A community led wood ash recycling program to restore forest nutrition in Muskoka, Ontario

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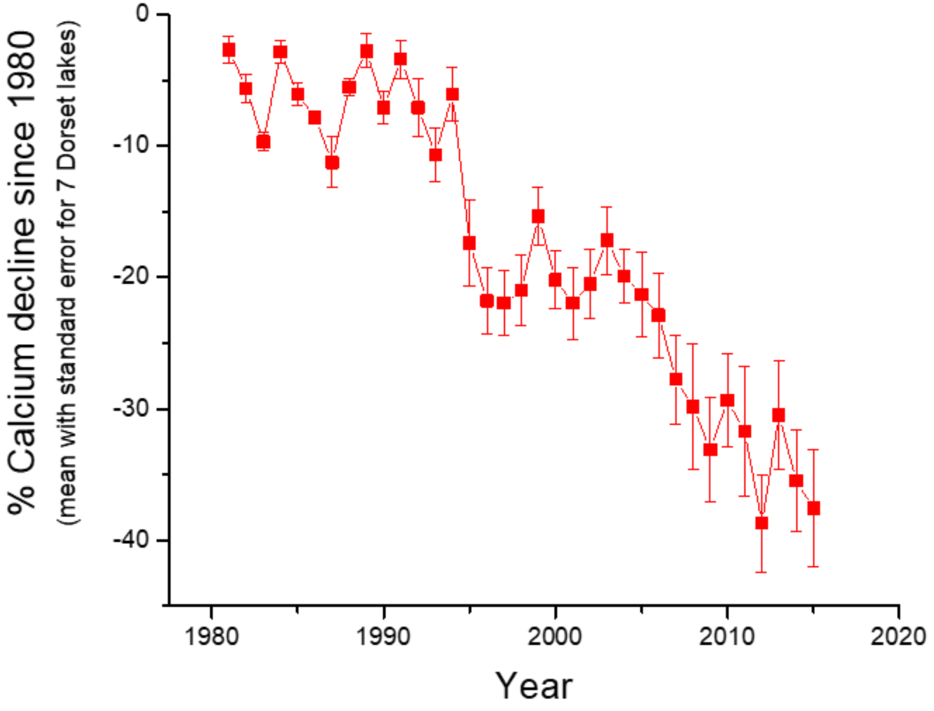
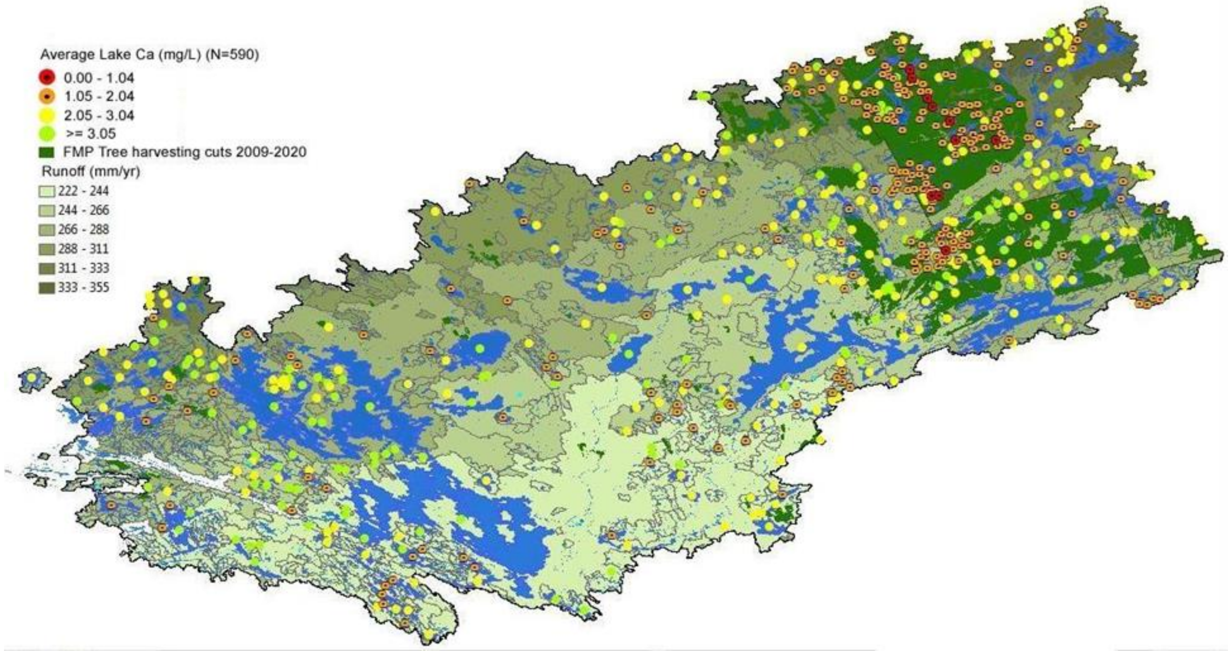
TRENT UNIVERSITY

Many thanks to (all the students) [Shelby, Sylvie, Dawson, Kira, Kayla, Kaylen, Batool, Victor] and our many community partners (especially Norman Yan):

I am a Friend

the issue: widespread Ca decline in lakes and soils:





