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Eurosoil 2021

Long-term nitrogen addition experiment to a sub-alpine forest in Switzerland: where does this N go and what are the consequences?

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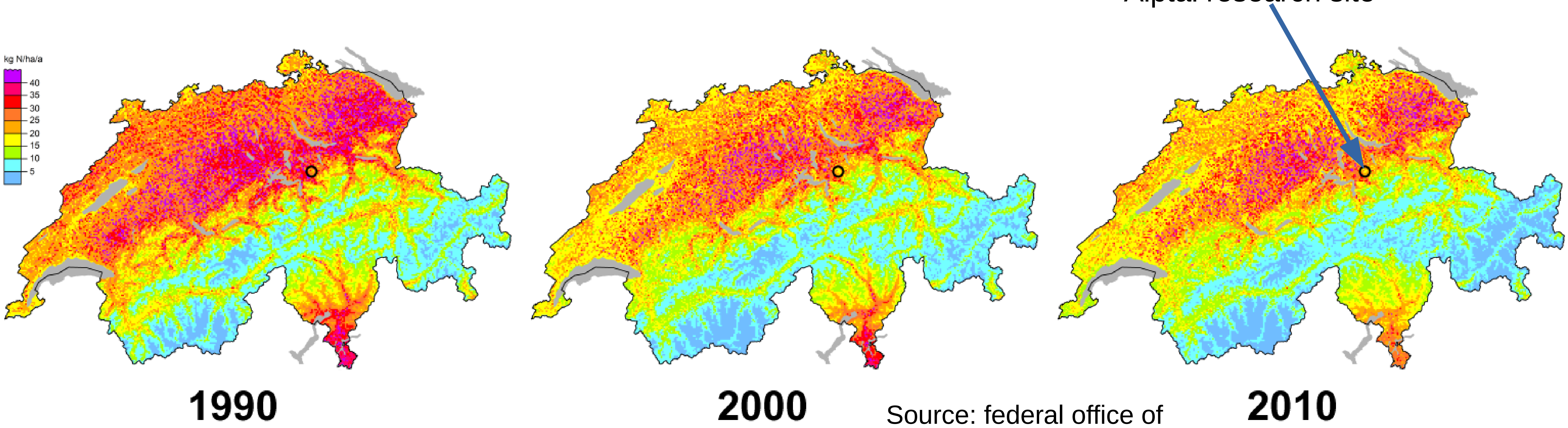
Modelled N deposition over Switzerland

- reduction trend since 1990
- what are the effects on forests (and other semi-natural ecosystems):
  - for N as nutrient
  - for N as acidifying agent (along with S)

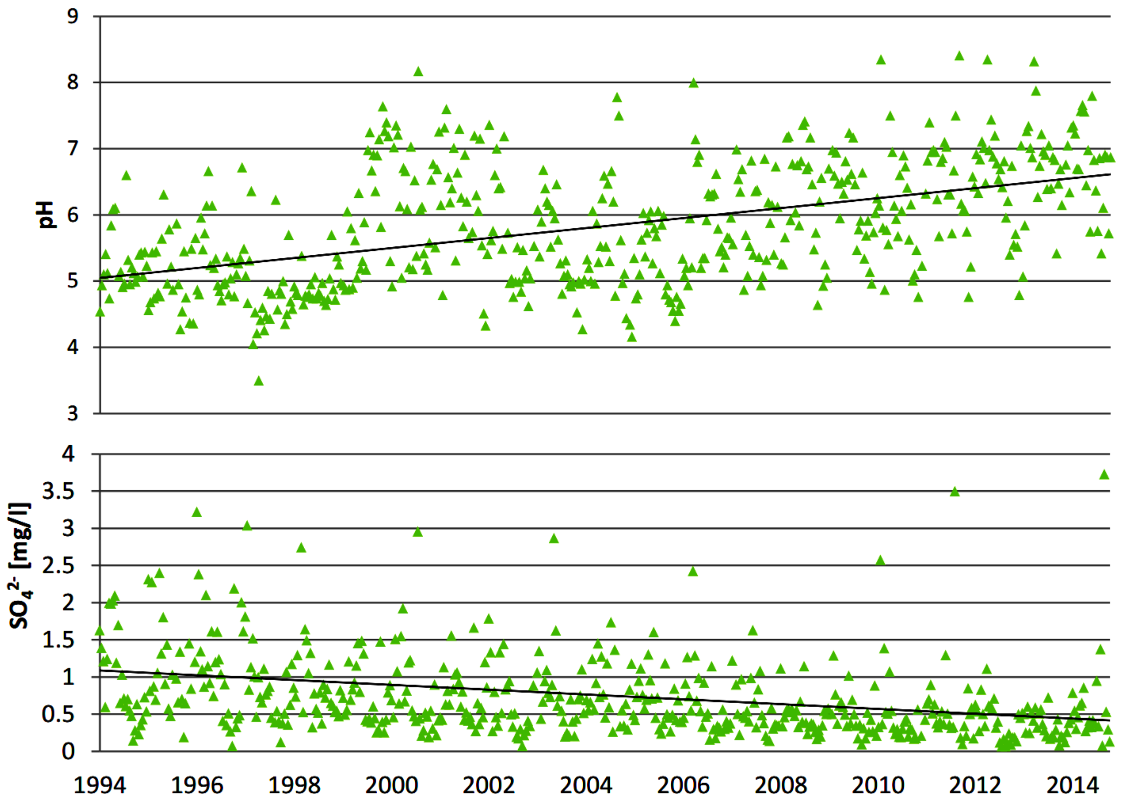


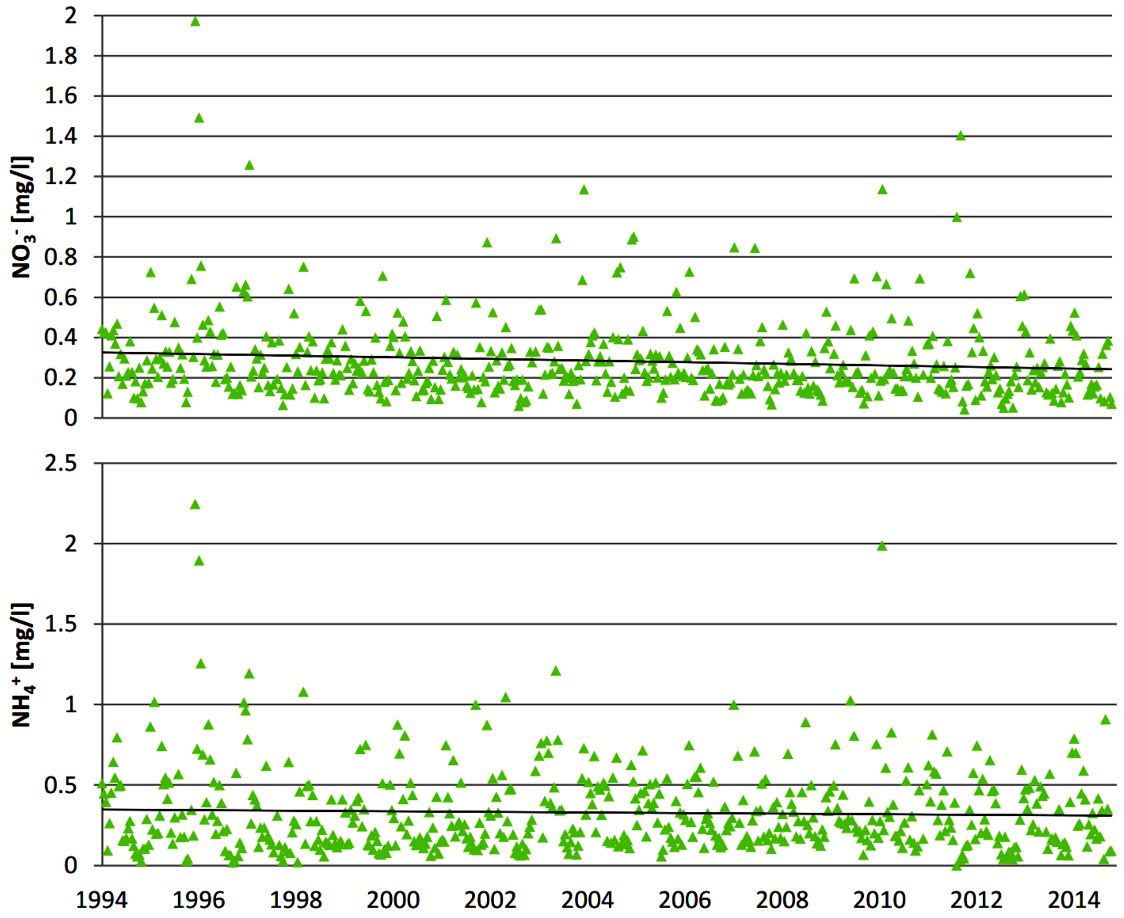
Source: federal office of the envirnoment

