

# Denitrification in terrestrial ecosystems

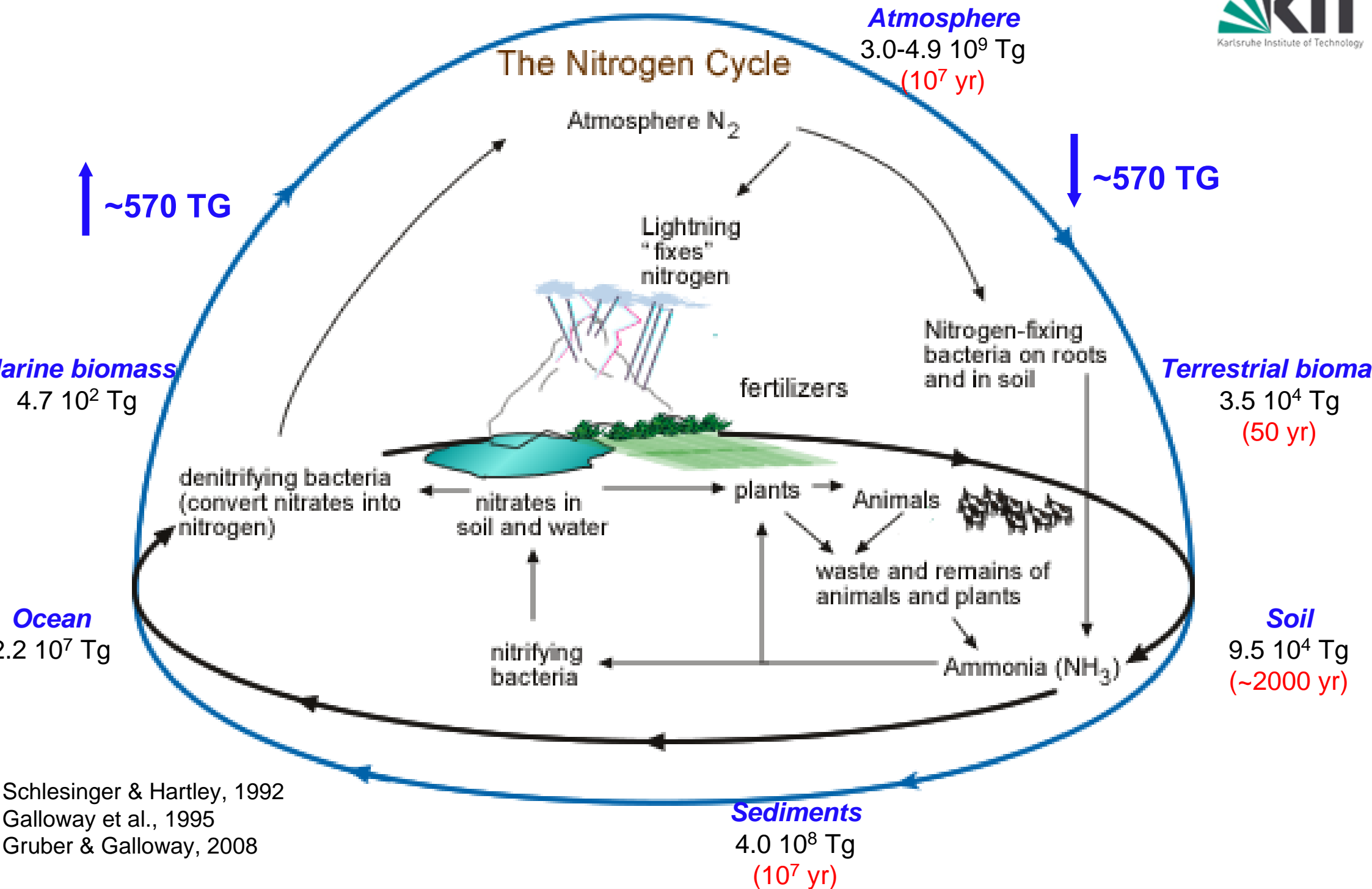
-

## A problem of scale?!

**Klaus Butterbach-Bahl**

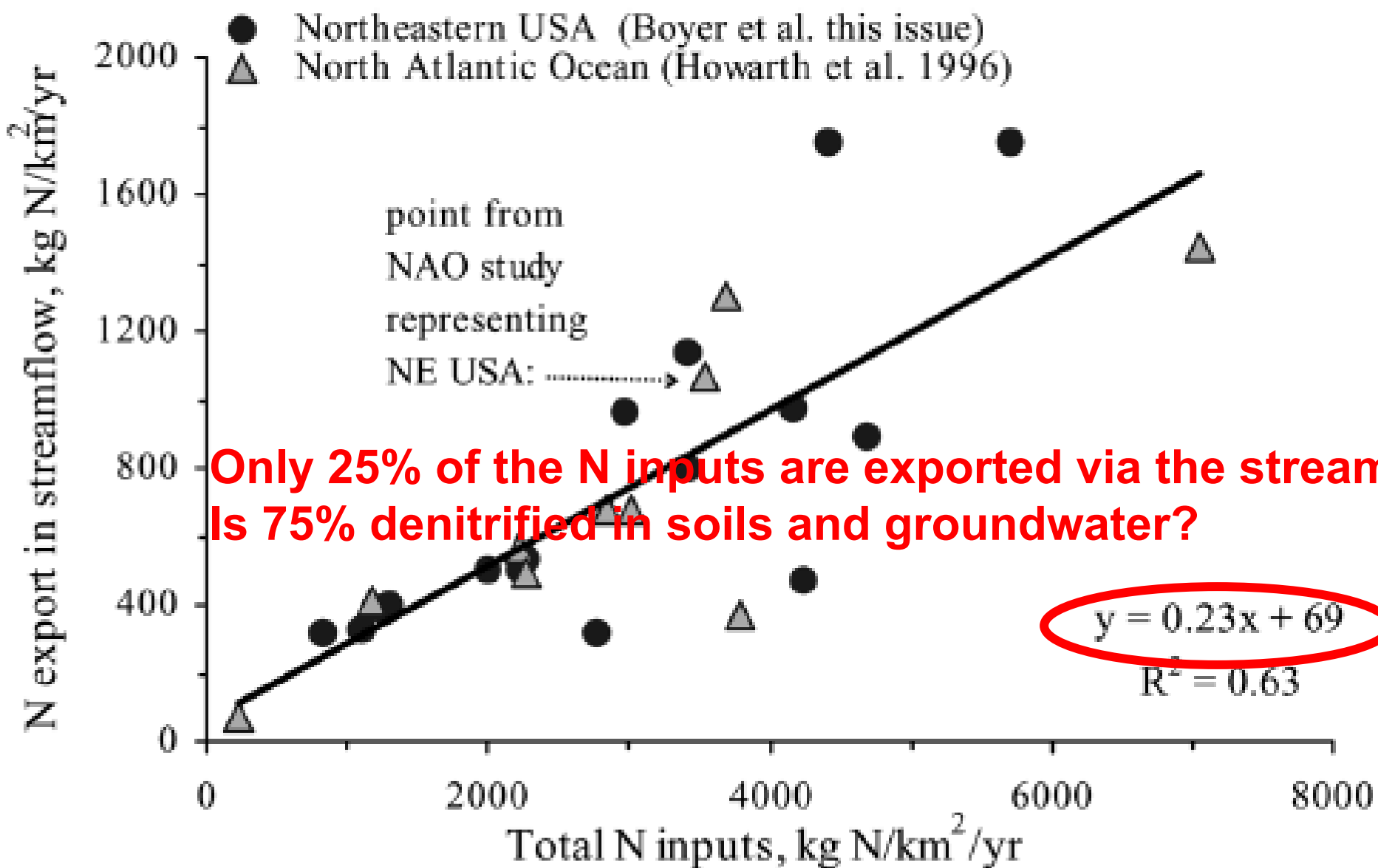
*Institute of Meteorology and Climate Research, Karlsruhe Institute of Technology,*