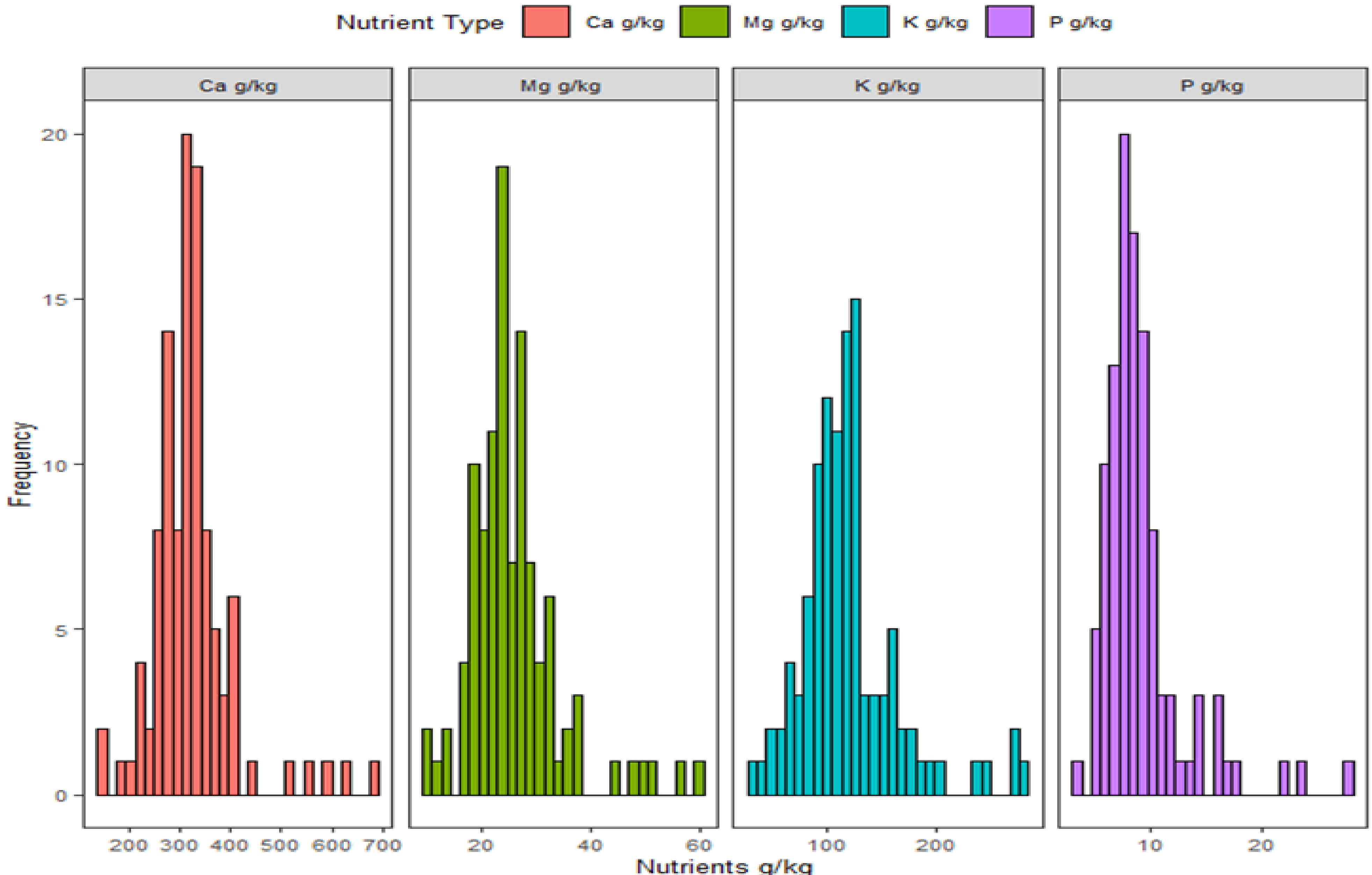
Natural recovery (kg ha^{-1}) will be slow (or may never occur)

VSD–hindcasted and forecasted changes in base cation pools for scenarios that considered enhanced dry deposition in coniferous dominated plots.

Site	Historic Change						Forecasted Change		
	1850–2000			2000–2020			2000–2100		
	Ca	Mg	K	Ca	Mg	K	Ca	Mg	K
Balsam Fir	-365	-38	-59	38	4	6	100	11	17
Eastern Hemlock	-360	-41	-83	52	6	10	107	12	23
White Pine	-309	-51	-99	27	4	9	78	13	25

Ott & Watmough (2022); Can. J. For Res. 52(3): 372-384

Wood ash is rich in many nutrients



but is a waste product in Ontario:

ON Reg 267/03 - Non-Aqueous Non-Agricultural Source Materials Guideline (NASM)

