20-year results of liming northern hardwoods to ameliorate acidification

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Response of northern hardwoods to experimental soil acidification and alkalinisation after 20 years

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Decreasing sugar maple, increasing American beech

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Sugar maple regeneration: a rare situation

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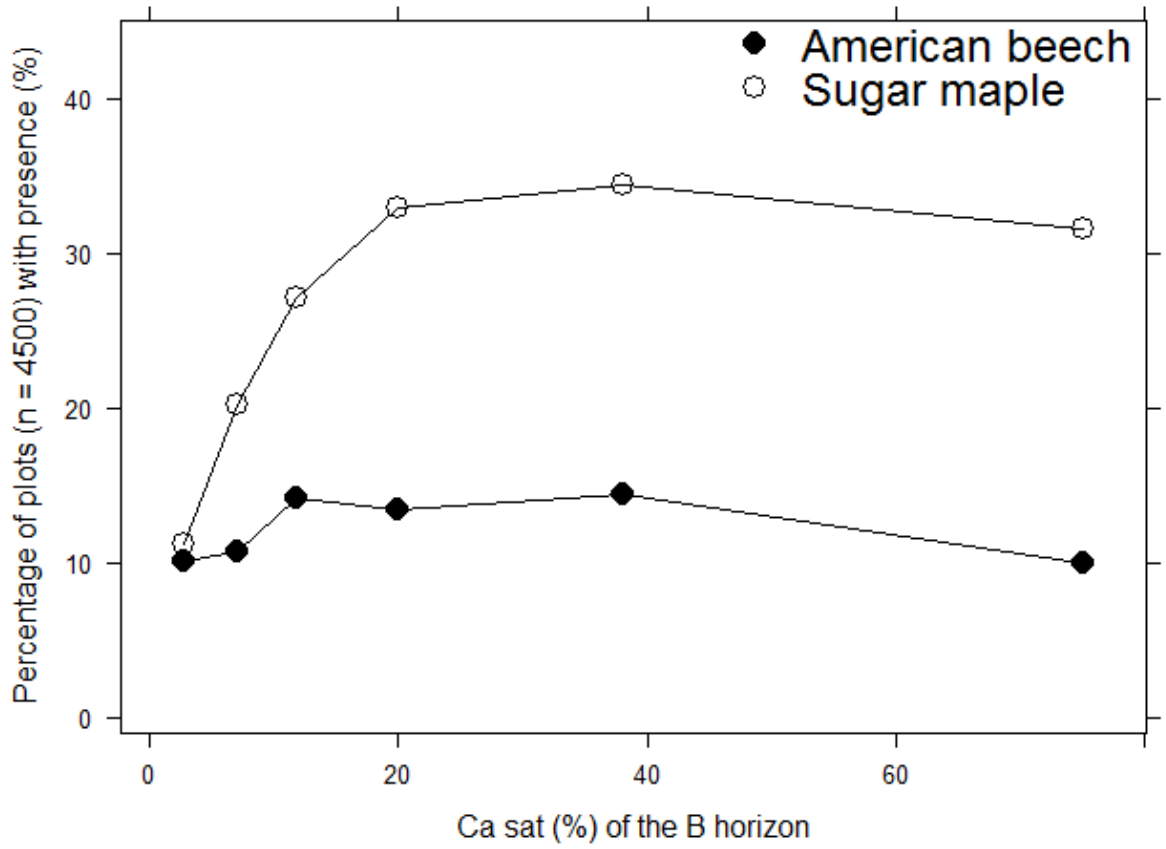
Importance of soil exch. Ca