*Garmisch-Partenkirchen, Germany*

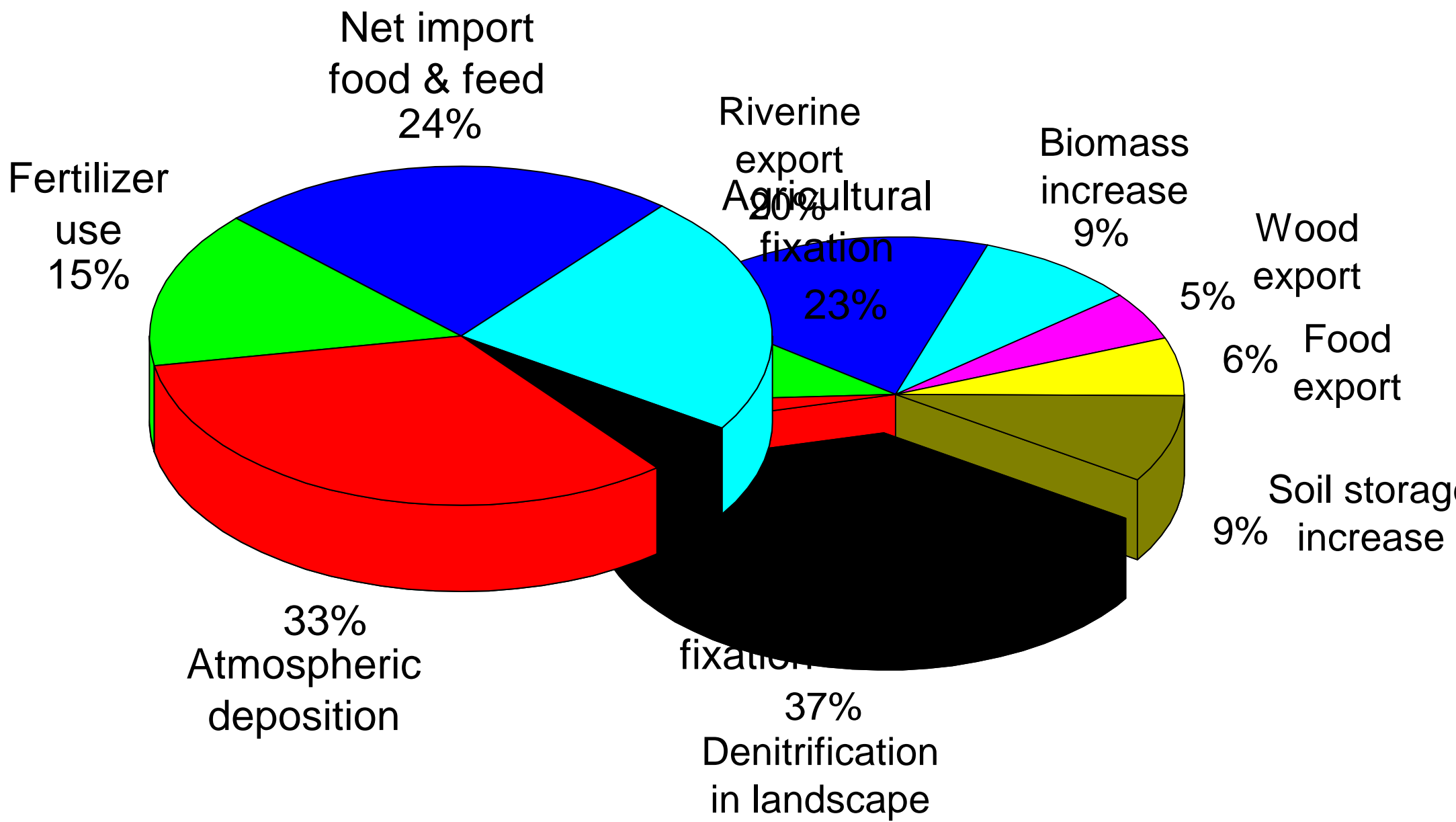


Schlesinger & Hartley, 1992  
Galloway et al., 1995  
Gruber & Galloway, 2008

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



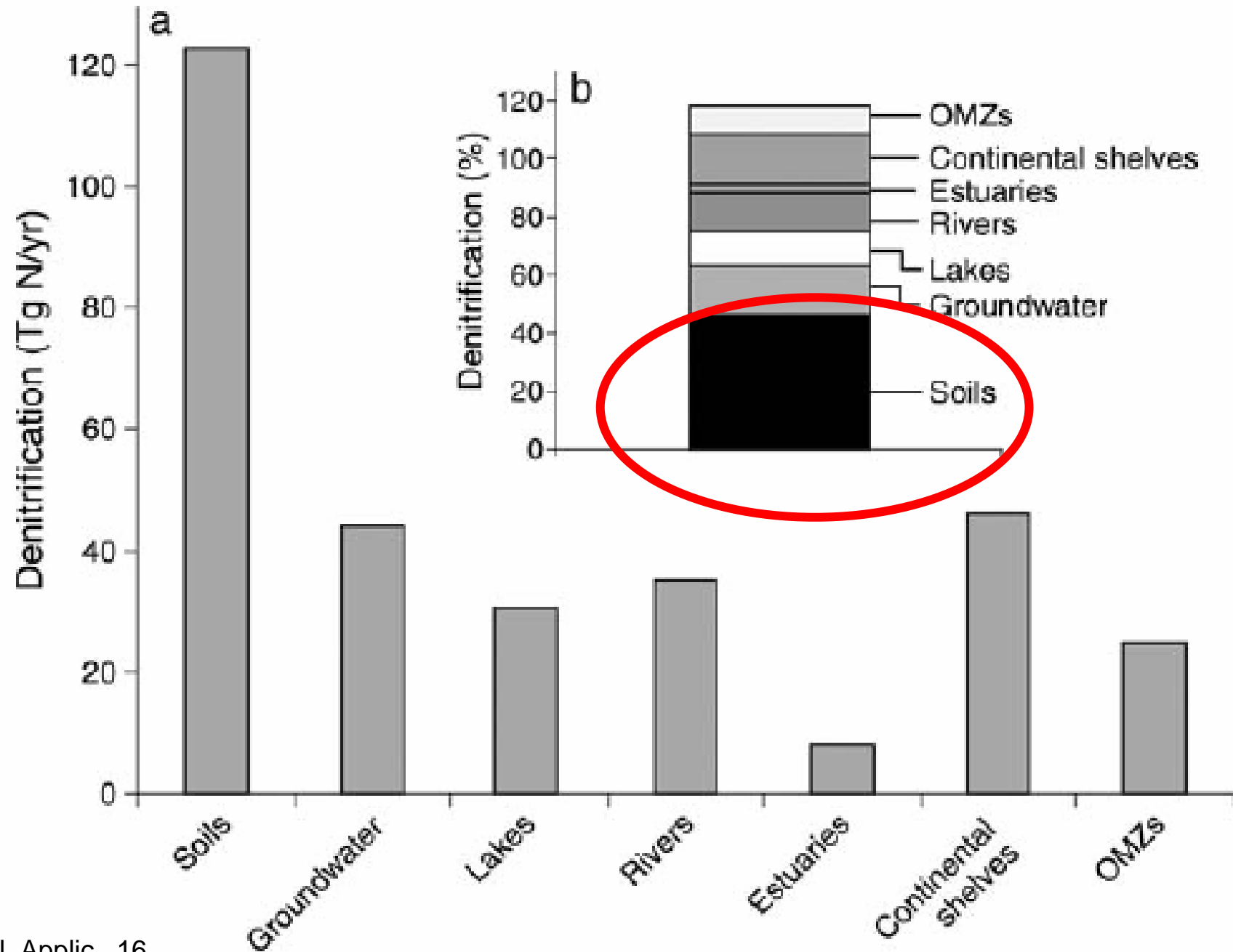
# Van Breemen et al., 2002: Where did all the nitrogen go?



Van Breemen et al., 2002, Biogeochemistry

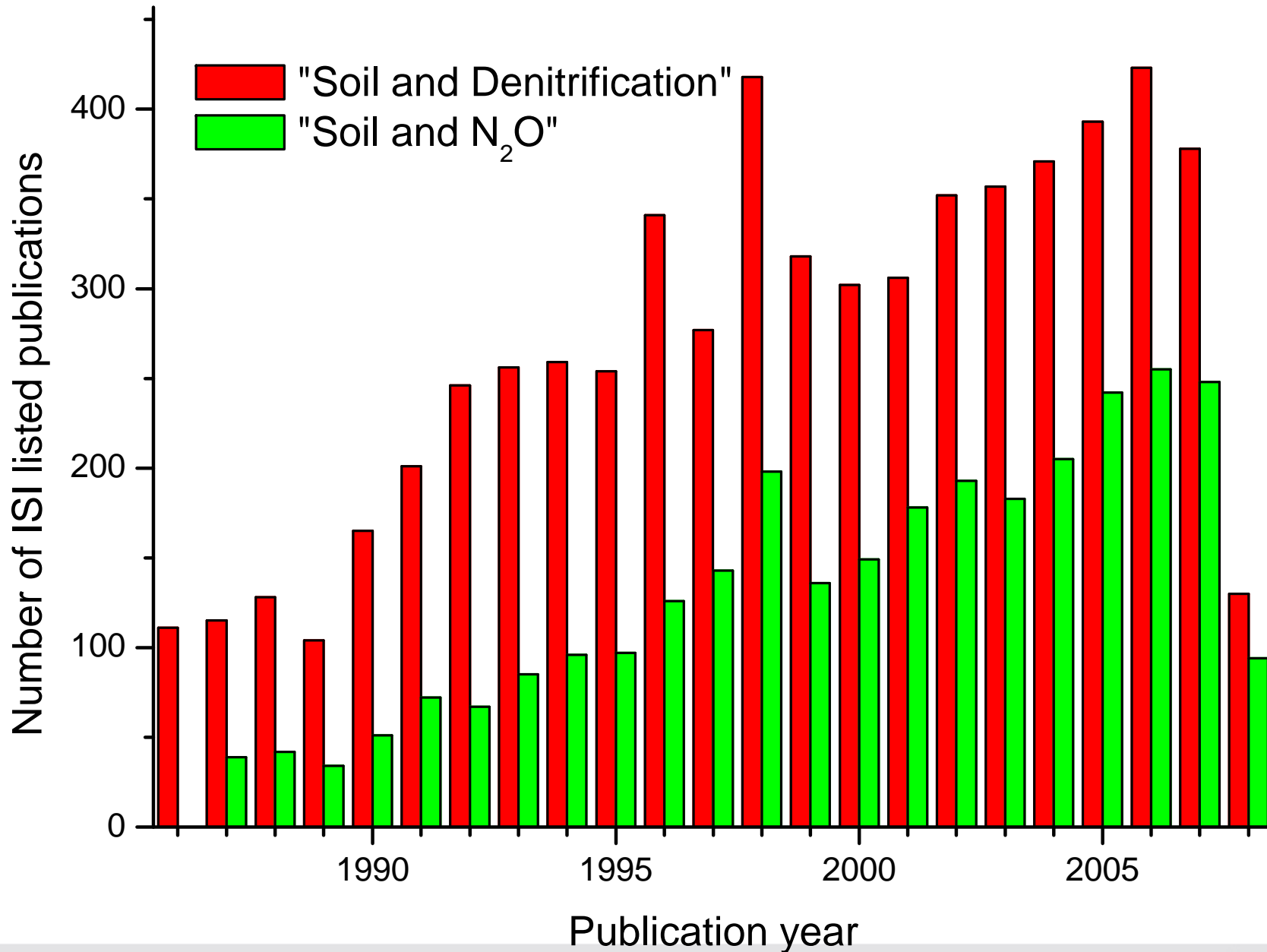
# Seitzinger et al., 2006: 40% of N input is denitrified in soils

**Approx. 270 Tg N<sub>r</sub> additions to terrestrial systems**

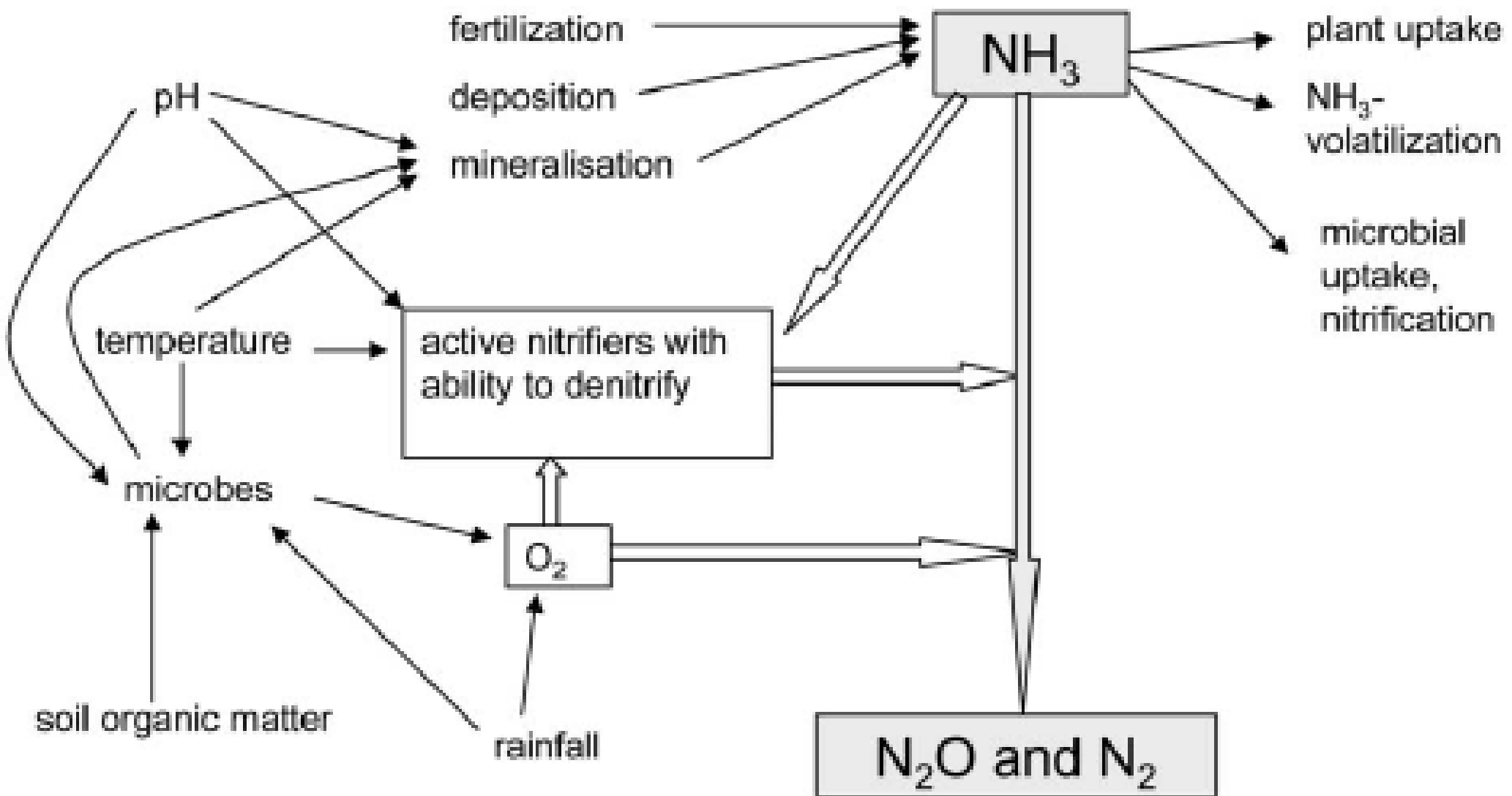


It seems that we do know the “big” numbers quite well,  
but how good is our knowledge on site and landscape scales?

