Long-term tracing of whole catchment ^{15}N additions in a mountain spruce forest: measurements and simulations with the TRACE model

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Standards and δ notation

H	VSMOW Vienna Standard Mean Ocean Water	$^{2}H = 0.01558\%$
C	PDB Pee Dee Belemnite	$^{13}C = 1.12372\%$
N	air	$^{15}N = 0.3663\%$
O	VSMOW Vienna Standard Mean Ocean Water	$^{18}O = 0.20052\%$

attention: 2 definitions coexist, either on isotope ratio R or on isotope fraction F

$$\delta\,^{15}N = \frac{R_{sample}}{R_{standard}} - 1 \qquad \text{where:} \quad R = \frac{^{15}N}{^{14}N} \qquad R_{standard} = 0.0036765$$

$$\delta\,^{15}N = \frac{F_{sample}}{F_{standard}} - 1 \qquad \text{where:} \quad F = \frac{^{15}N}{^{14}N + {}^{15}N} \qquad F_{standard} = 0.003663$$

δ usually expressed in ‰

for calculations, see Providoli *et al.*, Biogeochem. 2005 (from: http://www.schleppi.ch/patrick/publi)

NITREX

Manipulation of N deposition

Alptal

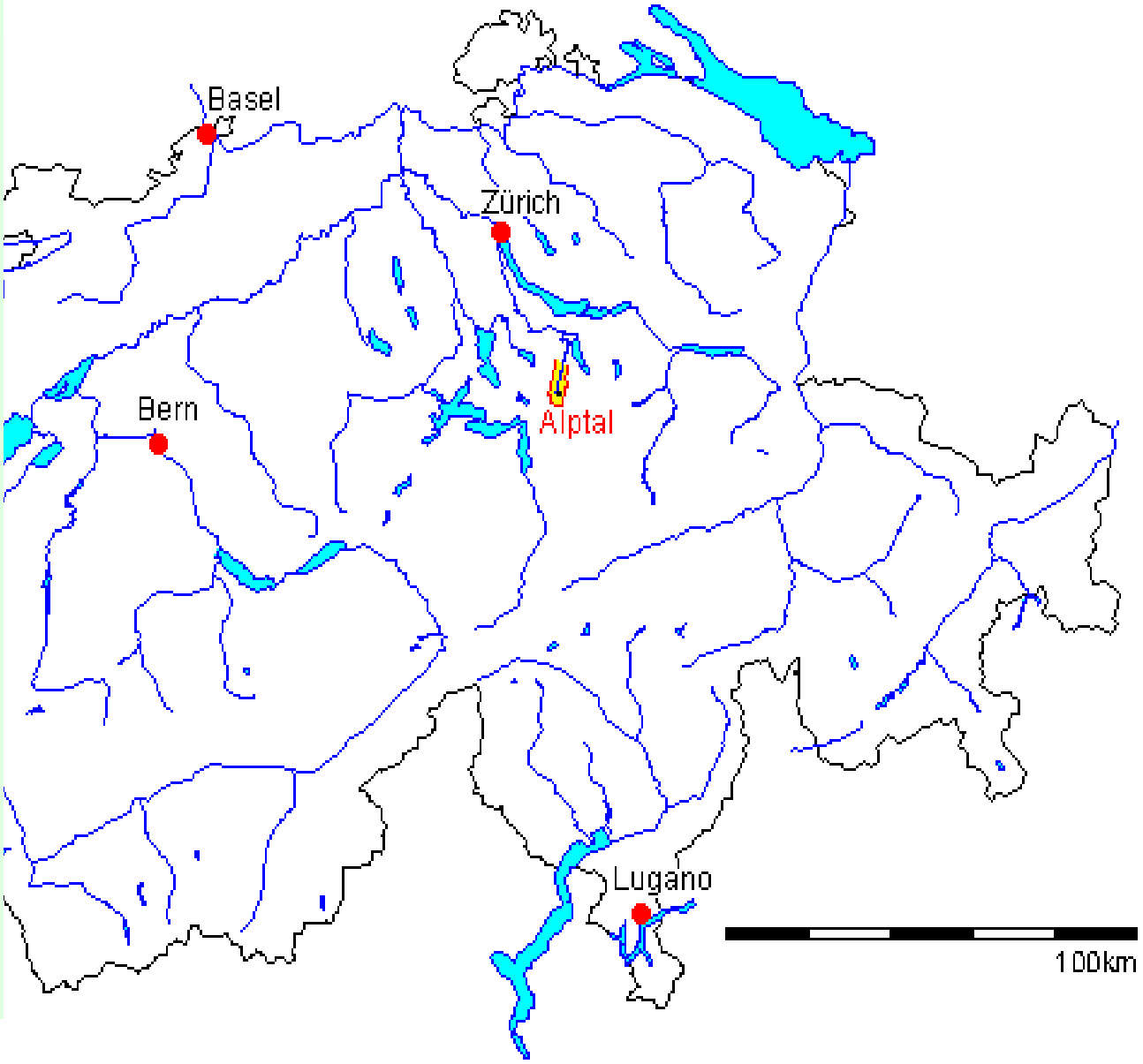
Altitude:
1200 m

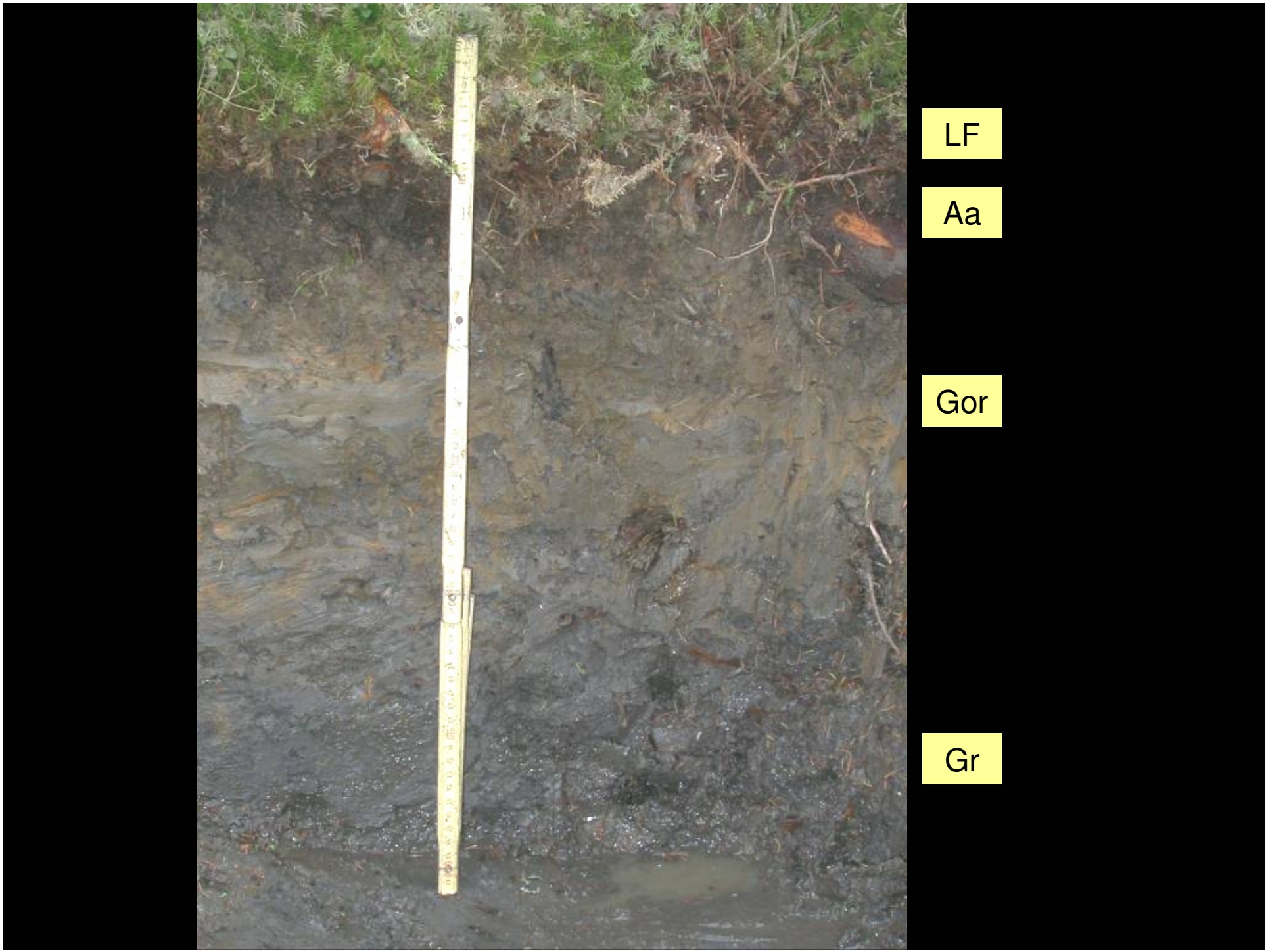
Geology and soils:
Gleysol over Flysch

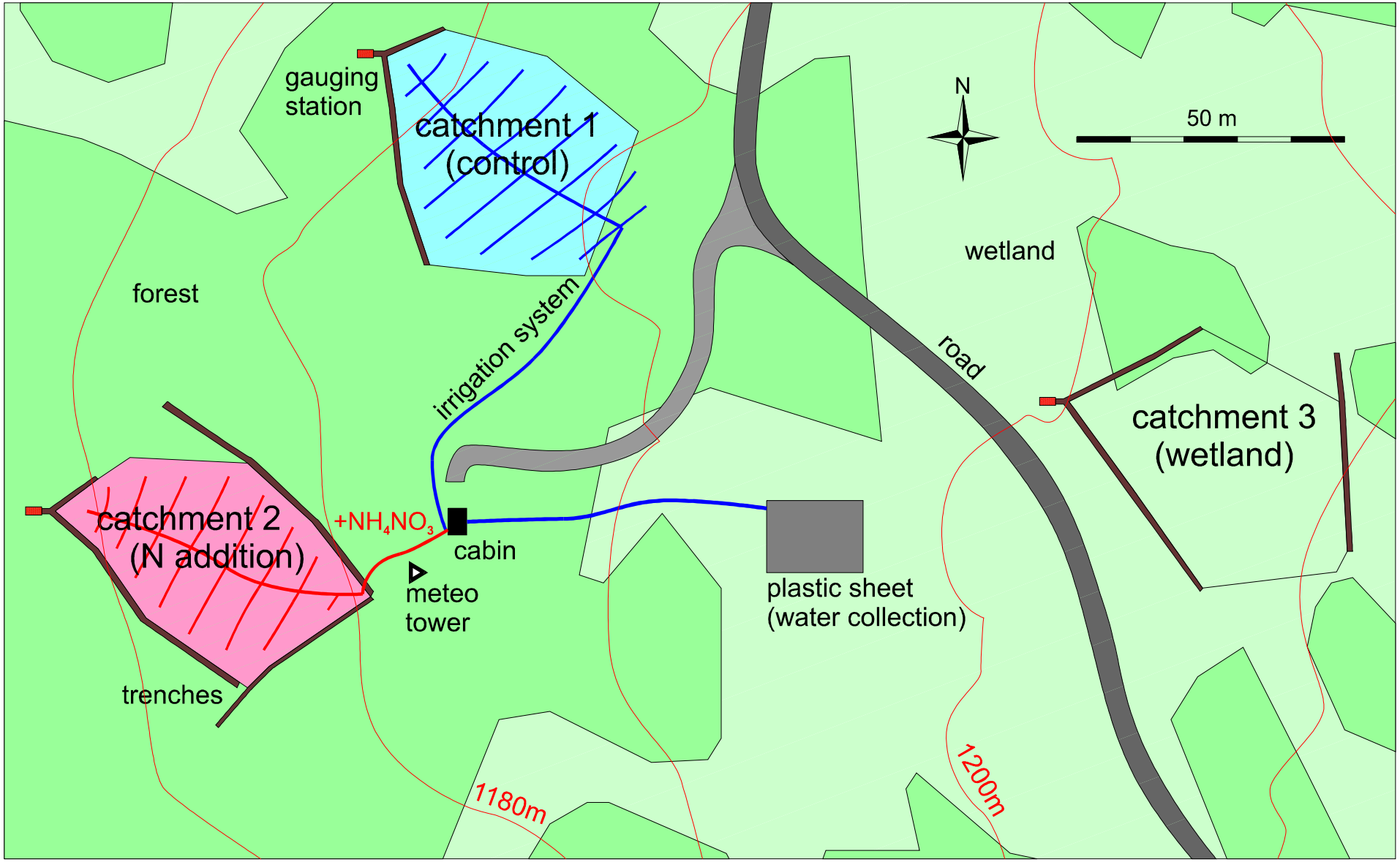
Vegetation:
mosaic of forest and wetland patches

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

NITREX

IRISALP

N

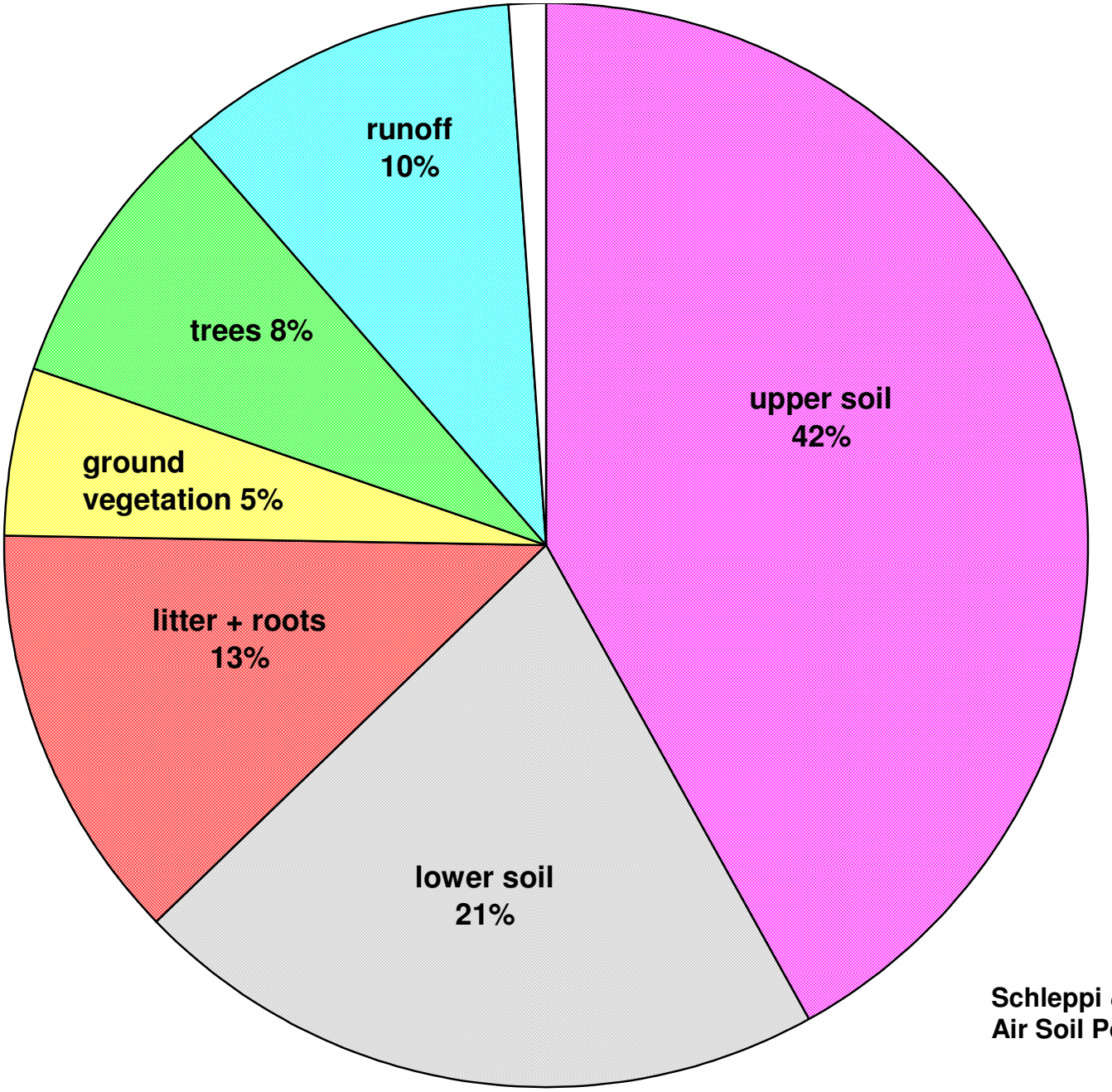
50 m

wetland

irrigation s

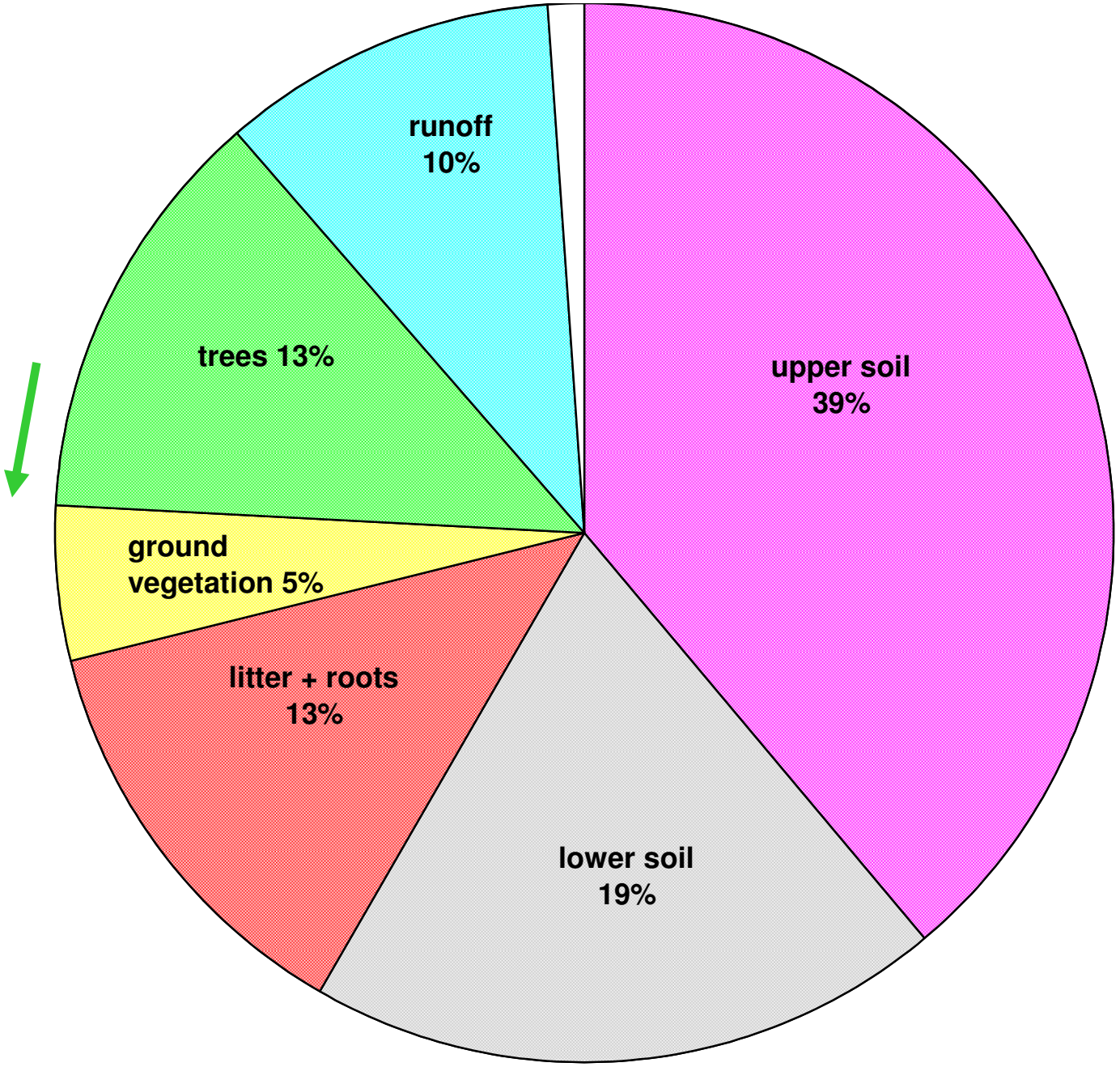
catchment 3
(wetland)

