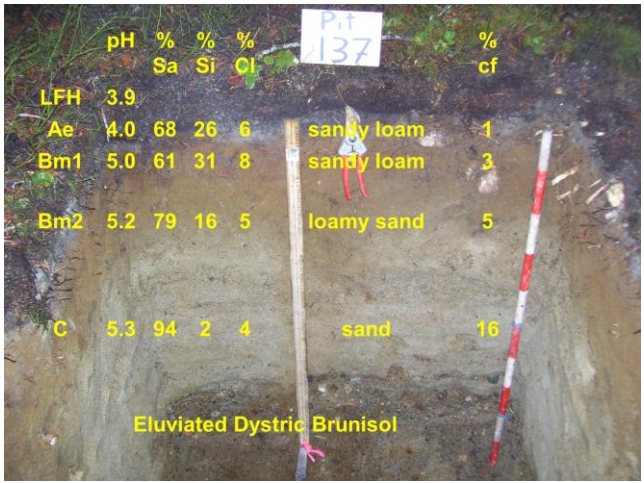
1825 stems/ha, 30 m^2/ha

deep glaciofluvial deposit

coarse textured

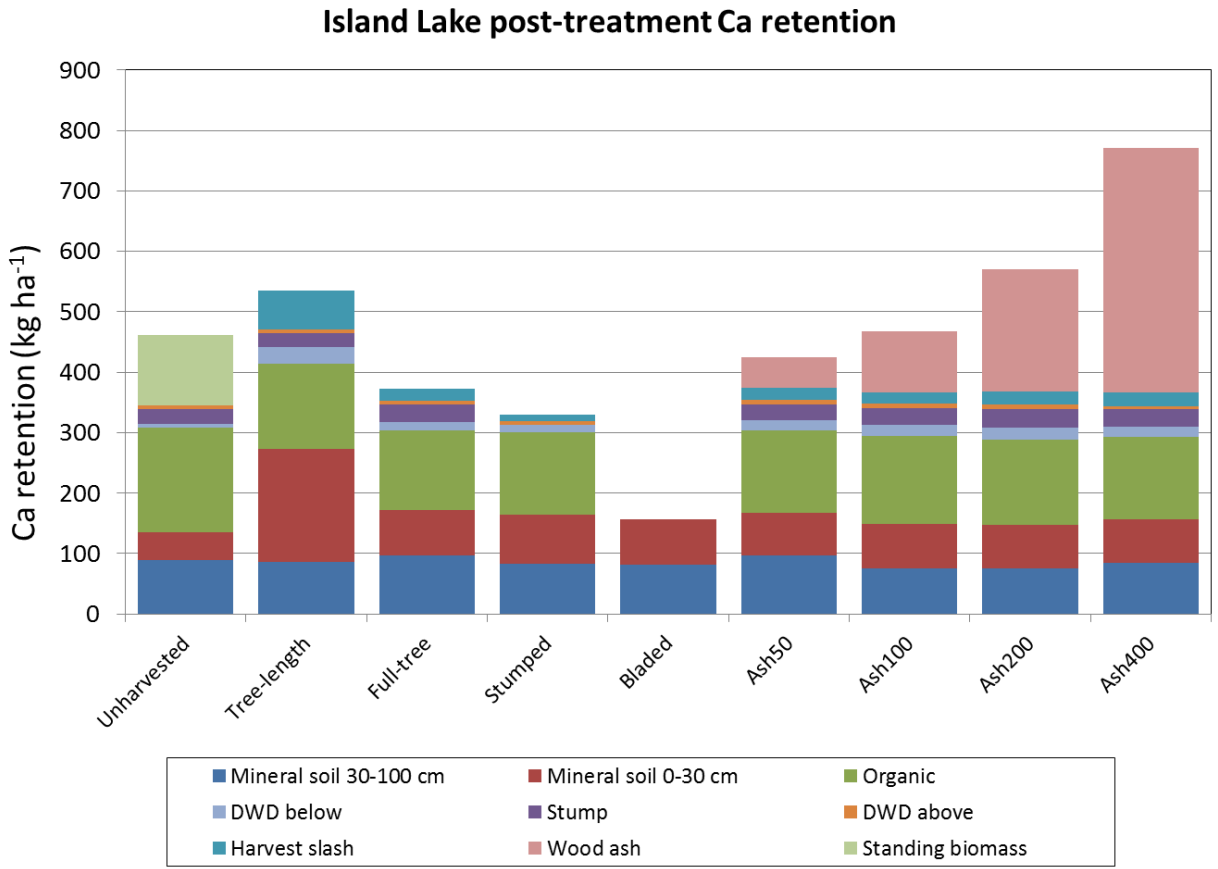
10 cm forest floor

clearcut full-tree biomass harvest

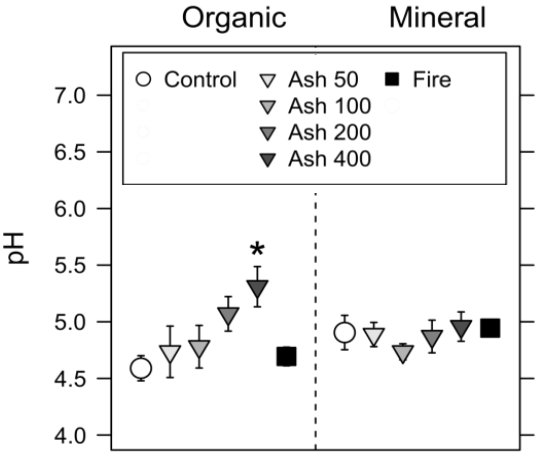


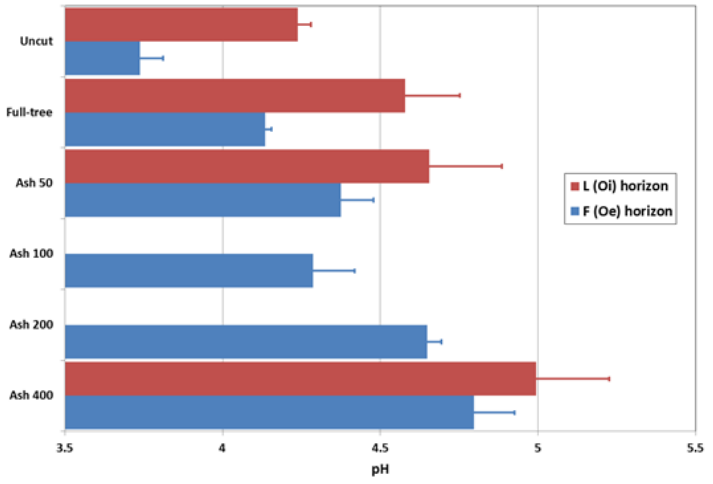
Harvest - December 2010/January 2011
Grinding - January/February 2011
Plot treatments - July 2011
Site preparation - September 2011
Ash application - October 2011
Tree plant - May 2012