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



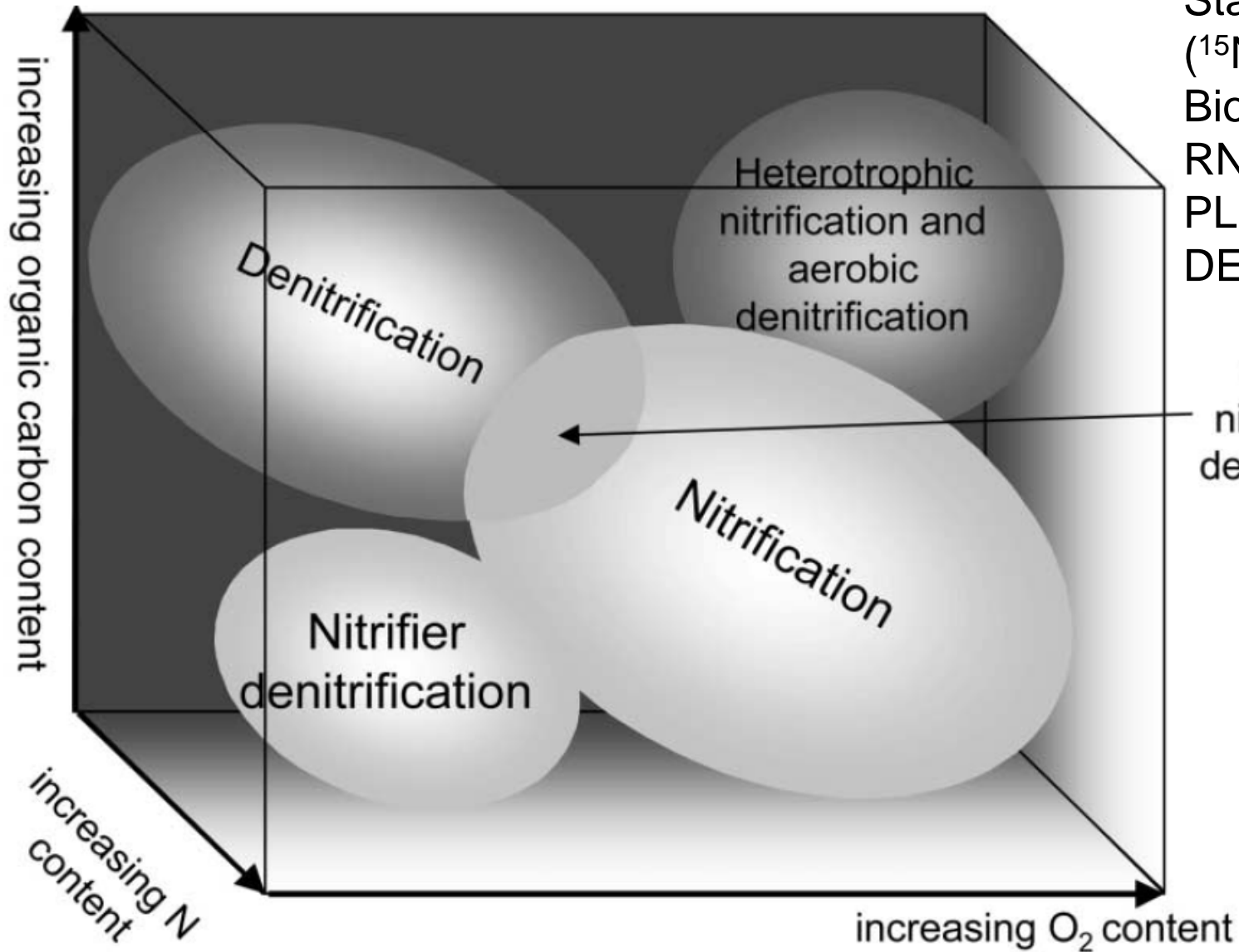
# New pathways were identified, e.g. nitrifier-denitrification



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



# Ecological niche of nitrifier-denitrification



## Tools for process identification:

Stable isotope techniques

(<sup>15</sup>N/ <sup>18</sup>O) ± C<sub>2</sub>H<sub>2</sub>

Bio-Molecular techniques

RNA/DNA extractions

PLFA analysis

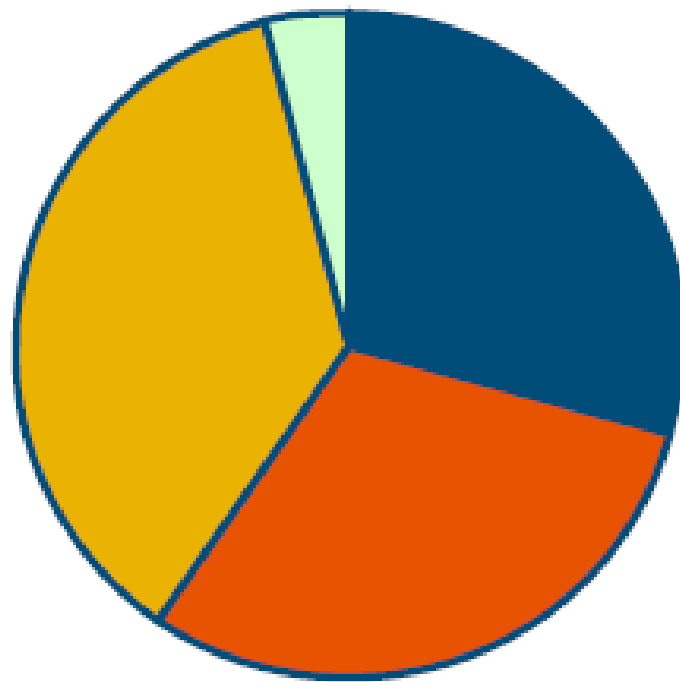
DEA, etc.

coupled  
nitrification-  
denitrification

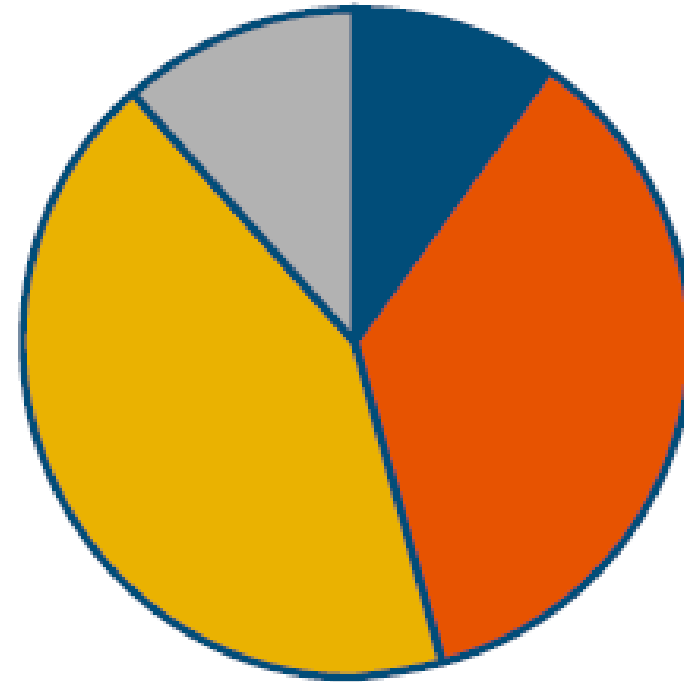
Wrage et al., 2001, Soil Biol. Biochem.

# Importance of nitrifier denitrification for soil N<sub>2</sub>O emissions

Relative contribution to N<sub>2</sub>O emission from soil:



Method I

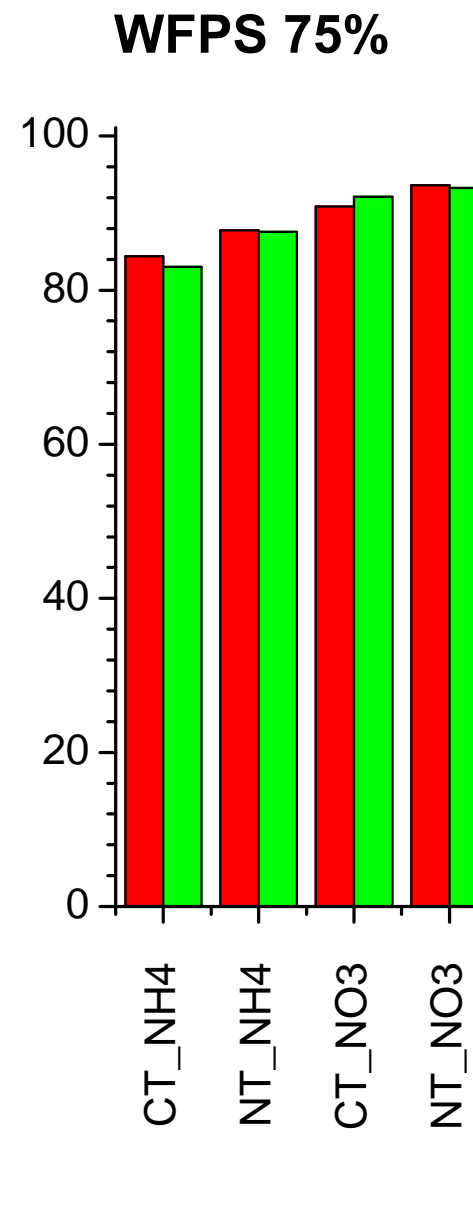
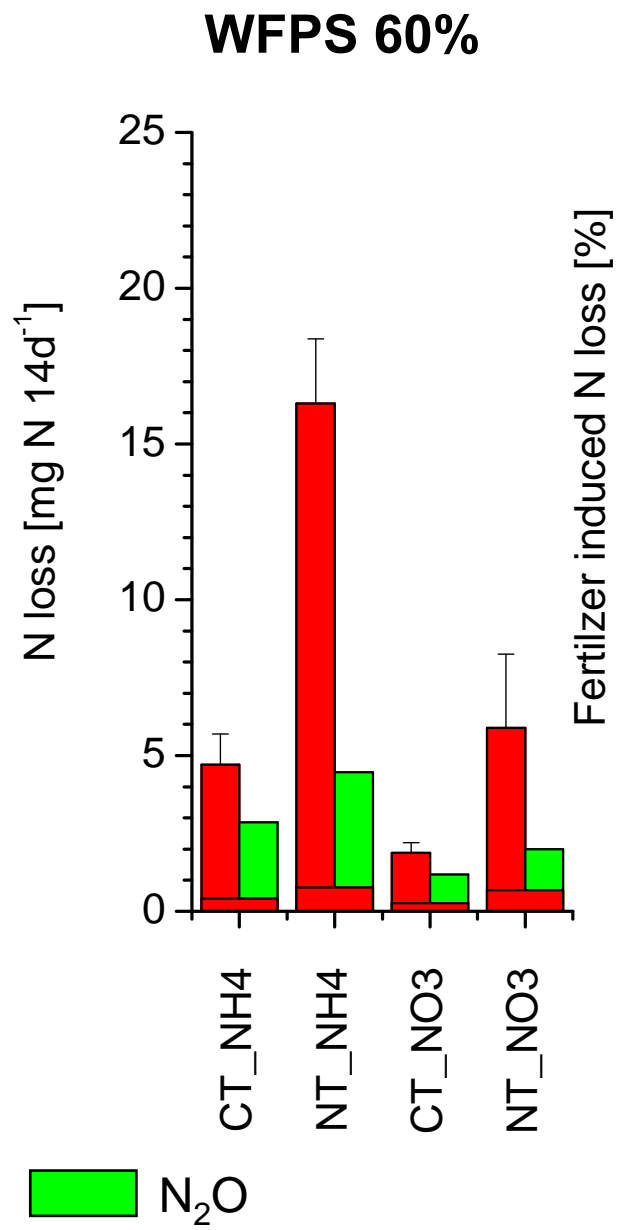
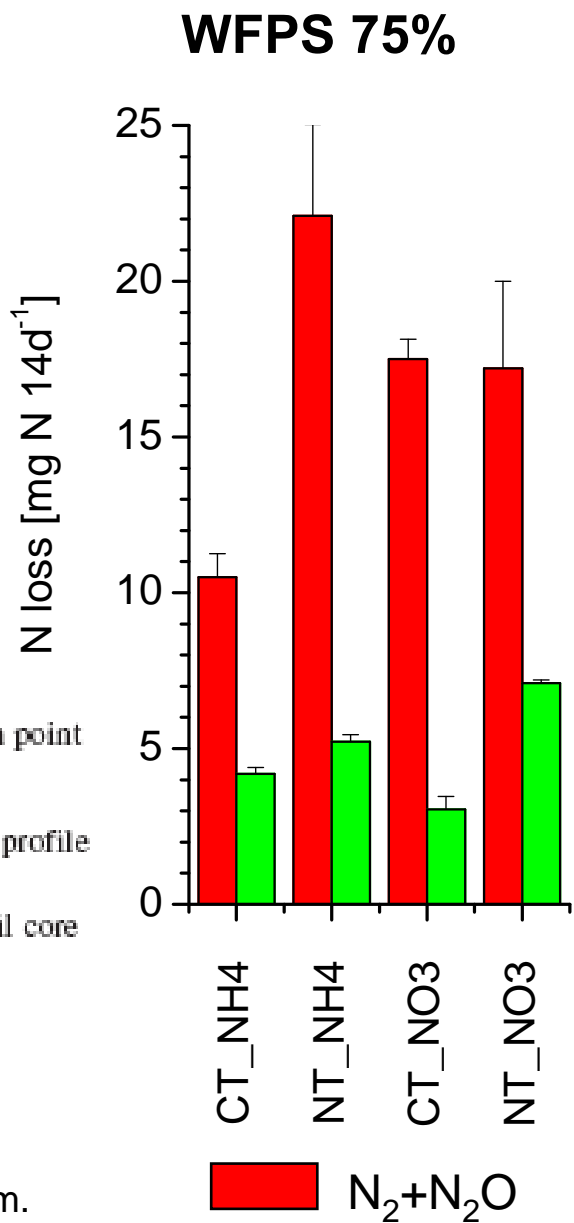
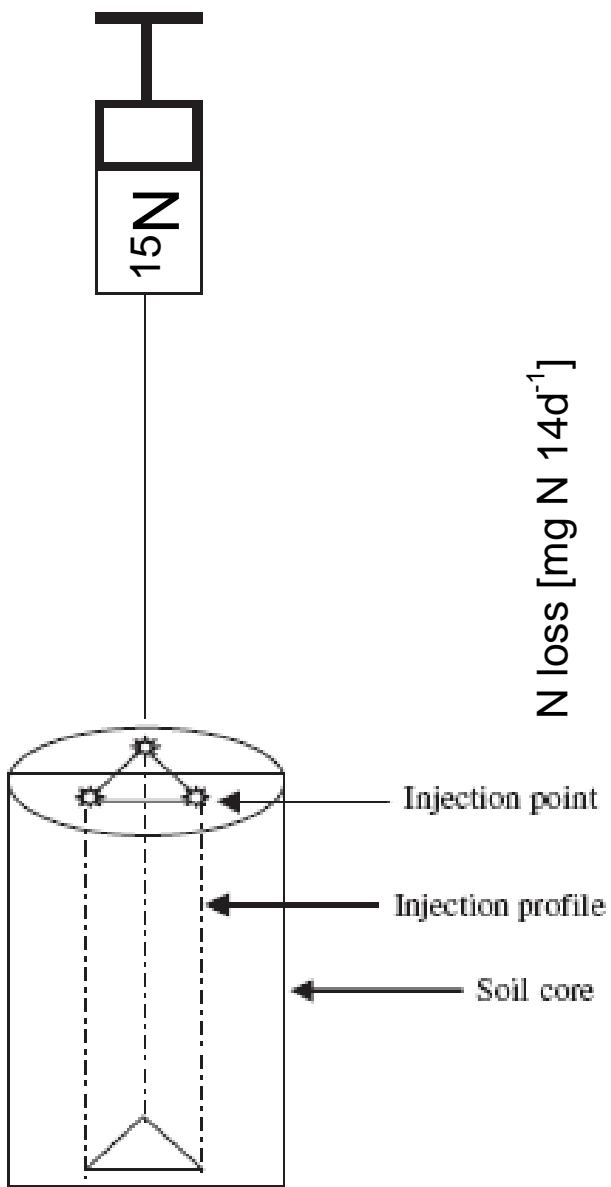


