MAGIM (**Ma**tter fluxes in **g**rasslands of **I**nner **M**ongolia)

Biosphere-Atmosphere Exchange Processes in Steppe Ecosystems as Affected by Grazing

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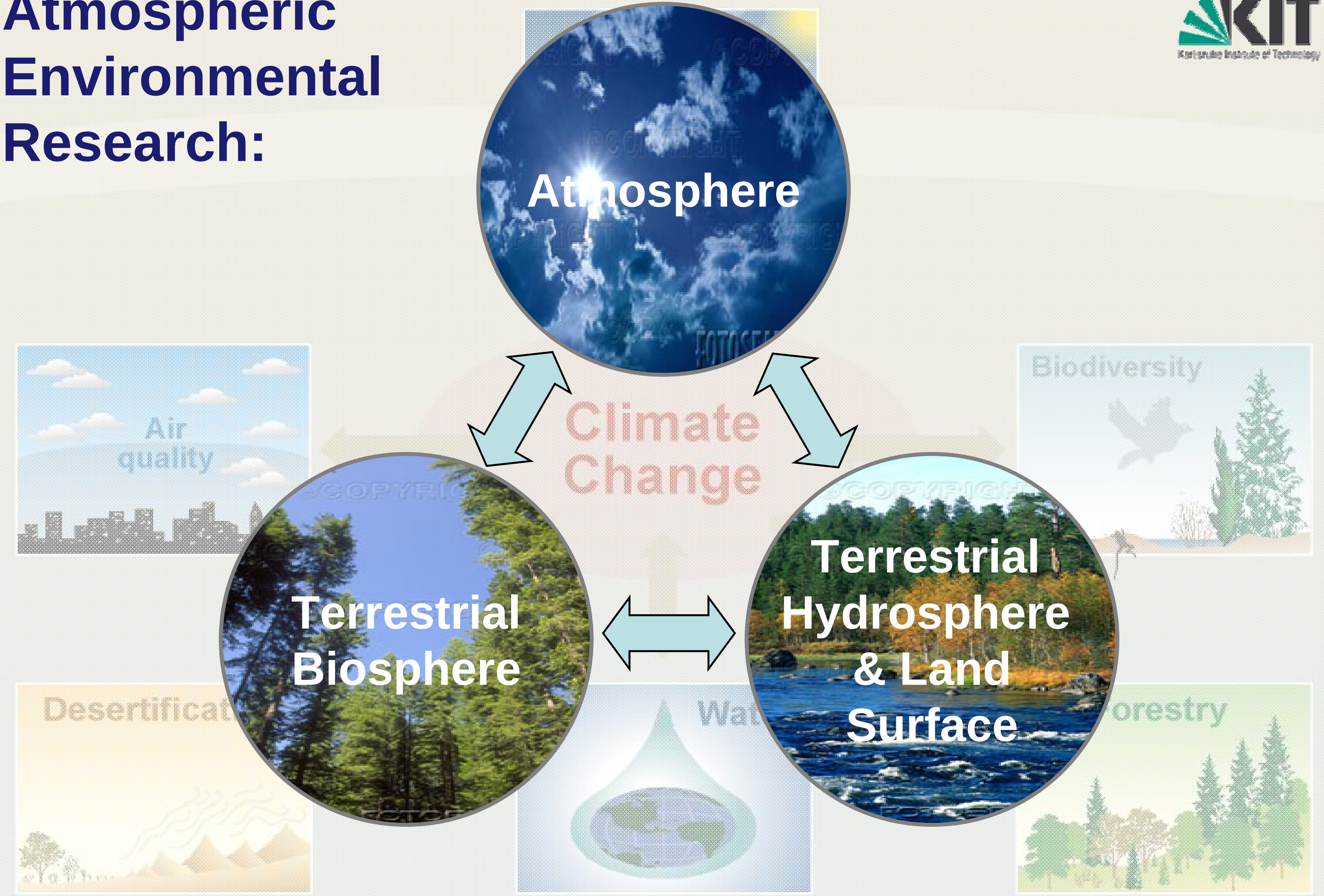
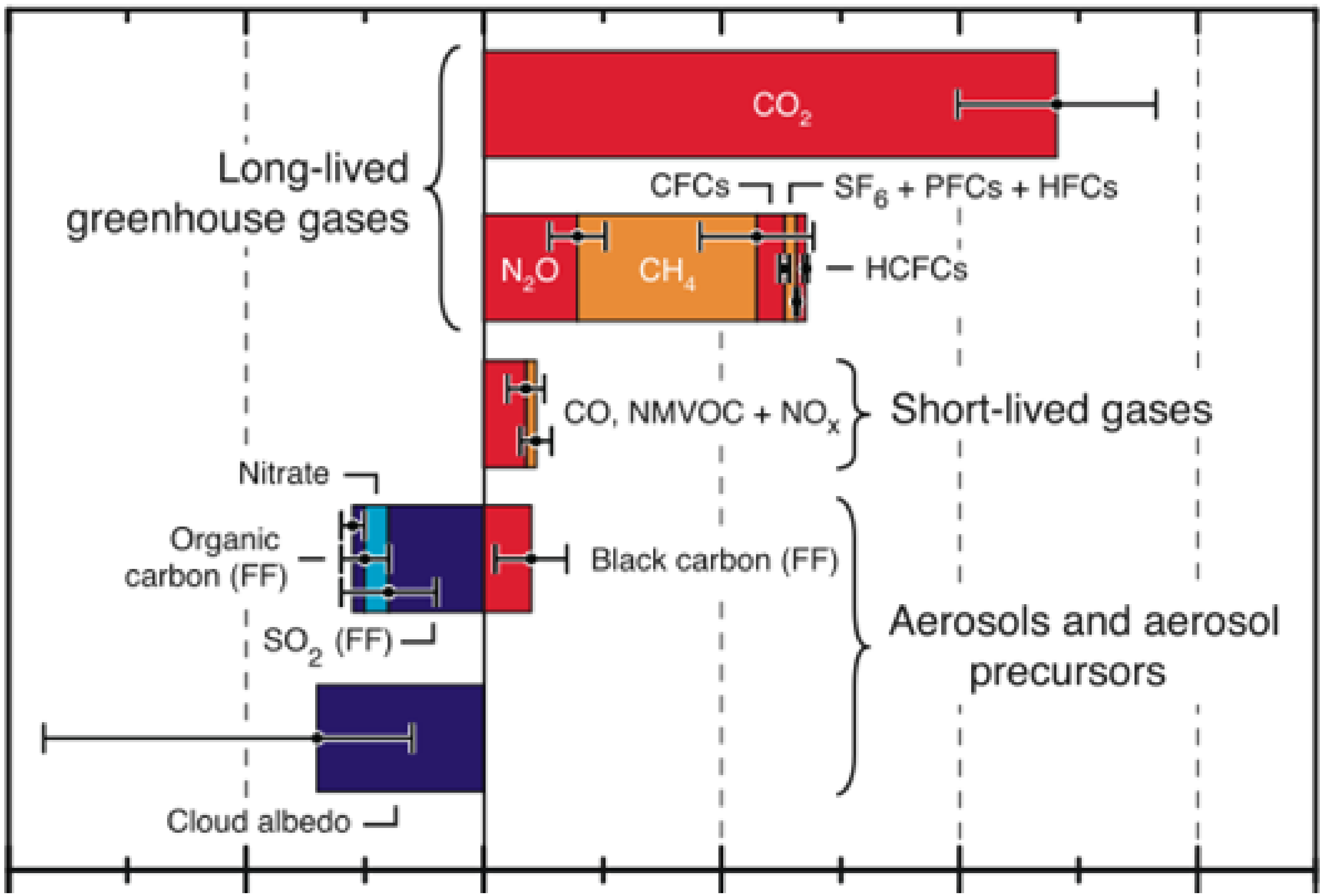
Atmospheric Environmental Research:



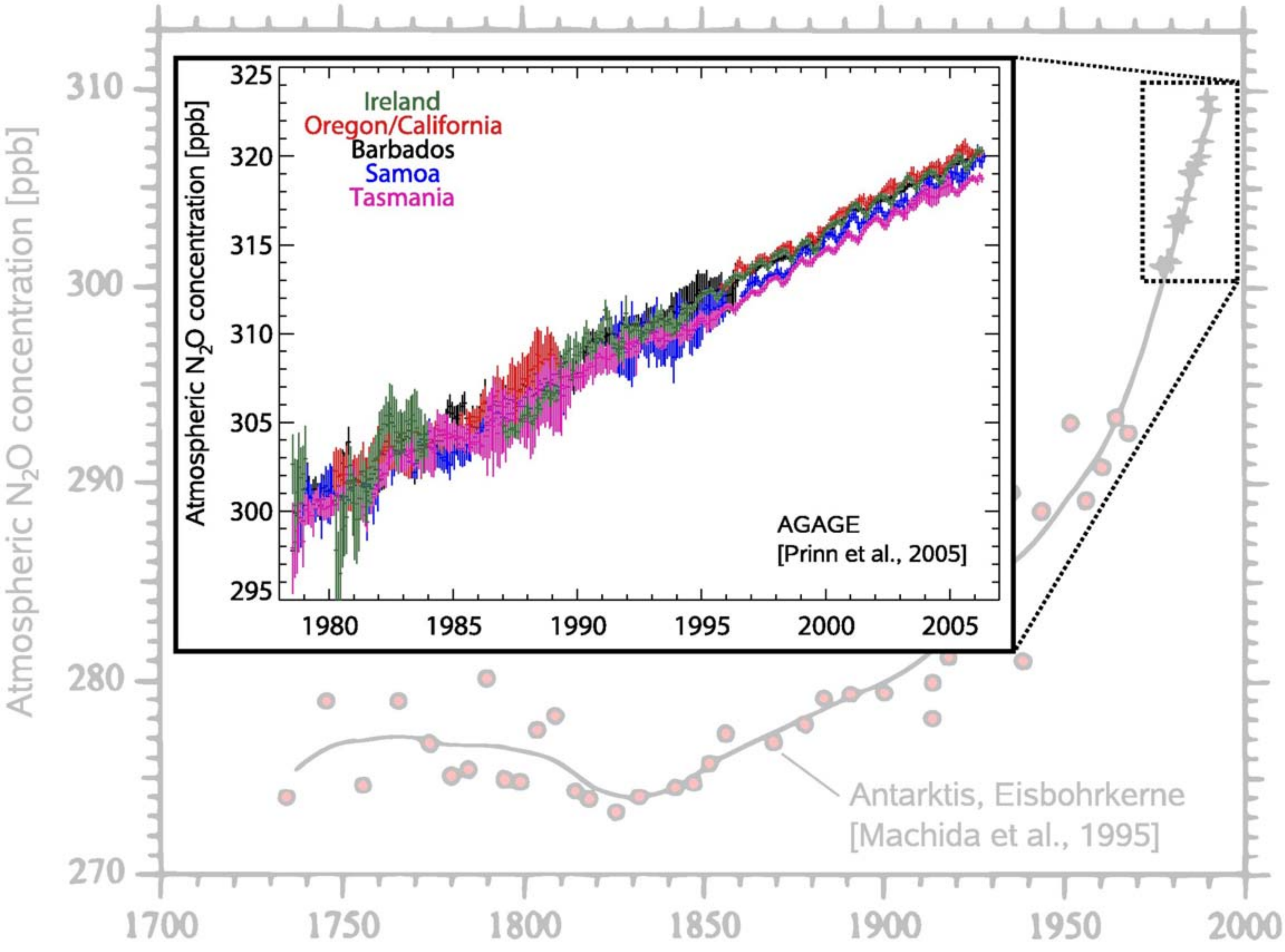
(source: IPCC 2001, WG1 Report, Summary)

Radiative forcing by atmospheric trace gases

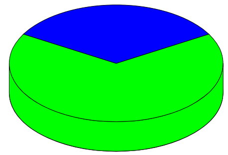


Integrated radiative forcing, 100 yrs (W m^{-2} yr^{-1})

Atmospheric N_2O concentrations



Industrial sources



iculture, forests, ozeans

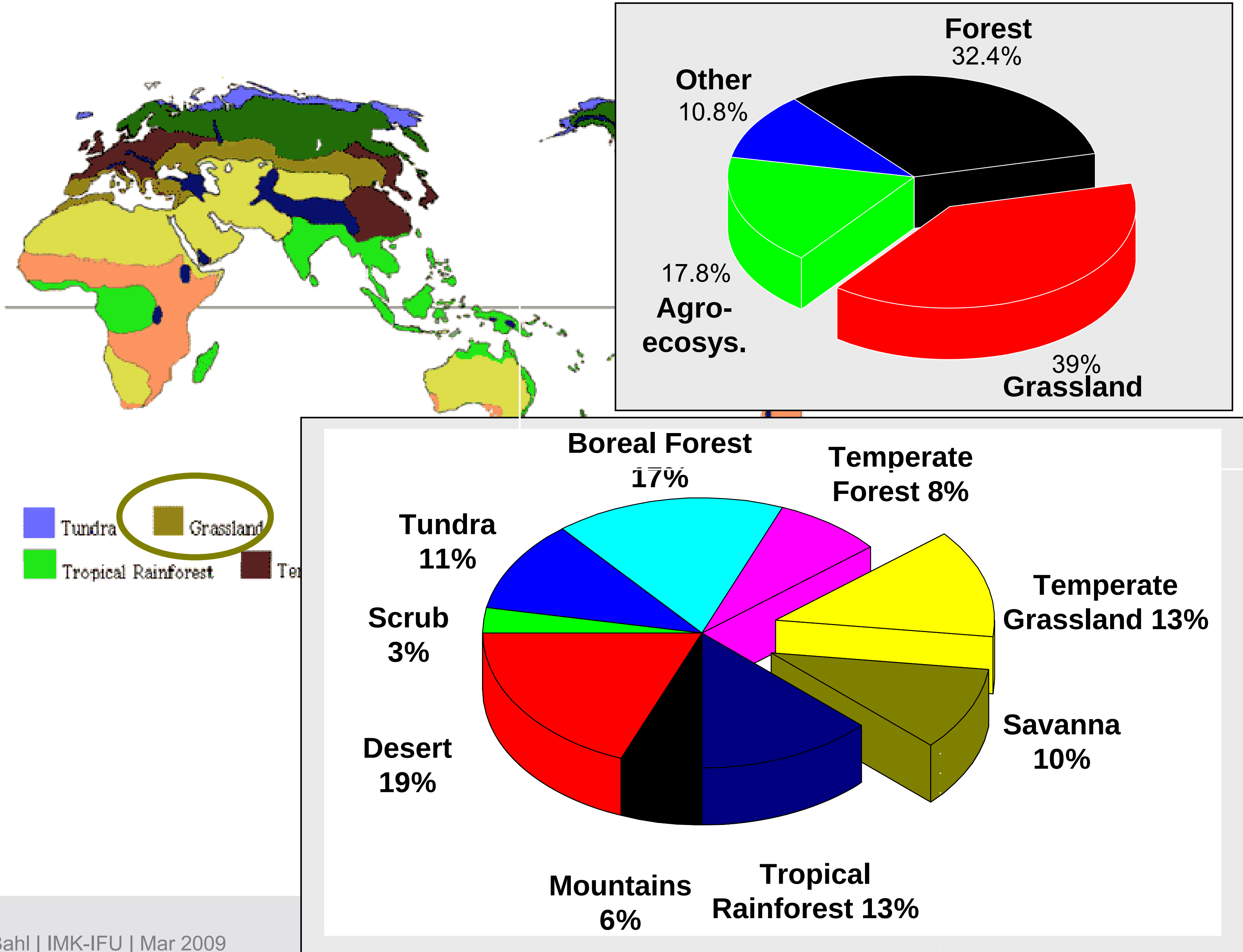
N_2O

Soils: 60-70%

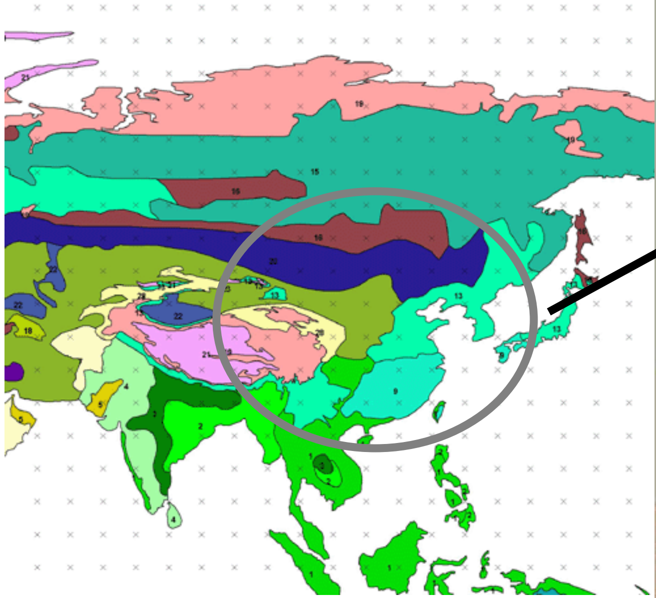
Research teams within MAGIM

	Forschungszentrum Karlsruhe **Institute for Meteorology & Climate Research (IMK-IFU), Garmisch-P.**	• **Microbial turnover** • **Trace gas exchange**	
	Technical University Munich		
	Lehrstuhl für Bodenkunde	• **SOC dynamics** • **Soil aggregation**	
	Lehrstuhl für Grünlandlehre	• **Ecophysiology** • **Isotopic signatures**	
	Christian Albrechts University		
	Institute for Plant Nutrition and Soil Science	• **Plant production** • **H_2O/N interactions**	
	Institute for Plant Nutrition and Soil Science	• **Soil hydrology** • **Soil physics**	
	Institute of Crop Science and Plant Breeding	• **Grassland science** • **Feed quality**	
	Institute of Animal Nutrition and Physiology	• **Animal production**	
	Justus-Liebig University **Department of Agriculture and Environmental Protection, Giessen**	• **Regional hydrology** • **Central database**	
	Technical University of Dresden **Institute for Hydrology and Meteorology, Dresden**	• **CO_2/H_2O exchange** • **Remote sensing**	
	Leibniz-Centre for Agricultural Landscape Research (ZALF) **Institute of Soil Landscape Research, Müncheberg**	• **Winderosion on local and regional scales**	
	German Meteorological Service **Meteorological Observatory Lindenberg**	• **Remote sensing** • **Precipation**	