Island Lake – site Ca post ash application

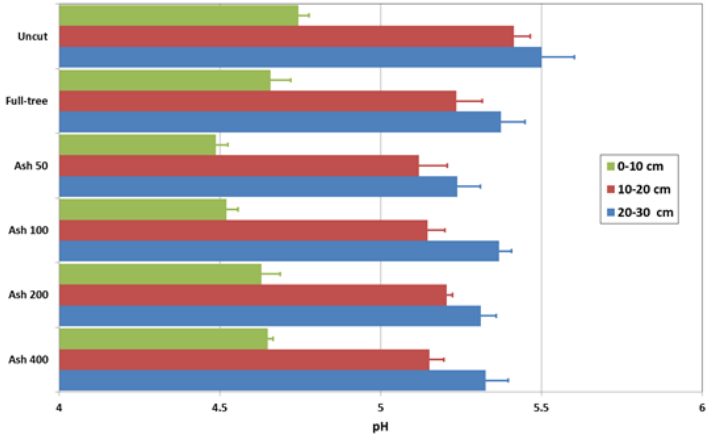


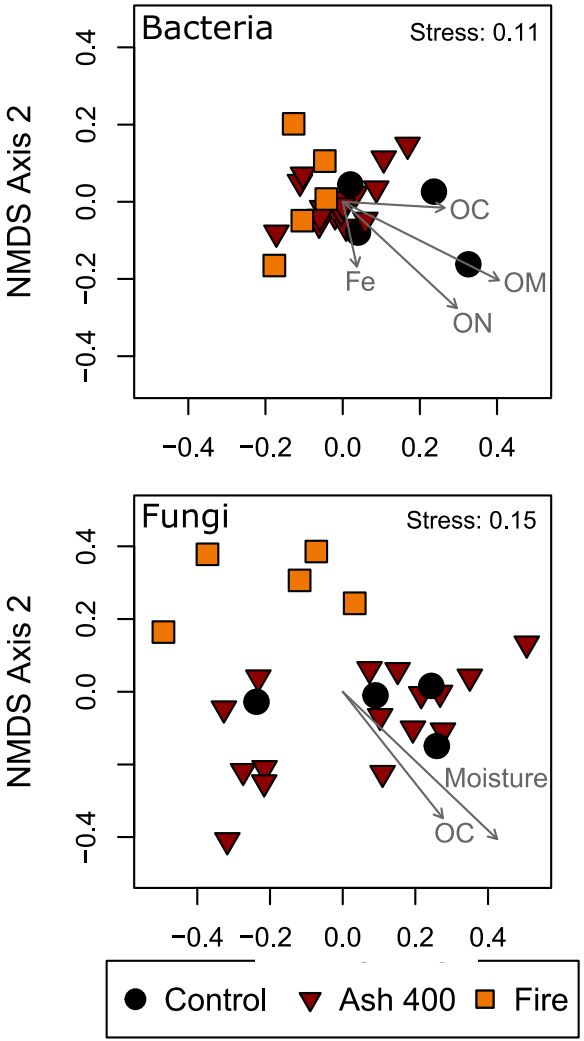
Soil pH





- 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





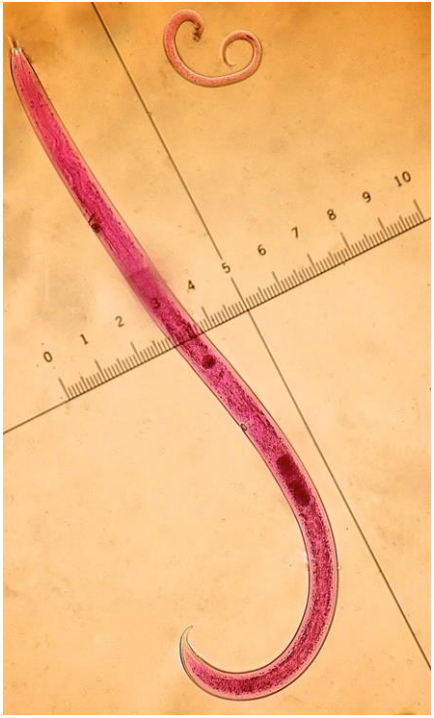
Microbial community composition

- 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

Noyce et al. 2016. Soil microbial responses to wood ash addition and forest fire in managed Ontario forests. Applied Soil Ecology 107, 368-380.

