Global change effects and feedbacks on N_2O and CH_4 emissions from natural and managed land

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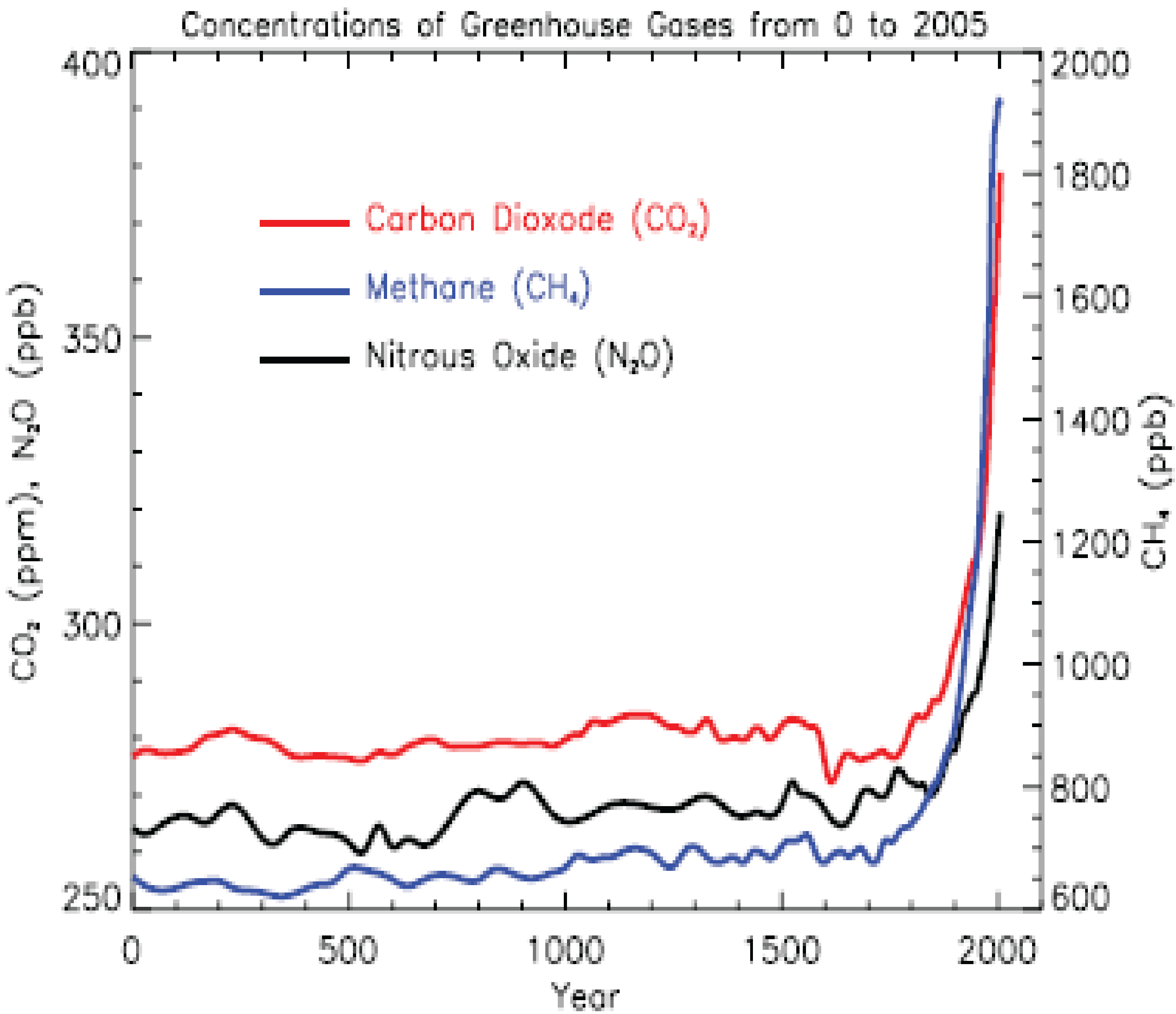
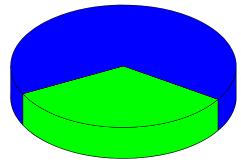
Why to look at soils when talking about atmospheric C and N-trace gases and global change ?



Forster et al., 2007, In: Climate Change 2007

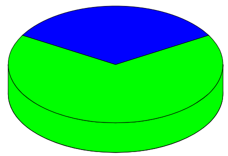
Fossil fuel burning



Land use change

CO_2

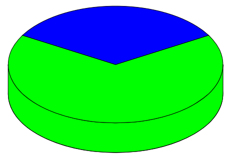
Industrial sources



Rice paddies, wetlands, ruminants

CH_4

Industrial sources

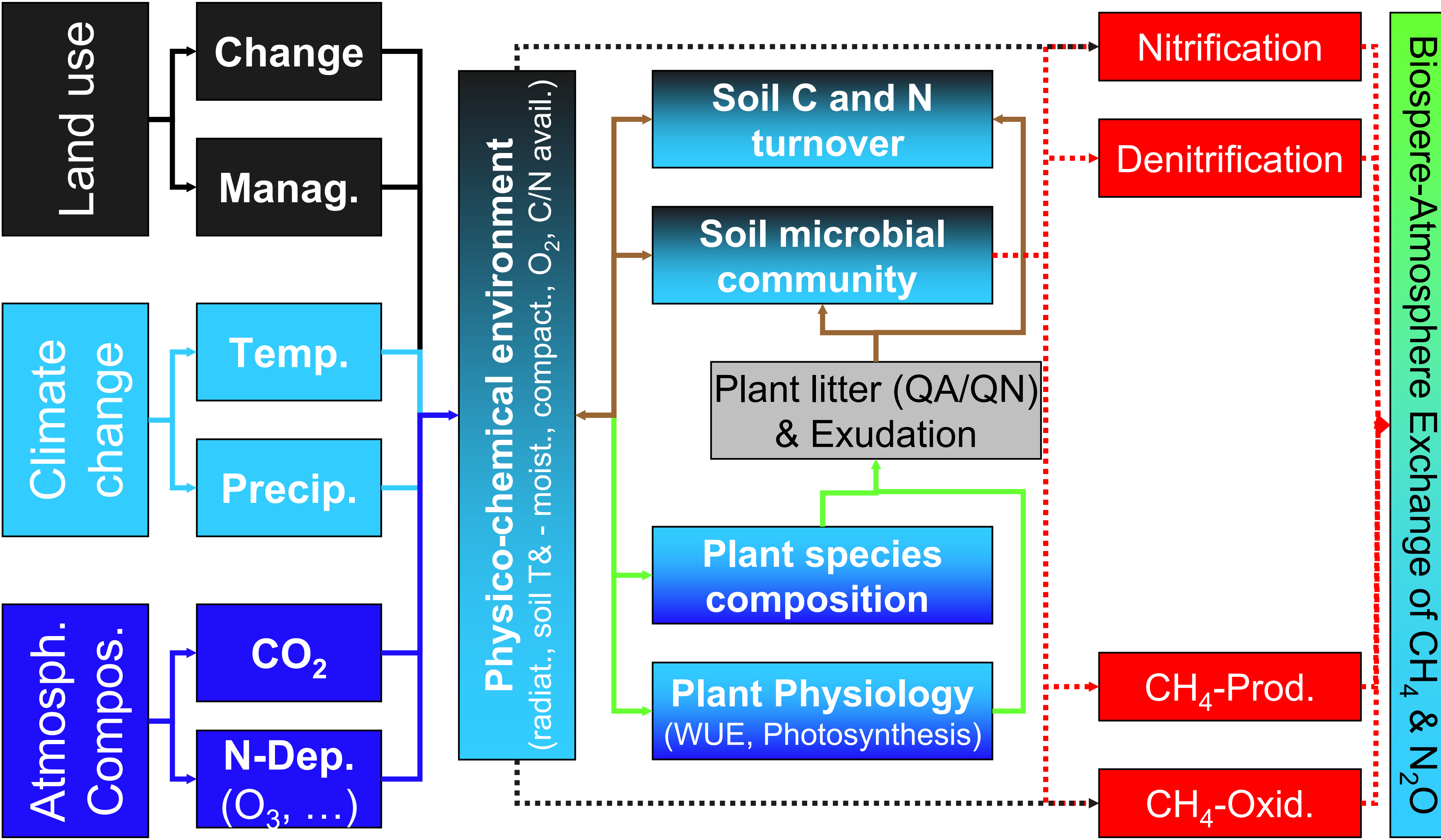


Agriculture, forests, ozeans

N_2O

Soils: 60-70%

Global Changes and soil N_2O and CH_4 exchange

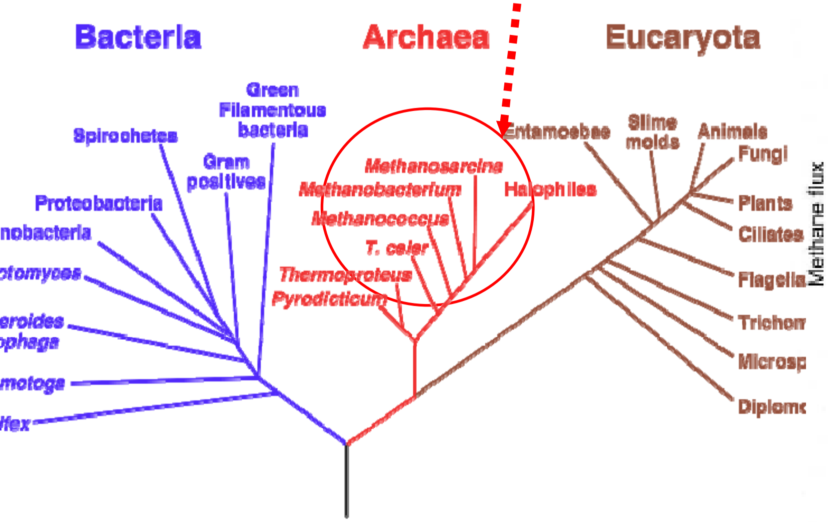


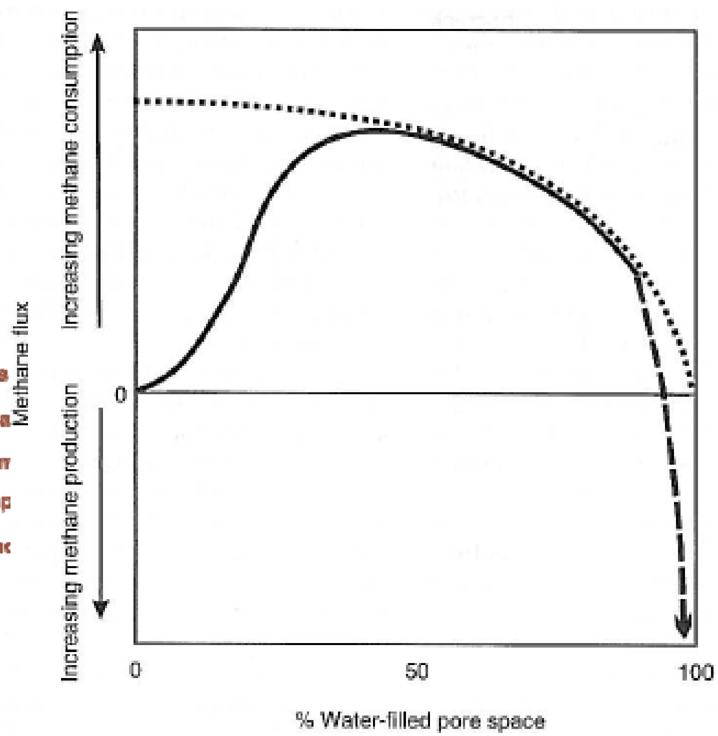
CH_4-exchange is the result of simultaneous microbial production and consumption processes

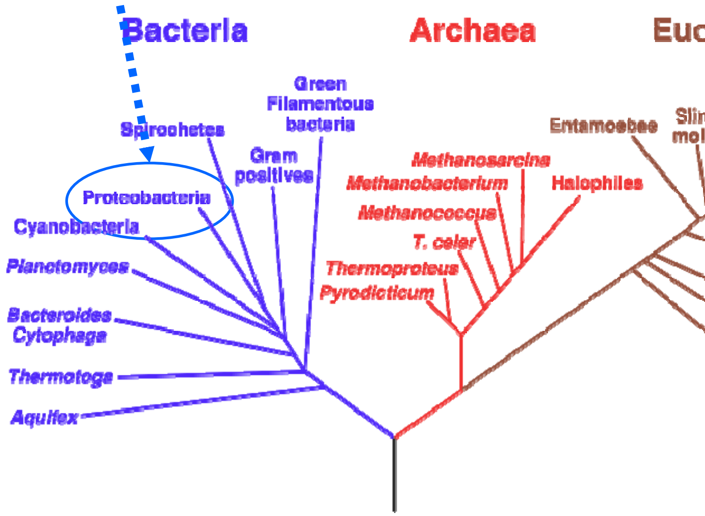
CH_4-flux = CH_4-Production – CH_4-Oxidation