Method II

- Denitrification
- Nitrification
- Nitrifier denitrification
- Coupled Nitrification / Denitrification
- Other

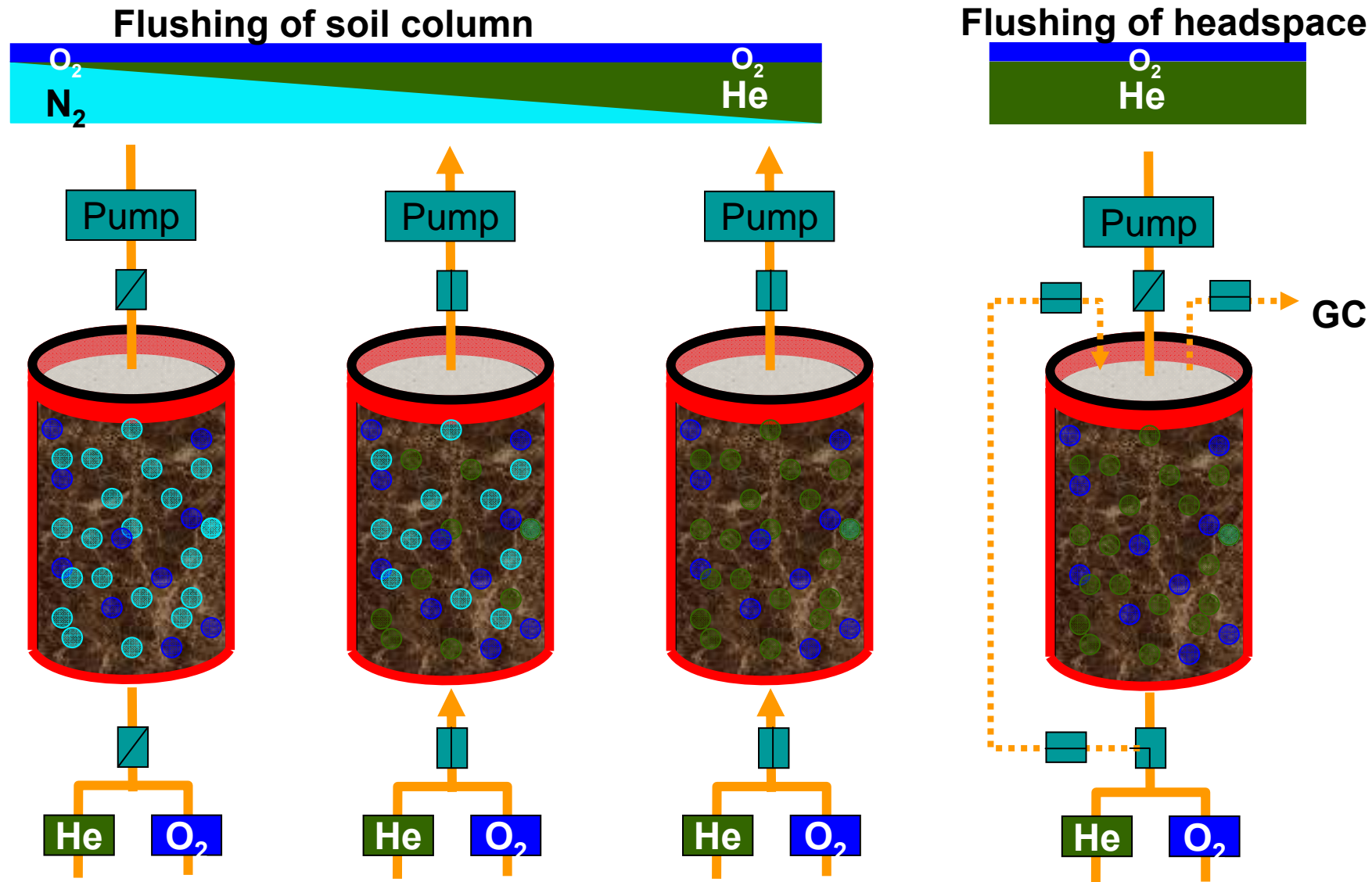
Wrage et al., 2005, RCMS

# Denitrification in NT versus CT systems (laboratory)

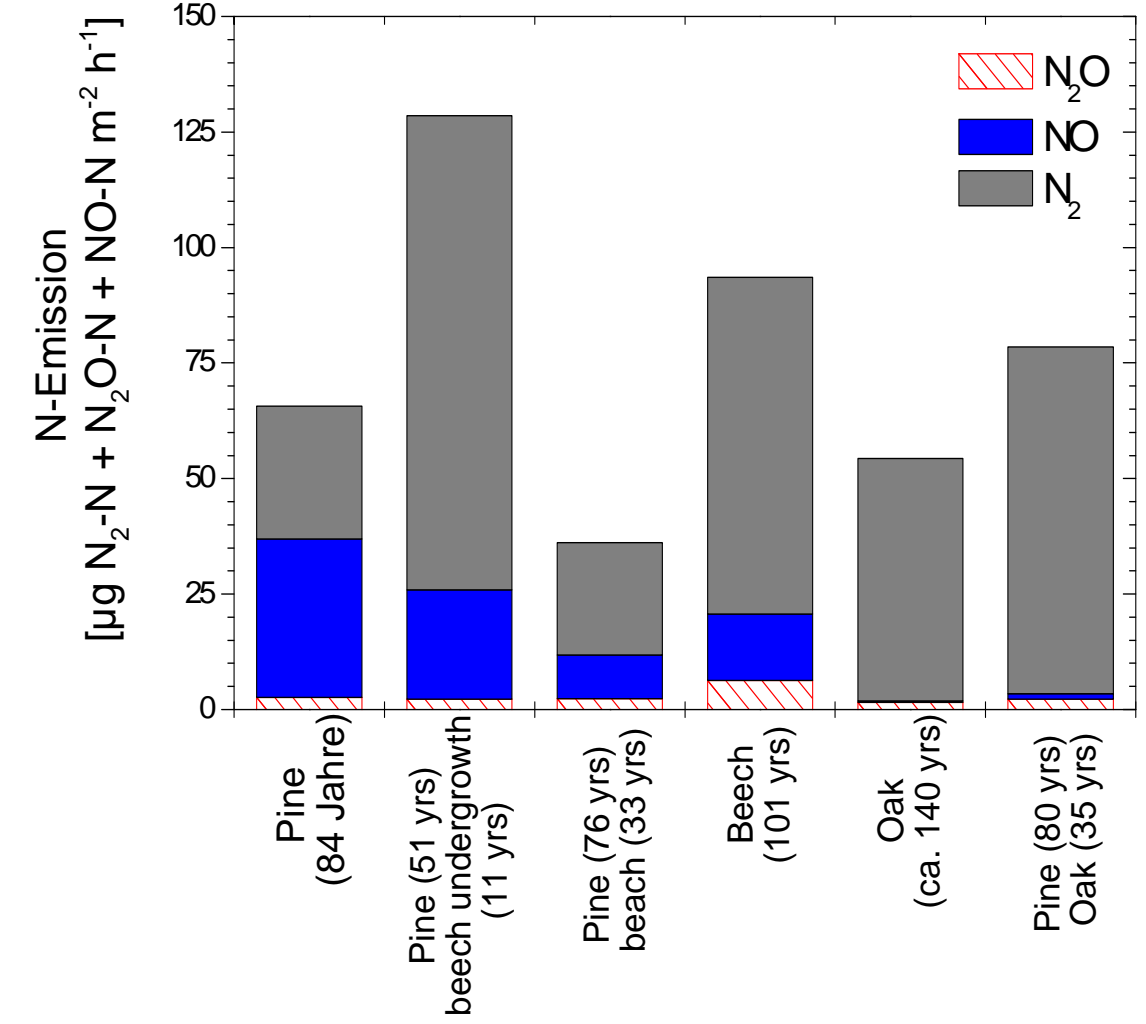