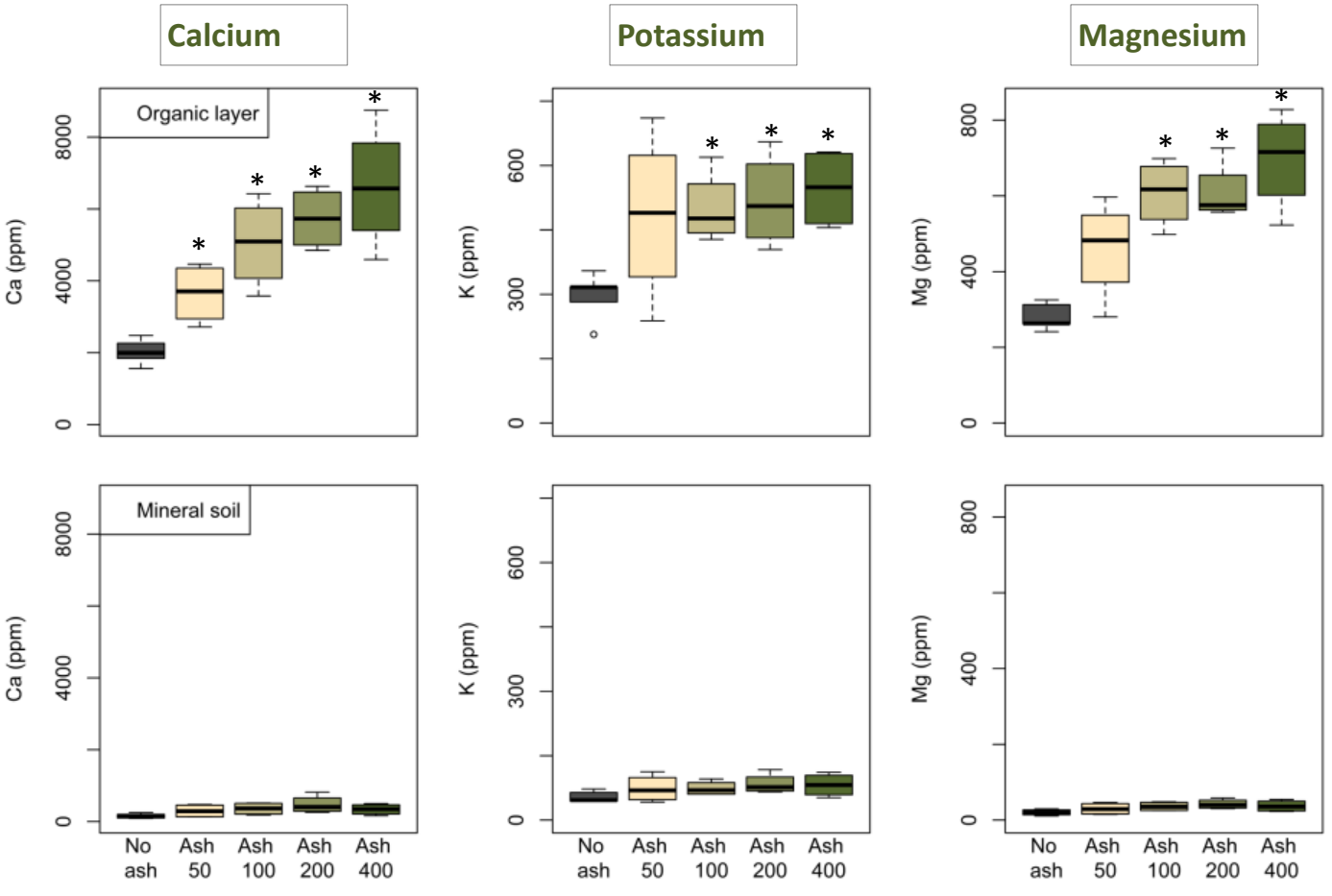
Soil fauna - nematodes

- 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



George, 2014. A comparison of community composition analyses for the assessment of responses to wood-ash soil amendment by free-living nematodes. M.Sc.Thesis, Western University.

