
pH *in situ* –
Nature ignores a tipping point
Nielsen, K.E., Irizar, A., Nielsen, L.P., Kristiansen , S.M., Damgaard, C., Holmstrup, M., Petersen, A.R., Strandberg, M. 2017. *In situ measurements reveal extremely low pH in soil*. Soil Biol. and Biochem. 115: 63-65.
https://authors.elsevier.com/a/1VYVw_tPj7bnn

pHoto: Kristian Dalsgaard

Acidified soil

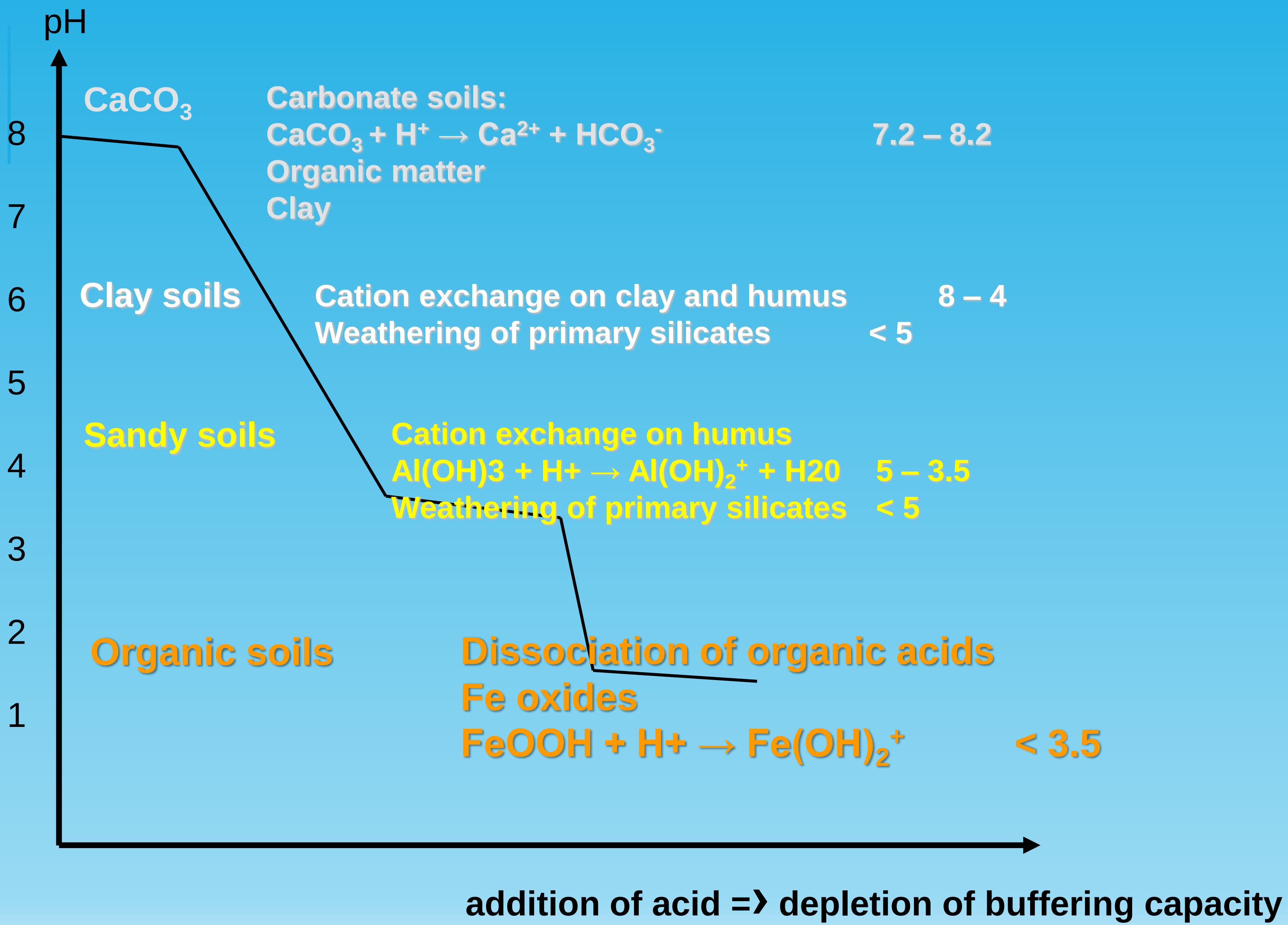
Low

- pH
- base saturation
- decomposition
- clay content
- bioturbation
- bacteria activity
- biodiversity
- R and C plants

High

- C:N ratio
- weathering
- organic acids
- Al and Fe
- sand
- fungi activity
- S-strategy

Most important pH buffering systems in soils



Soil acidification

Increase in acidity – proton sources:

- Atmospheric dry/wet deposition of N and S compounds
- Ammonia oxidized to nitrate and if leached it acidifies
- Leaching of anions (like NO_3^-, SO_4^{2-}, Cl^- and org. anions
- Plant removal - acidifying due to base cations removal
- Plant growth – uptake of cations – release of protons
- Degradation of organic matter
- Root respiration

Decrease in acidity – proton sinks:

- Weathering of minerals (liming)
- Liming
- CEC – protons adsorbed on exchange sites under release of base cations
- Protons neutralized by reaction with silicate minerals and sesq.oxides
- Rejuvenation of soil –bioturbation, wind/water erosion – exposure of subsoils

What caused the die-back of Erica tetralix?