Partitioning of ^{15}N after 1 year

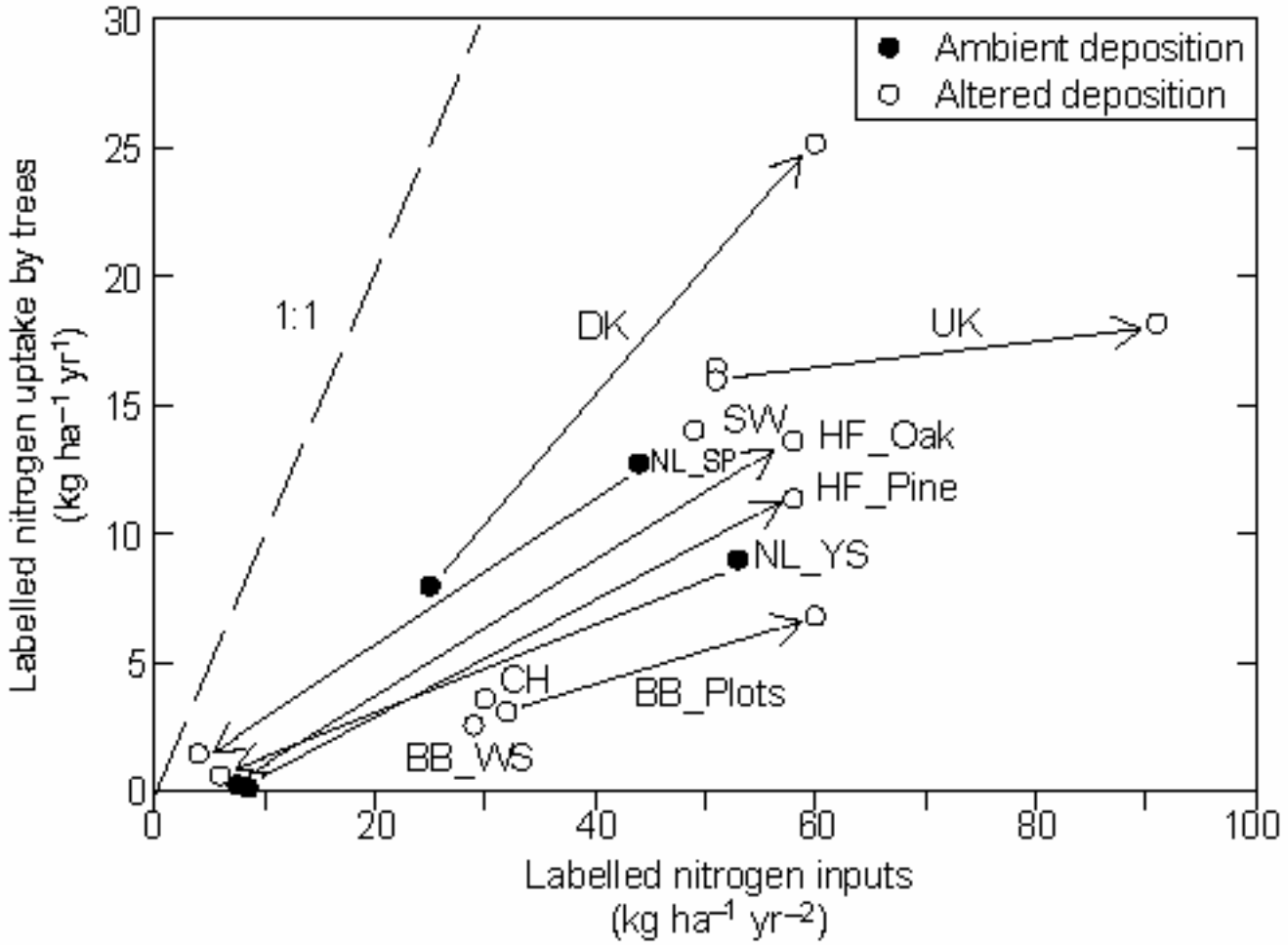


Schleppi *et al.*, Water Air Soil Pollut. 1999

Partitioning of ^{15}N after 7 years

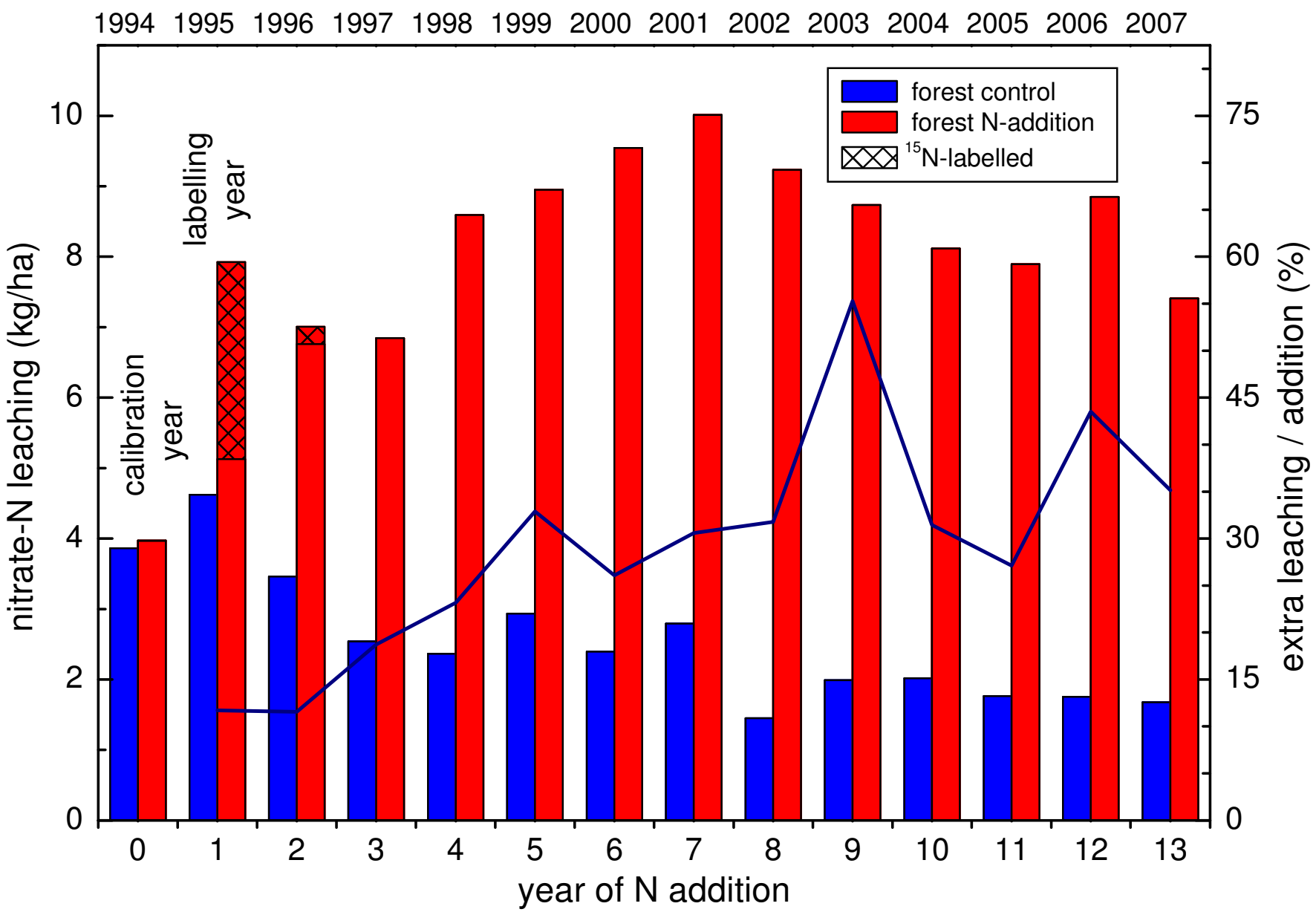


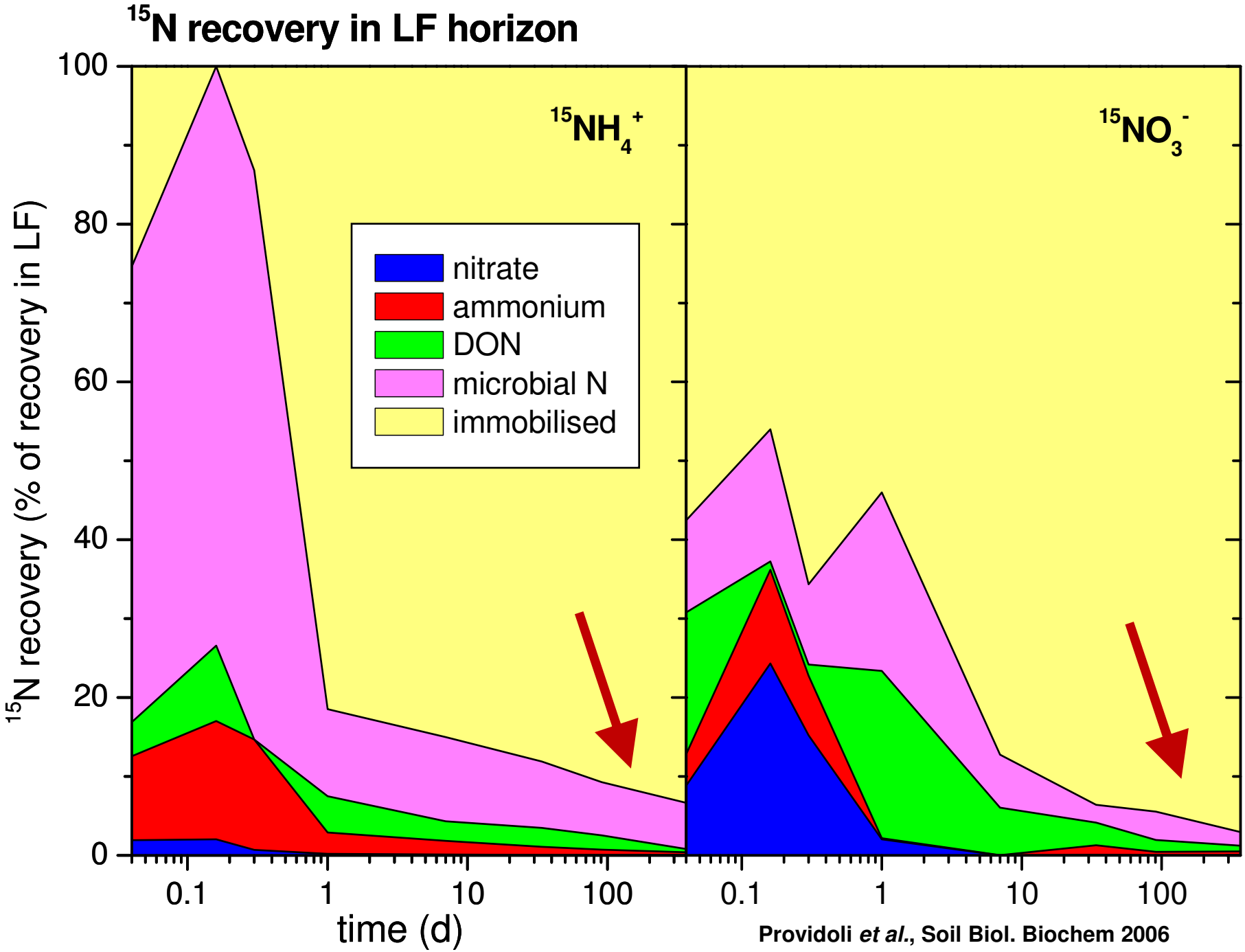
EU and US sites: uptake by trees