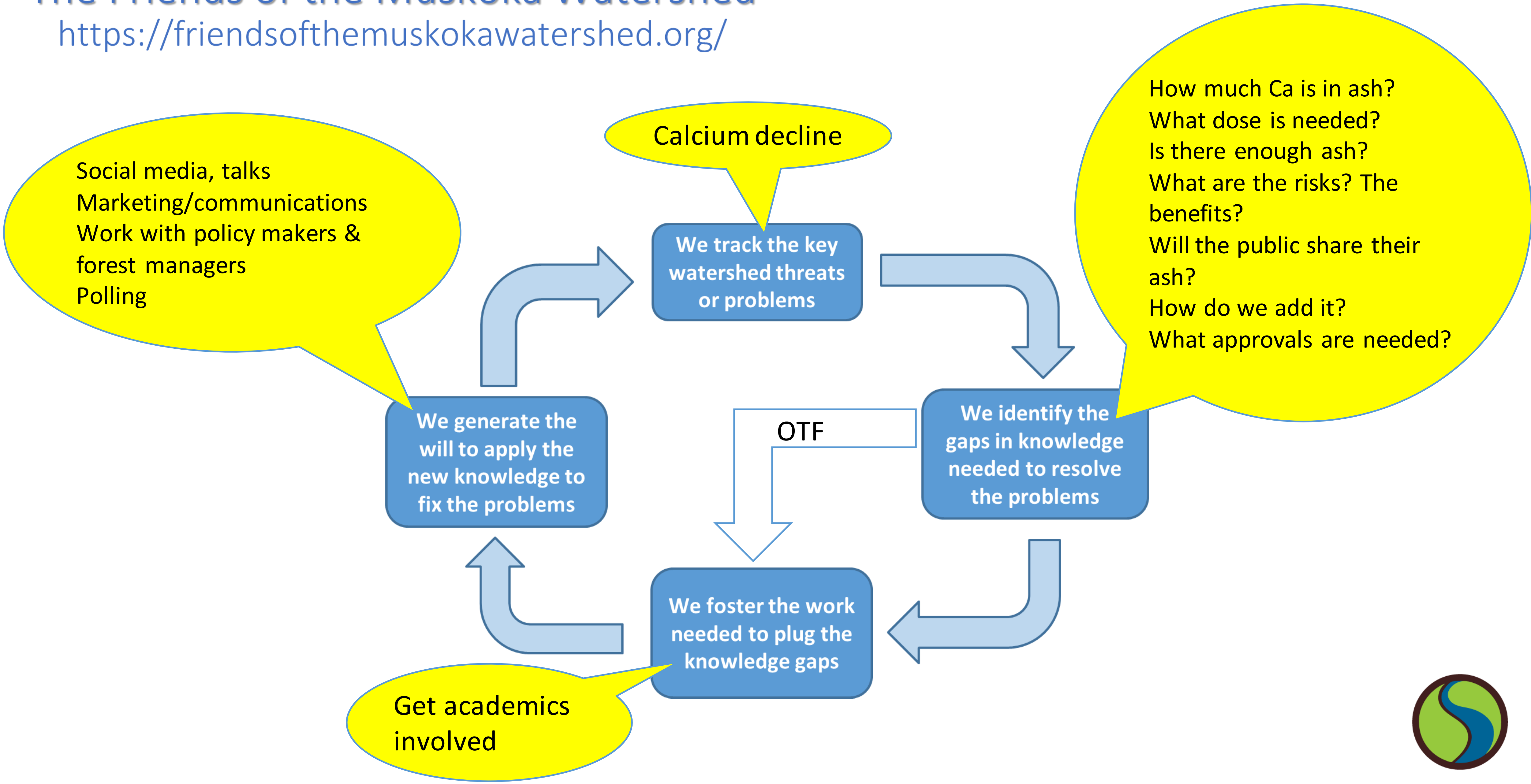
Regulated metals and metalloids

- CM1 unrestricted limits
- CM2 restricted limits

Reg. Metals (mg.kg)	CM1	CM2
Arsenic	13	170
Cadmium	3	34
Chromium	210	2800
Cobalt	34	340
Copper	100	1700
Lead	150	1100
Mercury	0.8	11
Molybdenum	5	94
Nickel	62	420
Selenium	2	34
Zinc	500	4200

The Friends of the Muskoka Watershed

https://friendsofthemuskokawatershed.org/



Goals of ASHMUSKOKA

Friends of the Muskoka Watershed

- To encourage public engagement in environmental protection
- To develop Canada's first Non-Industrial Wood Ash recycling program designed to solve the problem of calcium decline
- To learn how to do it: the amounts of wood ash needed, proof it works, how to get it approved, how to get people involved

FOMW were thoughtful and a bit cheeky about branding

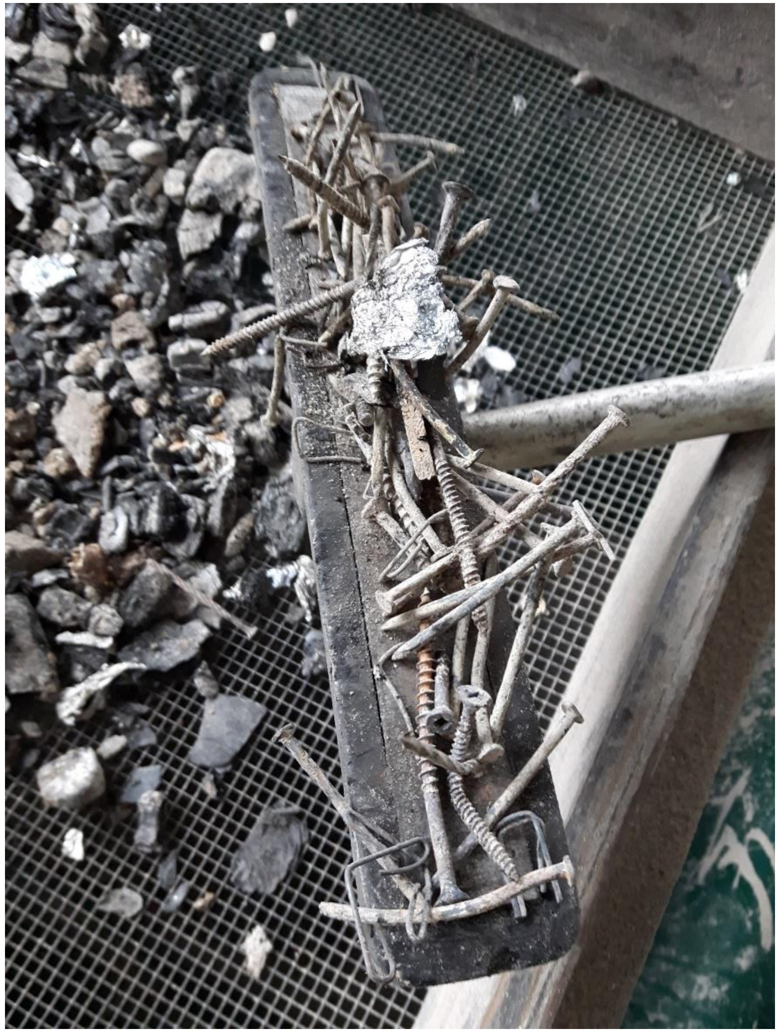
Evidence it is working*

1000+ folks are collecting their ash for the project

*Thanks to Gravenhurst Timber Mart and Momma Bears Ice-cream and Sweets for ash collection buckets