Strandberg et al., 2012. Evidence for Acidification-Driven Ecosystem Collapse of Danish *Erica tetralix* Wet Heathland AMBIO 2012, 41
Decrease in morlayer pH from above 4 to 3-3.8 (mean 3.3) since the 1960s
Major hypotheses that explain the observations:
1. toxic concentrations of aluminium ions
2. Depletion of base cations
Soil pH was measured *in situ* due to direct similarity of ancient standard measurements in pH_{H2O}........?

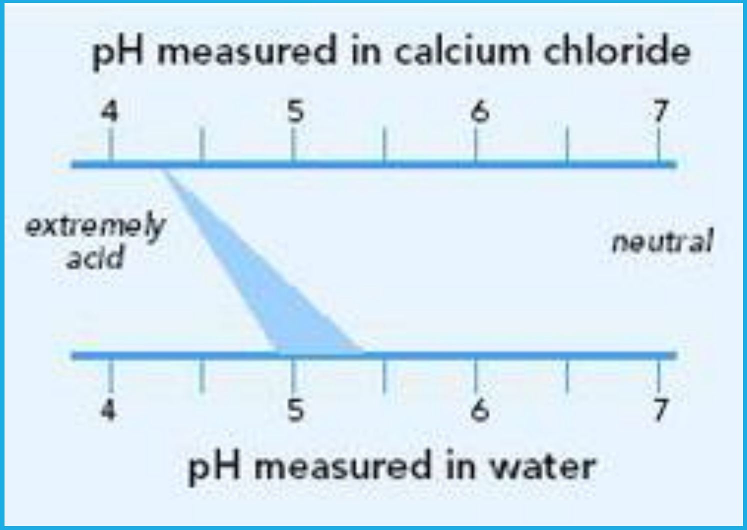



pH lab. analysis – various preparative manipulations:

pH *in situ* no manipulations

sampling
sorting
drying
crushing
sieving
choice of buffer solutions
dilution factors
shaking time
resting period
measurement