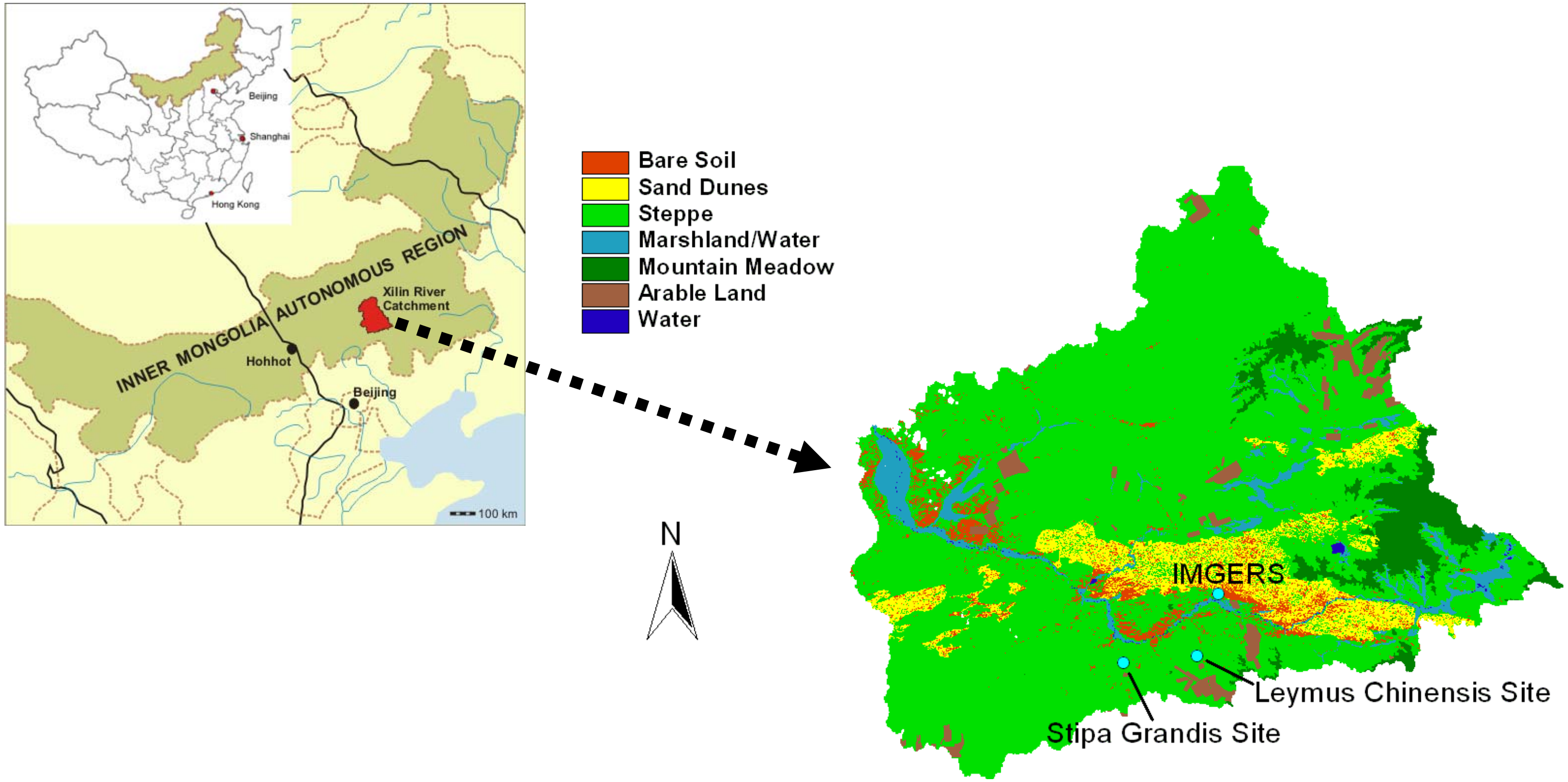
Global importance of the biome type „grassland “



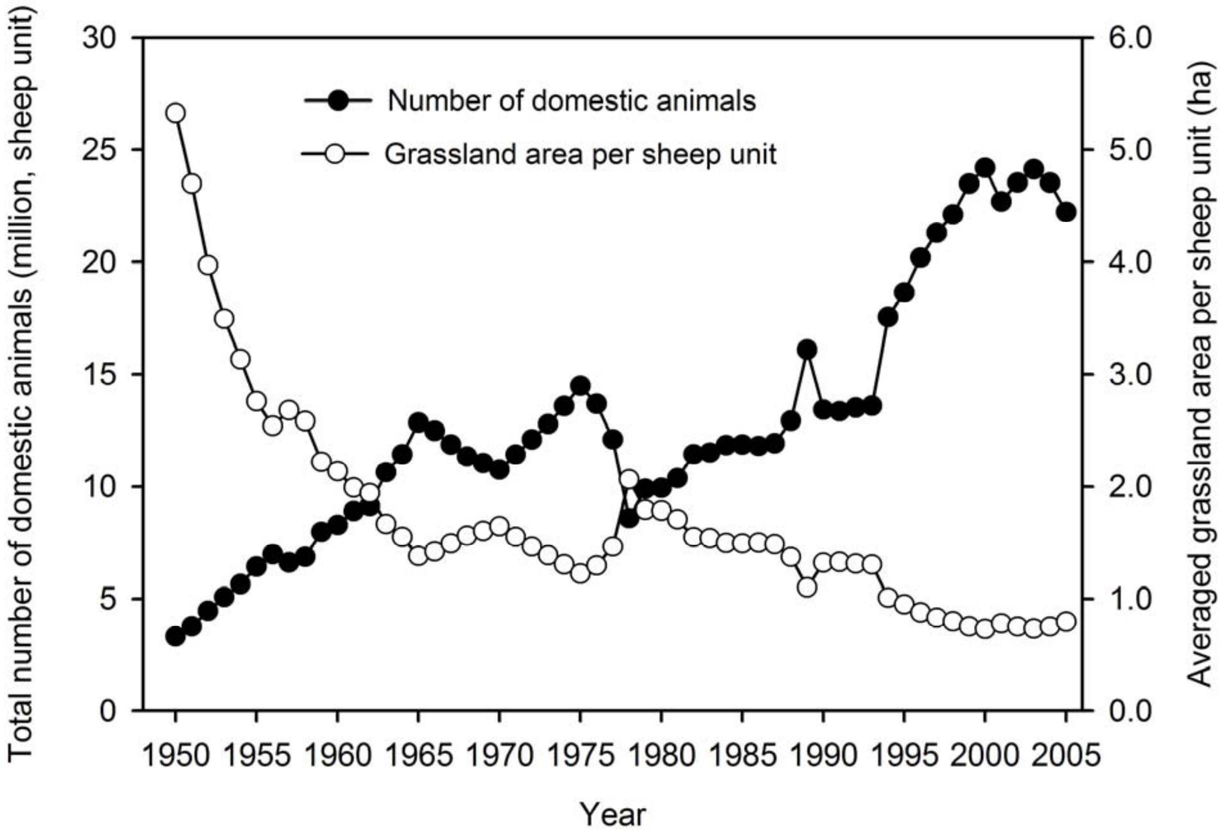
Location of the target region



Landuse in the Xilin catchment



Grazing pressure and degradation



Objectives of MAGIM

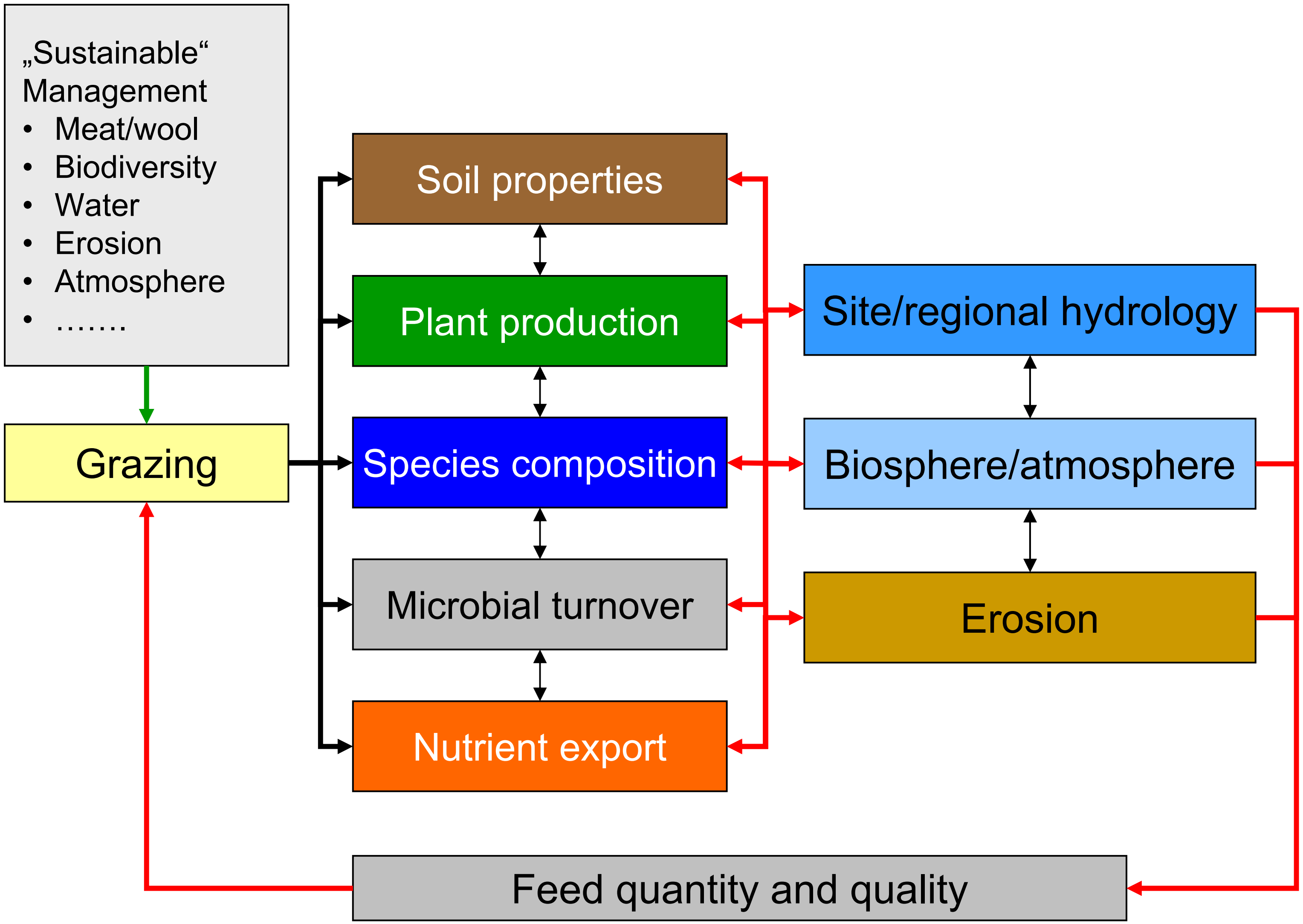
Central Aims of the Research Group

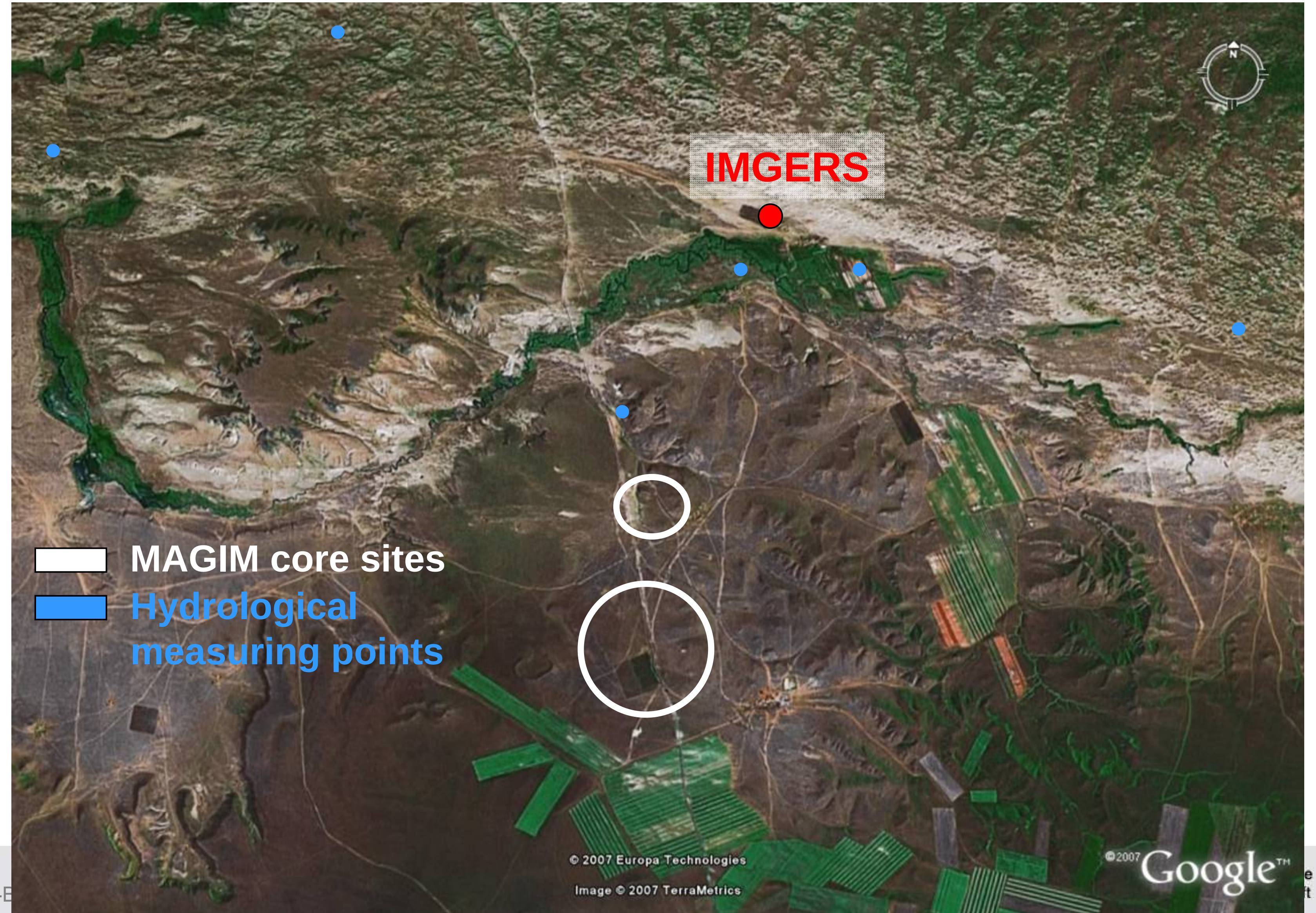
- **Understanding of feedbacks between grazing and degradation on bases of a detailed analysis of the cycles of C, N and water**