Data: QC Forest permanent plots

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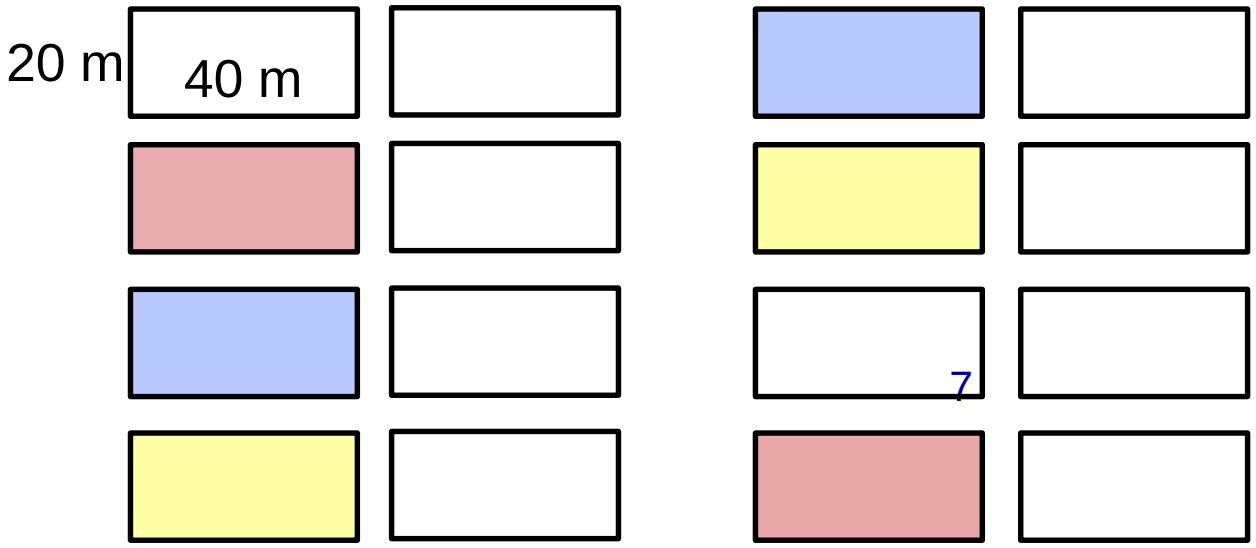
1990 Alkalinization – acidification experiment

Table 2: Fertilizer treatments applied at the two sites in spring 1990.

Treatment No.	Fertilizer	Rate [kg ha^{-1}]	N	K_2O	CaO	Mg	S	ANC[b] [kmol ha^{-1}]
1	elemental S[a]	285					256	–16
2	elemental S[a]	142.5					128	–8
3	$(NH_4)_2SO_4$	370	78				88	–8
4	control							0
5	$MgSO_4$	625			14	66	88	0
6a	K_2SO_4 [c]	500		250	3.5	6	88	0
6b	6a + $(CaMg)CO_3$ [d]	886		250	89.5	59	88	8
7	$CaCO_3$	400			160			8
8	$CaCO_3$	800			320			16