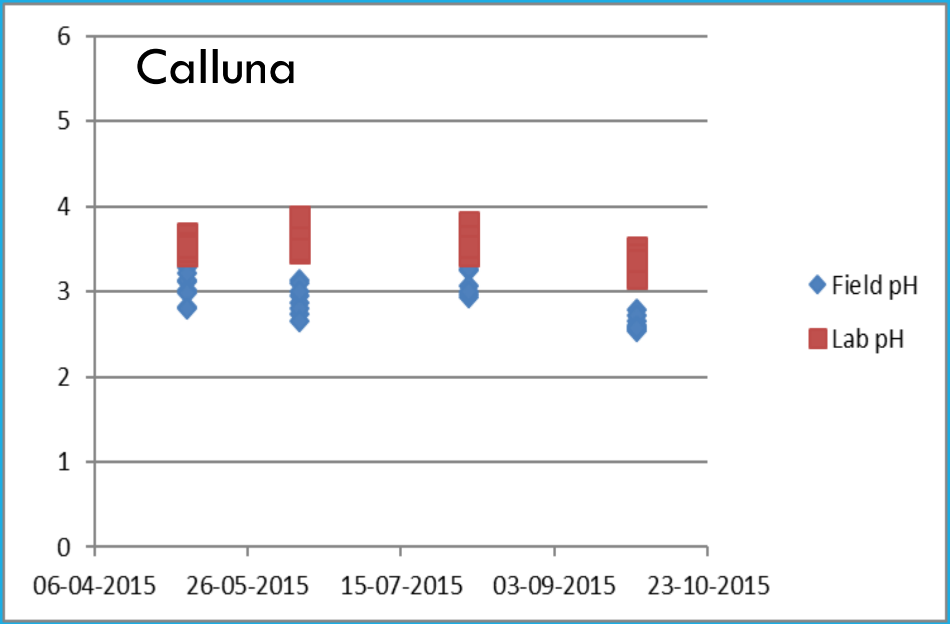
Measurement

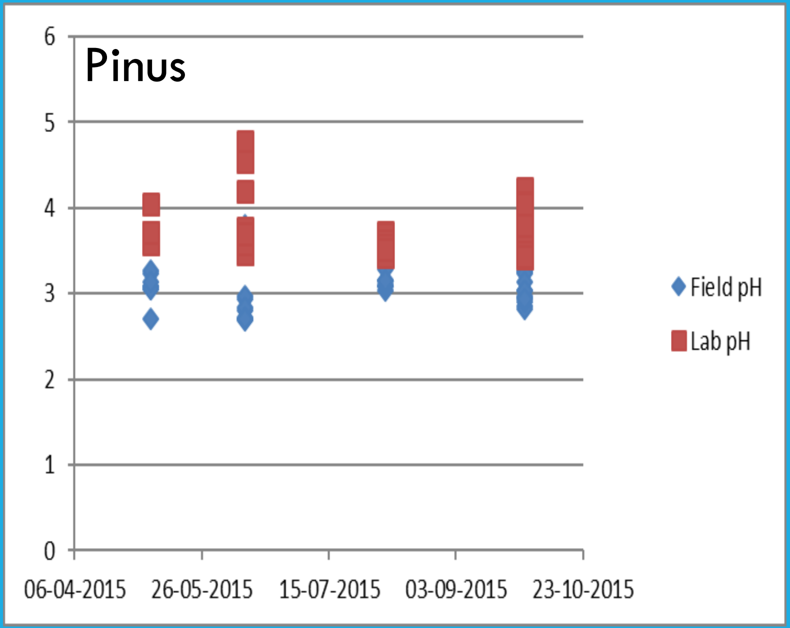


General rule, pH measured in calcium chloride is 0.7 of a pH unit lower than pH measured in water

Difference between pH measured *in situ* and in laboratory

Date	Calluna *in situ*	Calluna laboratory	Calluna difference	Pinus *in situ*	Pinus lab.	Pinus difference
May n=8	3.05	3.57	0.52	3.08	3.72	0.64
June n=10	2.91	3.64	0.74	3.10	3.95	0.85
Aug. n=8	3.17	3.62	0.44	3.14	3.60	0.46
Sept. n=8	2.63	3.39	0.77	3.03	3.81	0.78

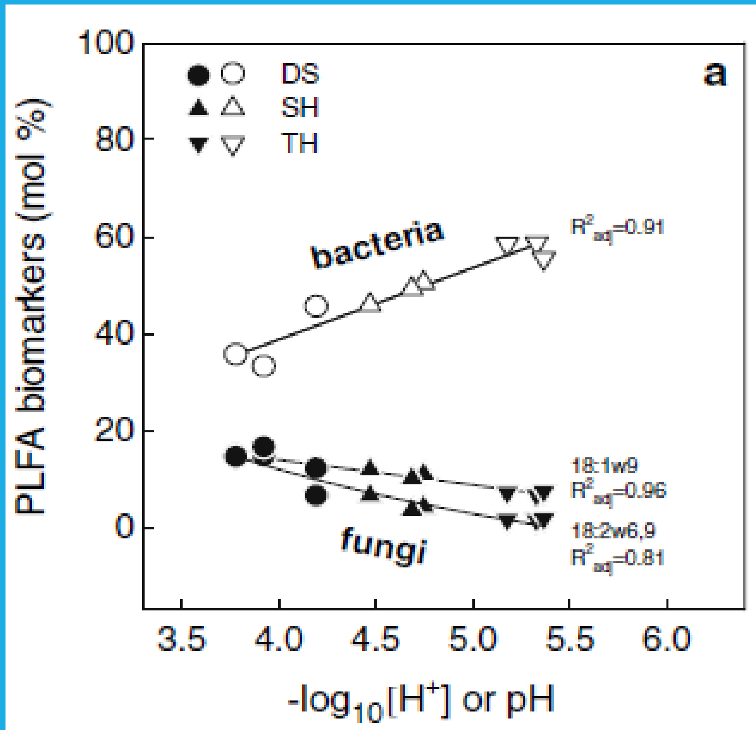




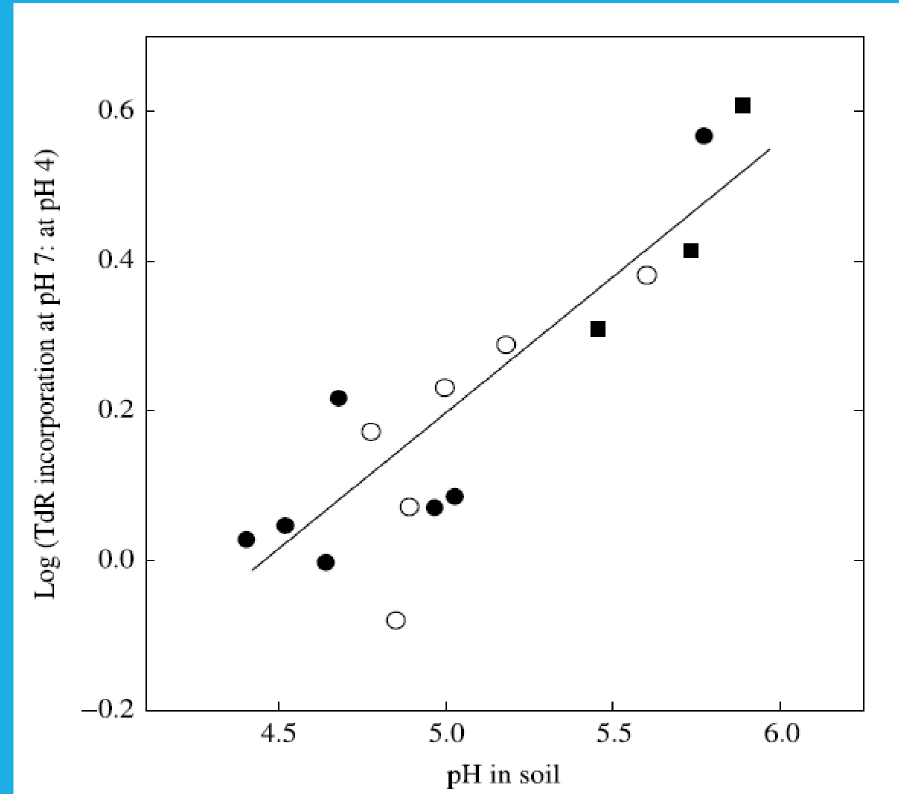
Most investigations since the last 30 years have found that variability in surface soil pH are as high or even higher than other soil parameters.

