

Des femmes, des hommes, des régions, nos ressources...



Sampling soil for detecting change after 20 years in a northern hardwood stand in Quebec

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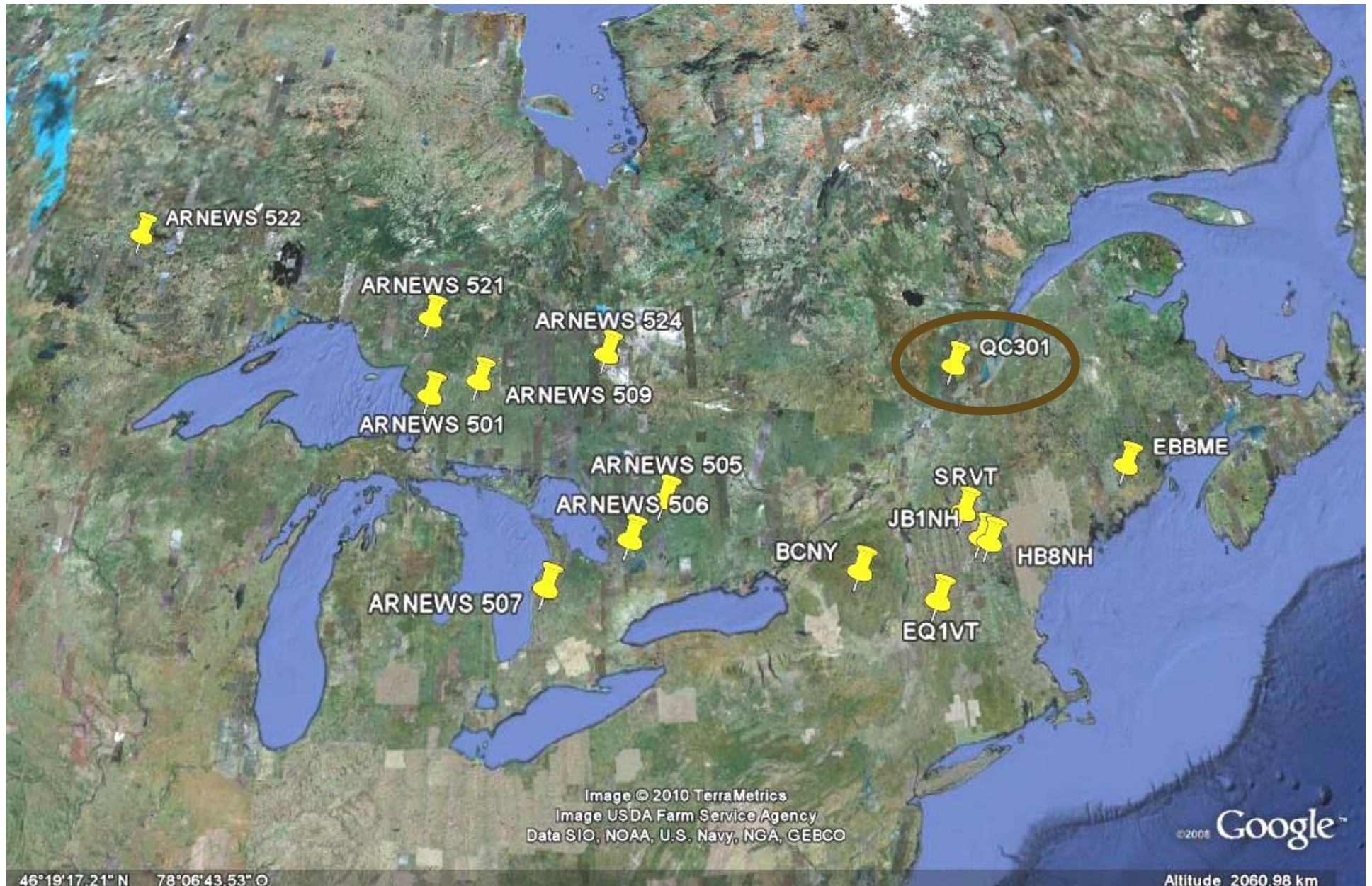
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Québec 

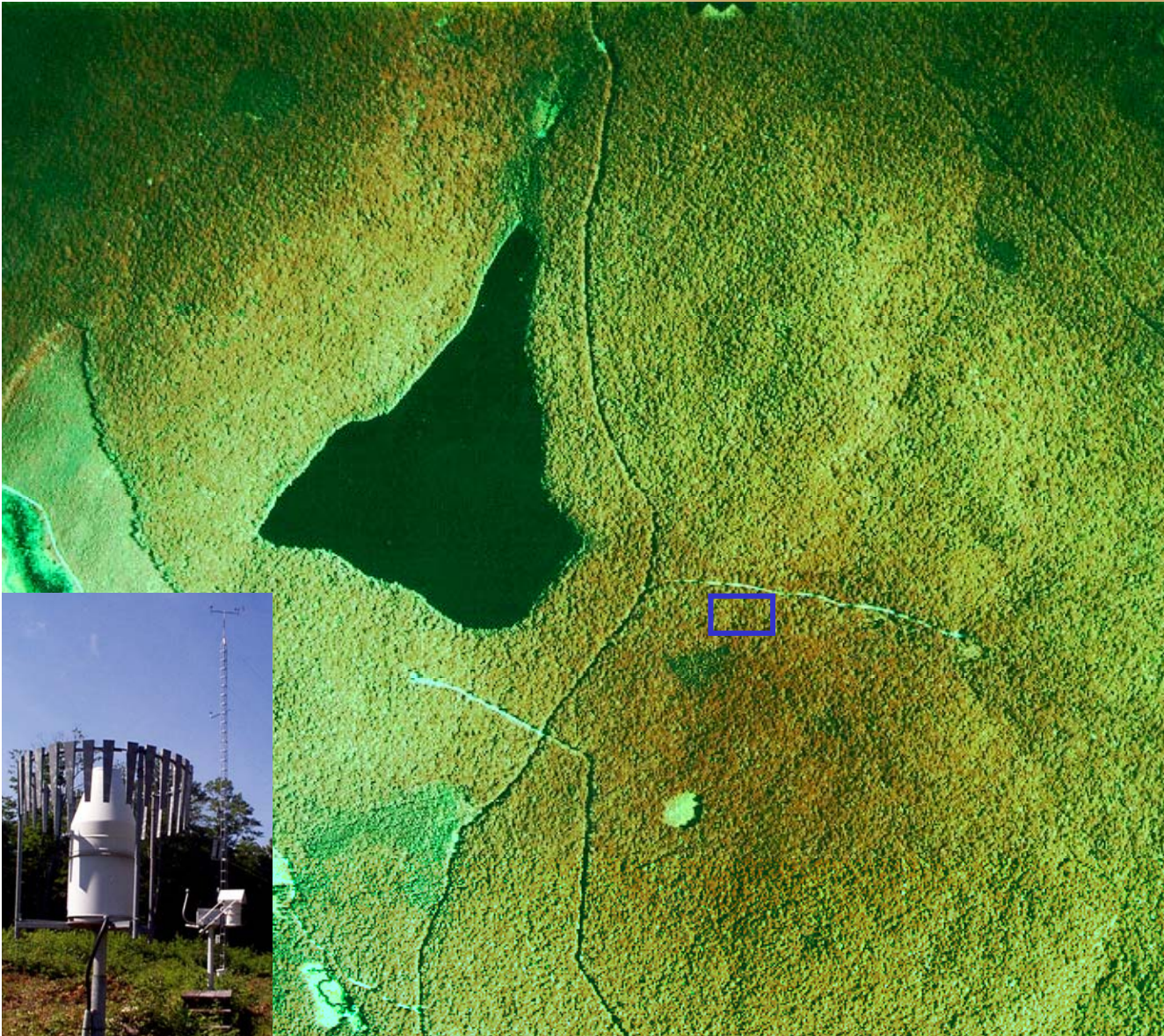
Soil resampling project

- Assessment of repeated soil sampling as a monitoring tool for investigating the effects of changes in soil chemistry
 - Retrospective soil study funded by NERC
 - ✓ 2-year project
 - ✓ 15 sites located in Ontario, the western Adirondacks of NY, VT, NH, eastern ME and eastern Quebec, 246 forest soil profiles
 - ✓ Previous sampling was done 12 to 24 years ago
 - ✓ Previous samples were available for reanalysis