~20 years 1990's depositions

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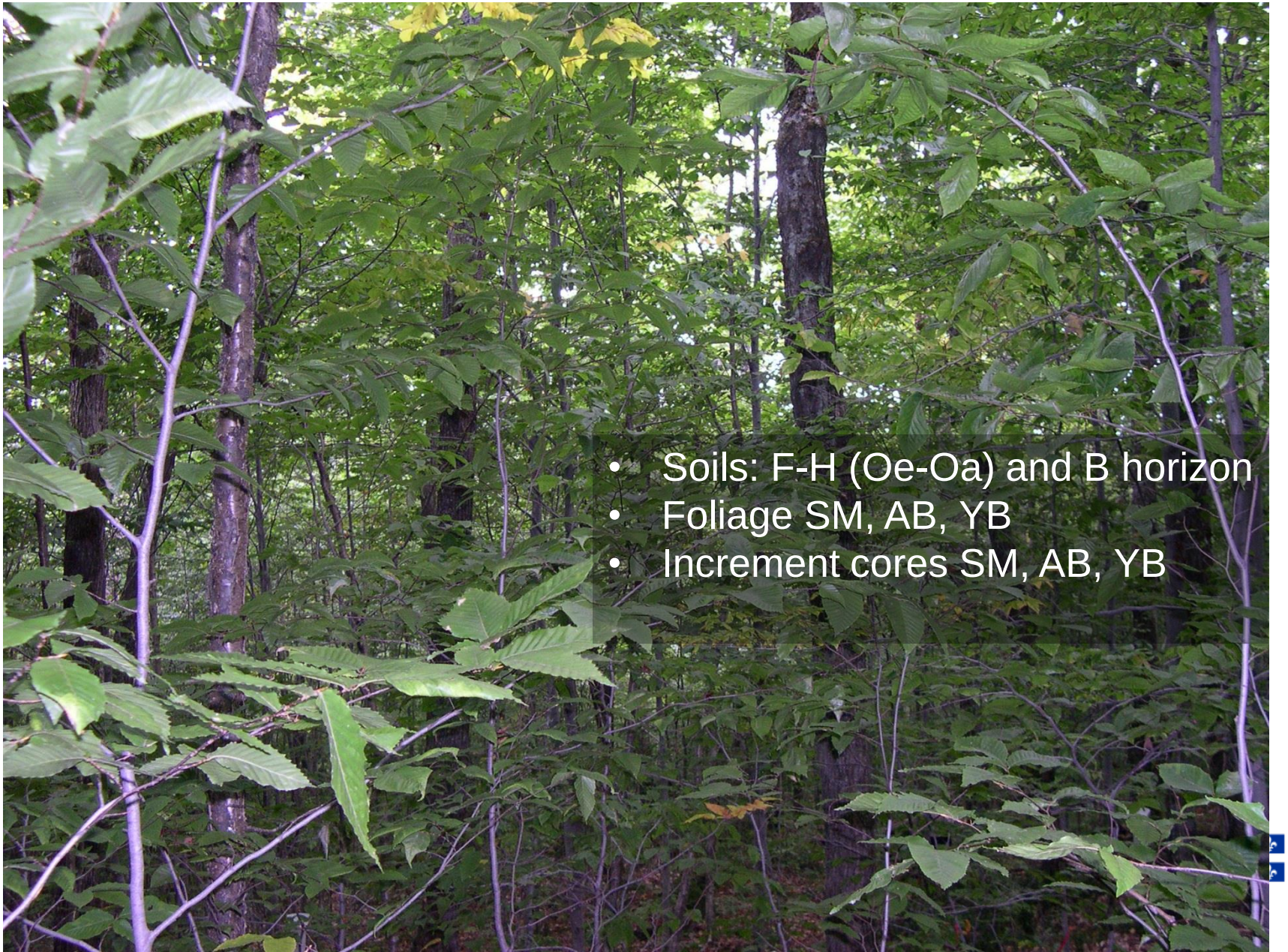
Resampling 20 years later



Results : soils

Table 2
Indicators of soil acidity measured in the forest floor and mineral B horizon 20 years after treatment (acid neutralizing capacity [ANC]; acidified: −16 kmol(+) ha^{-1}, control: 0, limed: +16 kmol(+) ha^{-1}). Data shown are adjusted means, with associated standard errors in parentheses.

Treatment	pH_{CaCl2}	Saturation (% of cation exchange capacity)					Ca/Al	C/N
		K	Mg	Ca	Al	Base saturation	(M/M)	
Forest floor								
Acidified	3.06 (0.07)	8.0 (0.5)	10.7 (0.8)	49.1 (3.3)	21.0 (3.9)	68.2 (4.0)	3.6 (1.2)	21.9 (0.7)
Control	3.13 (0.07)	8.9 (0.5)	11.6 (0.8)	54.5 (3.3)	23.4 (4.1)	75.4 (4.0)	3.3 (1.3)	21.9 (0.7)
Limed	3.16 (0.07)	6.5 (0.5)	8.7 (0.8)	51.4 (3.4)	15.3 (3.9)	67.5 (4.1)	5.6 (1.2)	22.0 (0.7)
Mineral B horizon								
Acidified	3.51 (0.09)	1.7 (0.2)	1.5 (0.1)	3.3 (1.3)	91.6 (0.8)	6.9 (1.2)	0.02 (0.01)	23.1 (0.9)
Control	3.72 (0.09)	1.7 (0.2)	1.4 (0.1)	3.8 (1.3)	91.6 (0.8)	7.3 (1.2)	0.03 (0.01)	24.3 (0.9)
Limed	3.72 (0.09)	1.8 (0.2)	1.5 (0.1)	4.1 (1.3)	91.3 (0.8)	7.8 (1.2)	0.03 (0.01)	24.7 (0.9)
ANC × horizon ($p > F$)	0.349	**0.019**	0.069	0.533	0.334	0.304	0.915	0.512

