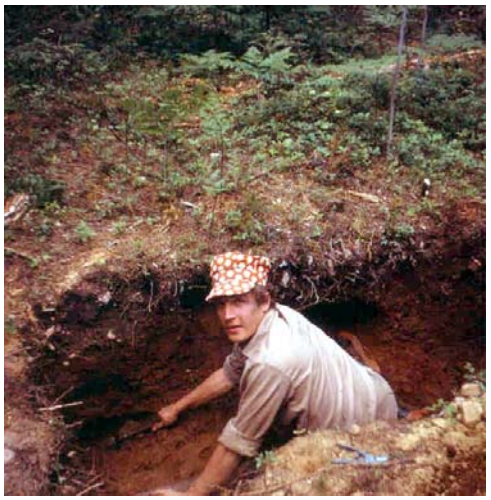
Some experiences resampling and reanalyzing soils from old plots at the Turkey Lake Watershed

Outline



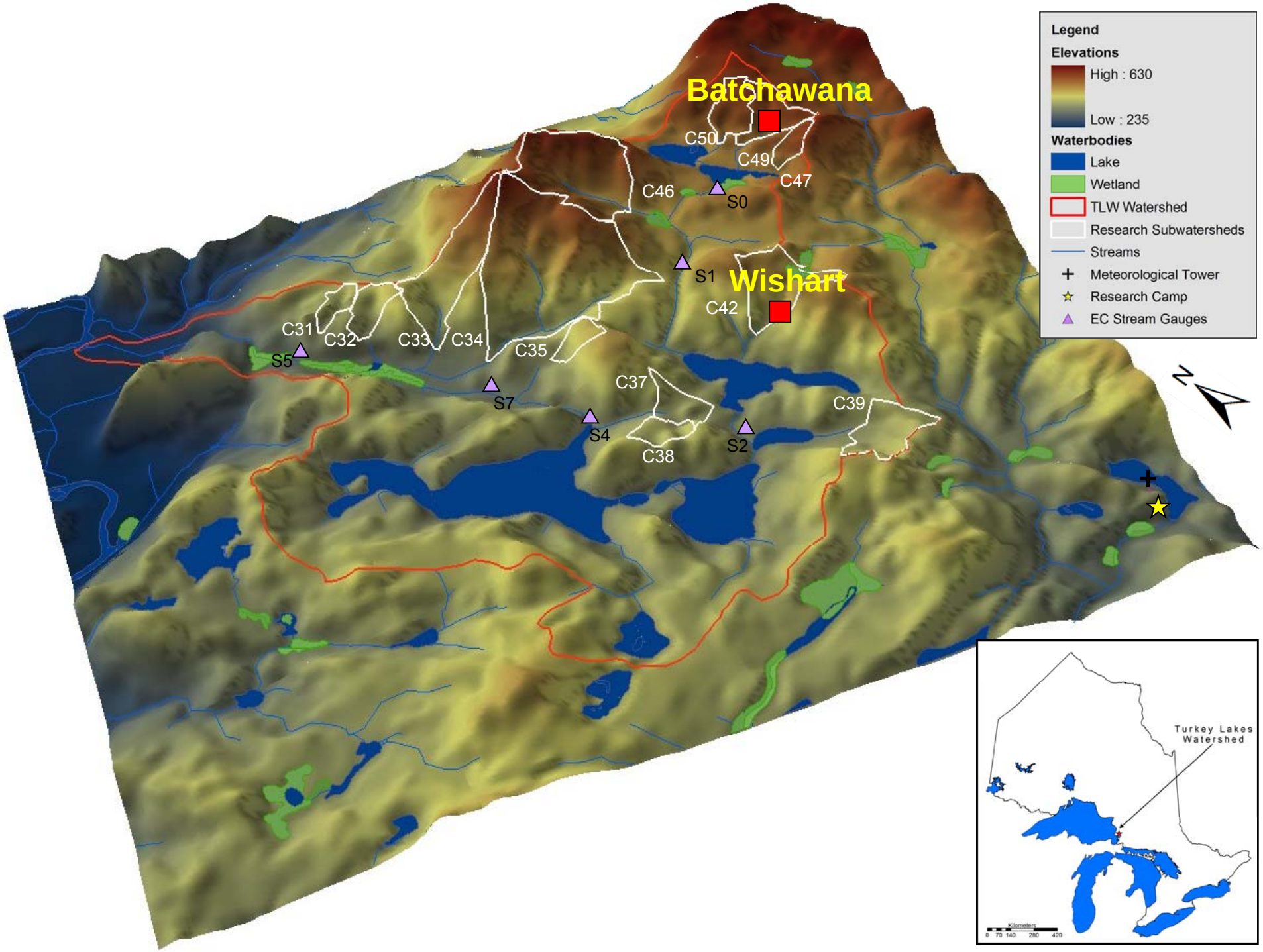
- the history, the opportunity
- the issues:
  - re-sampling single pit surveys
  - chemical analysis - archived samples
  - sampling genetic horizons - organic C and cations
  - site vs plot – topography
- future prospects

Turkey Lakes Watershed

- Established in 1979 as a partnership between NRCan-CFS, Environment Canada, Fisheries & Oceans Canada to study the effects of acid rain on a forested ecosystem