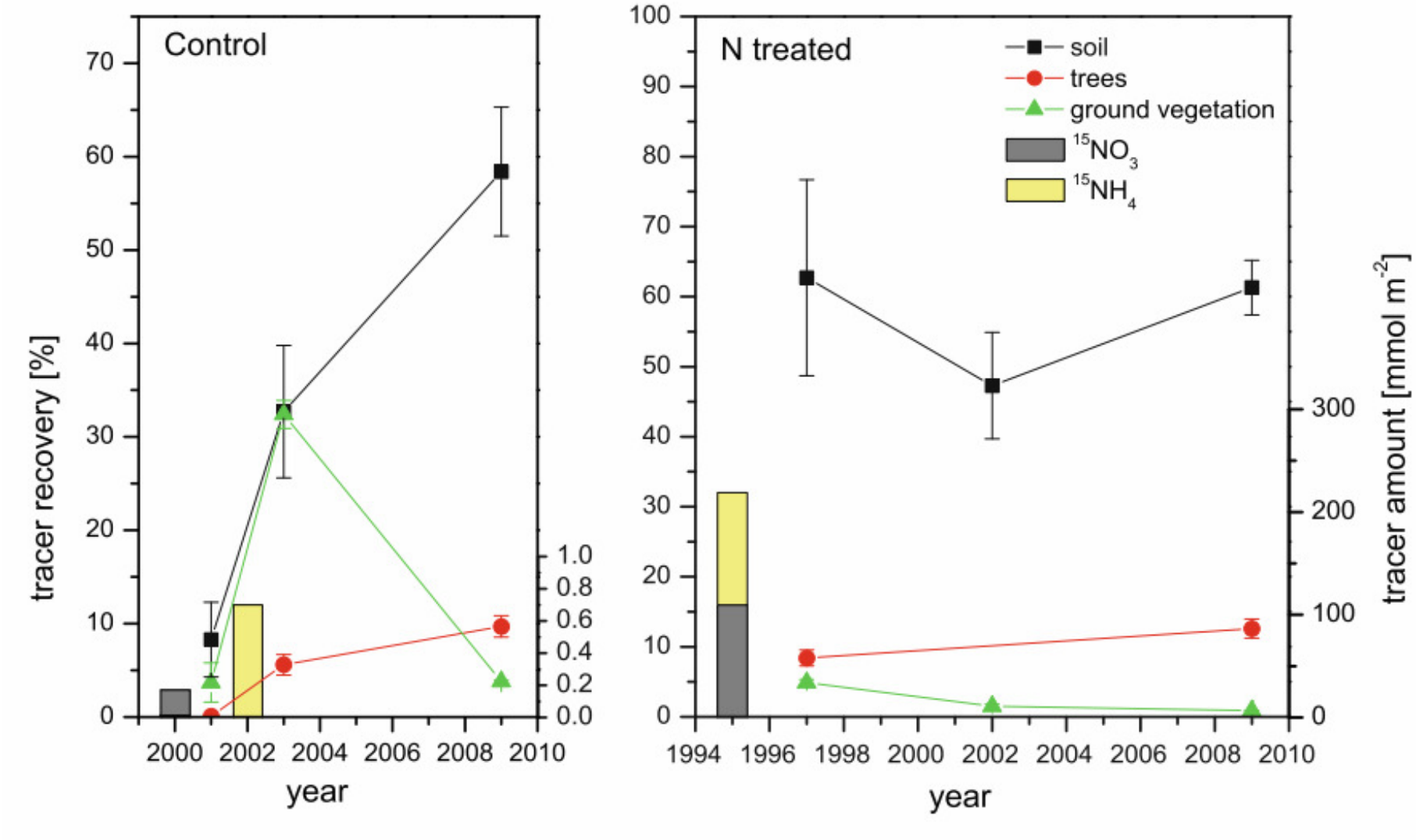
Nadelhoffer *et al.*,
Nature 1999

Nitrate leaching




15N recovery in LF horizon
15NH4+
15NO3-
nitrate
ammonium
DON
microbial N
immobilised
15N recovery (% of recovery in LF)
time (d)
0
20
40
60
80
100
0.1
1
10
100
Providoli et al., Soil Biol. Biochem 2006