Exchangeable cations 20 months after ash application



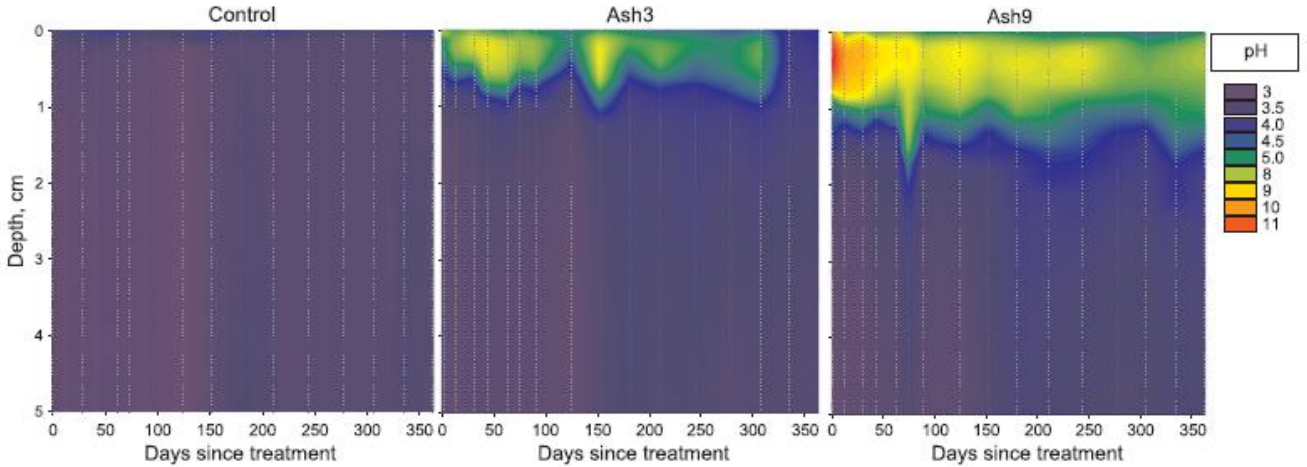
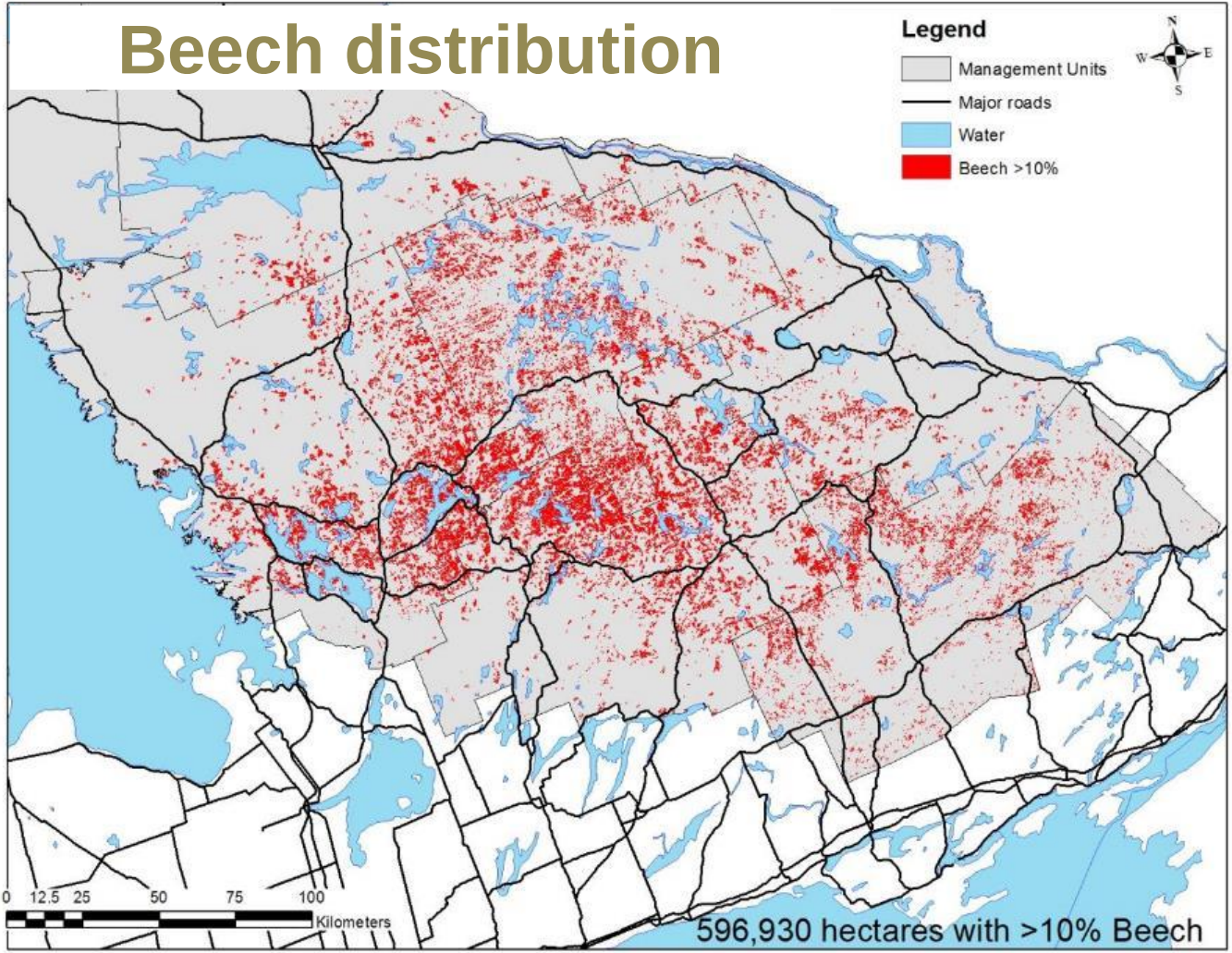


Fig. 1. Contour maps of the micro vertical changes in soil pH over time for Control, Ash3 and Ash9. Dotted grey lines indicate measuring points.