Methanogenic bacteria

Methanotrophic bacteria

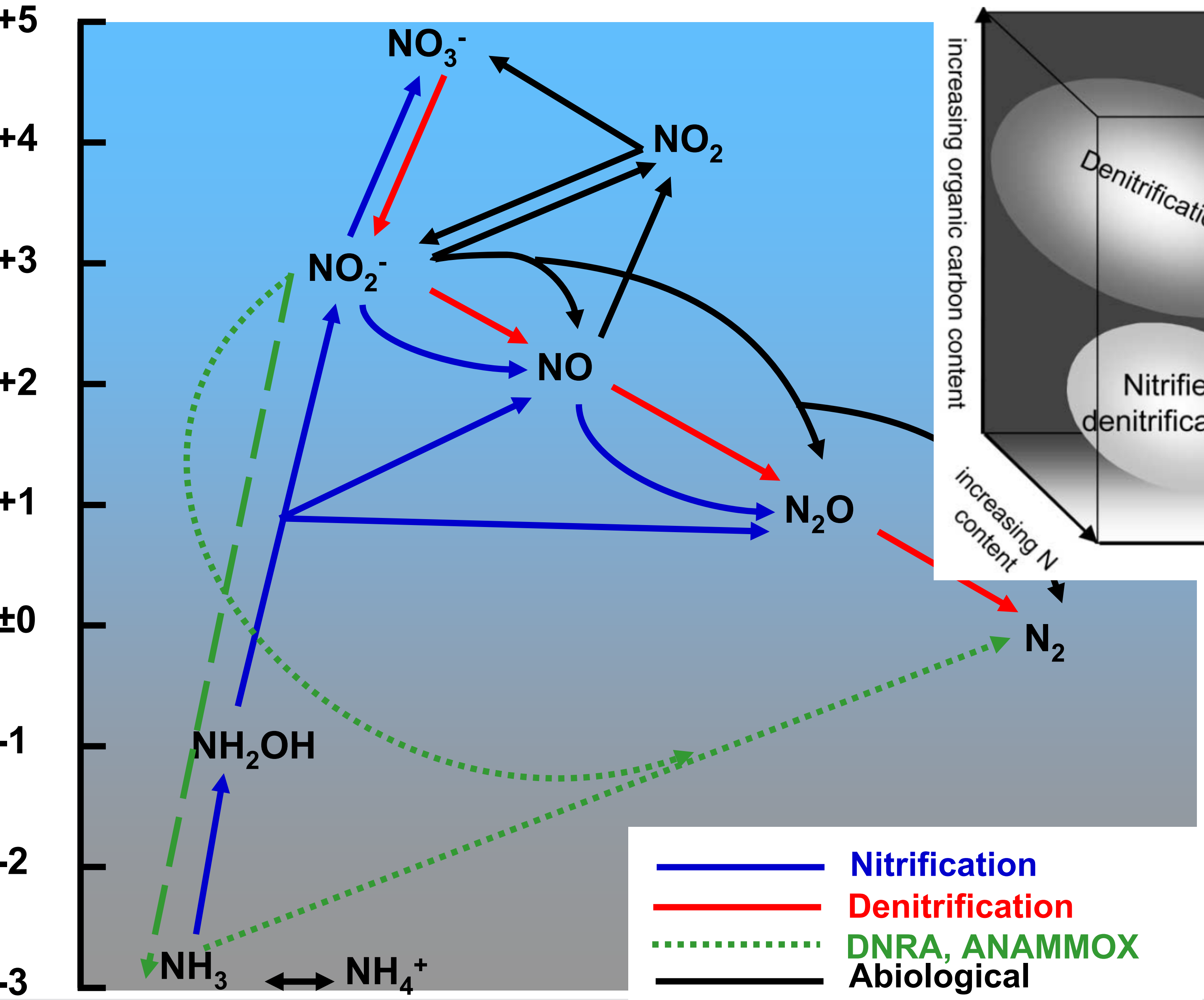


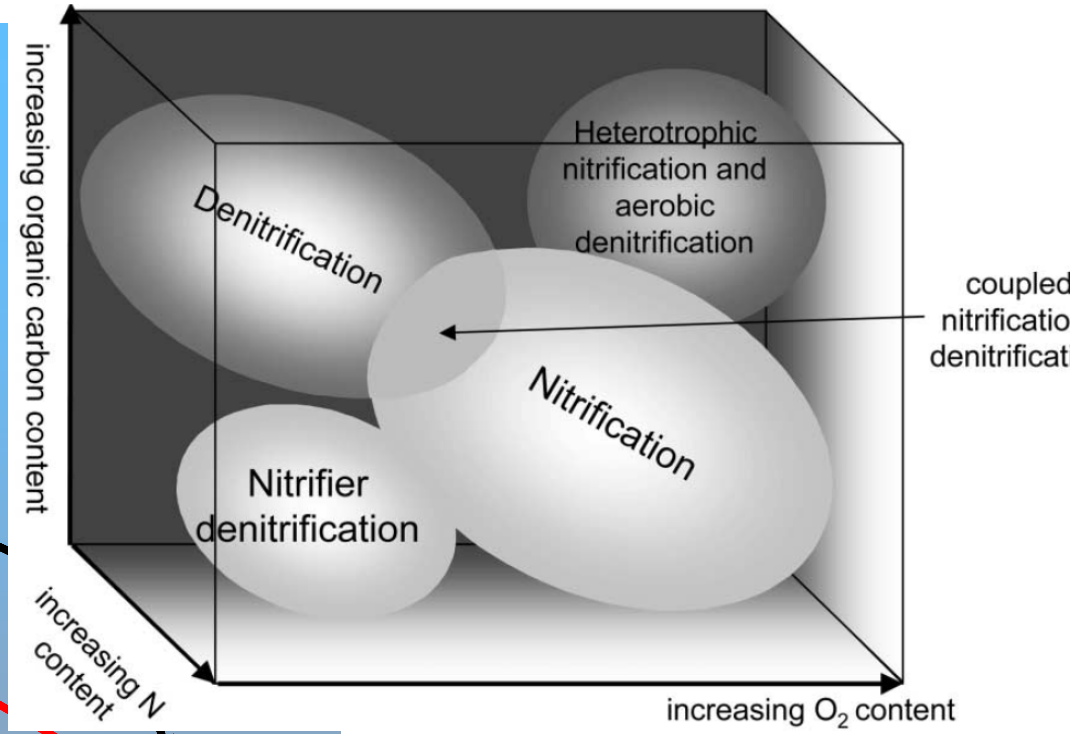




Dunfield, 2007, Cabi.org

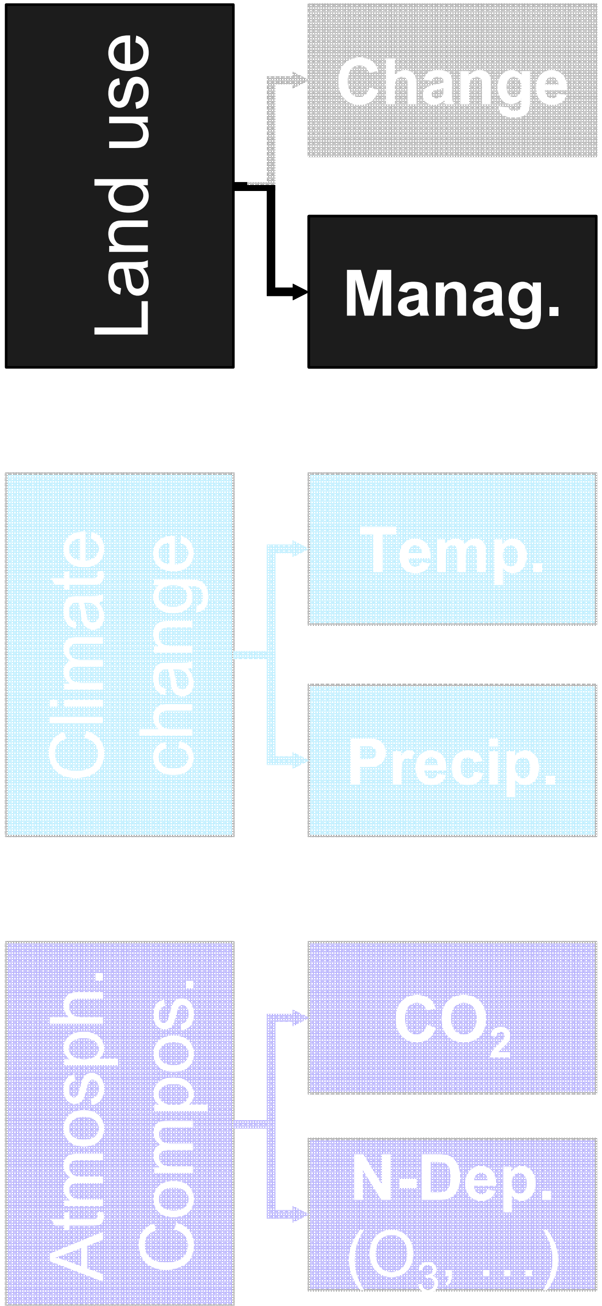
N_2O-exchange is the result of simultaneous microbial production and consumption processes

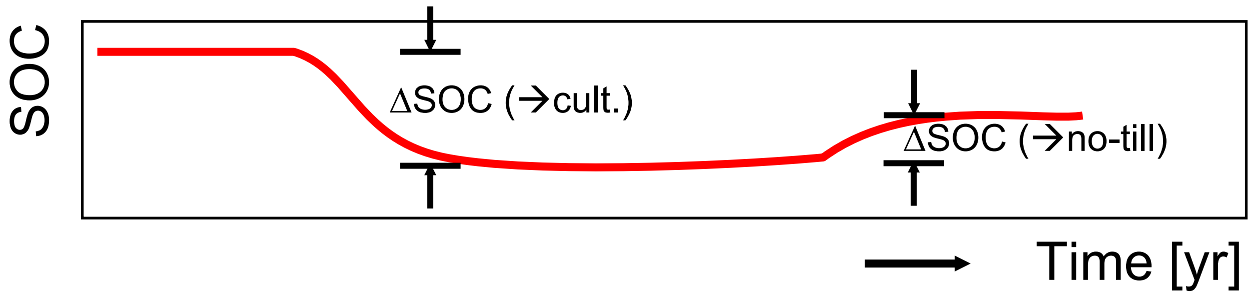




Wrage et al. 2001, Soil Biol. Biochem.