^{15}N tracer recoveries in ecosystem pools



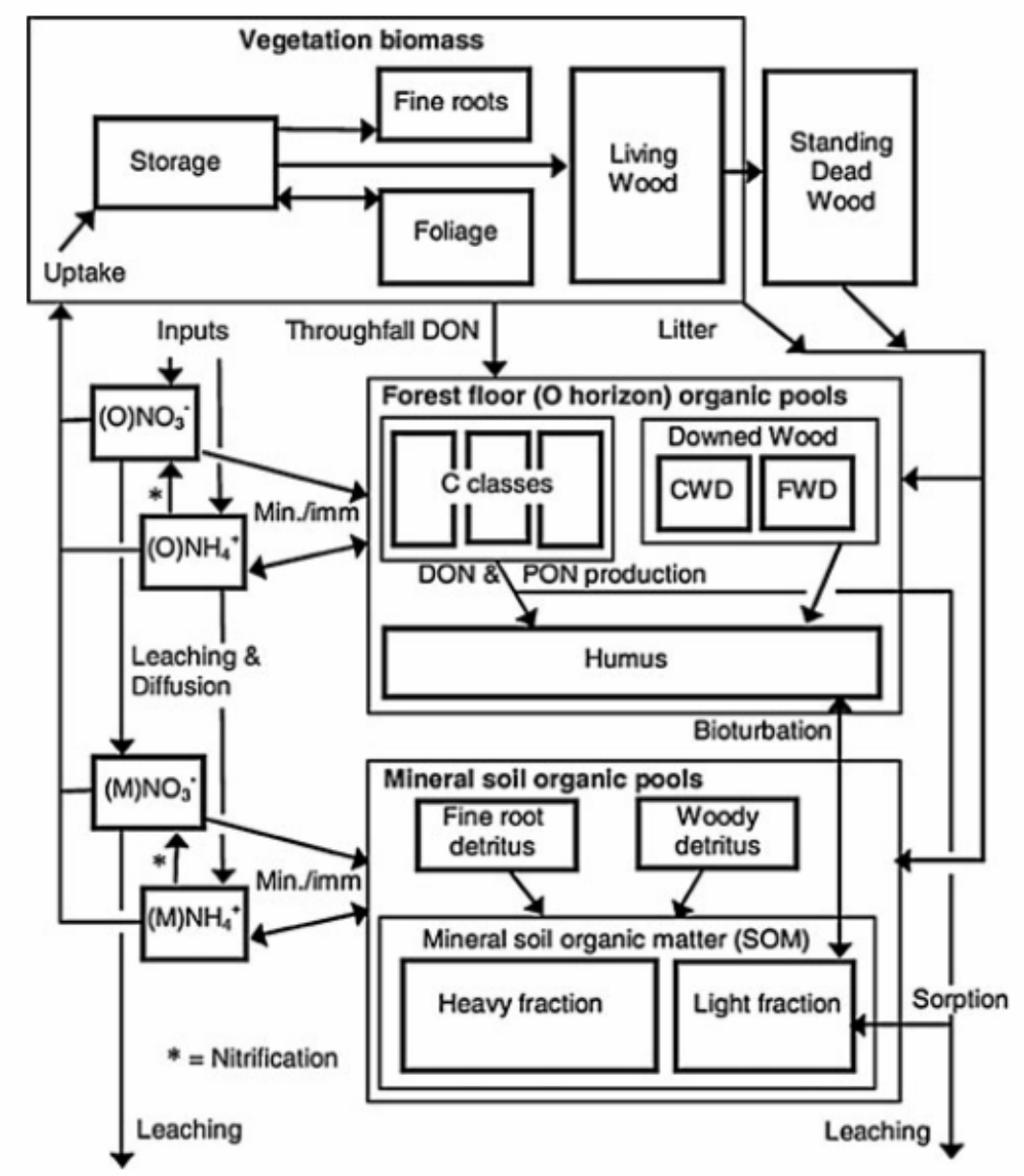
Krause *et al.*, Trees 2012

TRACE

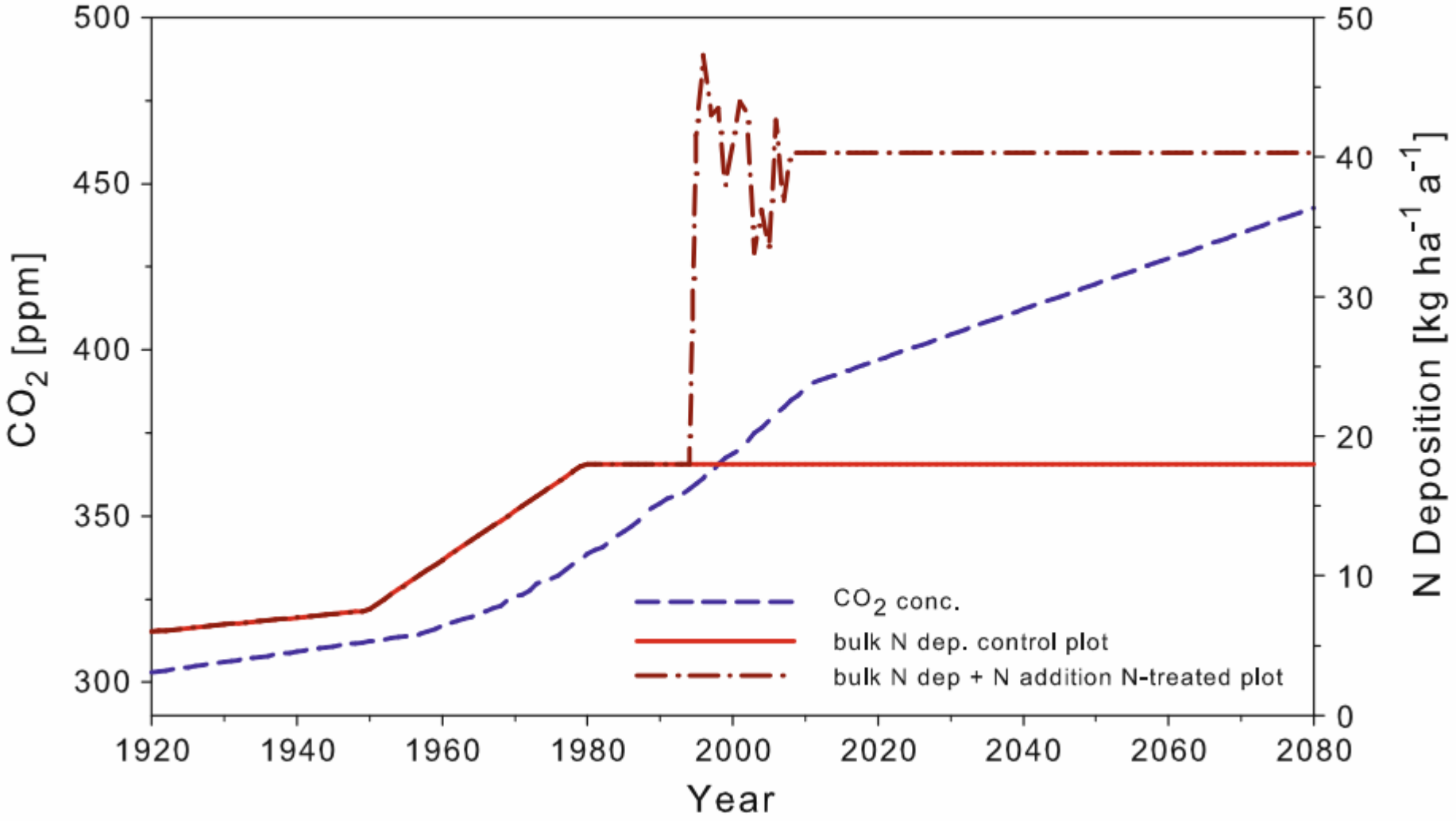
Tracer Redistributions Among Compartments in Ecosystems

by Bill Currie

- aboveground: based on PnET-CN
- belowground: based on DocMod
- complex model of: C, N and water cycles
- time step: 1 month
- special: all N pools and fluxes separately for ^{14}N and ^{15}N