And bringing it to the local transfer station

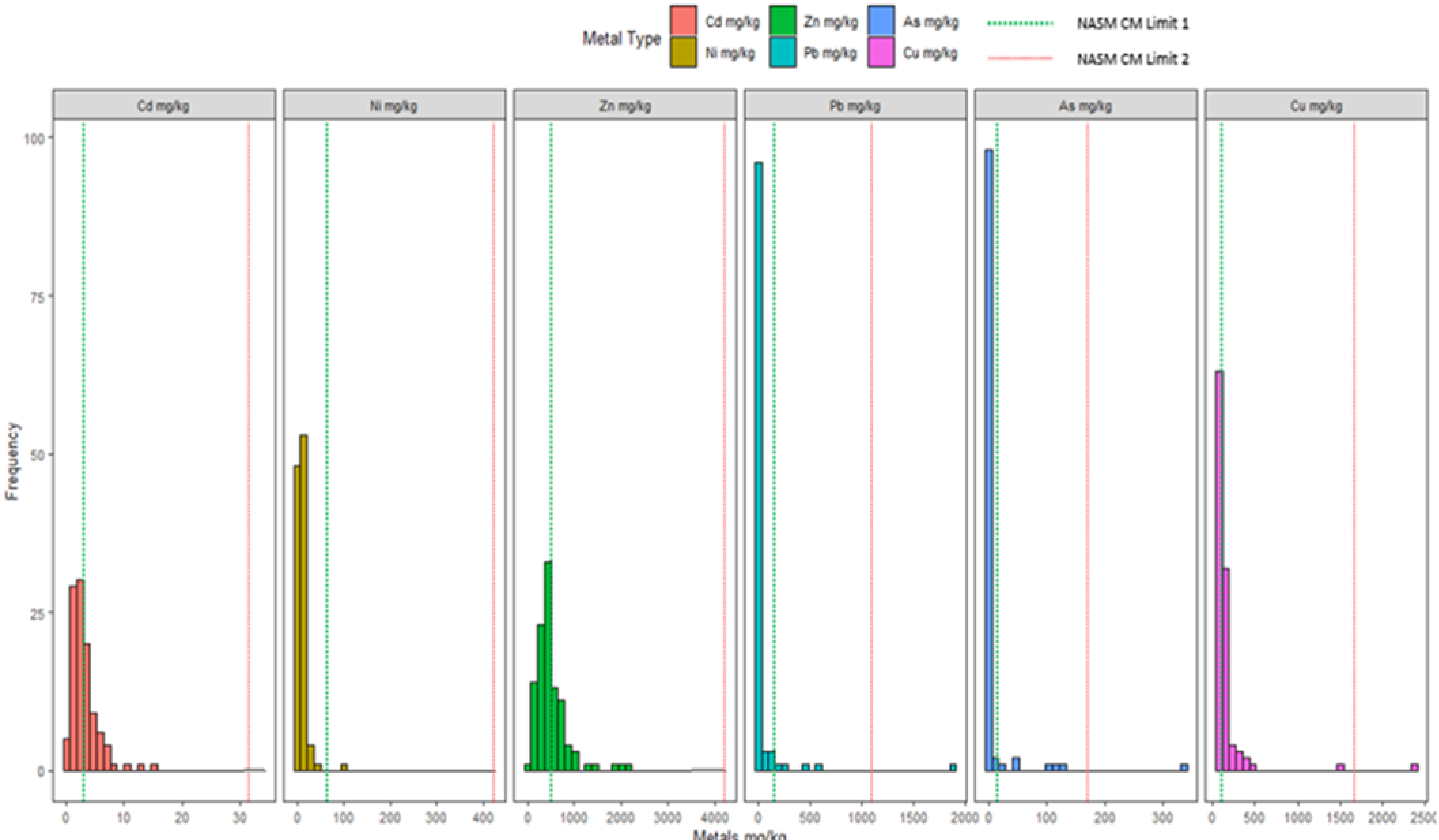
Where it is screened to remove particulates



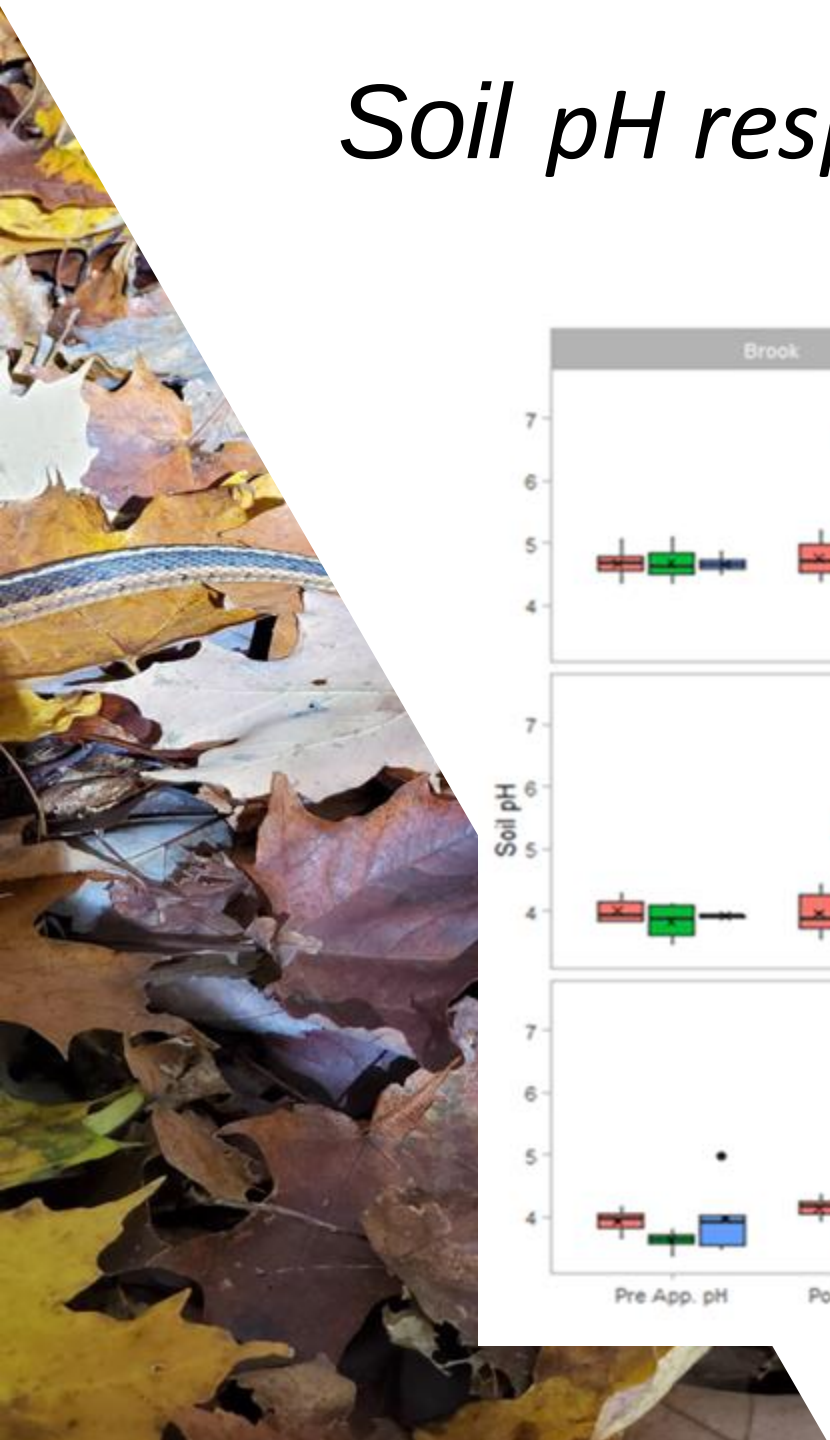
Then hauled and spread the ash to identify the needed dose

