Denitrification in terrestrial ecosystems

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A problem of scale?!

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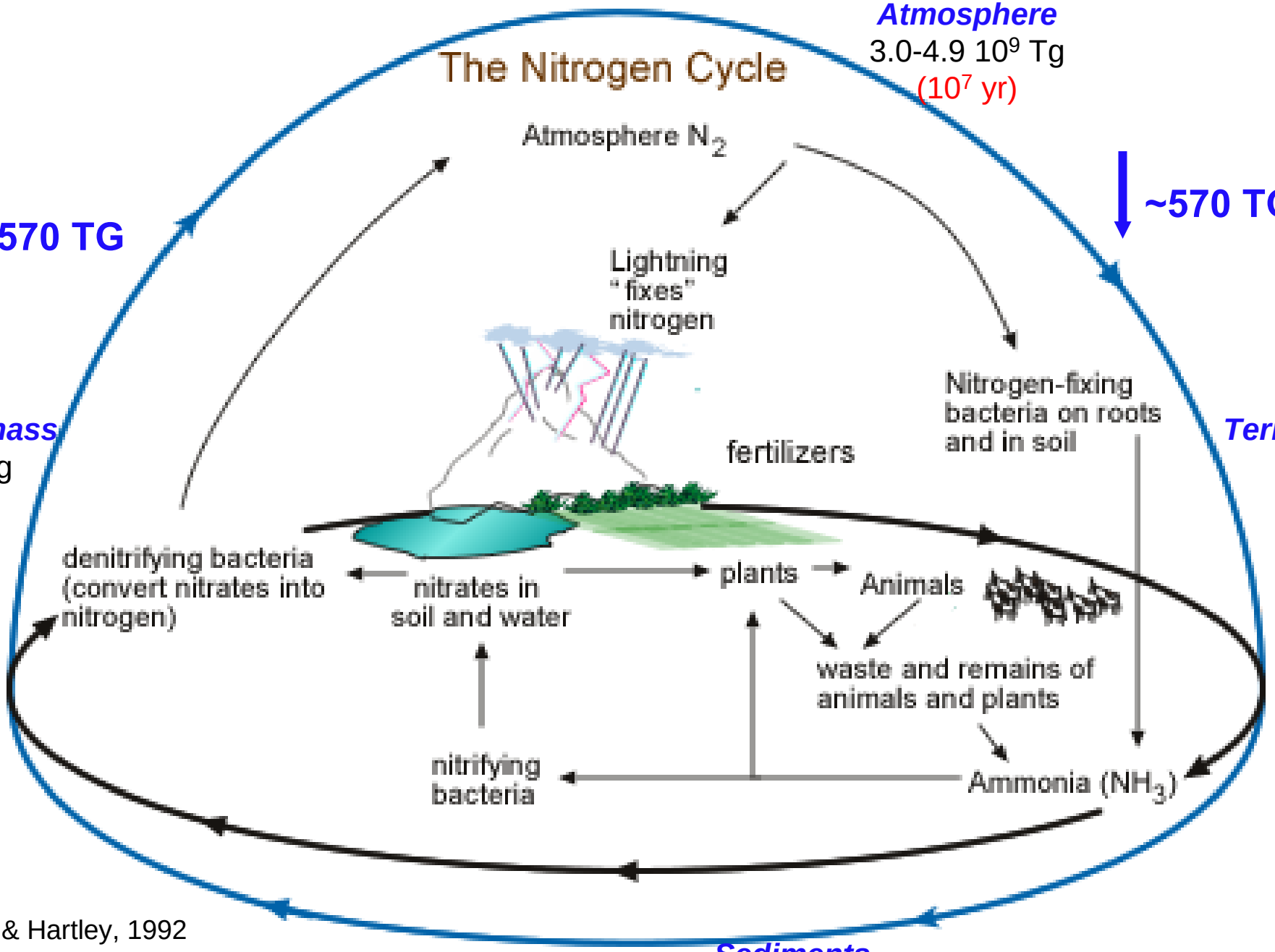


Atmosphere
3.0-4.9 10^9 Tg
(10^7 yr)

~570 TG

~570 TG

arine biomass
4.7 10^2 Tg

Terrestrial bioma
3.5 10^4 Tg
(50 yr)

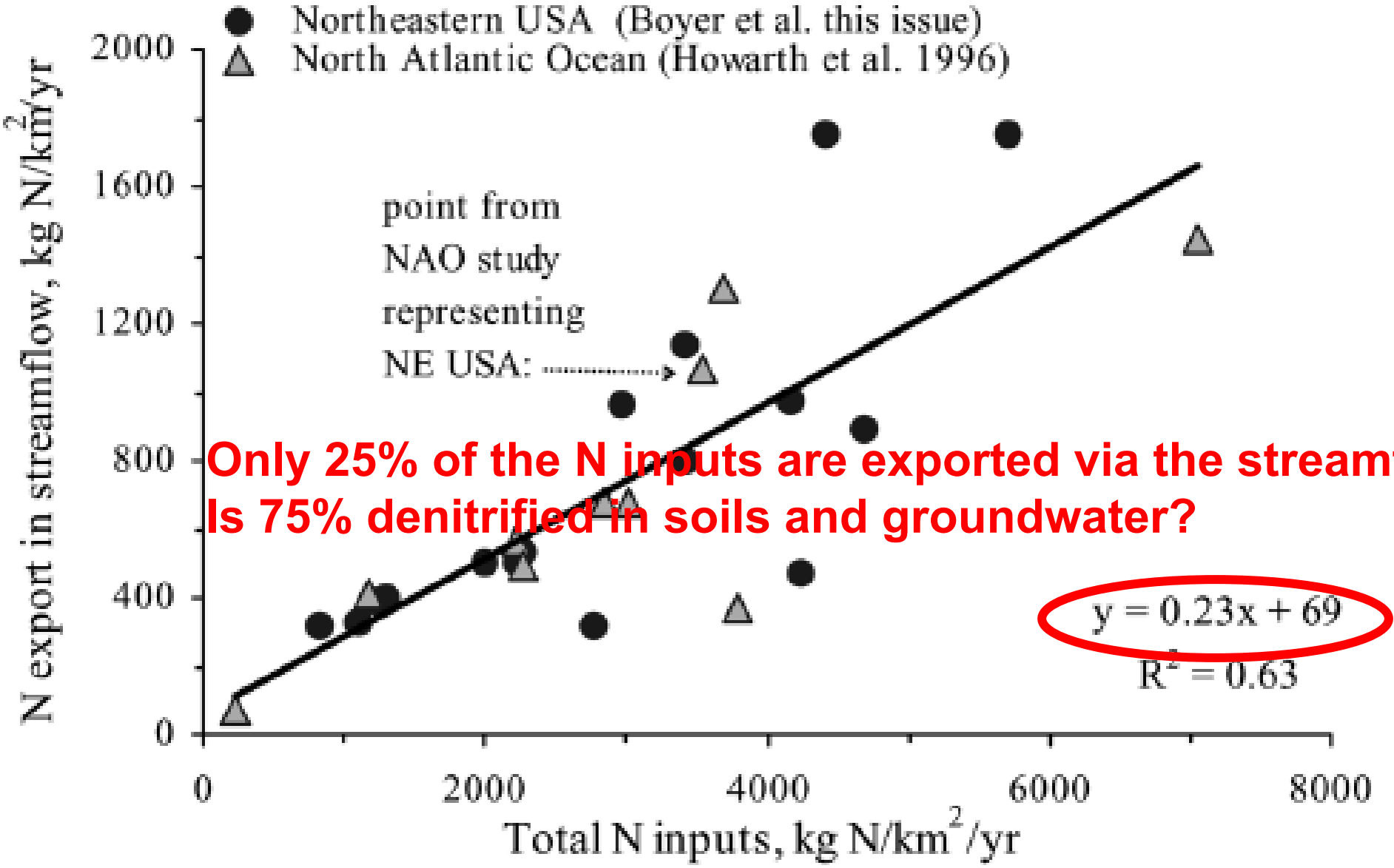
Ocean
2.2 10^7 Tg

Soil
9.5 10^4 Tg
(~2000 yr)

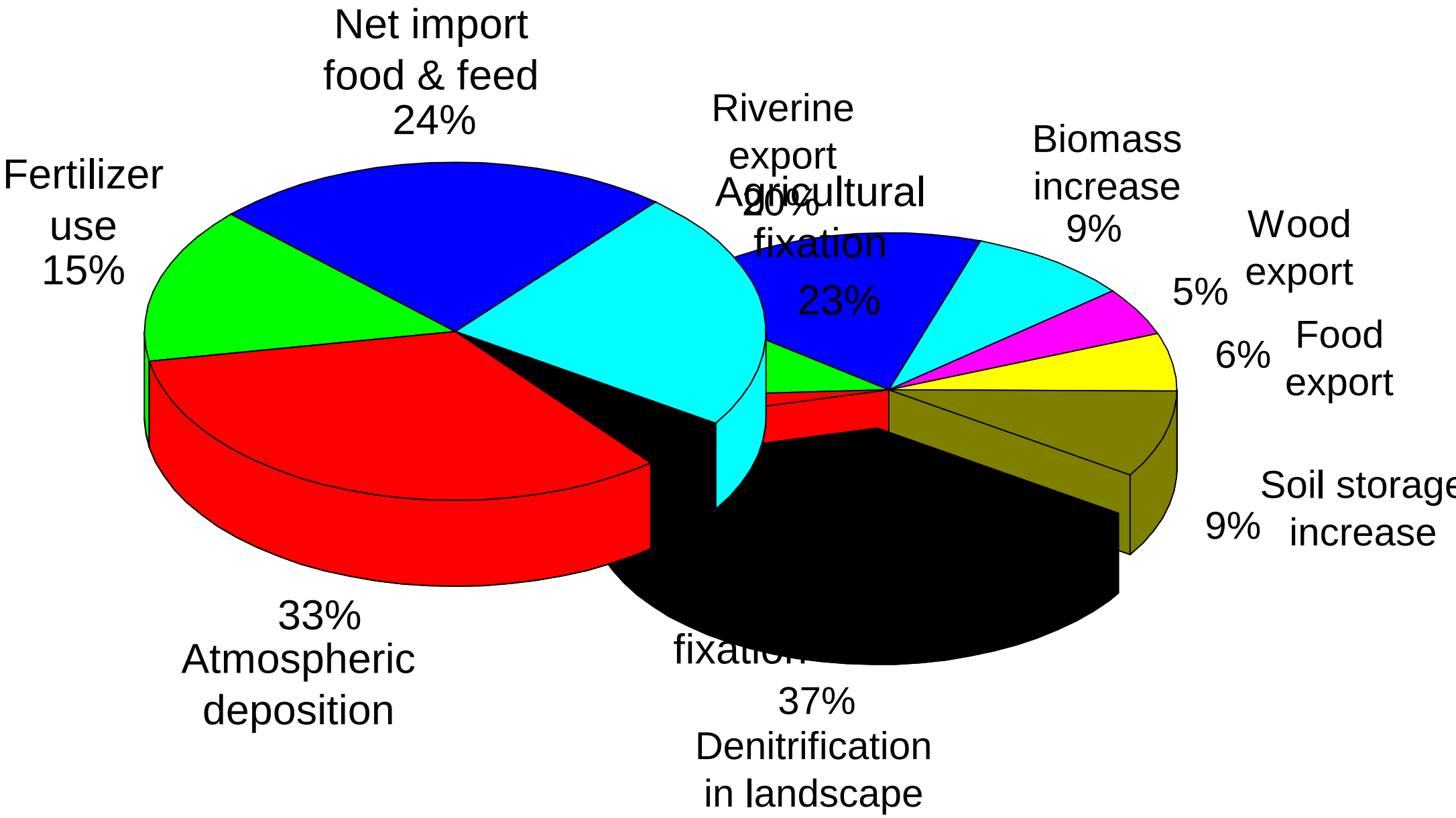
Sediments
4.0 10^8 Tg
(10^7 yr)

Schlesinger & Hartley, 1992
Galloway et al., 1995
Gruber & Galloway, 2008

Van Breemen et al., 2002: Where did all the nitrogen go?