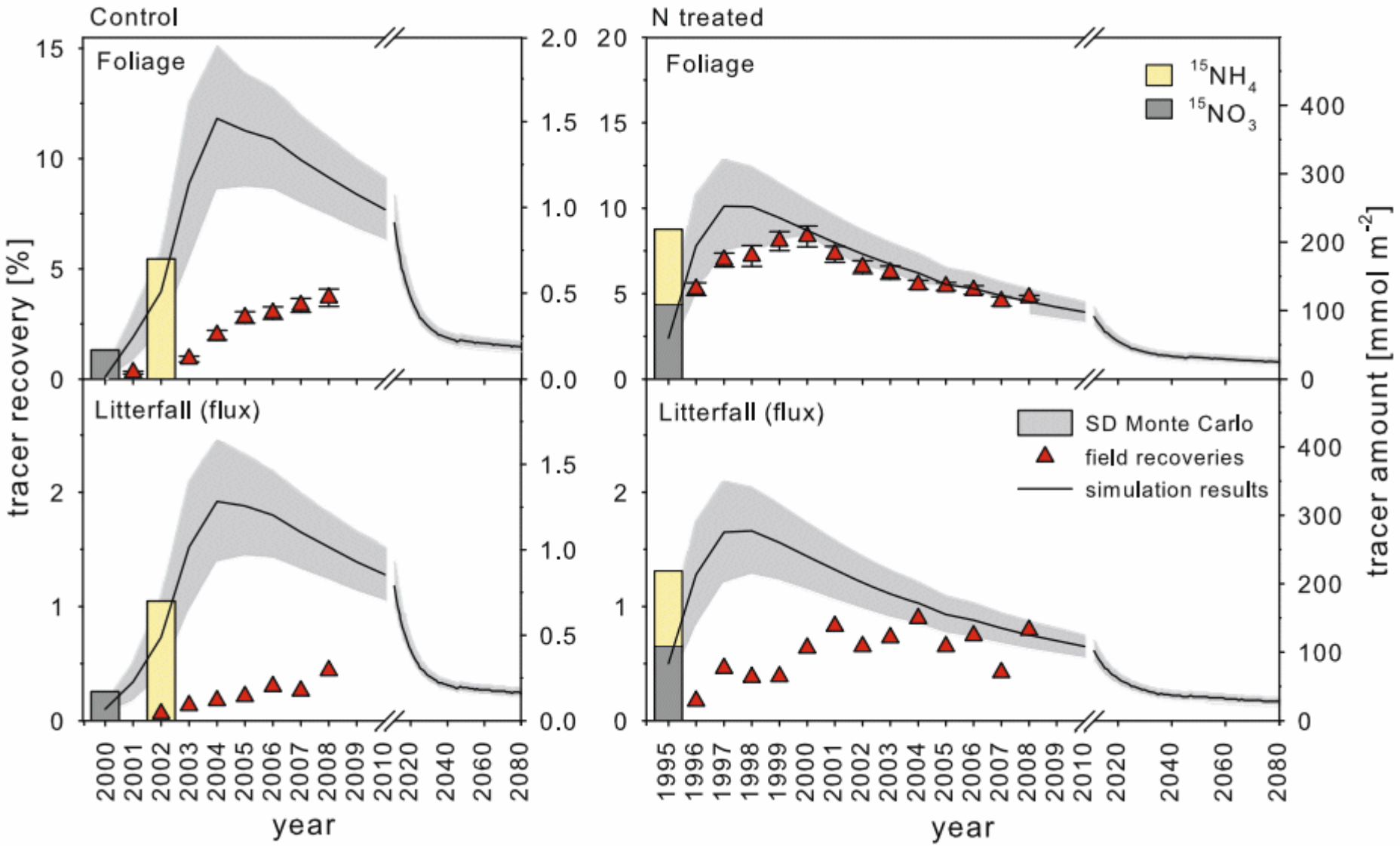


TRACE base scenario for Alptal



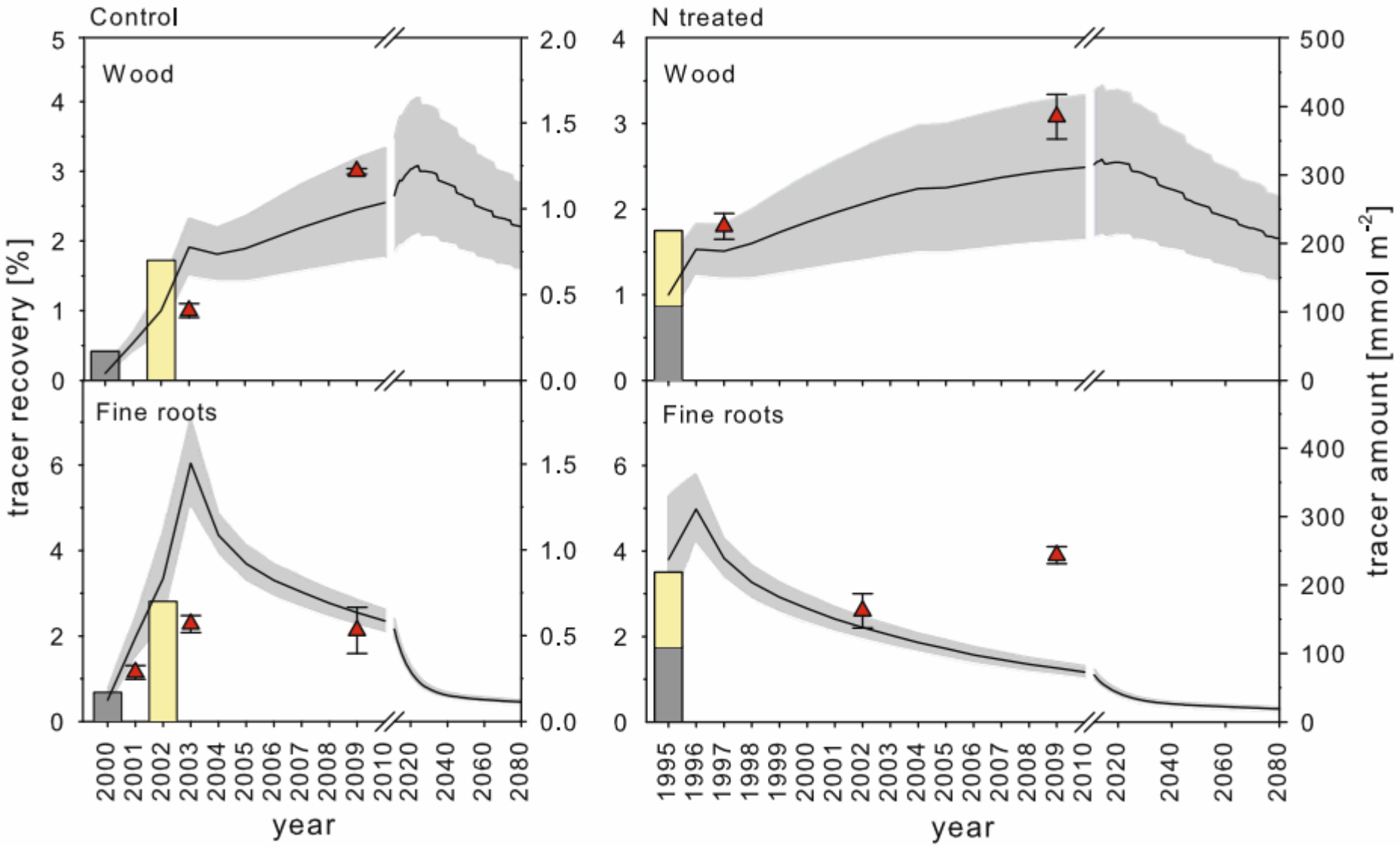
Krause *et al.*, Trees 2012

Model vs. measurements: foliage and litterfall



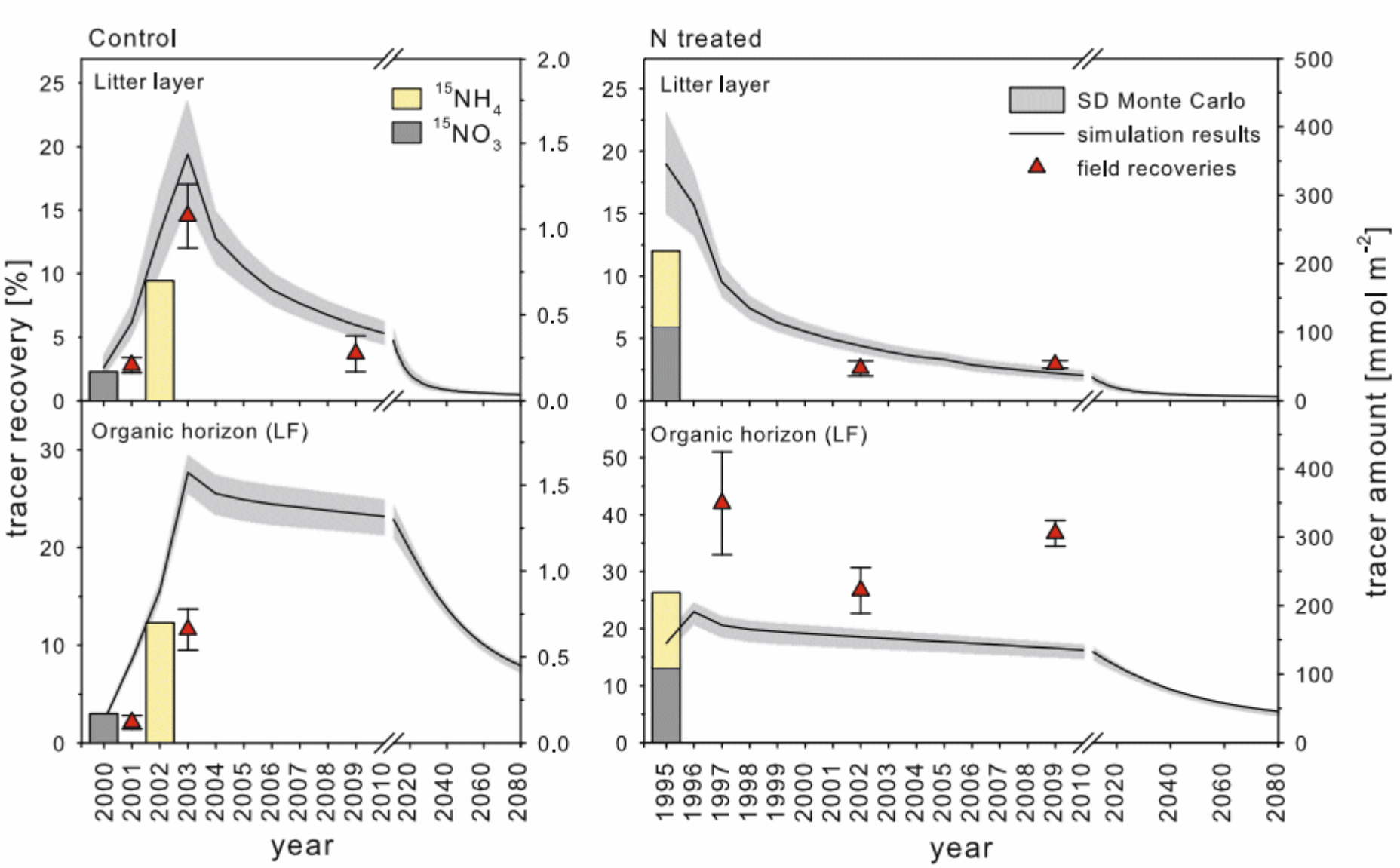
Krause *et al.*, Trees 2012

Model vs. measurements: wood and fine roots