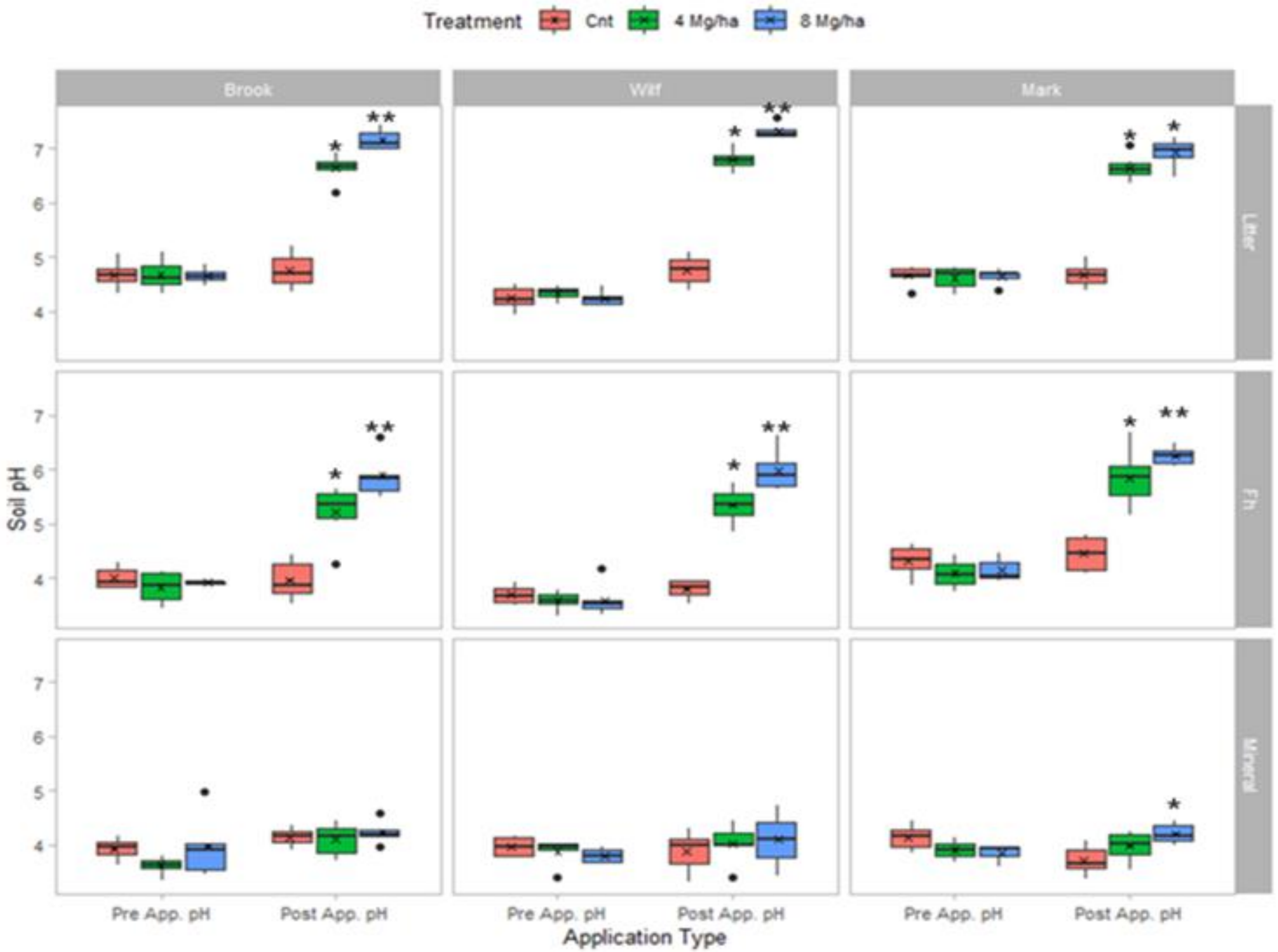
Trials established in 3 sugar bushes and Camp Big Canoe with a lot of volunteer help