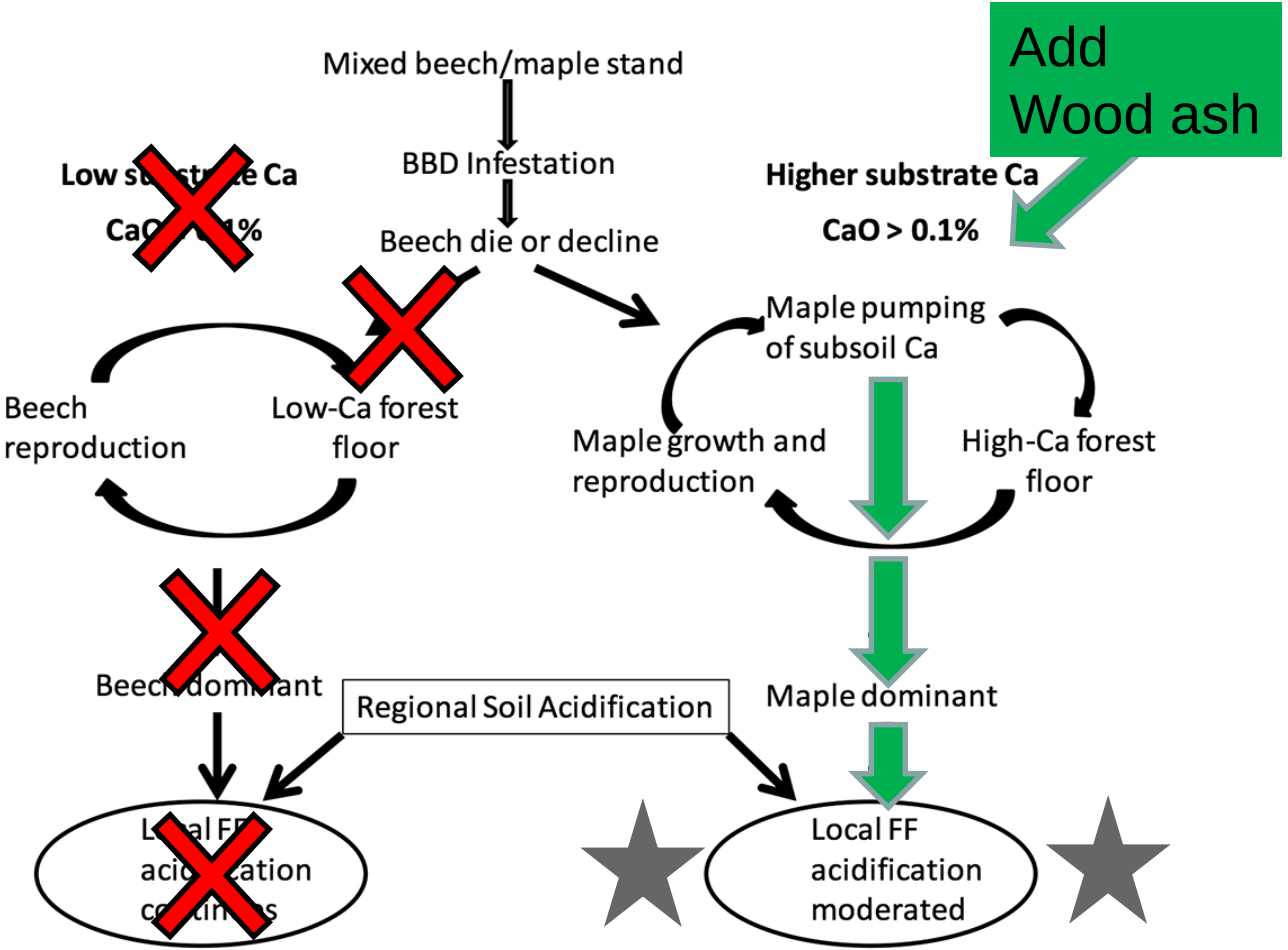
Hansen et al. 2017. Micro vertical changes in soil pH and base cations over time after application of wood ash on forest soil. Forest Ecology and Management 406, 274-280