Tilled versus no-tilled systems





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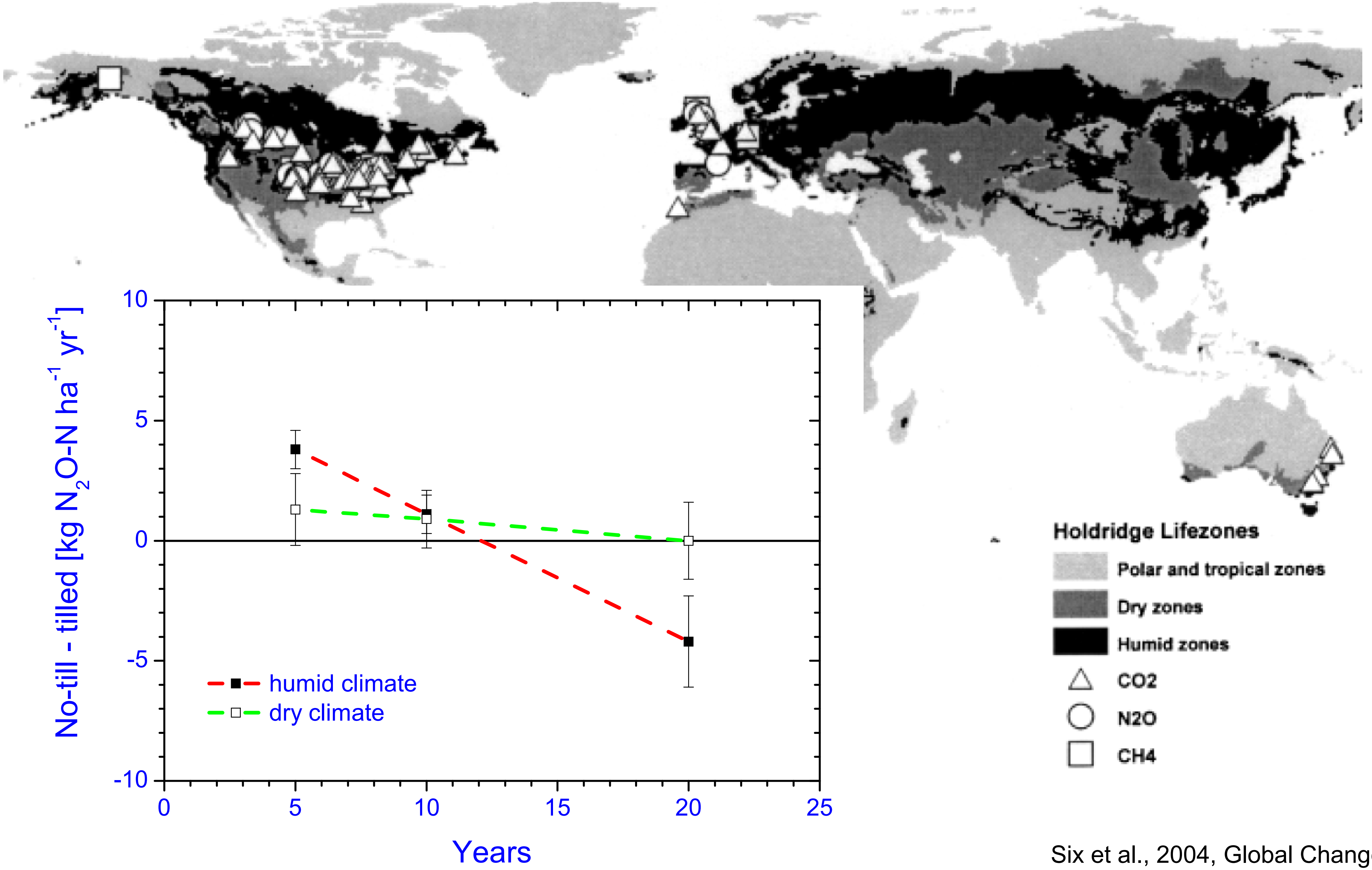
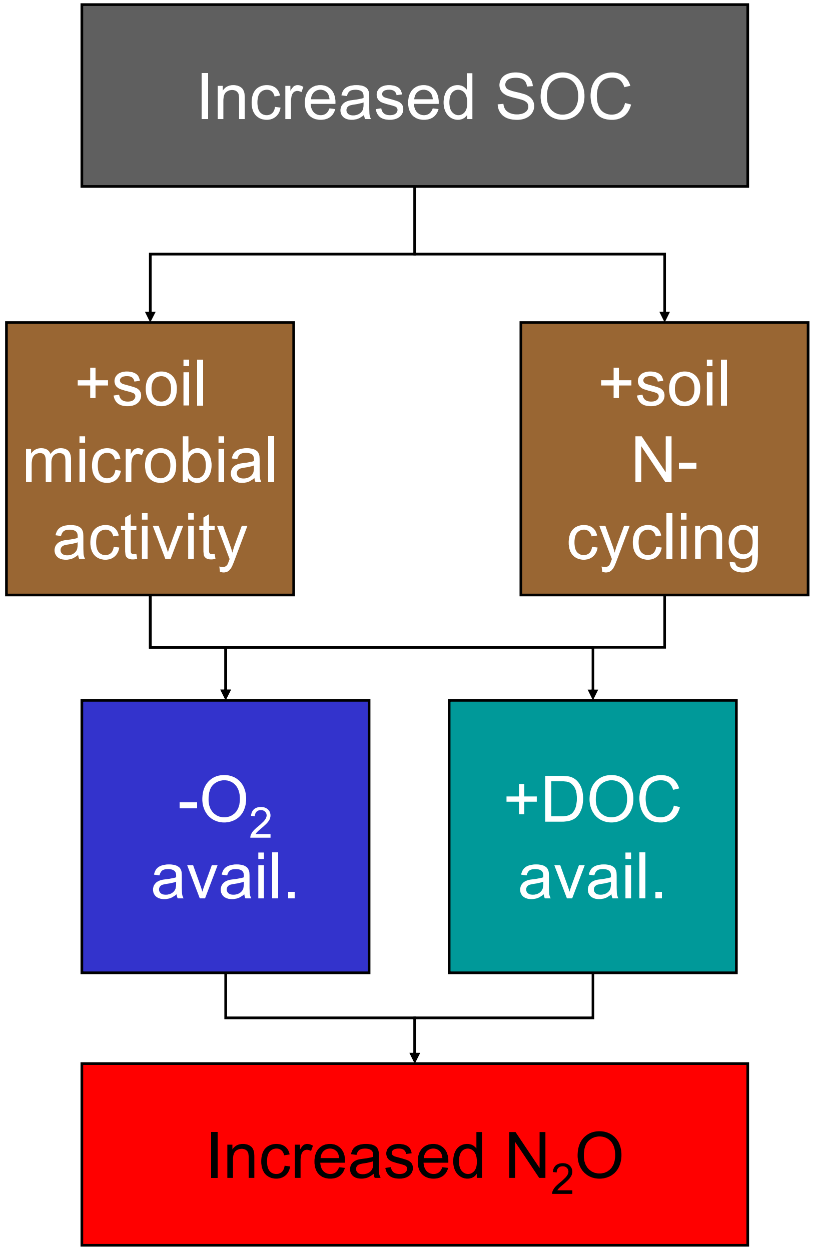
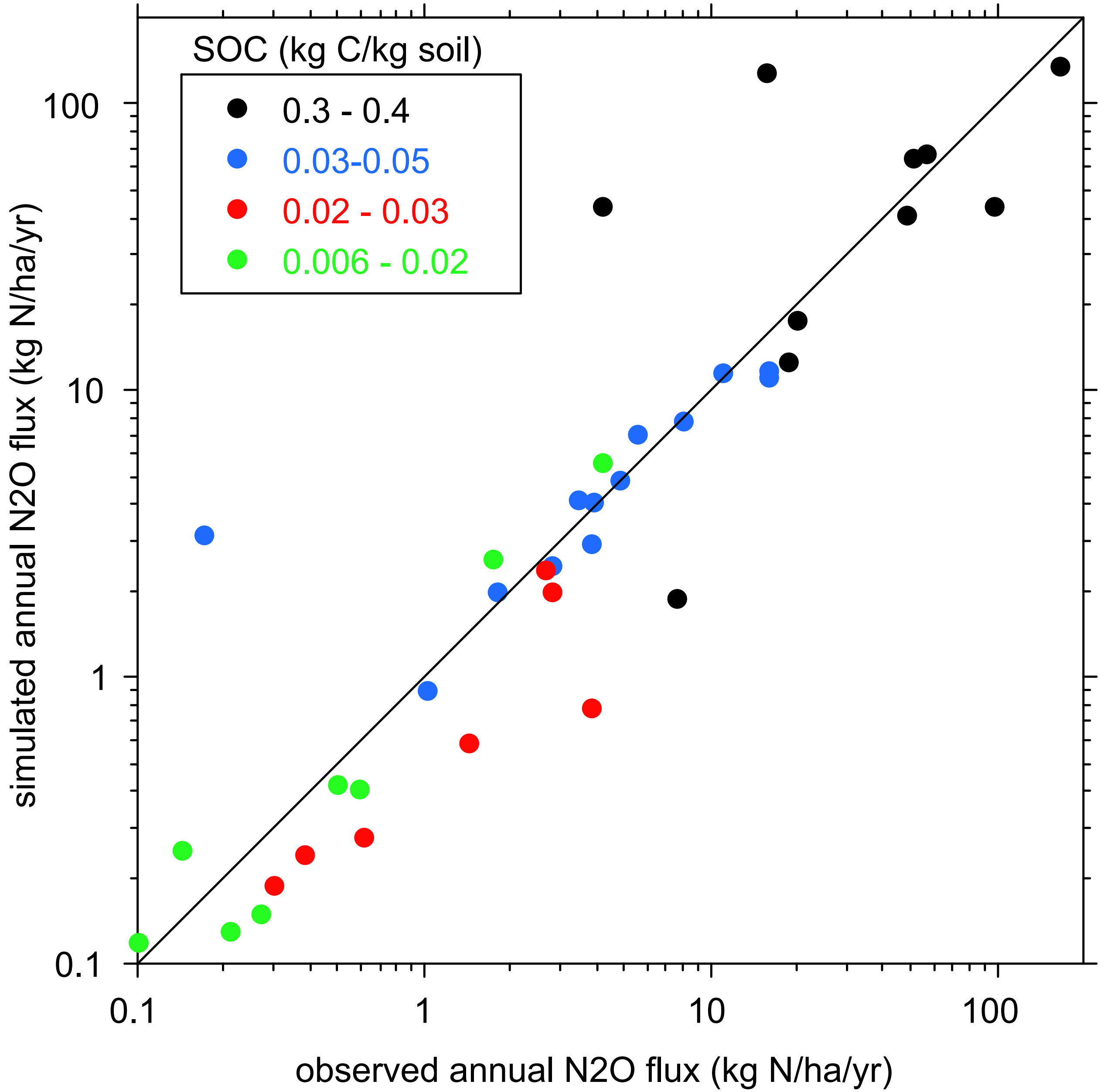


Six et al., 2004, Global Change Biol

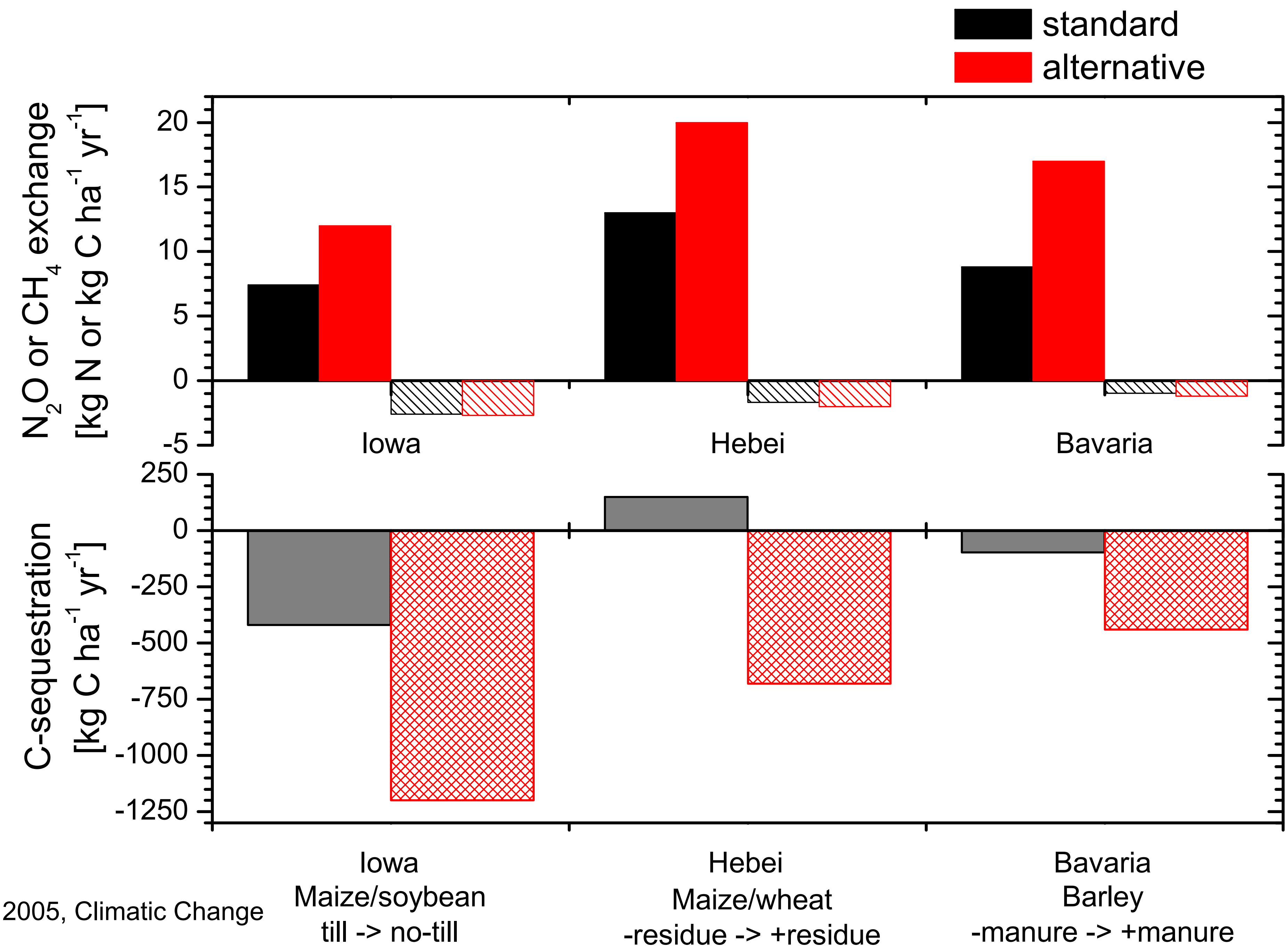
Understanding the coupling between C and N cycling