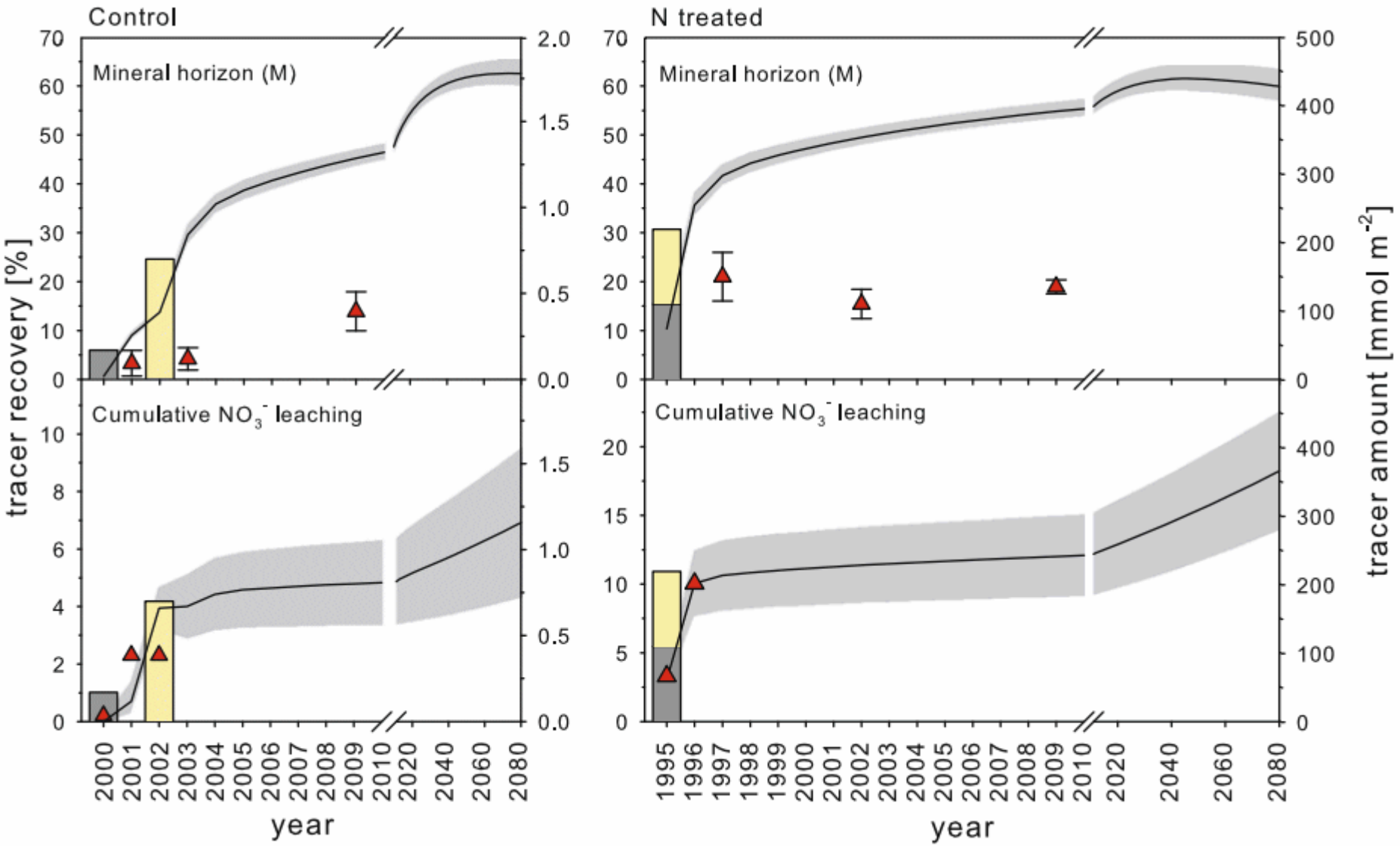
Krause *et al.*, Trees 2012

Model vs. measurements: soil litter layer & organic horizon

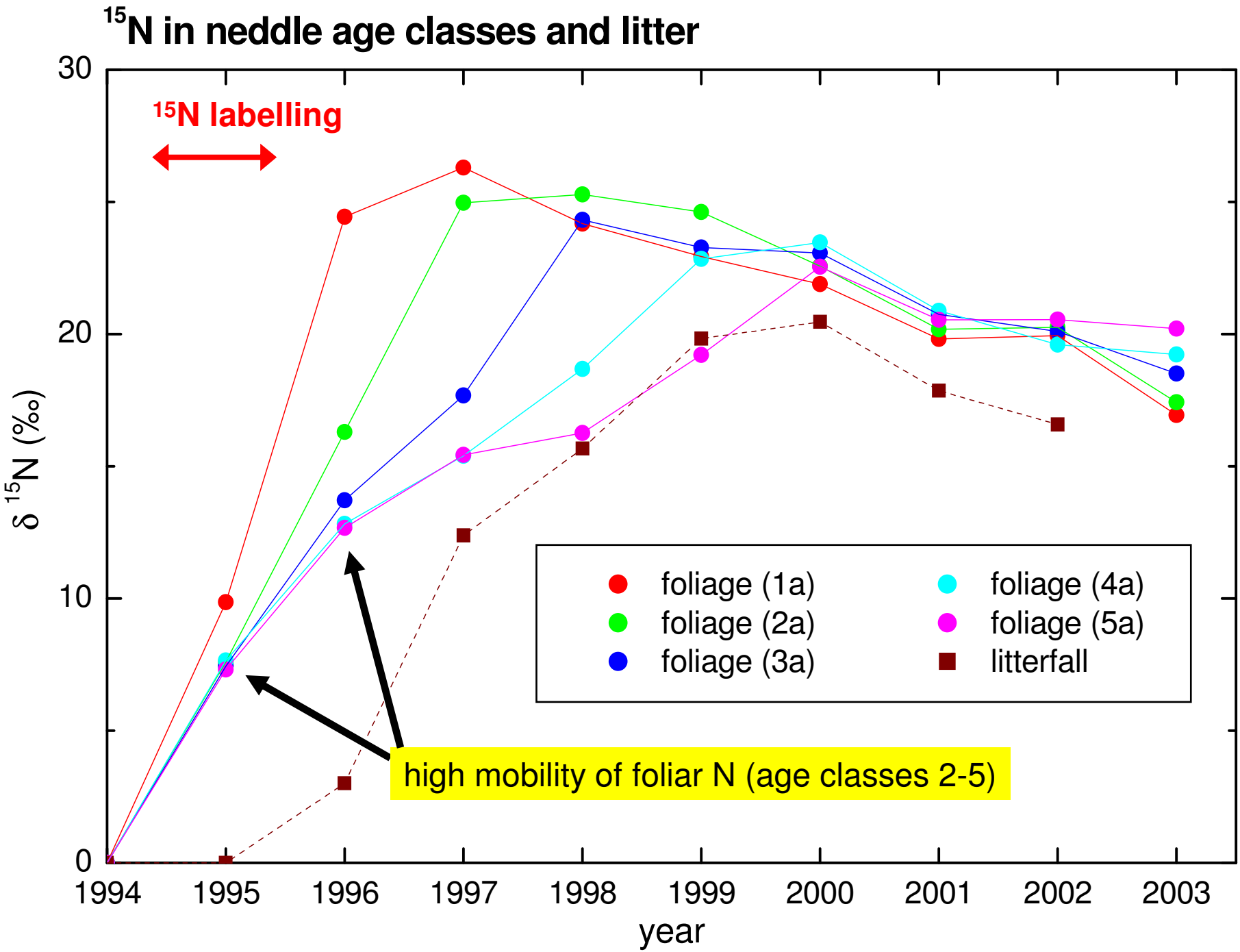


Krause *et al.*, Trees 2012

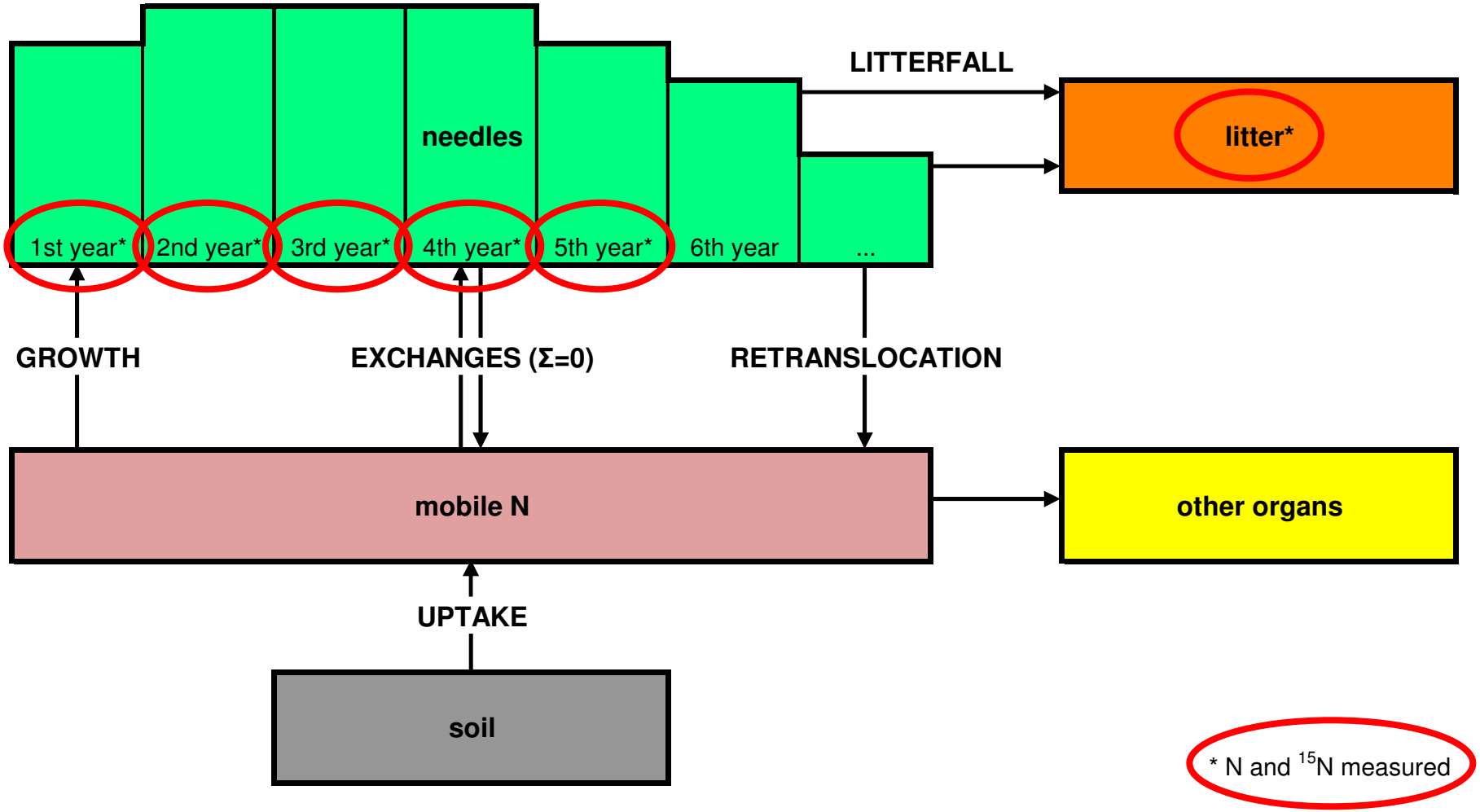
Model vs. measurements: mineral horizon & nitrate leaching

