Nitrogen retention and nitrate leaching in a sub-alpine forest subjected to experimentally increased N deposition for 15 years

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Warnings

This presentation may partly be difficult to understand without the oral comments of the author. Questions can be addressed to: patrick.schleppi@wsl.ch

Some of the results are not yet definitive and thus subject to changes

NITREX

Manipulation of N deposition

Alptal

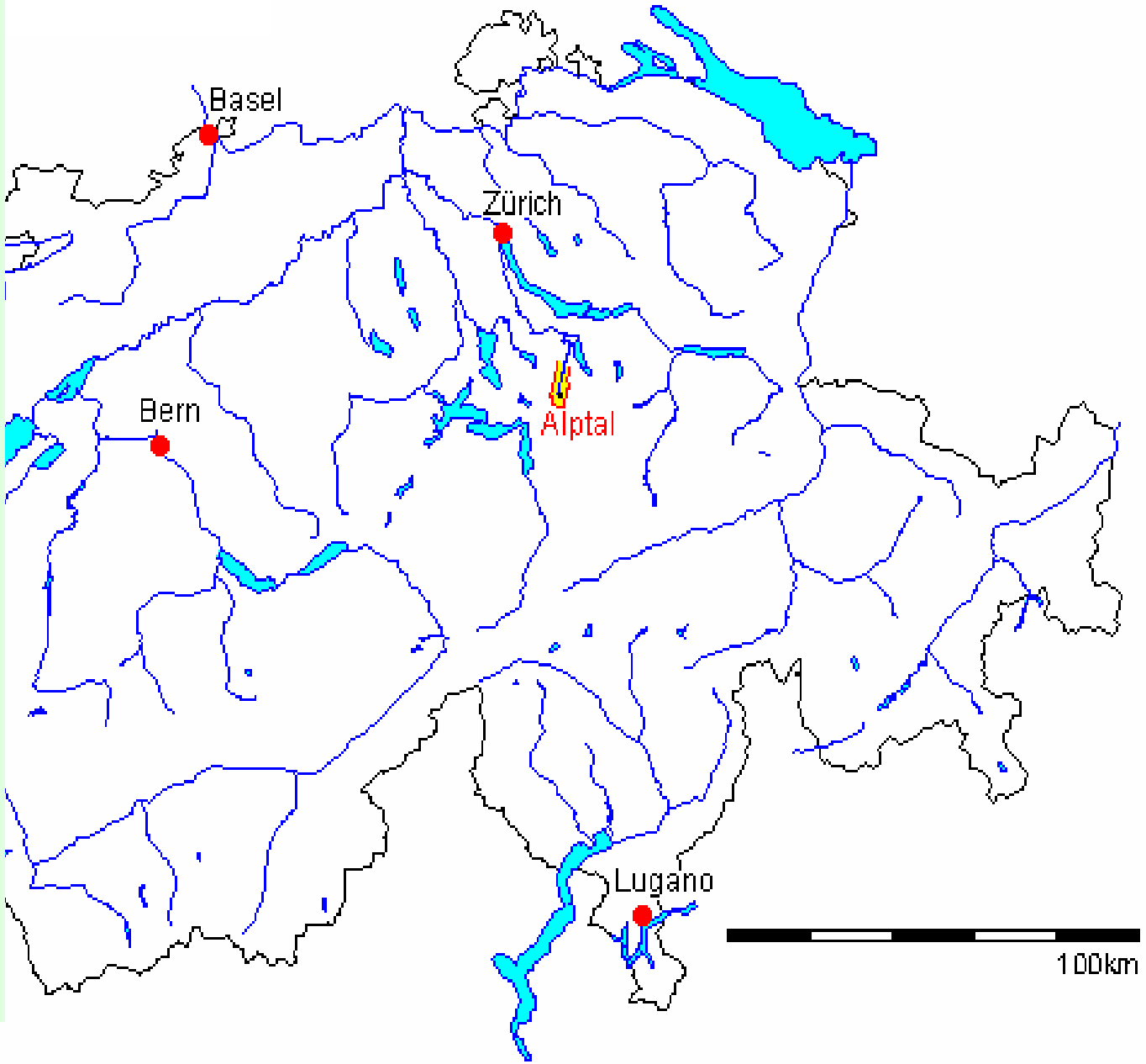
Altitude:
1200 m

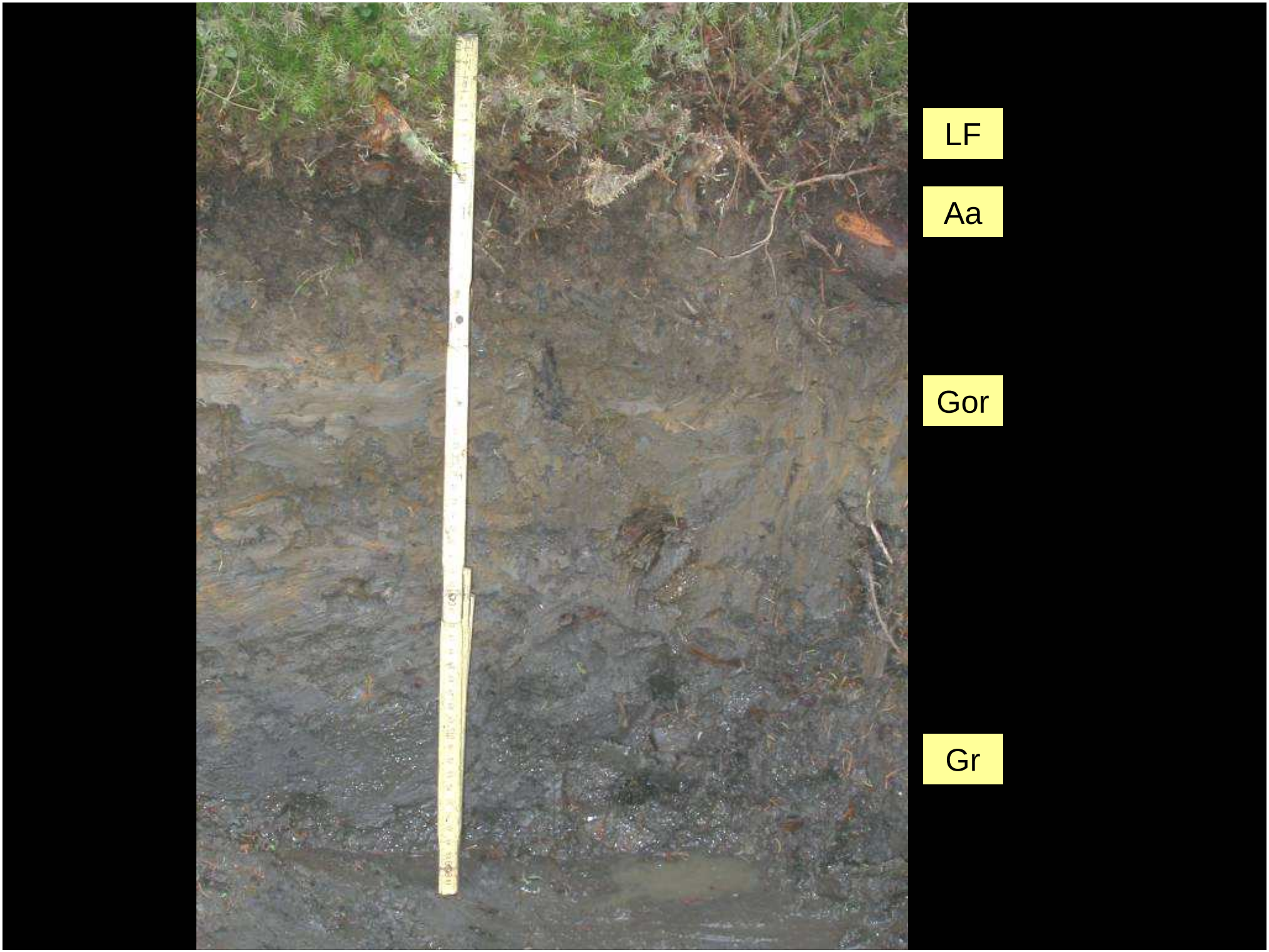
Geology and soils:
Gleysol over Flysch

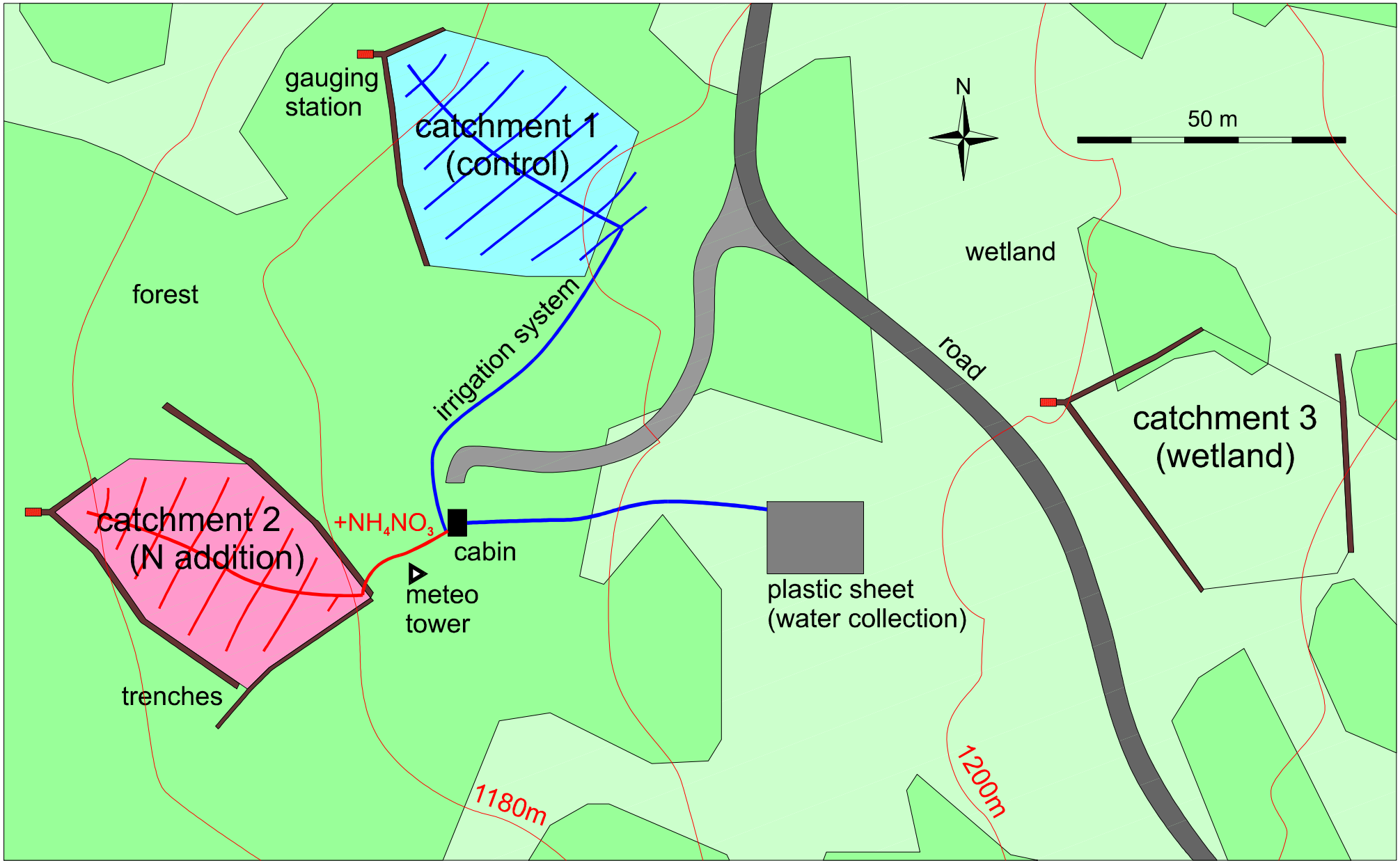
Vegetation:
mosaic of forest and wetland patches