Soil resampling project



The project in Quebec

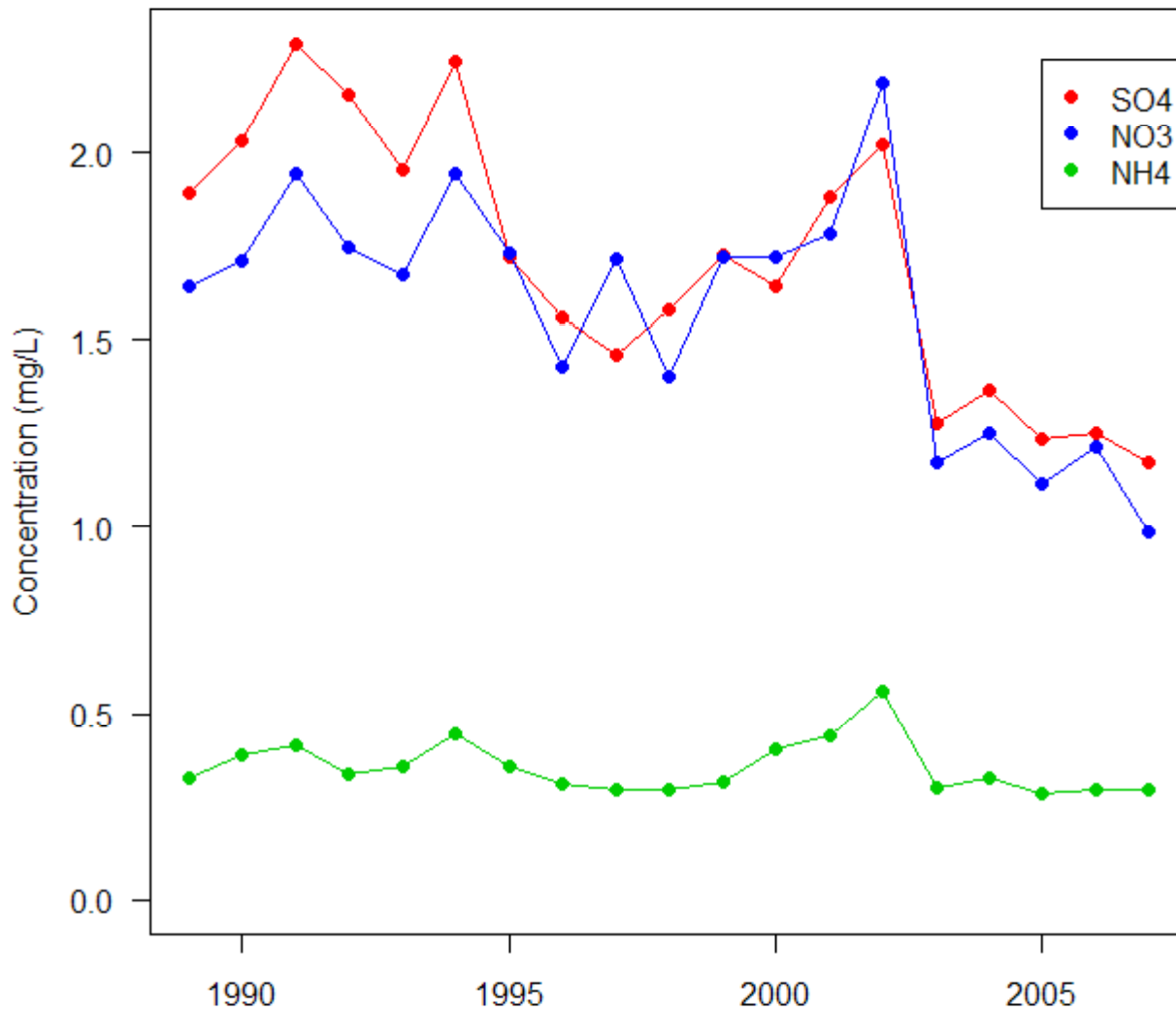


Lake Clair Watershed
Northern hardwoods
Latitude: 46° 57' 7"
Altitude: 285 m
MAT: 3.9 °C
MAP: 1480 mm
Growing season: 152 d

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The project in Quebec



Atmospheric depositions

SO4: -0.049 ppm/yr ***

NO3: -0.034 ppm/yr ***

NH4: n.s.

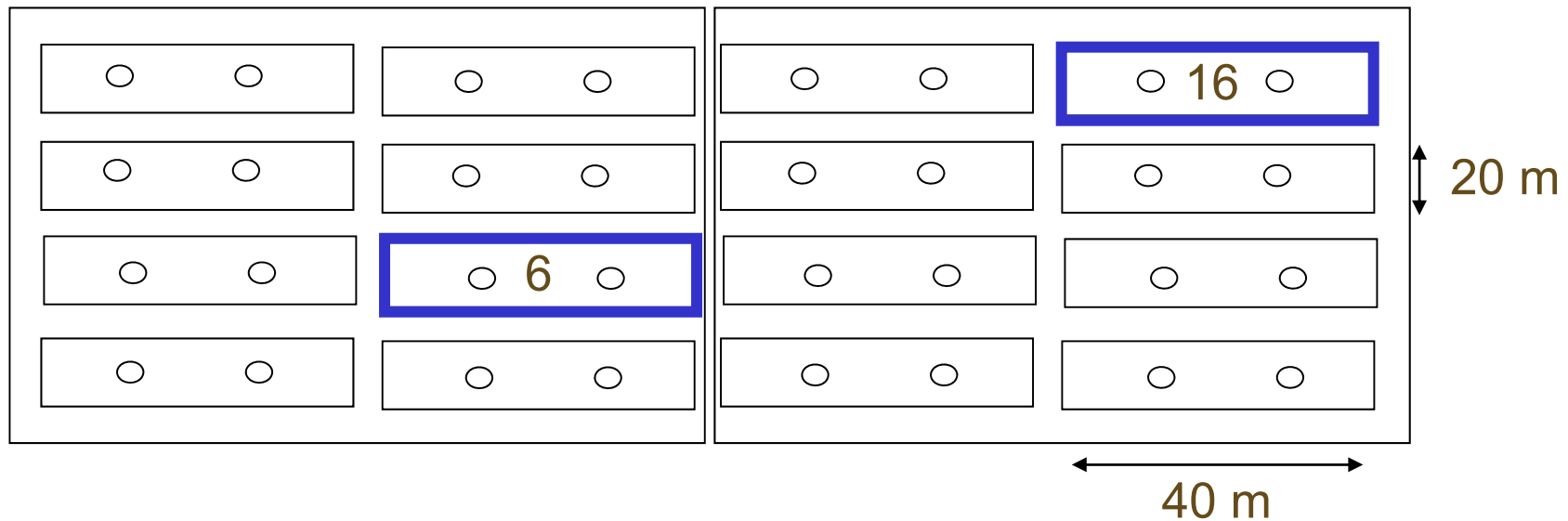
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The project in Quebec

- Fertilization - acidification experiment (1990 - 2000)
- 2 blocks, 8 treatments (1 control)



Ouimet, R., J. D. Moore, and L. Duchesne. 2008. Effects of experimental acidification and alkalization on soil and growth and health of *Acer saccharum* Marsh. *Journal of Plant Nutrition and Soil Science* 171:858-871.

In 1989

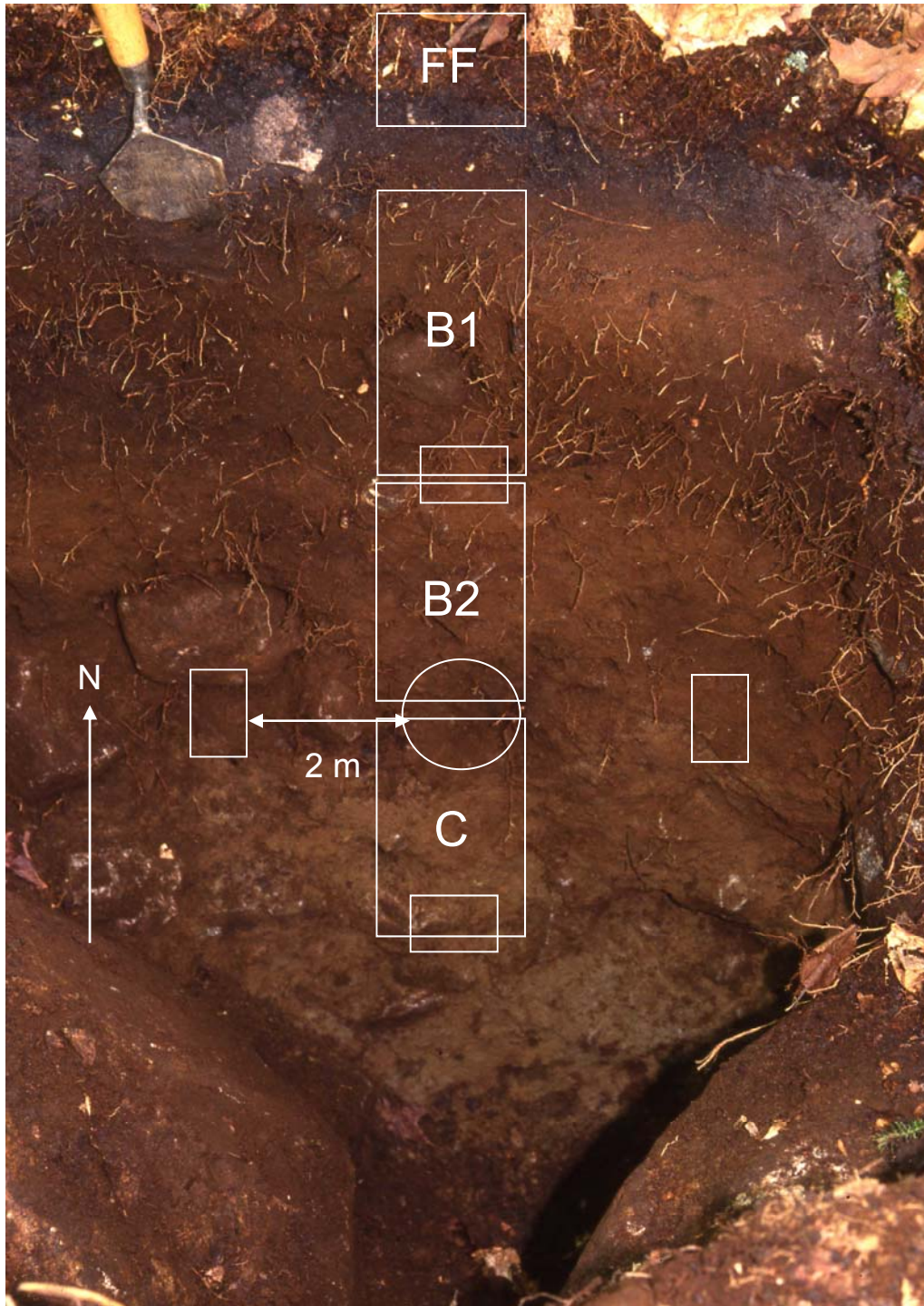




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1989:

- 06/26 - 07/13, 1989
- Forest floor: 2 rep / subplot
- Min. soil: 1 rep / subplot
- Depth of sampling recorded
- FF (LFH), B1, B2, C
- FF: 7.62 cm (3 in.) diam. vol. sampler

2009:

06/30 - 07/06, 2009

4 rep / subplot

Mini-pedons at 2 m from 1989 sampling

Same depth of sampling

LFH: 8.0 cm diam. vol. sampler



21-77 C-3143

Rock - RESEF
Pd. MINERAL 1991 Pl. 201
C-3143

21-74

C3154
C4028
C3030
C4169

21-77 C-2103

21-74 C-3137

C3137
Rock
OWNER

21-74 C-3139

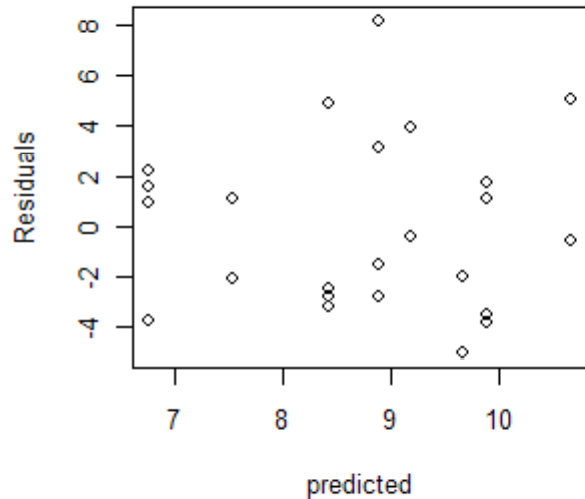
21-77 C-3104

Sample processing

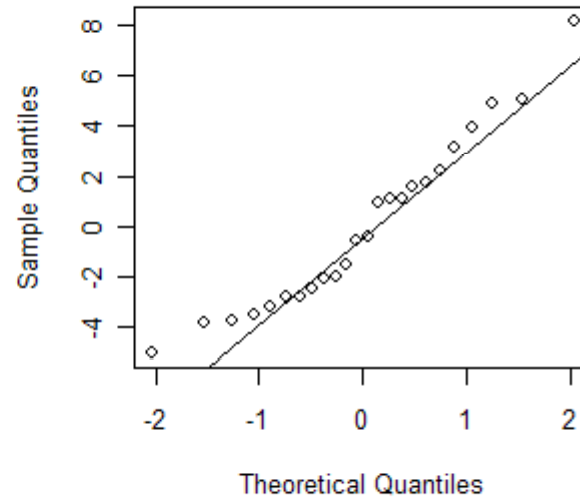
- Frozen for 2-4 months
- Air-dried for 6 - 10 days at 22 - 25 °C
- FF dried at 60 °C for 48 h, then passed through the Wiley mill (2 mm) (as in 1989)
- Mineral samples passed through 2 mm sieve
- pH (water, 1 : 2.5 soil : solution ratio)
- Exchangeable cations: NH_4Cl 1 N, 12 h
- C by dry combustion (LECO)
- N by Kjeldahl
- All results reported on a dry mass (105 °C) basis

Results: Forest floor stocks (kg m⁻²)