In situ **pH seems to have a lower SEM than lab pH.**

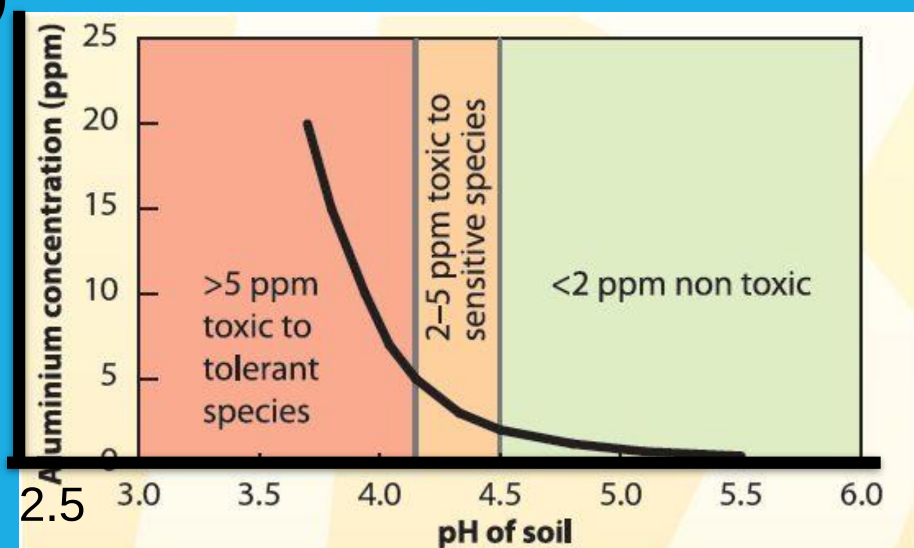
?



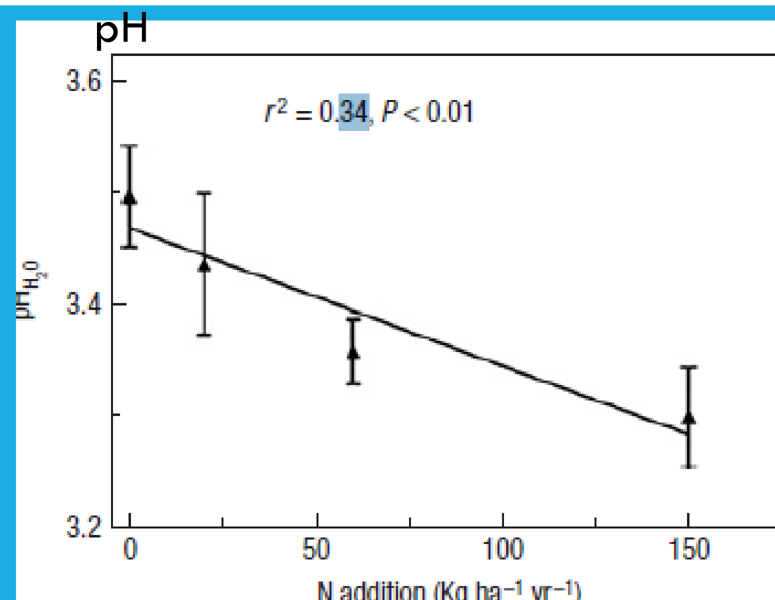
a
DS
SH
TH
bacteria
R^2_{adj}=0.91
fungi
18:1w9
R^2_{adj}=0.96
18:2w6,9
R^2_{adj}=0.81
PLFA biomarkers (mol %)
100
80
60
40
20
0
3.5
4.0
4.5
5.0
5.5
6.0
$-\log_{10}[H^+]$ or pH