The p values ≤0.05 are indicated in bold.

Results: foliage

Table 3
Foliar elemental concentrations of northern hardwoods 20 years after soil treatment (acid neutralizing capacity [ANC]; acidified: −16 kmol(+) ha^{-1}, control: 0, limed: +16 kmol (+) ha^{-1}) from the analysis of individual elements. Data shown are adjusted means, with associated standard errors in parentheses.

Tree species[a]	Treatment	N	P	K	Ca	Mg
				(g kg^{-1})		
SM	Acidified	17.59 (0.93)	1.76 (0.13)	5.85 (0.53)	3.71[c] (0.36)	0.87 (0.09)
	Control	18.48 (0.90)	1.68 (0.13)	6.62 (0.53)	4.57 (0.33)	1.08 (0.08)
	Limed	17.52 (0.90)	1.48 (0.13)	5.72 (0.53)	5.47[c] (0.33)	1.01 (0.14)
ANC_L[b] ($p > F$)		0.998	0.247	0.982	**0.001**	0.662
YB	Acidified	25.65[c] (0.98)	2.11 (0.09)	9.40 (0.90)	7.08 (0.53)	2.29 (0.11)
	Control	22.68 (0.98)	1.87 (0.10)	7.58 (0.90)	7.92 (0.53)	2.15 (0.10)
	Limed	22.47 (0.95)	2.10 (0.09)	7.05 (0.90)	9.61[c] (0.58)	2.38 (0.22)
ANC_L ($p > F$)		**0.051**	0.996	0.156	**0.004**	0.927
AB	Acidified	18.90 (1.22)	1.32[c] (0.08)	6.33 (0.47)	4.28 (0.27)	1.16 (0.08)
	Control	20.74 (1.29)	1.67 (0.08)	6.37 (0.47)	4.66 (0.30)	1.21 (0.08)
	Limed	22.49 (1.29)	1.49 (0.08)	5.77 (0.47)	5.47[c] (0.27)	1.18 (0.13)
ANC_L ($p > F$)		0.108	0.254	0.670	**0.006**	0.989

The p values ≤ 0.05 are indicated in bold.
[a] SM: sugar maple; YB: yellow birch; AB: American beech.
[b] L: linear effect.
[c] For a given species, the mean is different from that of the control treatment with a probability of ≤ 0.05.