Alptal:

1200 m a.s.l., 2300 mm annual precipitation, 6°C average temperature

- deposition: SO_4^{2-} ↘↘ NO_3^- ↘ NH_4^+ not significant
- precipitation pH ↗





Gleysol

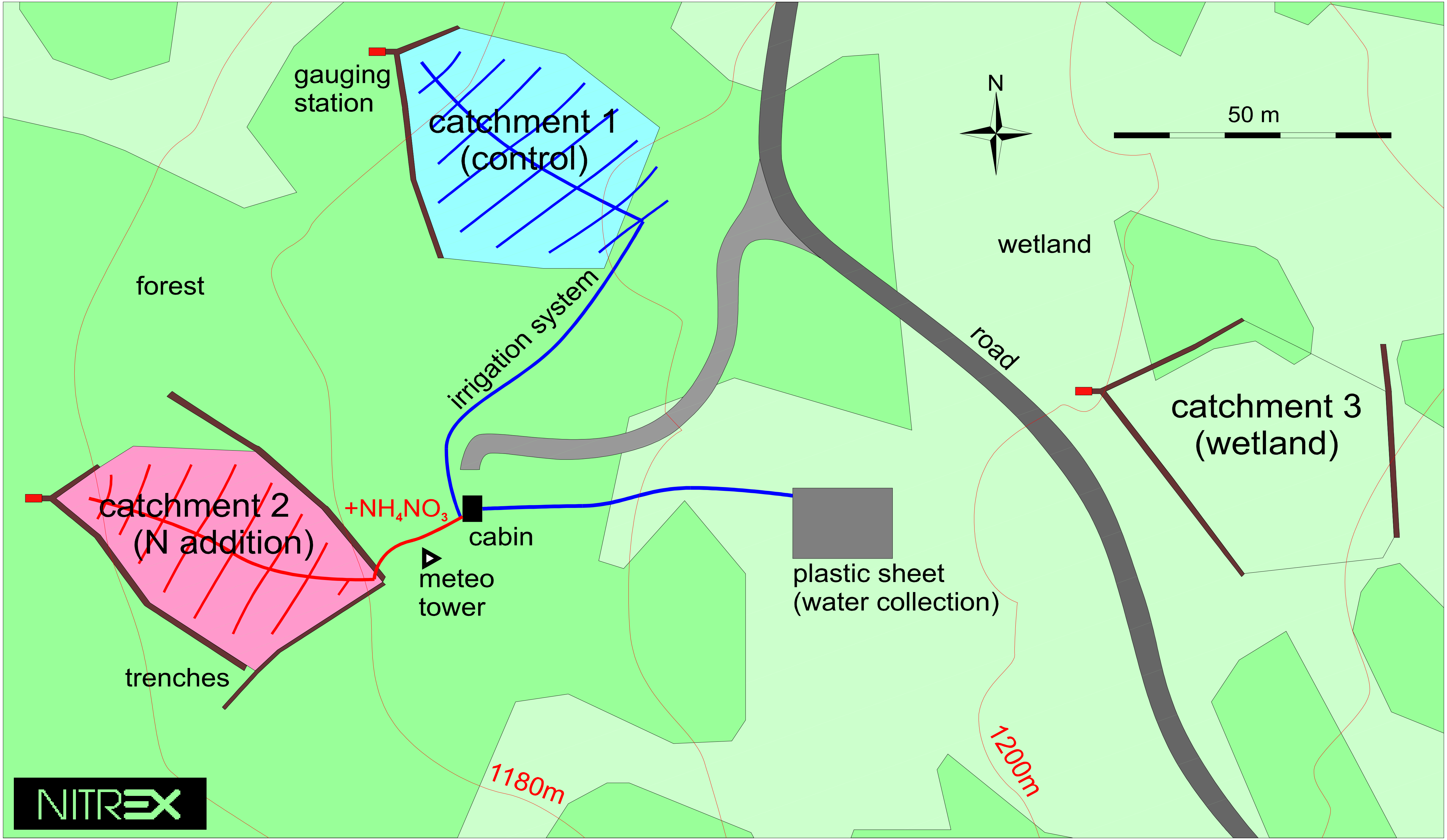
L

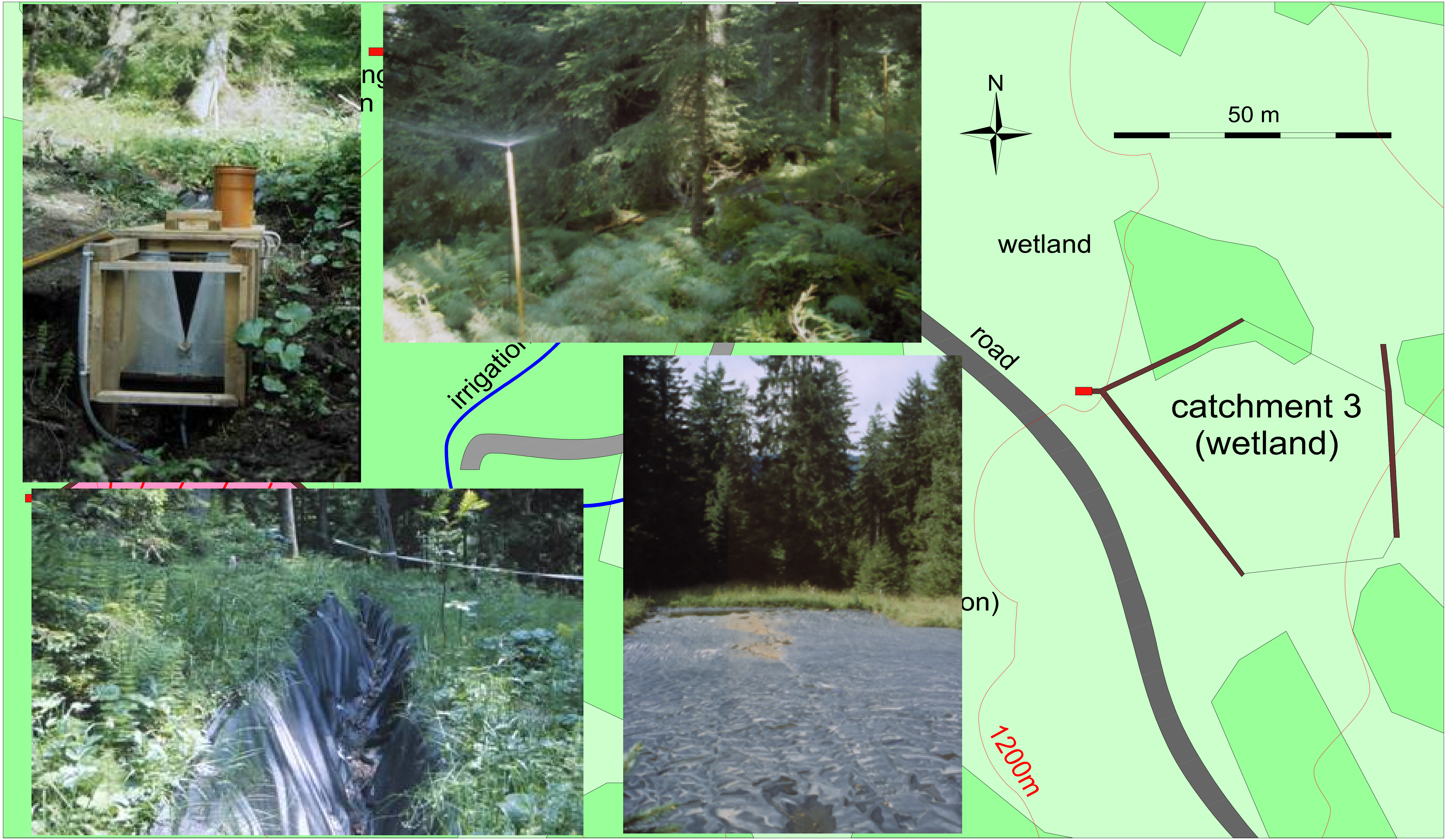
Aa (depressions) or Ah (mounds), pH 3.5 - 5