Metals in wood ash, NASM Restriction Limits

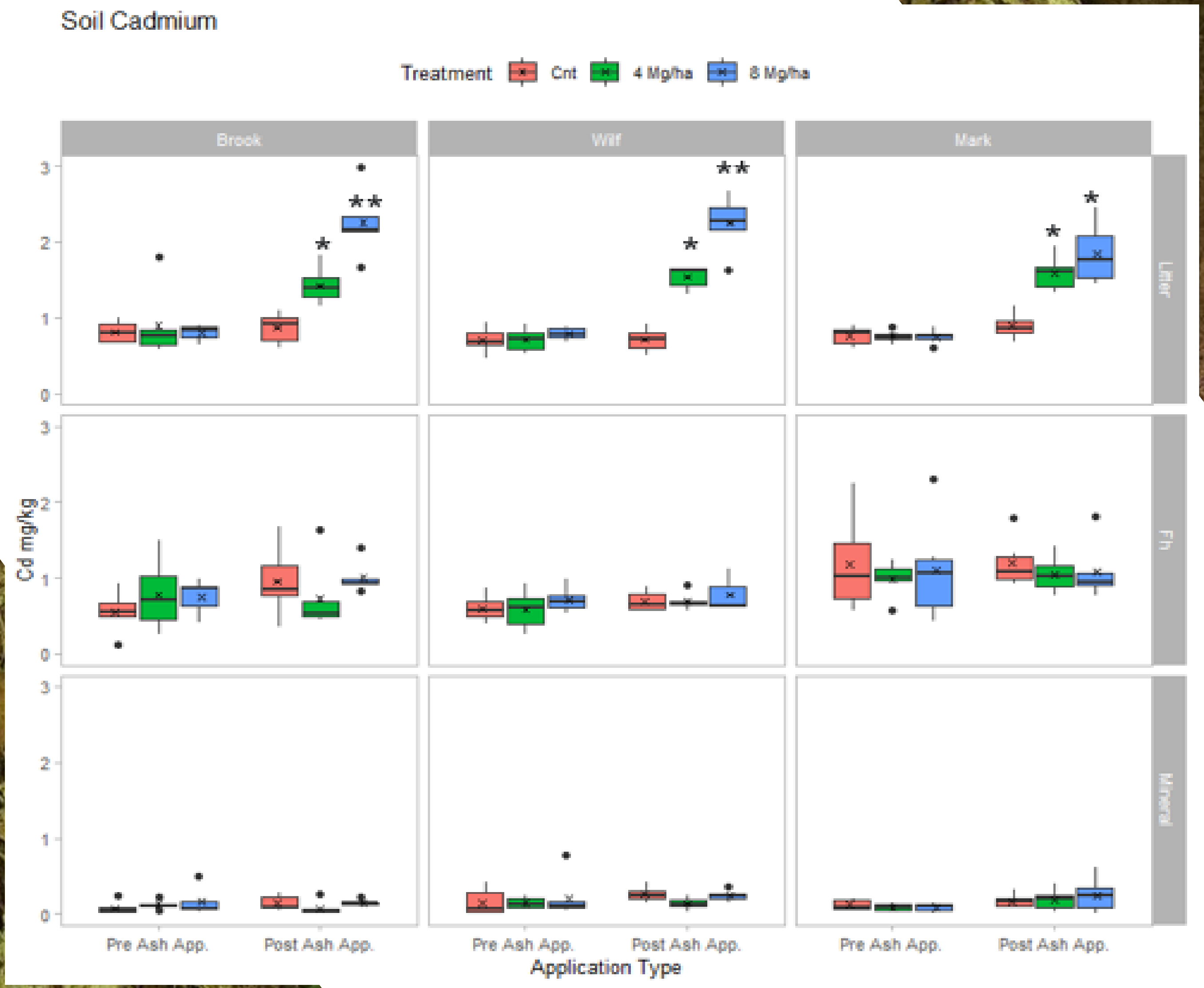


Soil pH response to wood ash

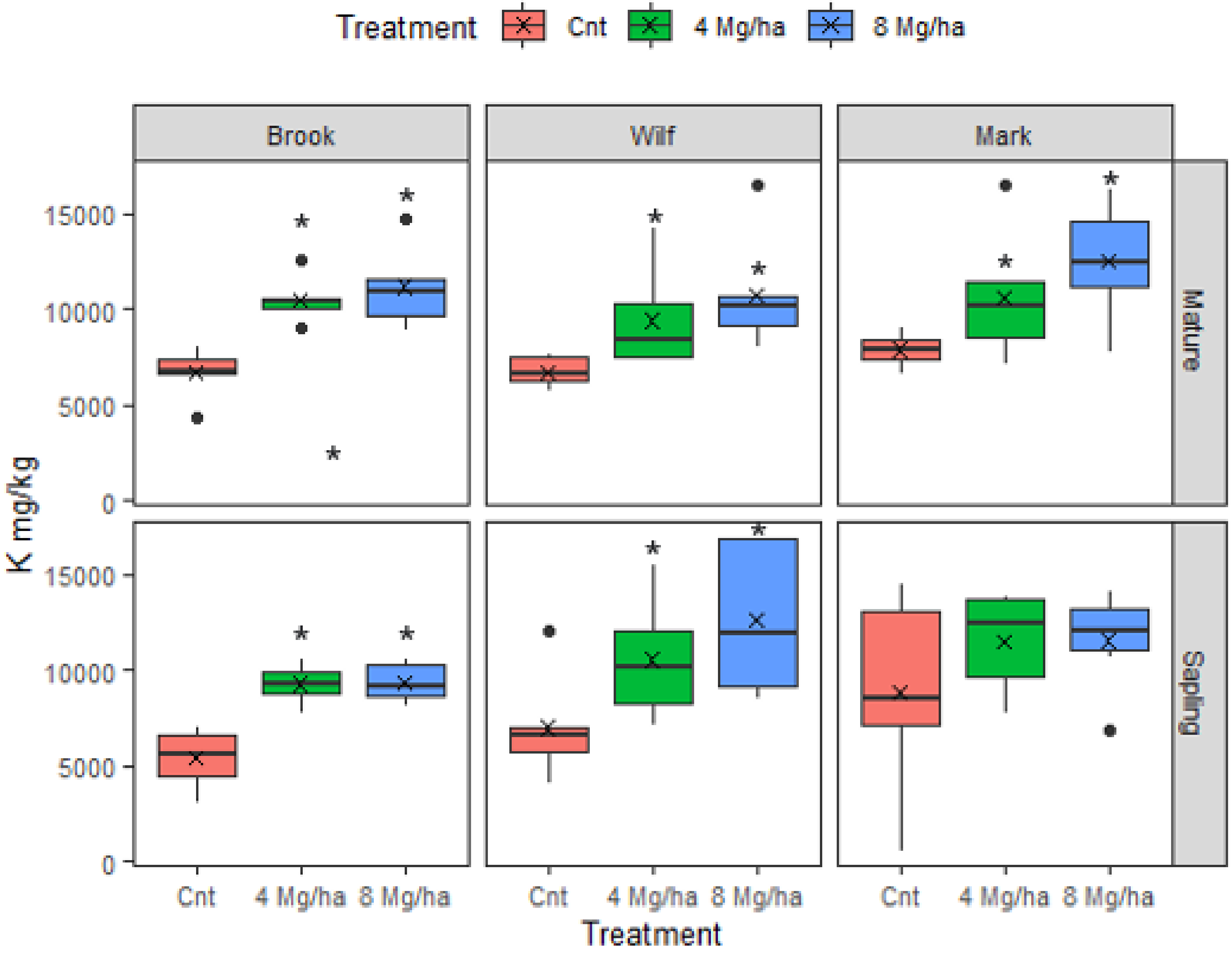




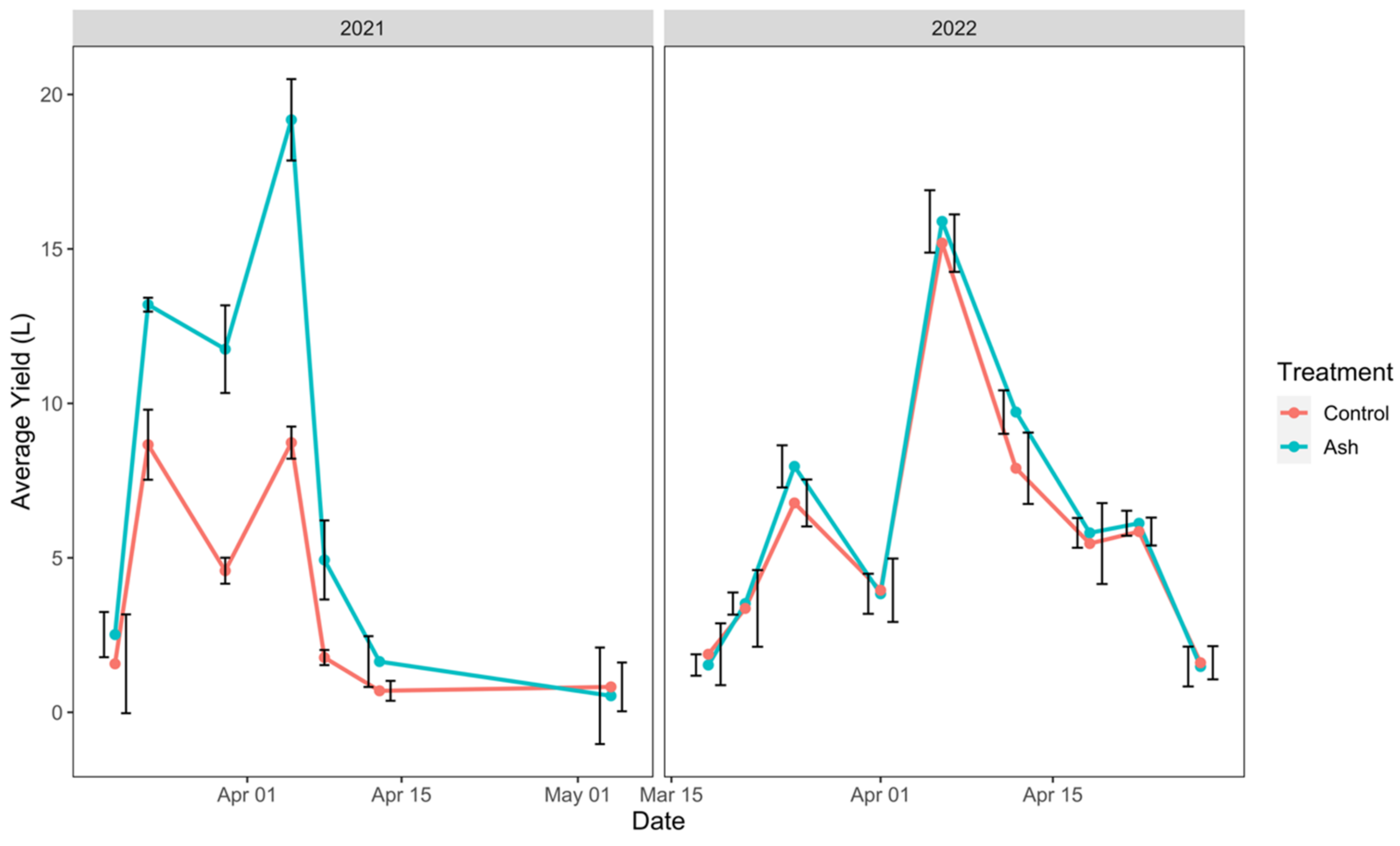
Soil cadmium response to wood ash



Sugar maple foliage - Potassium



Sugar Maple sap



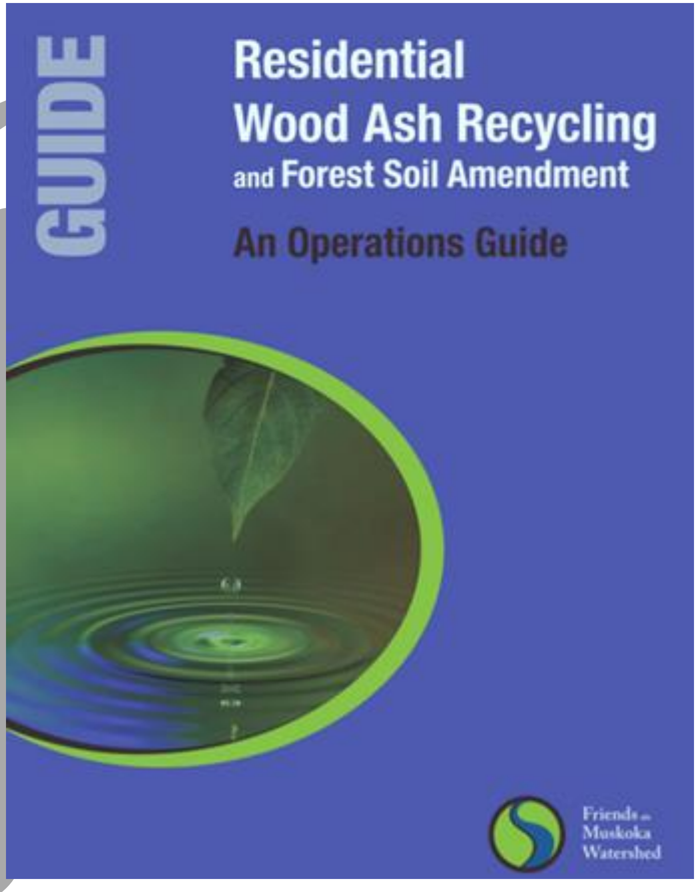
Sap Properties and Nutrient Chemistry

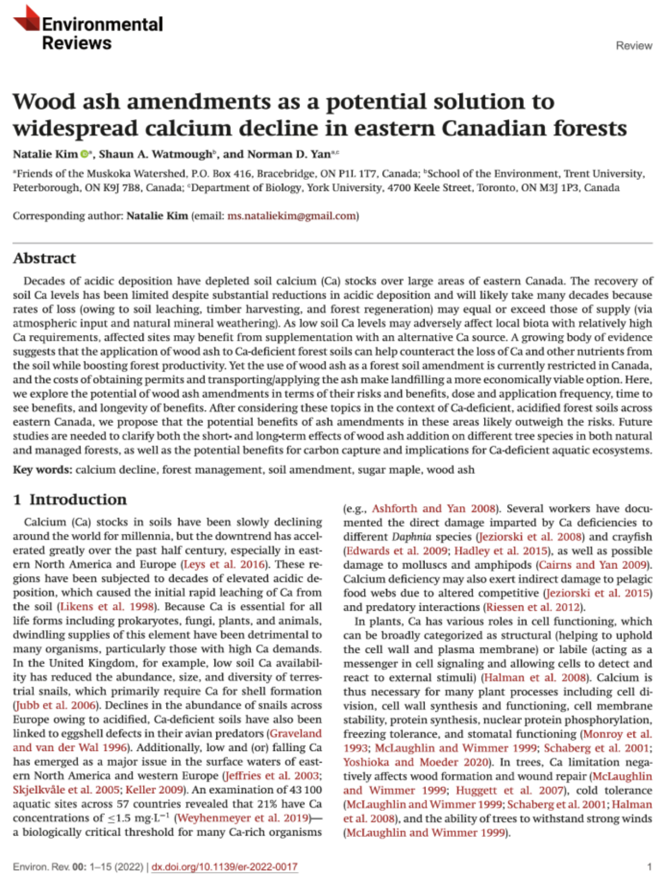
	2021 Sap		2022 Sap		Range of Concentrations in Sugar Maple Syrup†
	Control (n = 12)	Treatment (n = 12)	Control (n = 12)	Treatment (n = 12)	
Avg. Total Yield (L)	26.8 (4.6)[a]	53.8 (5.5)[b]**	52.0 (5.7)[b]	55.9 (5.5)[b]	
pH	6.40 (0.21)[a]	6.41 (0.25)[a]	7.00 (0.04)[b]	7.04 (0.03)[b]	
°Brix	1.35 (0.07)[a]	1.44 (0.07)[a]	1.37 (0.06)[a]	1.39 (0.05)[a]	
	---------------mg·L^{-1}---------------				-----mg·L^{-1}-----
Ca	64.7 (4.5)[a]	78.8 (3.7)[c]***	52.2 (2.5)[b]	24.9 (1.4)[d]***	5.3 – 80.6
K	60.8 (4.3)[a]	63.0 (4.1)[a]	37.7 (1.4)[b]	63.4 (2.3)[a]***	10.8 – 80.6
Mg	6.0 (0.4)[a]	6.9 (0.3)[c]**	4.2 (0.2)[b]	4.0 (0.2)[b]	0 – 11.5
Mn	5.1 (0.4)[a]	6.0 (0.3)[c]**	4.0 (0.2)[b]	1.2 (0.1)[d]***	0 – 5.0
P	0.4 (0.1)[a]	0.5 (0.1)[a]	0.6 (0.0)[b]	1.6 (0.1)[c]***	0 – 4.7
Na	0.1 (0.0)[a]	0.2 (0.0)[a]	0.2 (0.1)[a]	0.1 (0.0)[a]	0 – 9.84

†Mohammed et al. (2022)

Now, we are exploring more community engagement, and asking if ash additions can restore tree growth to foster a nature-based solution to climate change

We summarize what we've learned so other communities can set up their own ash recycling programs





Environmental Reviews

Review

Wood ash amendments as a potential solution to widespread calcium decline in eastern Canadian forests

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Abstract

Decades of acidic deposition have depleted soil calcium (Ca) stocks over large areas of eastern Canada. The recovery of soil Ca levels has been limited despite substantial reductions in acidic deposition and will likely take many decades because rates of loss (owing to soil leaching, timber harvesting, and forest regeneration) may equal or exceed those of supply (via