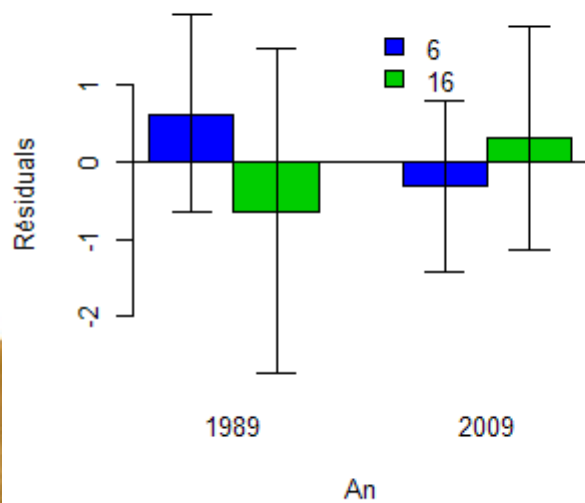
Residuals vs. predicted



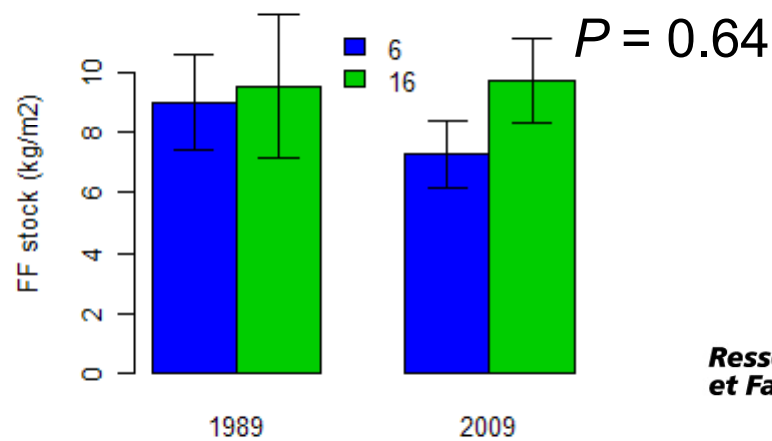
Normal Q-Q Plot



Residuals vs. year



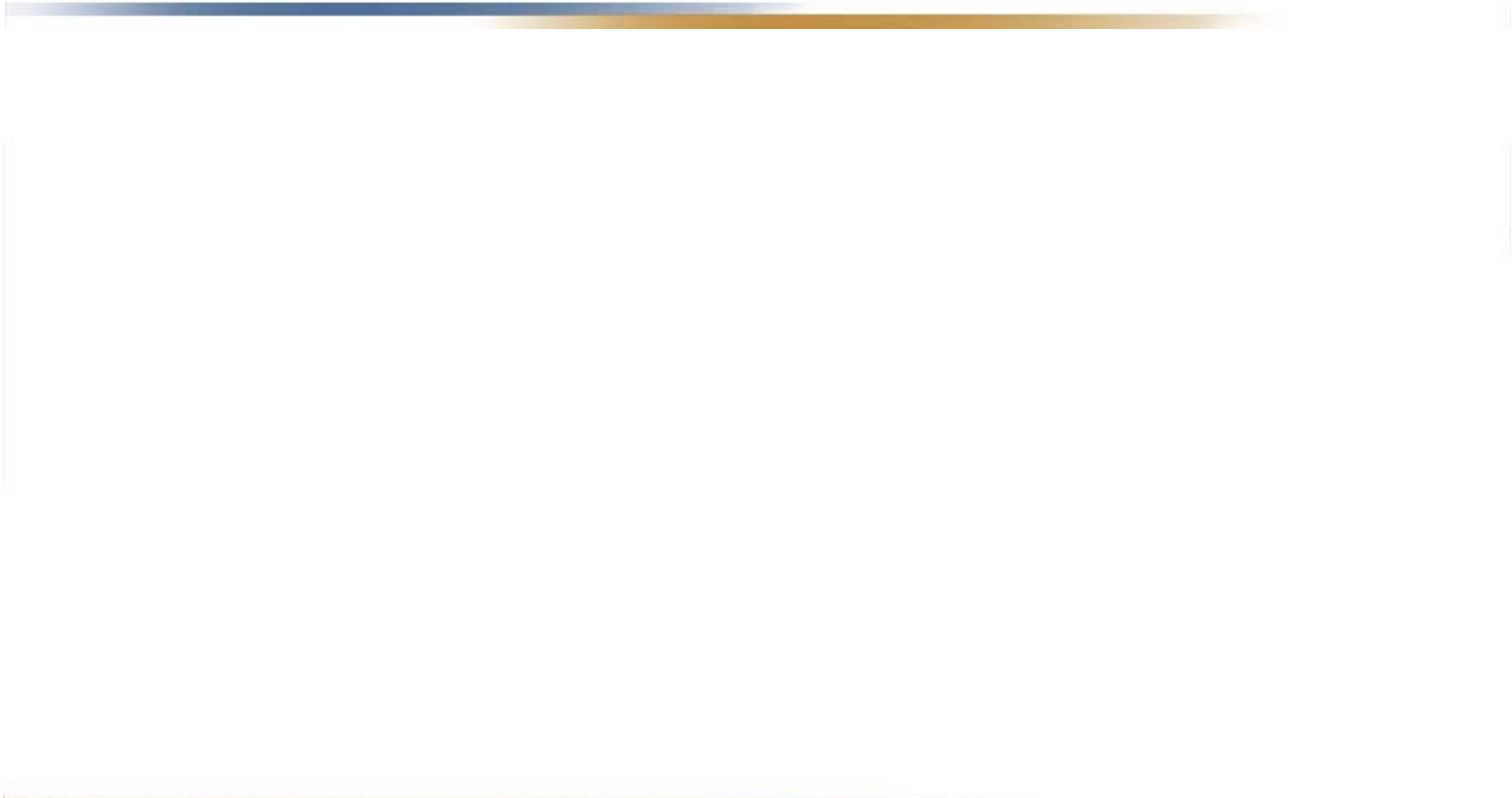
FF stocks vs. year



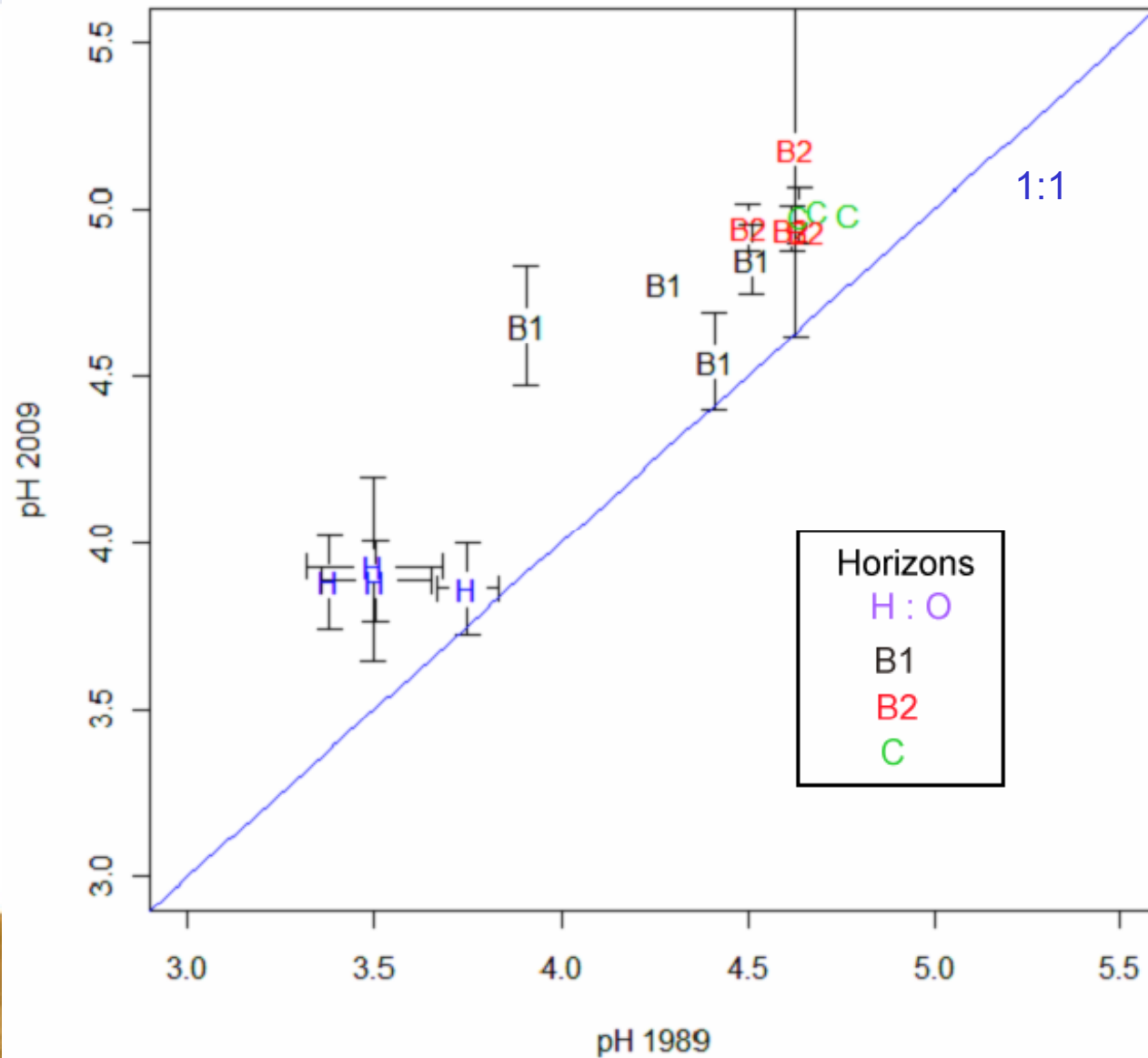
Results

1. 2009 samples vs. 1989 samples
 2. 2009 analyses vs. 1989 analyses (1989 samples)
- Model: $y_{ij} = \text{plot}_j + \text{year}_{ij} + E_{ij}$
 - $E_{ij} \sim N(0, \sigma_j^2)$, $j: 6, 16$