- 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 distribution

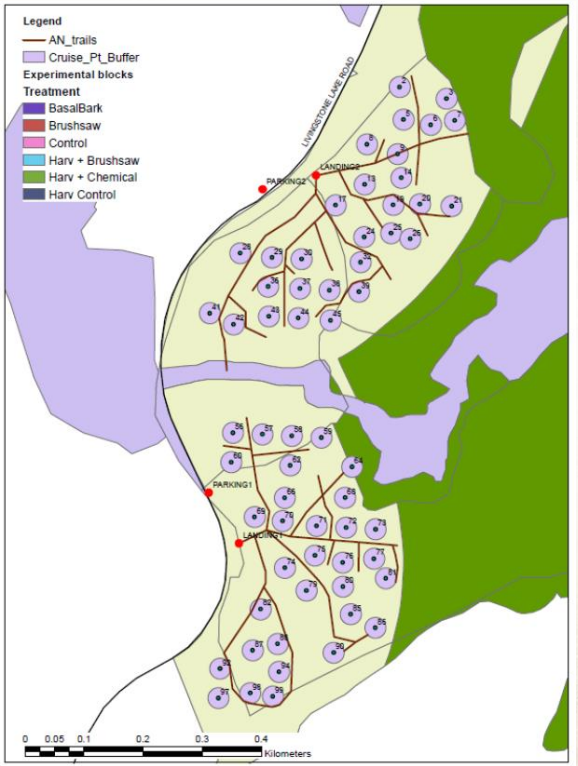


Beech bark disease



Arthur et al Can. J. For. Res. 47: 875–882 (2017)

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 competiveness
- beech control, ash application planned for 2018

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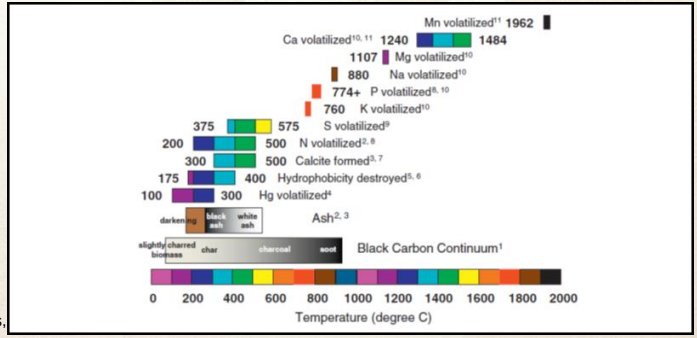
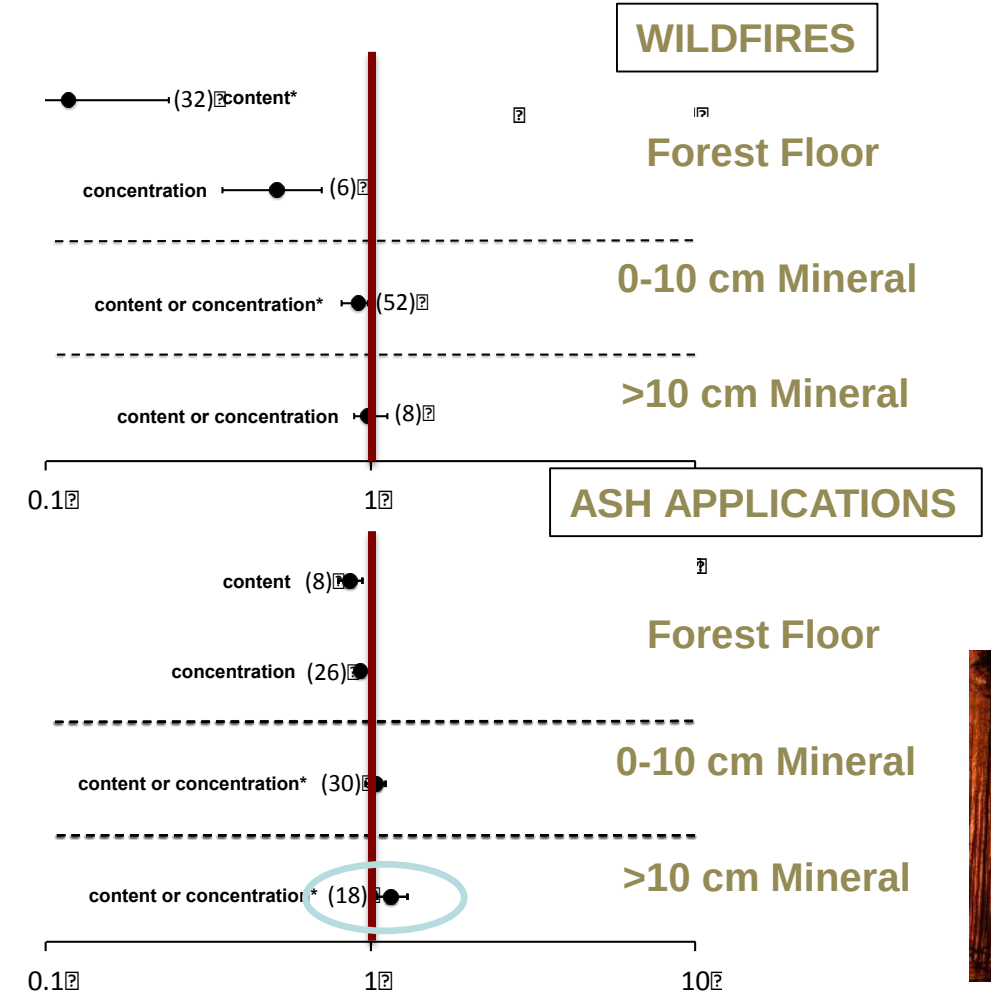
Ash chemistry