Li et al., 2005, Climatic Change

Feedback of SOC increase on total GHG balance



Li et al., 2005, Climatic Change

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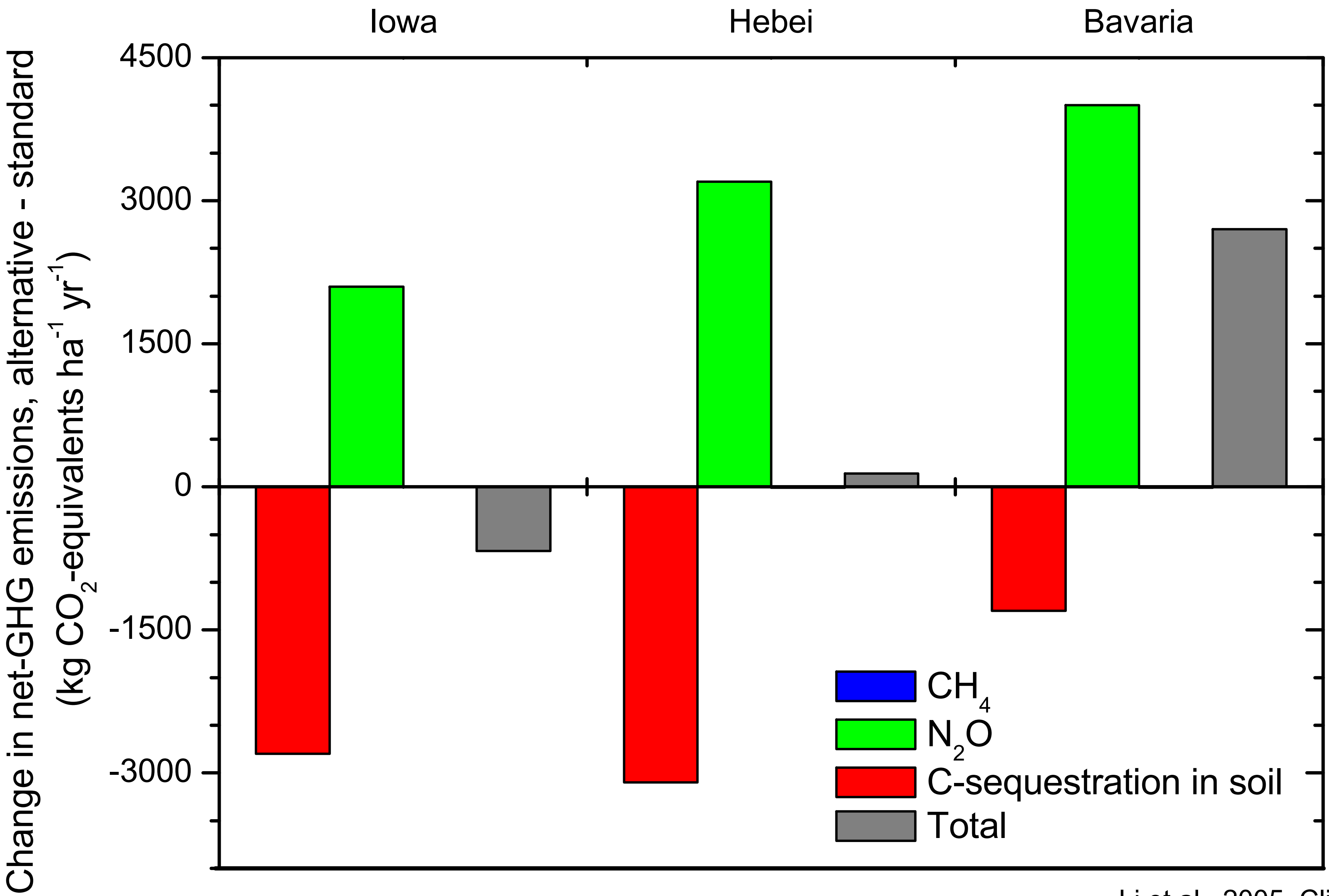


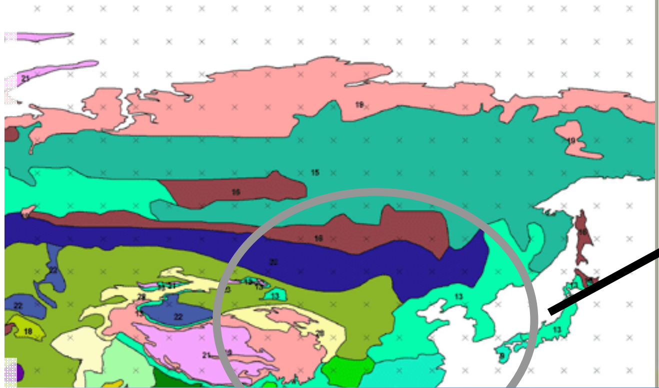
Li et al., 2005, Climatic Change

Grazed versus non-grazed steppe systems

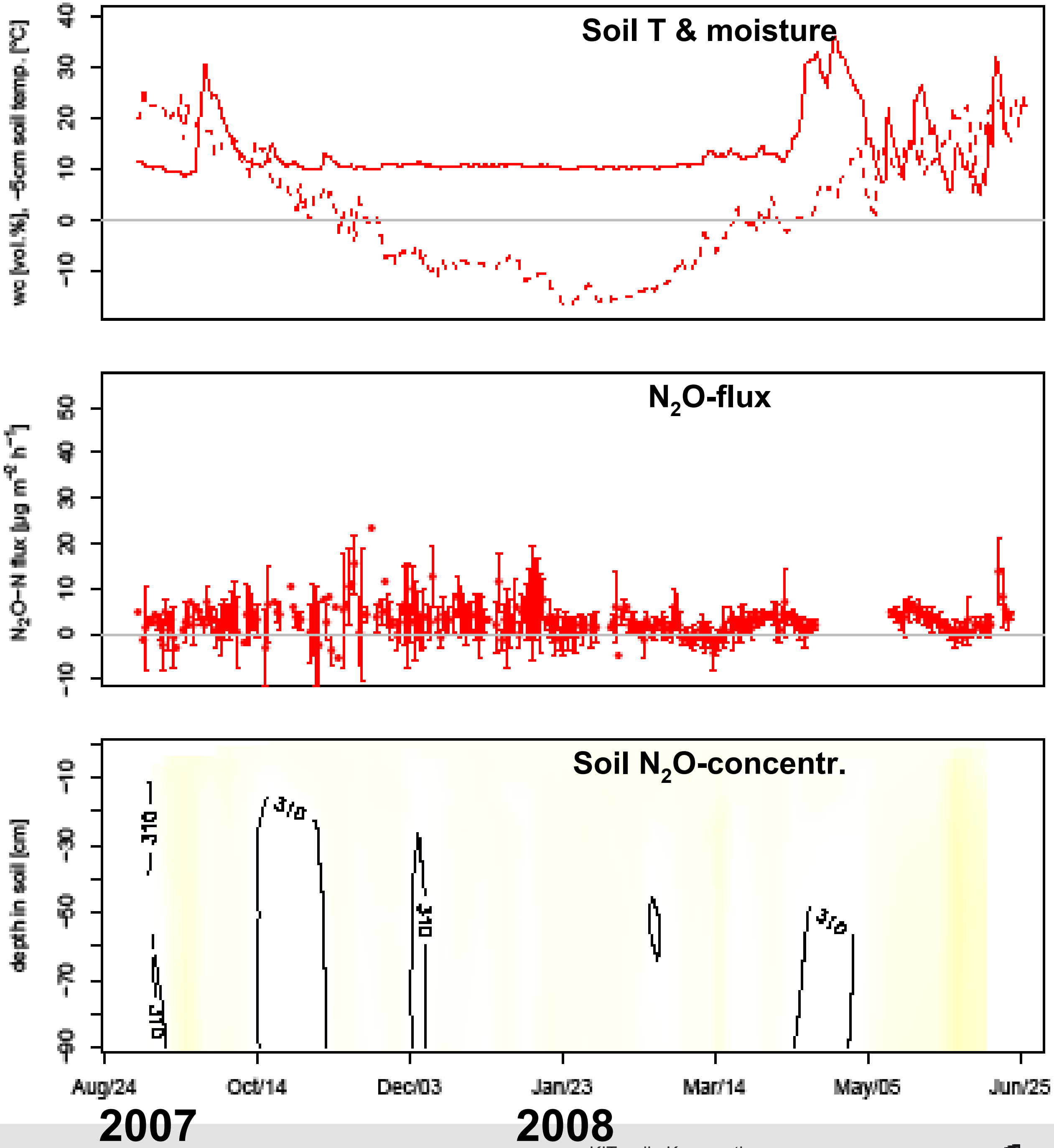
Land use
- Change
- **Manag.**

Climate change
- Temp.
- Precip.

Atmosph. Compos.
- CO_2
- N-Dep. (O_3, …)



Grazed versus non-grazed steppe systems: N_2O



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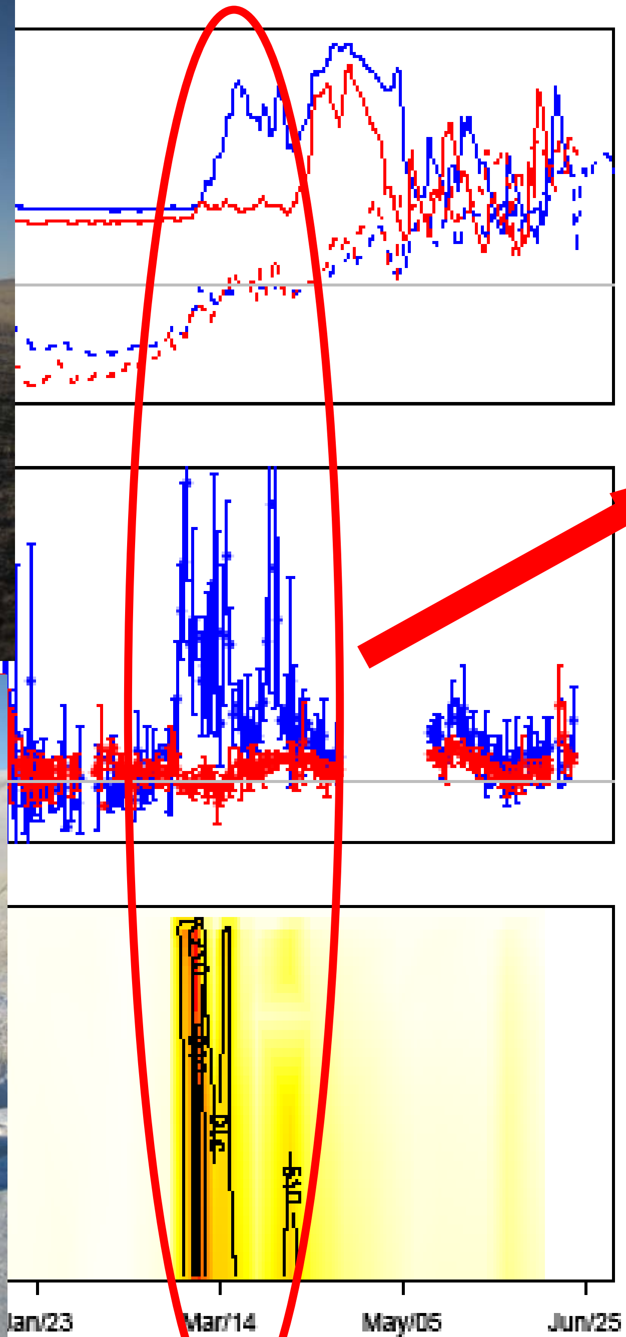