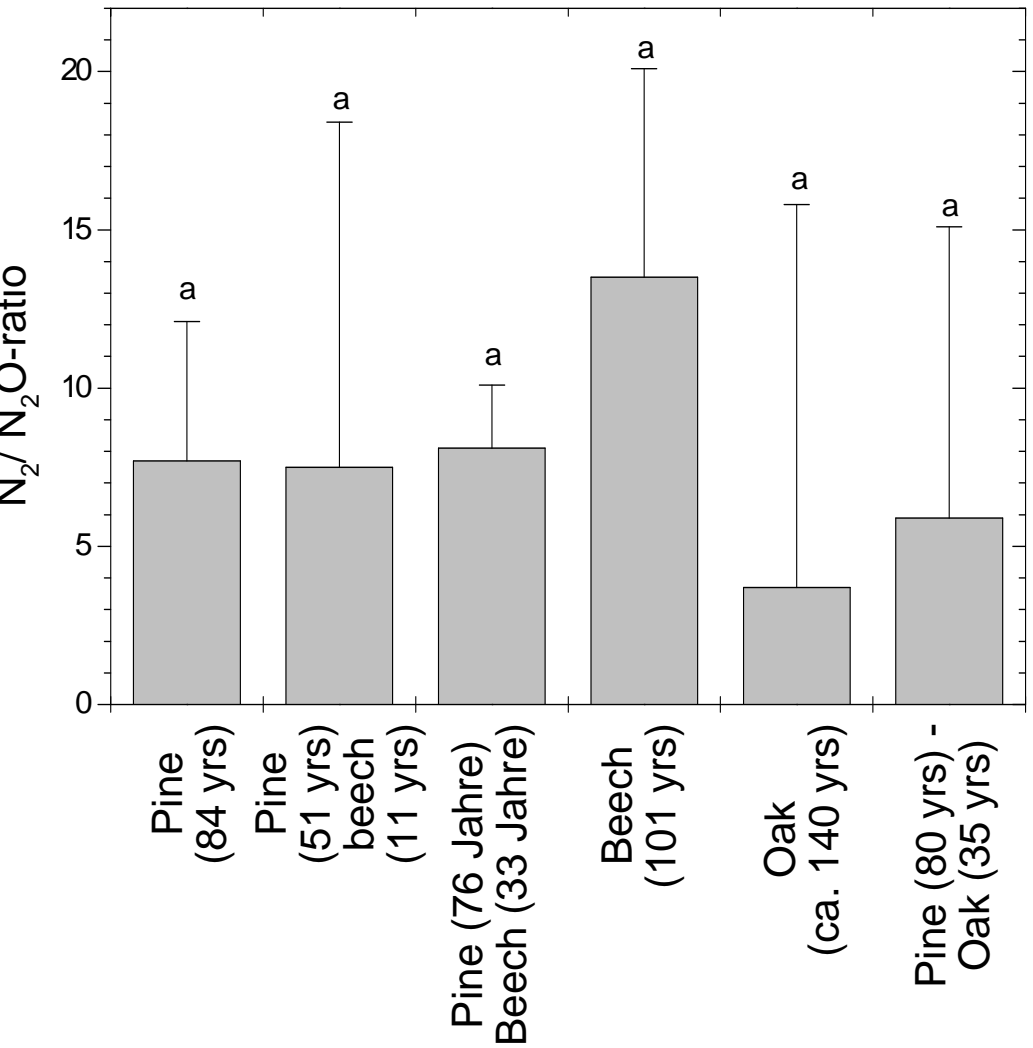


Liu et al., 2007, Soil Biol. Biochem.

# Replacement of the soil atmosphere

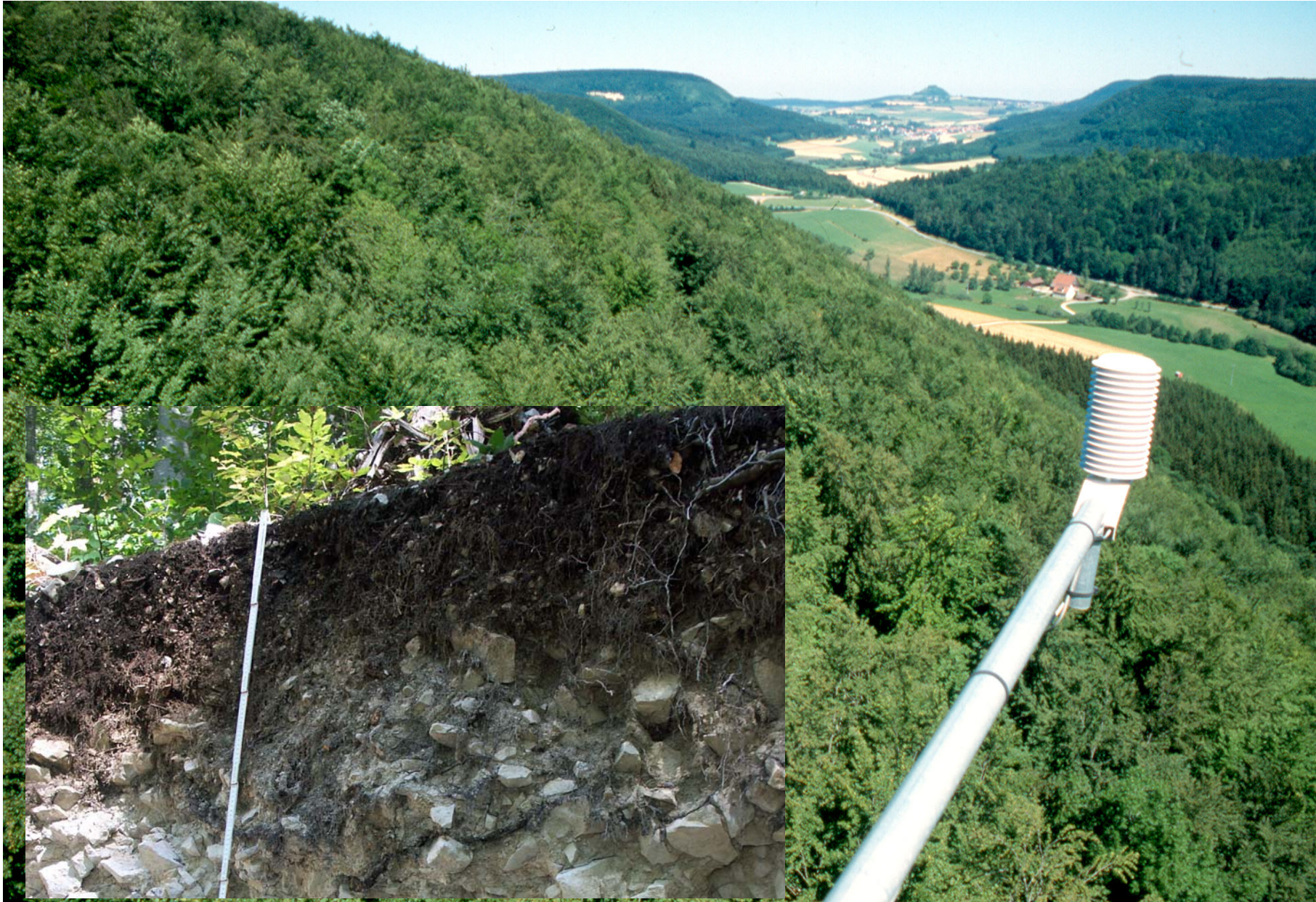


+field NO/N<sub>2</sub>O measurements



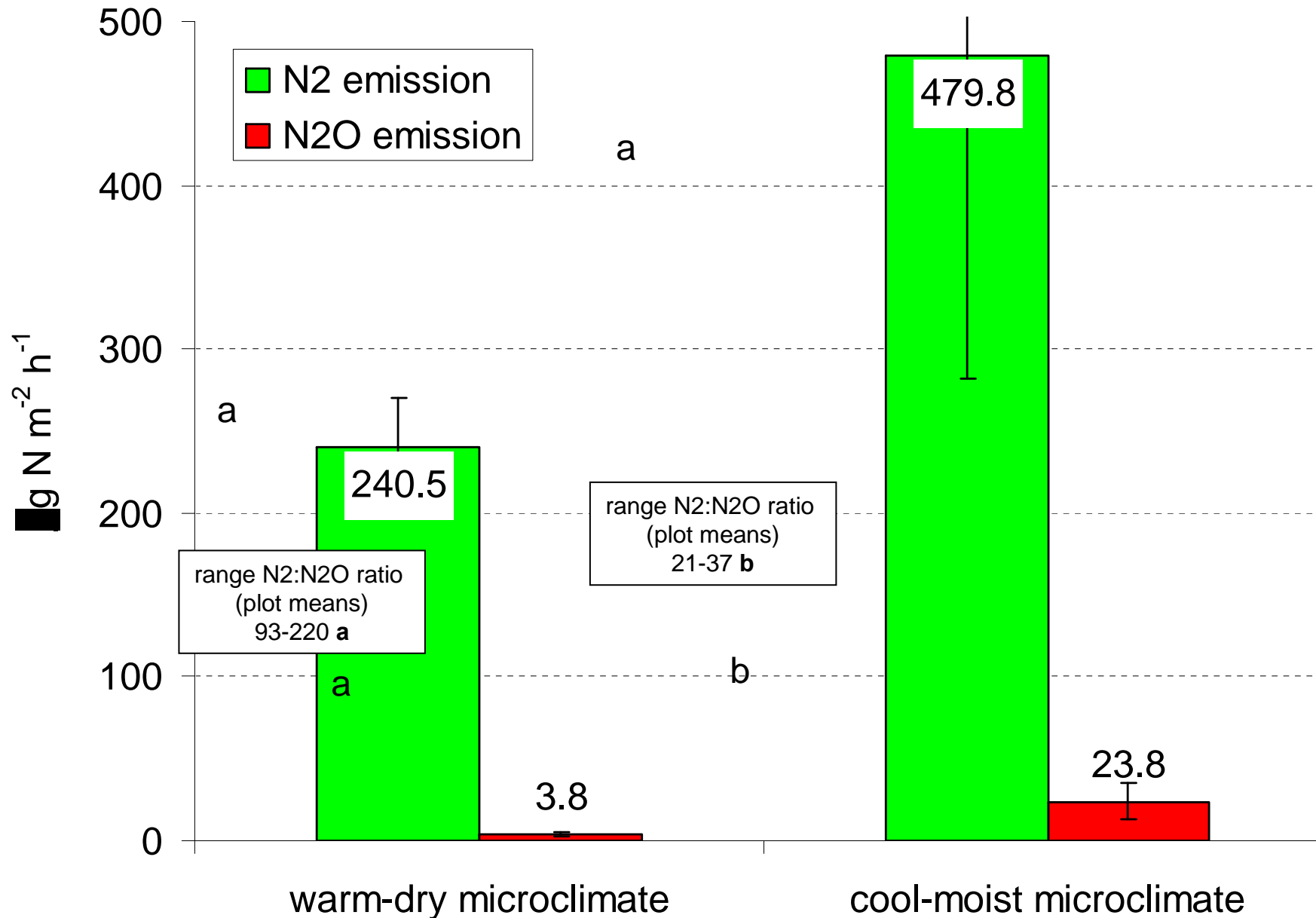
Butterbach-Bahl et al., unpubl.