  → local - regional scales, gradient in grazing intensities

- **Process oriented description of fluxes and pools with models**
- **Evaluation of strategies for grazing of steppe ecosystems**
- **Regionalisation of results and scenario studies**

Grazing effects




IMGERS
MAGIM core sites
Hydrological measuring points
© 2007 Europa Technologies
Image © 2007 TerraMetrics
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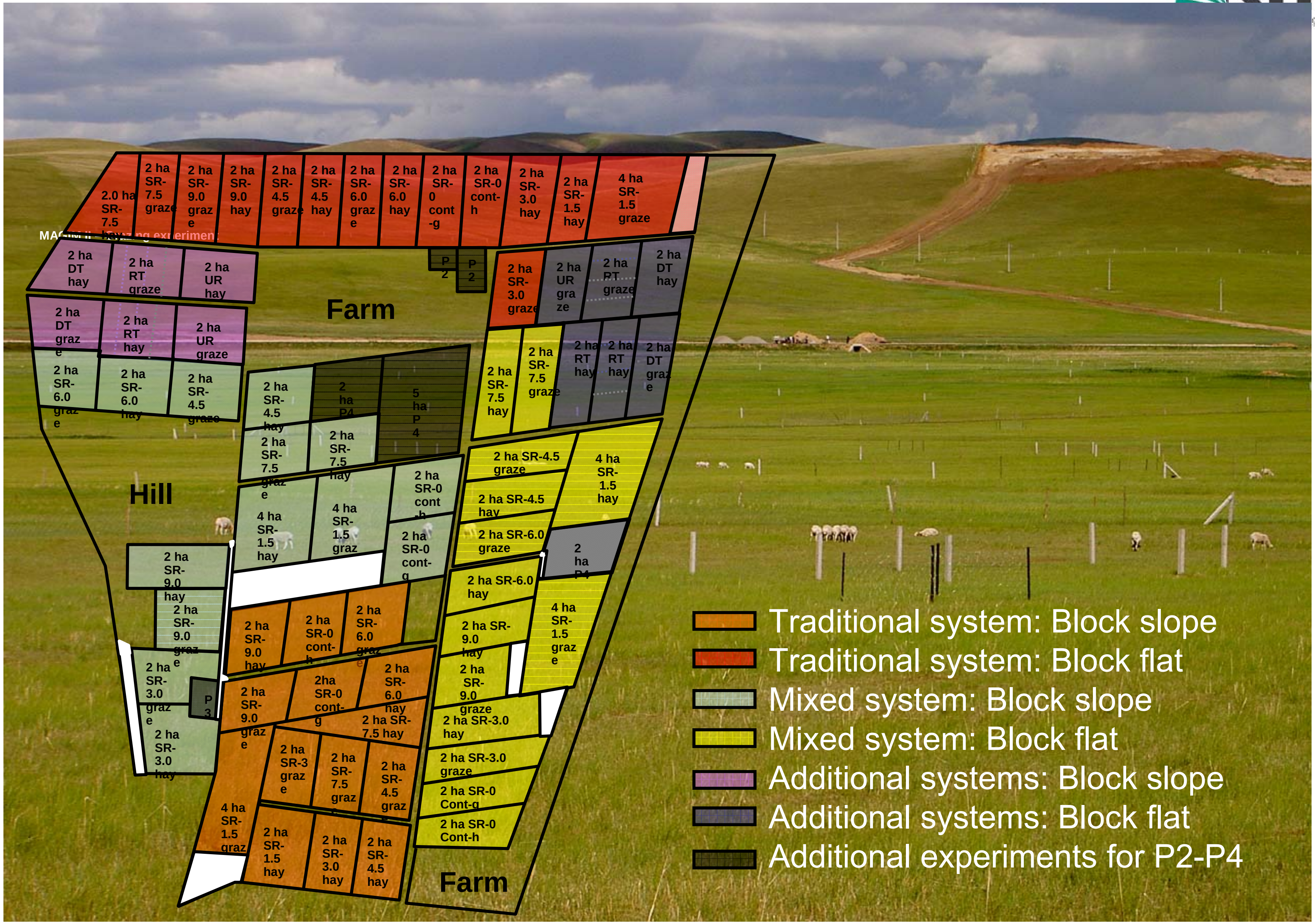
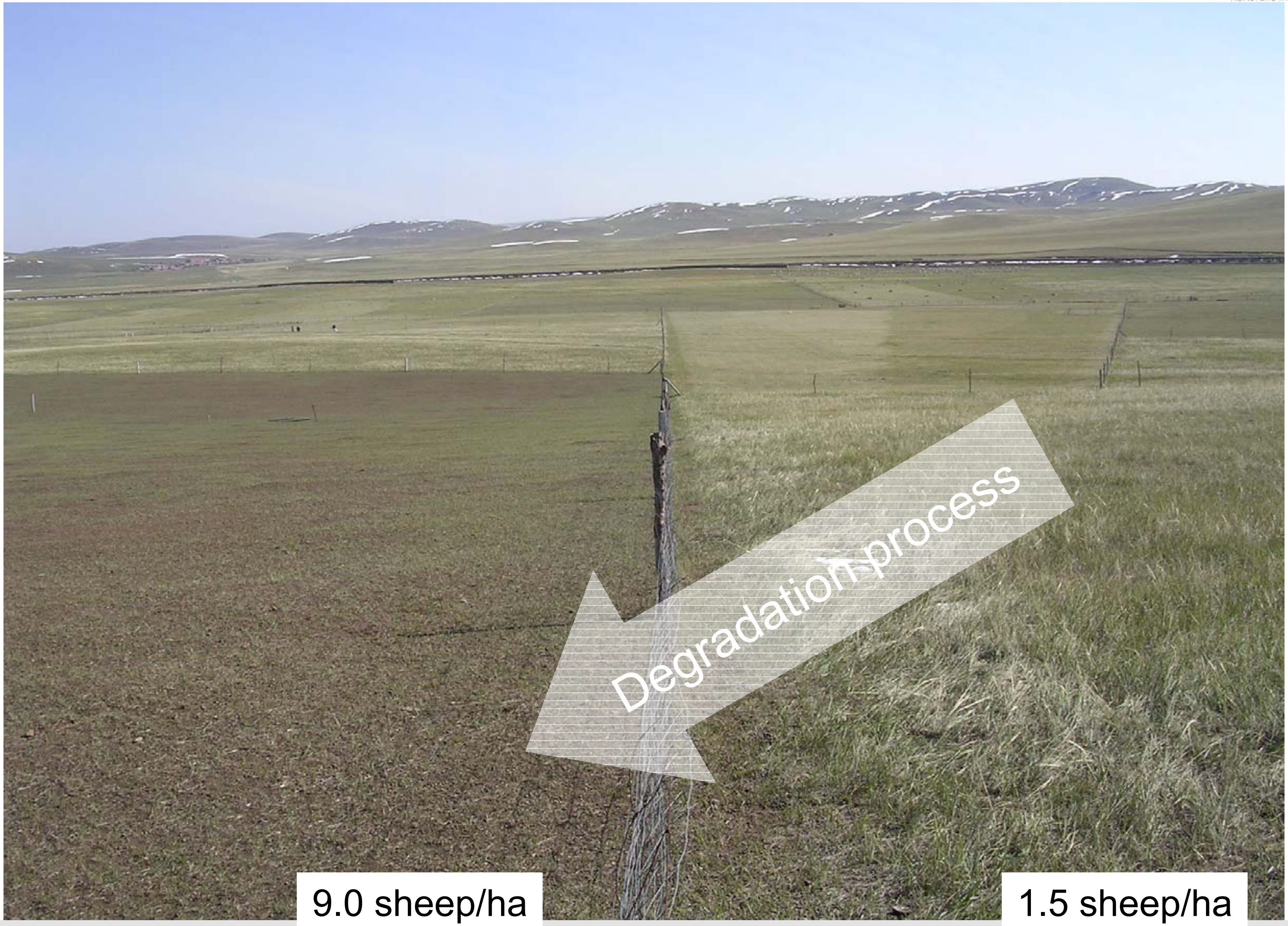
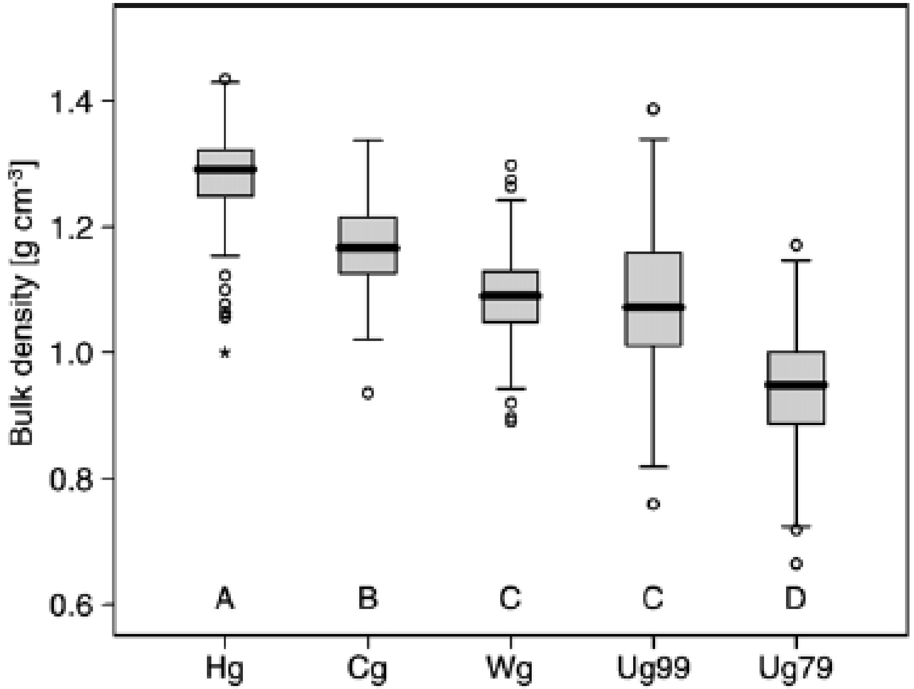
Grazing experiment

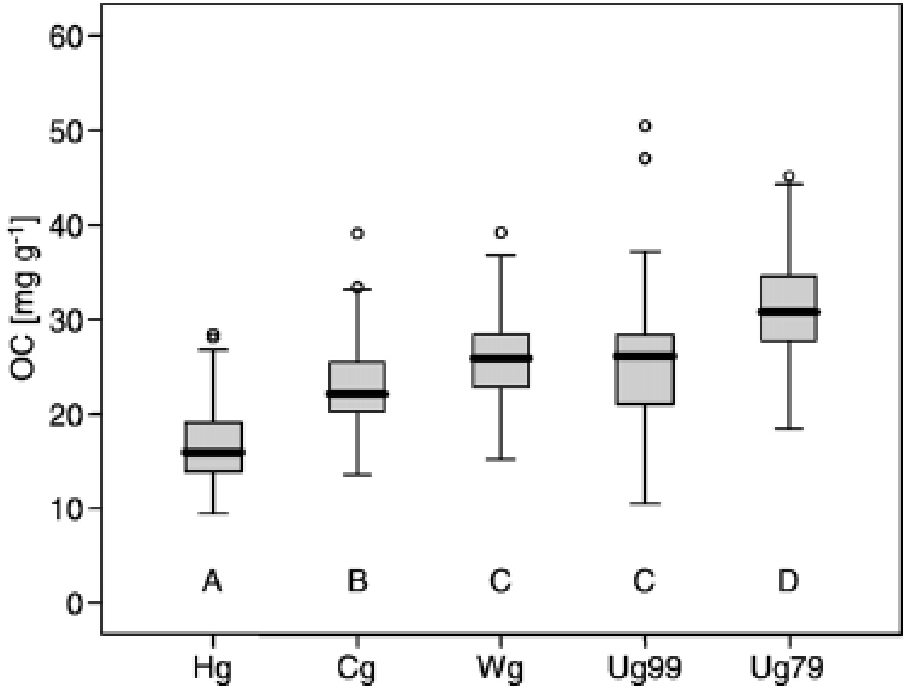


Sward degradation due to grazing



Grazing and soil properties



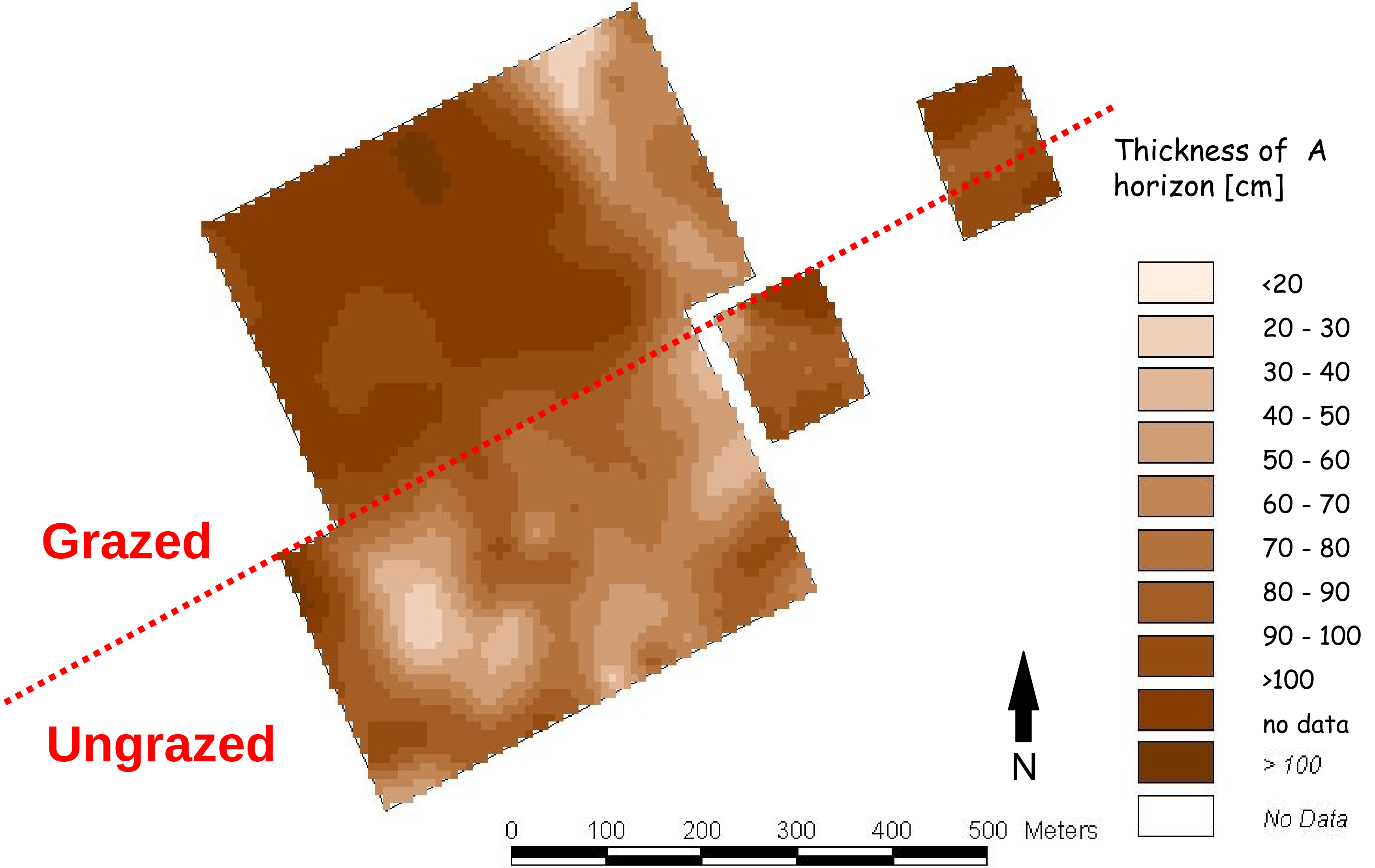


⇒ Grazing has lowered topsoil SOC and particulate organic matter due to lower inputs and decomposition following aggregate deterioration