Gor, pH 4 - 7

Gr, pH 5 - 7.5

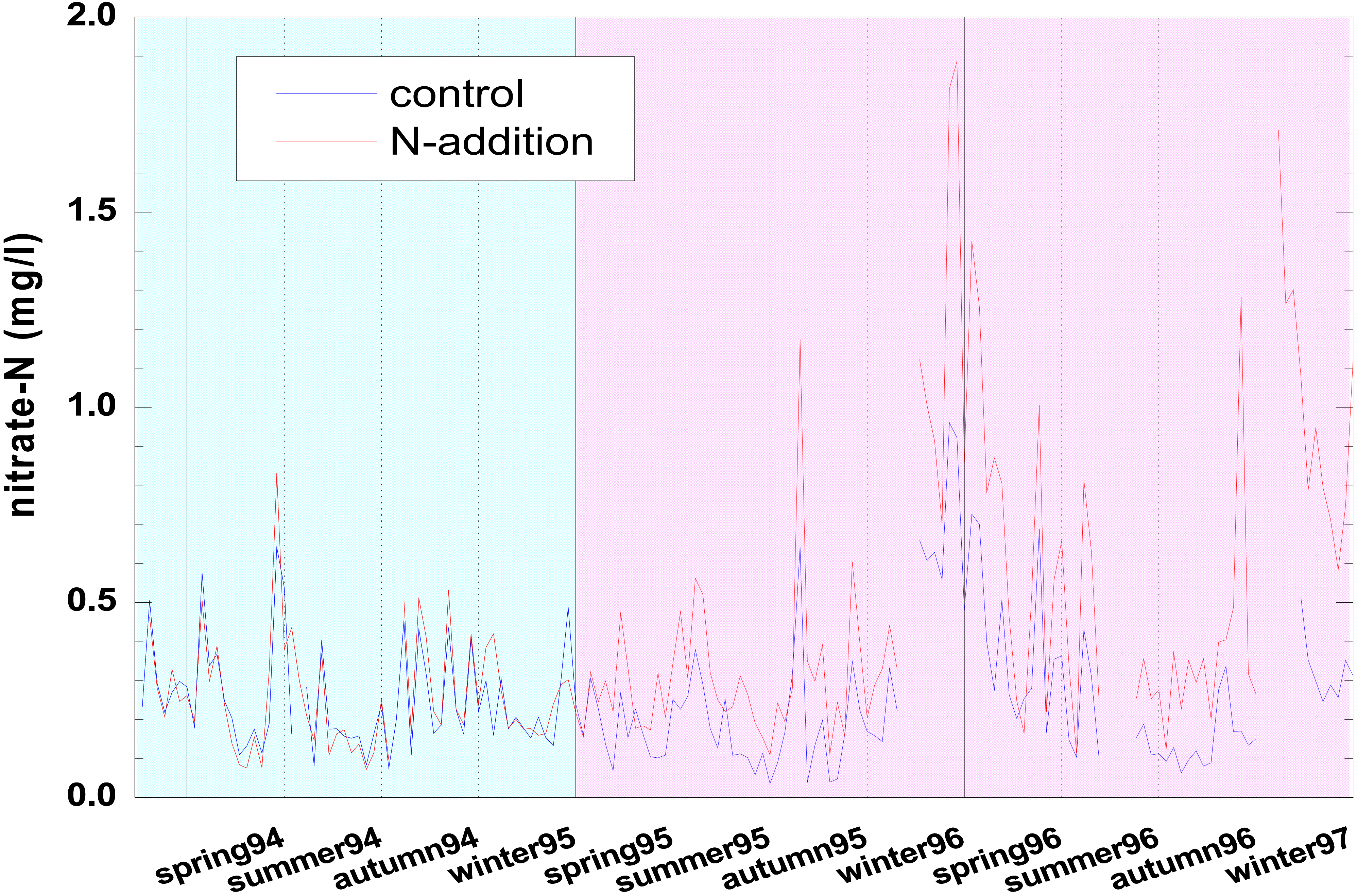
texture: A/U/S = 45/45/10 %


gauging station
catchment 1 (control)
N
50 m
forest
wetland
irrigation system
road
catchment 3 (wetland)
catchment 2 (N addition)
+NH4NO3
cabin
meteo tower
plastic sheet (water collection)
trenches
1180m
1200m
NITREX



N
50 m
wetland
road
irrigatio
catchment 3
(wetland)
on)
1200m

Nitrate leaching: weekly concentrations



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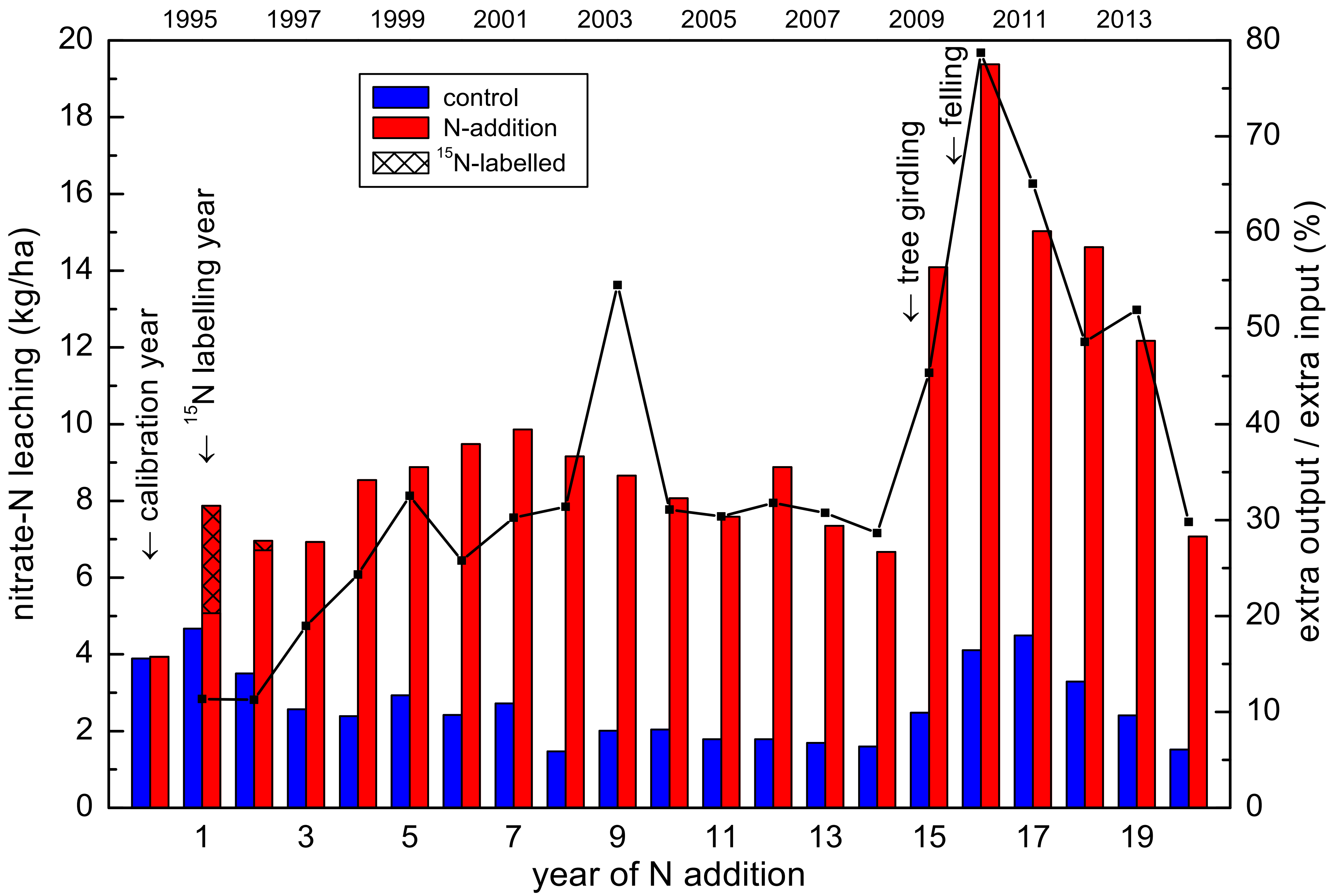