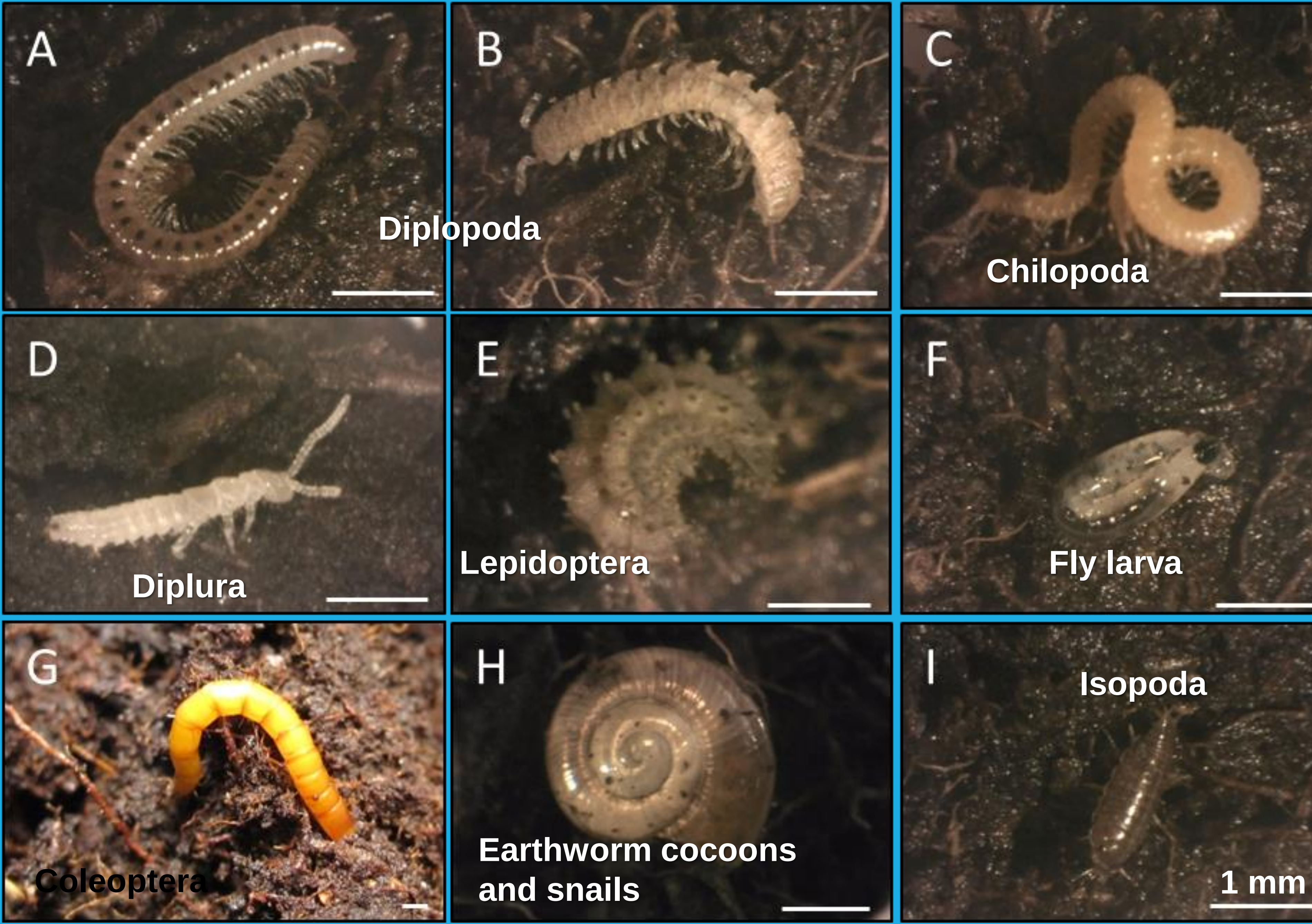
Log (TdR incorporation at pH 7: at pH 4)
0.6
0.4
0.2
0.0
−0.2
4.5
5.0
5.5
6.0
pH in soil



Aluminium concentration (ppm)
25
20
15
10
5
0
>5 ppm
toxic to
tolerant
species
2–5 ppm toxic to
sensitive species
<2 ppm non toxic
2.5
3.0
3.5
4.0
4.5
5.0
5.5
6.0
pH of soil