Precipitation:
2300 mm/a
(30% as snow)

Bulk N deposition:
12 kg/ha/a
($NO_3^- \cong NH_4^+$)




LF
Aa
Gor
Gr


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

NITREX

IRISALP

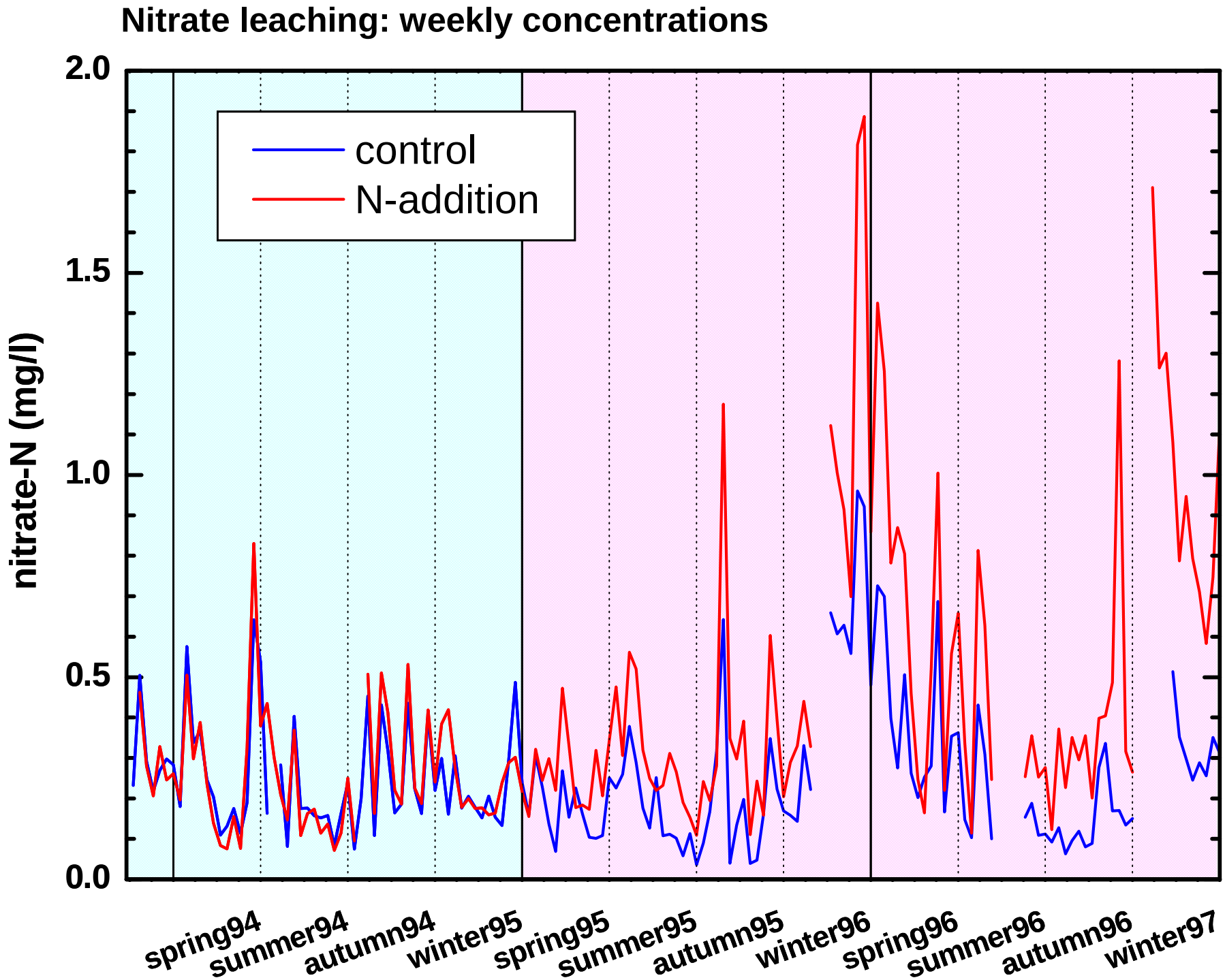
N

50 m

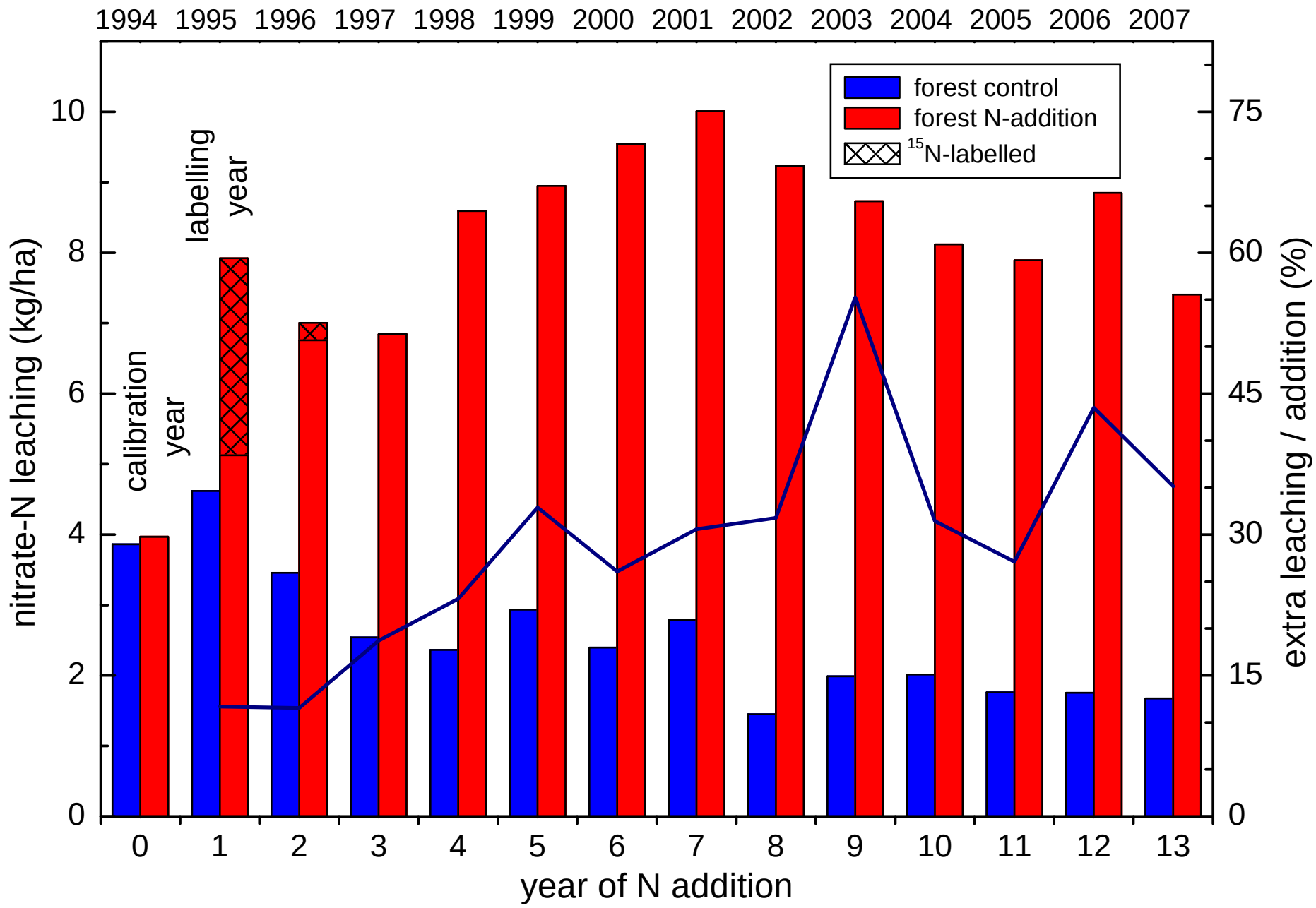
wetland

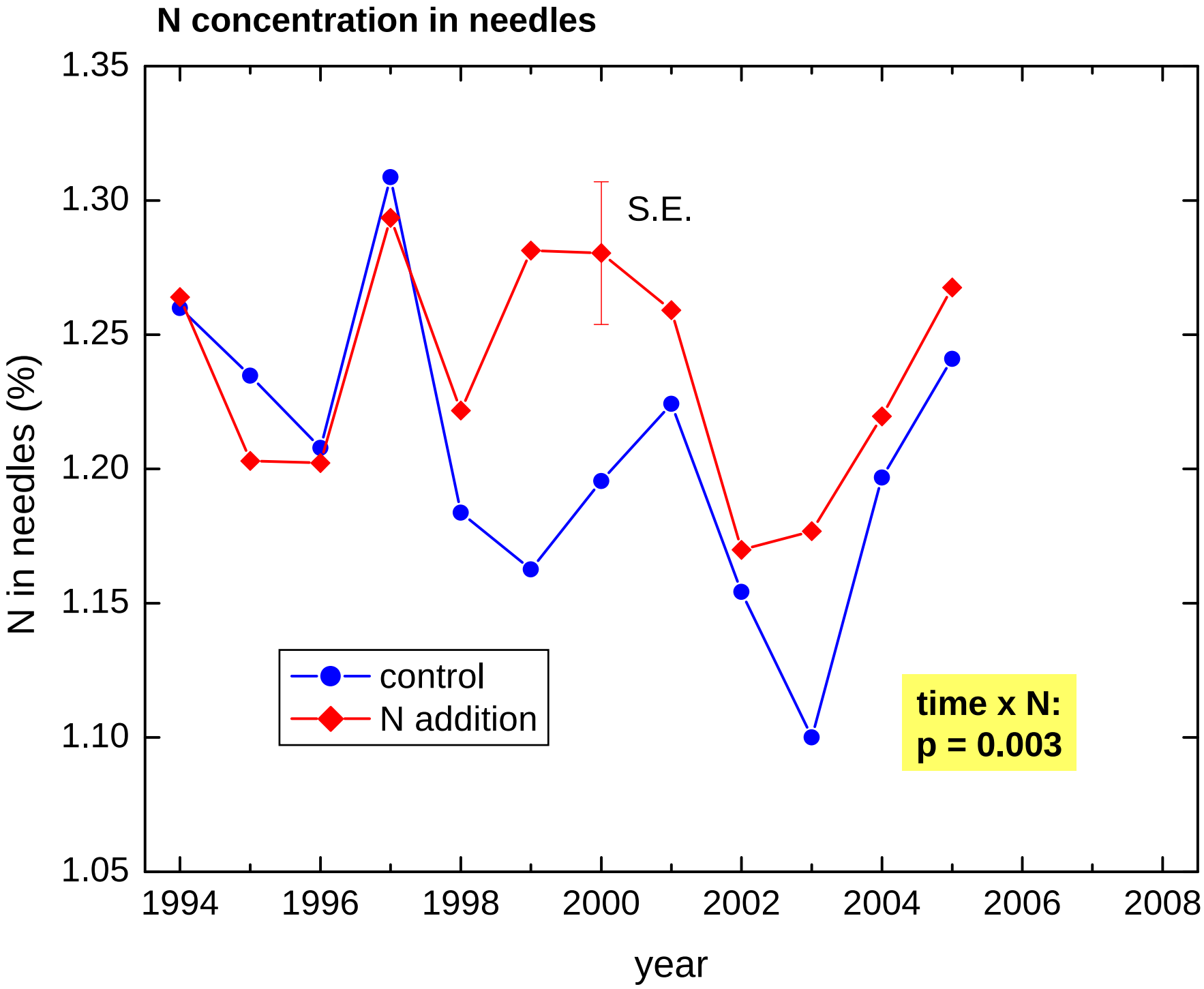