# Microclimate effects on the N<sub>2</sub>:N<sub>2</sub>O ratio



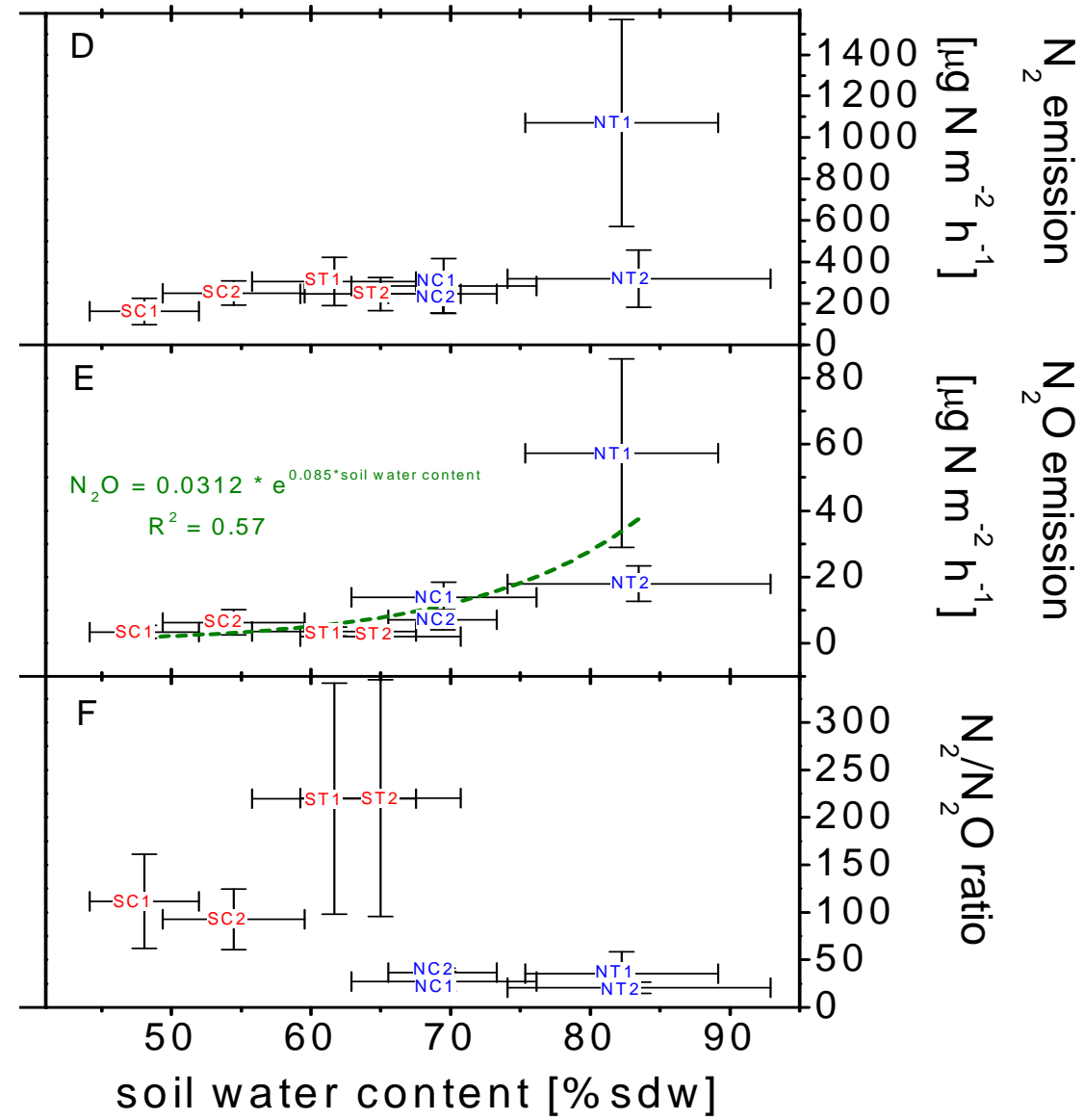
Dannenmann et al., Soil Biol Biochem, in press

# Microclimate effects on the N<sub>2</sub>:N<sub>2</sub>O ratio



Dannenmann et al., Soil Biol Biochem, in press

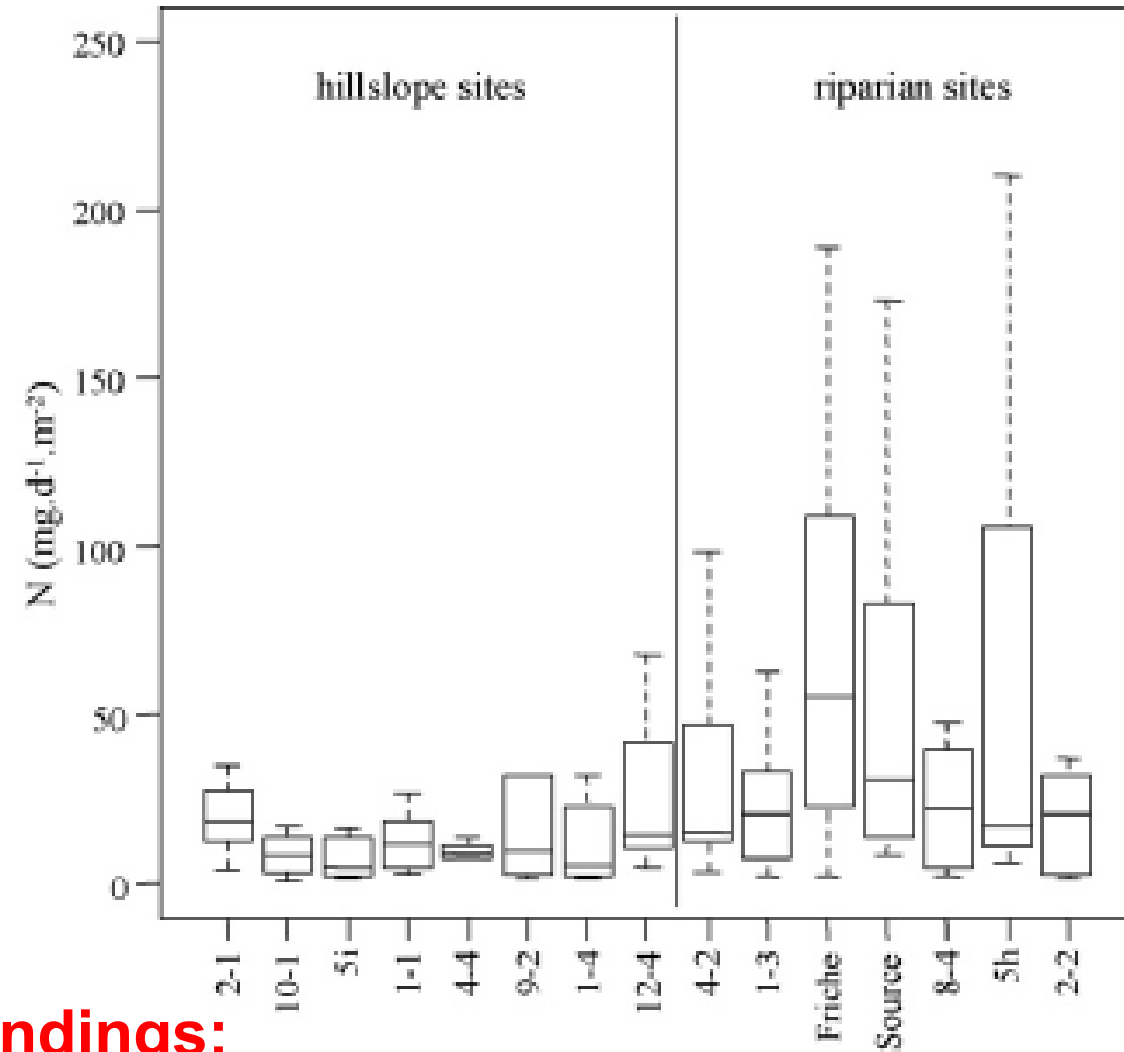
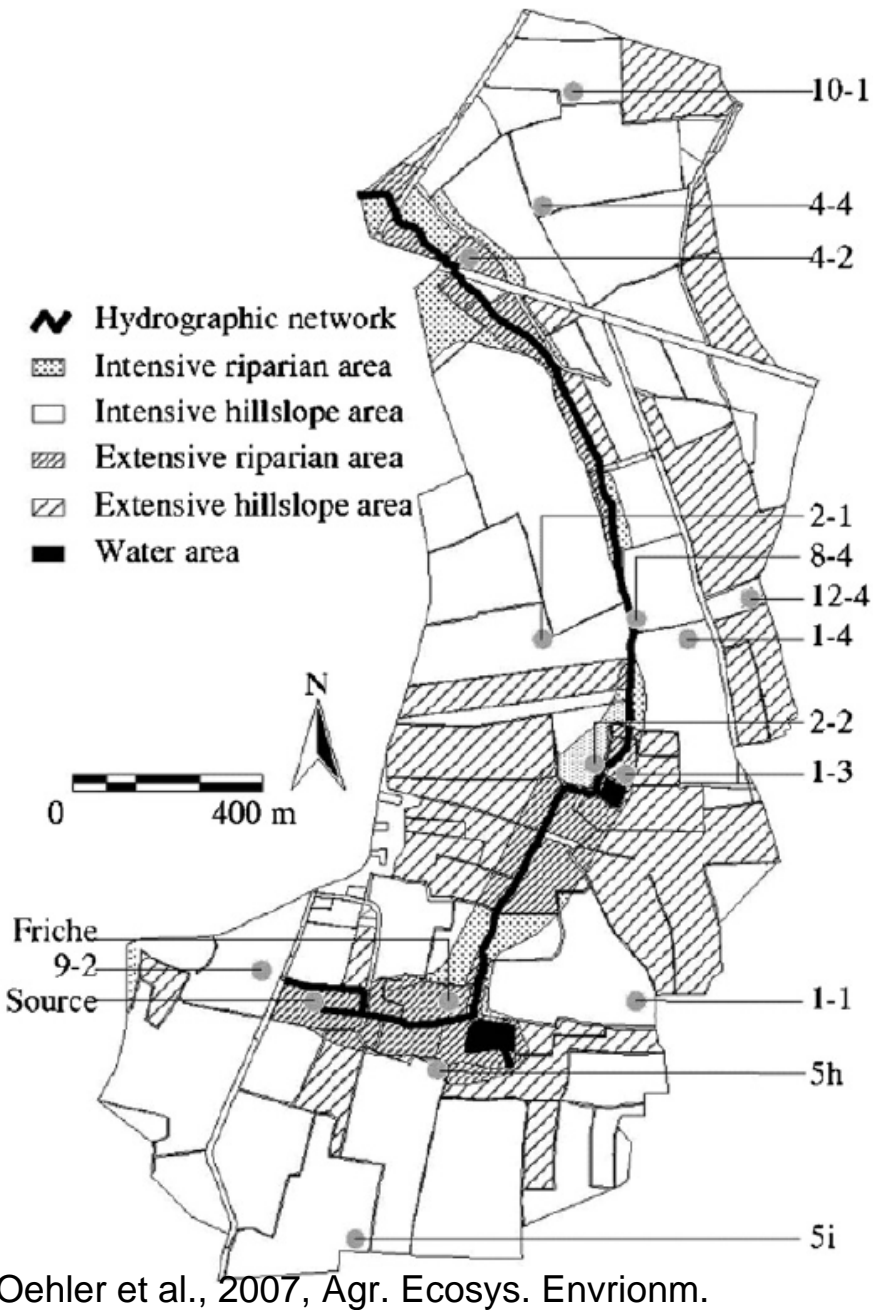
# Soil water and pH effects on the N<sub>2</sub>:N<sub>2</sub>O ratio