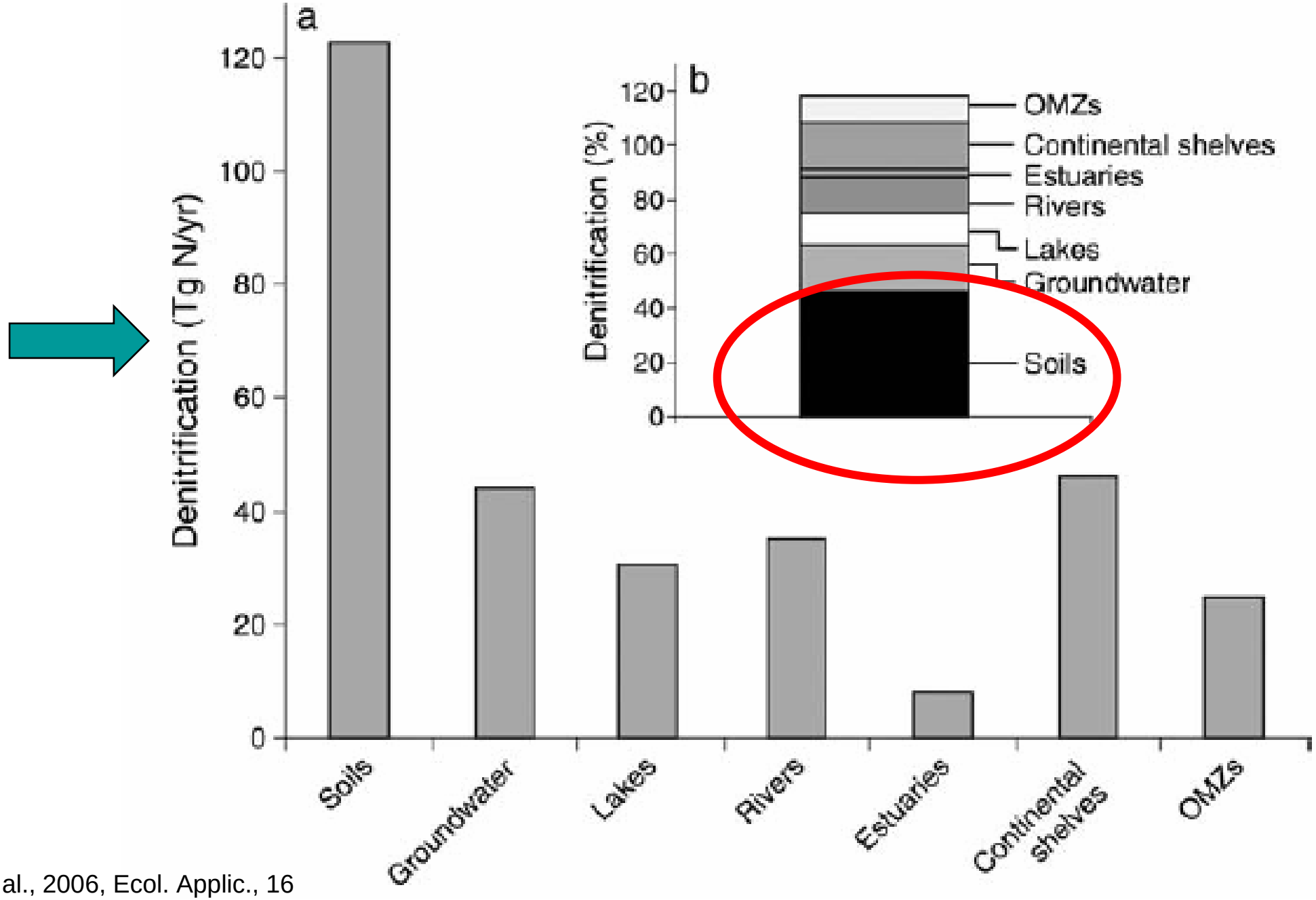
Van Breemen et al., 2002: Where did all the nitrogen go?



Van Breemen et al., 2002, Biogeochemistry

Seitzinger et al., 2006: 40% of N input is denitrified in soils

Approx. 270 Tg N_r additions to terrestrial systems

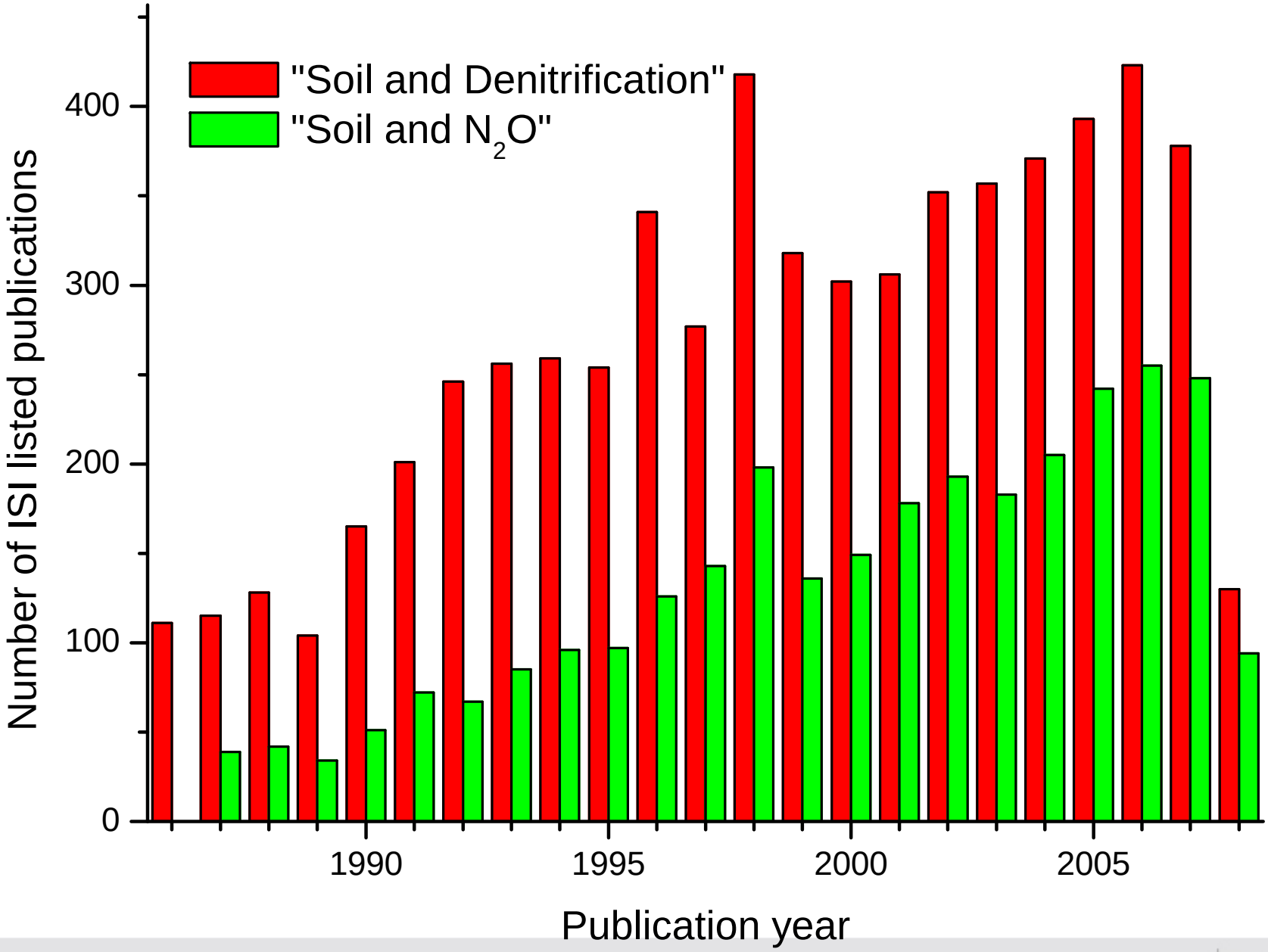


Seitzinger et al., 2006, Ecol. Applic., 16

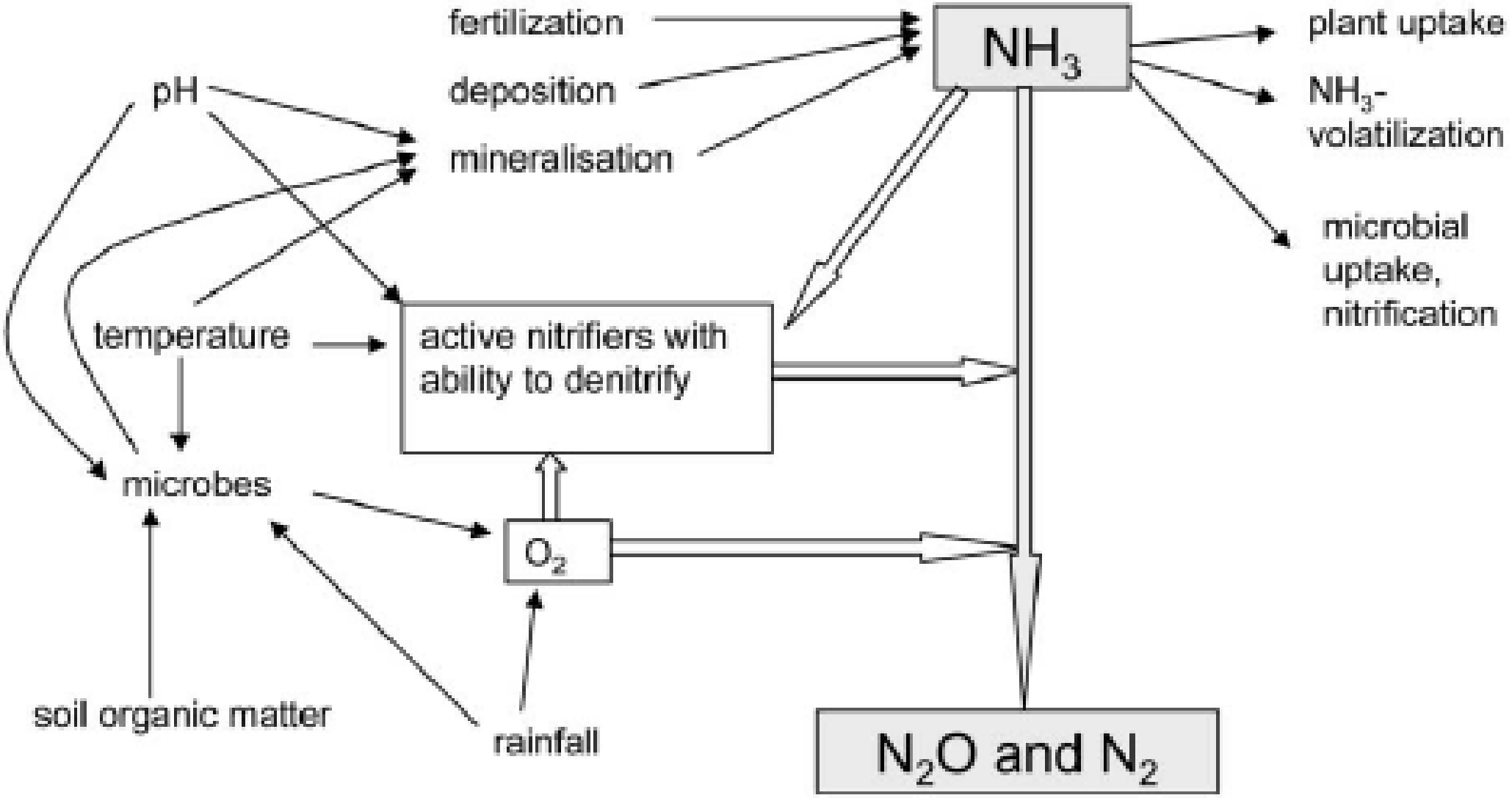
It seems that we do know the “big” numbers quite well,

but how good is our knowledge on site and landscape scales?