irrigation s

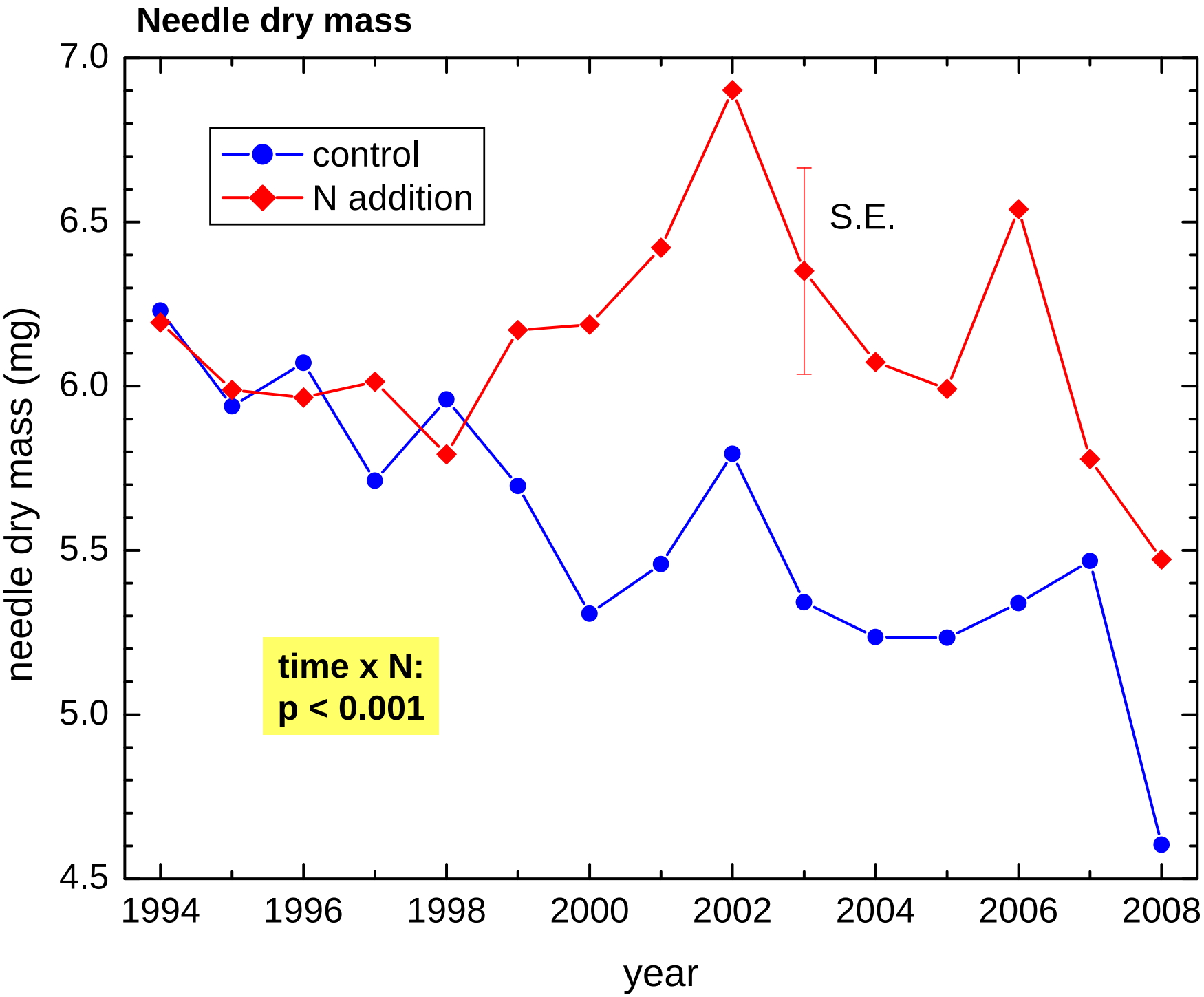
catchment 3
(wetland)

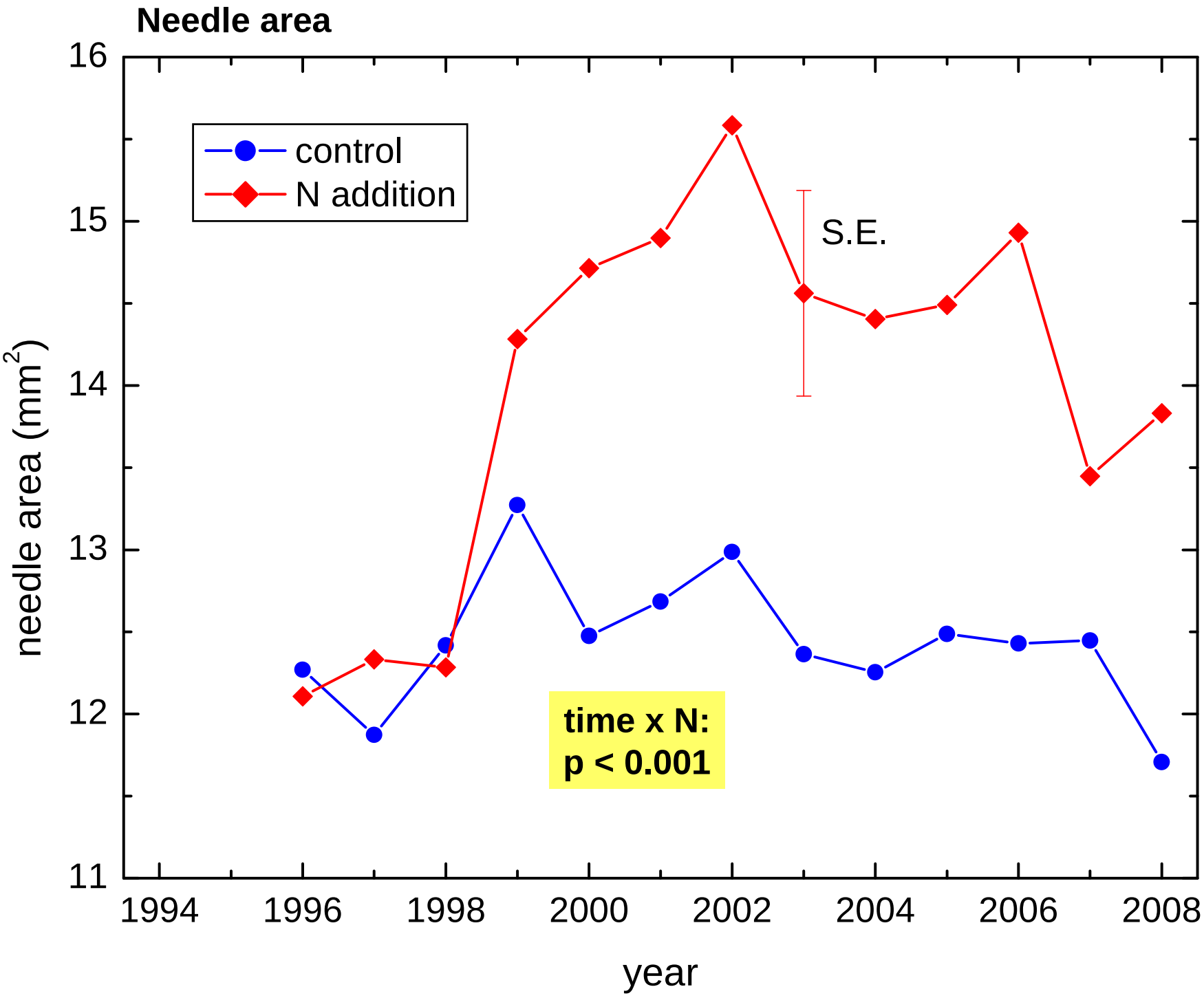

Nitrate leaching: weekly concentrations
nitrate-N (mg/l)
2.0
1.5
1.0
0.5
0.0
control
N-addition
spring94
summer94
autumn94
winter95
spring95
summer95
autumn95
winter96
spring96
summer96
autumn96
winter97