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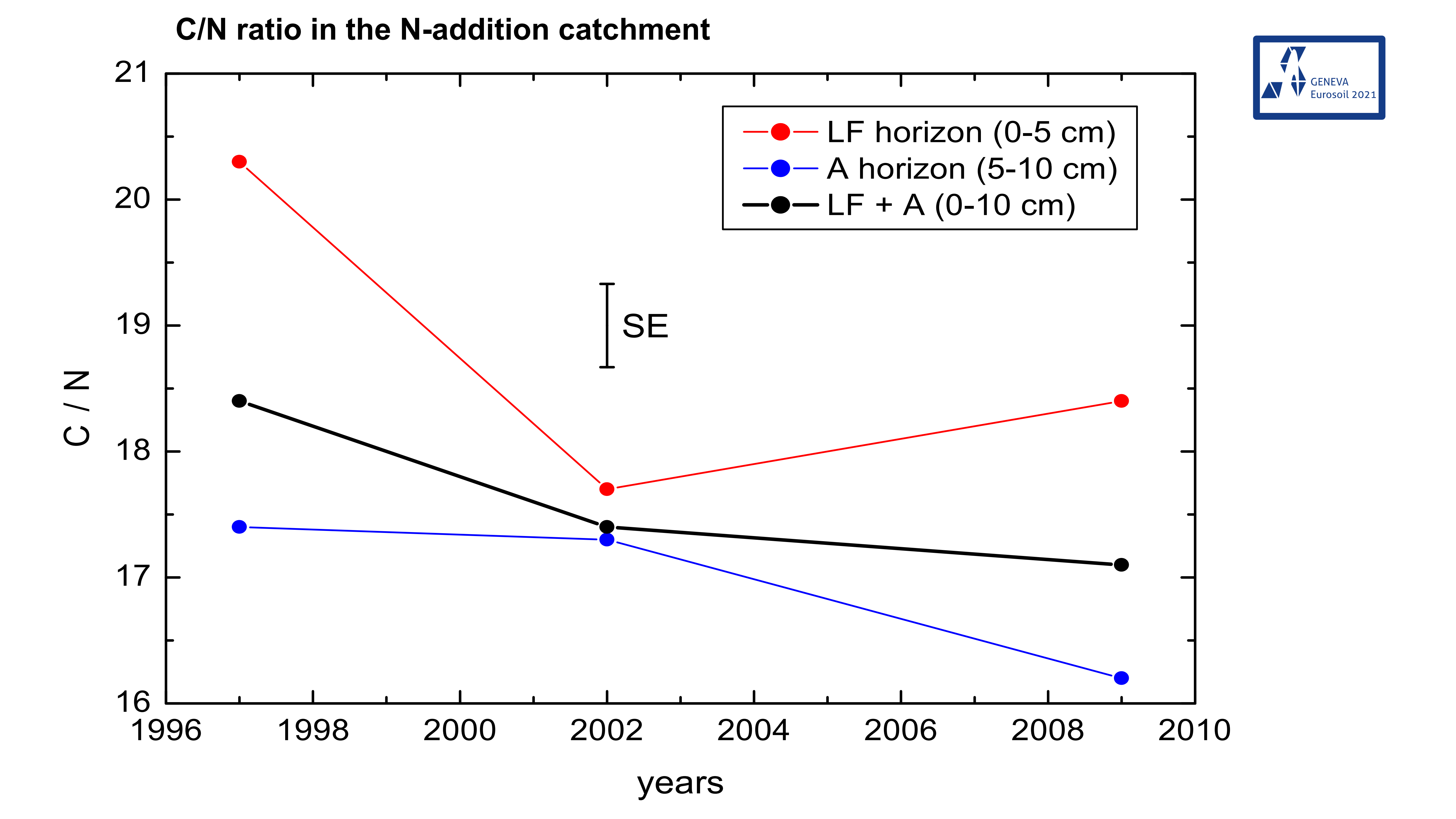
C/N ratio in the N-addition catchment
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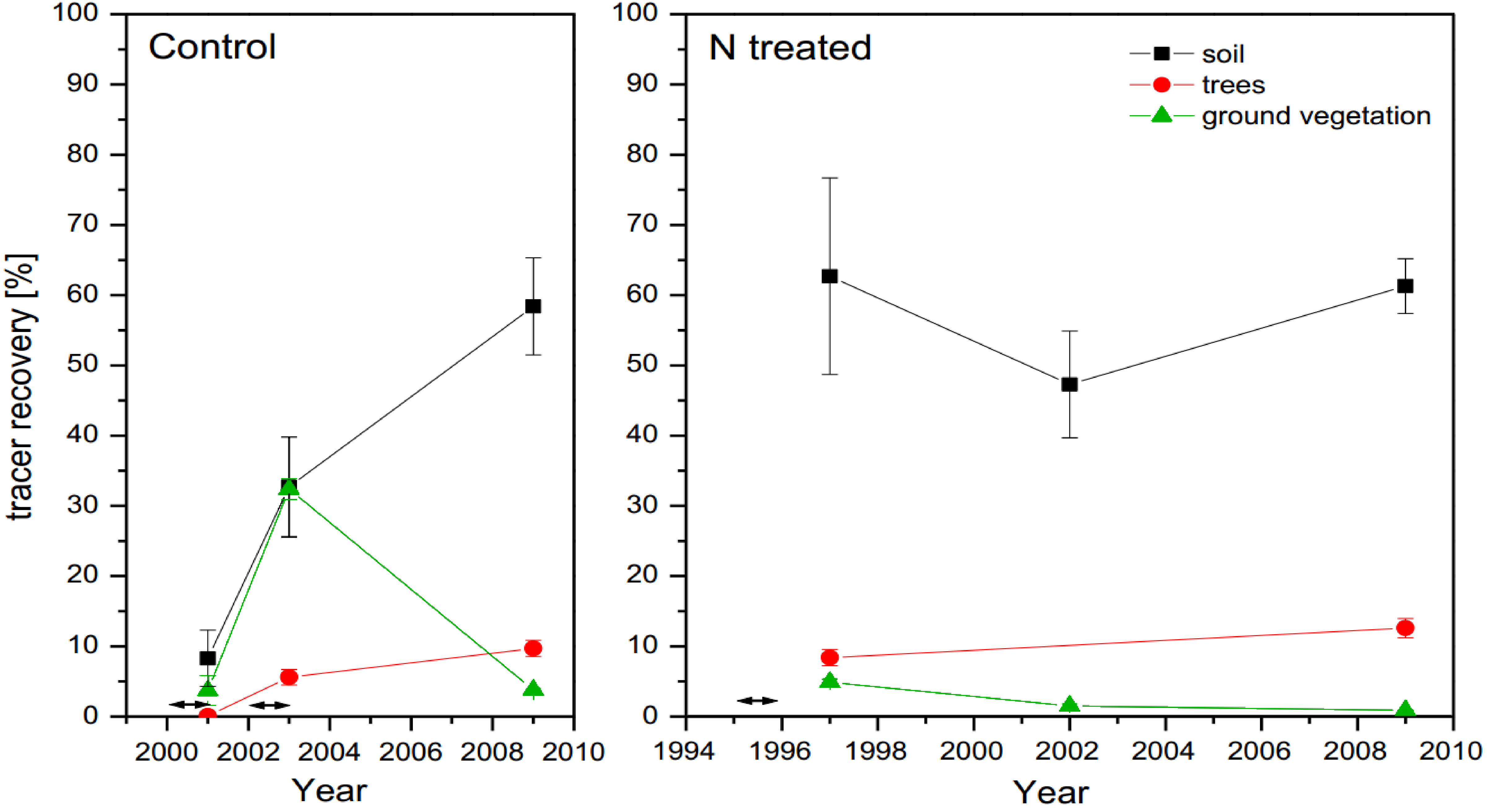
LF horizon (0-5 cm)
A horizon (5-10 cm)
LF + A (0-10 cm)
SE
C / N
21
20
19
18
17
16
1996
1998
2000
2002
2004
2006
2008
2010
years