1989 soils vs. 2009 soils for the analyses made in 2009

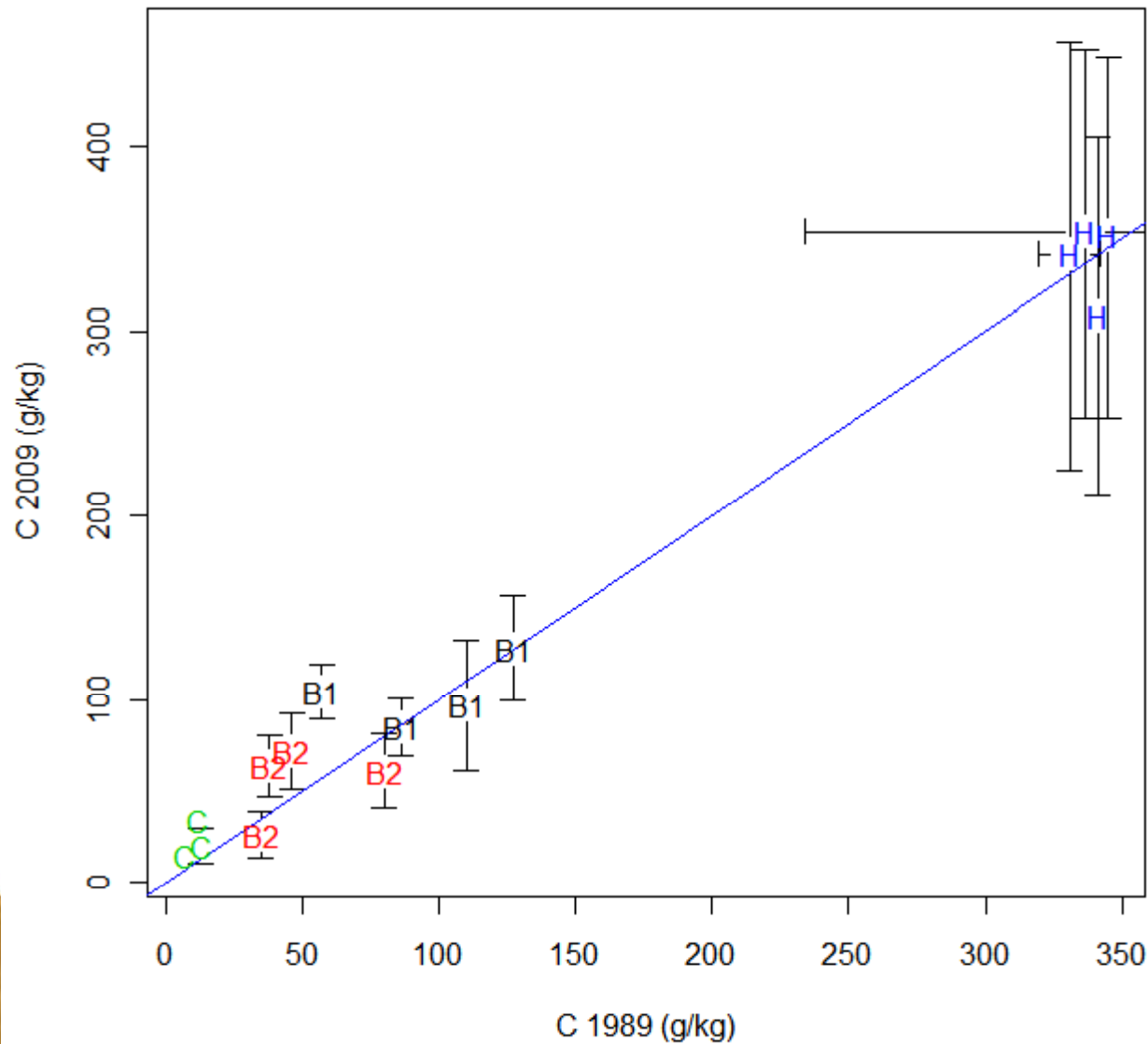


pH



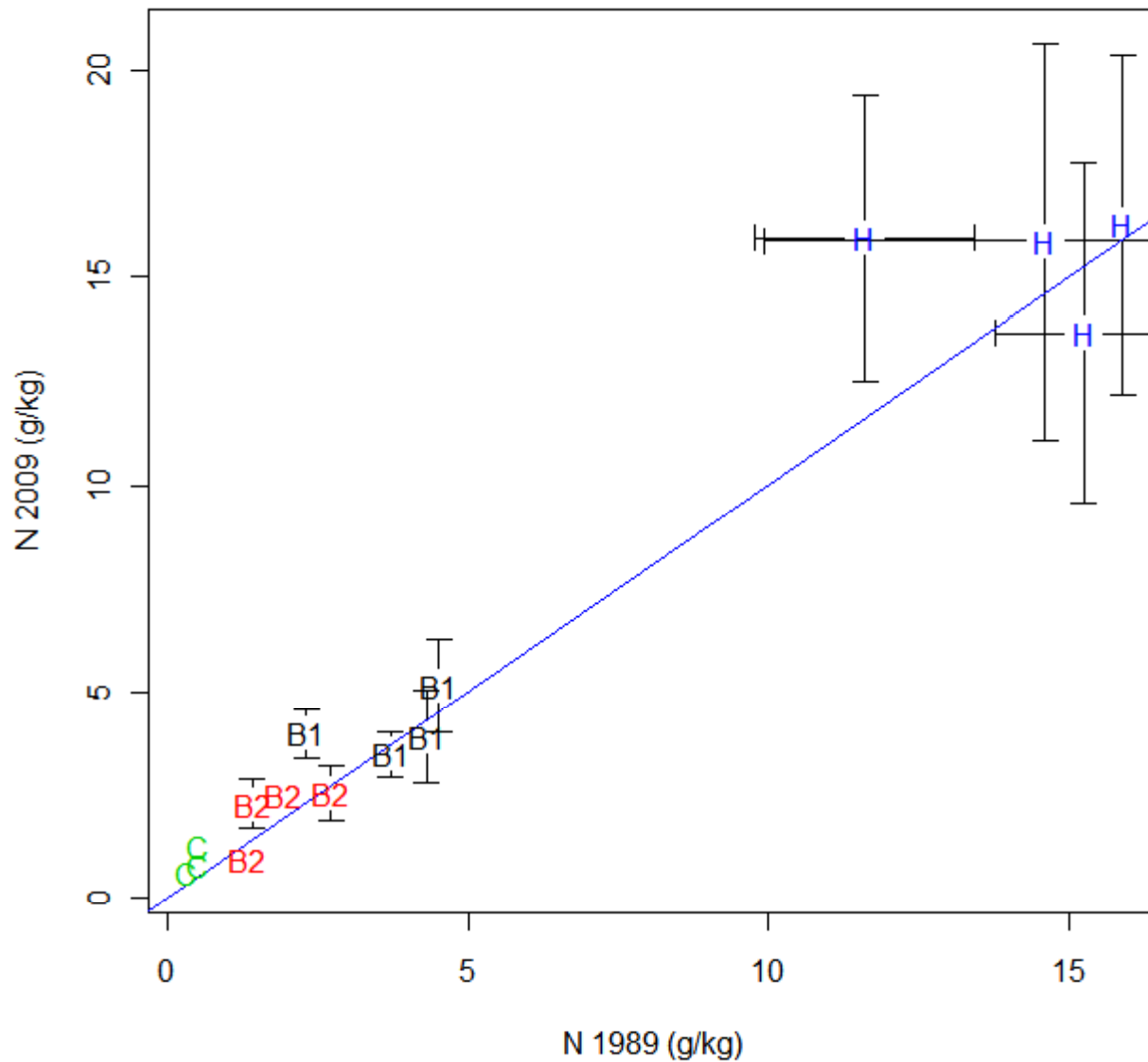
Main year effect***:
+0.35 pH units

Carbon conc.



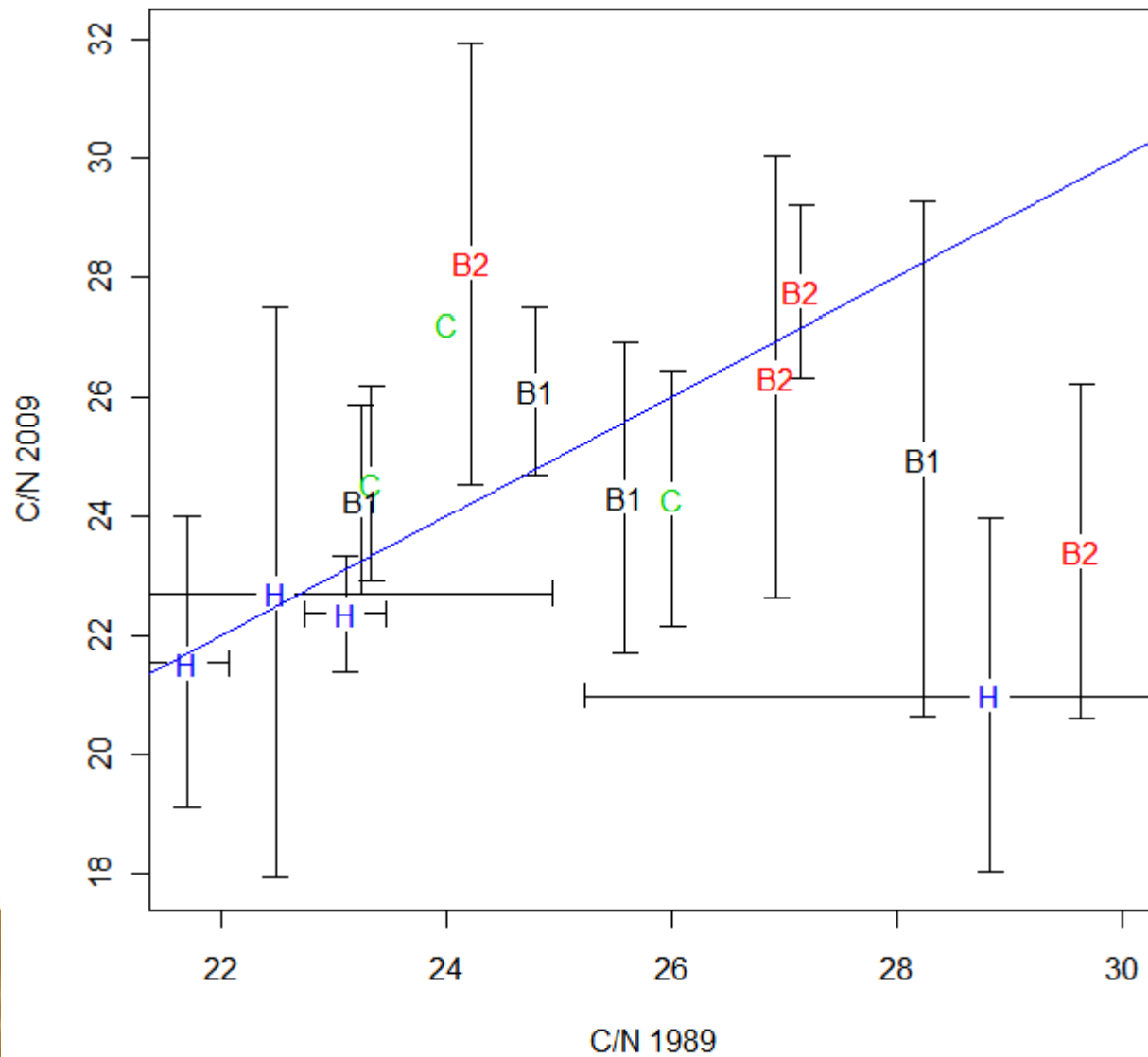
No year effect:
 $P = 0.99$

Nitrogen conc.