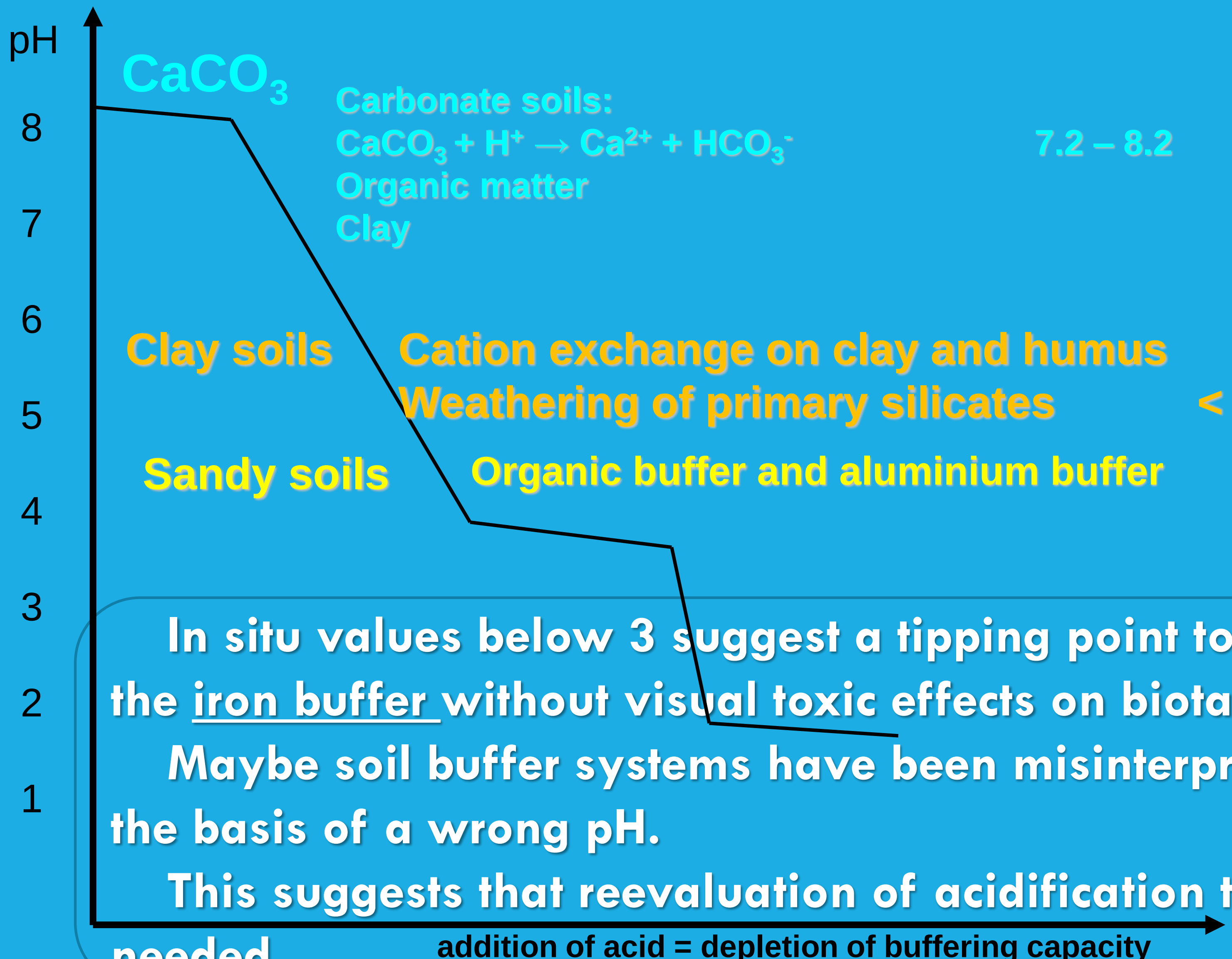


pH
$r^2 = 0.34$, $P < 0.01$
pH_{H_2O}
3.6
3.4
3.2
0
50
100
150
N addition (Kg ha^{-1} yr^{-1})



+ Three annelid species were identified

Most important pH buffering systems in soils



In situ values below 3 suggest a tipping point towards the <u>iron buffer</u> without visual toxic effects on biota, or:

Maybe soil buffer systems have been misinterpreted on the basis of a wrong pH.

This suggests that reevaluation of acidification theory is needed

Conclusion

- In situ pH is possible due to robust field electrodes
- mor layers extremely acid–most data between 2.5 and 3.0
- No visual toxic effect on biota – above or below ground
- Does living and dead soil fauna in the sample contribute to increase pH?
- Substantial error in lab. pH due to preparative manipulation
- Deviation up to 1 pH unit between in situ and standard pH of the same soil sample both measured in dem. water
- pH *in situ* well within the iron buffer?
- This suggests that reevaluation of acidification theory is needed