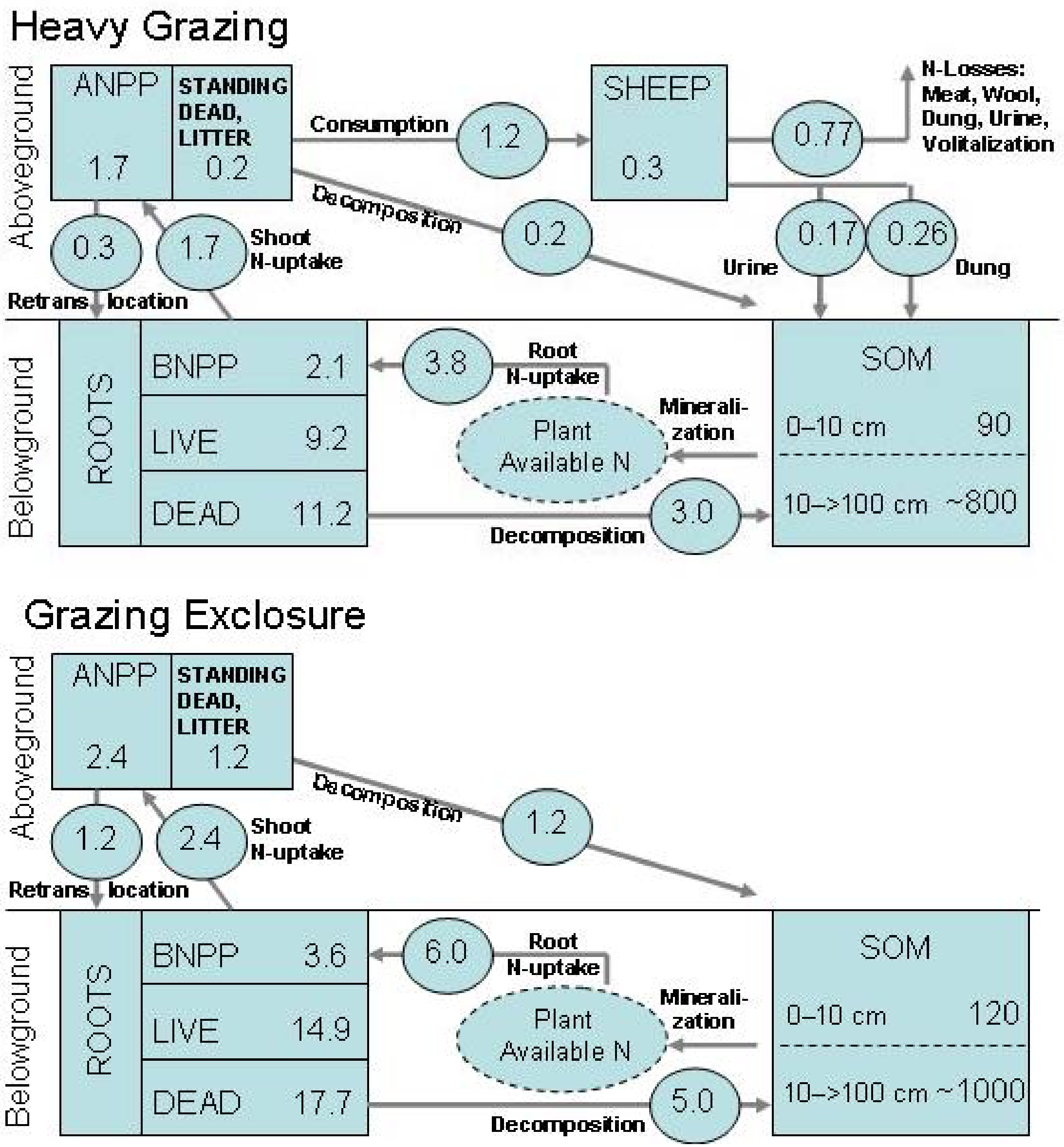
⇒ Grazing has led to to an increase in soil bulk density

Steffens et al., 2008, Geoderma

Soil properties, grazing and spatial heterogeneity

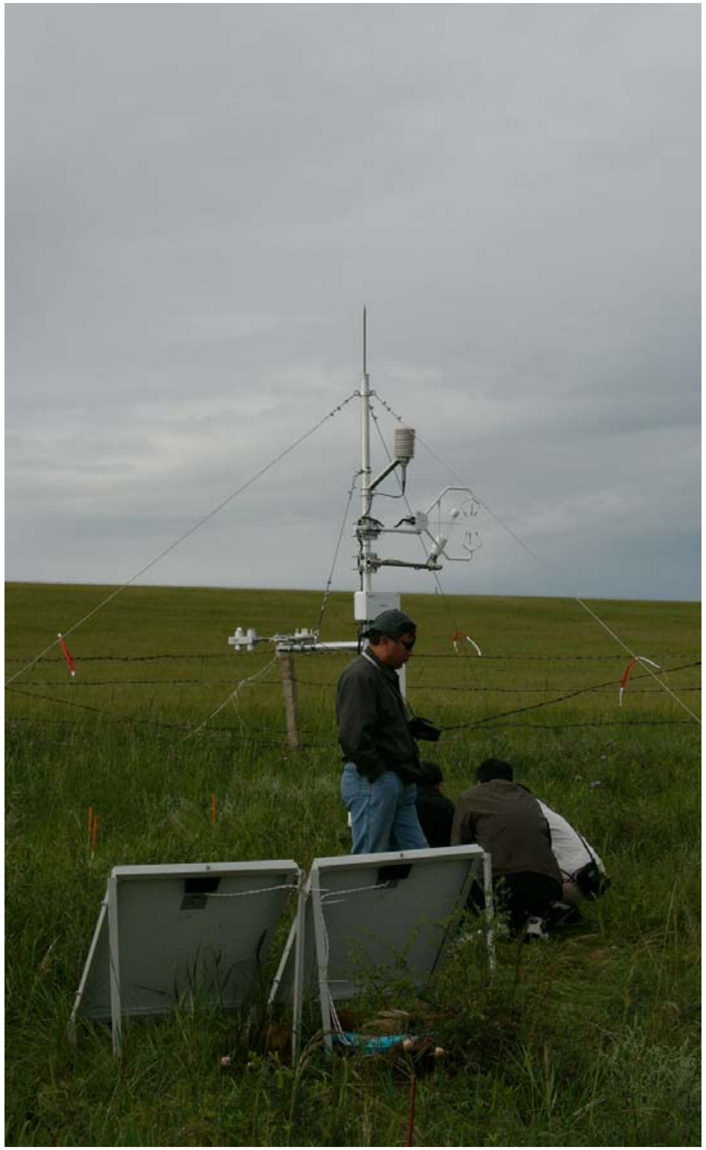


Grazing and biomass production



Giese et al., unpublished

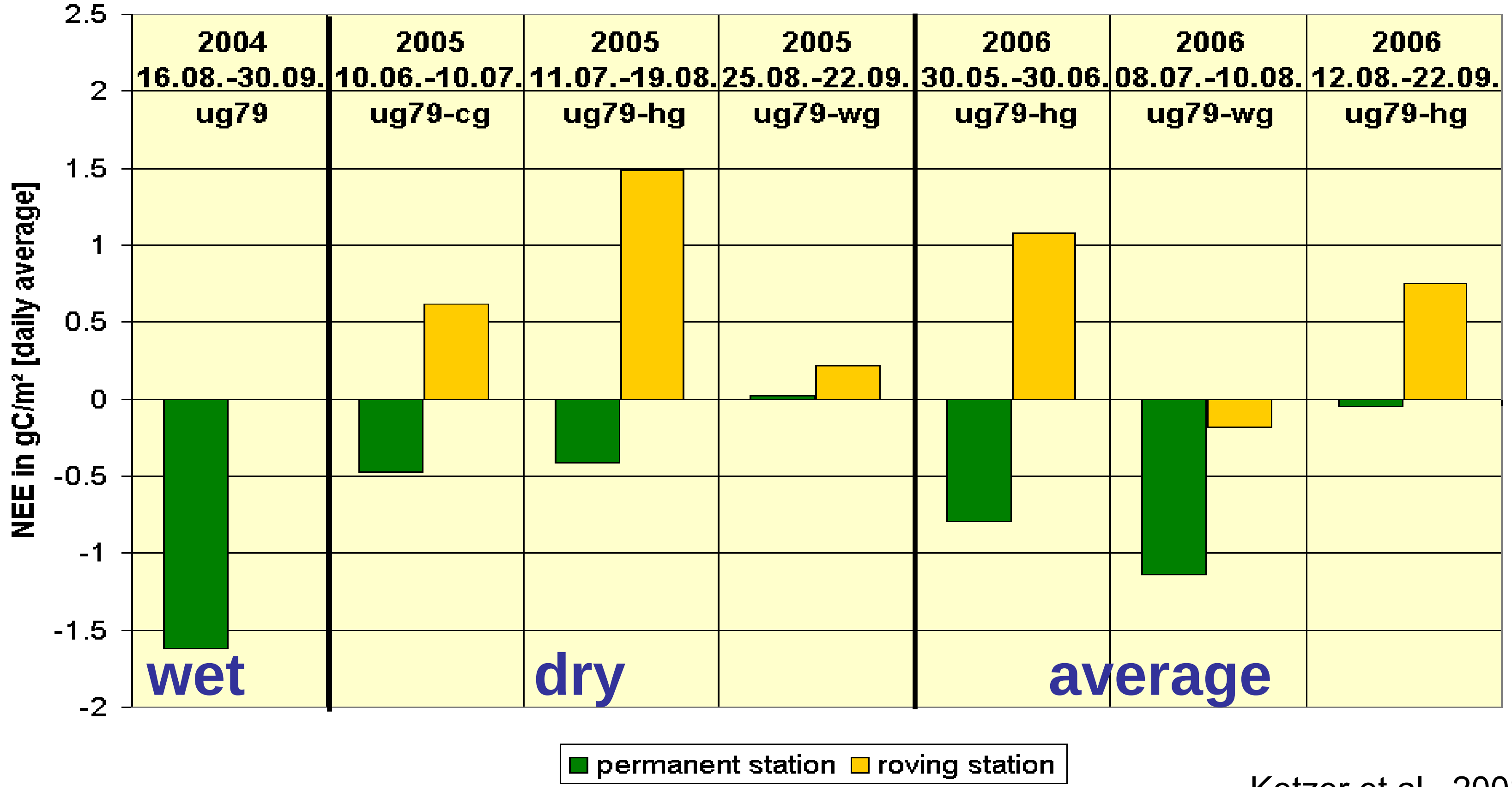
Grazing and trace gas fluxes



Soil CO_2 exchange

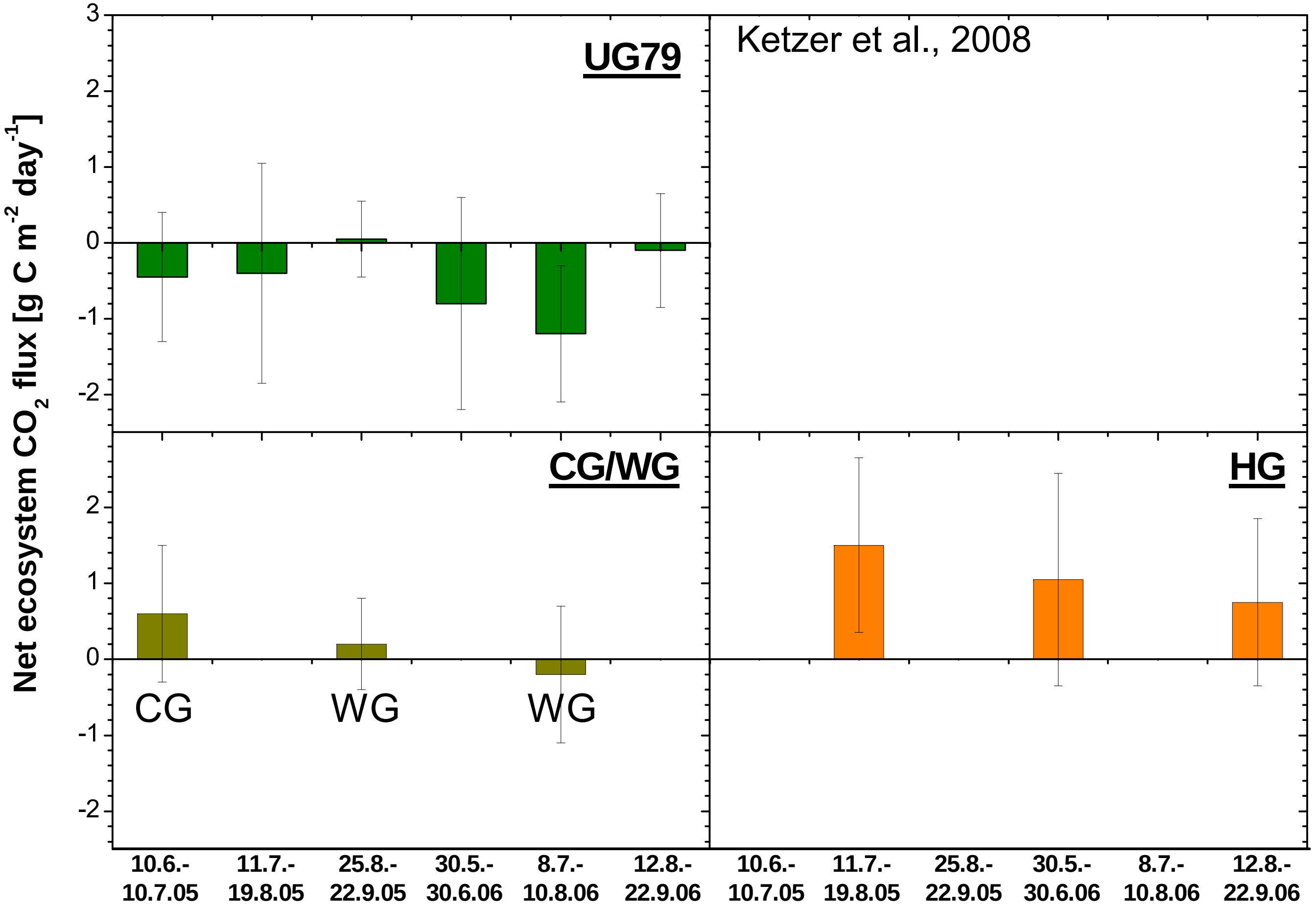
Interannual variability and grazing variability large!