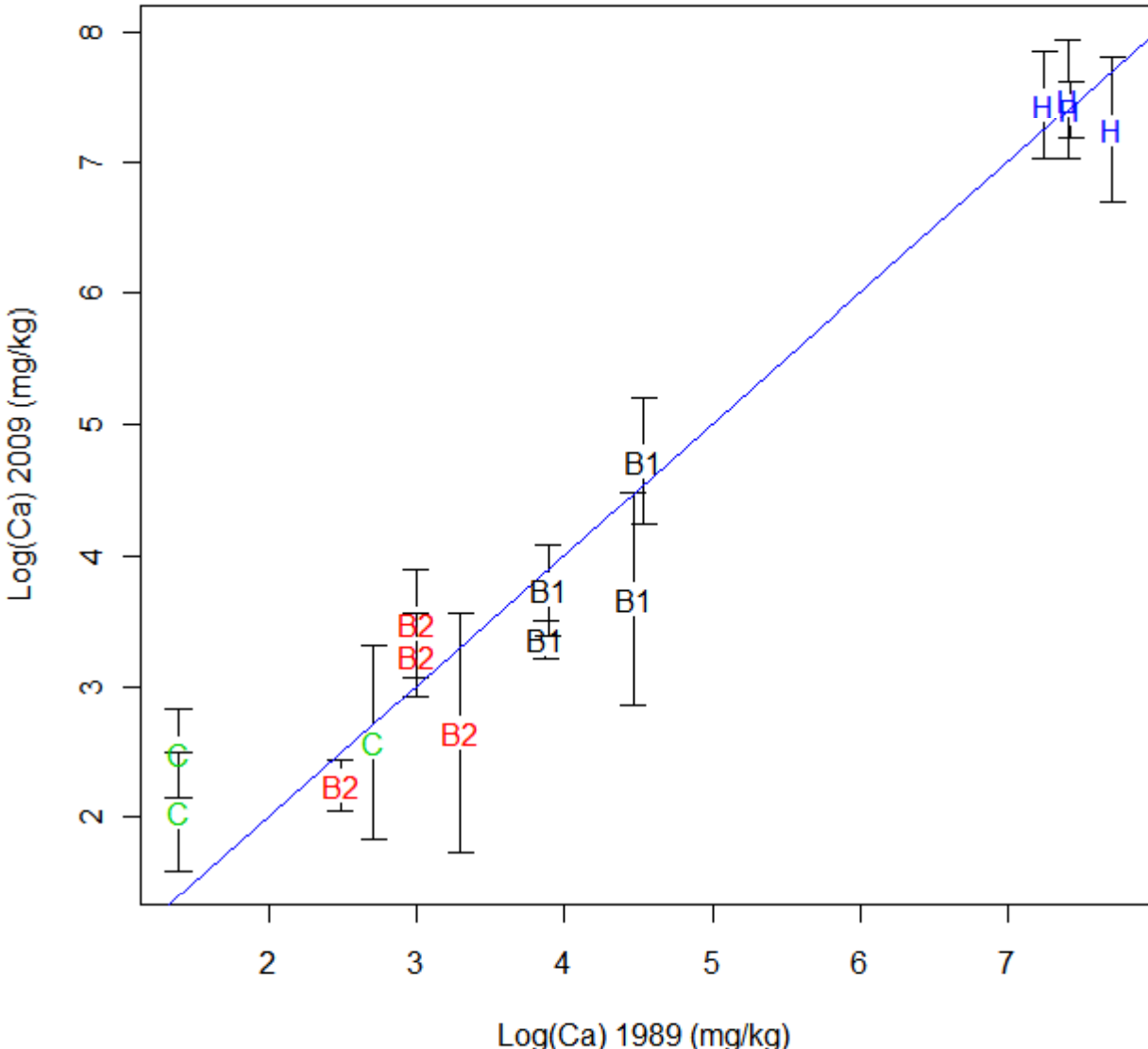
No year effect:
 $P = 0.65$

C/N ratio



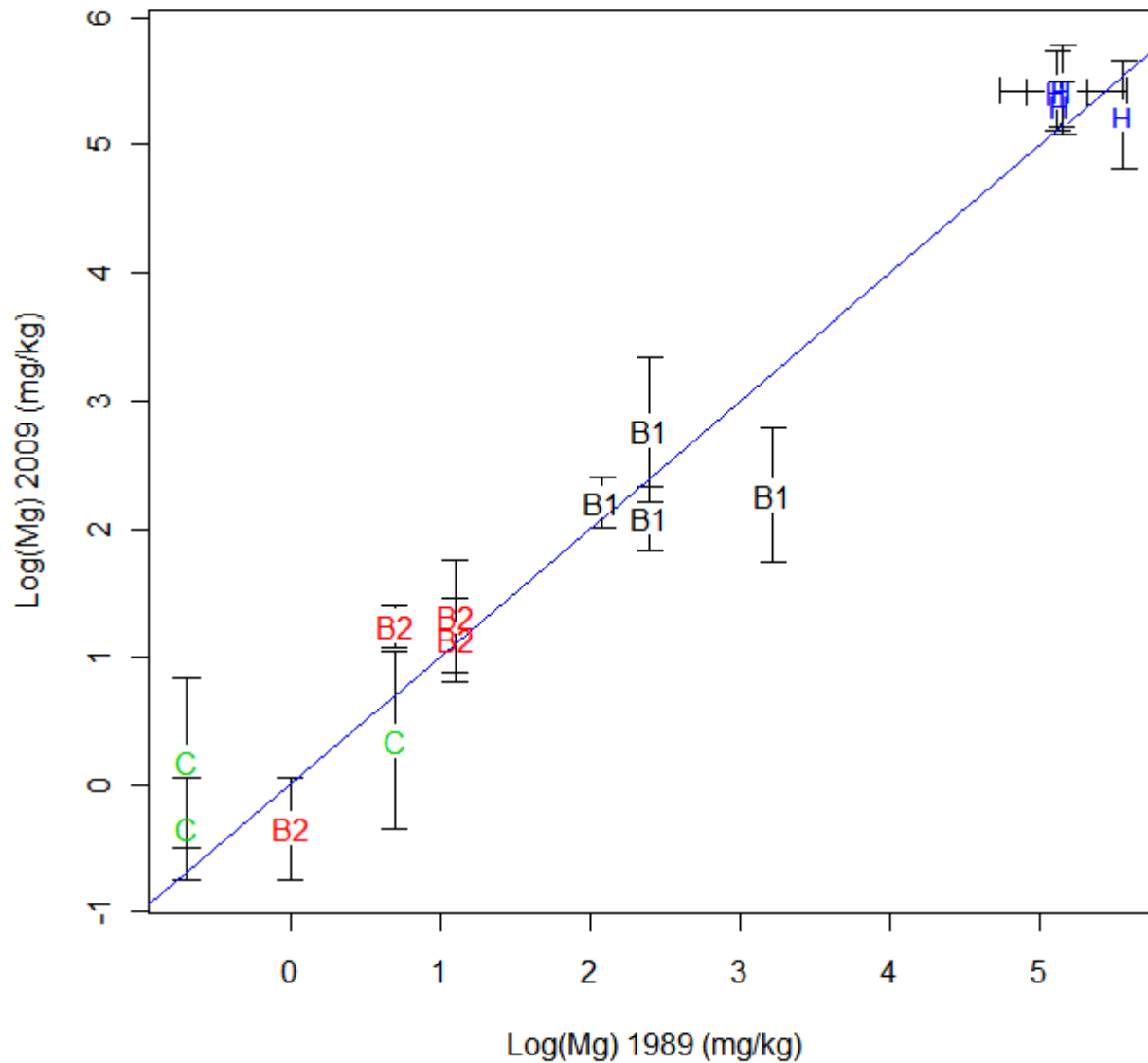
No year effect:
 $P = 0.087$

Exch. base cations: Ca



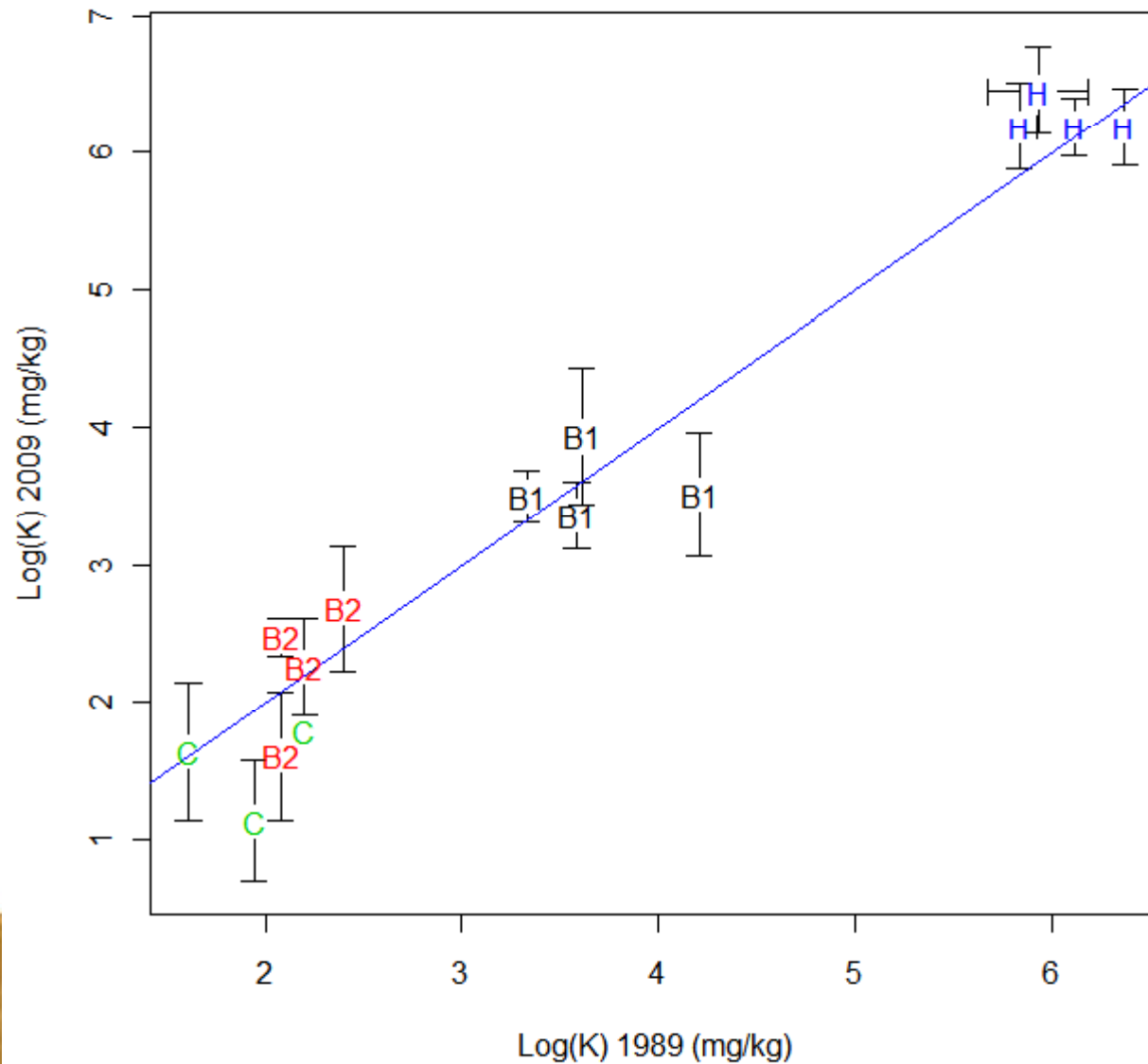
No year effect:
 $P = 0.81$

Exch. base cations: Mg



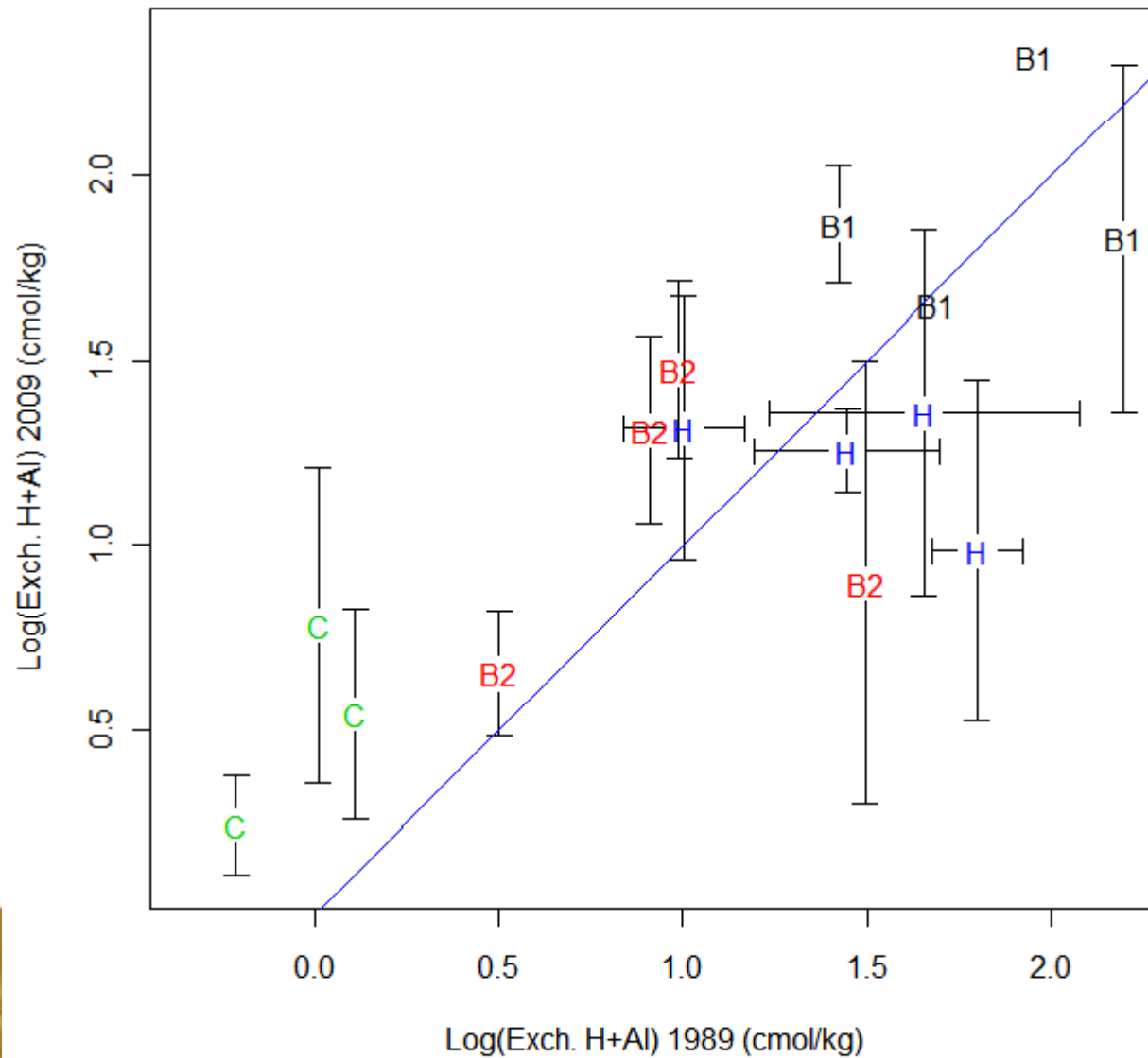
No year effect:
 $P = 0.72$