Turkey Lakes Watershed

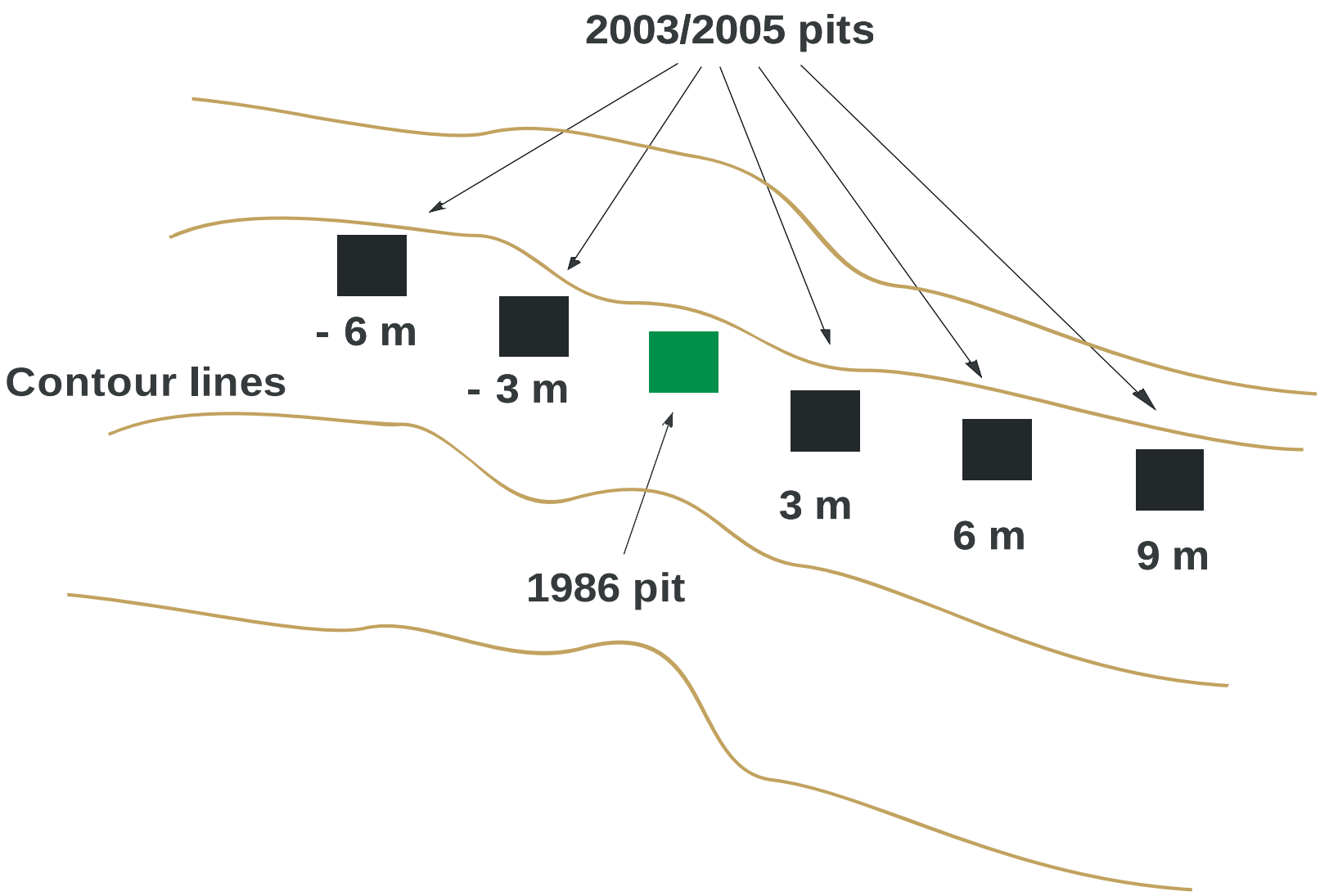
- uneven-aged old-growth maple-birch forest – net accumulation of nutrients low due to mortality
- deposition SO_4 and NO_3
  - currently 14 and 15 kg/ha/yr
  - early 1980's 30 and 20 kg/ha/yr
- input/output Ca and Mg
  - deposition 3 and 1 kg/ha/yr
  - leaching 30 and 4 kg/ha/yr
  - export 25 and 3 kg/ha/yr
- comparative watershed studies – high soil nitrification, high base cation leaching
- 1986 sampling – 7 nutrient cycling plots – archived samples


Batchawana
Wishart
C50
C49
C47
C46
S0
S1
C42
C31
C32
C33
C34
C35
S5
S7
C37
C39
S4
S2
C38
Legend
Elevations
High : 630
Low : 235
Waterbodies
Lake
Wetland
TLW Watershed
Research Subwatersheds
Streams
Meteorological Tower
Research Camp
EC Stream Gauges
N
Turkey Lakes Watershed
Kilometers
0 70 140 280 420

Resampling single pits

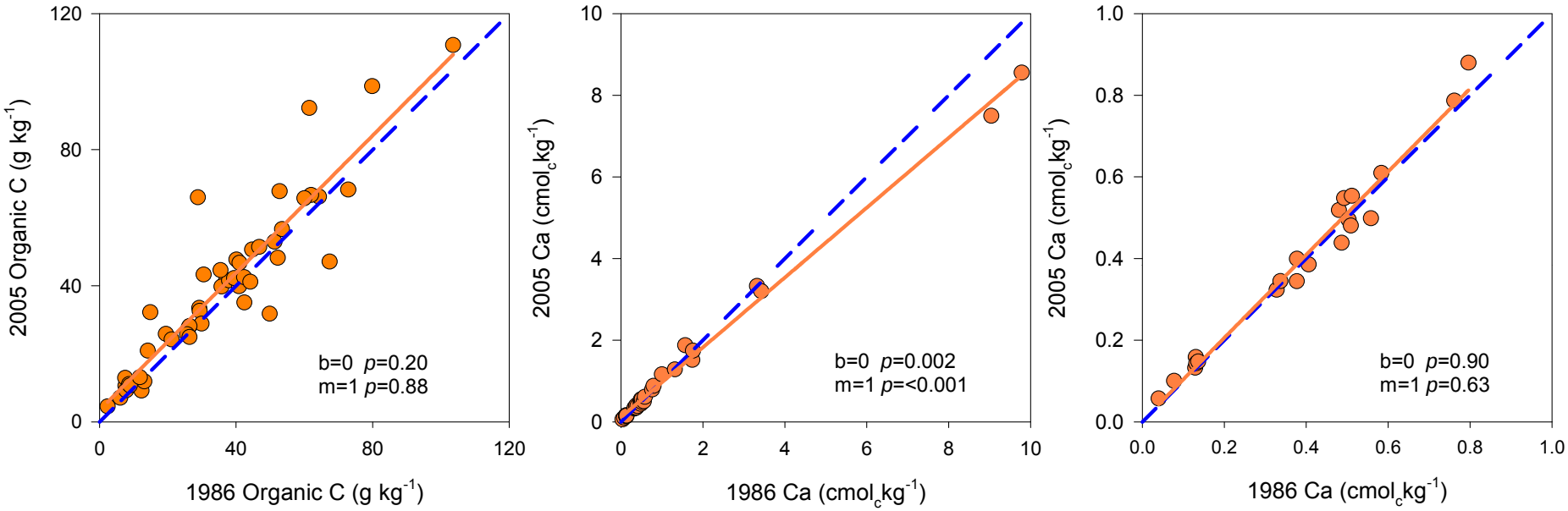
- no plot level replication in initial sampling – broad scope of topographic position for pits – landscape scale and microscale (divergent/convergent)
- attempt to capture plot variance by resampling multiple pits
- hydrologic condition key factor controlling element accumulation or loss from the soil profile
- flow paths, depth to water table, groundwater residence time some relationship with topography (Buttle et al. 2001, Monteith et al. 2006)