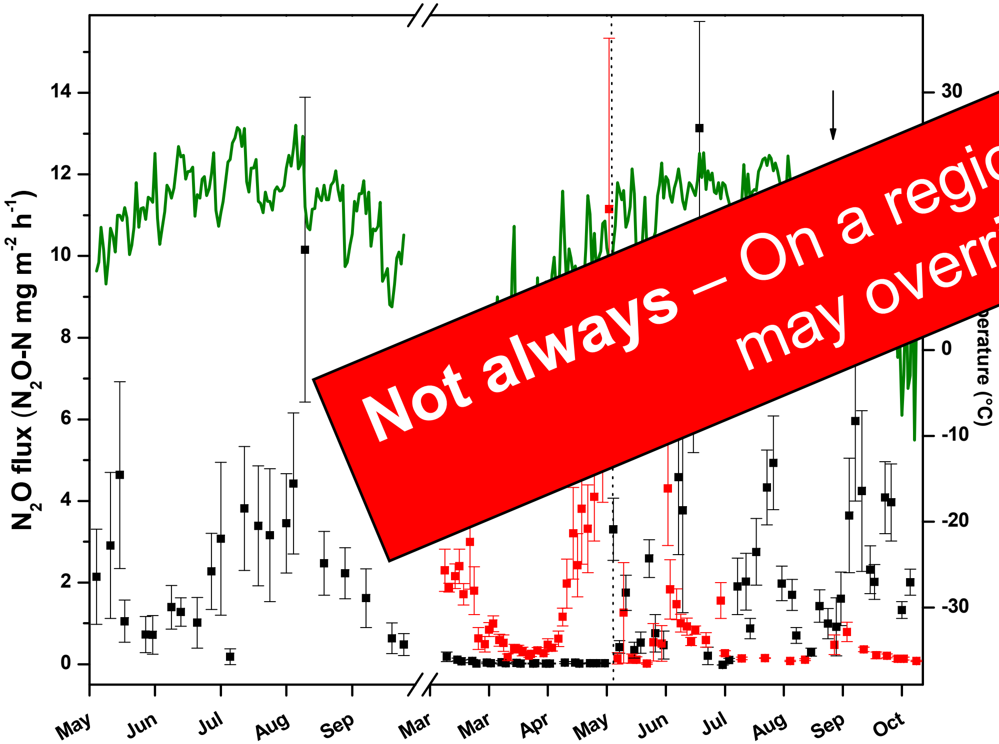
2008

Extremely high N_2O-fluxes during freeze-thaw from ungrazed steppe

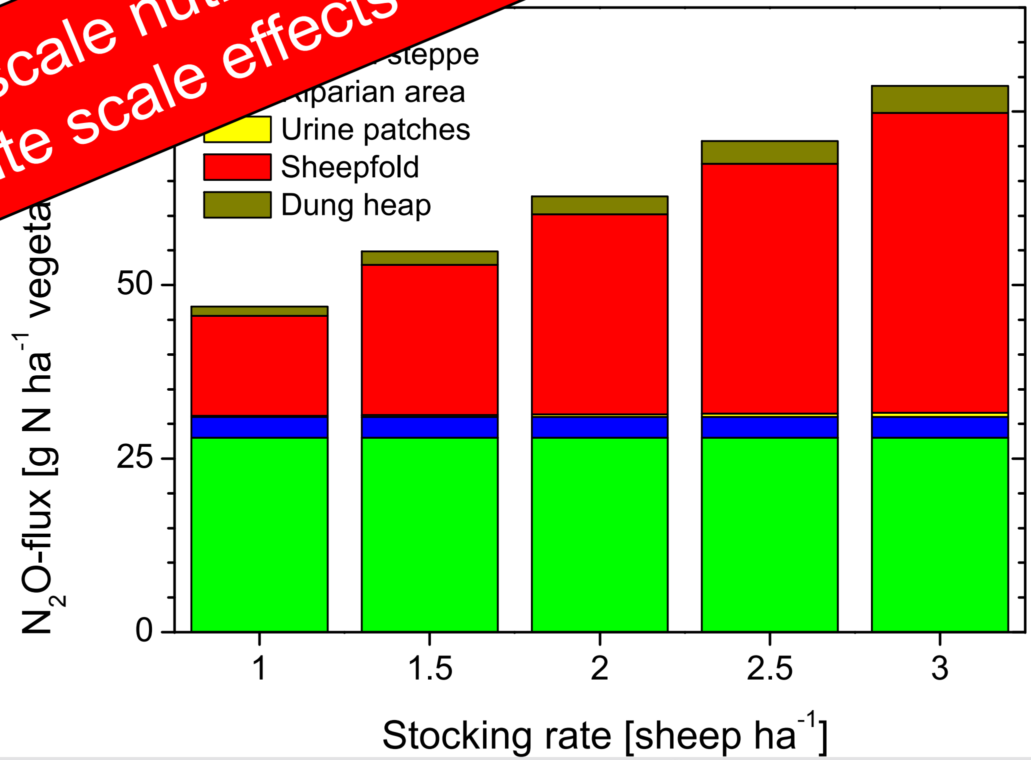
→ **>70% of annual fluxes**

Do natural steppe systems emit more N_2O than grazed systems?

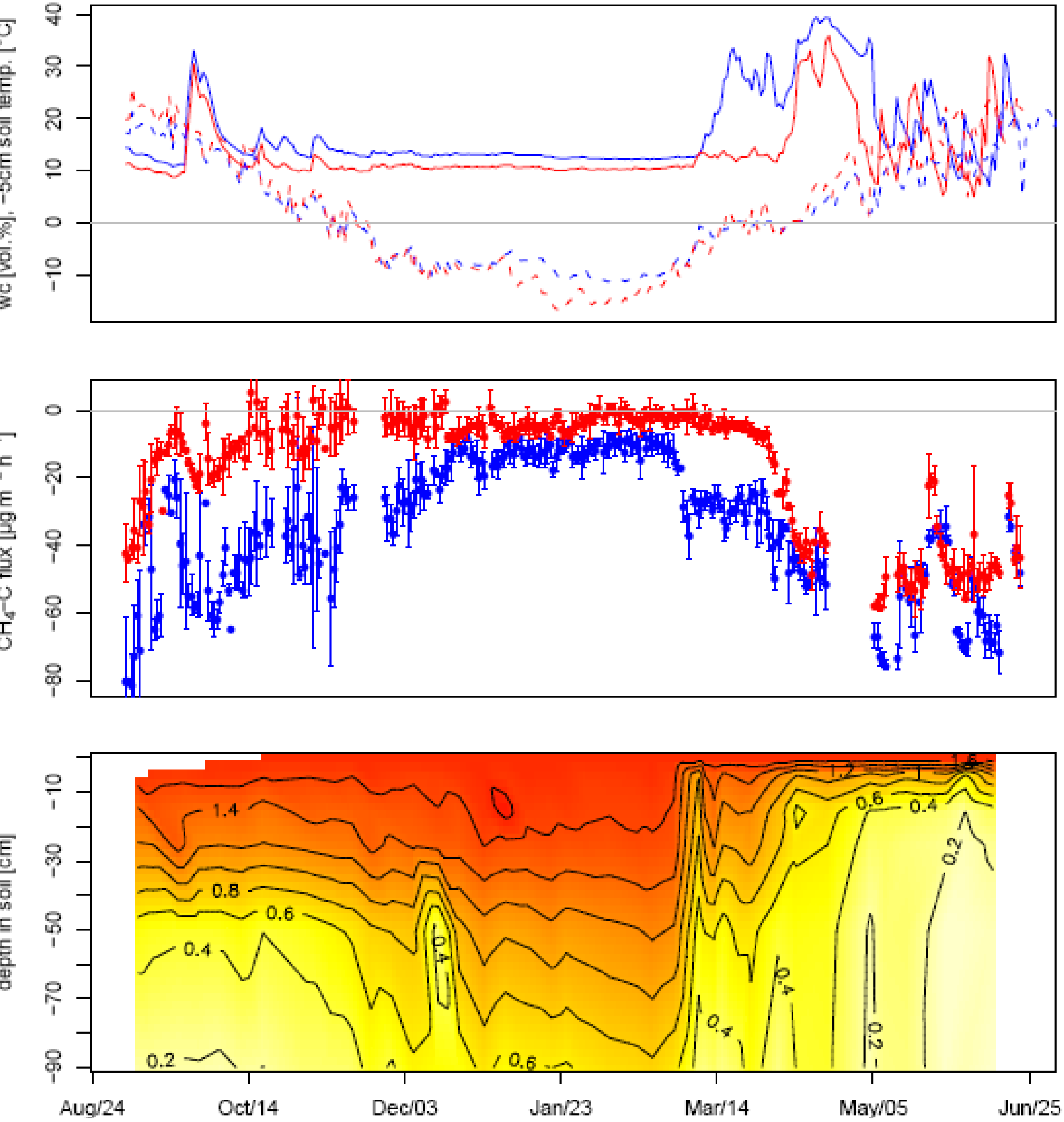
Not always – On a regional scale nutrient management may override site scale effects



Holst et al., 2007, Plant and Soil



Grazed versus non-grazed steppe systems: CH_4



	UG	WG
Texture	sL	sL
pH	6.8±0.3	6.7±0.3
SOC [%]	2.5±0.6	2.6±0.5
Bulk dens. [g cm^{-3}]	1.09±0.1	1.09±0.1
Gas Perm. -30kPa [cm d-1]	**99.6±67**	**55.5±38**

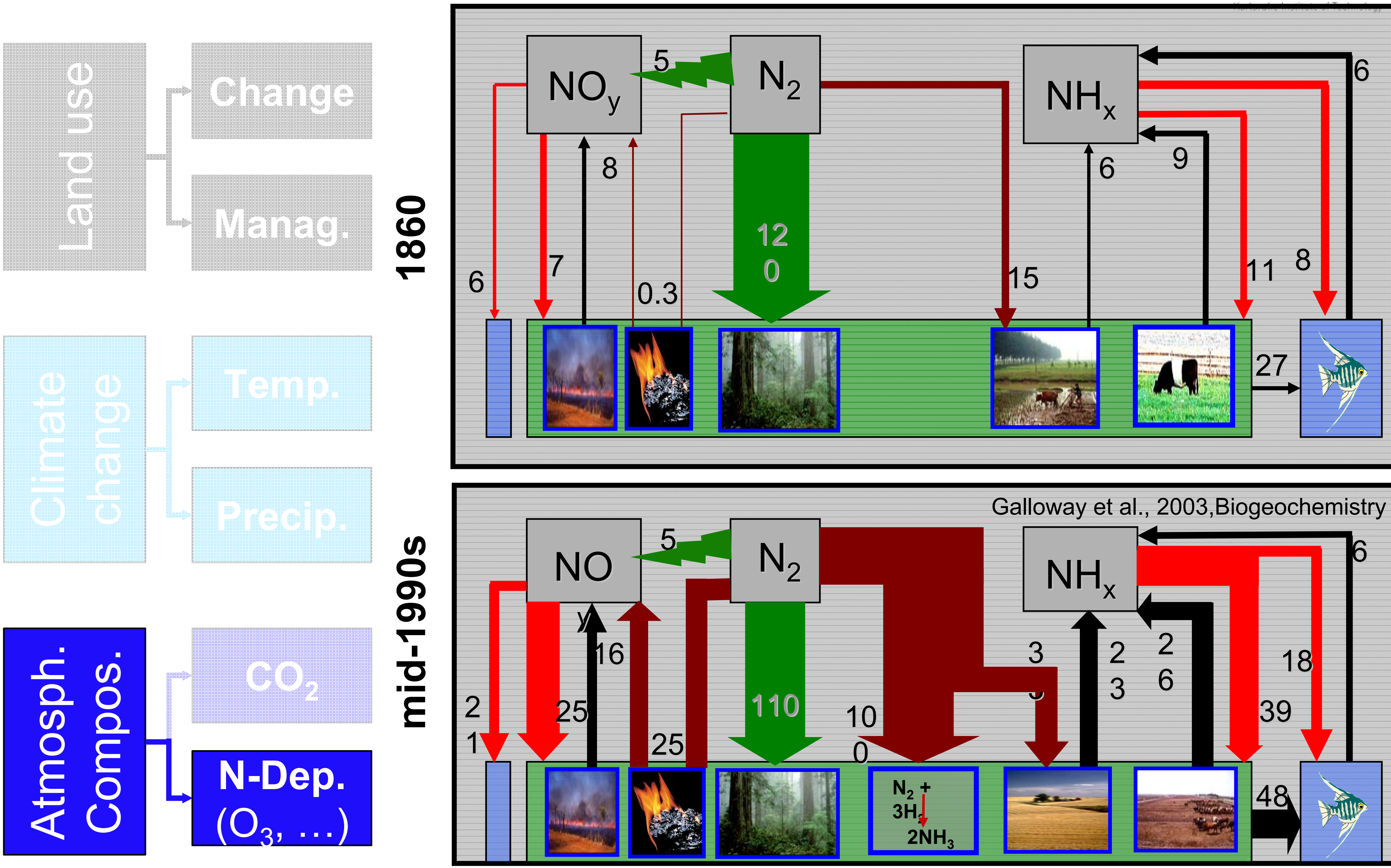
Do natural steppe systems take up more CH_4 than grazed systems?