Publications on denitrification and soils increased by a factor of four within the last 20 yrs

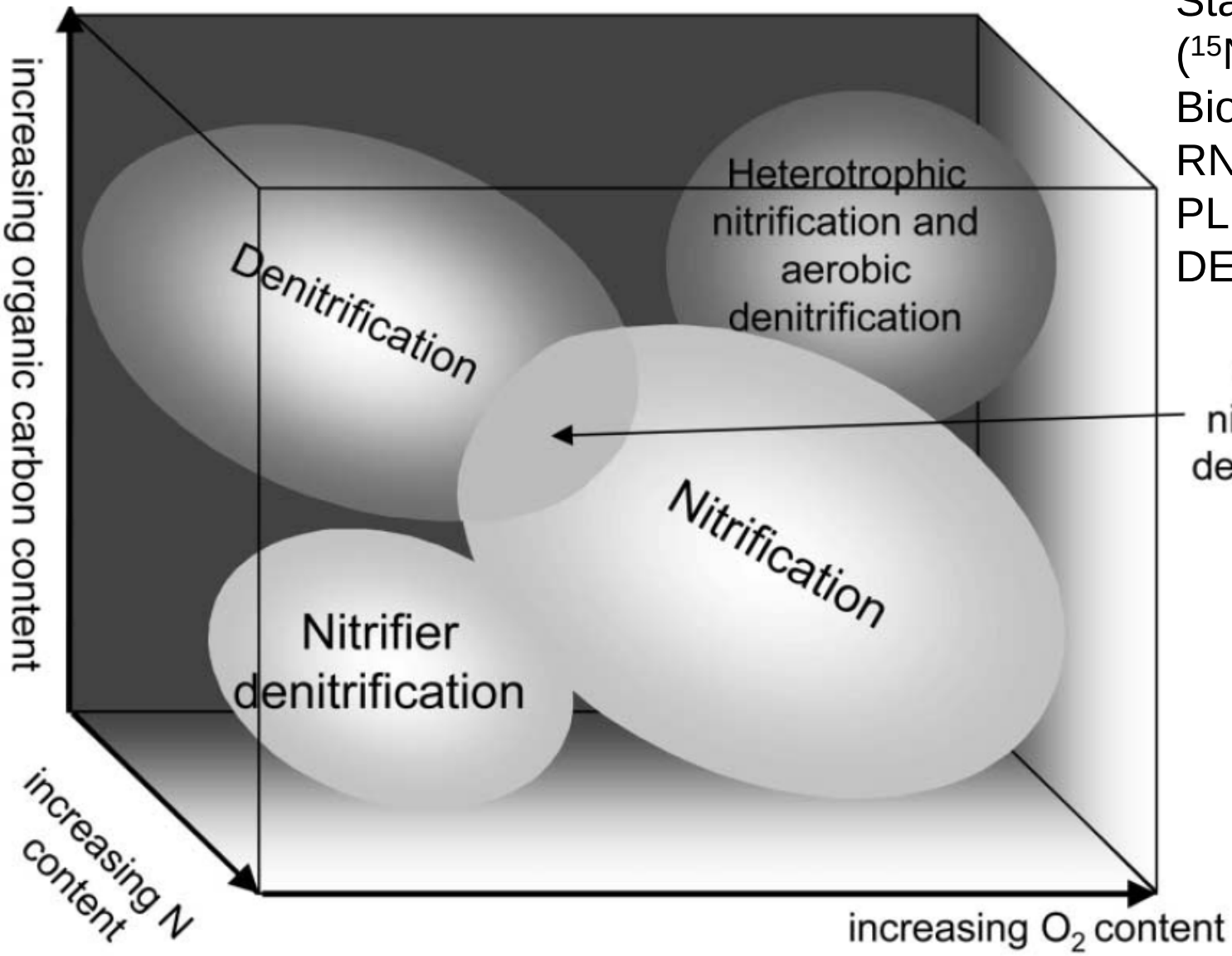


New pathways were identified, e.g. nitrifier-denitrification



Wrage et al., 2001, Soil Biol. Biochem.

Ecological niche of nitrifier-denitrification



Wrage et al., 2001, Soil Biol. Biochem.

<u>Tools for process identification:</u>

Stable isoptope techniques

(^{15}N/ ^{18}O) ± C_2H_2

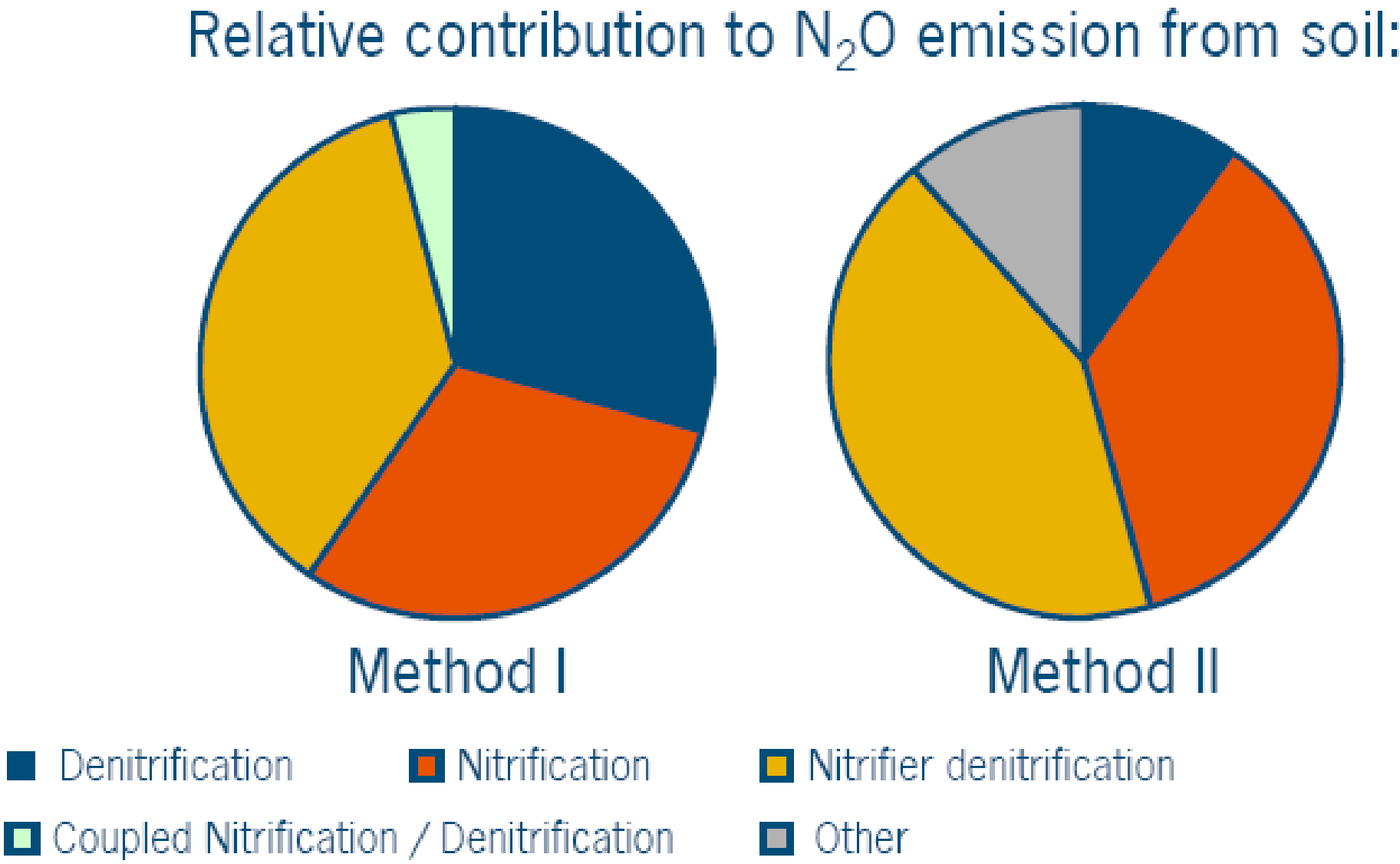
Bio-Molecular techniques

RNA/DNA extractions

PLFA analysis

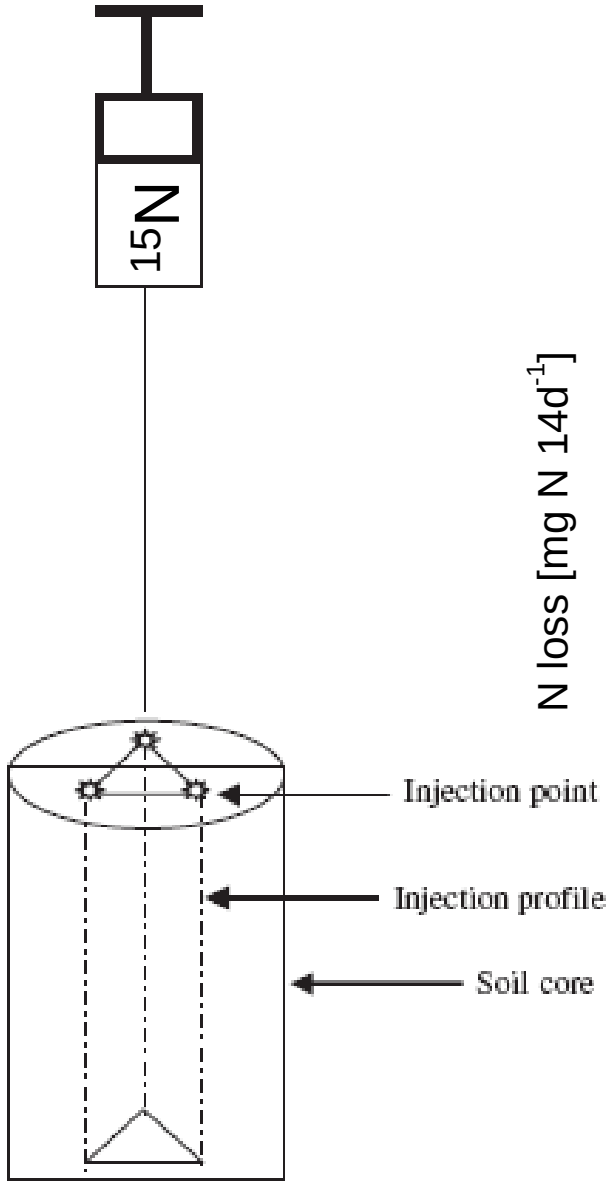
DEA, etc.