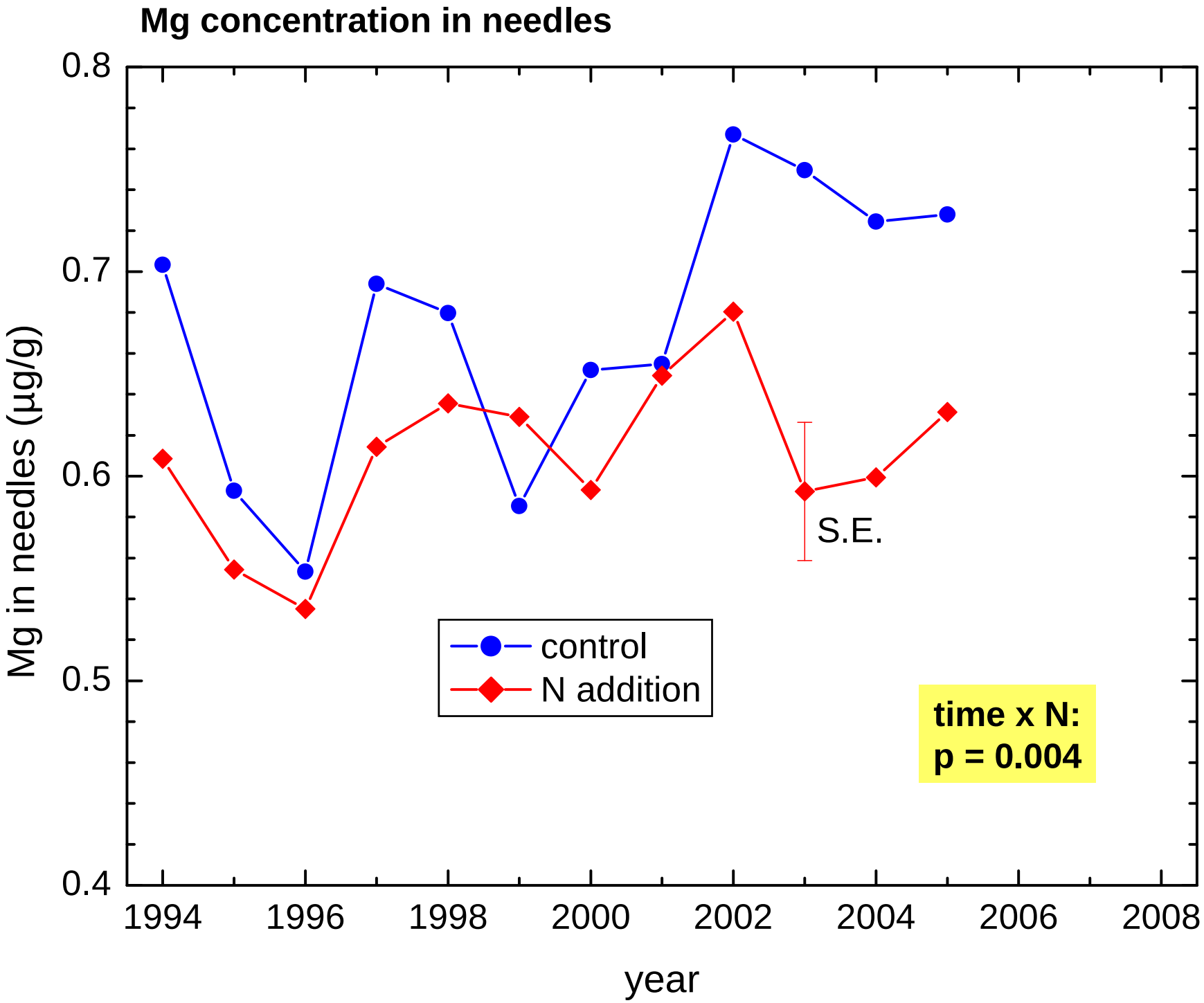
Nitrate leaching: long-term effects

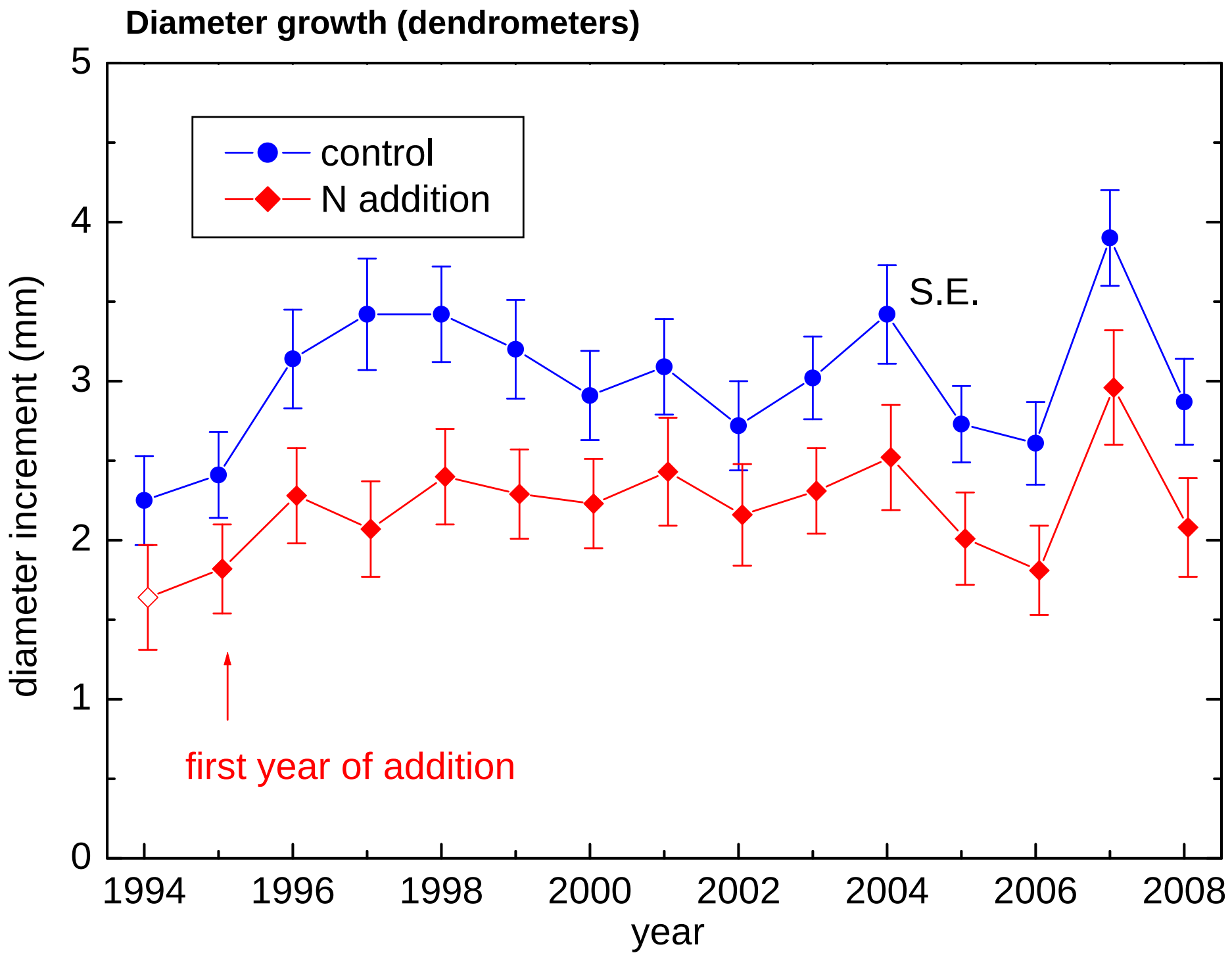


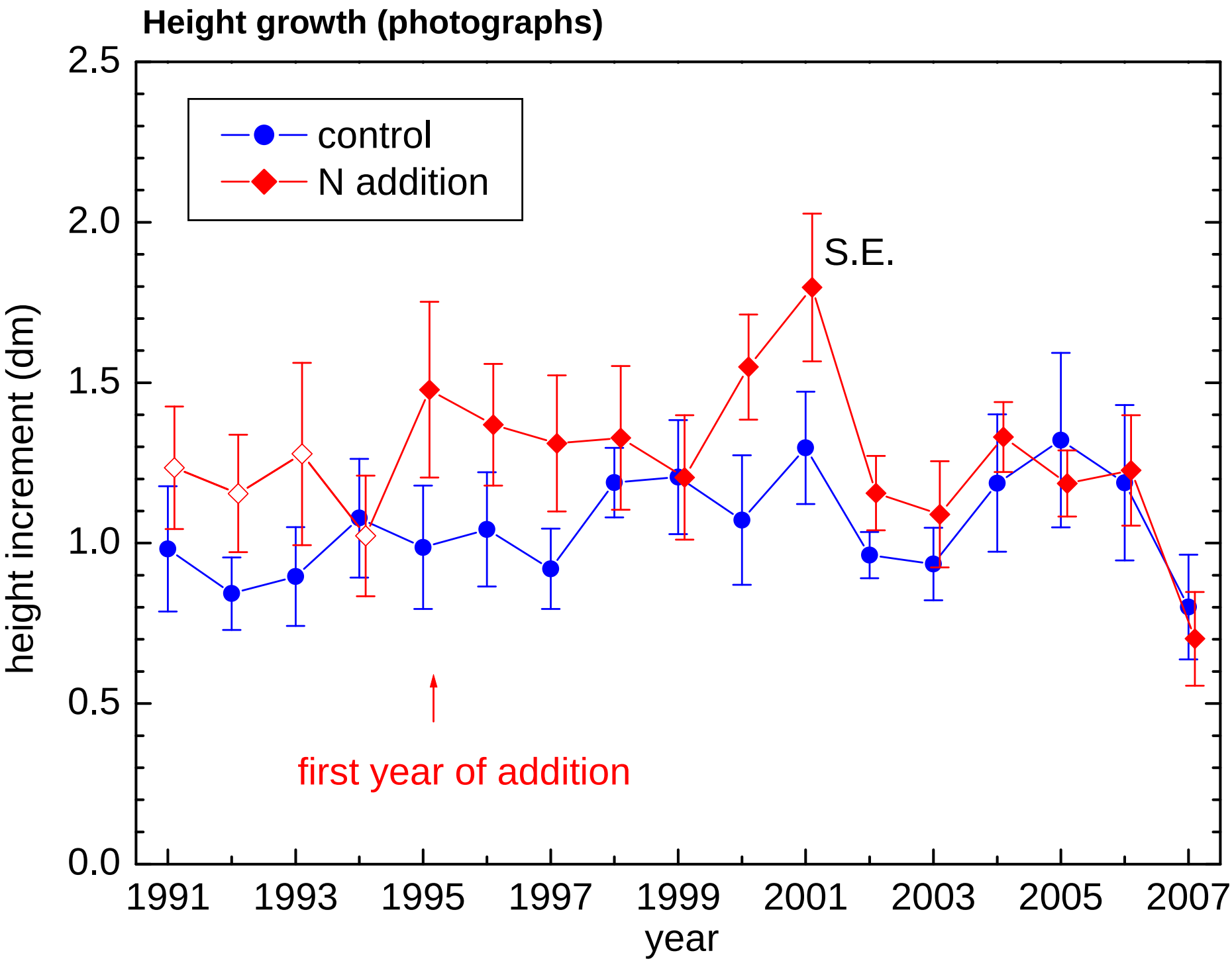

N concentration in needles
1.35
1.30
1.25
1.20
1.15
1.10
1.05
N in needles (%)
1994
1996
1998
2000
2002
2004
2006
2008
year
S.E.
control
N addition
time x N:
p = 0.003

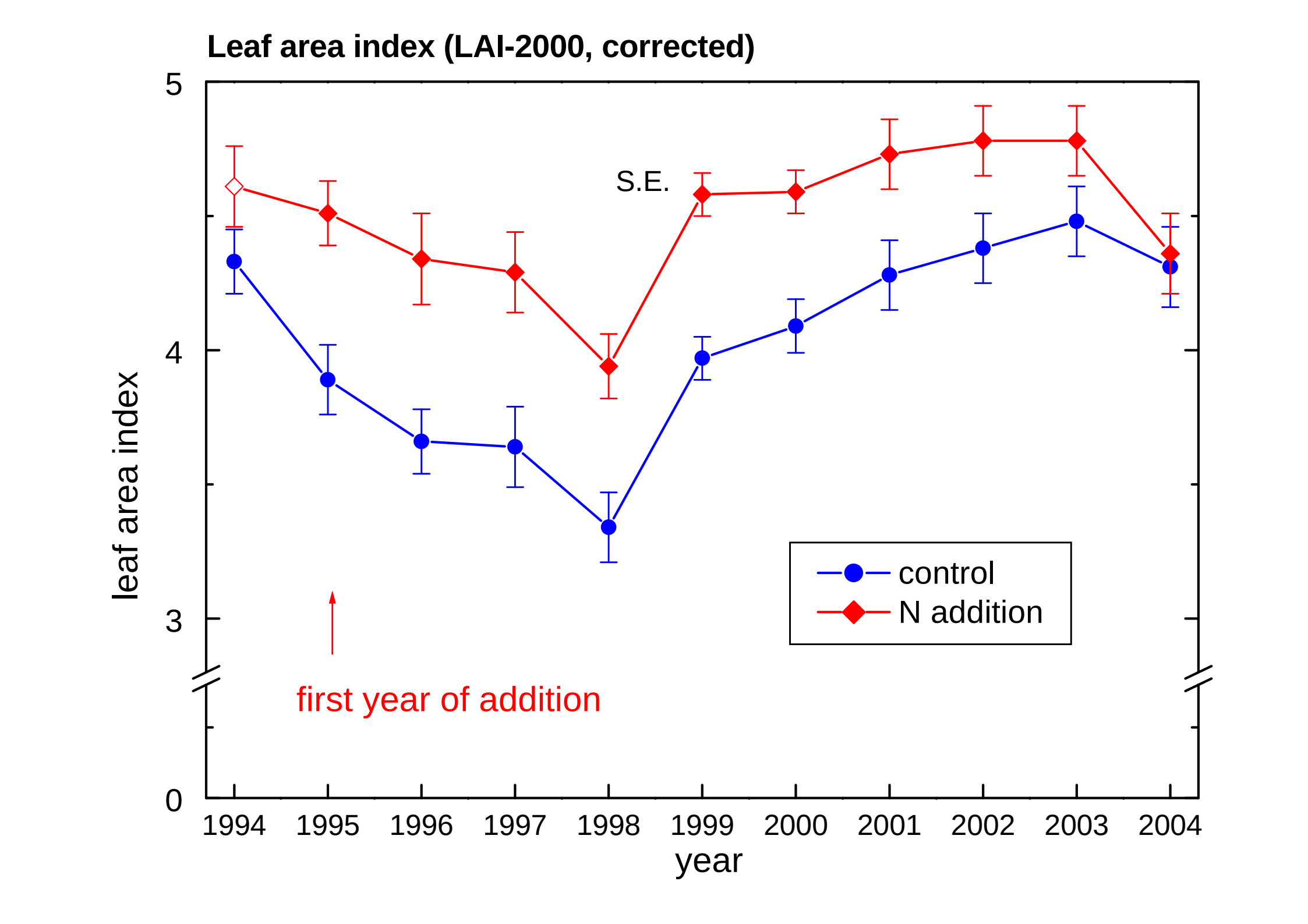

Needle dry mass
7.0
6.5
6.0
5.5
5.0
4.5
needle dry mass (mg)