# Estimating landscape scale denitrification losses

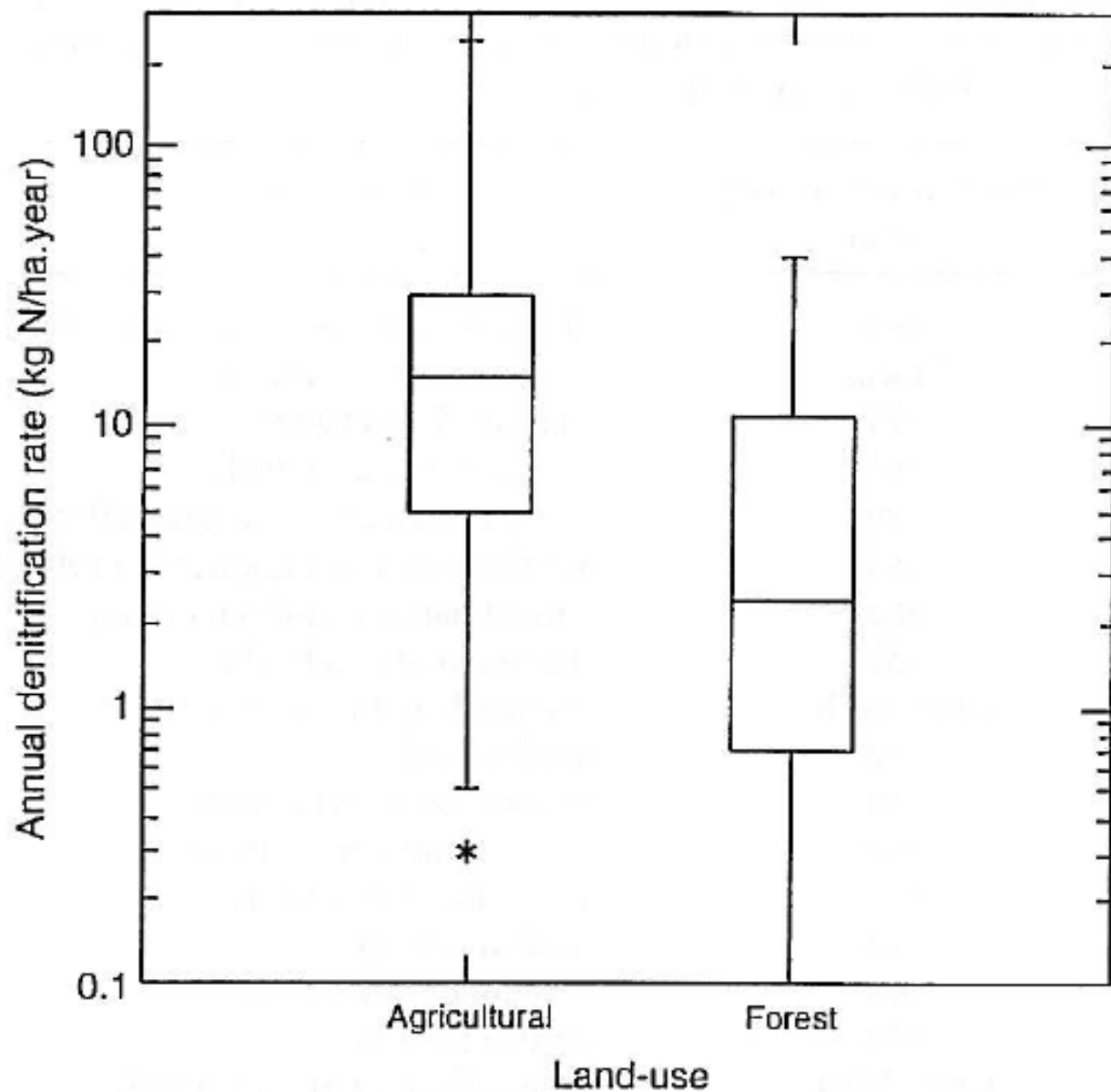
## Annual mean $N_2+N_2O$ losses



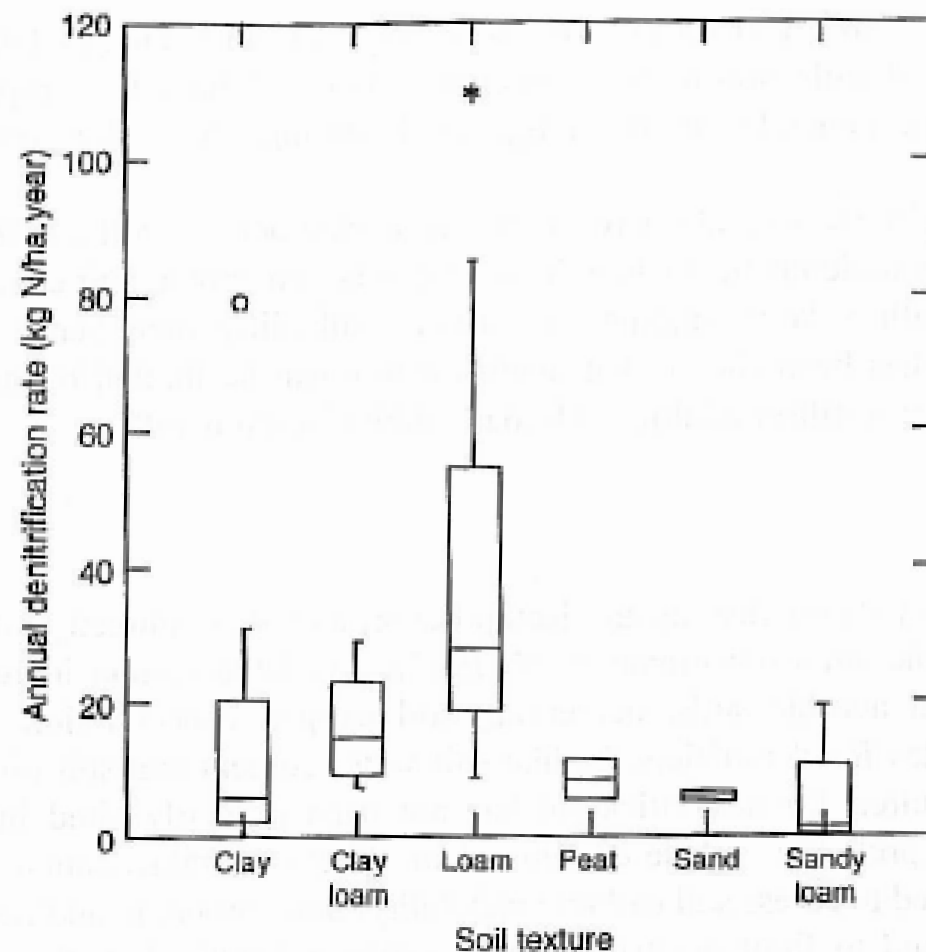
### Main findings:

- 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

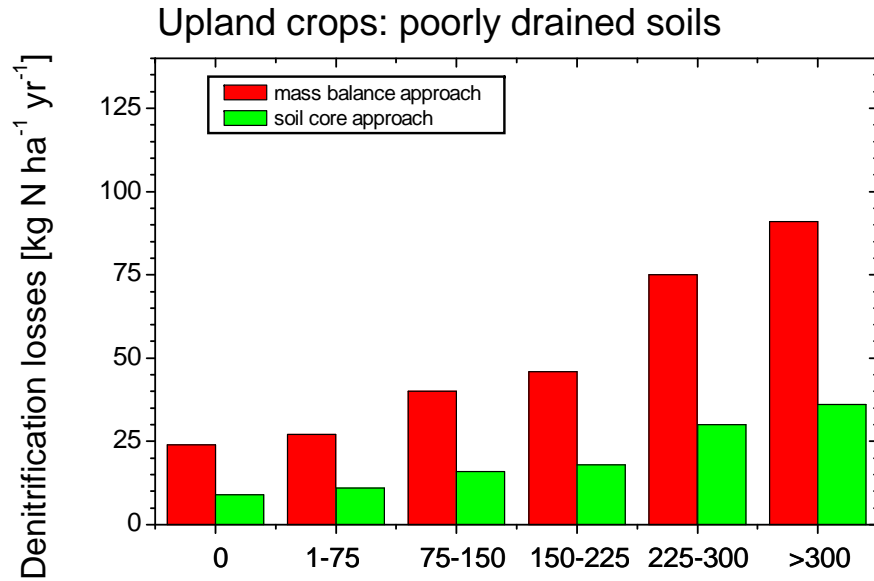


## Denitrification & texture (grasslands)



Barton et al., 1999, Aust J Soil Res

# Uncertainties of denitrification estimates



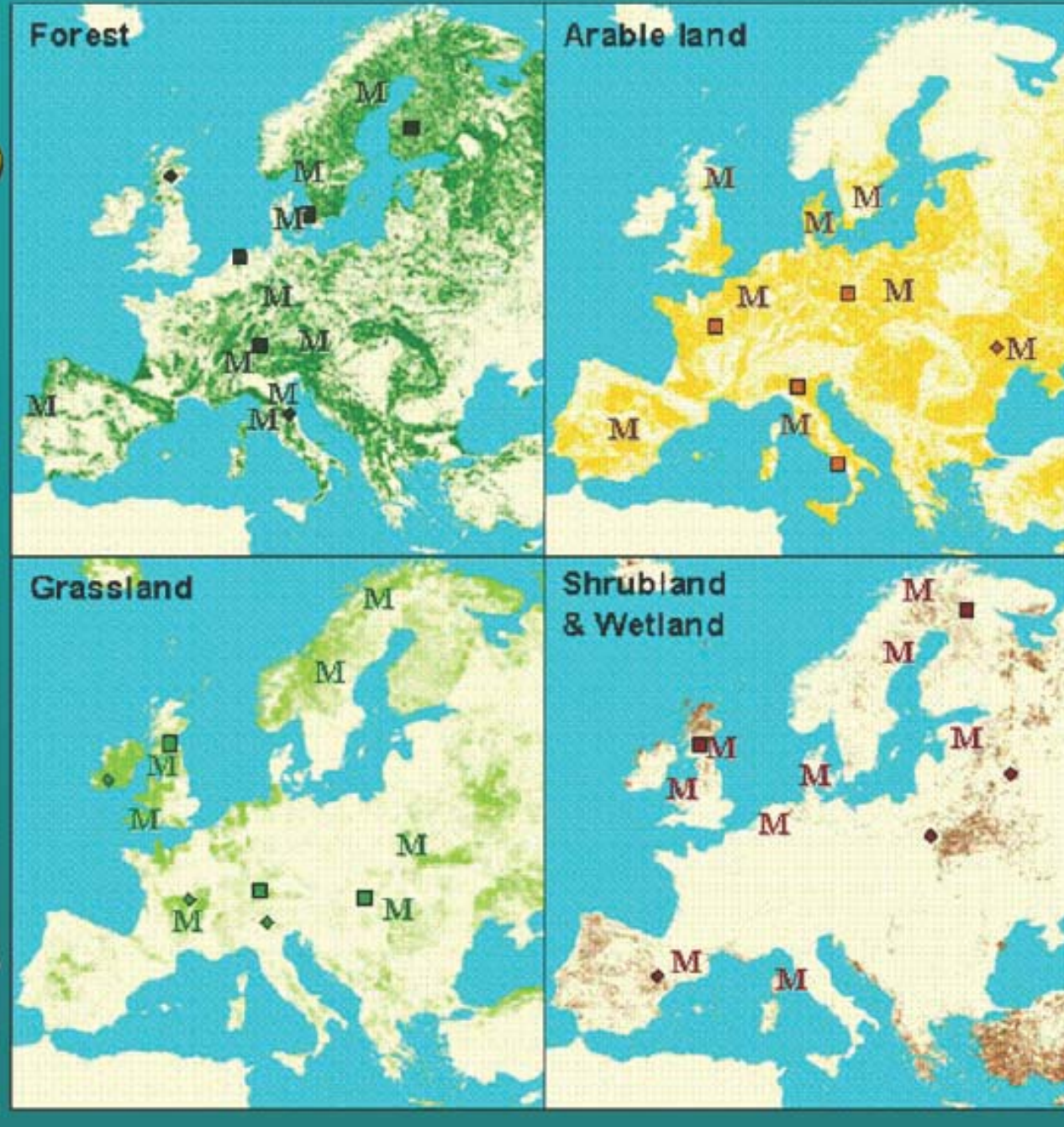
Hofstra & Bouwman, 2005, Nutr Cycl Agroecosys