Turkey Lakes mineral soil change experiment

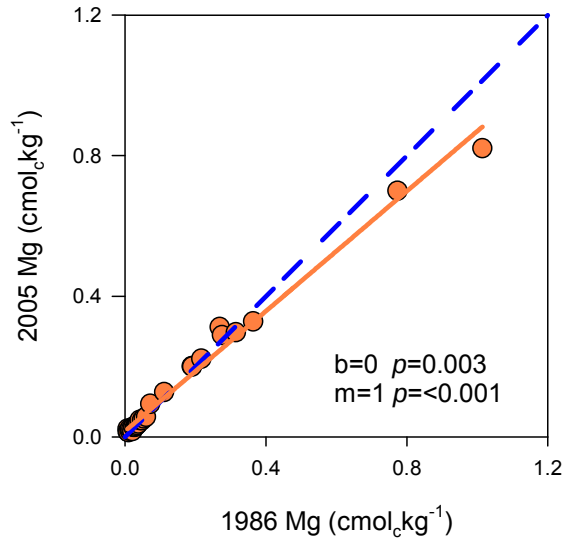


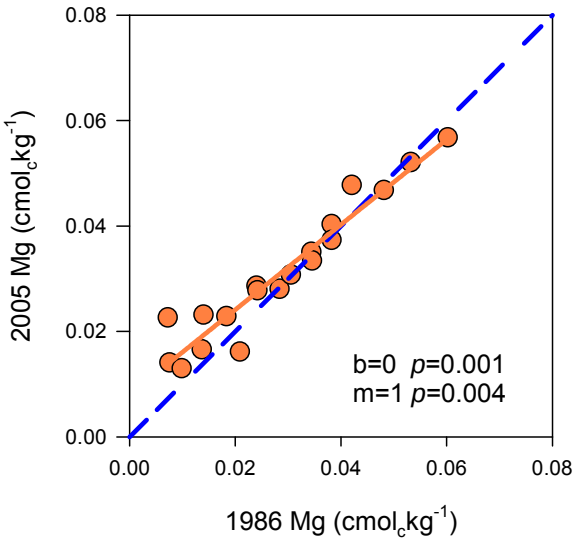
Lab analysis – archived samples

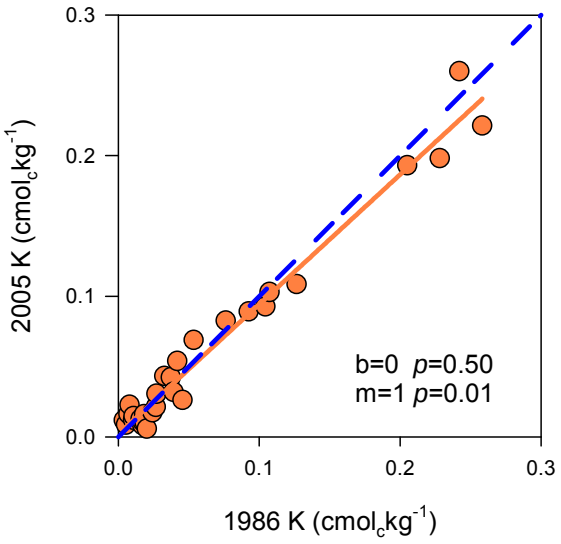
- < 2 mm, air-dried
  plastic jars
  unheated, uncooled building
- C original wet oxidation
  reanalysis combustion
  n=49
- cations 1 M NH_4Cl
  vacuum extraction
  ICAP upgrade
  n=30

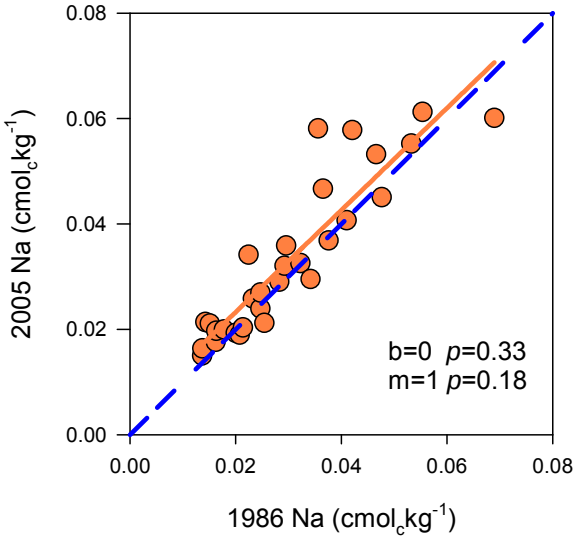


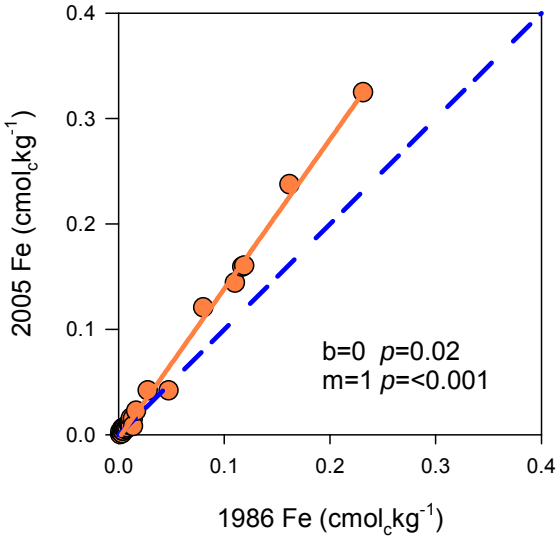
Regression differ in slope or intercept from 1:1 line?