1994
1996
1998
2000
2002
2004
2006
2008
year
control
N addition
S.E.
time x N:
p < 0.001

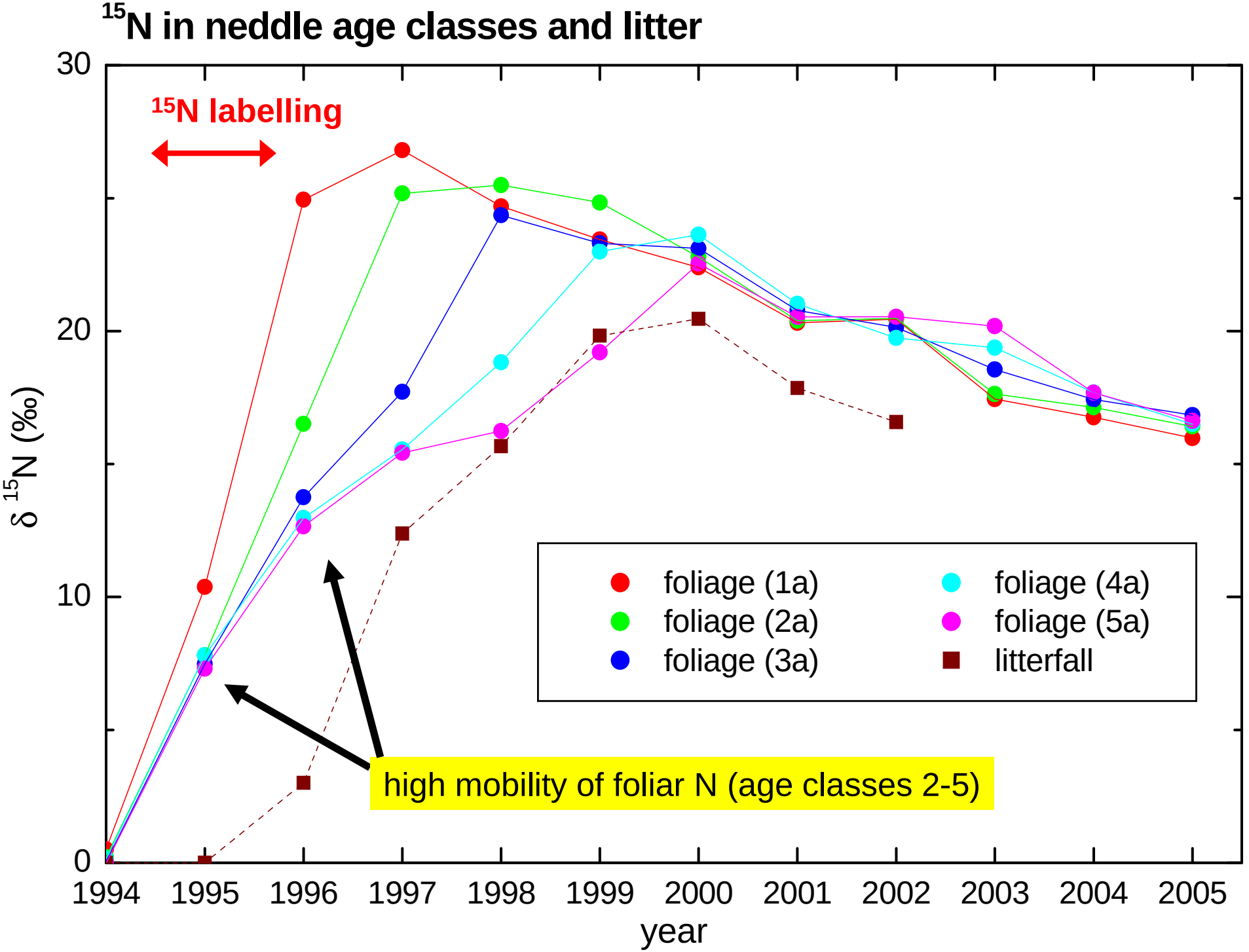

Needle area
control
N addition
S.E.
time x N:
p < 0.001
needle area (mm2)
year
16
15
14
13
12
11
1994
1996
1998
2000
2002
2004
2006
2008


Mg concentration in needles
0.8
0.7
0.6
0.5
0.4
Mg in needles (µg/g)
1994
1996
1998
2000
2002
2004
2006
2008
year
S.E.
control
N addition
time x N:
p = 0.004