^{15}N recovery over time



^{15}N abundance in pools and fluxes, and mixing ratio of LF horizon and precipitation NO_3^- as potential sources of NO_3^- leaching

pool / flux	N species	period	$\delta^{15}N$		precipitation mixing ratio	
			control	N addition	control	N addition
runoff (leaching)	NO_3^-	2005-2009 (1)	-3.8	-0.5	0.98	0.72
runoff (leaching)	NO_3^-	2009-2010 (2)	-1.5	-1.4	0.82	0.79
runoff (leaching)	NO_3^-	2010-2013 (3)	0.4	-0.7	0.68	0.73
yearly litterfall	total	2009	8.5	4.0		
LF horizon	total	2009	10.1	8.7		
A horizon	total	2009	0.5	2.7		
B horizon	total	2009	1.0	1.7		
precipitation	NO_3^-	1994-2002	-4.1			
precipitation	NH_4^+	1994-2002	-7.0			

(1) before tree girdling

(2) between girdling and felling

(3) after tree felling

Regressions of NO_3^- concentration in runoff water (mg L^{-1}, after log-transformation) against five independent variables. Fortnightly data without snow.

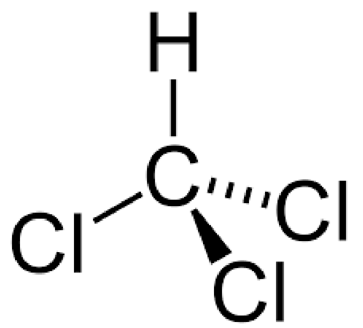
independent variable	control catchment (R^2 = 0.55) coefficient	standard error	*P* value	N-addition catchment (R^2 = 0.37) coefficient	standard error	*P* value
NO_3^--N concentration in throughfall (mg L^{-1}) (1)	0.88	0.10	< 0.0001	0.52	0.08	< 0.0001
tree basal area (m^2 ha^{-1}) (2)	-0.115	0.015	< 0.0001	-0.101	0.015	< 0.0001
Cl^- leaching ratio	0.069	0.016	< 0.0001	0.065	0.017	0.0001
discharge volume (mm) (1)	-0.146	0.046	0.0017	-0.222	0.034	< 0.0001
soil temperature (°C)	-0.014	0.011	0.19	-0.013	0.011	0.24

(1) log-transformed

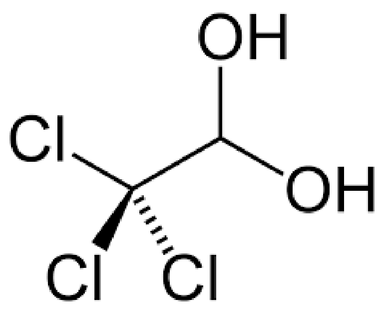
(2) living trees > 10 cm diameter at breast height

Disinfection Byproduct Formation Potentials (DBP-FP)

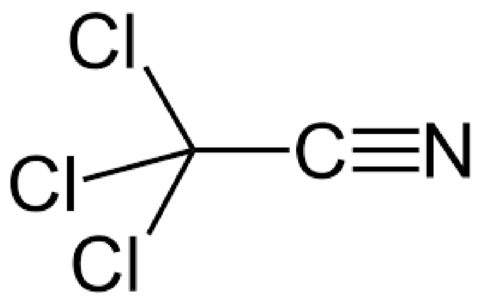
- Over 600 disinfection byproducts have been identified
- All disinfection processes including UV-light and ozone can generate DBPs
- 3 commonly observed DBPs are examined in this study using chlorination
- Excess chlorine was added into filtered water for 24 hours
- Concentrations of DBPs were determined using GC-ECD