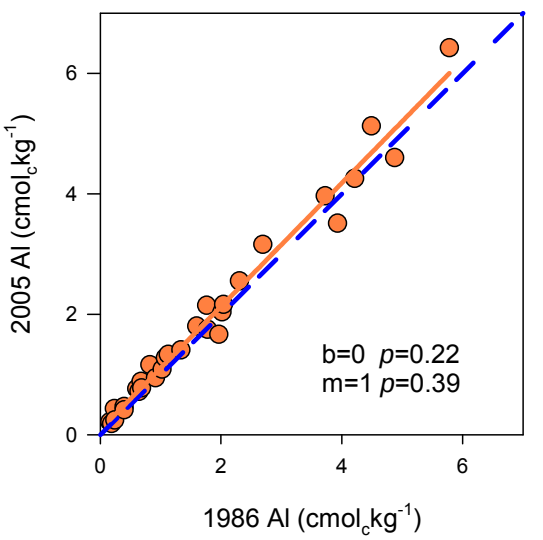

2005 Mg (cmol$_c$kg^{-1})
1986 Mg (cmol$_c$kg^{-1})
b=0 p=0.003
m=1 p=<0.001


2005 Mg (cmol$_c$kg^{-1})
1986 Mg (cmol$_c$kg^{-1})
b=0 p=0.001
m=1 p=0.004


2005 K (cmol$_c$kg^{-1})
1986 K (cmol$_c$kg^{-1})
b=0 p=0.50
m=1 p=0.01

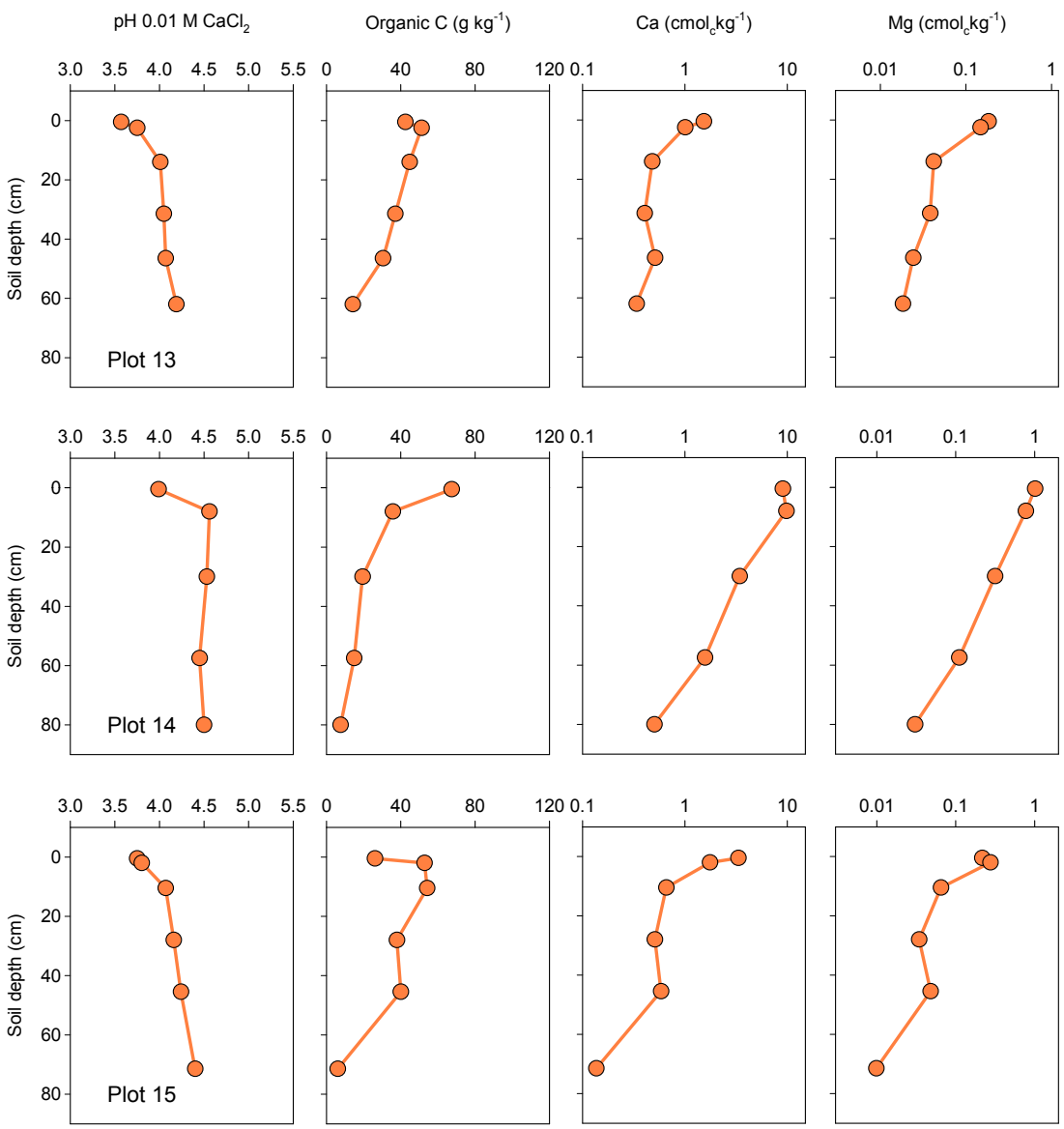

2005 Na (cmol$_c$kg^{-1})
1986 Na (cmol$_c$kg^{-1})
b=0 p=0.33
m=1 p=0.18

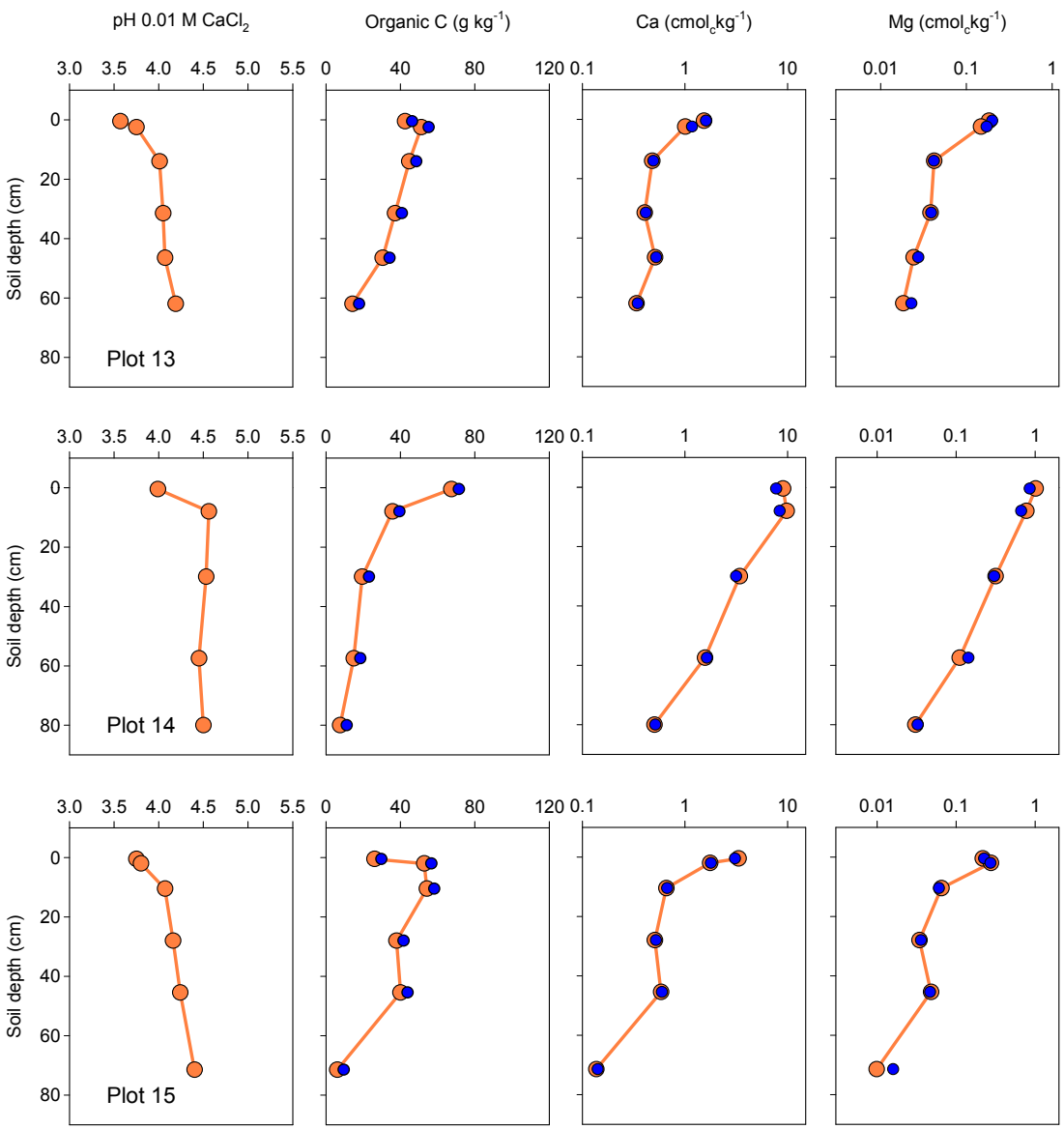

2005 Fe (cmol$_c$kg^{-1})
1986 Fe (cmol$_c$kg^{-1})
b=0 p=0.02
m=1 p=<0.001

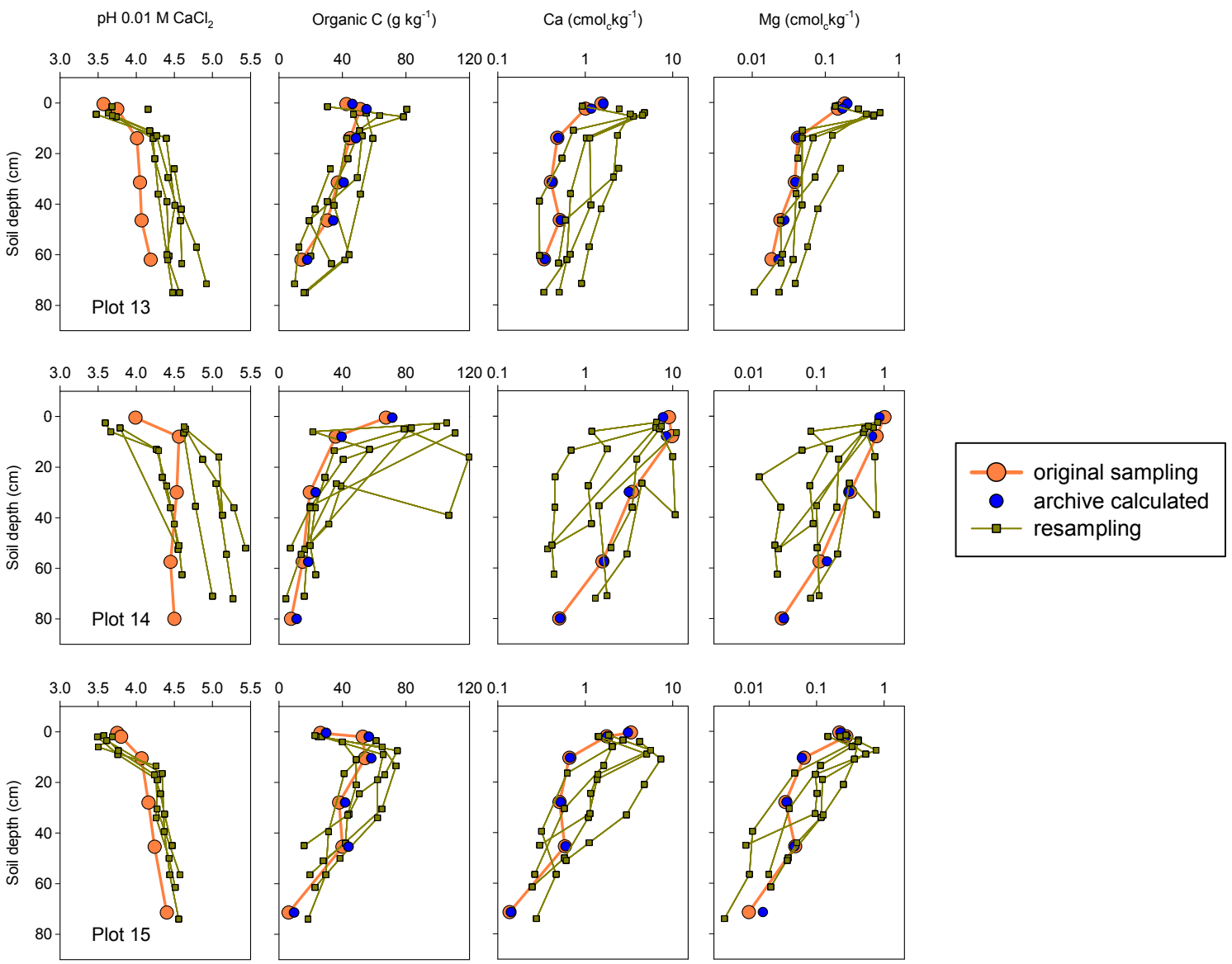

2005 Al (cmol$_c$kg^{-1})
1986 Al (cmol$_c$kg^{-1})
b=0 p=0.22