Added Ca has been recirculating in the ecosystem

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Result: growth

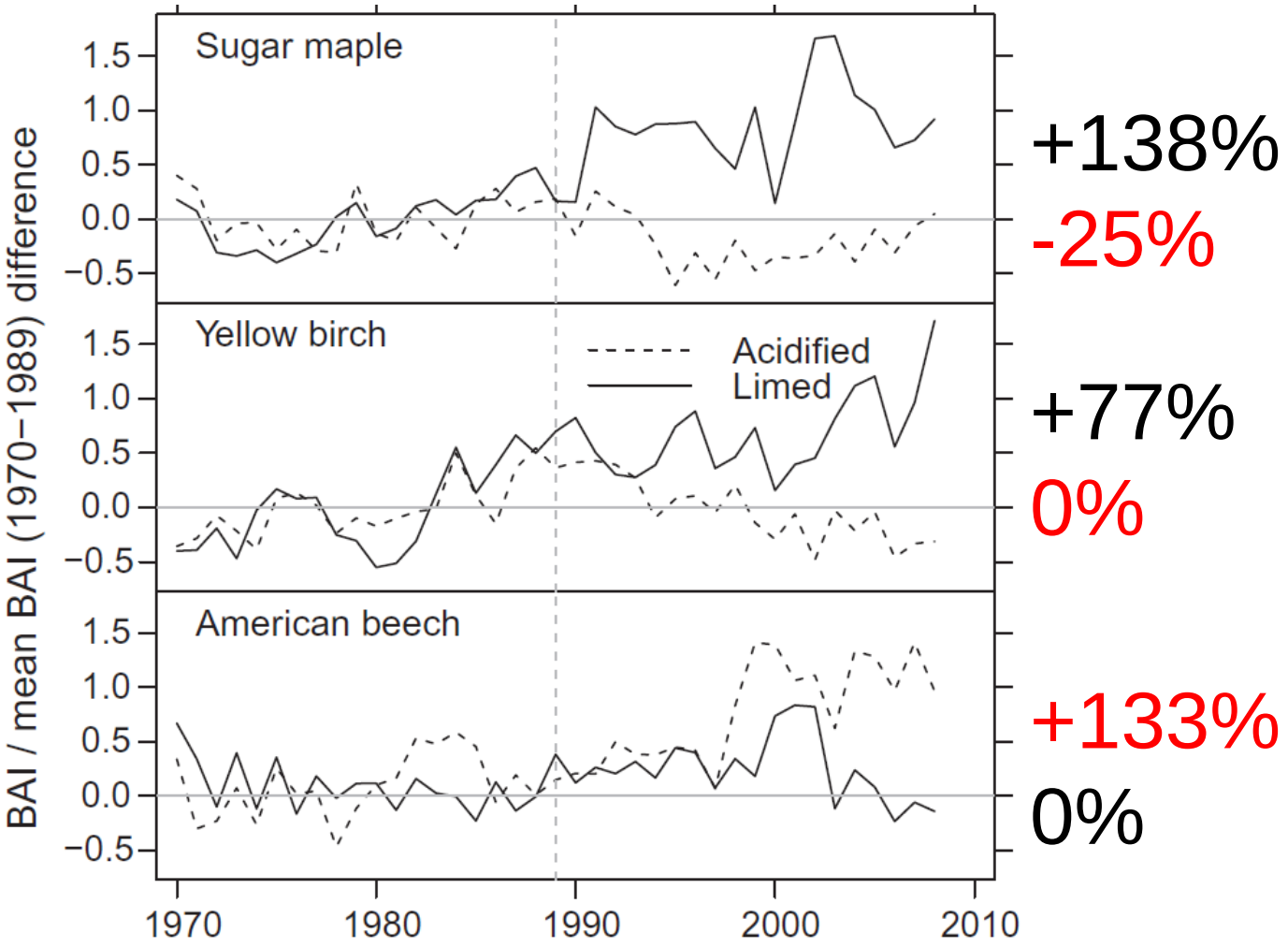

Fig. 2. Average differences in tree growth between the treated and control blocks for sugar maple, yellow birch and American beech. For each species, data is expressed as raw values of tree basal area increment (BAI) relative to the mean BAI for 1970–1989, before (1970–1989), and after (1990–2008) soil treatment in spring 1990. The dashed vertical line indicates the year prior to treatment application.

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Conclusions

- The effects of acidification/alkalinisation were no longer noticeable in the soil after 20 years according to the standard methods used;
- Foliar Ca concentrations were still influenced by the treatments applied 20 years before;
- Tree growth was also still influenced by the treatments
  - Sugar maple growth: increased by liming, decreased by acidification
  - Yellow birch growth: increased by liming, not affected by acidification
  - American beech growth: not affected by liming, increased by acidification
- Ca is still recirculating after 20 years
- Soil Ca status appears to influence stand dynamics in northern hardwood forests