Ungrazed: C-sink (-40 to -80 gC/m²yr)
heavily grazed: C-source (≈ 60 gC/m²yr)



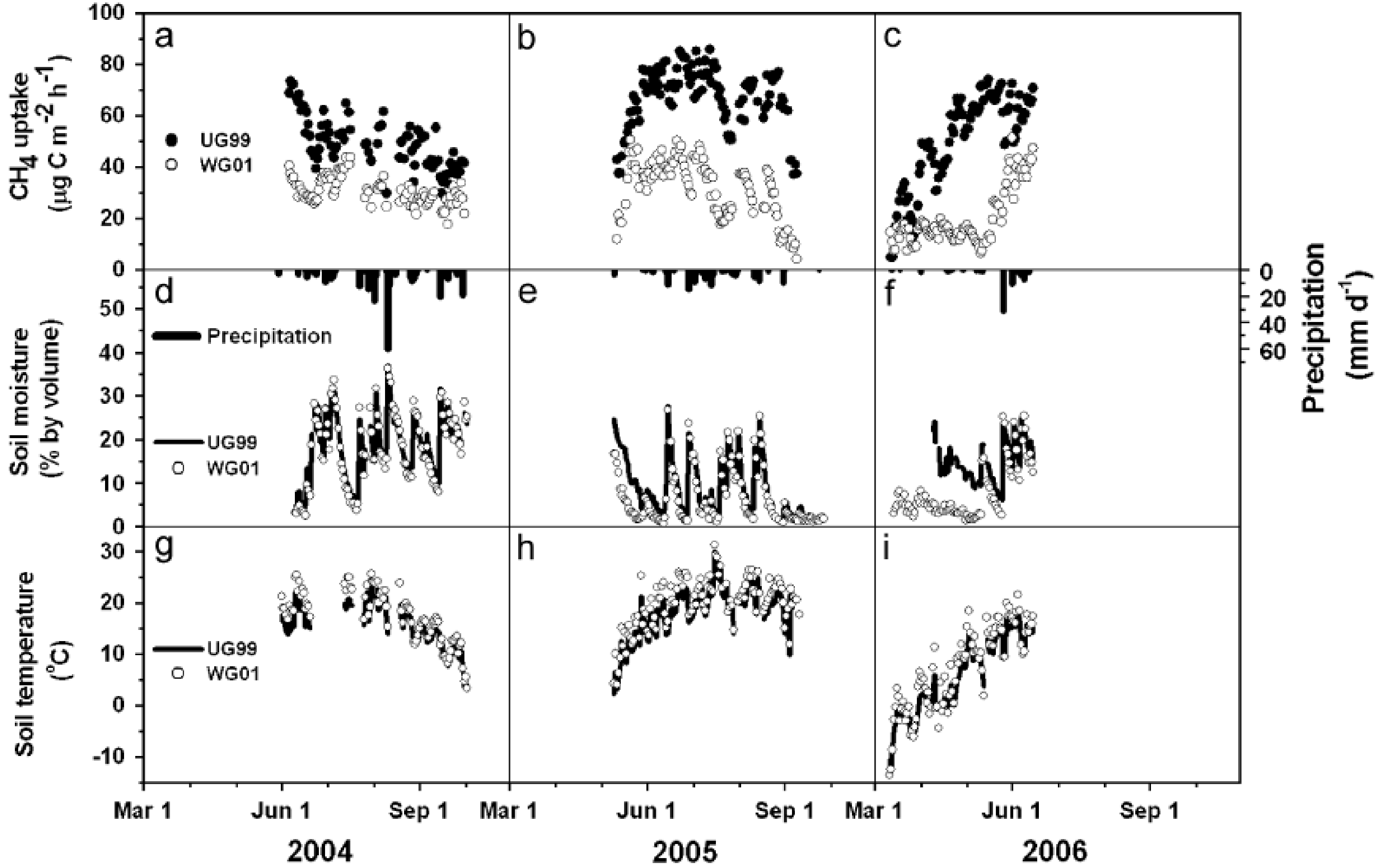
Ketzer et al., 2008

Grazing and NEE



- Grazed plots are mostly net sources of CO_2
- No significant differences in respiratory fluxes (data not shown)

Grazing and CH_4 exchange



Liu et al., 2007, Atmospheric Environment

Grazing and CH_4 exchange

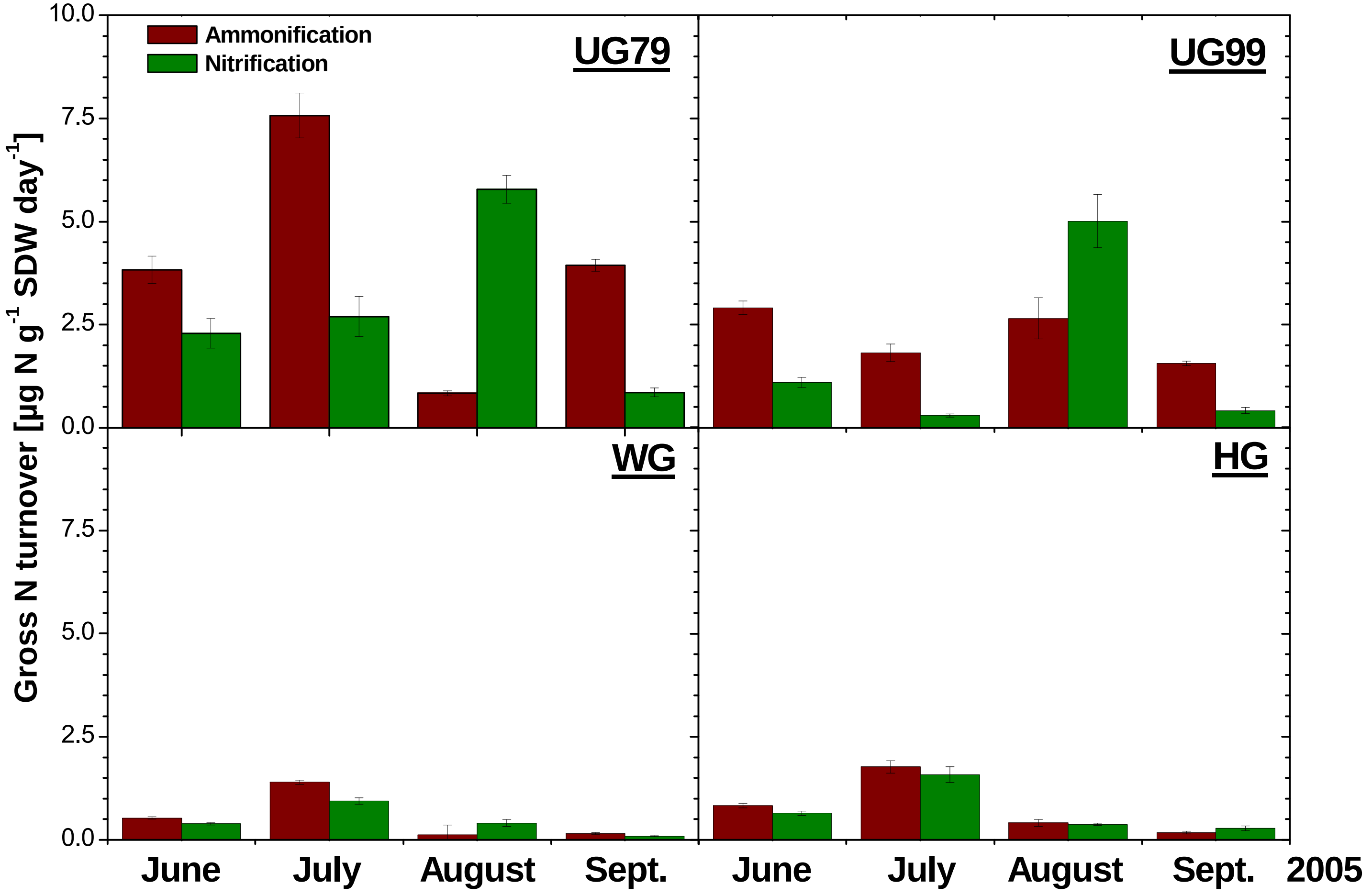
Main characteristics of both the ungrazed since 1999 (UG99) and winter-grazed since 2001 (WG01) sites

	UG99	WG01
Longitude	116°40.2′E	116°40.1′E
Latitude	43°33.1′N	43°33.0′N
Altitude (m)	1268	1267
Vegetation type	*Leymus chinensis*	*Leymus chinensis*
Soil type	Calcic chernozem	Calcic chernozem
Soil parent material	Loess	Loess
Sand (%)[a]	48.3	54.9
Silt (%)[a]	25.8	18.2
Clay (%)[a]	25.9	27.0
Slope (°)	2.2–2.5	2.5–2.7
pH[b]	6.8 (0.27)	6.7 (0.29)
Bulk density ($g\,cm^{-3}$)[b]	1.09 (0.12)	1.09 (0.08)
Organic C to N ratio[b]	9.7 (0.7)	9.5 (0.4)
Organic C content (%)[b]	2.55 (0.63)	2.59 (0.45)
Inorganic N ($mg\,N\,kg^{-1}$)[c,d,e]	2.53 (0.38)	2.53 (0.54)
Inorganic N ($mg\,N\,kg^{-1}$)[c,d,f]	3.28 (0.34)	2.27 (0.14)
Vertical SHC ($cm\,d^{-1}$)[g]	95.8 (54.1)	53.9 (27.6)
Horizontal SHC ($cm\,d^{-1}$)[g]	67.7 (41.5)	37.9 (14.1)
GP at −30 kPa ($cm\,d^{-1}$)[g]	99.6 (66.9)	55.5 (38.6)

Differences in gas permeability are most likely the dominating factor for explaining differences in CH_4 uptake between sites

Liu et al., 2007, Atmospheric Environment

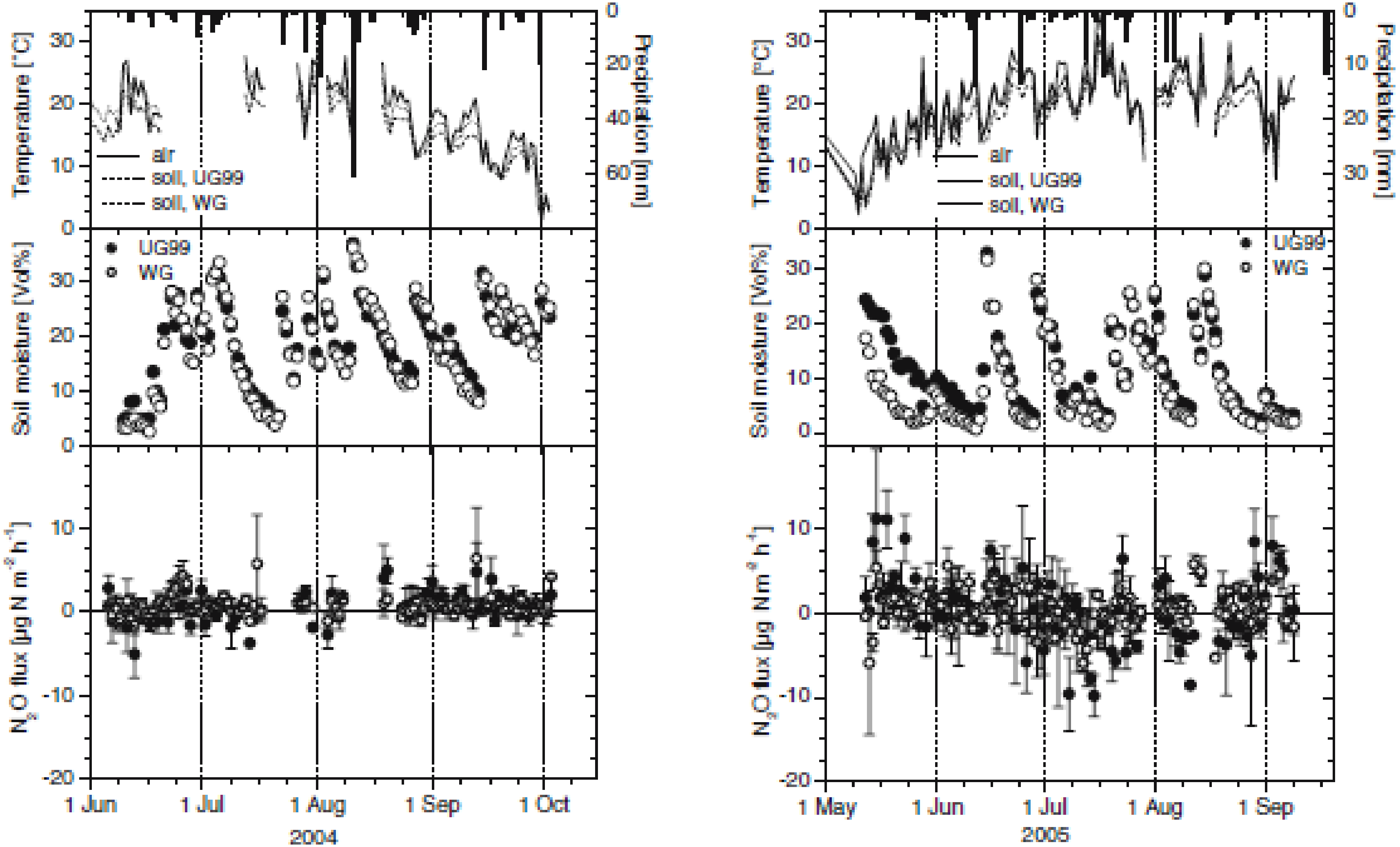
Grazing negatively affects microbial N turnover, but