m=1 p=0.39

Variable	n	Concentration difference 1986 to 2005	% difference 1986 to 2005
Organic C all data	**49**	**3.7**	**10.4**
Ca all data	30	-0.09	-6.4
Ca < 1 $cmol_c kg^{-1}$	**21**	**0.009**	**2.3**
Ca > 1 $cmol_c kg^{-1}$	**9**	**-0.31**	**-8.6**
Mg all data	30	-0.005	-3.6
Mg < 0.085 $cmol_c kg^{-1}$	**19**	**0.002**	**8.4**
Mg > 0.085 $cmol_c kg^{-1}$	**11**	**-0.02**	**-5.3**
K all data	30	-0.003	-4.7
K < 0.075 $cmol_c kg^{-1}$	**21**	**0.001**	**0.5**
K > 0.075 $cmol_c kg^{-1}$	**9**	**-0.01**	**-6.4**
Na all data	**30**	**0.003**	**9.7**
Al all data	**30**	**0.13**	**7.0**
Fe all data	30	0.01	32.1
Fe < 0.02 $cmol_c kg^{-1}$	**21**	**0.001**	**-3.5**
Fe > 0.02 $cmol_c kg^{-1}$	**9**	**0.04**	**37.7**

Organic C concentration difference expressed as g kg^{-1}, all others $cmol_c kg^{-1}$


pH 0.01 M CaCl2
Organic C (g kg-1)
Ca (cmolc kg-1)
Mg (cmolc kg-1)
Soil depth (cm)
Plot 13
Plot 14
Plot 15


pH 0.01 M CaCl2
Organic C (g kg-1)
Ca (cmolc kg-1)
Mg (cmolc kg-1)
Soil depth (cm)
Plot 13
Plot 14
Plot 15

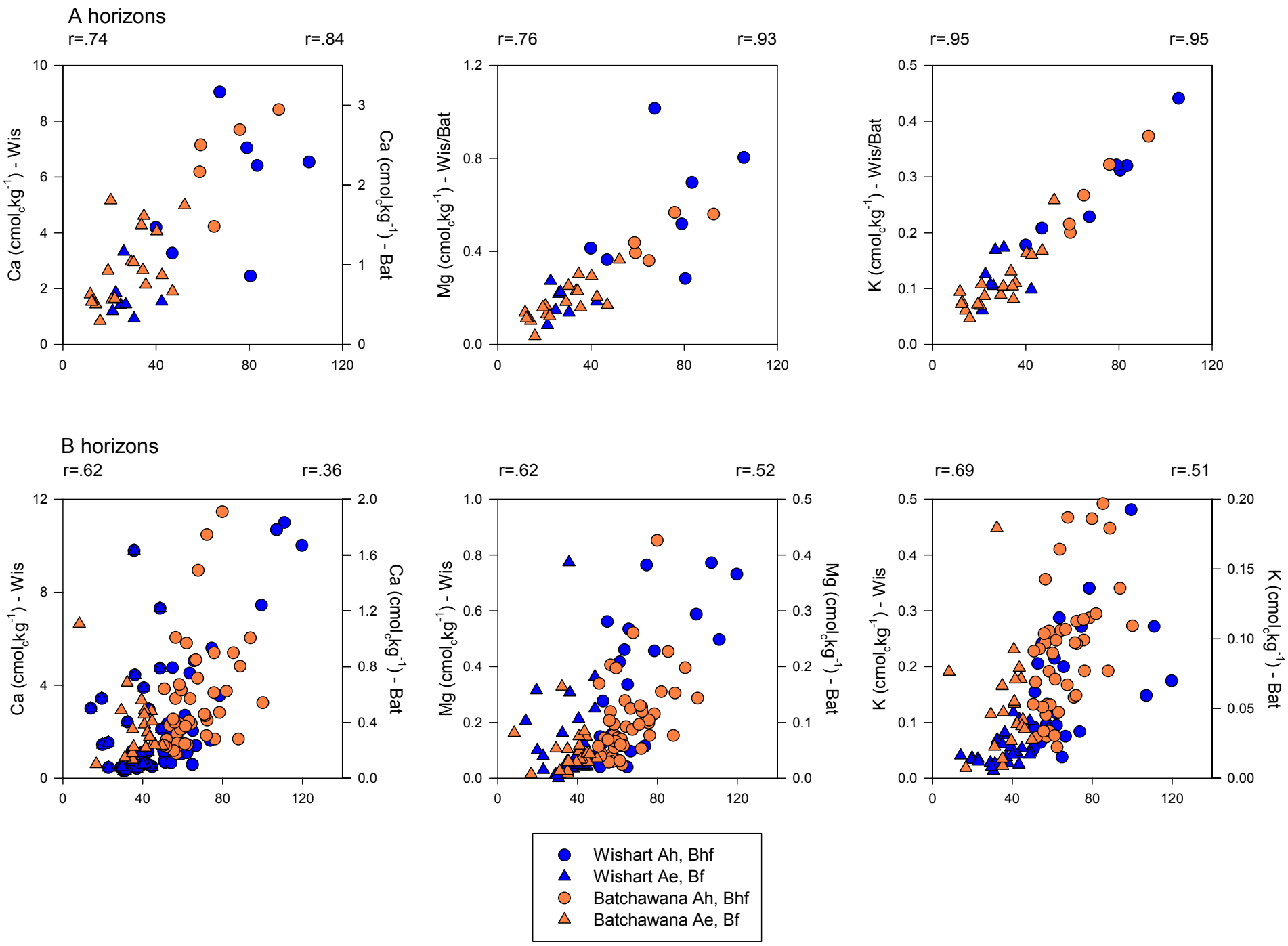

pH 0.01 M CaCl2
Organic C (g kg-1)
Ca (cmolc kg-1)
Mg (cmolc kg-1)
Soil depth (cm)
Plot 13
Plot 14
Plot 15
original sampling
archive calculated
resampling