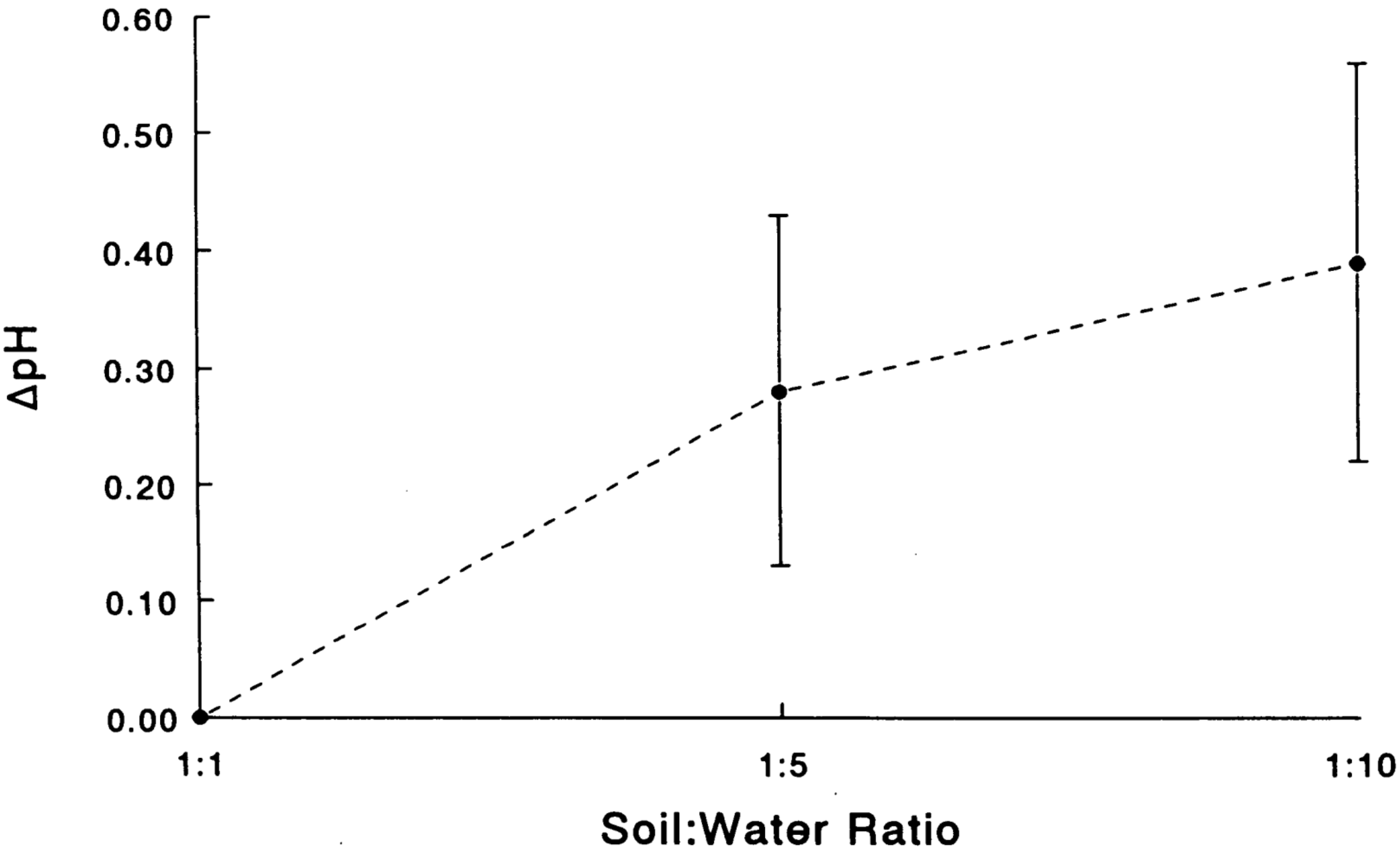
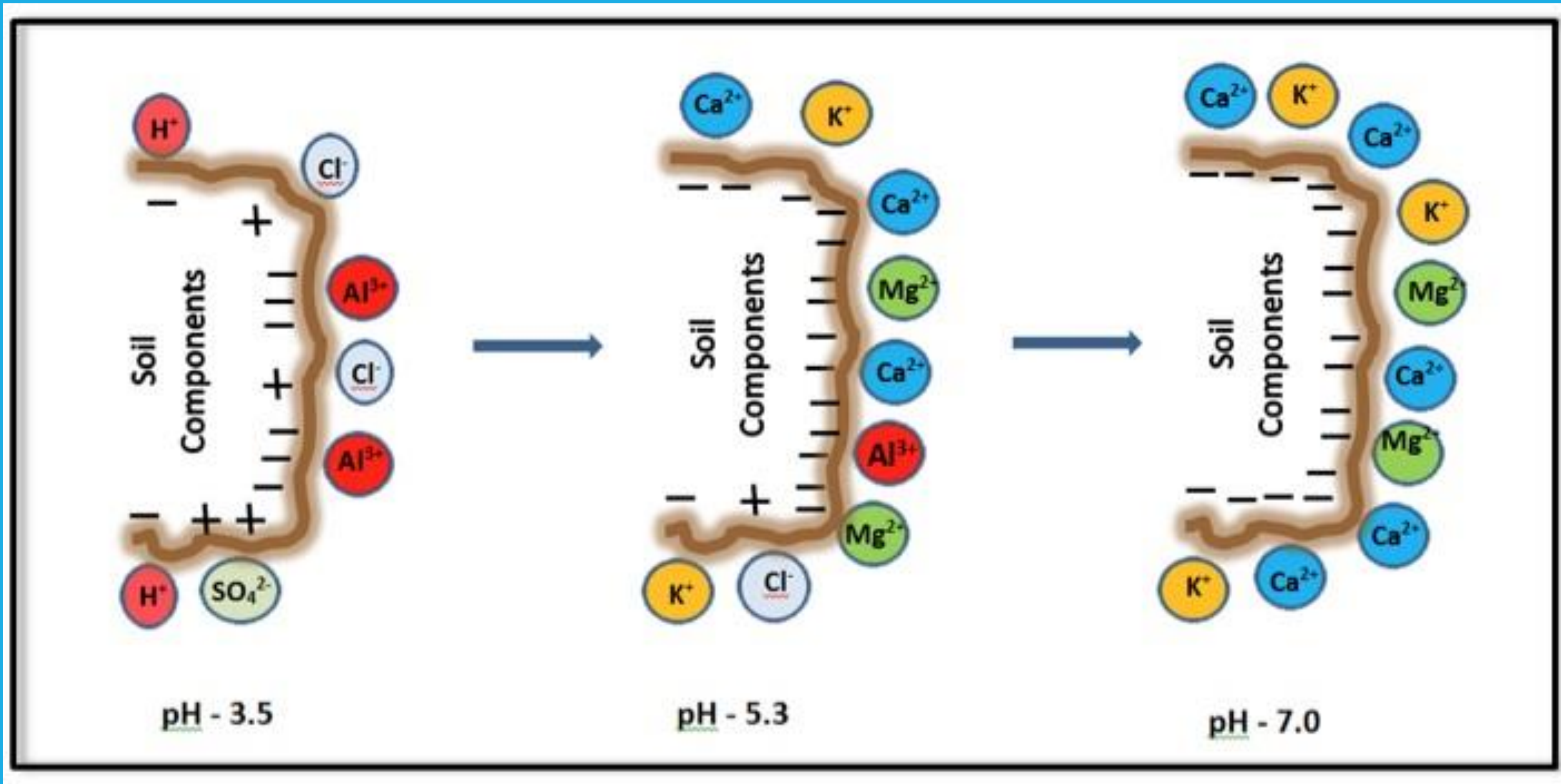
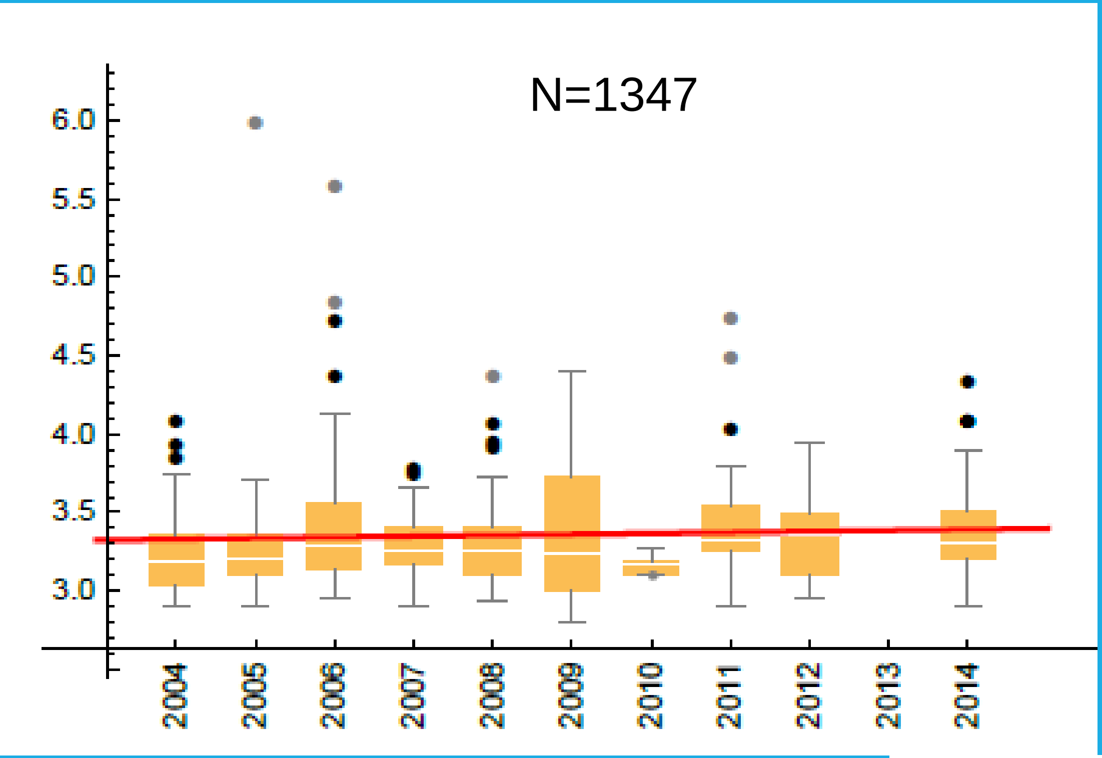


Fig. 16–1. The effect of dilution on pH values of California soils showing standard deviation at each dilution (data from Davis, 1943).



Soil Components
pH - 3.5
pH - 5.3
pH - 7.0

pH_{CaCl2} in Danish heathland



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