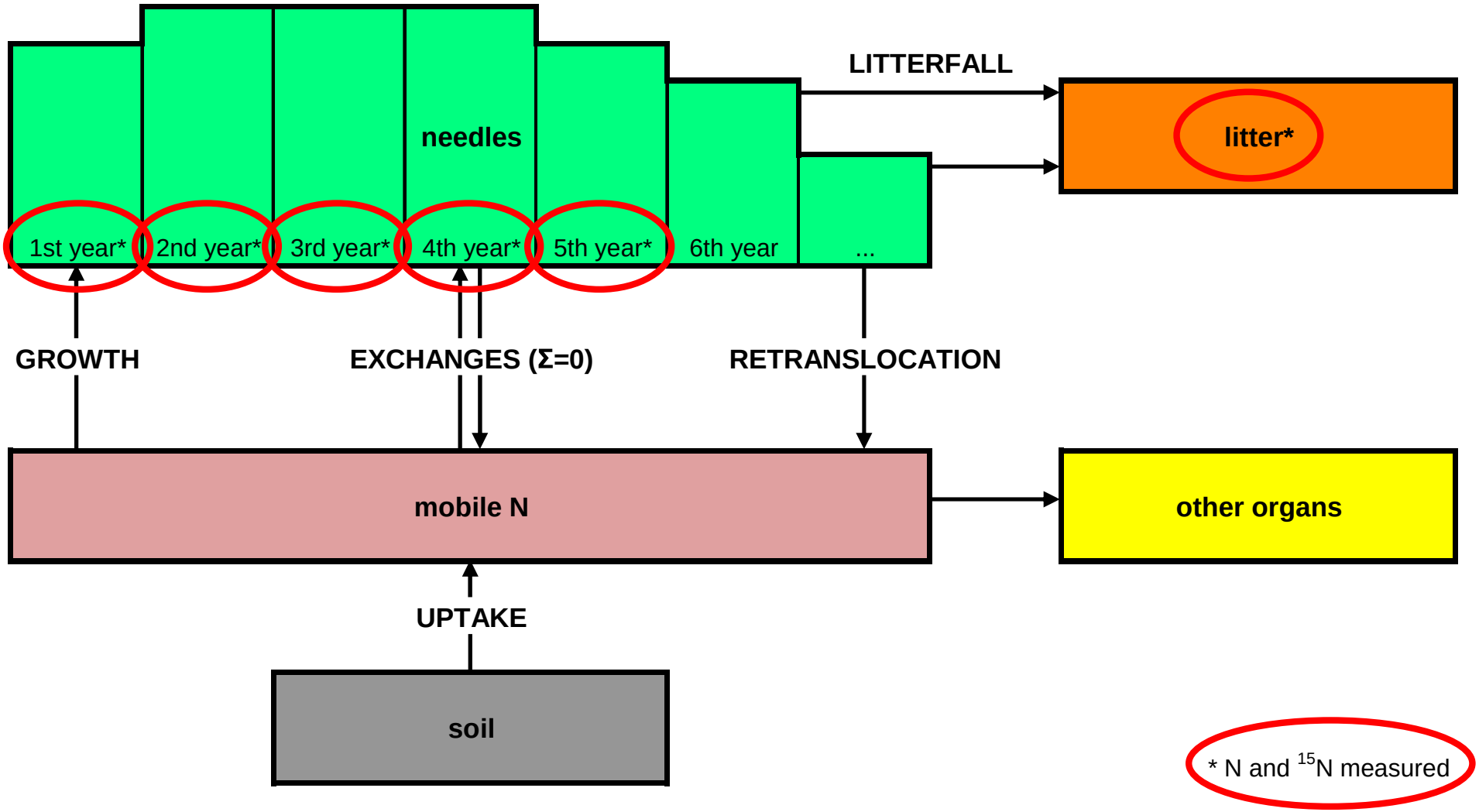

Diameter growth (dendrometers)
control
N addition
S.E.
first year of addition
diameter increment (mm)
year
0
1
2
3
4
5
1994
1996
1998
2000
2002
2004
2006
2008

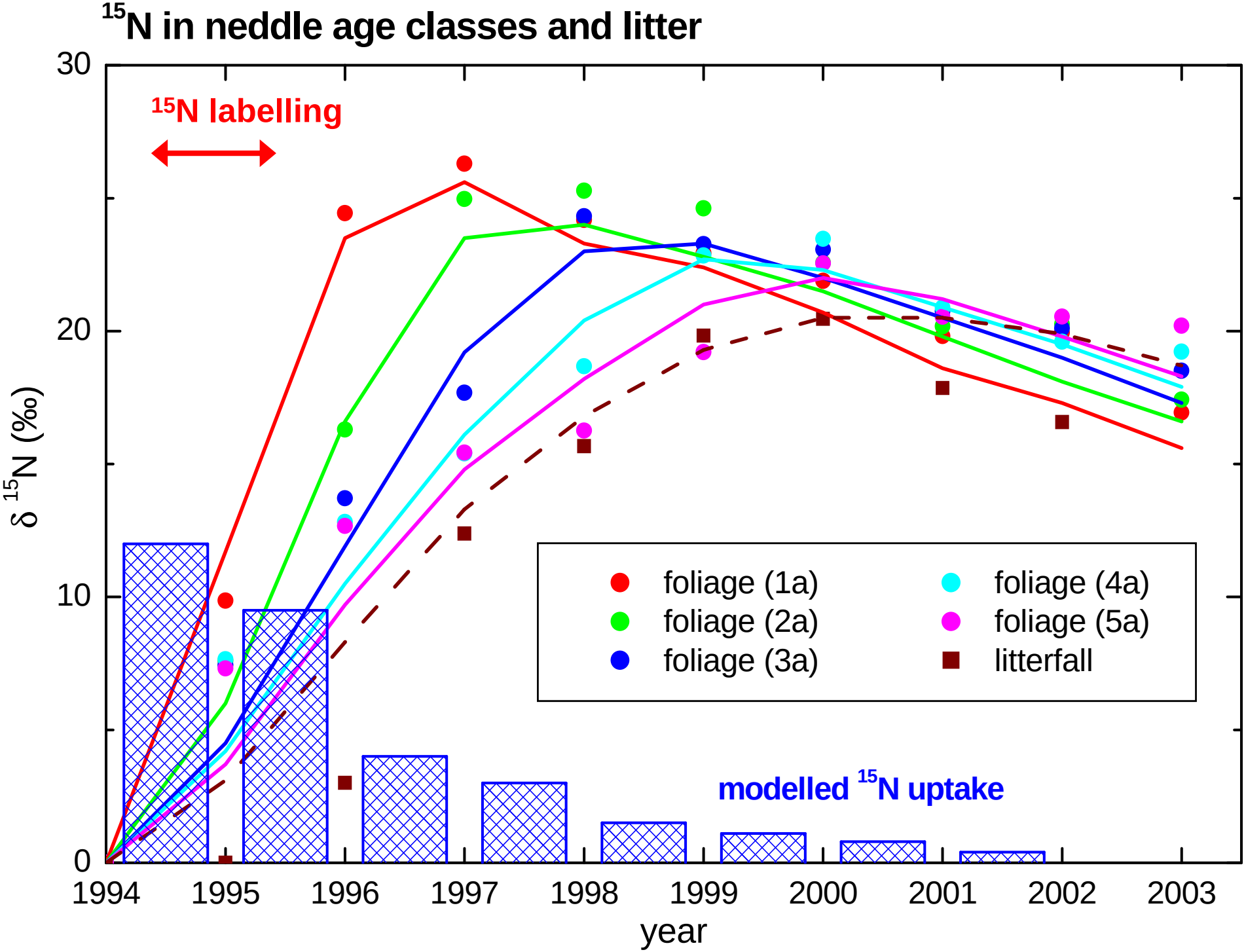

Height growth (photographs)
control
N addition
S.E.
first year of addition
height increment (dm)
year
0.0
0.5
1.0
1.5
2.0
2.5
1991
1993
1995
1997
1999
2001
2003
2005
2007

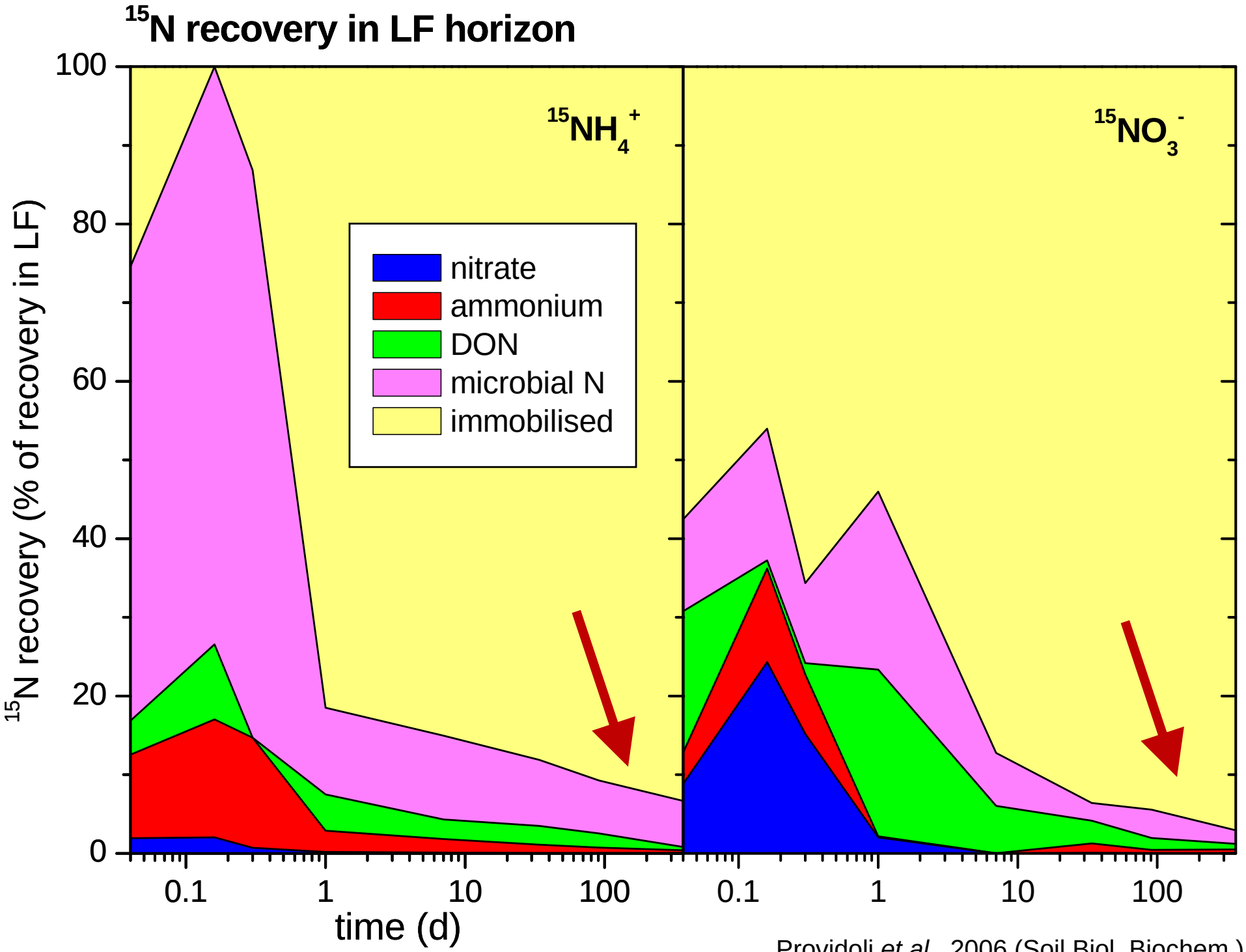

Leaf area index (LAI-2000, corrected)
leaf area index
5
4
3
0
S.E.
control
N addition
first year of addition
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
year