Soil storage

- statistical differences between original analysis and archive sample analysis, 19 years in storage
- magnitude of differences small (high range Fe exception), difference small in relation to spatial variation
- mechanisms for changes due to storage? same methods, ICAP quality assurance
- determination of relationships between original and archived sample
- repeating identical lab protocols, instrument quality assurance, yield defensible long-term soil change comparisons

Sampling horizons: organic C and cations

- a particular pedon can only be sampled once, diffuse and irregular boundaries in these spodosols
- slight differences in sampling location and compositing can give different organic C concentrations, cation concentrations influenced by organic C
- calculate normalized (cation:organic C ratio) concentrations (Johnson et al. 1994, Warby et al. 2009 for organic horizons)
- assumes no change in organic C or small compared to difference due to sampling


A horizons
r=.74
r=.84
Ca (cmol$_c$kg^{-1}) - Wis
Ca (cmol$_c$kg^{-1}) - Bat
r=.76
r=.93
Mg (cmol$_c$kg^{-1}) - Wis/Bat
r=.95
r=.95
K (cmol$_c$kg^{-1}) - Wis/Bat
B horizons
r=.62
r=.36
Ca (cmol$_c$kg^{-1}) - Wis
Ca (cmol$_c$kg^{-1}) - Bat
r=.62
r=.52
Mg (cmol$_c$kg^{-1}) - Wis
Mg (cmol$_c$kg^{-1}) - Bat
r=.69
r=.51
K (cmol$_c$kg^{-1}) - Wis
K (cmol$_c$kg^{-1}) - Bat
Wishart Ah, Bhf
Wishart Ae, Bf
Batchawana Ah, Bhf
Batchawana Ae, Bf

pH and cation concentrations 7 plots

	pH H_2O		Ca		Mg	
	1986	2003 2005	1986	2003 2005	1986	2003 2005
				$cmol_c kg^{-1}$		
Ae	4.16	4.00	1.54	1.11	0.23	0.18
Bhf1	4.45	4.34	1.00	1.90	0.19	0.26
Bf1	4.71	4.87	1.57	1.31	0.13	0.09
IIC	5.12	5.12	0.29	0.47	0.02	0.03

pH and normalized cation concentrations - 7 plots

	Organic C		Ca:OC		Mg:OC	
	1986	2003 2005	1986	2003 2005	1986	2003 2005
	%		$cmol_c kg^{-1}$ organic C			
Ae	4.2	2.6	40.6	44.1	5.7	7.0
Bhf1	6.2	7.0	16.4	28.8	3.0	3.8
Bf1	4.3	4.2	38.8	31.5	3.3	2.3
IIC	1.3	2.1	24.2	41.6	1.8	2.5

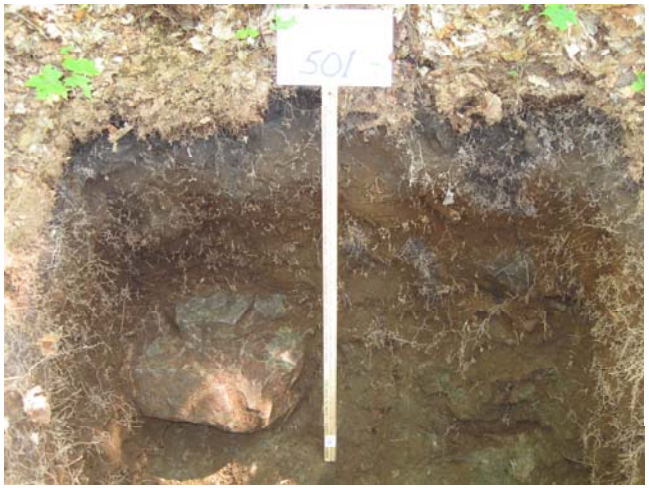
pH and normalized cation concentrations - 7 plots

	Organic C		Ca:OC		Mg:OC	
	1986	2003 2005	1986	2003 2005	1986	2003 2005
	%		$cmol_c kg^{-1}$ organic C			
Ae	4.2	2.6	40.6	44.1	5.7	7.0
Bhf1	6.2	7.0	16.4	28.8	3.0	3.8
Bf1	4.3	4.2	38.8	31.5	3.3	2.3
IIC	1.3	2.1	24.2	41.6	1.8	2.5

pH and normalized cation concentrations - 7 plots

	Organic C		Ca:OC		Mg:OC	
	1986	2003 2005	1986	2003 2005	1986	2003 2005
	%		$cmol_c kg^{-1}$ organic C			
Ae	4.2	2.6	40.6	44.1	5.7	7.0
Bhf1	6.2	7.0	16.4	28.8	3.0	3.8
Bf1	4.3	4.2	38.8	31.5	3.3	2.3
IIC	1.3	2.1	24.2	41.6	1.8	2.5

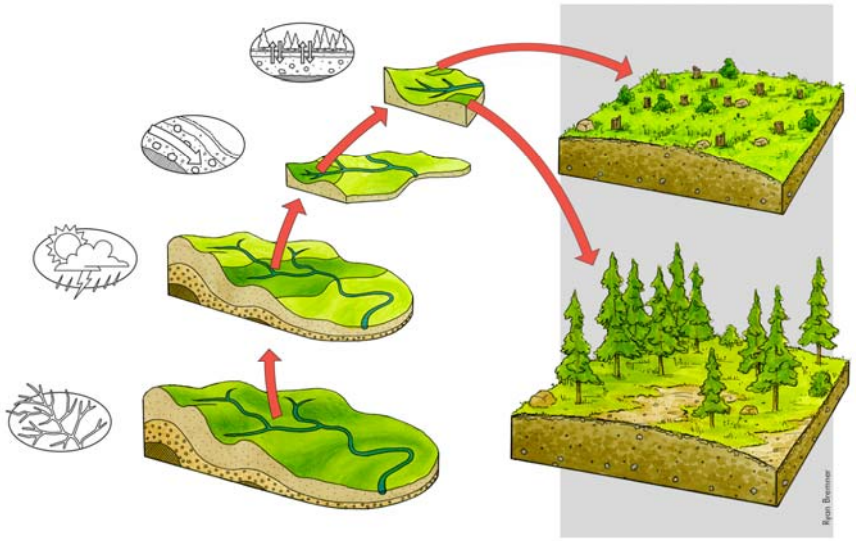
Site or plot level change?