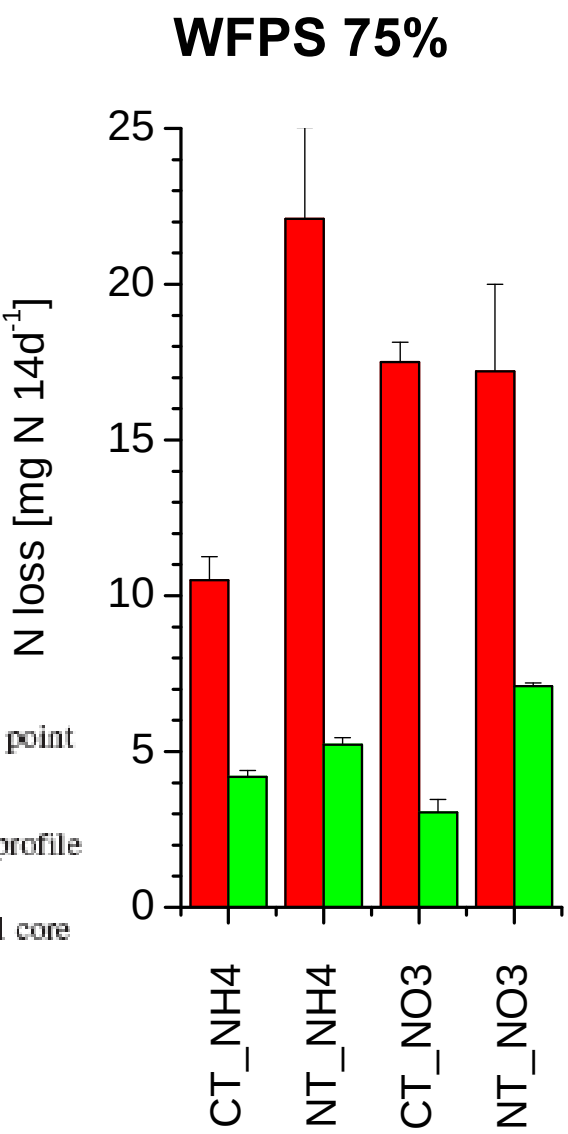
Importance of nitrifier denitrification for soil N_2O emissions

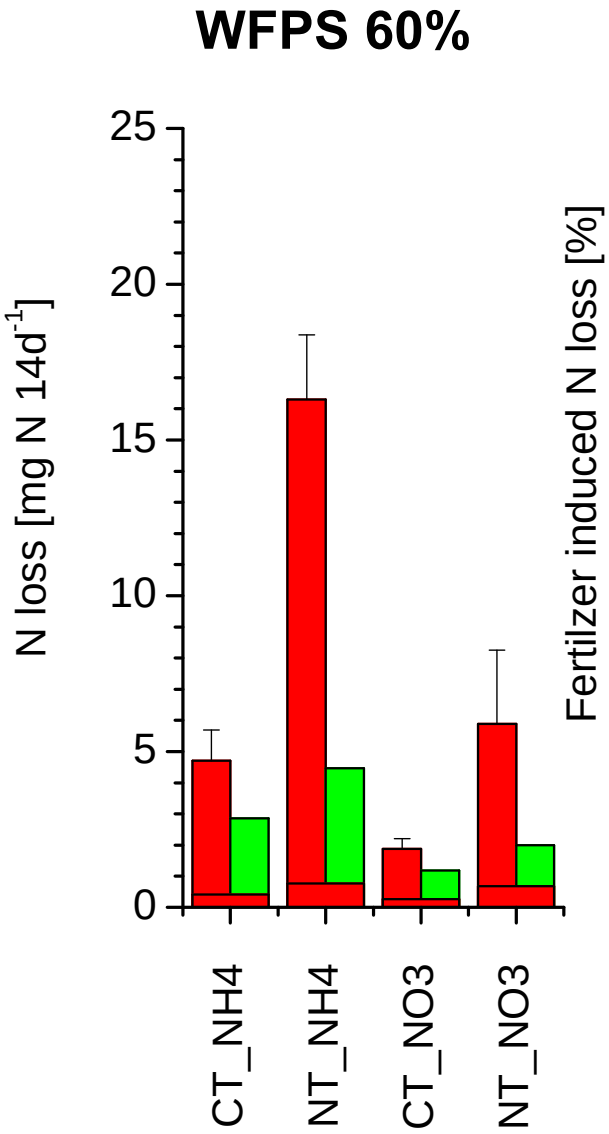


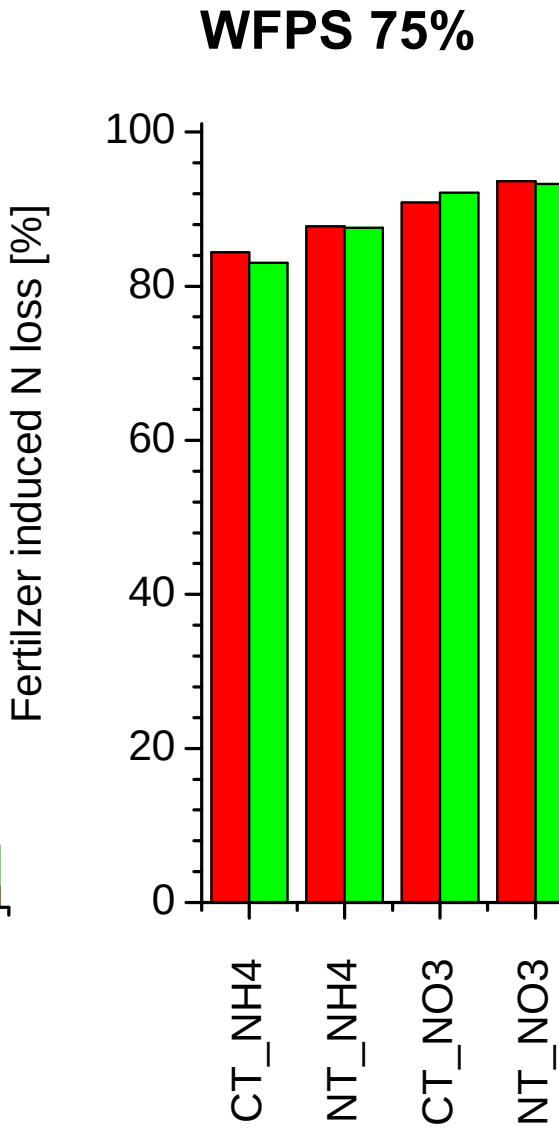
Wrage et al., 2005, RCMS

Denitrification in NT versus CT systems (laboratory)



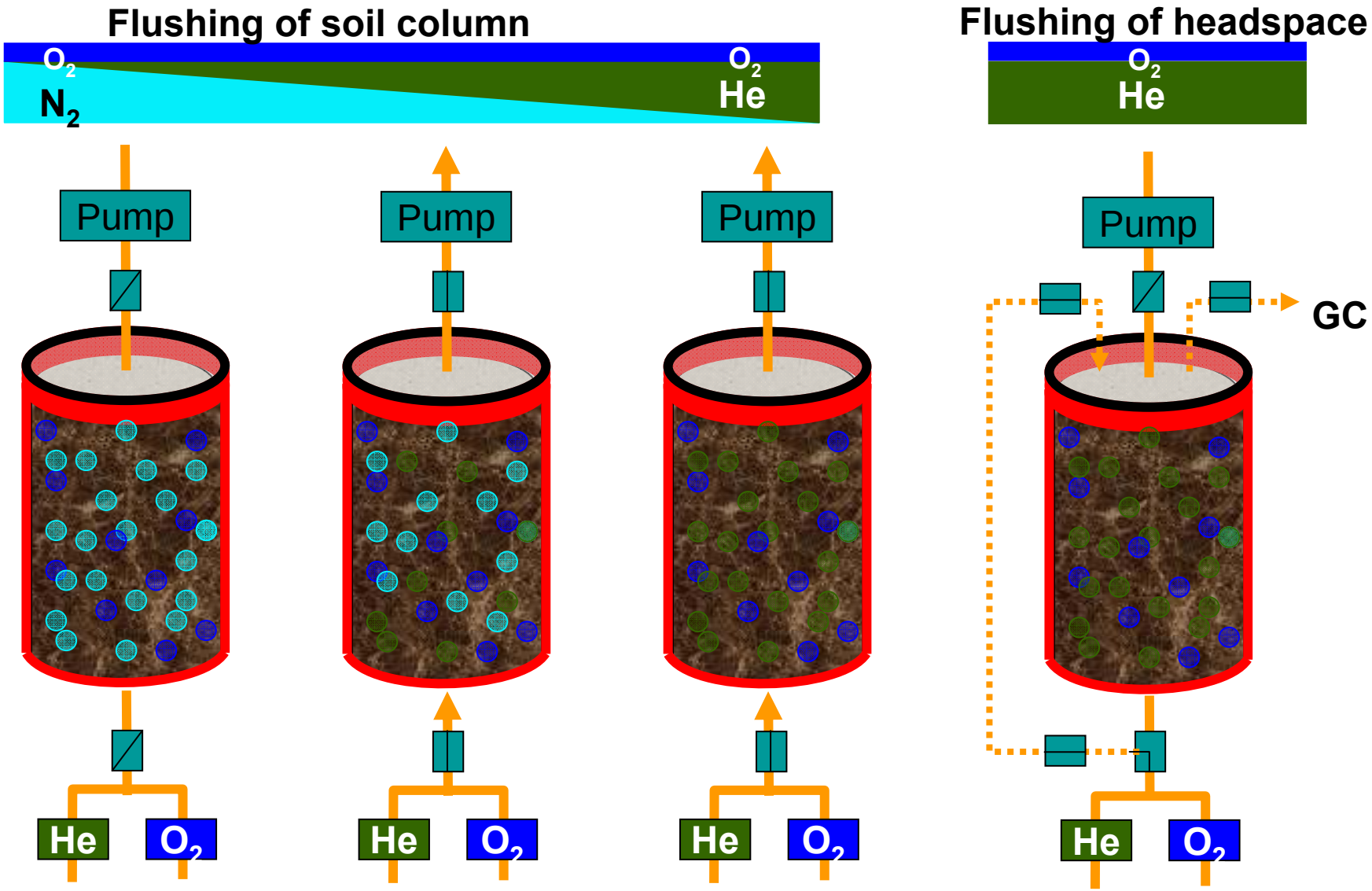






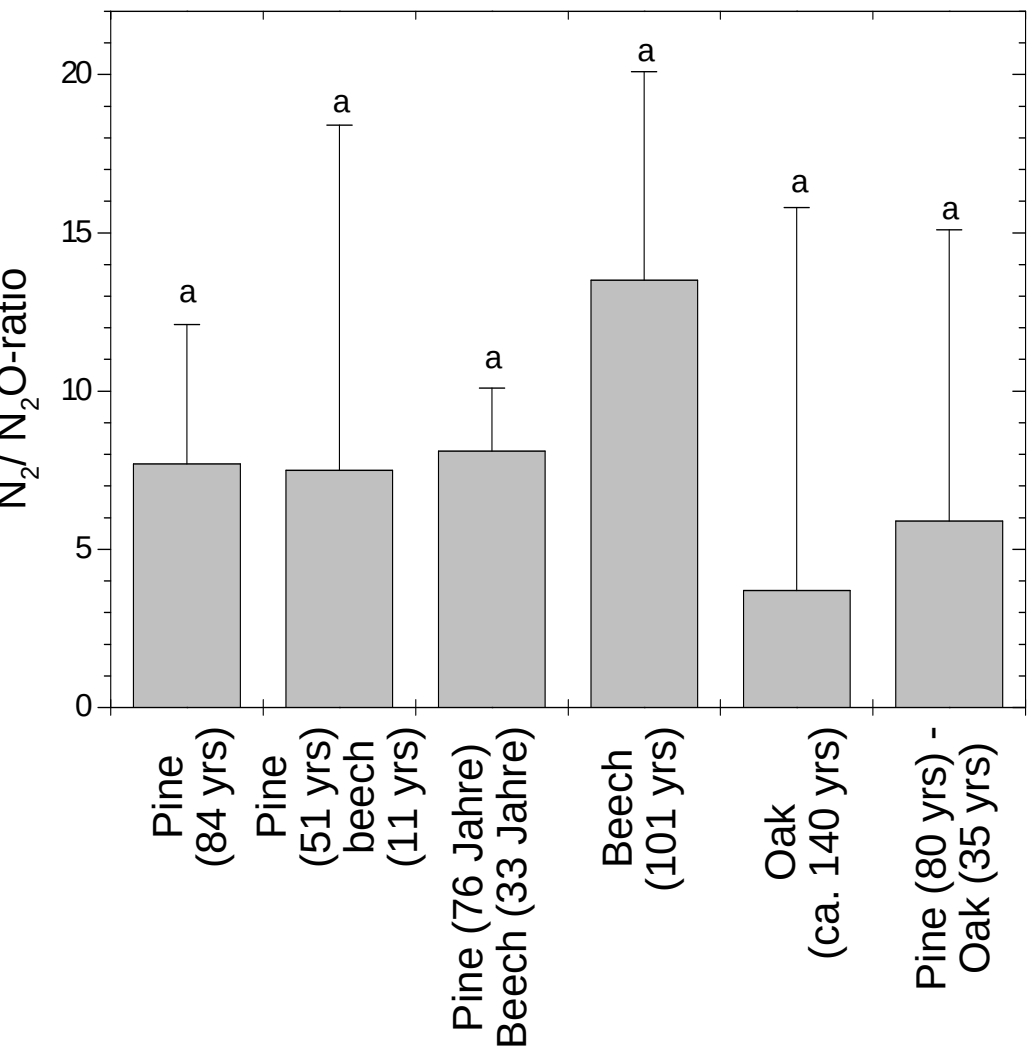
Liu et al., 2007, Soil Biol. Biochem.