	Fly ash (g kg^{-1})	Bottom ash (g kg^{-1})	Wildfire ash (g kg^{-1})
Carbon	180.9	203.6	282.5
Nitrogen	1.7	0.9	8.6
Phosphorus	6.3	4.9	3.0
Calcium	153.5	103.7	159.5
Magnesium	14.6	11.8	15.8
Potassium	33.1	24.1	23.8



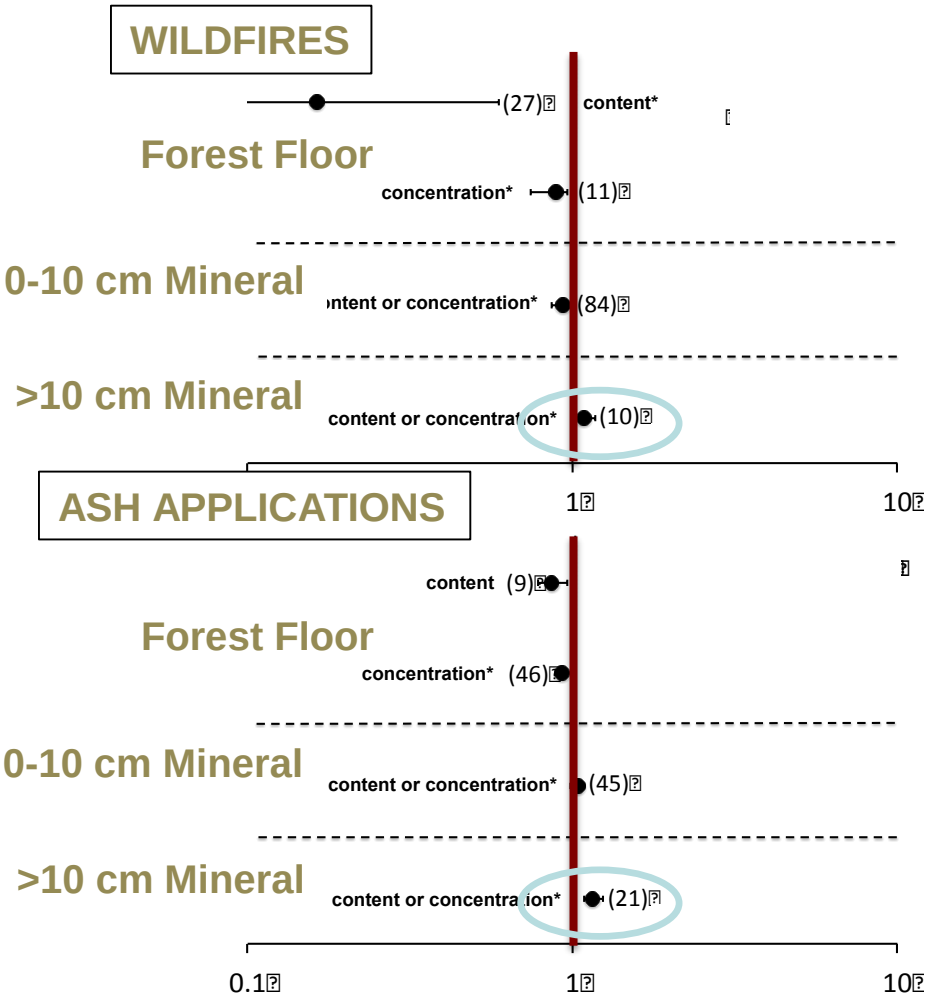


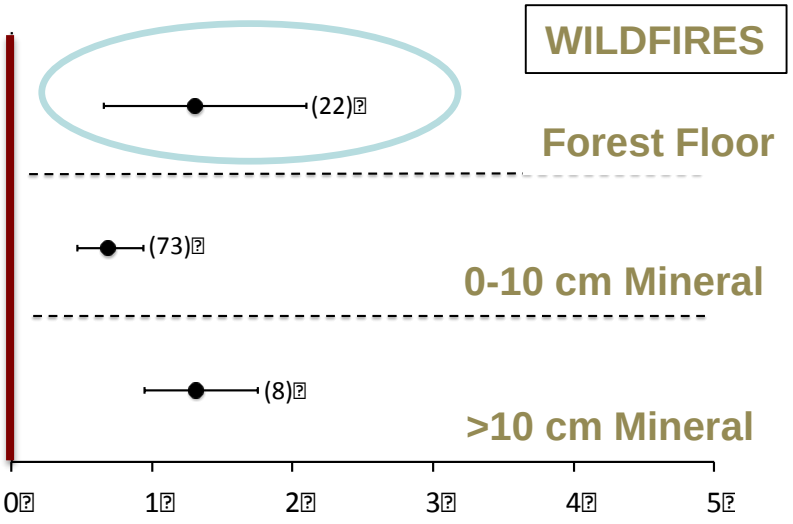
CARBON

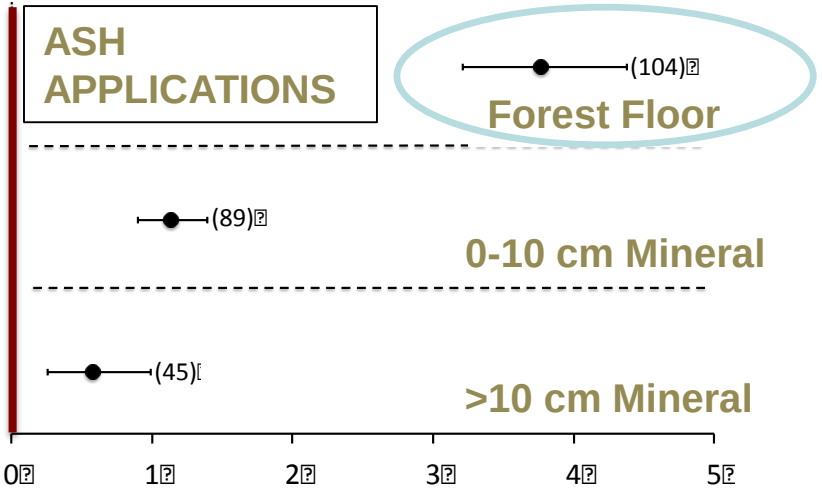
More soil C is retained after ash applications than after wildfires

NITROGEN

More soil N is retained after ash applications than after wildfires



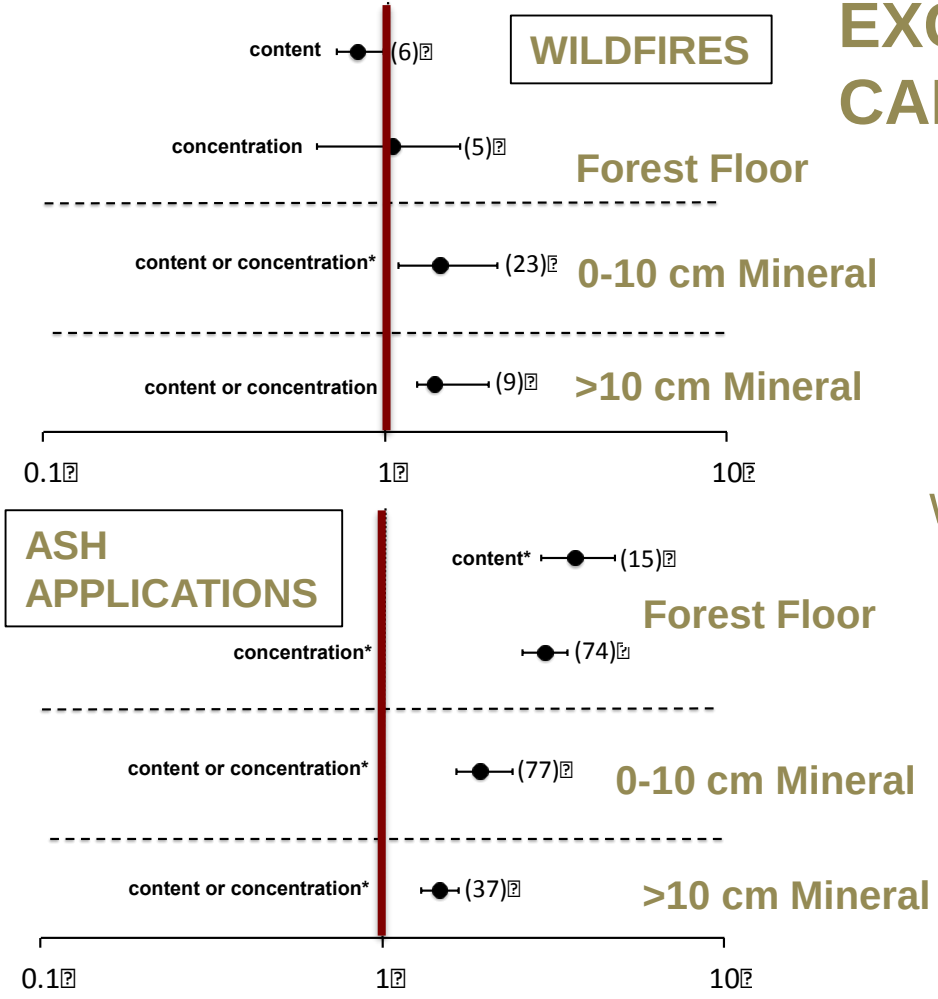




pH

…is increased much more by applications of ash

EXCHANGEABLE CALCIUM



…tends to increase in the mineral soil following wildfires and ash applications

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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).

- Introduction to wood ash: in pictures
- AshNet publications and presentations
- Future AshNet work
- Canadian Wood Ash Chemistry Database

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.

http://www.nrcan.gc.ca/forests/research-centres/glfc/ashnet/20279

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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.