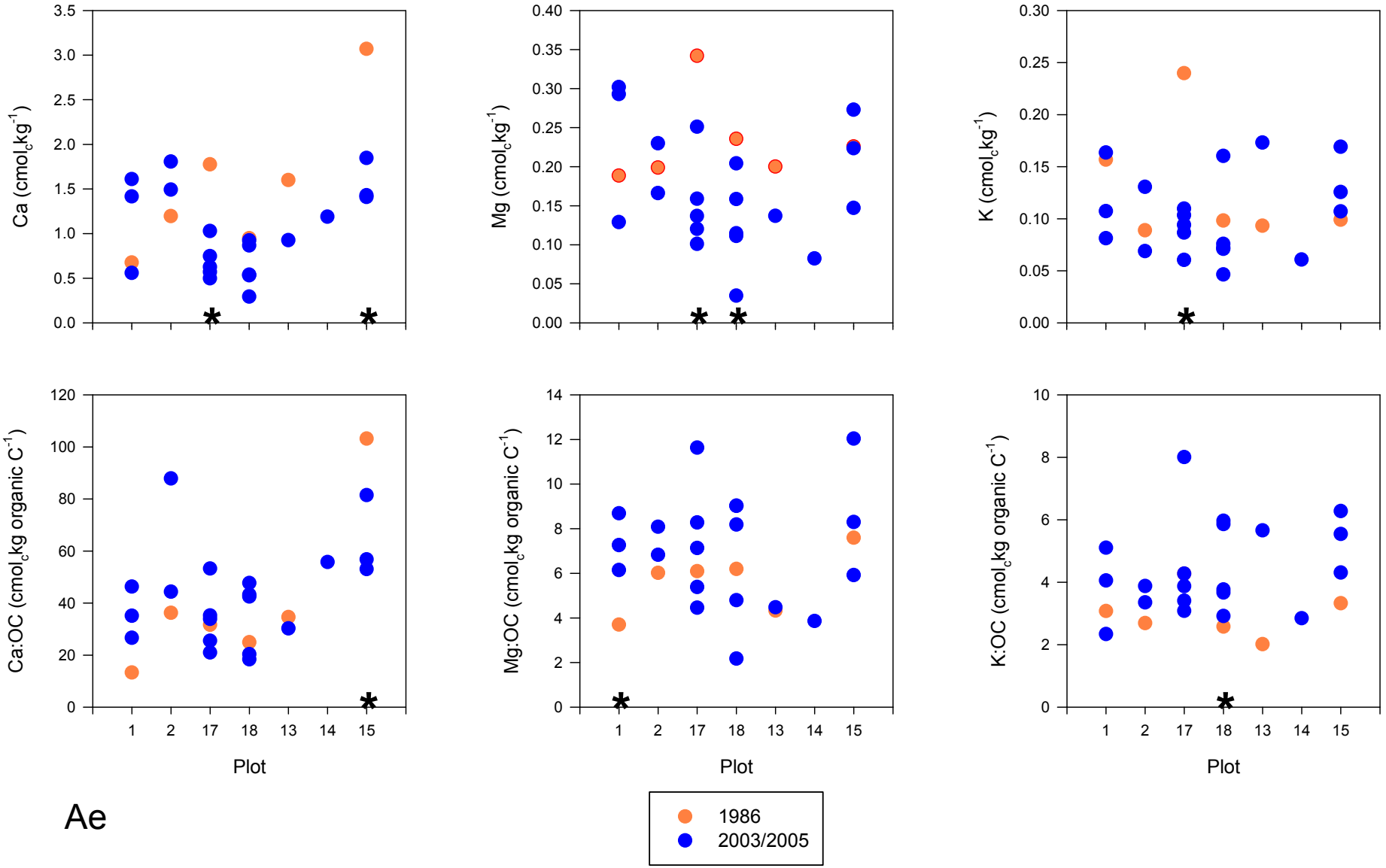


- at site level sample replication limited - variable initial condition, high standard deviation in paired differences
- minimum detectable differences high - in general differences for Na were lower
- subtle changes with deposition or climate change rather than strong manipulative treatments

Site or plot level change?

- increase sample size or stratify sampling?
- spatial differences in soil change at plot level obscured by analysis of the site condition
- one sample t-test, variance from resampling



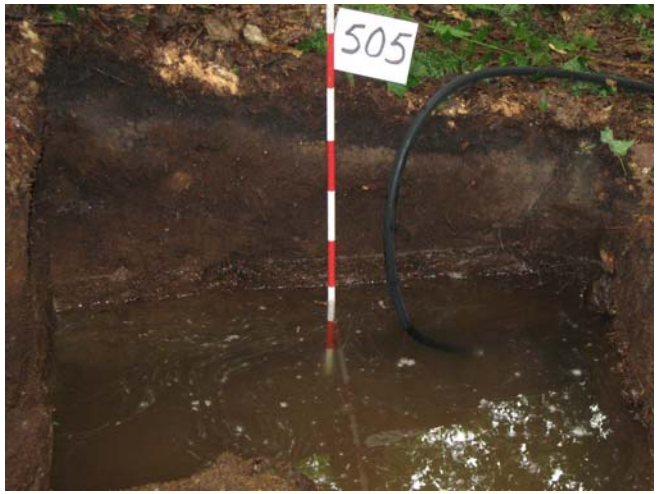

Ca (cmol$_c$kg^{-1})
Mg (cmol$_c$kg^{-1})
K (cmol$_c$kg^{-1})
Ca:OC (cmol$_c$kg organic C^{-1})
Mg:OC (cmol$_c$kg organic C^{-1})
K:OC (cmol$_c$kg organic C^{-1})
Plot
1 2 17 18 13 14 15
1986
2003/2005
Ae

Results/Conclusions

- storage impacts but less than 10% difference
- no declines in pH or base cations at the site level - exception Na
- topography playing a role in plot level changes
- base rich site – total cations greater than other sites that have shown declines in exchangeable
- limited survey – failure to reject the null hypothesis not evidence of acceptance of that hypothesis

Future prospects

- topographic feature classification (Webster et al. 2008) linked with overstory accumulation, soil element content
- other 1980's sampling Turkey Lakes, ARNEWS


505