atmospheric input and natural mineral weathering). As low soil Ca levels may adversely affect local biota with relatively high Ca requirements, affected sites may benefit from supplementation with an alternative Ca source. A growing body of evidence suggests that the application of wood ash to Ca-deficient forest soils can help counteract the loss of Ca and other nutrients from the soil while boosting forest productivity. Yet the use of wood ash as a forest soil amendment is currently restricted in Canada, and the costs of obtaining permits and transporting/applying the ash make landfilling a more economically viable option. Here, we explore the potential of wood ash amendments in terms of their risks and benefits, dose and application frequency, time to see benefits, and longevity of benefits. After considering these topics in the context of Ca-deficient, acidified forest soils across eastern Canada, we propose that the potential benefits of ash amendments in these areas likely outweigh the risks. Future studies are needed to clarify both the short- and long-term effects of wood ash addition on different tree species in both natural and managed forests, as well as the potential benefits for carbon capture and implications for Ca-deficient aquatic ecosystems.

Key words: calcium decline, forest management, soil amendment, sugar maple, wood ash

1 Introduction

Calcium (Ca) stocks in soils have been slowly declining around the world for millennia, but the downtrend has accelerated greatly over the past half century, especially in eastern North America and Europe (Leys et al. 2016). These regions have been subjected to decades of elevated acidic deposition, which caused the initial rapid leaching of Ca from the soil (Likens et al. 1998). Because Ca is essential for all life forms including prokaryotes, fungi, plants, and animals, dwindling supplies of this element have been detrimental to many organisms, particularly those with high Ca demands. In the United Kingdom, for example, low soil Ca availability has reduced the abundance, size, and diversity of terrestrial