15N in neddle age classes and litter
15N labelling
δ 15N (‰)
year
0
10
20
30
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
foliage (1a)
foliage (2a)
foliage (3a)
foliage (4a)
foliage (5a)
litterfall
high mobility of foliar N (age classes 2-5)

Nitrogen uptake and redistribution model

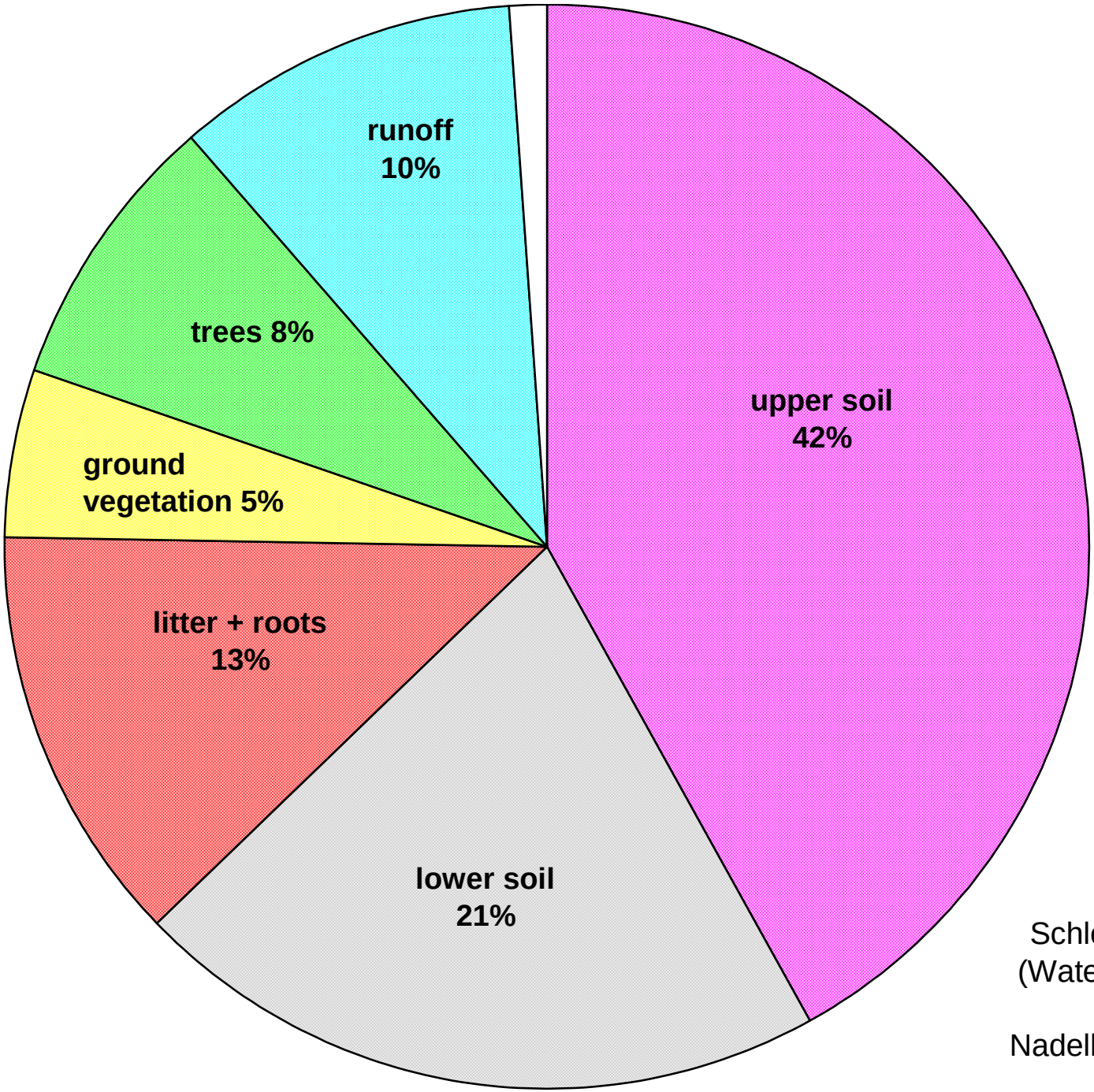



15N in neddle age classes and litter
15N labelling
δ 15N (‰)
30
20
10
0
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
year
foliage (1a)
foliage (2a)
foliage (3a)
foliage (4a)
foliage (5a)
litterfall
modelled 15N uptake



Providoli *et al*., 2006 (Soil Biol. Biochem.)

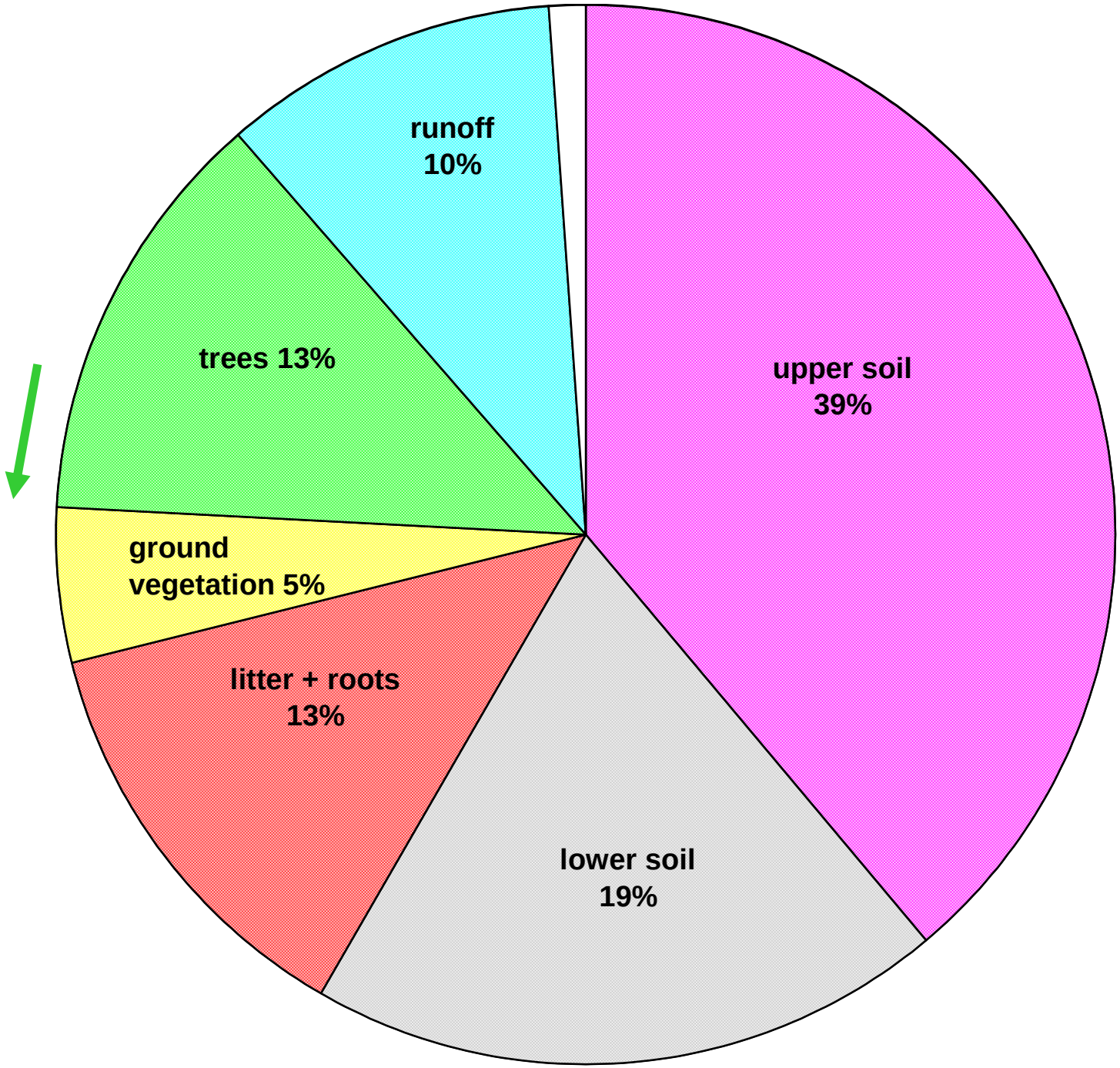
Partitioning of ^{15}N after 1 year



Schleppi *et al.*, 1999
(Water Air Soil Pollut.)