- Grazing negatively affects microbial N turnover processes

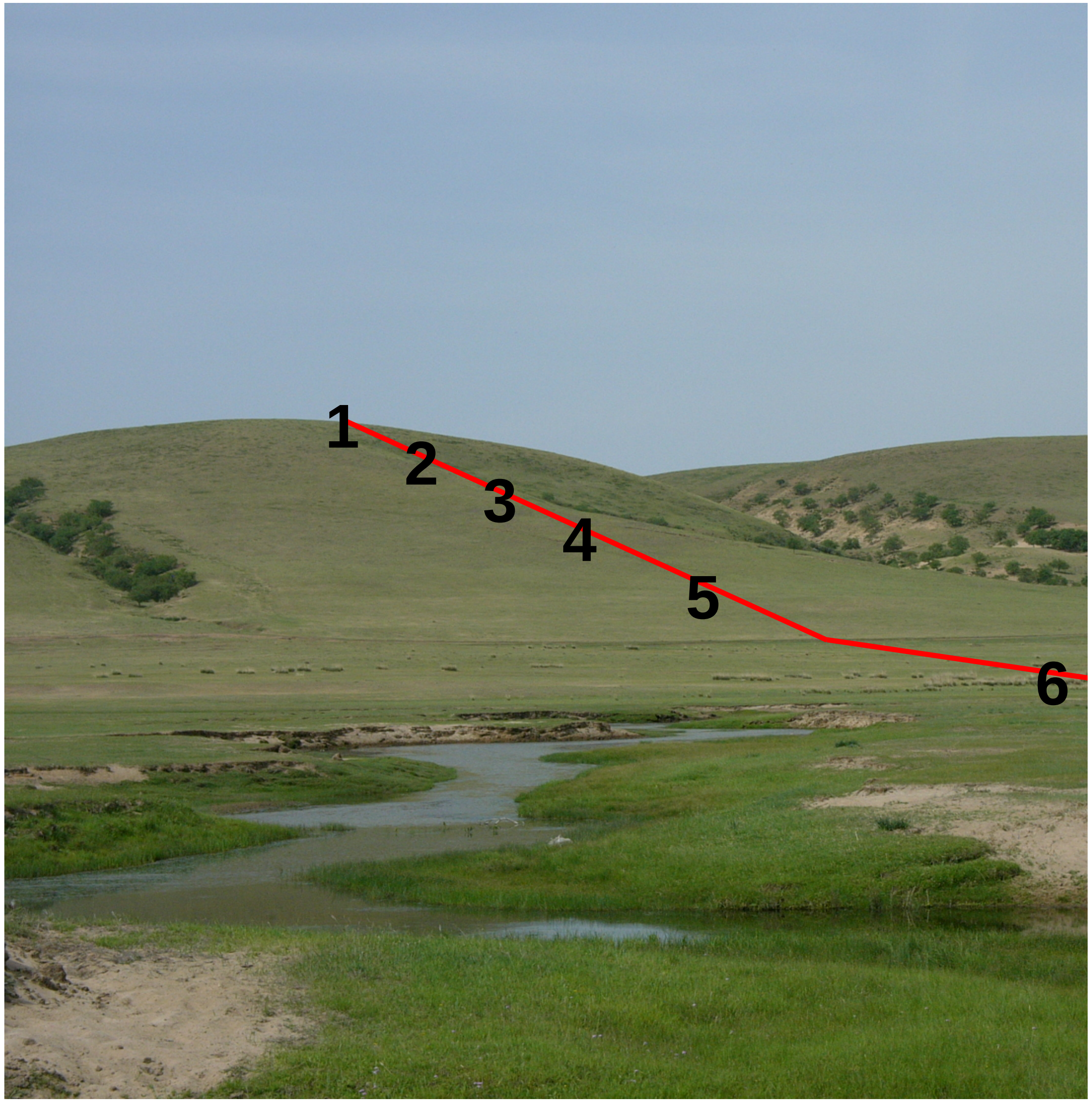
Holst et al., 2007, Ecosystems

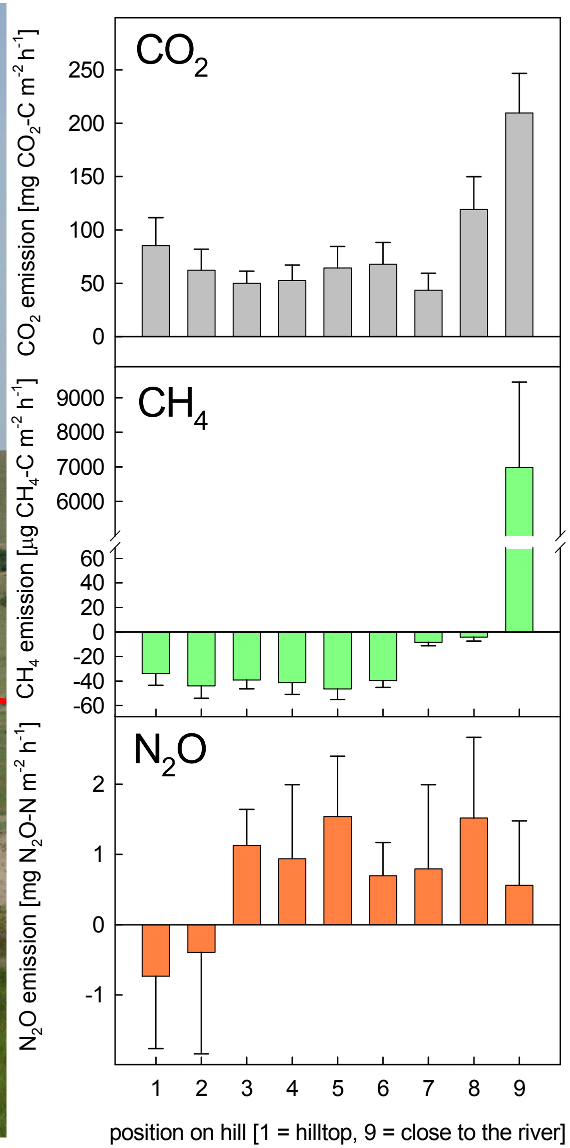
…., but not growing season N_2O fluxes



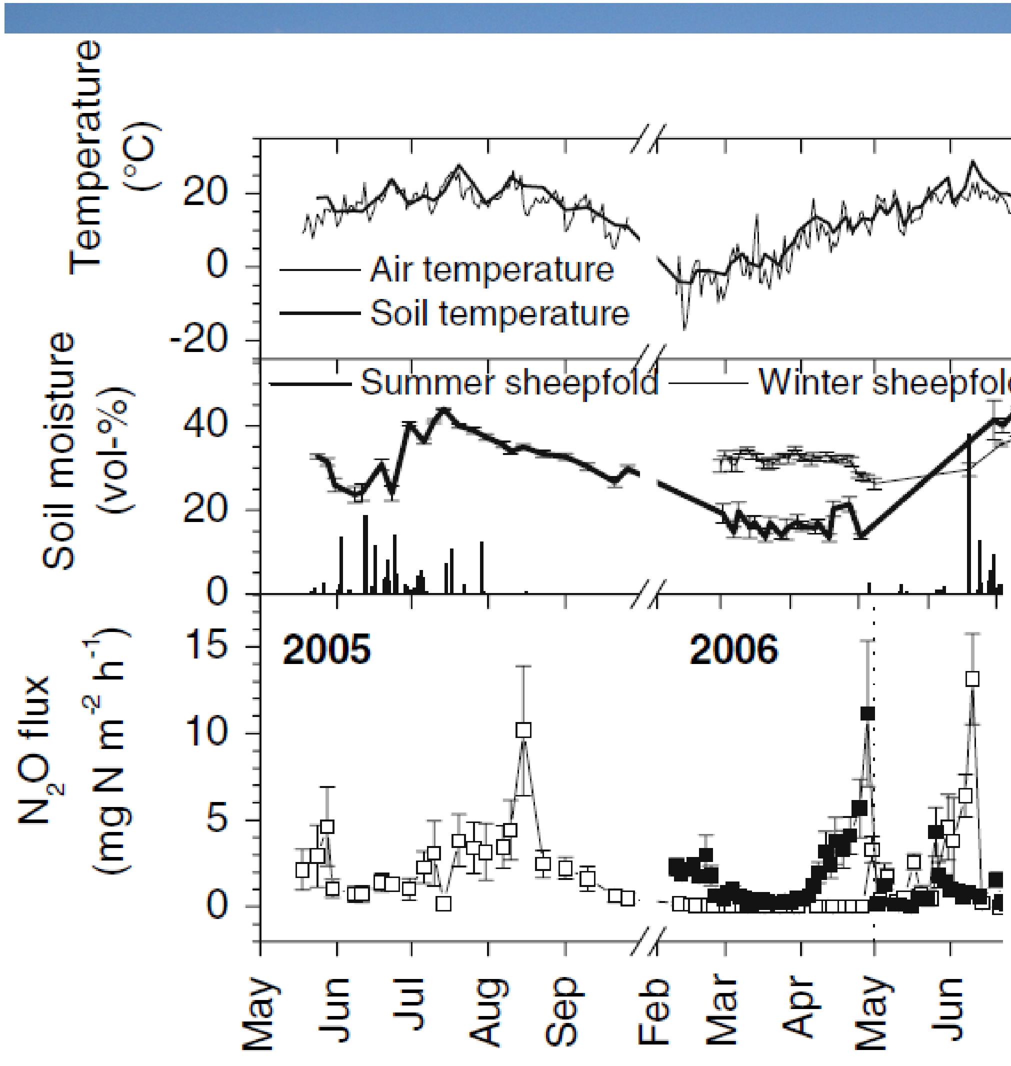
Holst et al., 2007, Ecosystems

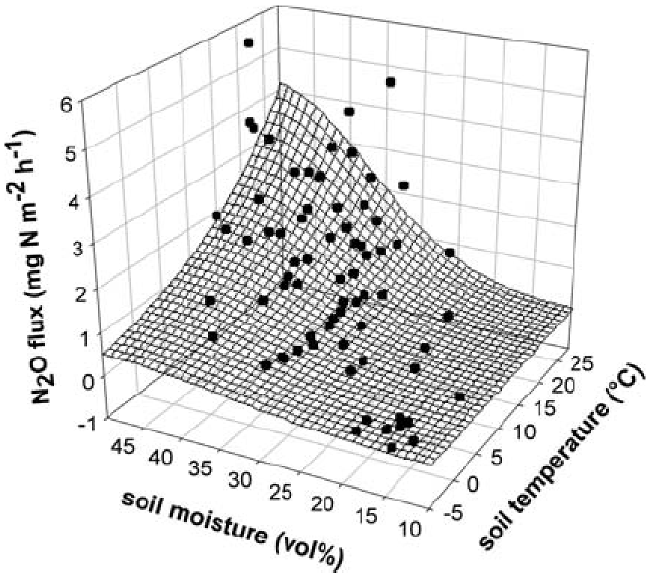
Topography as controller of GHG fluxes





Feedlots as regional hot spots of GHG fluxes

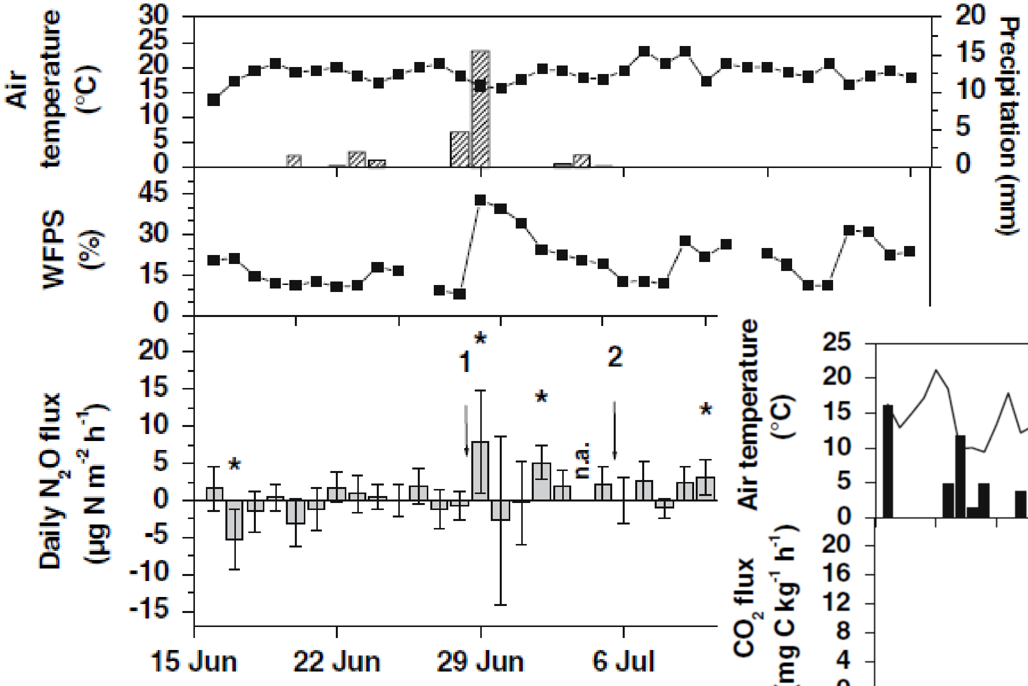




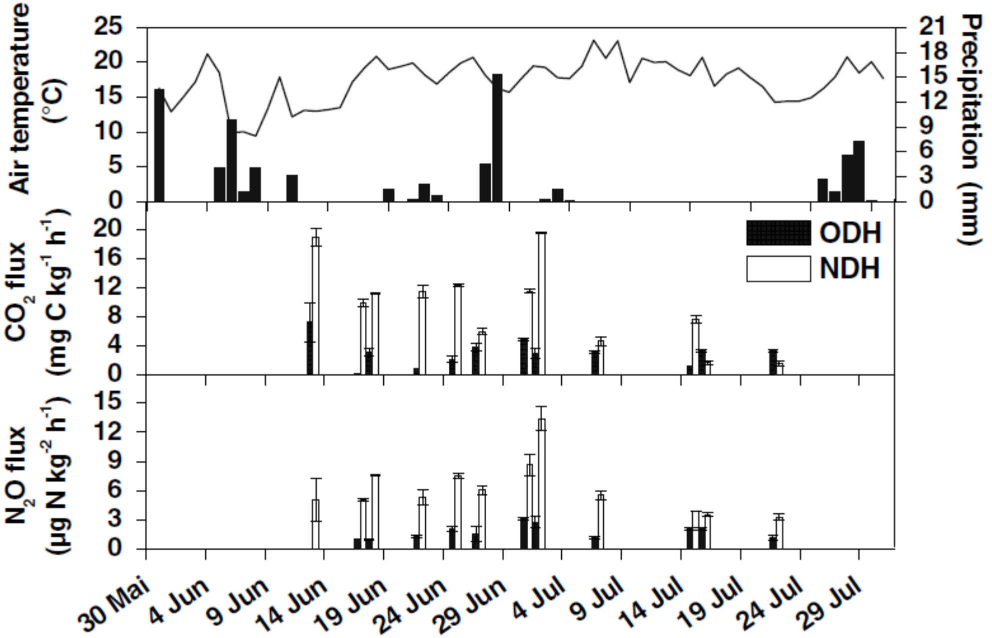
Holst et al., 2007, Plant Soil

Low N_2O fluxes for urine patches and dung heaps

Urine patches

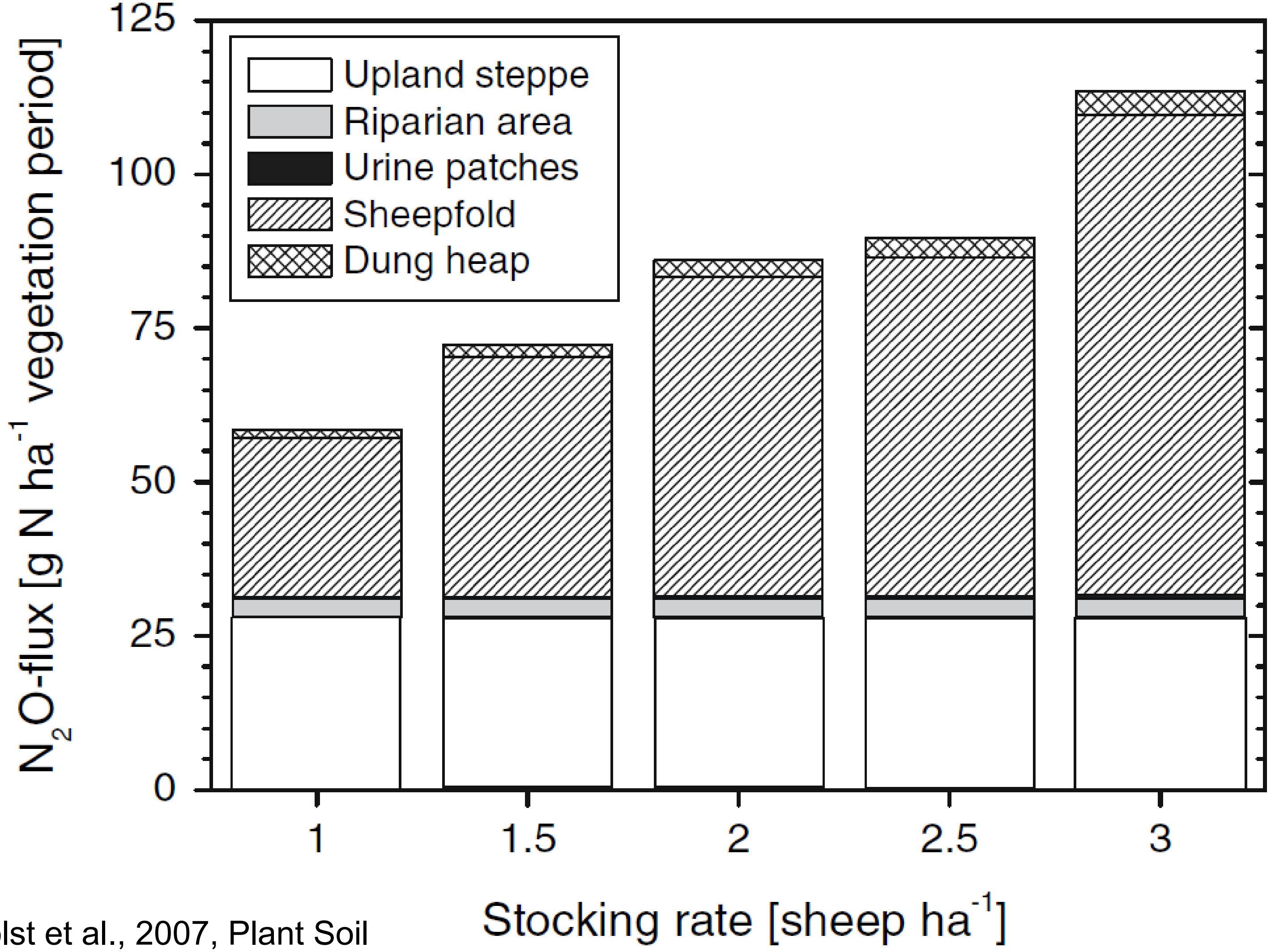


Dung heaps



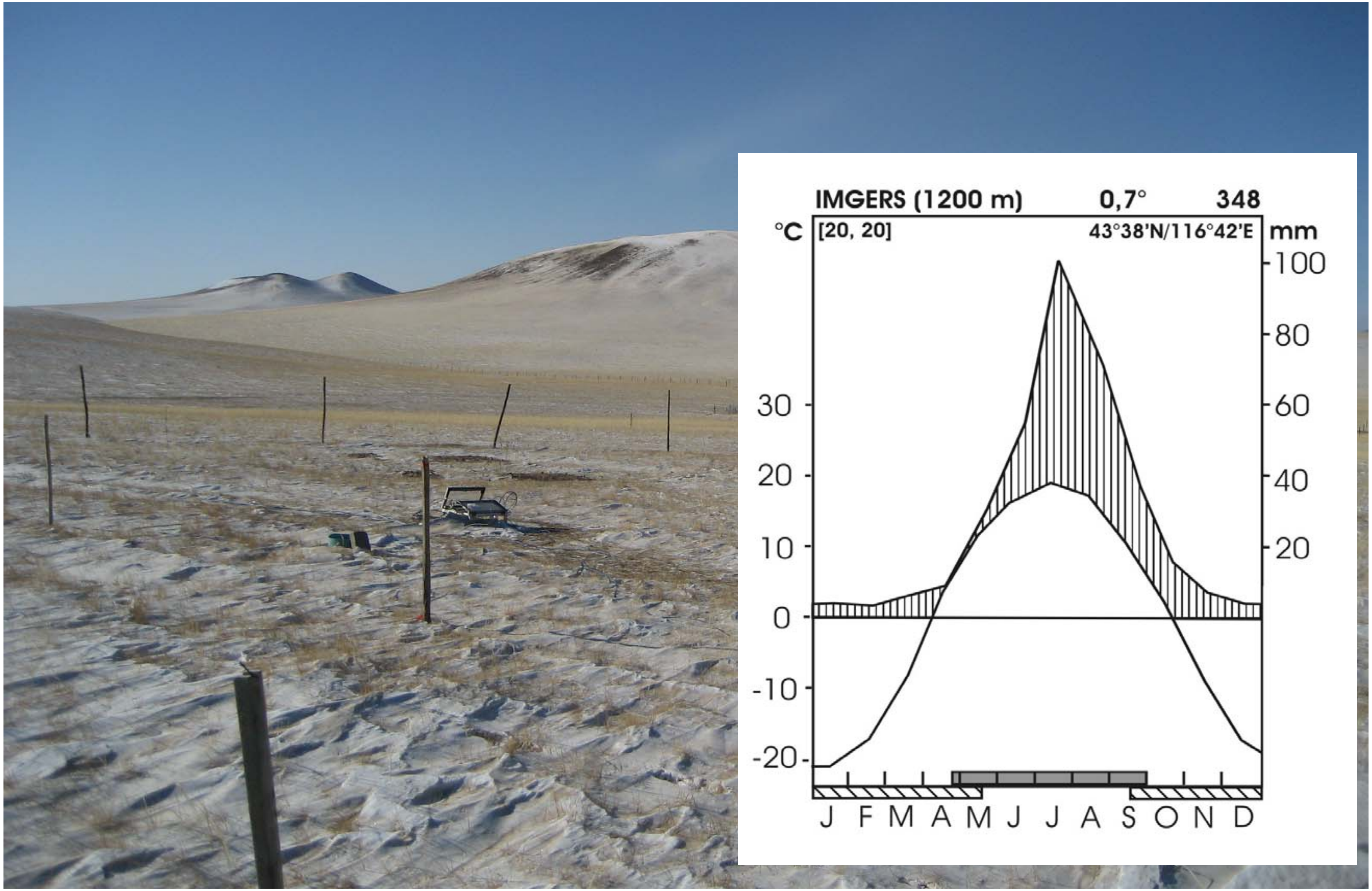
Holst et al., 2007, Plant Soil

Simple regional extrapolation for N_2O