# NitroEurope – Towards full N balance studies

## NitroEurope: Flux network (C1) & Manipulation network (C2)

13 Super Sites  
9 Regional Sites  
50 Inferential Sites

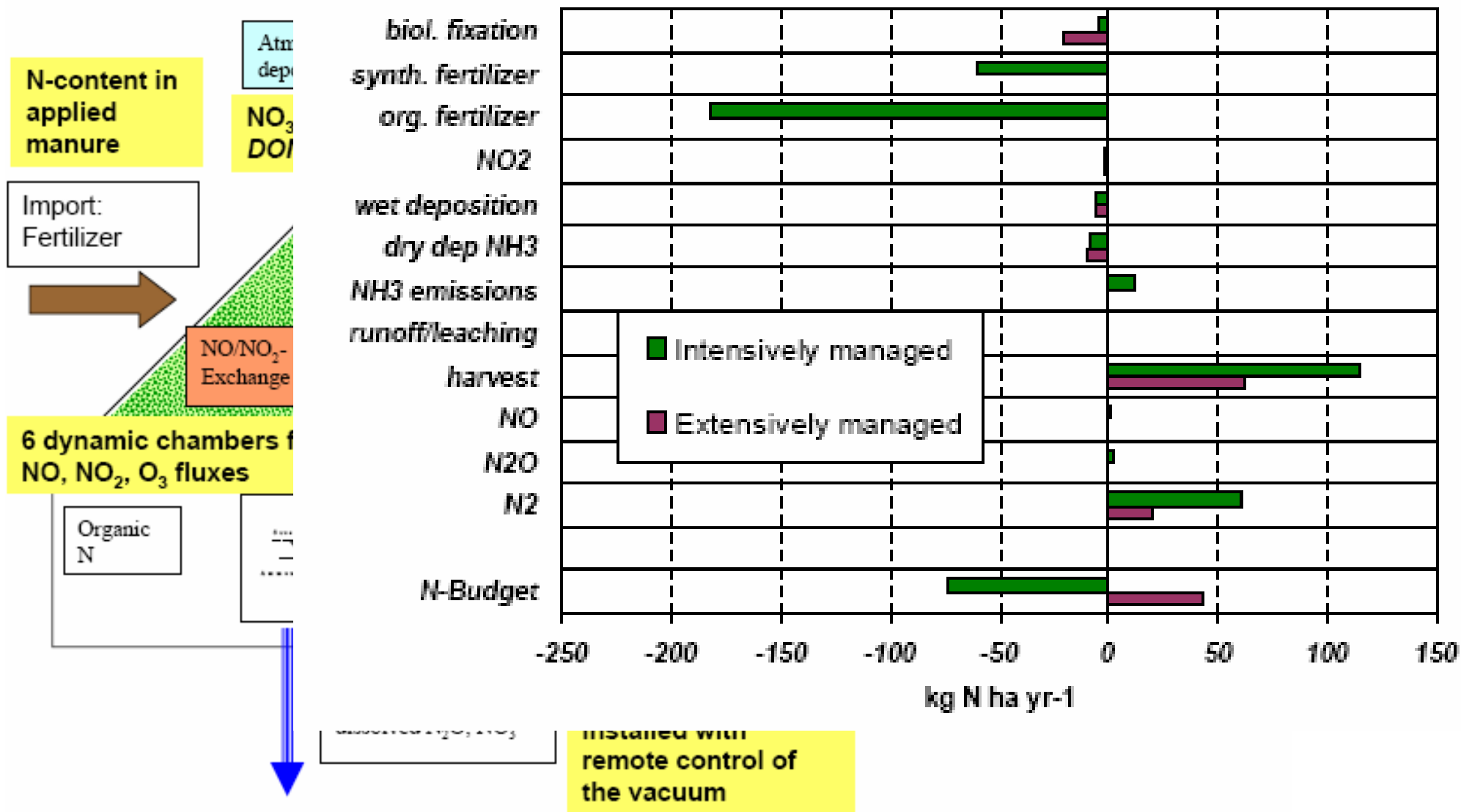
22 Core Manipulation Sites  
14 Assoc. Manipulation Sites



# NitroEurope – Towards full N balance studies

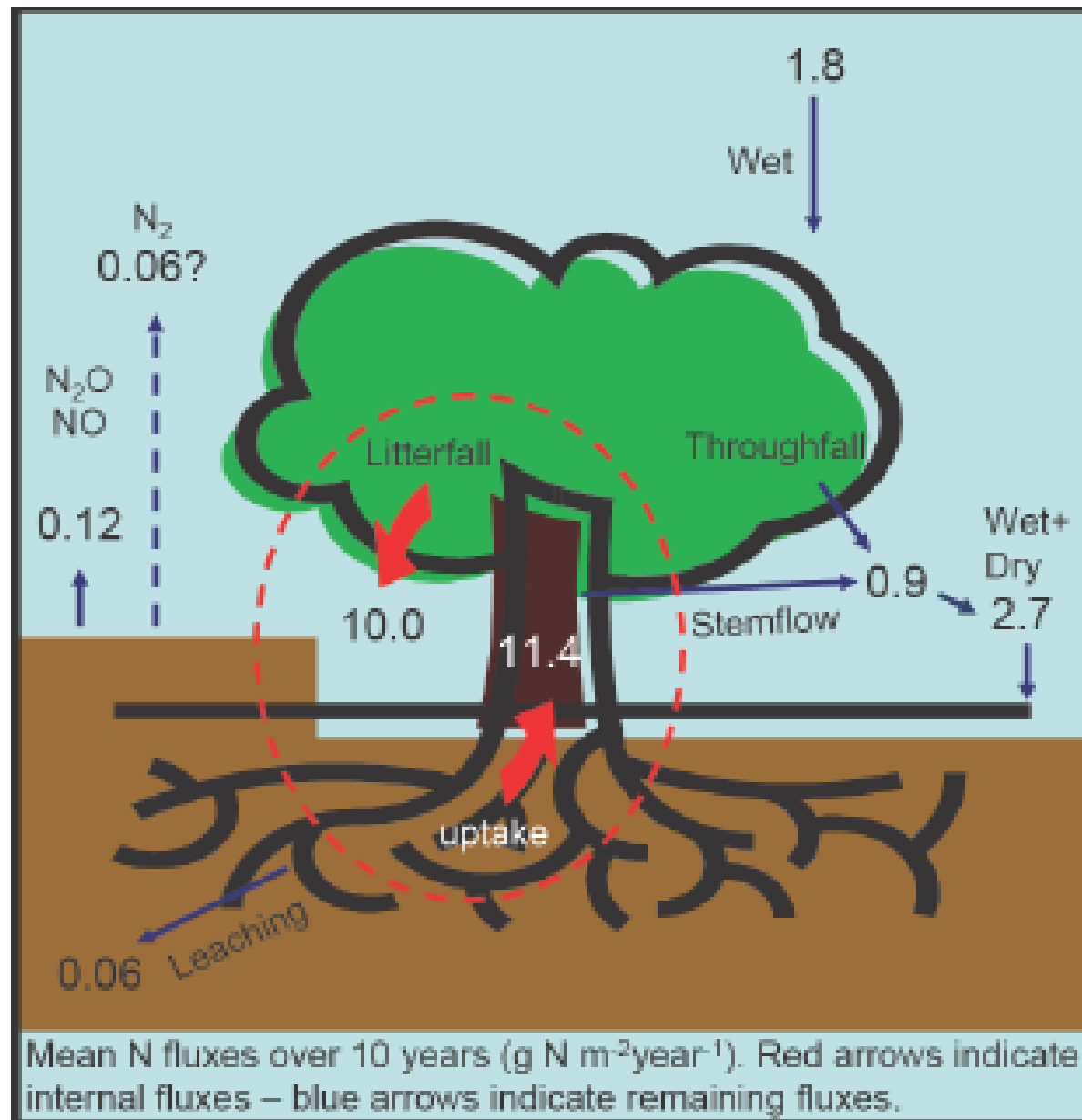
Oensingen, grassland (Switzerland), J Fuhrer, A Neftel, P Calanca (FAL)

## Oensingen Site: N-Budget Components



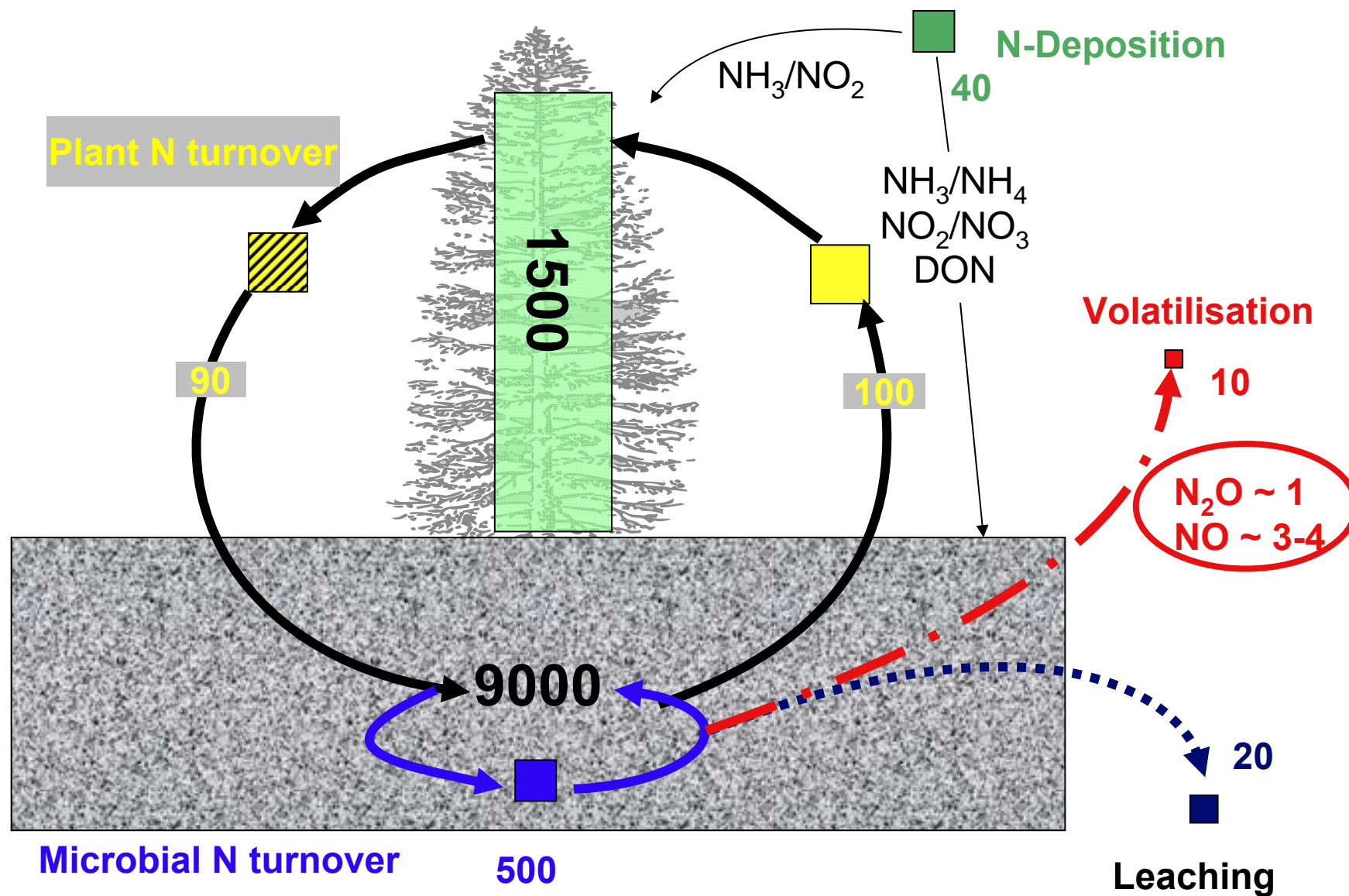
# NitroEurope – Towards full N balance studies

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



# 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<sub>2</sub>O 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