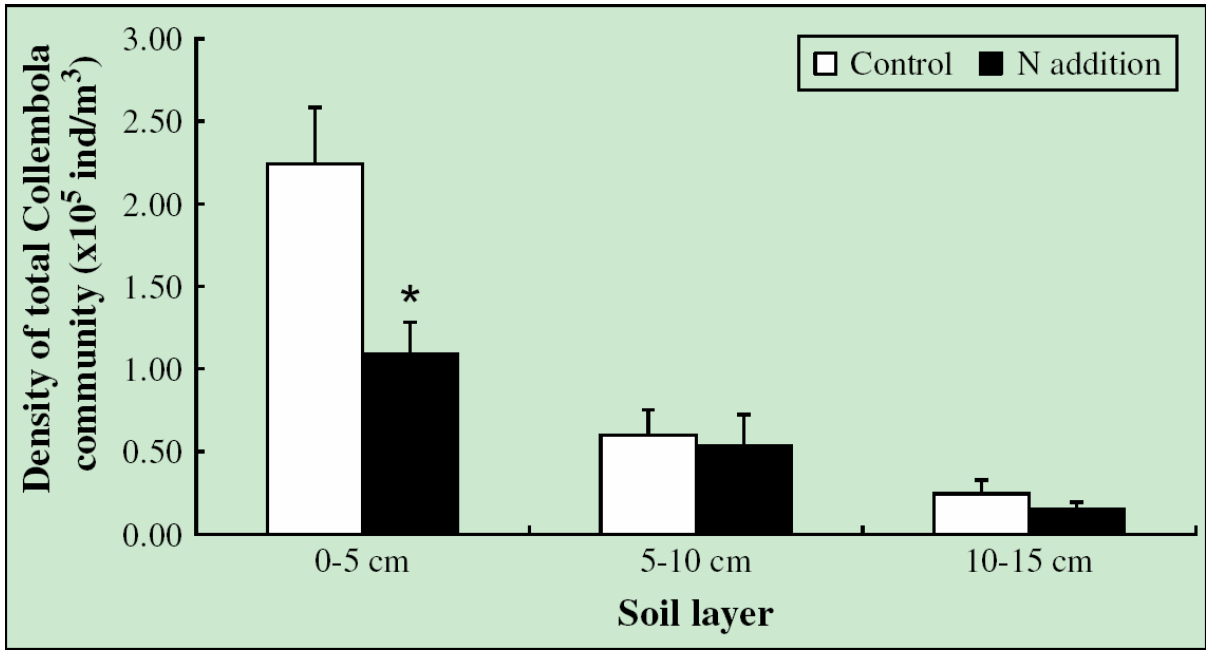
Nadelhoffer *et al.*, 1999
(Nature)

Partitioning of ^{15}N after 7 years

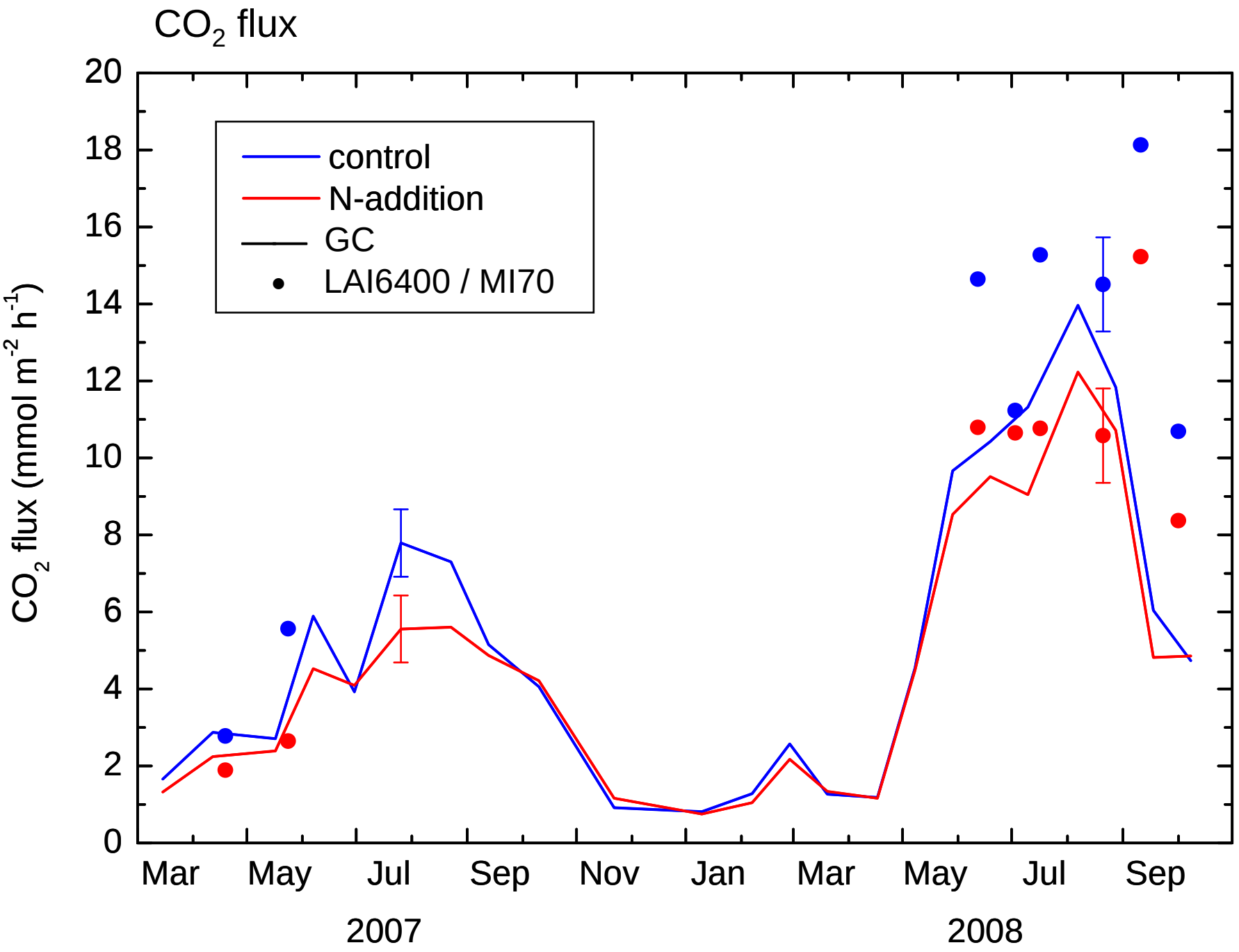


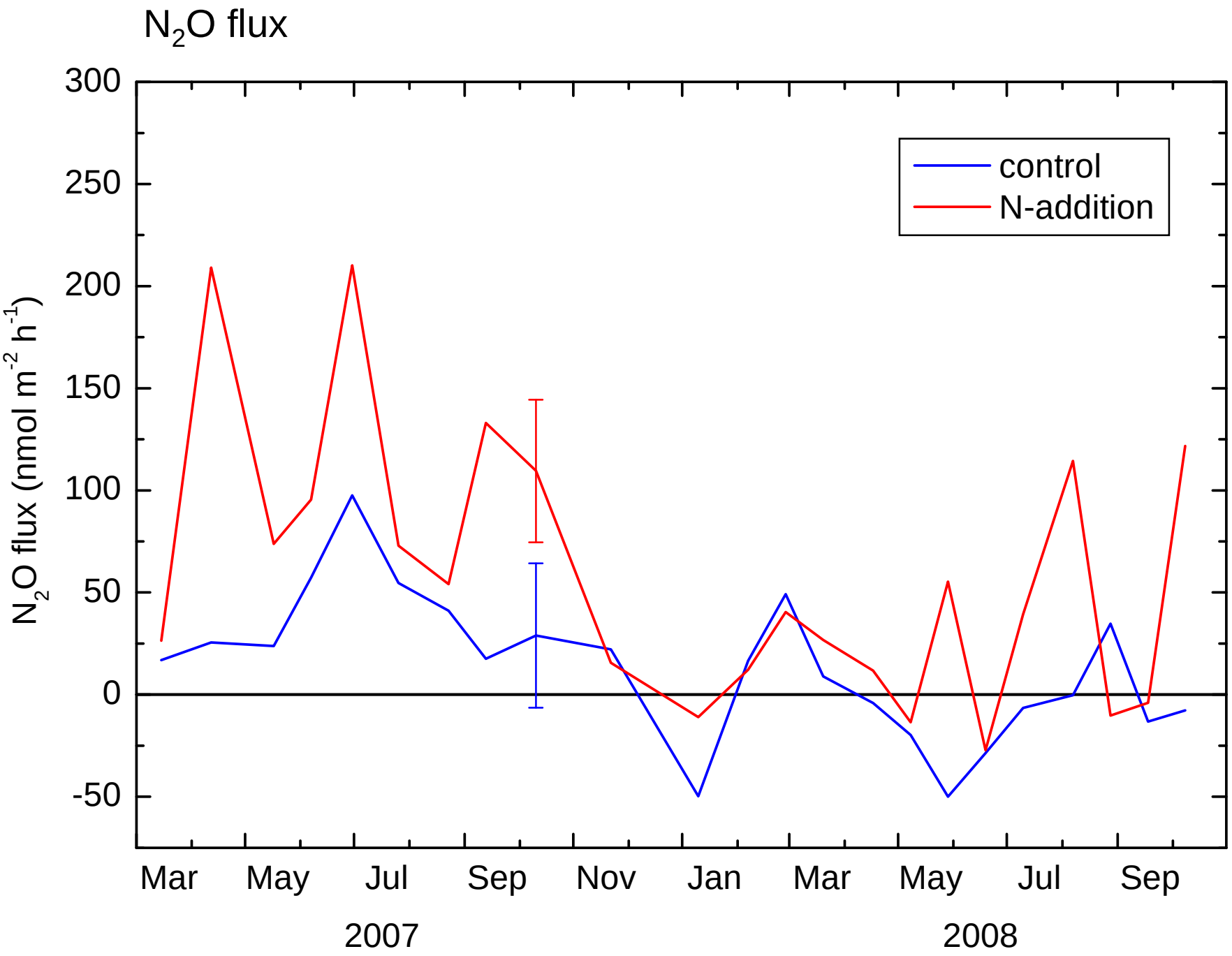
Some other aspects...

- Runoff generation (Feyen *et al.*, 1996)
- Nitrogen transformation in the soil (Hagedorn *et al.*, 1999, 2000, 2001)
- Vegetation (Schleppi *et al.*, 1999)
- Denitrification (Mohn *et al.*, 2000)
- Soil fauna (Xu *et al.*, 2009)
- etc.
- ... and many cross-site studies



Xu *et al.*, 2009 (Env. Pollut.)


CO2 flux
control
N-addition
GC
LAI6400 / MI70
CO2 flux (mmol m-2 h-1)
0
2
4
6
8
10
12
14
16
18
20
Mar
May
Jul
Sep
Nov
Jan
Mar
May
Jul
Sep
2007
2008


N2O flux
300
250
200
150
100
50
0
-50
N2O flux (nmol m-2 h-1)
control
N-addition
Mar
May
Jul
Sep
Nov
Jan
Mar
May
Jul
Sep
2007
2008

Conclusions

- N deposition mostly immobilised in the soil
- N extractable / leachable only in short term
- but uptake by trees continues a few years
- ~15% of N deposition taken up by trees
- effects on canopy or bole growth: later ?
- long-term experiment with short-term opportunities thanks to a double design: paired-catchment and replicated-block


THE END