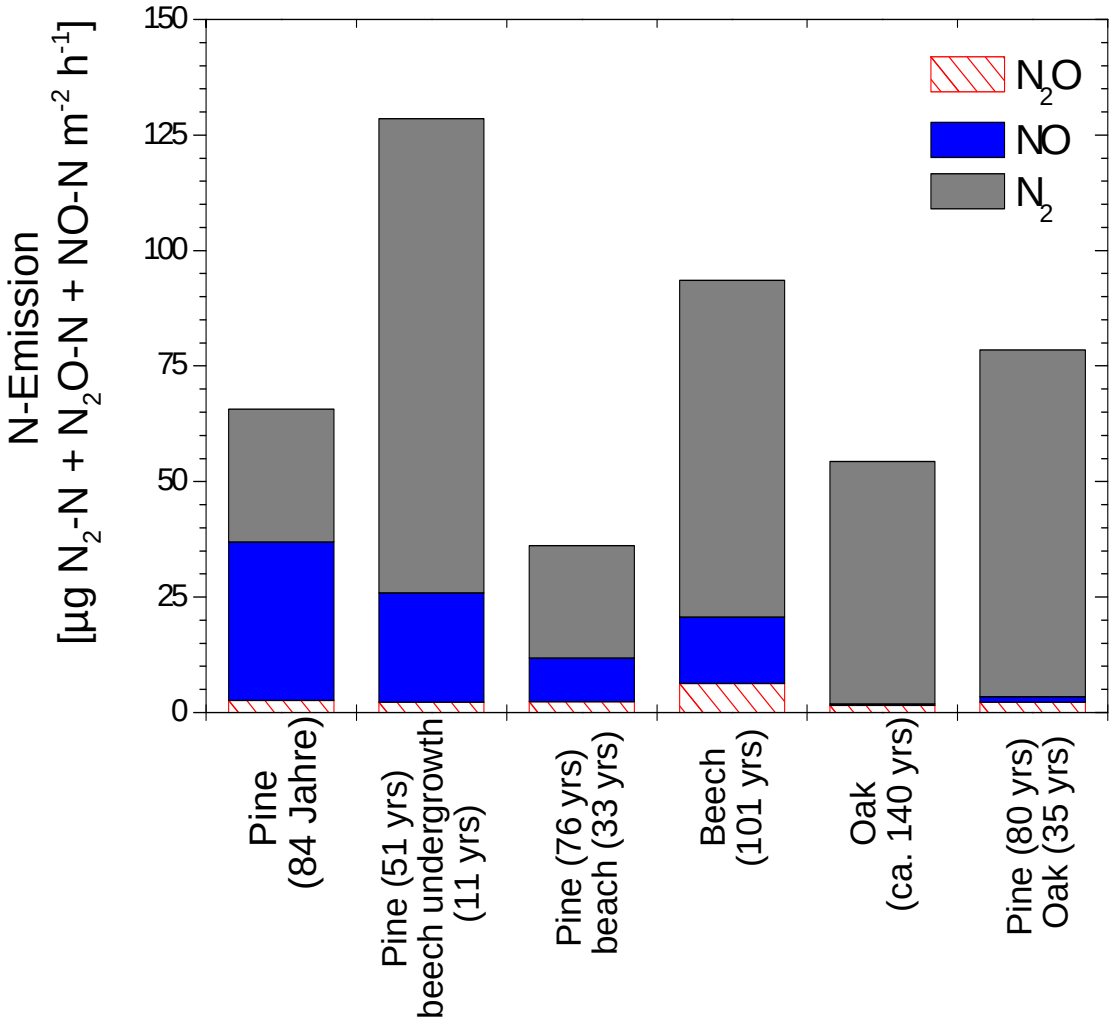
Replacement of the soil atmosphere



Gaseous N-losses from forest soils (North-Eastern Germany)

+field NO/N_2O measurements



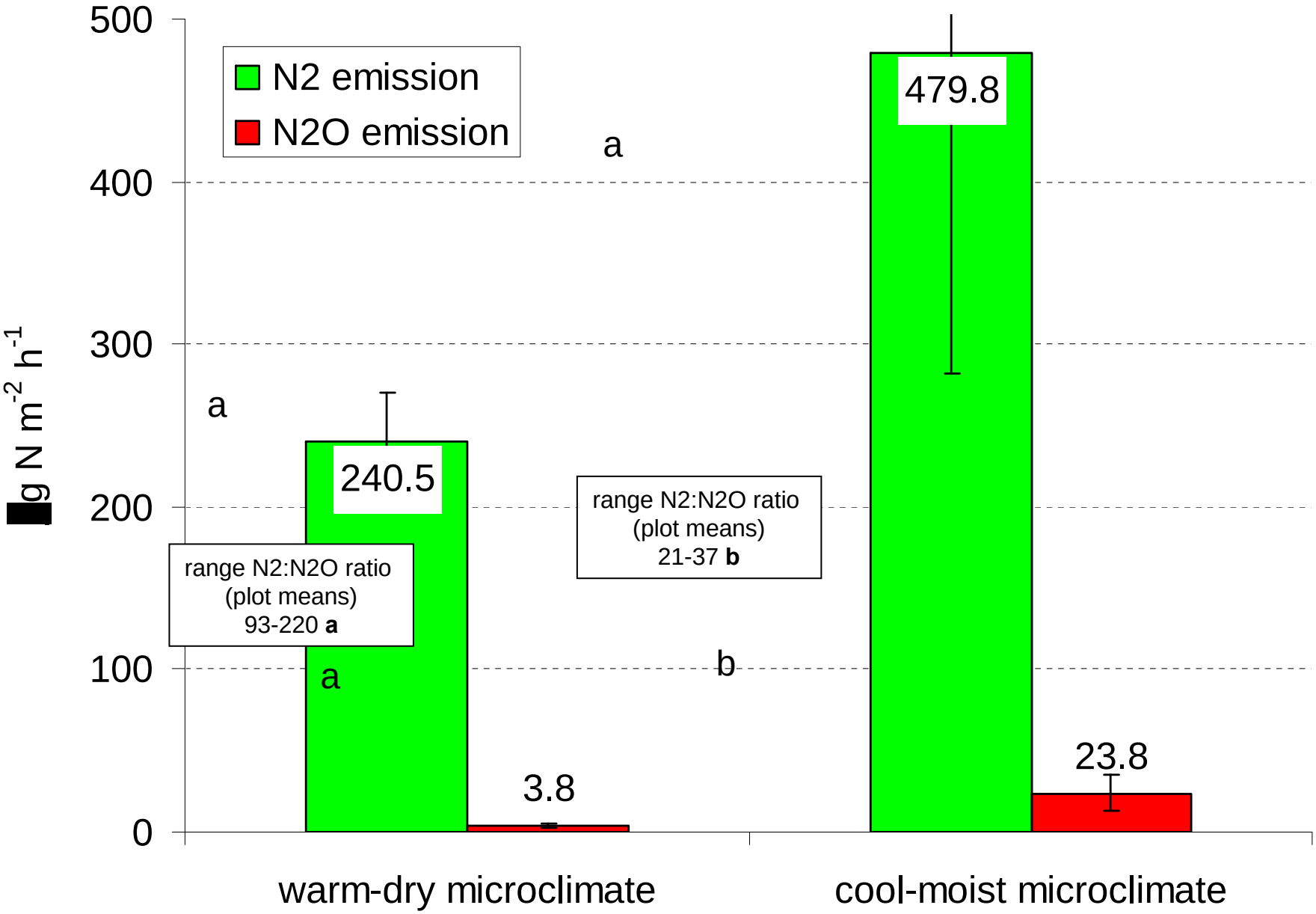


Butterbach-Bahl et al., unpubl.

Microclimate effects on the N_2:N_2O ratio

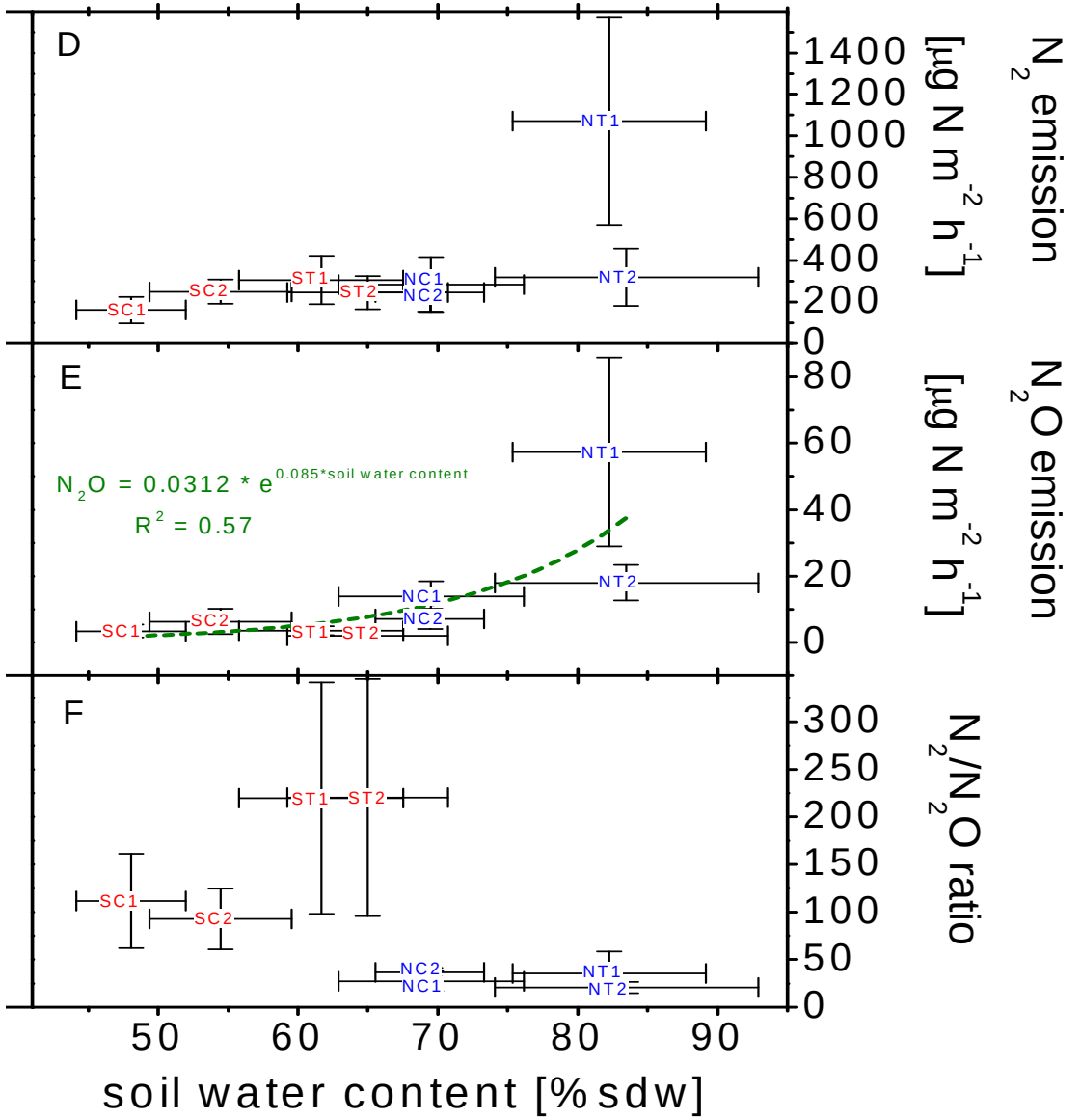
Dannenmann et al., Soil Biol Biochem, in press