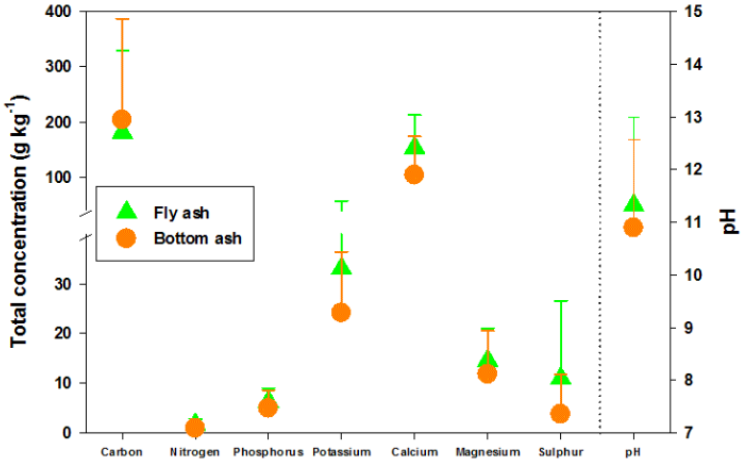
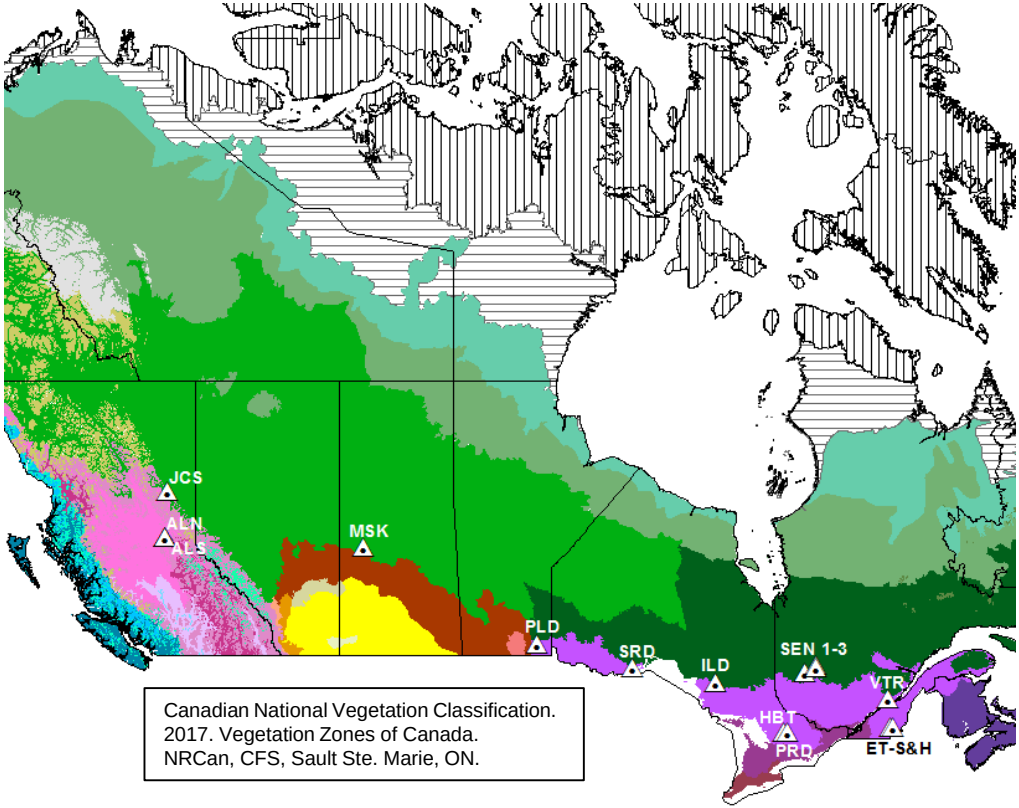


Figure 1. pH, carbon and nutrient concentrations of Canadian fly and bottom wood ashes in grams per kilogram (g kg-1). Data represent mean and standard deviation.

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

AshNet Sites



Canadian National Vegetation Classification. 2017. Vegetation Zones of Canada. NRCan, CFS, Sault Ste. Marie, ON.

Legend

Alpine Tundra
- Cordilleran Alpine Tundra
- Eastern Alpine Tundra
- Pacific Alpine Tundra
- Subarctic Alpine Tundra
- Western Boreal Alpine Tundra

Arctic Tundra
- High Arctic Sparse Tundra
- Low Arctic Shrub Tundra
- Mid-Arctic Dwarf Shrub Tundra

Boreal
- Atlantic Maritime Heathland
- Eastern Boreal Forest
- Northern Boreal Woodland
- Northwestern Boreal Forest
- Subarctic Woodland-Tundra
- West-Central Boreal Forest

Cordilleran Cool Temperate Forest
- Cordilleran Dry Forest
- Cordilleran Montane Forest
- Cordilleran Rainforest
- Cordilleran Subboreal Forest

Eastern Cool Temperate Forest
- Acadian Temperate Forest
- Erie Temperate Forest
- Huron - St. Lawrence Temperate Forest
- Northeastern Temperate Forest

Grassland & Parkland
- Central Tallgrass Grassland
- Great Basin Shrub-Steppe
- Great Plains Fescue Grassland
- Great Plains Mixedgrass Grassland
- Great Plains Parkland
- Intermontane Shrub-Steppe
- Rocky Mountain Foothills Fescue Grassland
- Rocky Mountain Foothills Parkland

Miscellaneous
- Cypress Hills
- Pacific Maritime Glacialized

Pacific Cool Temperate Forest
- Pacific Maritime Forest
- Pacific Mediterranean Forest
- Pacific Montane Forest

Thank you

NRC Research Press

DISCUSSION

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

Can. J. For. Res. 48: 1–9 (2018) dx.doi.org/10.1139/cjfr-2017-0351