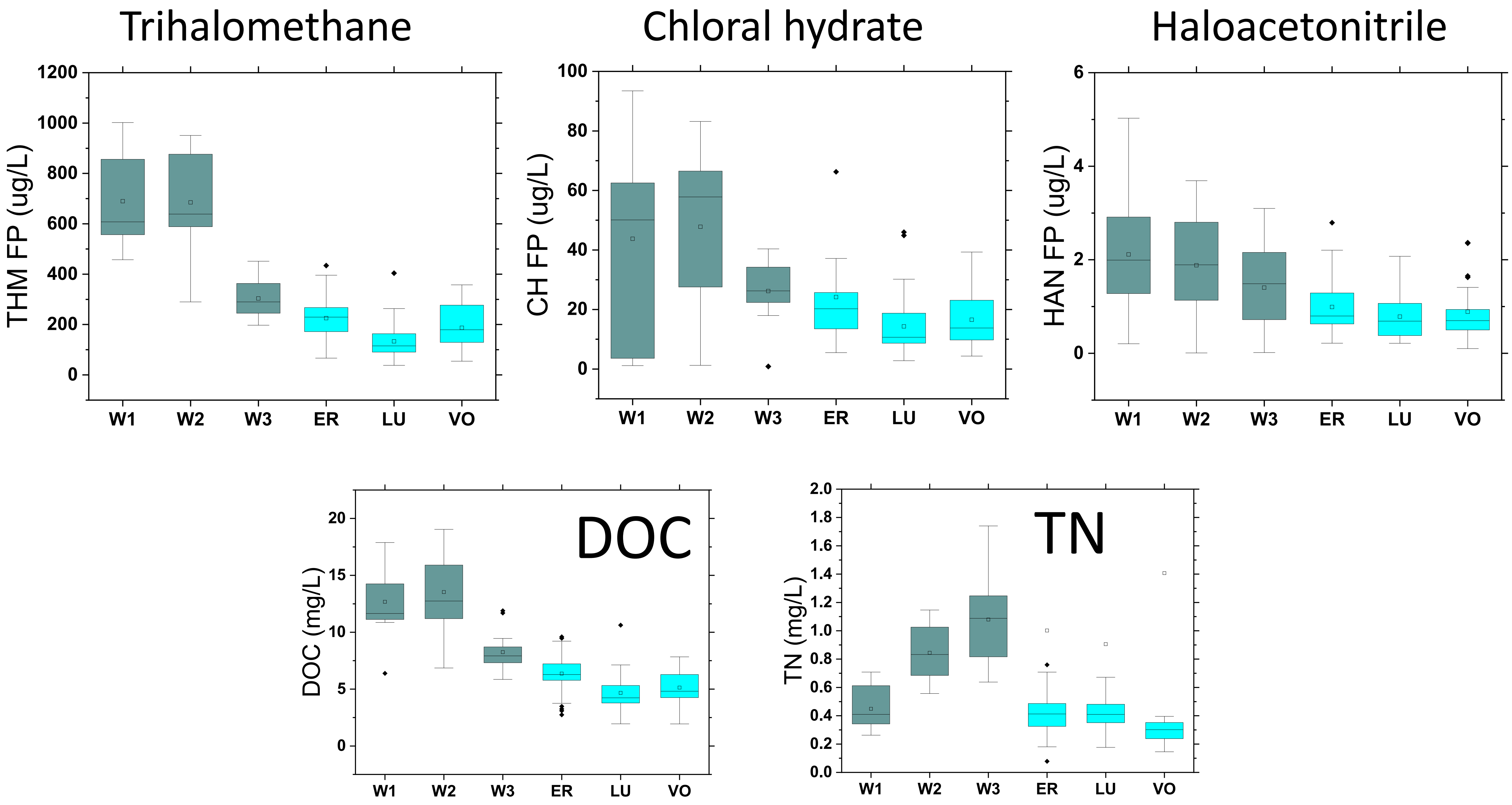
Trihalomethane



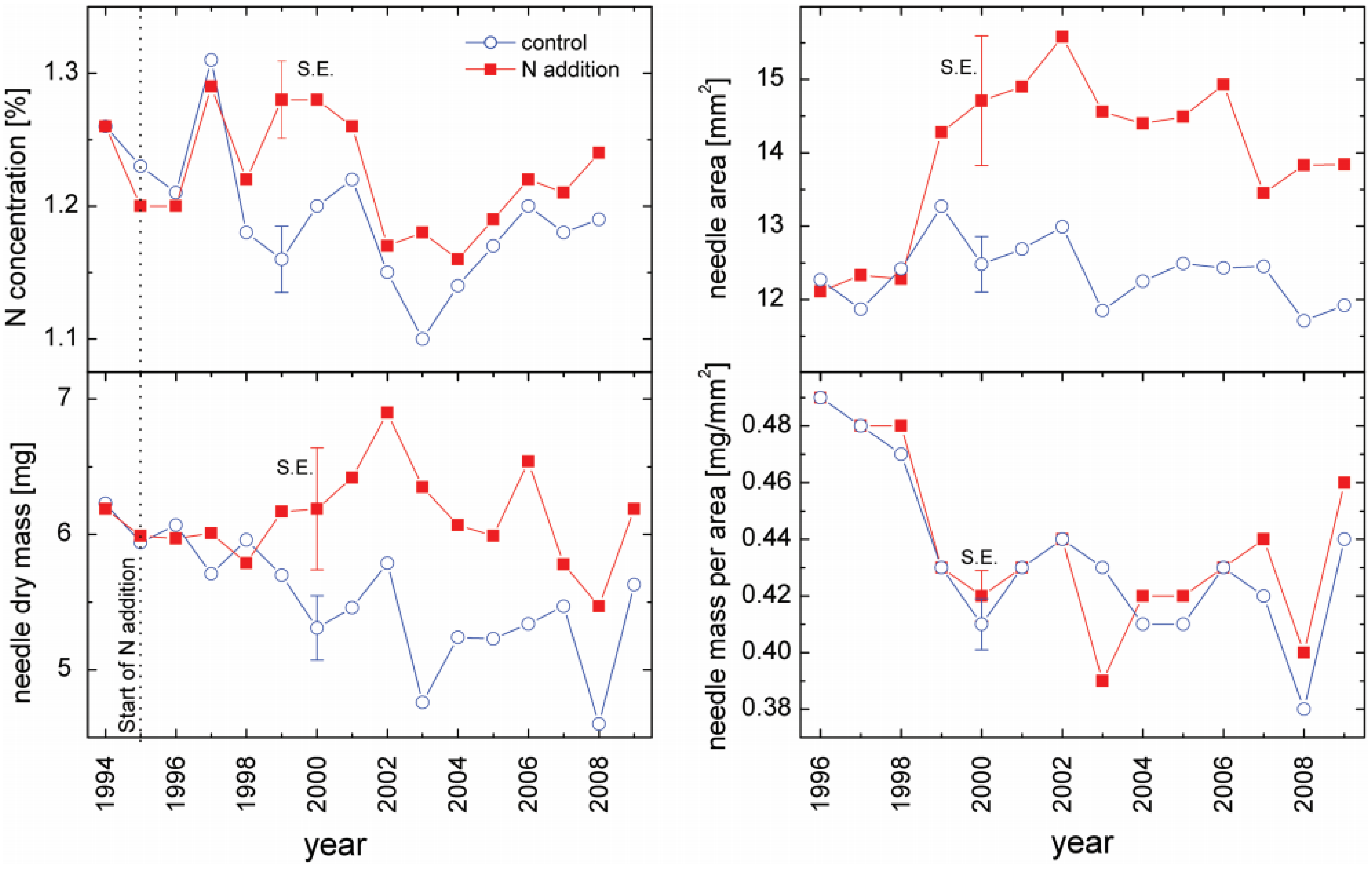
Chloral Hydrate



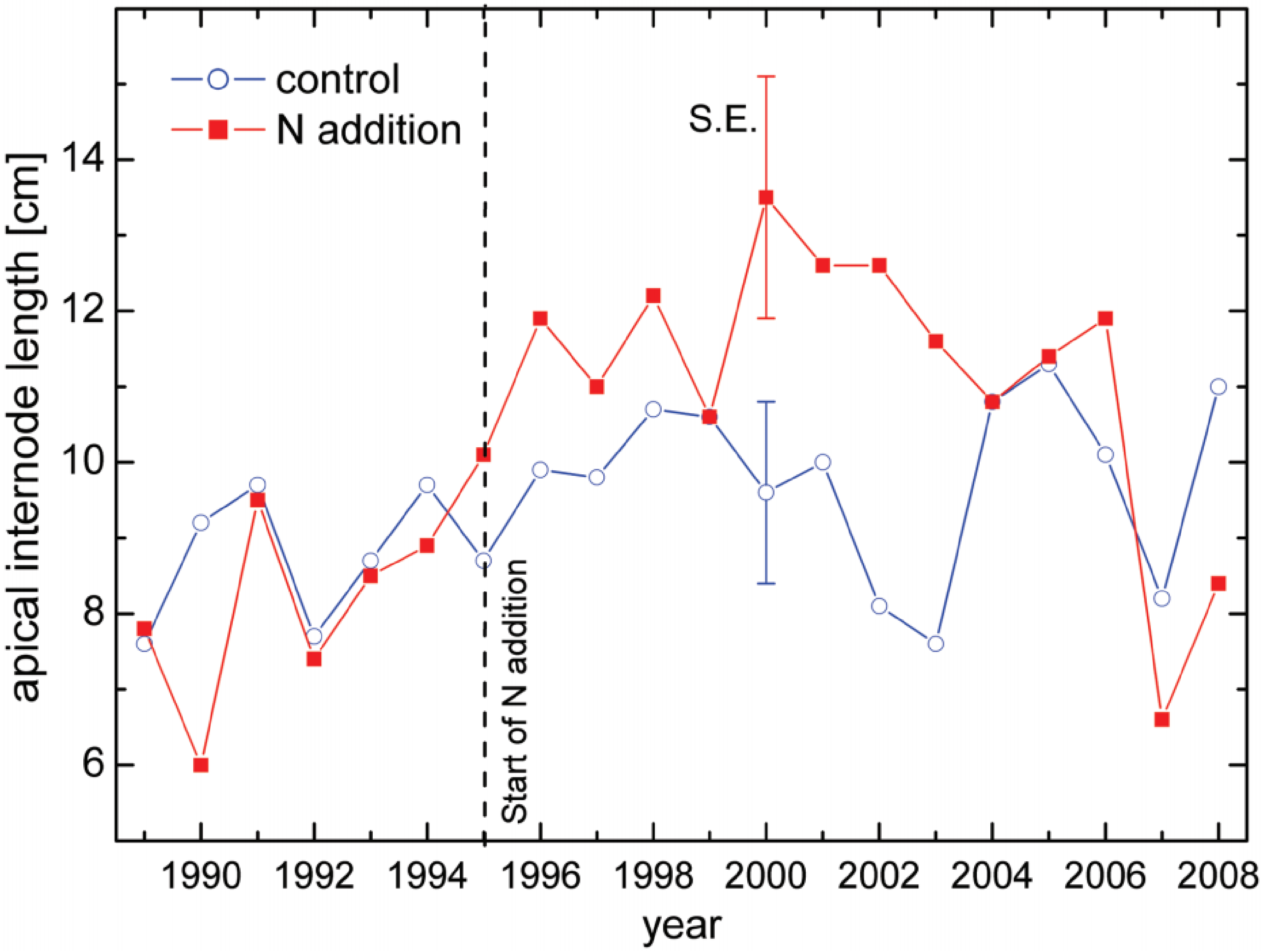
Haloacetonitrile