Microclimate effects on the N_2:N_2O ratio



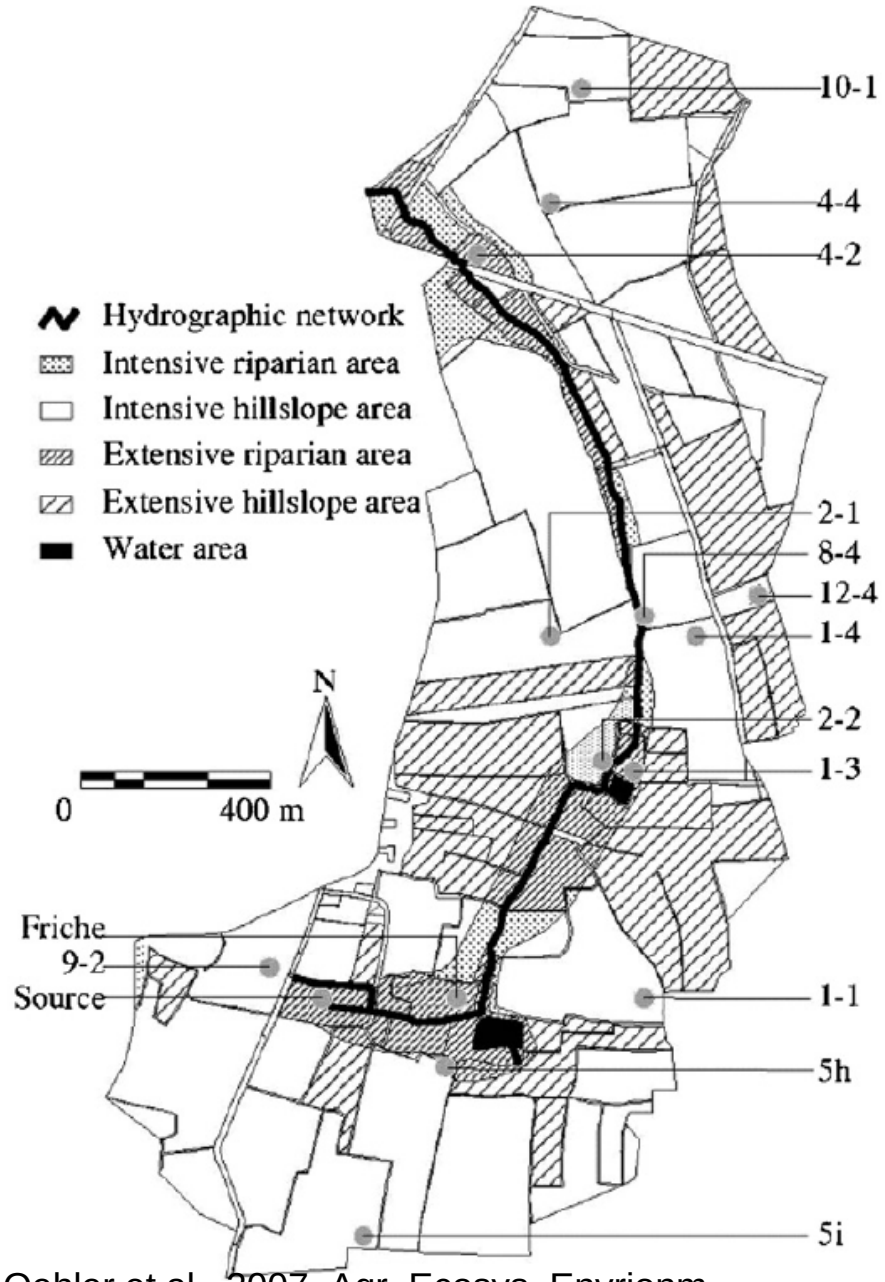
Dannenmann et al., Soil Biol Biochem, in press

Soil water and pH effects on the N_2:N_2O ratio



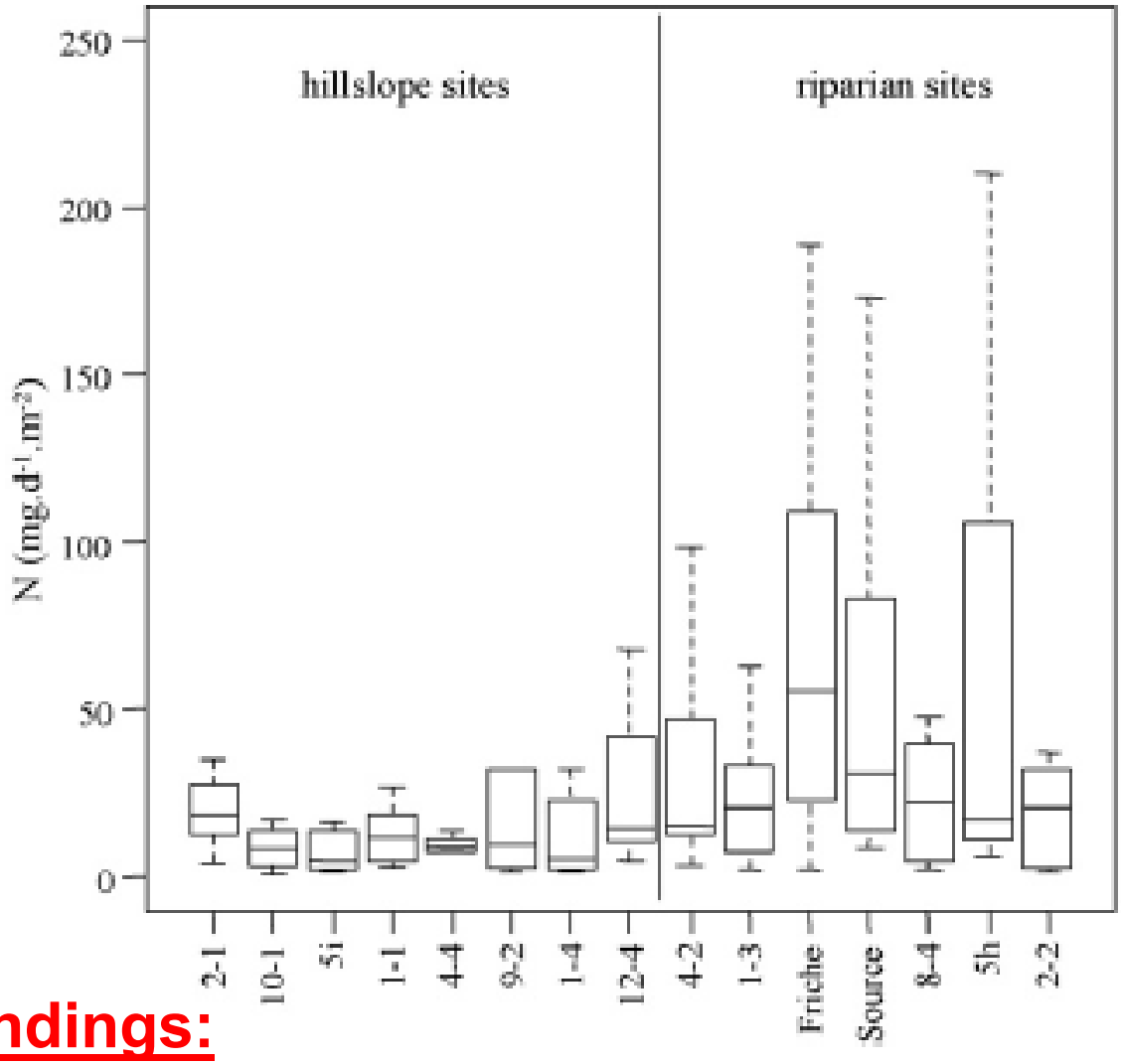
Dannenmann et al., Soil Biol Biochem, in press

Estimating landscape scale denitrification losses



Oehler et al., 2007, Agr. Ecosys. Envrionm.