Source/sink	Base unit for flux calculations	Mean flux [µg CH_4-C m^{-2} h^{-1}]	Total CH_4 emission/uptake [tons C GS^{-1}]
Upland steppe	286592 ha	-28.3±5.[illegible]	[illegible]8±56
Riparian area	4069 ha	[illegible]	232±145
Summer sheepfold	2.7 m^{-2} [illegible]	[illegible]678±168	2.7±0.7
Winter sheepfold	[illegible]eep	107±56	0.1±0.0
Faeces drop[illegible]	[illegible]6 kg FDW GS^{-1} $sheep^{-1}$	1344±219 [a]	34.6±5.6
Shee[illegible]	400685 capita	12.6±1.8 [b]	770±108
Total			**741±315**

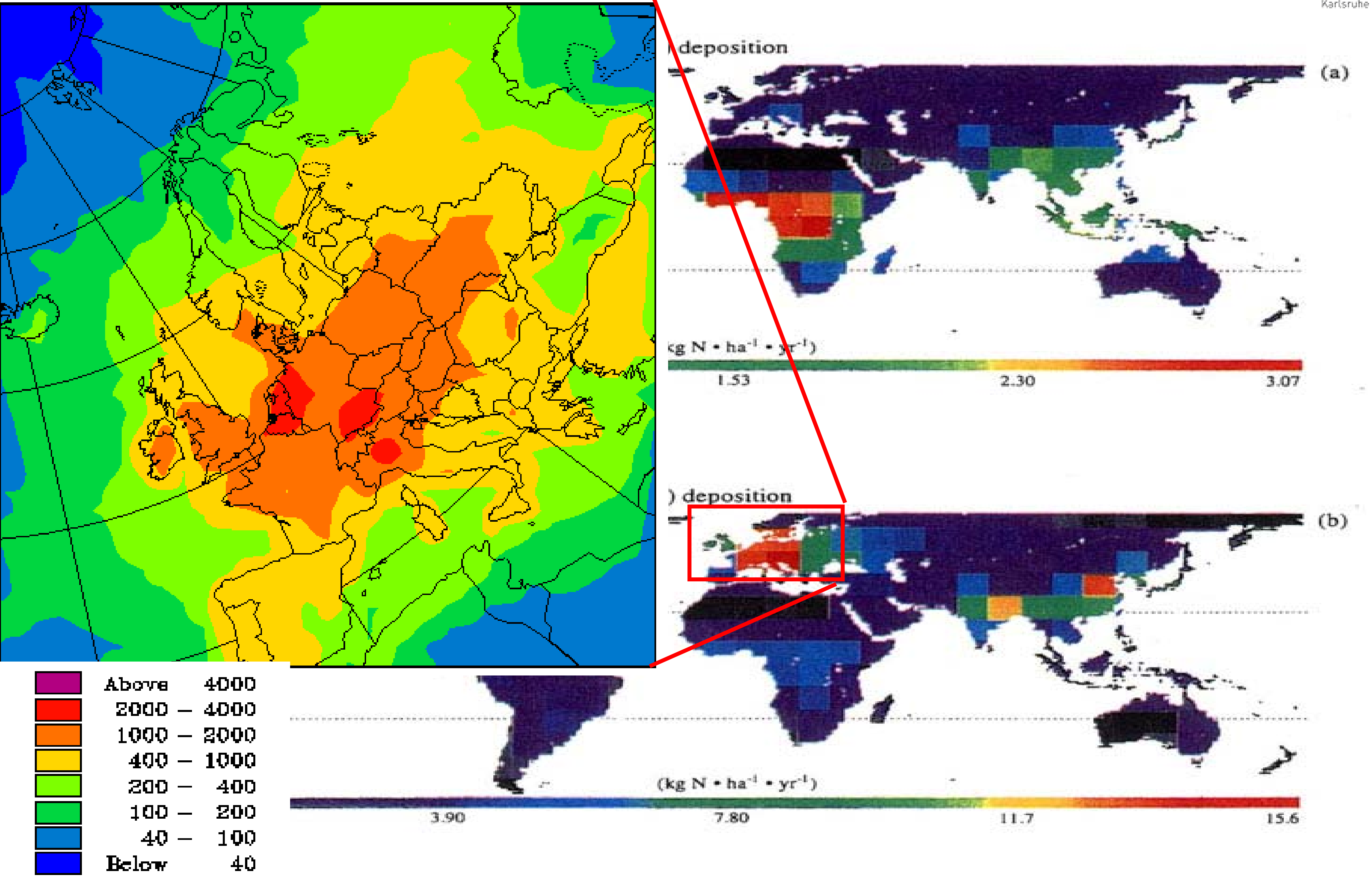
NO – CH_4 emission from riparian areas and from sheep are more important as CH_4 uptake by steppe soils

x0.98 = -1.96 kg C ha^{-1} **X0.02 = 1.4 kg C ha^{-1}** **X2 = 2.2 kg C ha^{-1}**

Nitrogen cycling changes during the past two centuries

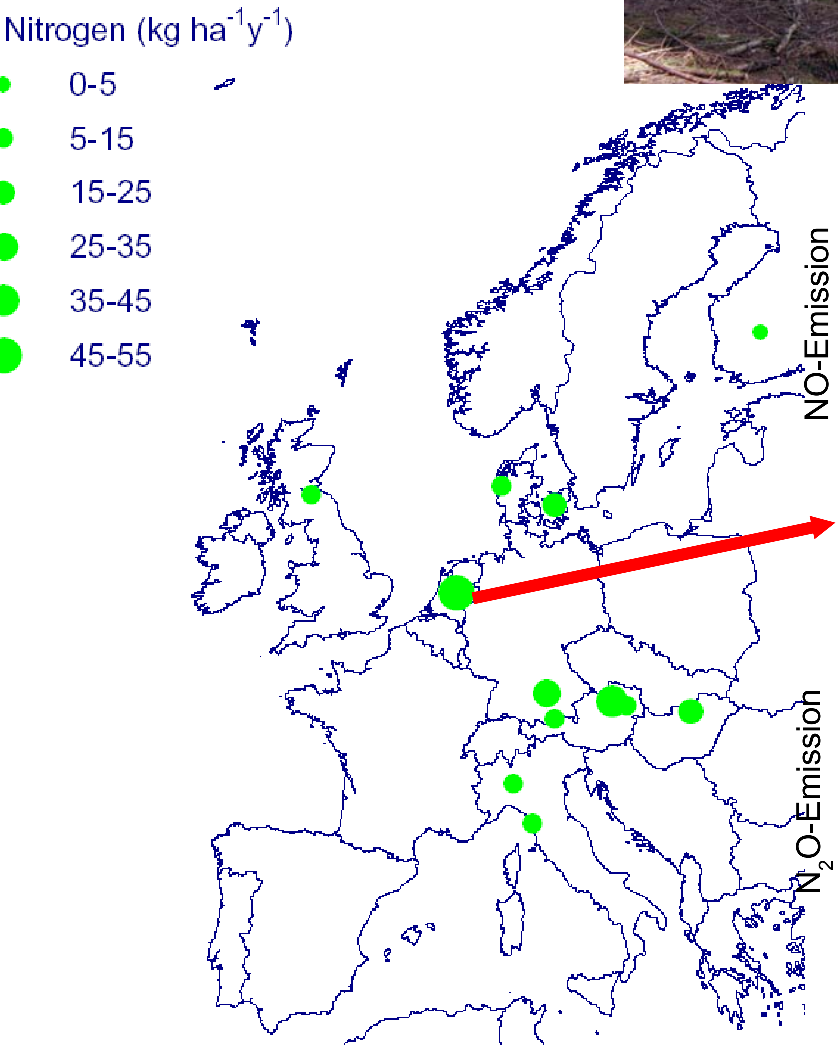


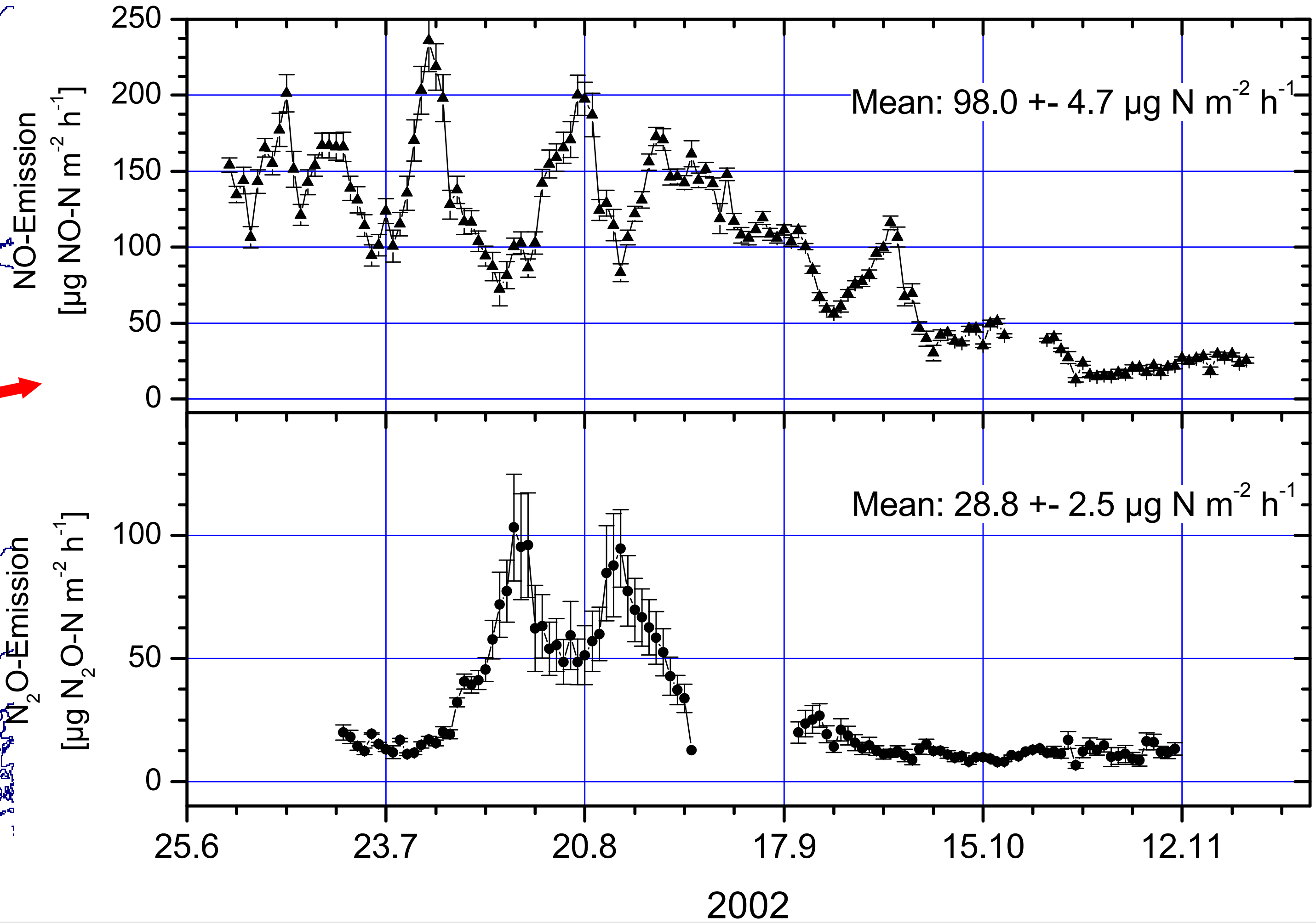
Nitrogen depostion – past and present



Holland et al., 1999, Biogeochemistry, EMEP, 2002

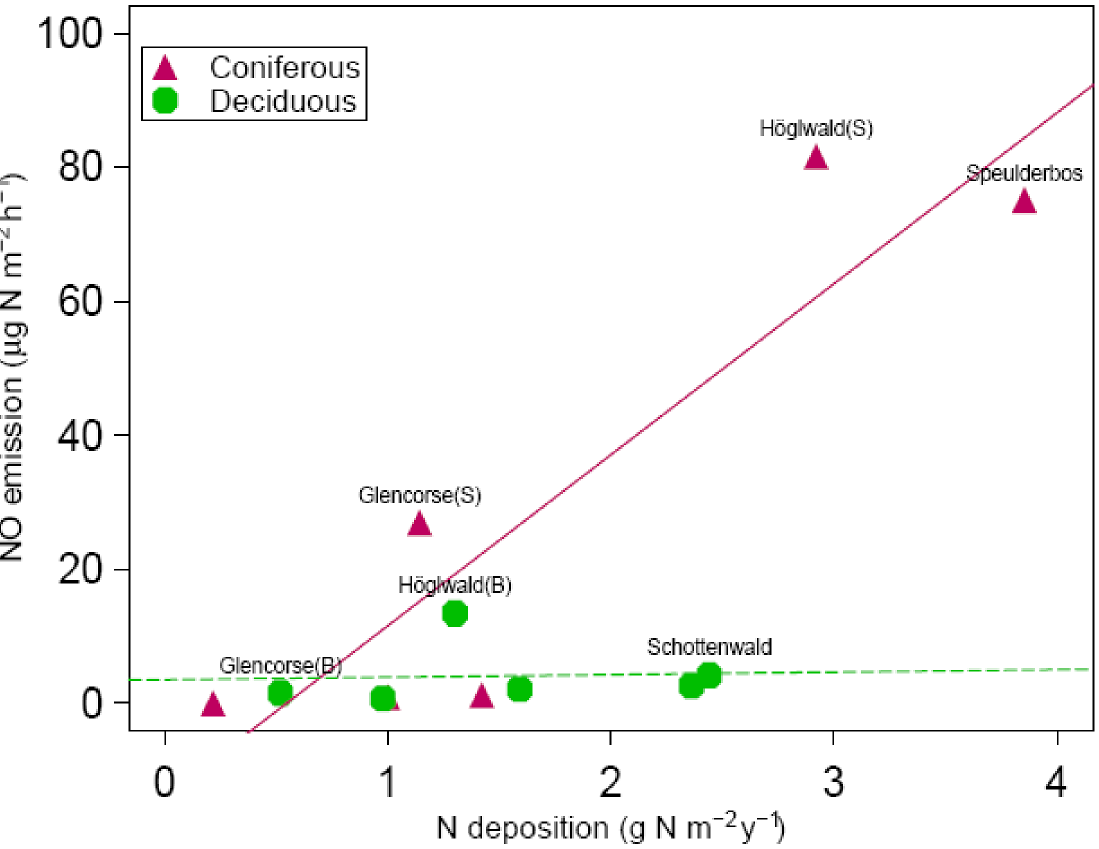
Nitrogen oxide emissions from Forests in Europe (NOFRETETE)