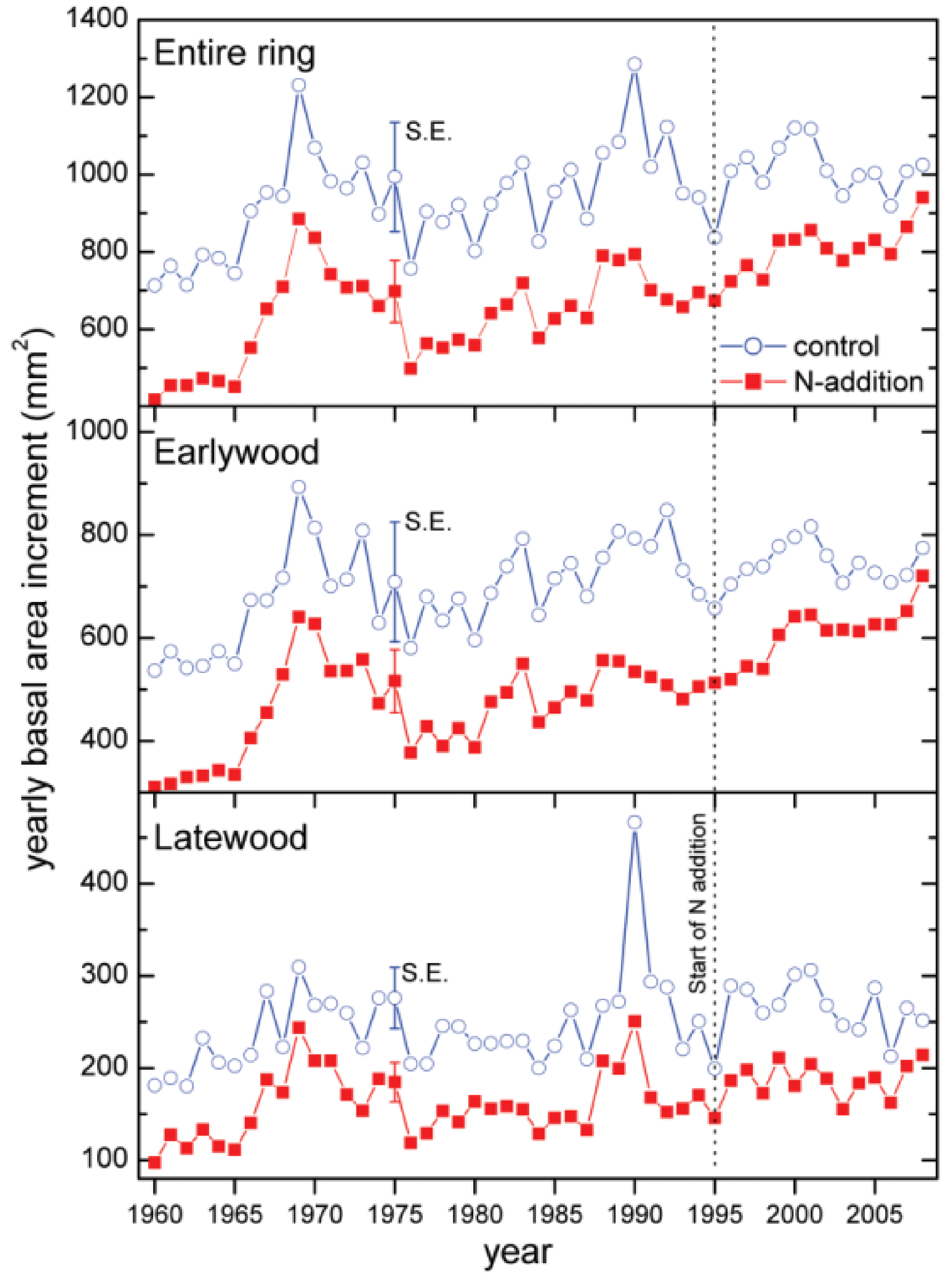

Trihalomethane
Chloral hydrate
Haloacetonitrile
THM FP (ug/L)
CH FP (ug/L)
HAN FP (ug/L)
DOC
TN
DOC (mg/L)
TN (mg/L)
W1
W2
W3
ER
LU
VO