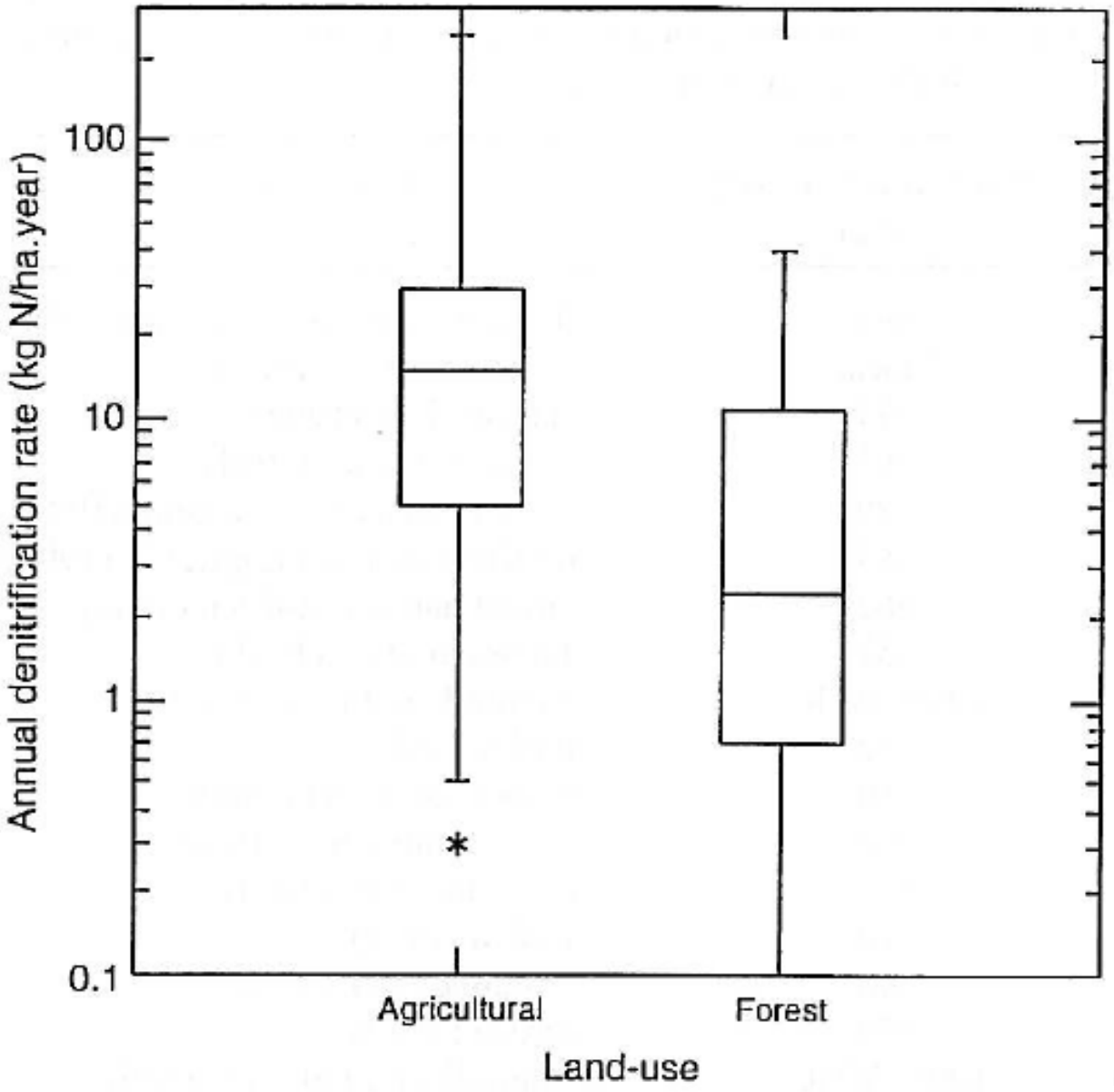
Annual mean N_2+N_2O losses



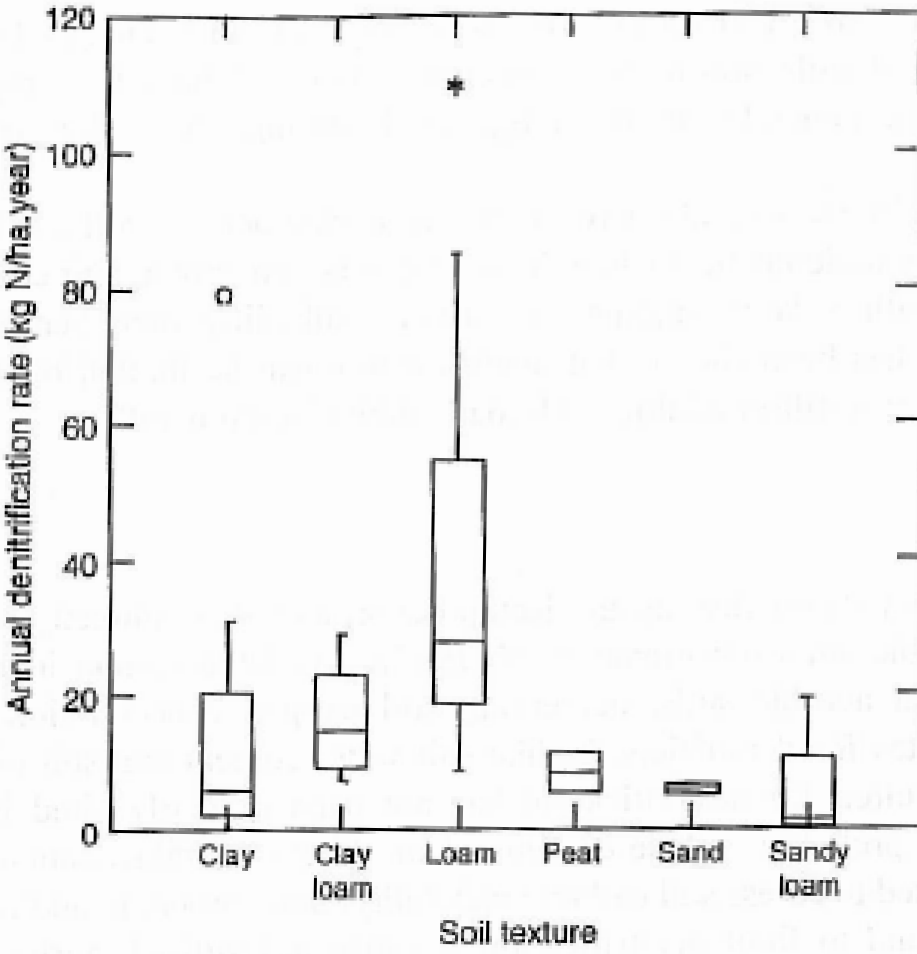
Main findings:

- 50% of denitrification occurs at hillslopes
- 20-40 cm layer contributed 50% to N losses
- N_2O:N_2 ratio approx. 1, i.e. main losses via N_2

Variability of denitrification estimates

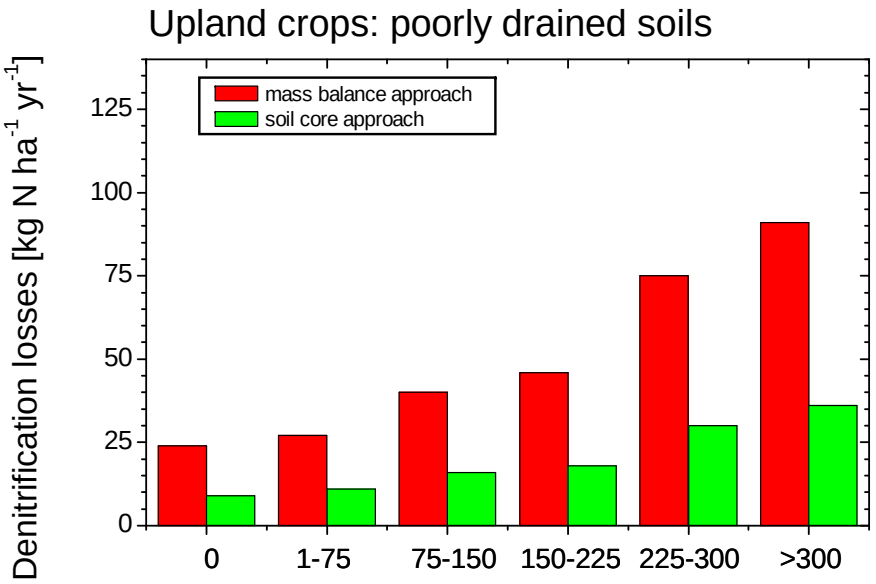


Denitrification & texture (grasslands)



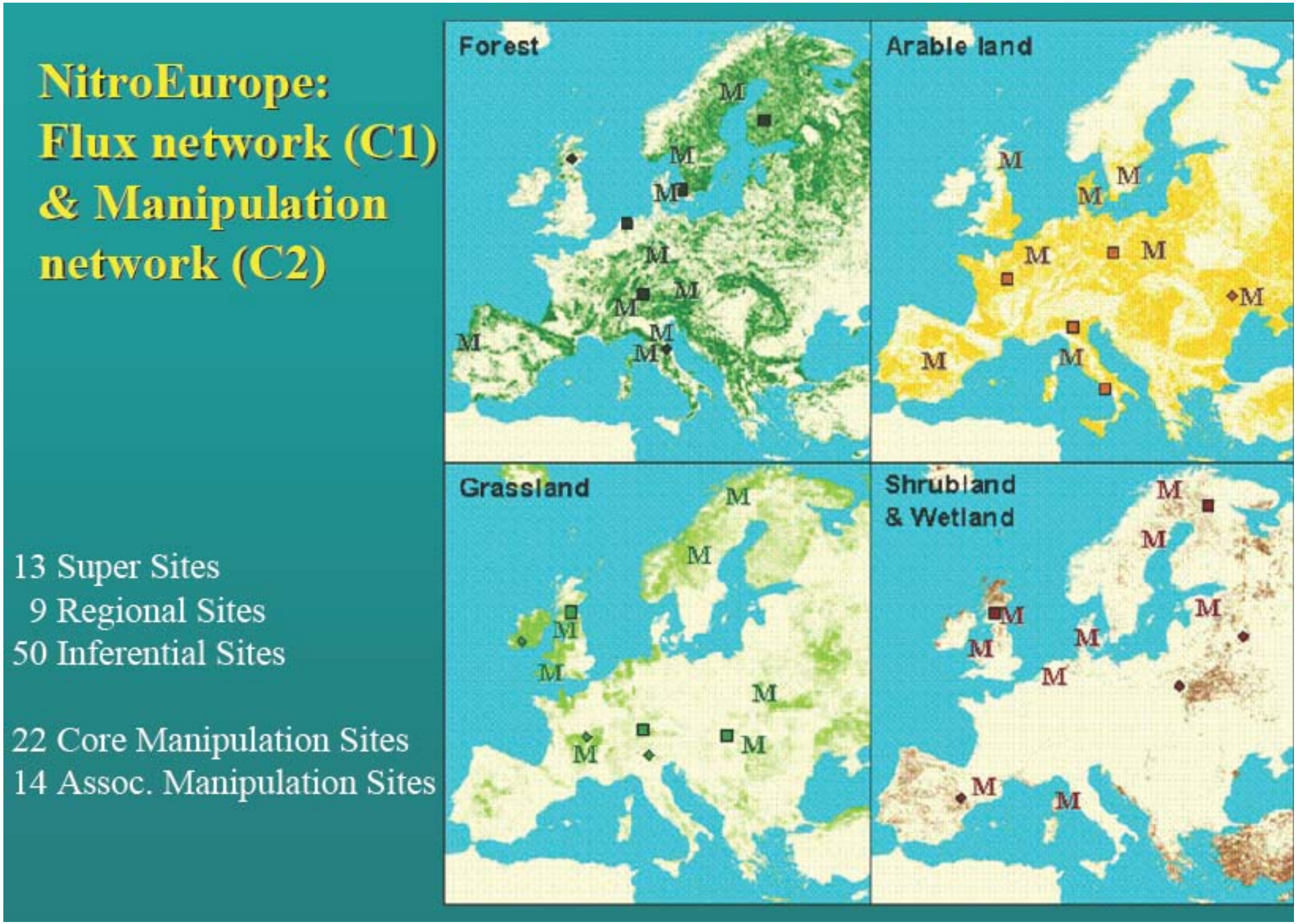
Barton et al.,1999, Aust J Soil Res

Uncertainties of denitrification estimates



Hofstra & Bouwman, 2005, Nutr Cycl Agroecosys

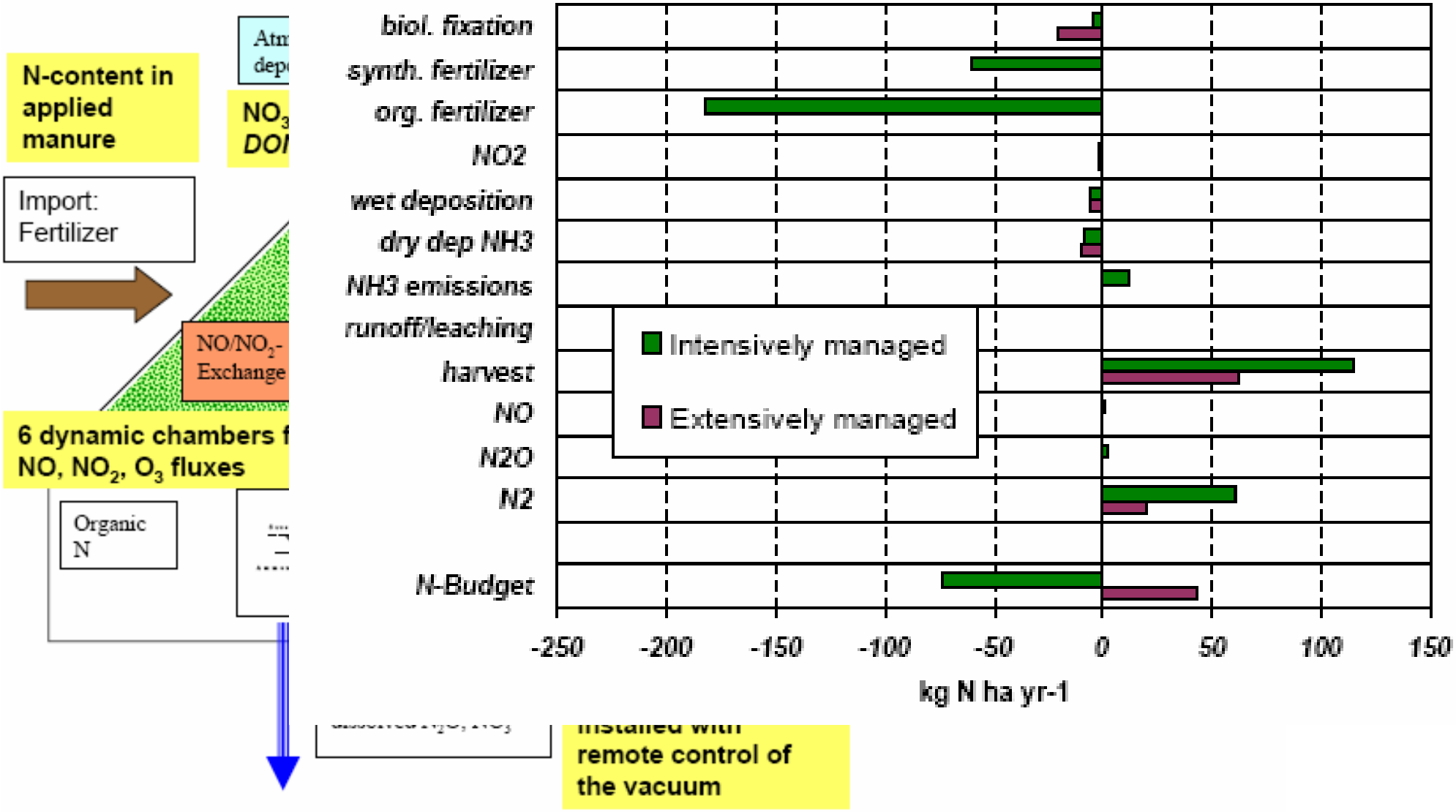
NitroEurope – Towards full N balance studies