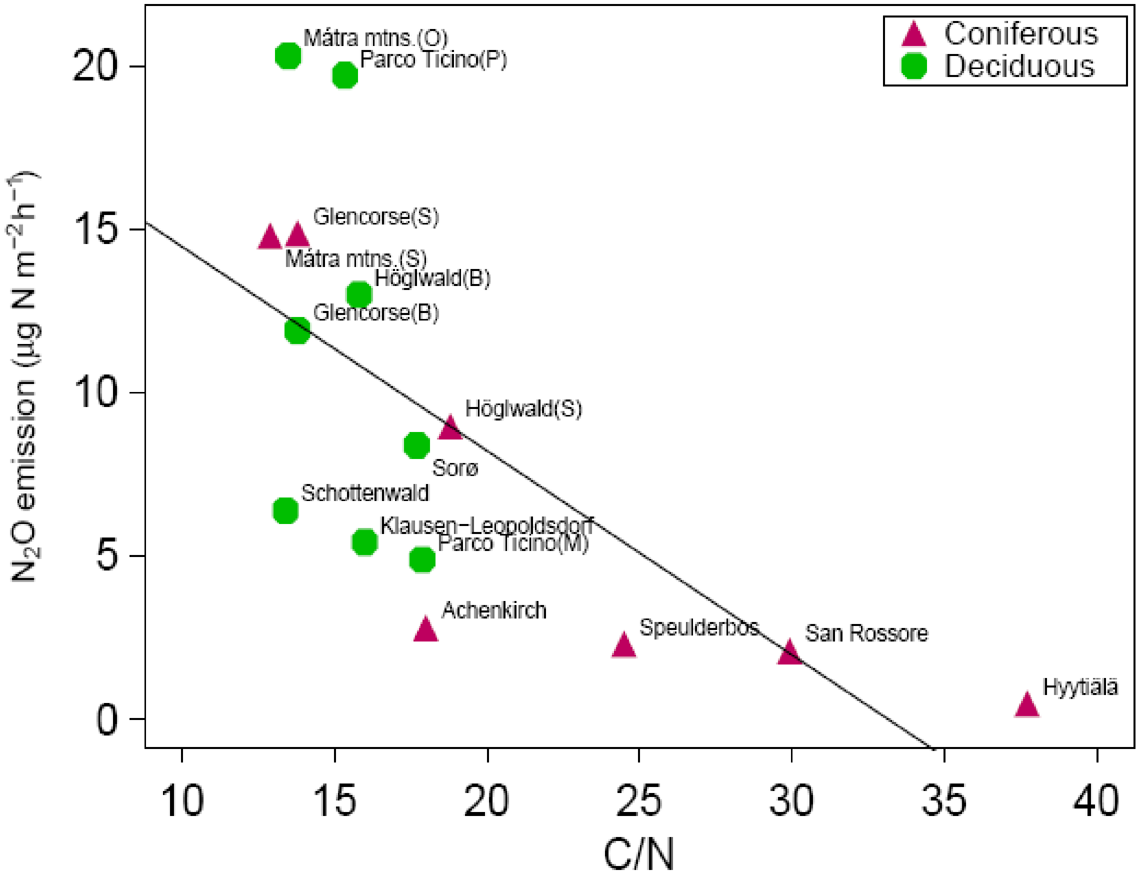




Nitrogen oxide emissions from Forests in Europe (NOFRETETE)

KIT
Karlsruhe Institute of Technology





Stimulation of N-oxide emissions from soils at sites with high N-deposition and narrow C/N ratios

Pilegaard et al., 2006, Biogeosciences

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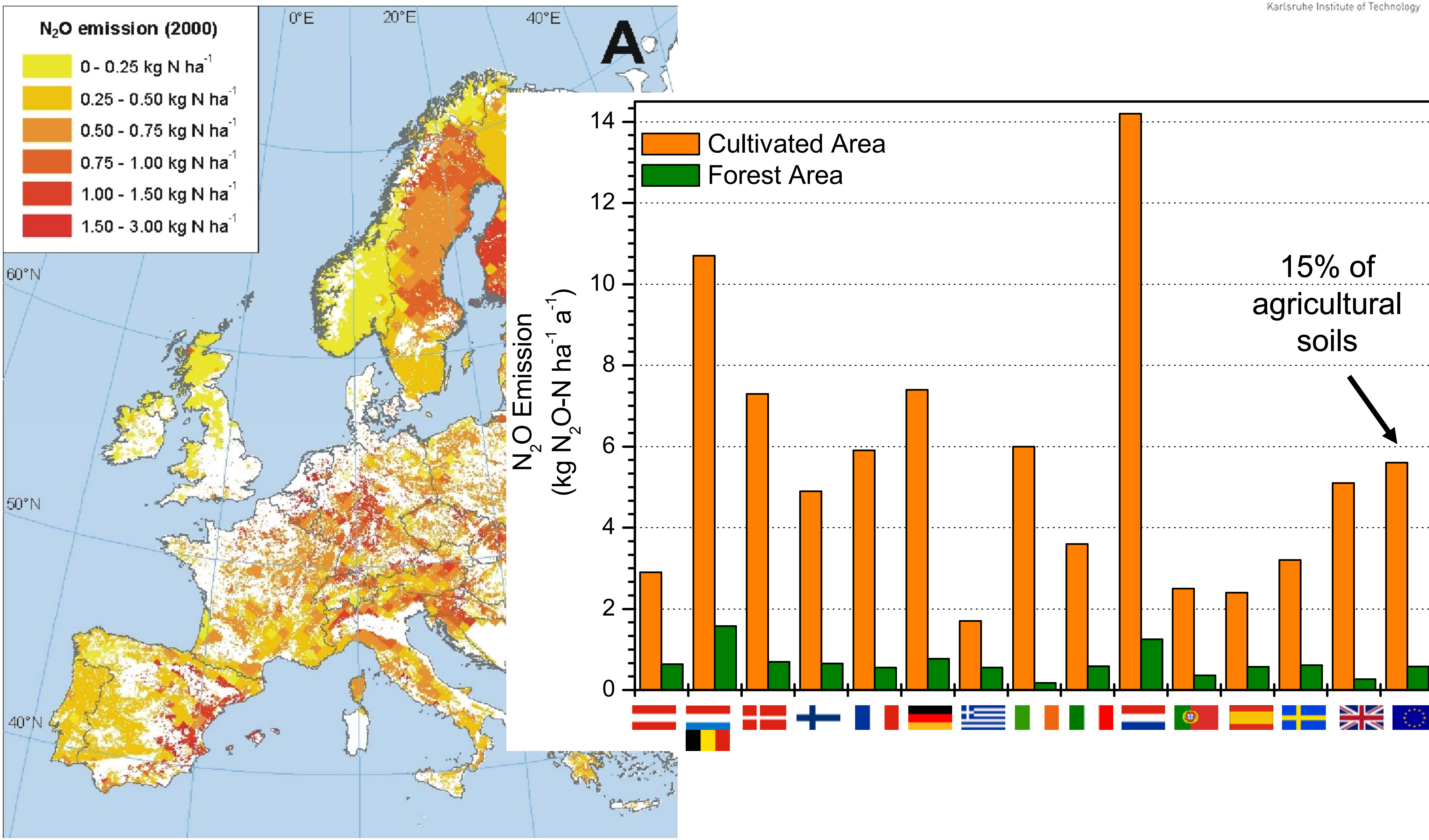


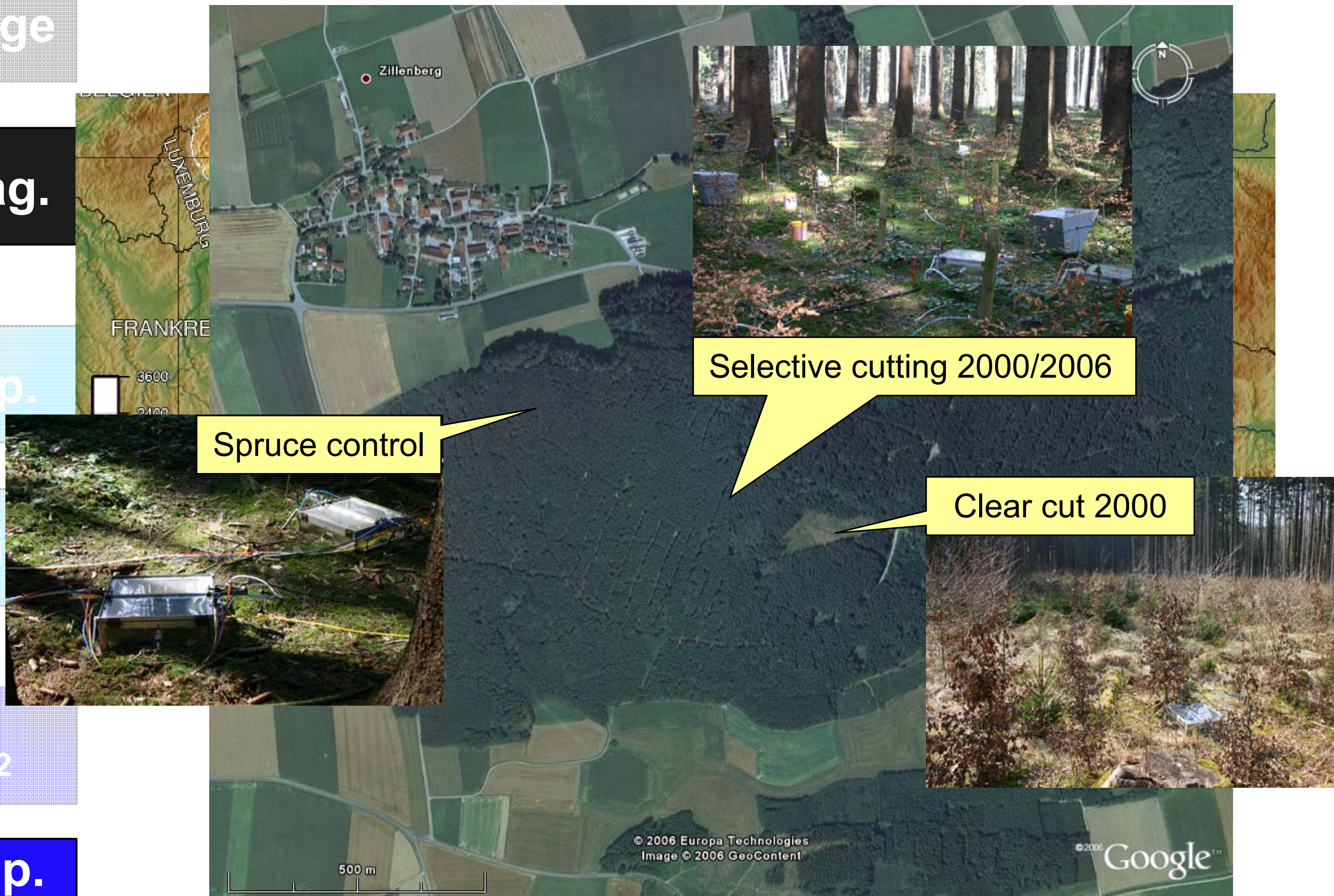
Kesik et al., 2005, Biogeosciences

Forest management, N deposition and N_2O fluxes (Höglwald)