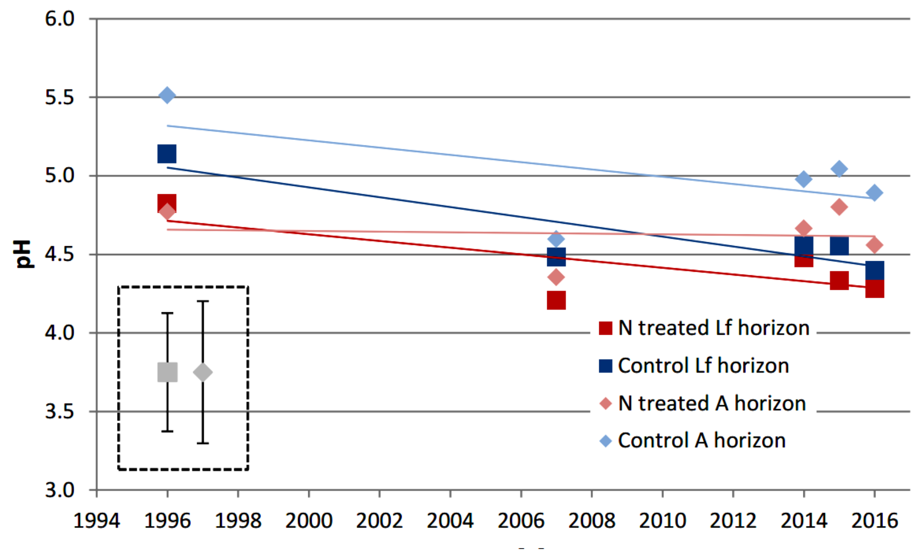
Effect of N addition on tree needles



Effect of N addition on tree growth







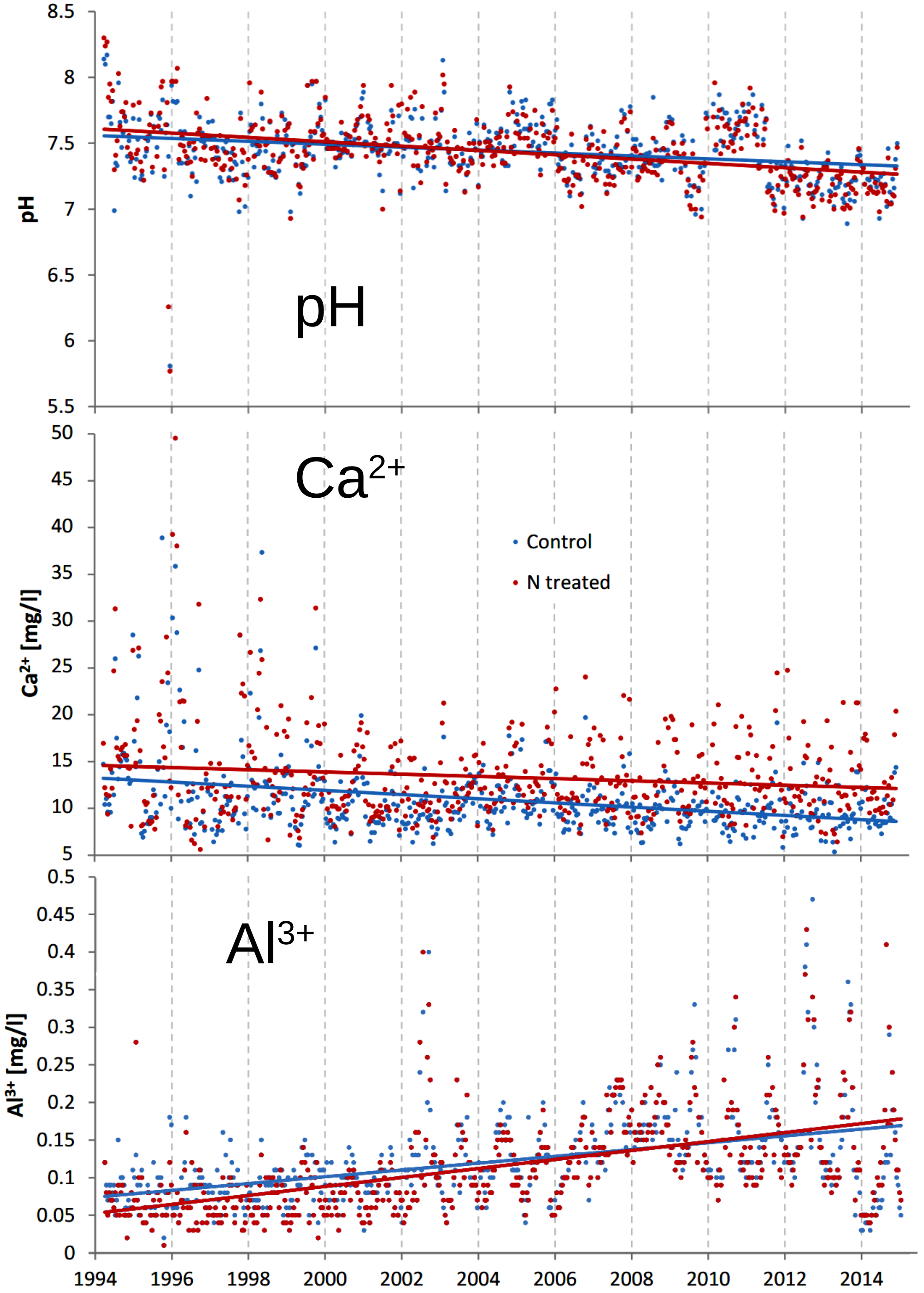
Acidification

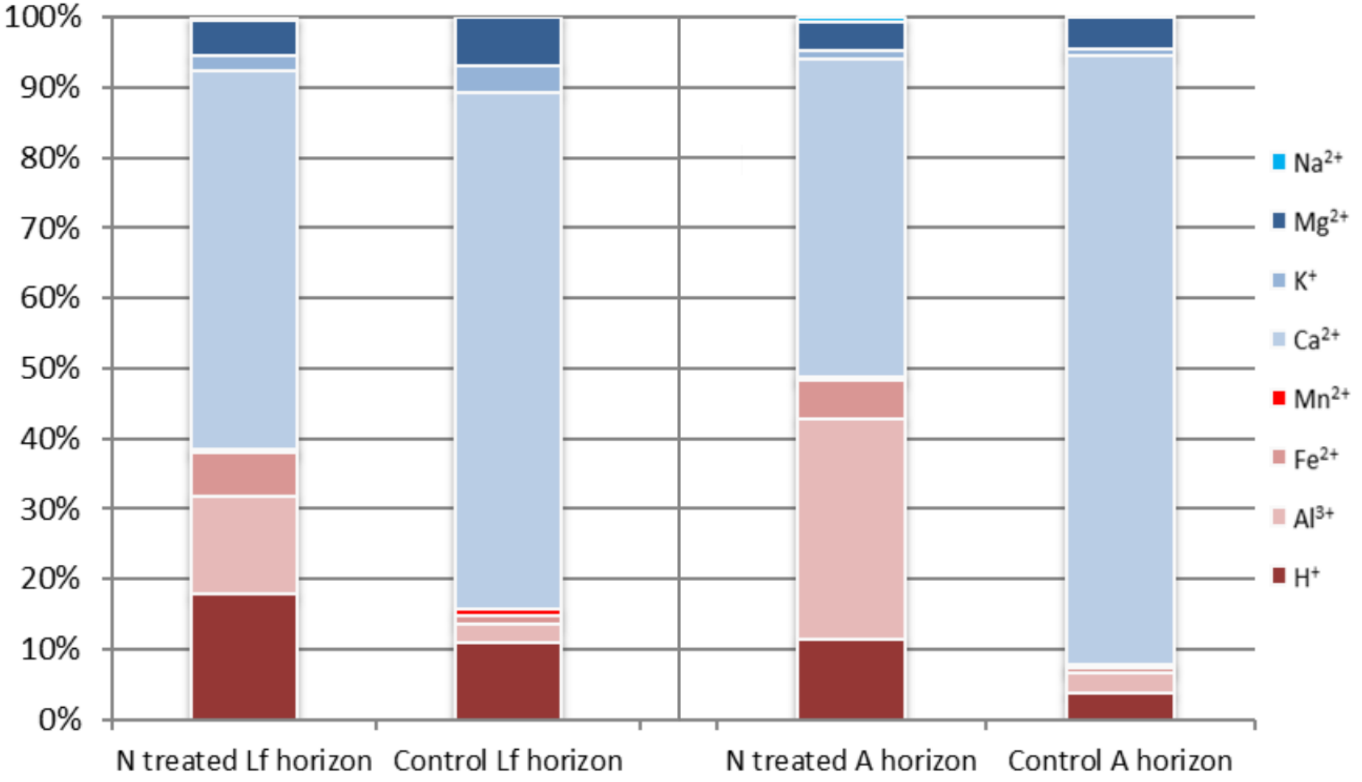
(Bär, 2017)

← soil pH

runoff water →

↙ soil CEC





Conclusions

- At decadal scale, N from deposition goes mainly into: soil > NO_3^- leaching > trees > ground vegetation
- Soil and runoff water acidification, in spite of buffered parent material and almost independently of N addition
- N addition decreases DOC/DON
- N deposition still positive for tree growth
- N accumulation in the soil ⇒ susceptibility to NO_3^- leaching in case of disturbances