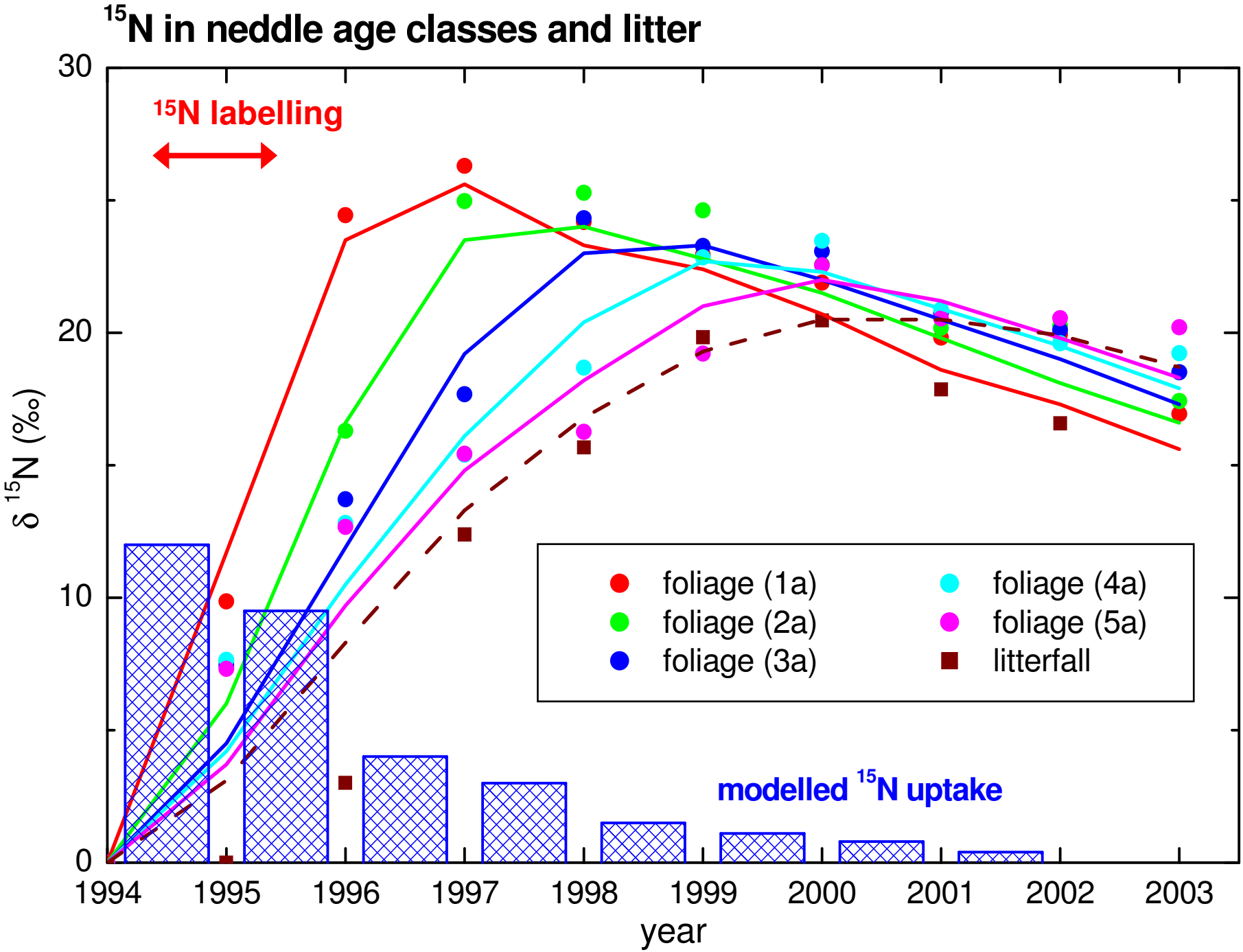


Krause *et al.*, Trees 2012


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
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

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30
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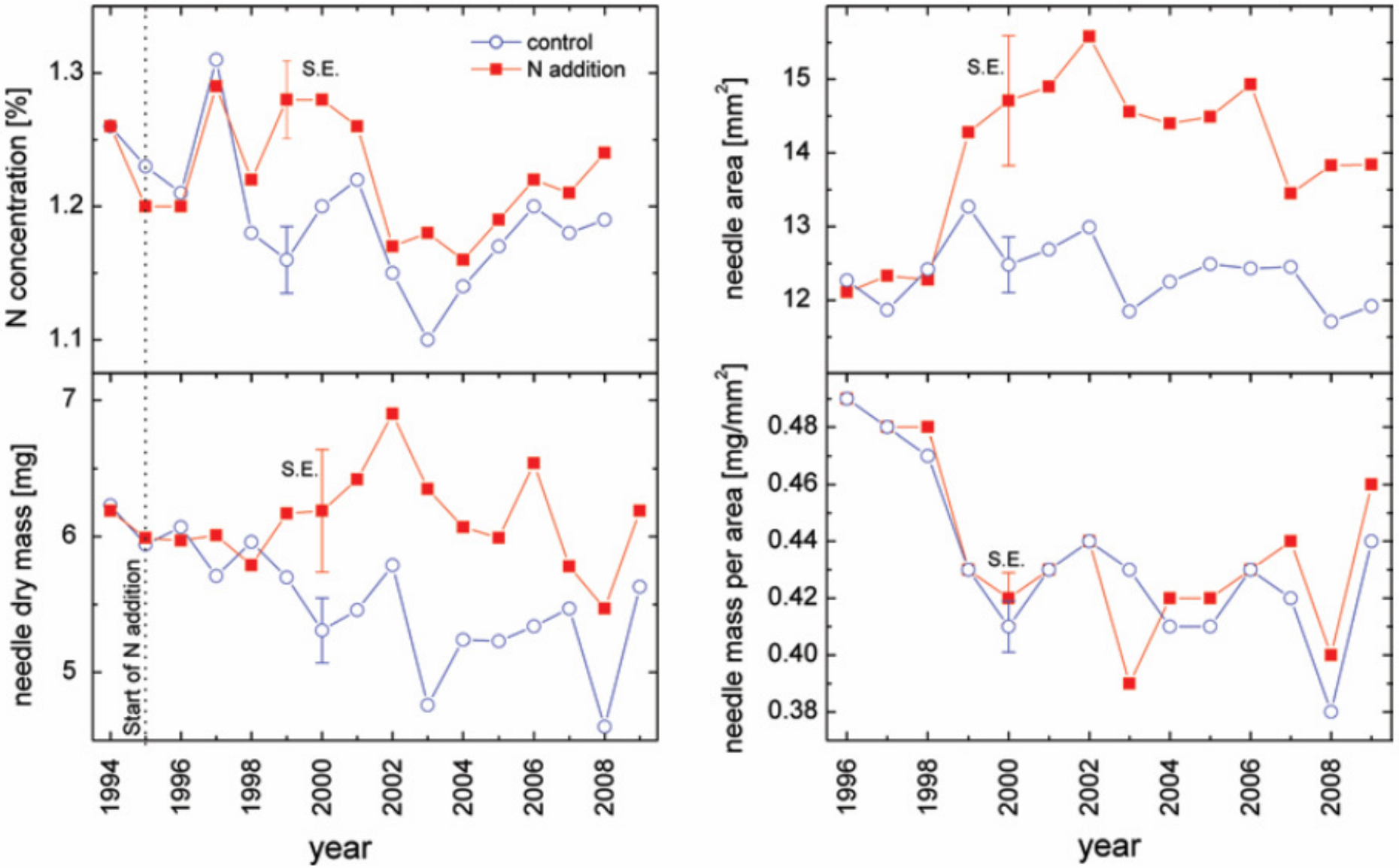
1998
1999
2000
2001
2002
2003
year
foliage (1a)
foliage (2a)
foliage (3a)
foliage (4a)
foliage (5a)
litterfall
modelled 15N uptake

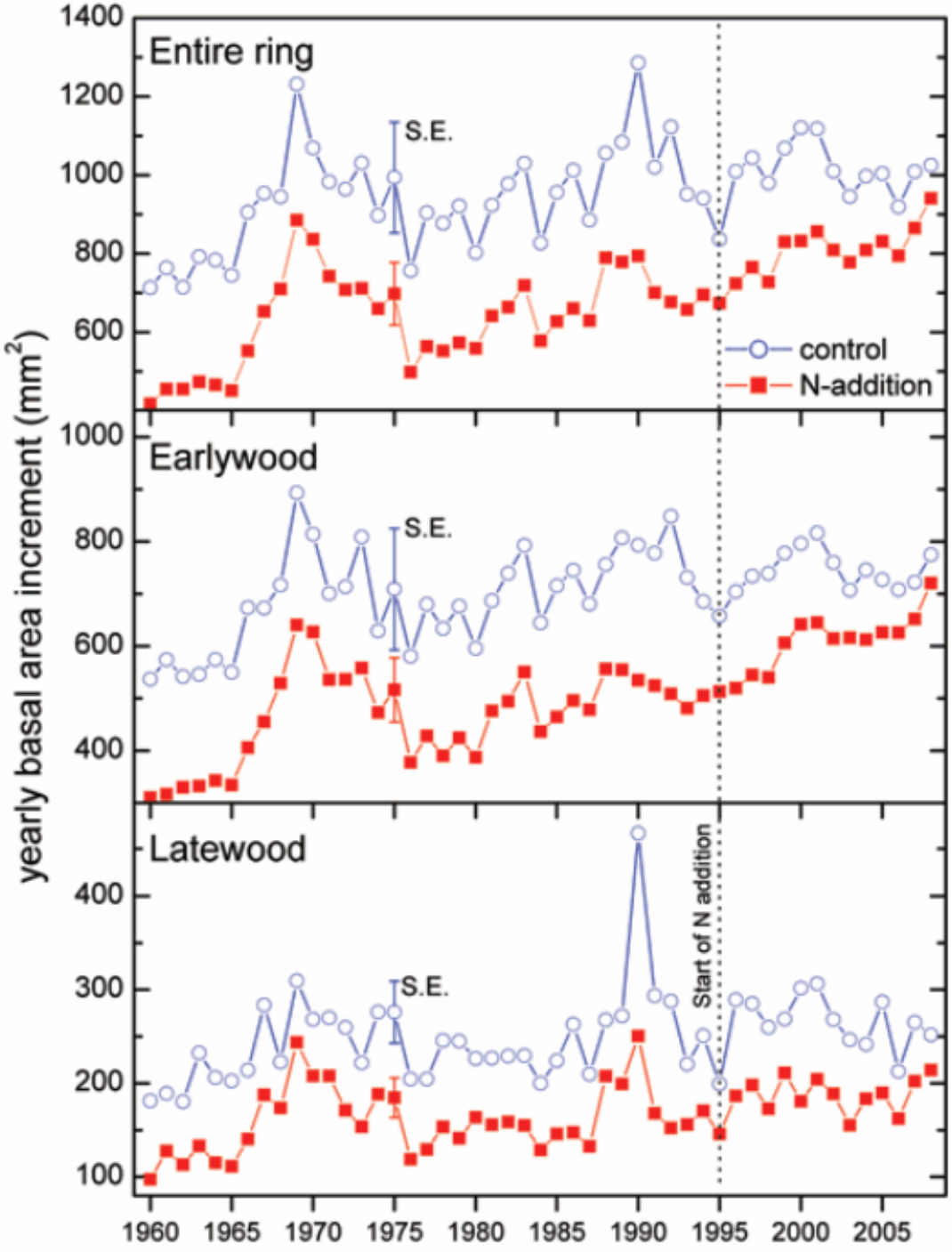
Effect of N addition on needles



Krause *et al.*, Tree Physiol. 2012

Effect of N addition on stem growth

Krause *et al.*, Tree Physiol. 2012



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
- high N mobility in 2-5 year-old needles
- TRACE powerful but complex
- larger needles => wood growth increase


THE END