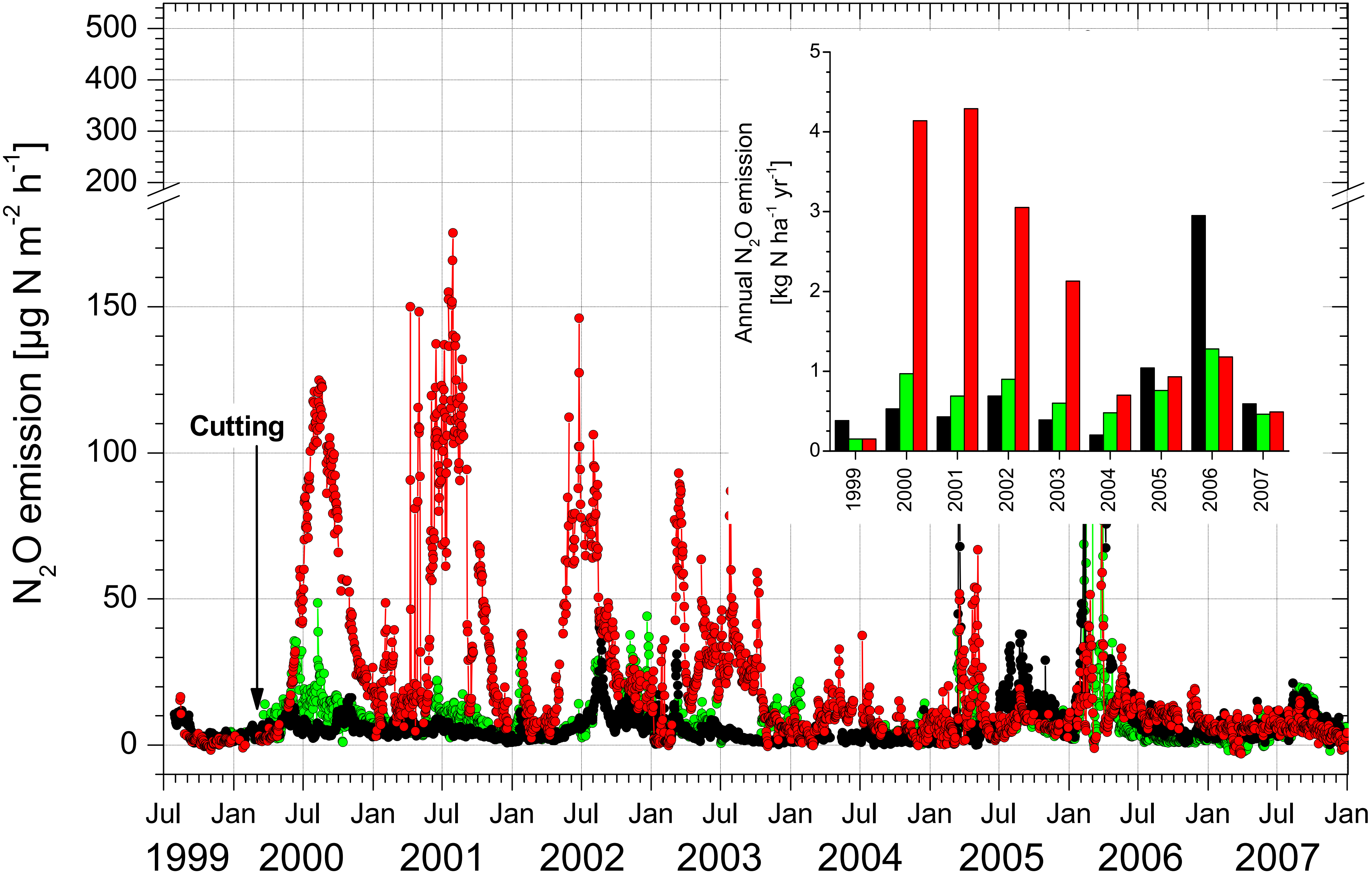
Land use
- Change
- Manag.

Climate change
- Temp.
- Preci

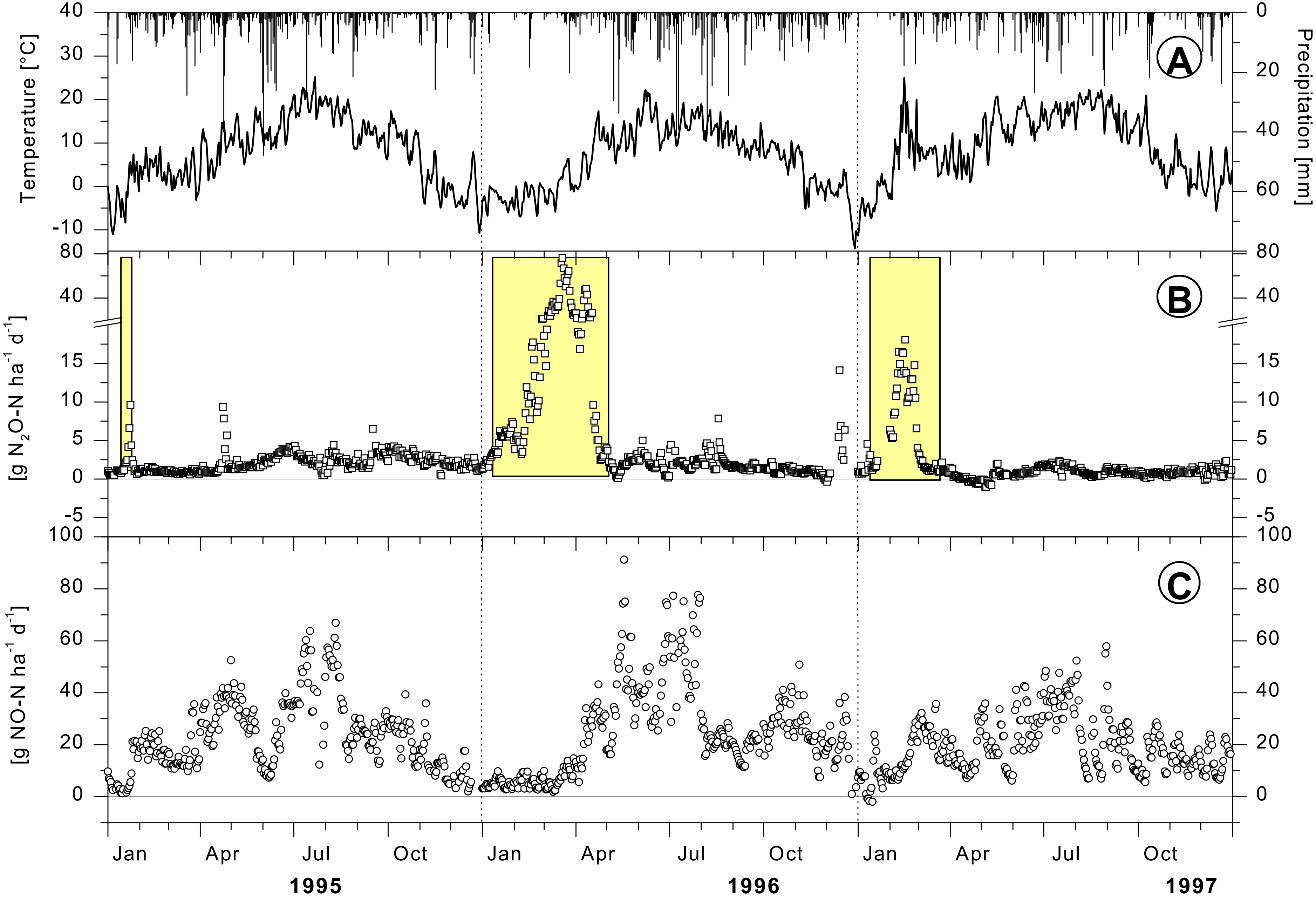
Atmosph. Compos.
- CO_2
- N-Dep. (O_3, …)



Clear-cutting enhances N_2O emissions for years

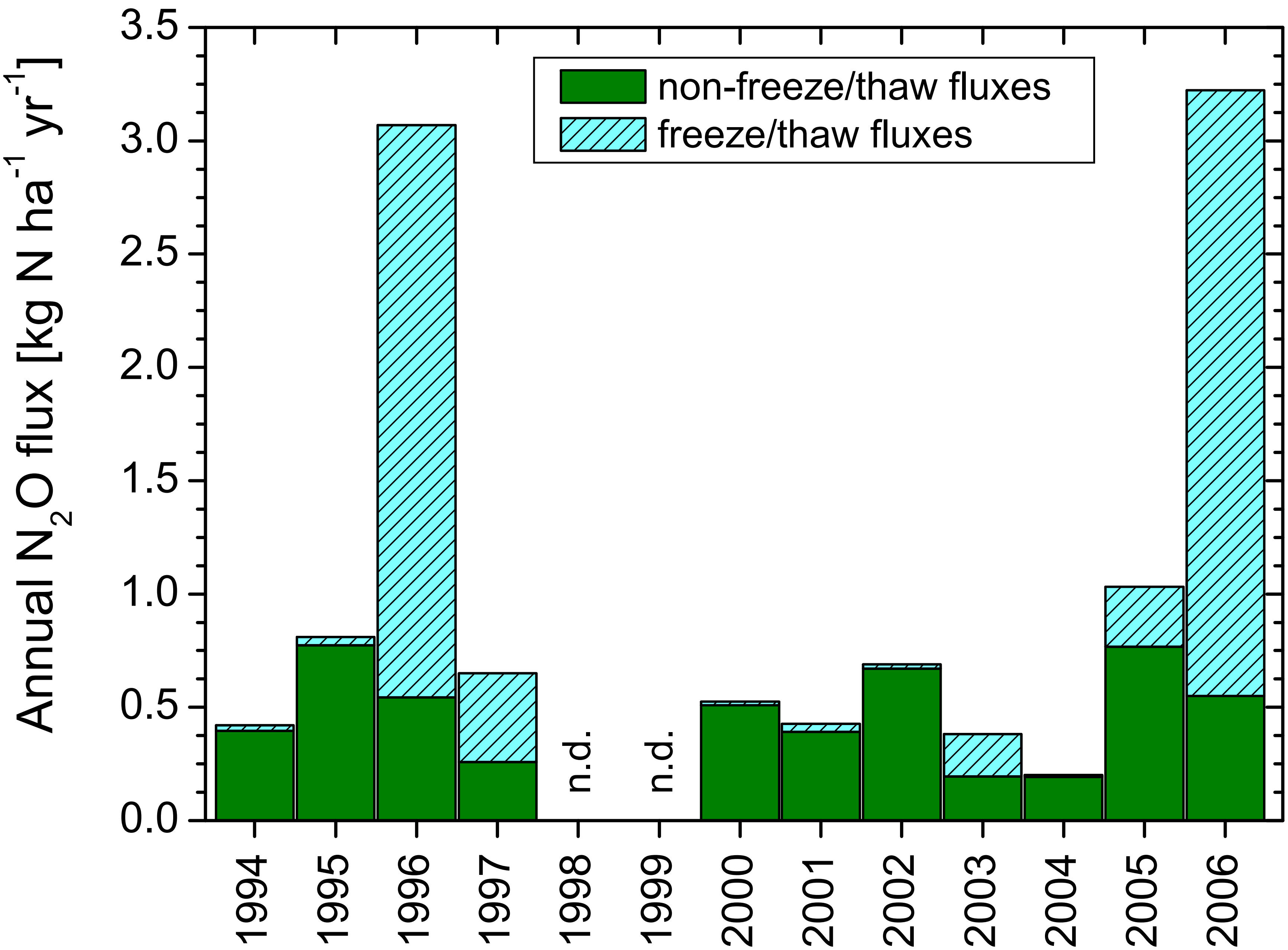


Climate change and the variability of fluxes - Höglwald



Papen & Butterbach-Bahl, J Geophys. Res, 1999; Butterbach-Bahl et al.,J. Geophys. Res. 2001

Climate change and the variability of fluxes - Höglwald



Summary

1) ***Human perturbation of N cycle may override climate effect***
   - **Additional Nr creation**
   - **Management largely feedback on soil N_2O emissions**

2) ***Emissions from "natural" sources most likely underestimated***
   - **Freeze-thaw is hardly accounted for**

3) ***Long-term monitoring is required to understand variability of fluxes***
   - **Landscape/ regional analysis of nutrient cycling and associated non-CO_2 and CO_2 GHG exchange at identified hotspots (e.g. China)**

4) ***CH_4 uptake is mostly negatively affected by human activity***
   - **Effect not quantified yet**