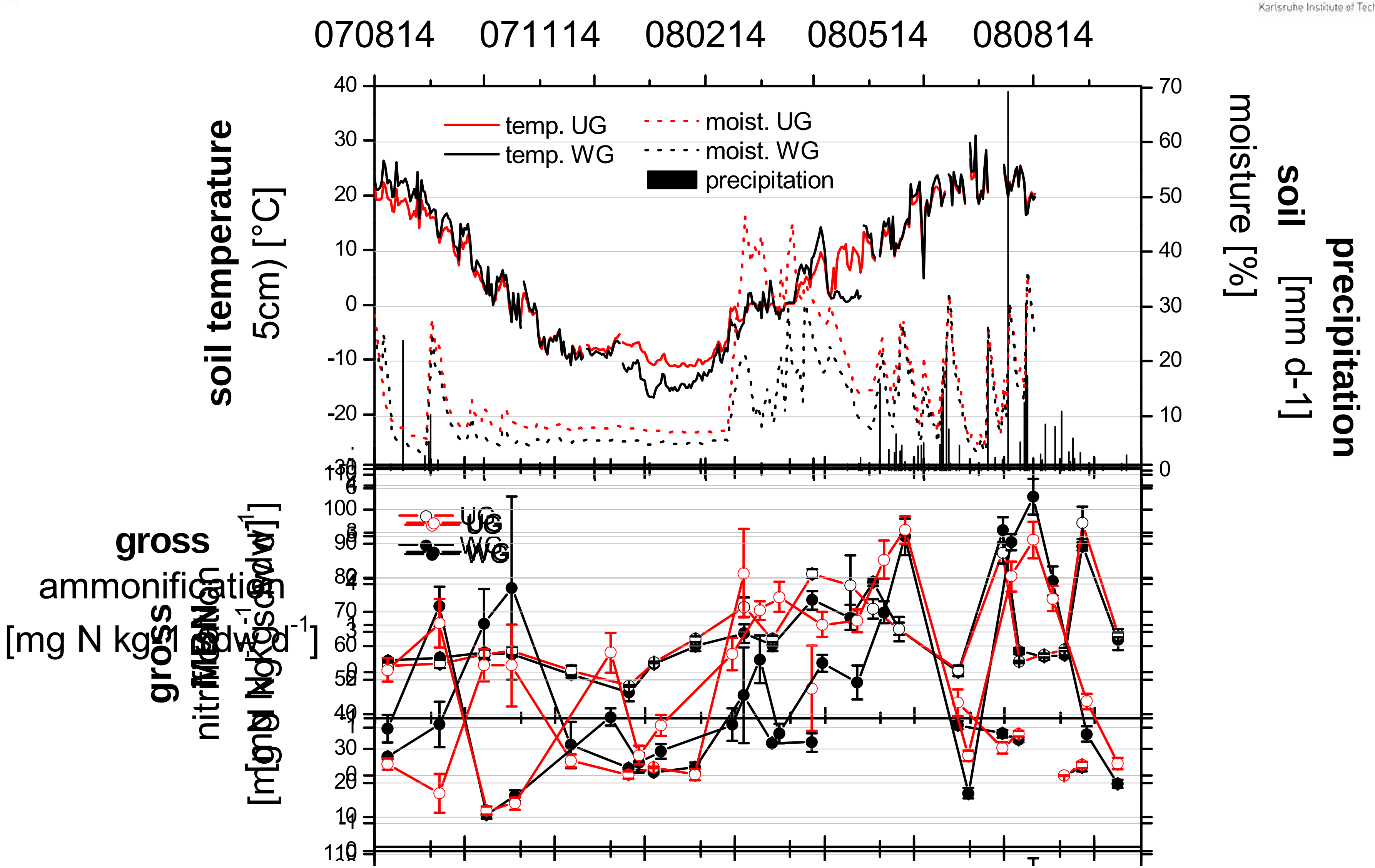
Holst et al., 2007, Plant Soil

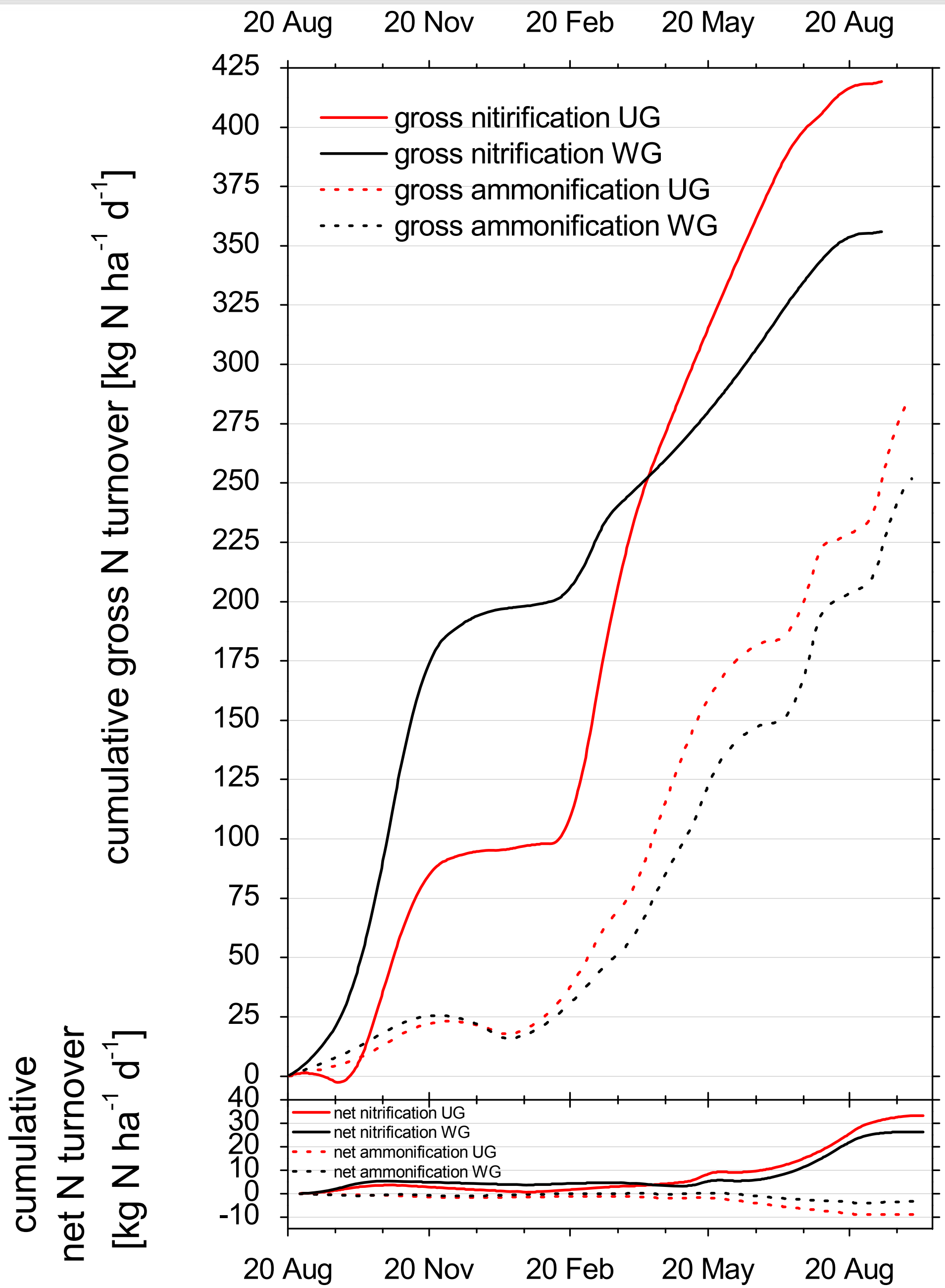
Did we miss something?



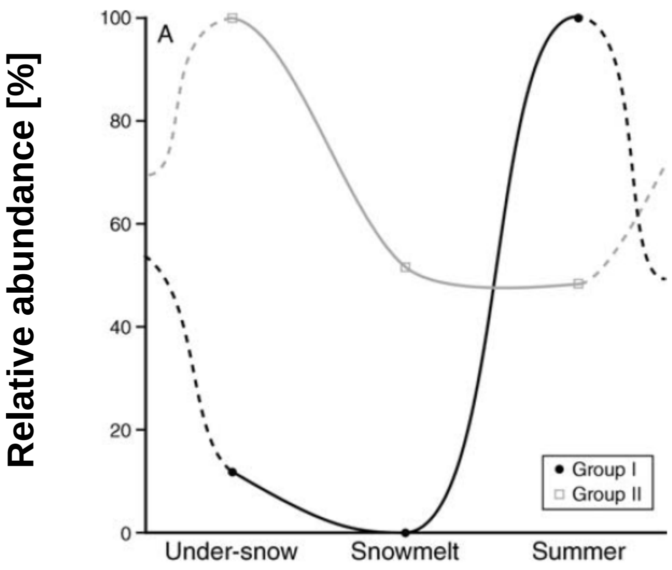
What happens during wintertimes?

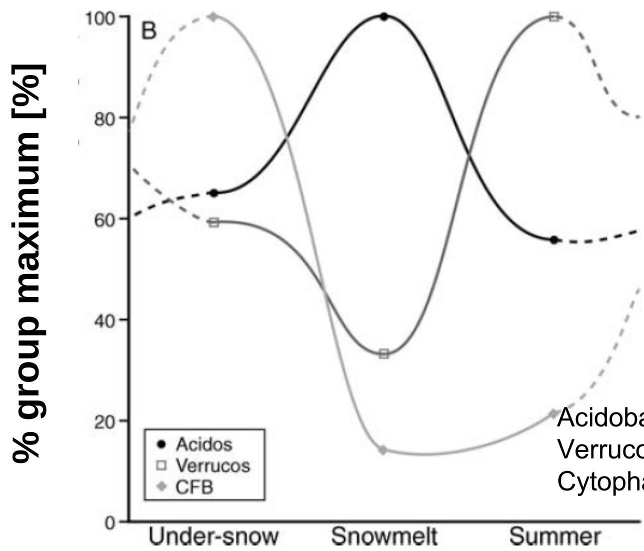
Seasonal dynamics of microbial parameters



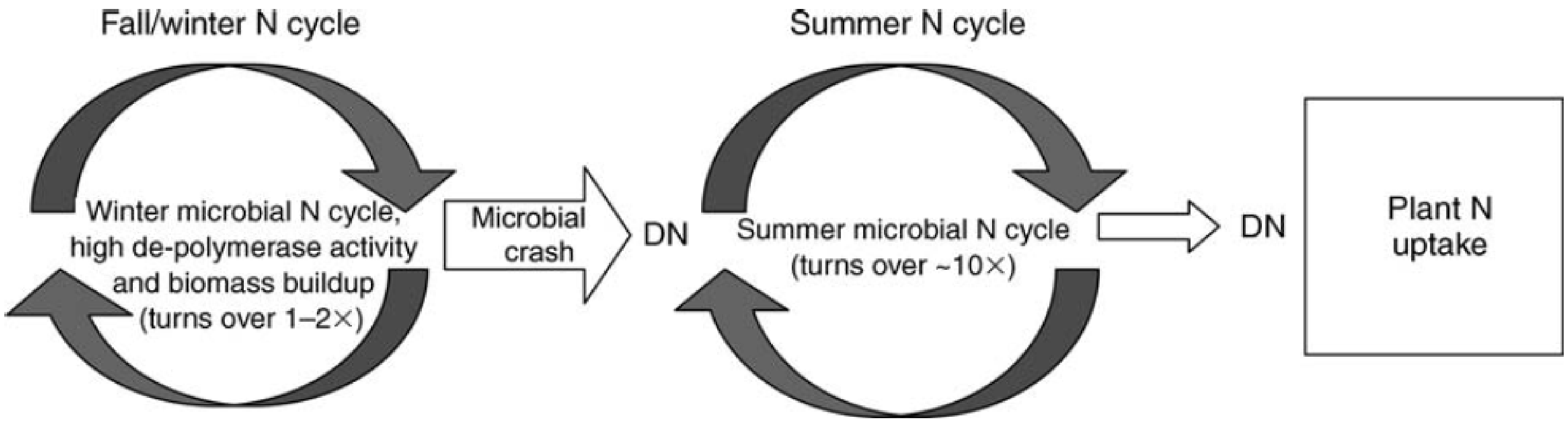

20 Aug
20 Nov
20 Feb
20 May
20 Aug
cumulative gross N turnover [kg N ha-1 d-1]
425
400
375
350
325
300
275
250
225
200
175
150
125
100
75
50
25
0
gross nitirification UG
gross nitrification WG
gross ammonification UG
gross ammonification WG
cumulative net N turnover [kg N ha-1 d-1]
40
30
20
10
0
-10
net nitrification UG
net nitrification WG
net ammonification UG
net ammonification WG
20 Aug
20 Nov
20 Feb
20 May
20 Aug