NitroEurope – Towards full N balance studies

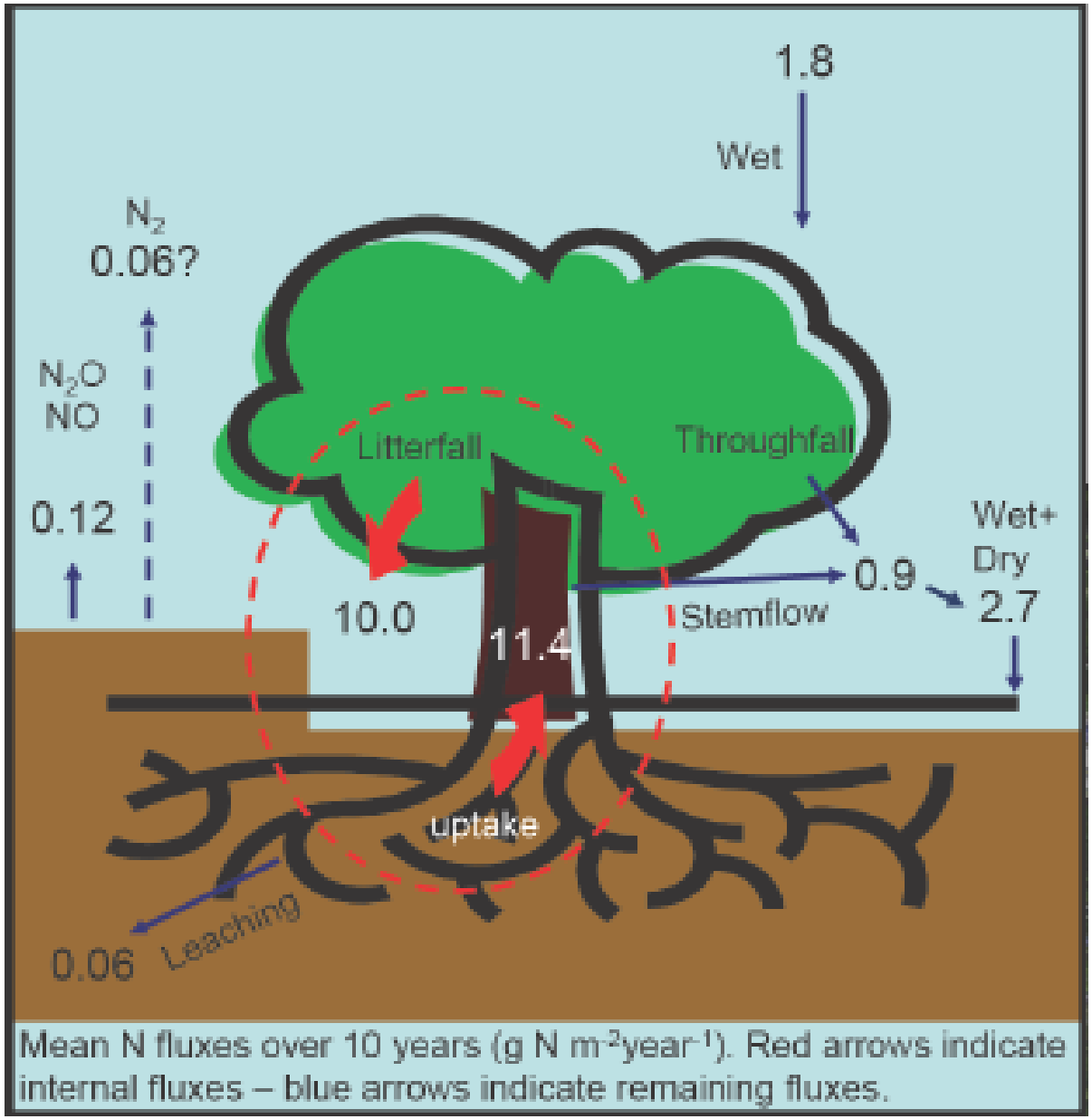
Oensingen, grassland (Switzerland), J Fuhrer, A Neftel, P Calanca (FAL)

Oensingen Site: N-Budget Components



NitroEurope – Towards full N balance studies

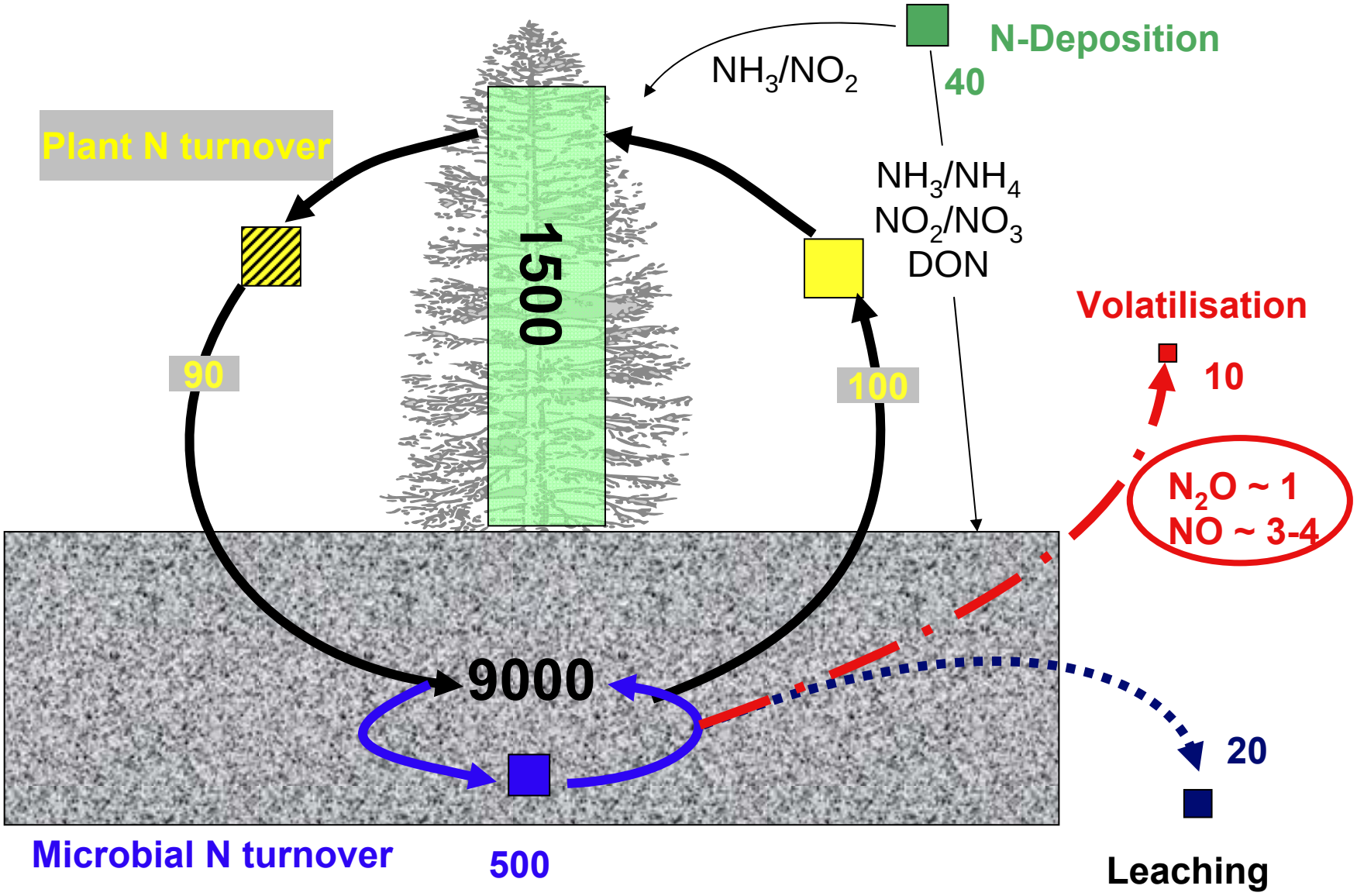
Soroe, beech forest (Denmark), K Pilegaard, C Beier, KS Larsen (Risoe)



Mean N fluxes over 10 years (g N $m^{-2}year^{-1}$). Red arrows indicate internal fluxes – blue arrows indicate remaining fluxes.

NitroEurope – Towards full N balance studies

Höglwald, spruce forest (Germany), N Brüggemann, H Papen, K Butterbach-Bahl (FZK

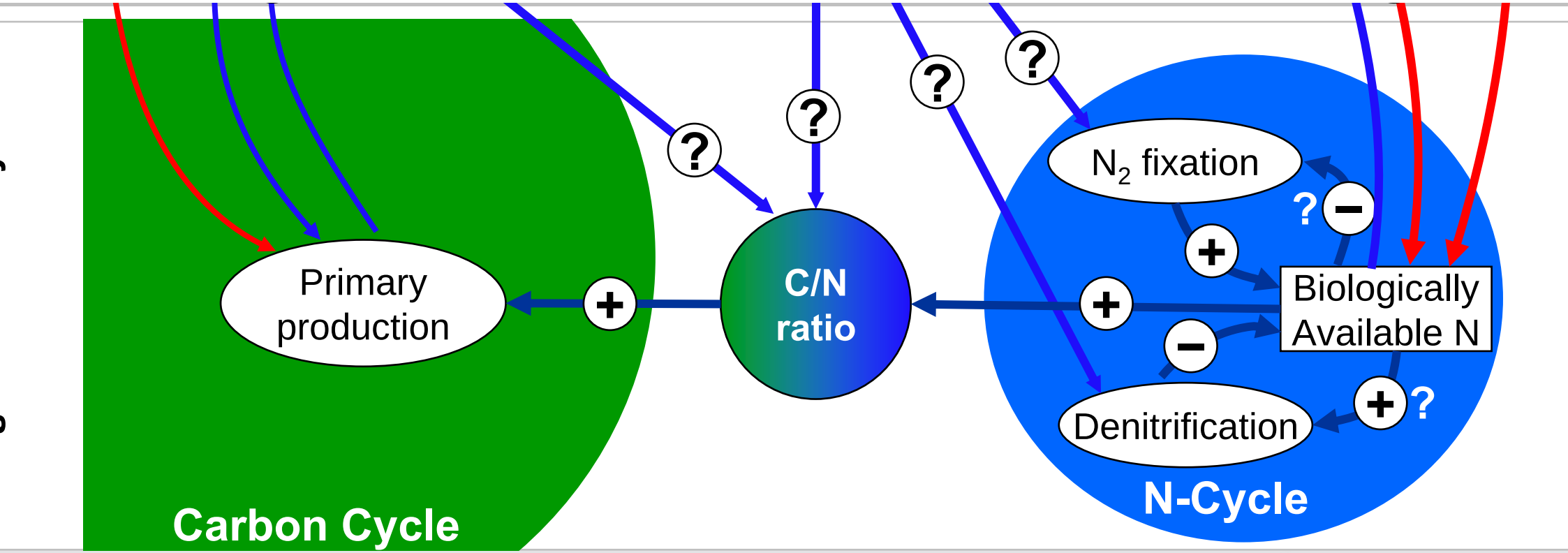


Summary and conclusions

- Publications on denitrification in terrestrial systems have strongly increased, but are still mainly driven by N_2O research
- Following the use of advanced techniques process understanding is increasing, but
- denitrification estimates on global and “continental” scales are better constrained as estimates on site and landscape scales,

Needed

- Method comparisons
- Detailed N budget studies for various ecosystem types
- Integrated landscape (catchment) studies


Primary production
C/N ratio
N_2 fixation
Biologically Available N
Denitrification
Carbon Cycle
N-Cycle
?
+
−