snails, which primarily require Ca for shell formation (Jubb et al. 2006). Declines in the abundance of snails across Europe owing to acidified, Ca-deficient soils have also been linked to eggshell defects in their avian predators (Graveland and van der Wal 1996). Additionally, low and (or) falling Ca has emerged as a major issue in the surface waters of eastern North America and western Europe (Jeffries et al. 2003; Skjelkvåle et al. 2005; Keller 2009). An examination of 43 100 aquatic sites across 57 countries revealed that 21% have Ca concentrations of ≤ 1.5 mg·L^{-1} (Weyhenmeyer et al. 2019)—a biologically critical threshold for many Ca-rich organisms (e.g., Ashforth and Yan 2008). Several workers have documented the direct damage imparted by Ca deficiencies to different *Daphnia* species (Jeziorski et al. 2008) and crayfish (Edwards et al. 2009; Hadley et al. 2015), as well as possible damage to molluscs and amphipods (Cairns and Yan 2009). Calcium deficiency may also exert indirect damage to pelagic food webs due to altered competitive (Jeziorski et al. 2015) and predatory interactions (Riessen et al. 2012).

In plants, Ca has various roles in cell functioning, which can be broadly categorized as structural (helping to uphold the cell wall and plasma membrane) or labile (acting as a messenger in cell signaling and allowing cells to detect and react to external stimuli) (Halman et al. 2008). Calcium is thus necessary for many plant processes including cell division, cell wall synthesis and functioning, cell membrane stability, protein synthesis, nuclear protein phosphorylation, freezing tolerance, and stomatal functioning (Monroy et al. 1993; McLaughlin and Wimmer 1999; Schaberg et al. 2001; Yoshioka and Moeder 2020). In trees, Ca limitation negatively affects wood formation and wound repair (McLaughlin and Wimmer 1999; Huggett et al. 2007), cold tolerance (McLaughlin and Wimmer 1999; Schaberg et al. 2001; Halman et al. 2008), and the ability of trees to withstand strong winds (McLaughlin and Wimmer 1999).

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