Exch. base cations: K



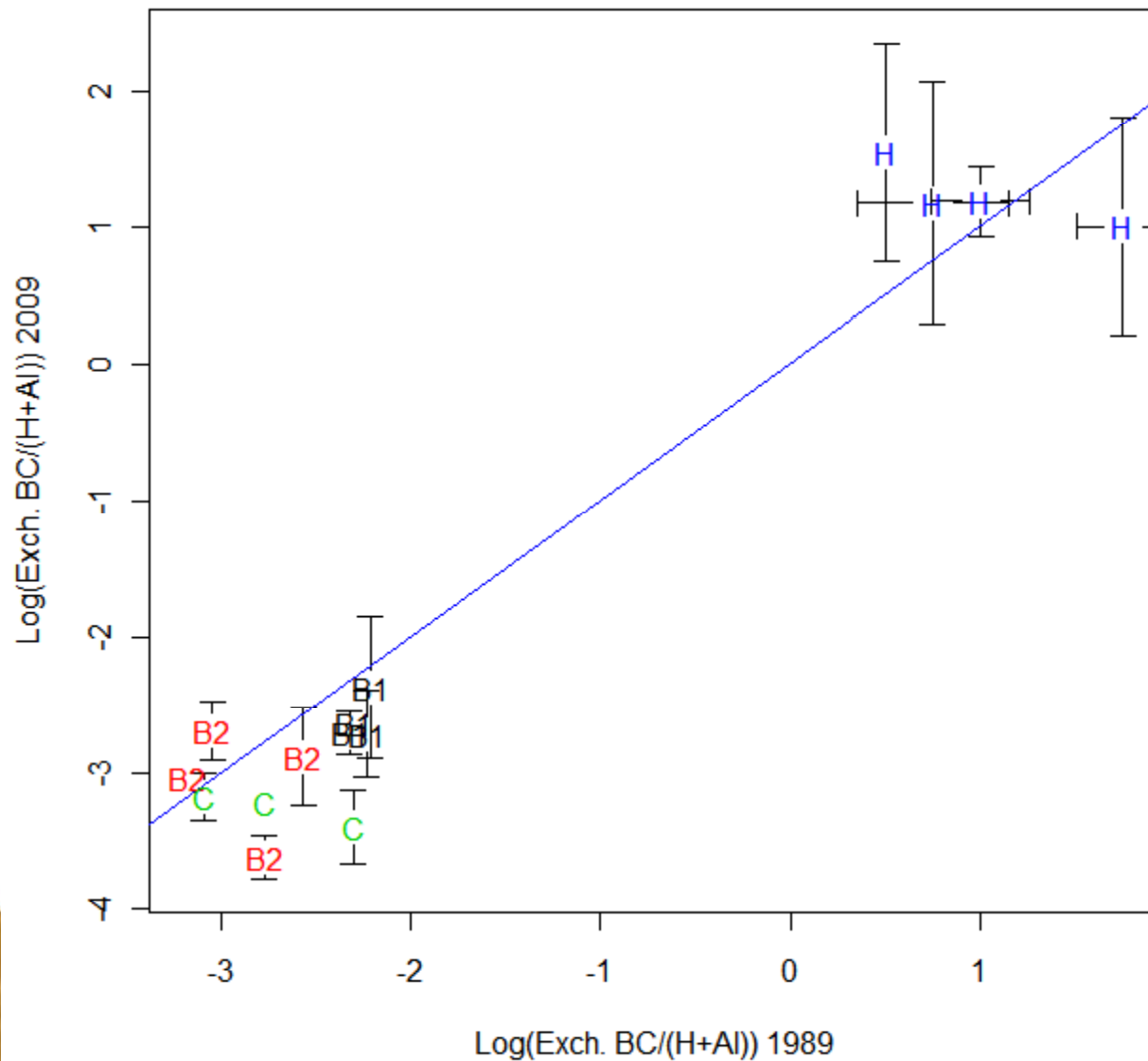
No year effect:
 $P = 0.89$

Exch. acid cations: H+Al



Interaction year
x horizon:
 $P = 0.04$

BC/(H+AI) ratio



Year effect: $P < 0.001$

Interaction year
x horizon:

$P = 0.10$

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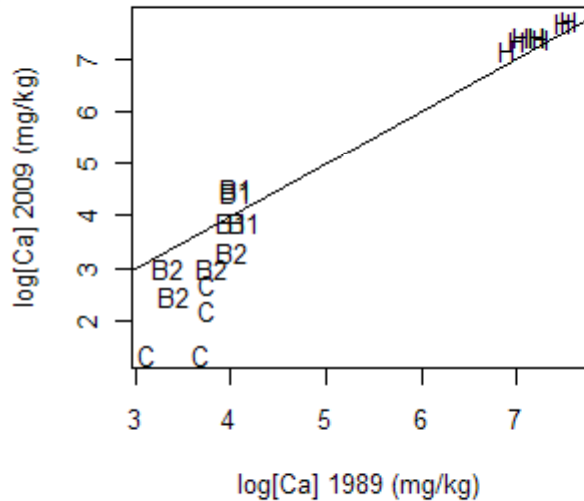