Seasonal succession of microbial communities
(Alpine meadow, Colorado)



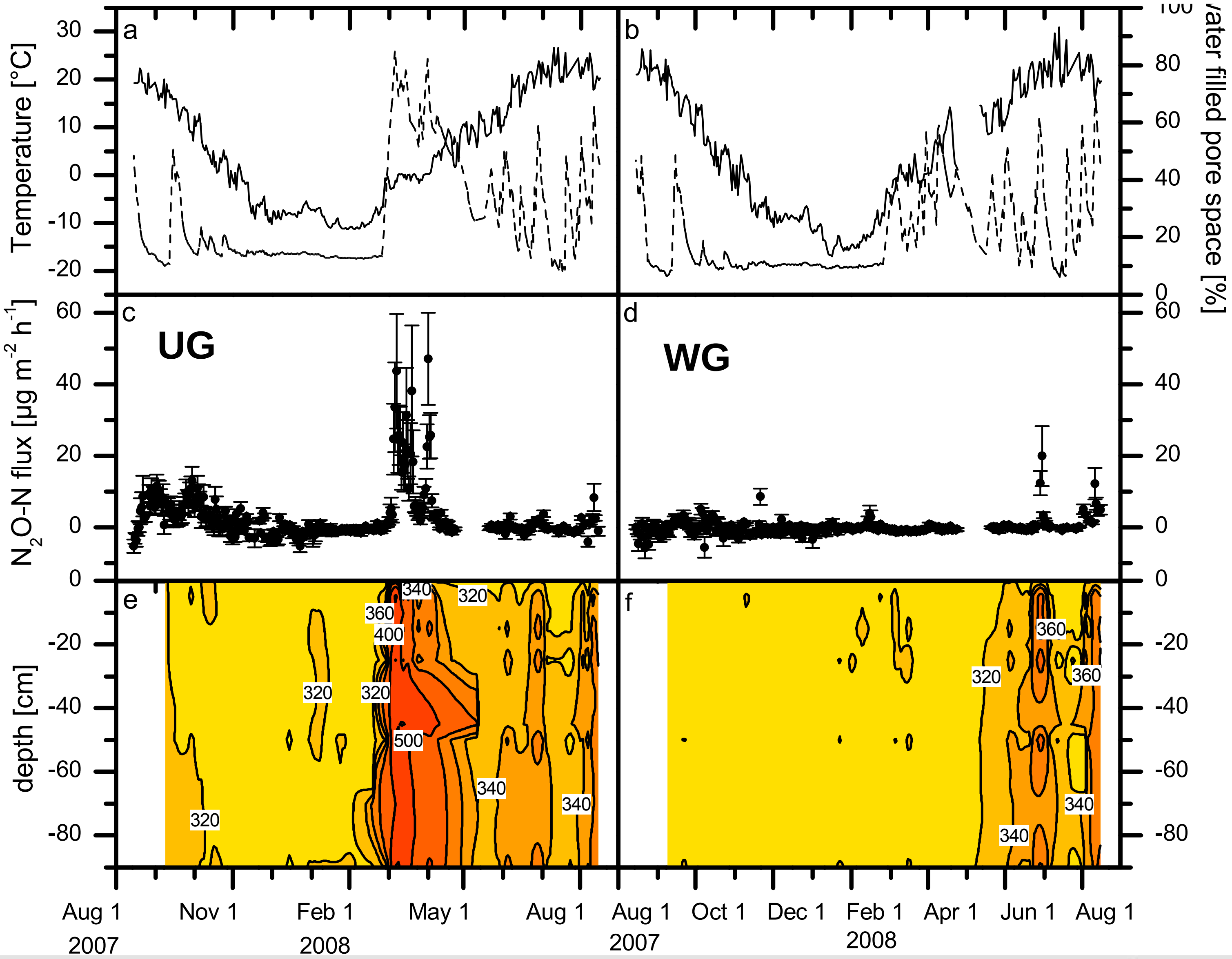


Acidobacteria
Verrucomicrobia
Cytophaga Flexibacter Bacteroides

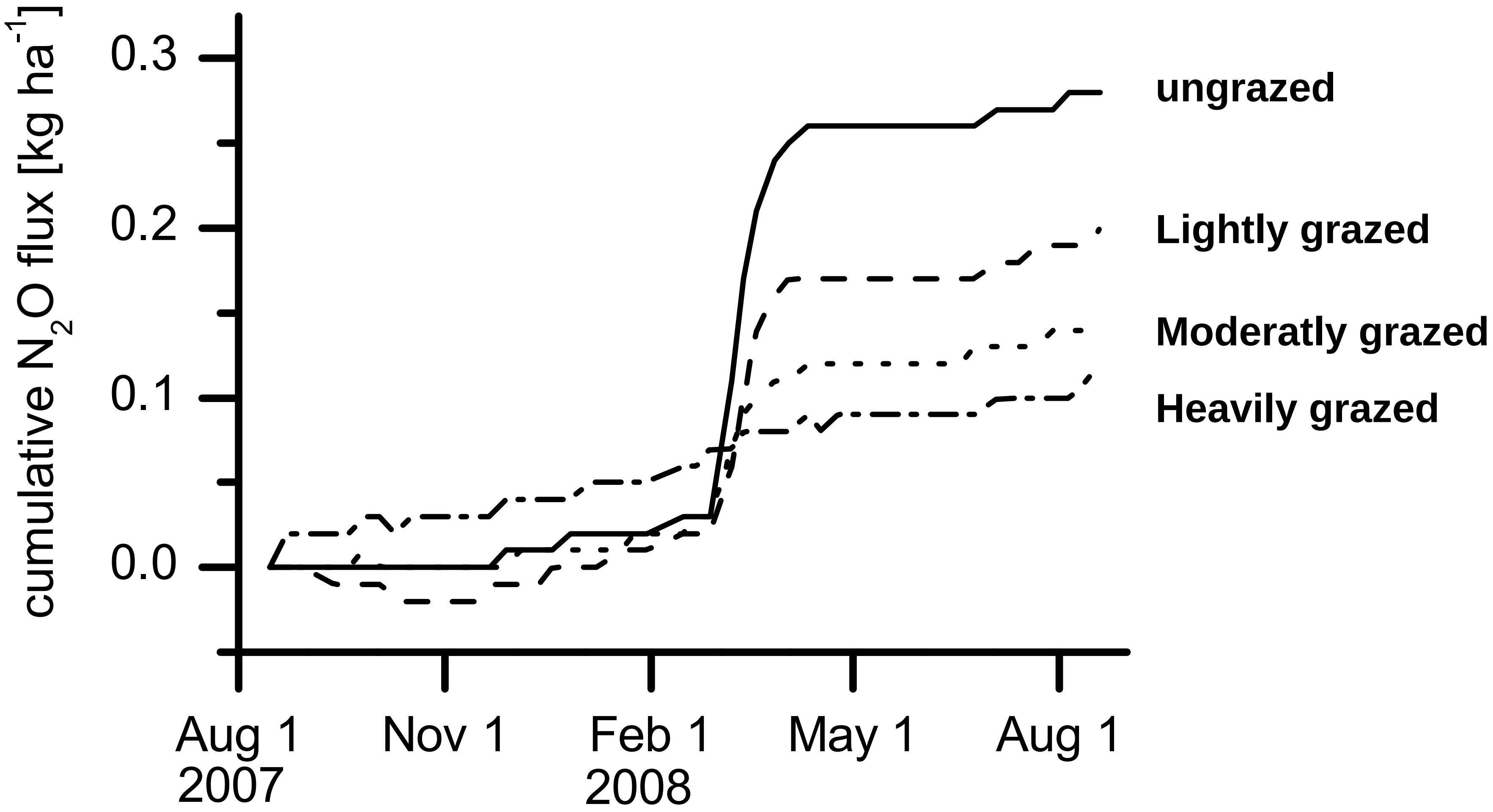


Schmidt et al., 2007, Ecology

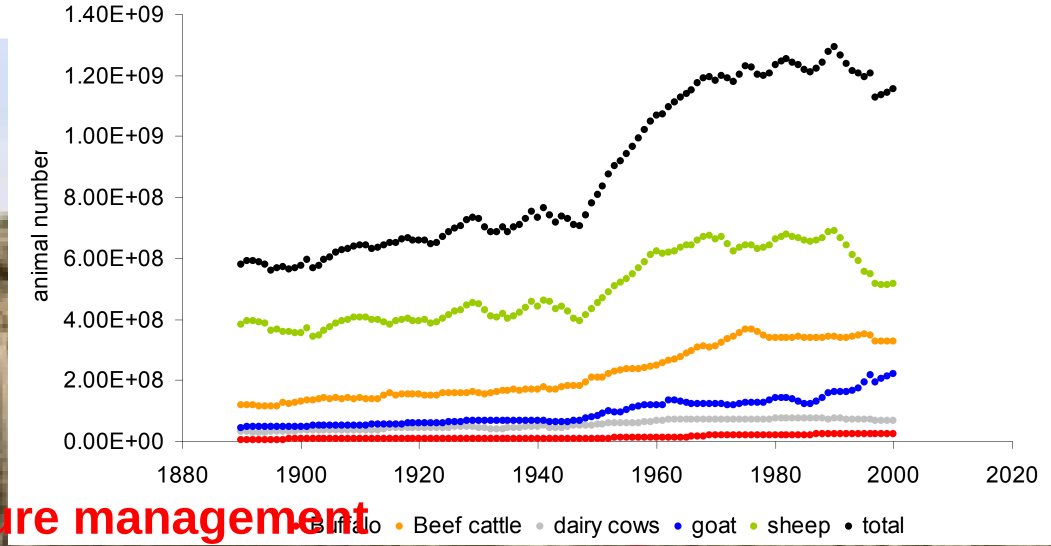
Freeze-thaw and the annual budget of N_2O



Cumulative N_2O fluxes and grazing intensity



IPCC approach for N_2O for livestock systems



Direct N_2O emissions from manure management

$$N_2O_{D(MM)} = \left[\sum_S \left[\sum_T N_{(T)} \cdot Nex_{(T)} \cdot MS_{(T,S)}\right] \cdot EF_{3(S)}\right]$$

Indirect N_2O emissions from manure management

$$N_2O_{G(MM)} = \left[\sum_S \left[\sum_T N_{(T)} \cdot Nex_{(T)} \cdot MS_{(T,S)} \cdot \left(\frac{Frac_{GasMS}}{100}\right)_{(T,S)}\right]\right] \cdot EF_4$$

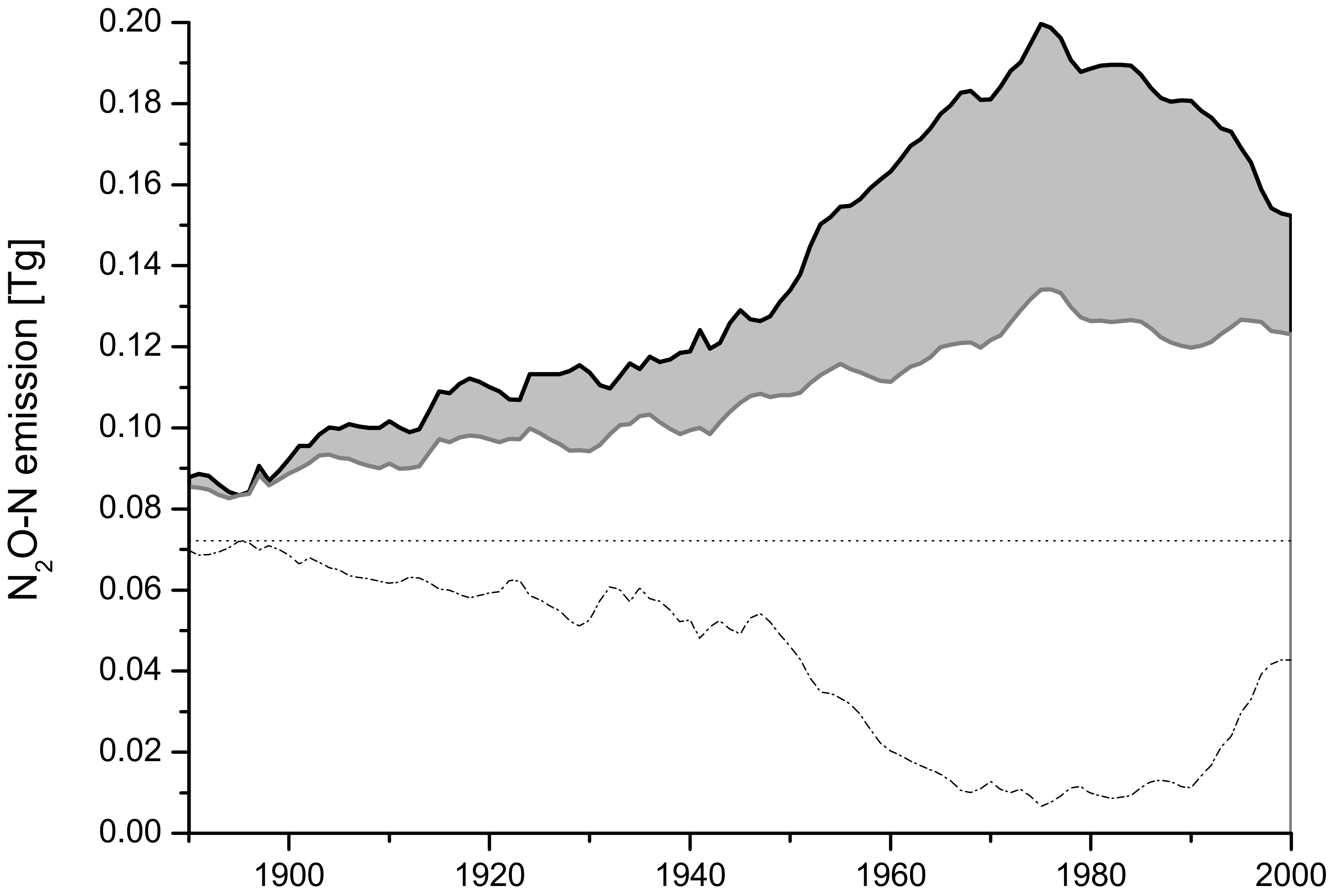
Managed manure N available for application to managed soils, …

$$N_2O_{MMS\_Avb} = \left[\sum_S \left[\sum_T N_{(T)} \cdot Nex_{(T)} \cdot MS_{(T,S)} \cdot \left(1-\frac{Frac_{LossMS}}{100}\right)_{(T,S)} + N_{(T)} \cdot MS_{(T,S)} \cdot N_{beddingMS}\right]\right]$$

Direct N_2O Emissions from Managed soils

$$N_2O_{Direct} - N = N_2O - N_{inputs} + N_2O - N_{OS} + N_2O - N_{PRP}$$

Implications for the global N_2O source estimate



Summary

- Grazing significantly affects plant production and soil properties and, thus,
  - Microbial dynamics
  - Trace gas fluxes (e.g. CH_4, CO_2)
- We do know to little about winter time dynamics
  - Shifts in microbial communities?
  - Importance of winter time N_2O fluxes
- How well constrained is the global N_2O budget when using IPCC approaches?

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Wolf, Benjamin
Yao, Zhisheng
Zheng, Xunhua

&

MAGIM team members