1989 analyses vs. 2009 analyses of the same samples

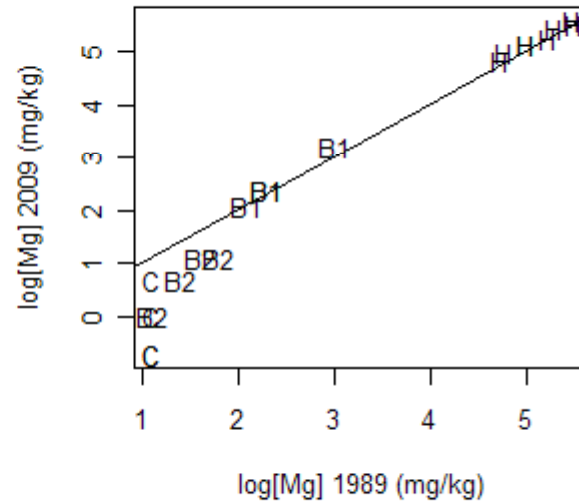
- Kjeldahl N
- Exch. Ca, Mg, K (NH_4Cl 1N, 12 h)

1989 analyses vs. 2009 analyses

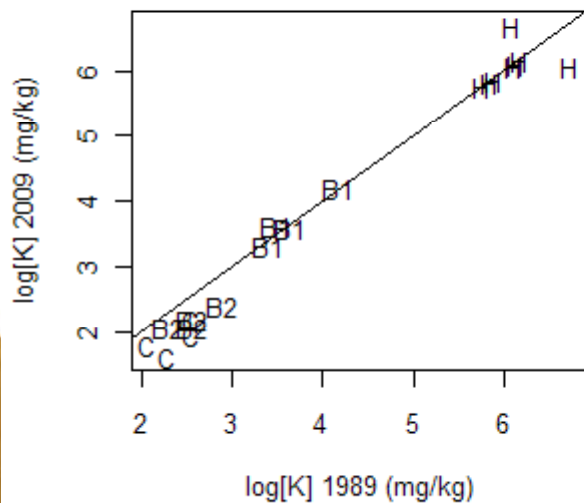
Exch. Ca conc. ***



Exch. Mg conc. ***



Exch. K conc. ***

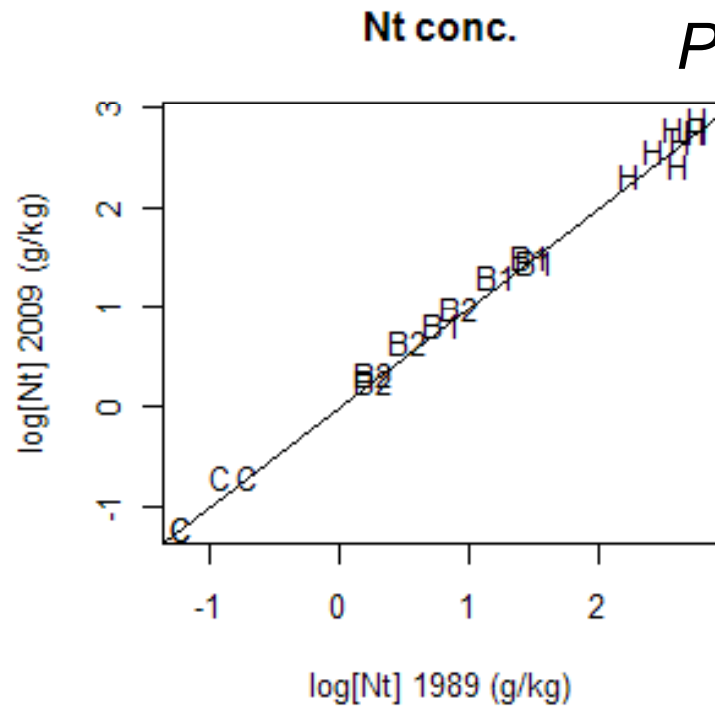


[Ca]	H	B1	B2	C
1989	1407	58.5	39.5	37.2
2009	1737	69.2	19.7	8.0
[Mg]				
1989	176	12.0	4.5	3
2009	195	13.7	2.2	1
[K]				
1989	464	41.5	13.5	11.0
2009	447	42.0	9.0	6.7

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1989 analyses vs. 2009 analyses

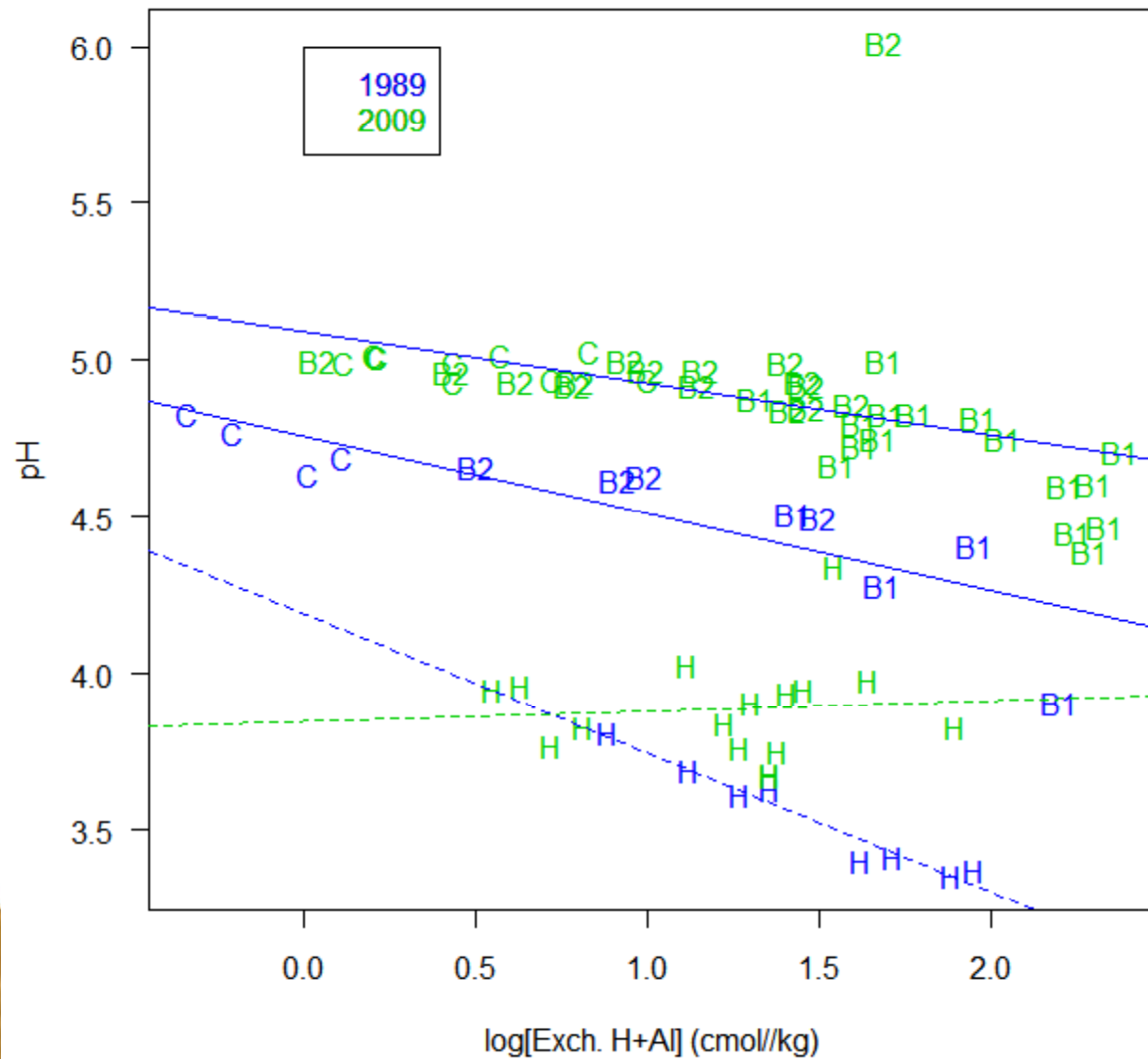


[Nt]	H	B1	B2	C
1989	13.6	3.57	1.70	0.37
2009	14.3	3.70	1.82	0.40

My interpretation

- Over 20 years in unevenaged northern hardwood stand:
 - In all soil horizons
 - ✓ No change in N, C, C/N
 - ✓ ↑ pH
 - In mineral soil horizons
 - ✓ No change in exch. base cations
 - ✓ ↓ BC/(H+Al) ratio
 - ✓ ↑ Exch. H+Al conc.

Exch. H+Al vs. pH (2009 analyses)



My interpretation

- Sample storage for 20 years may slightly underestimated changes for exch. base cations in deeper mineral soil horizons since results of the 1989 analyses > 2009 analyses
- The increase in soil exch. acidity in the mineral soil is consistent with the cumulative effect of atmospheric deposition of acidity
- The cause of change in the pH – Exch. H+Al relationship is counfounded by time and storage

What to look for recent soil change in undisturbed forest ecosystems?

- Adsorbed S
- Impact of forest type?
- Other gradients (Pb, Hg)?