NitroEurope IP

The nitrogen cycle and its influence on the European greenhouse gas balance

Impact of clear-cutting and selective cutting on the soil-atmosphere greenhouse gas exchange of an N-saturated spruce forest in the course of its conversion to a mixed deciduous forest

N. Brüggemann, R. Gasche, H. Papen, Stephan Thiel, Georg Willibald, K. Butterbach-Bahl

Forschungszentrum Karlsruhe (Karlsruhe Institute of Technology)
Institute of Meteorology and Climate Research
Atmospheric Environmental Research (IMK-IFU)
Garmisch-Partenkirchen
Germany

NitroEurope IP

Karlsruhe Institute of Technology

Research question

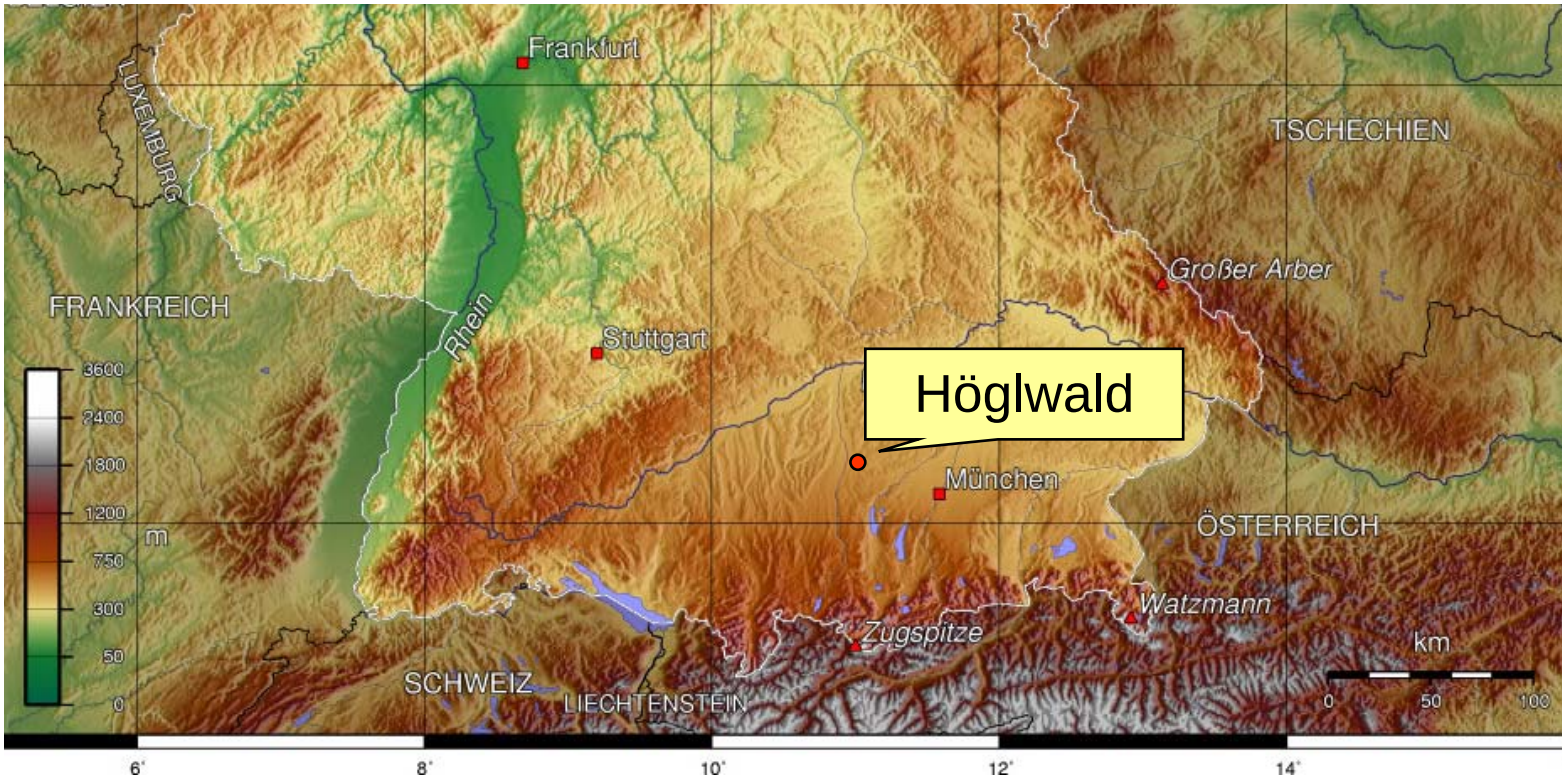
How do different forest conversion practices (clear cut, selective cutting) affect N cycling in an N-loaded spruce forest ecosystem?

KIT – a Cooperation between
Karlsruhe Research Center
and University of Karlsruhe

HELMHOLTZ GEMEINSCHAFT

Forschungszentrum Karlsruhe
in der Helmholtz-Gemeinschaft
IMK-IFU Garmisch-Partenkirchen

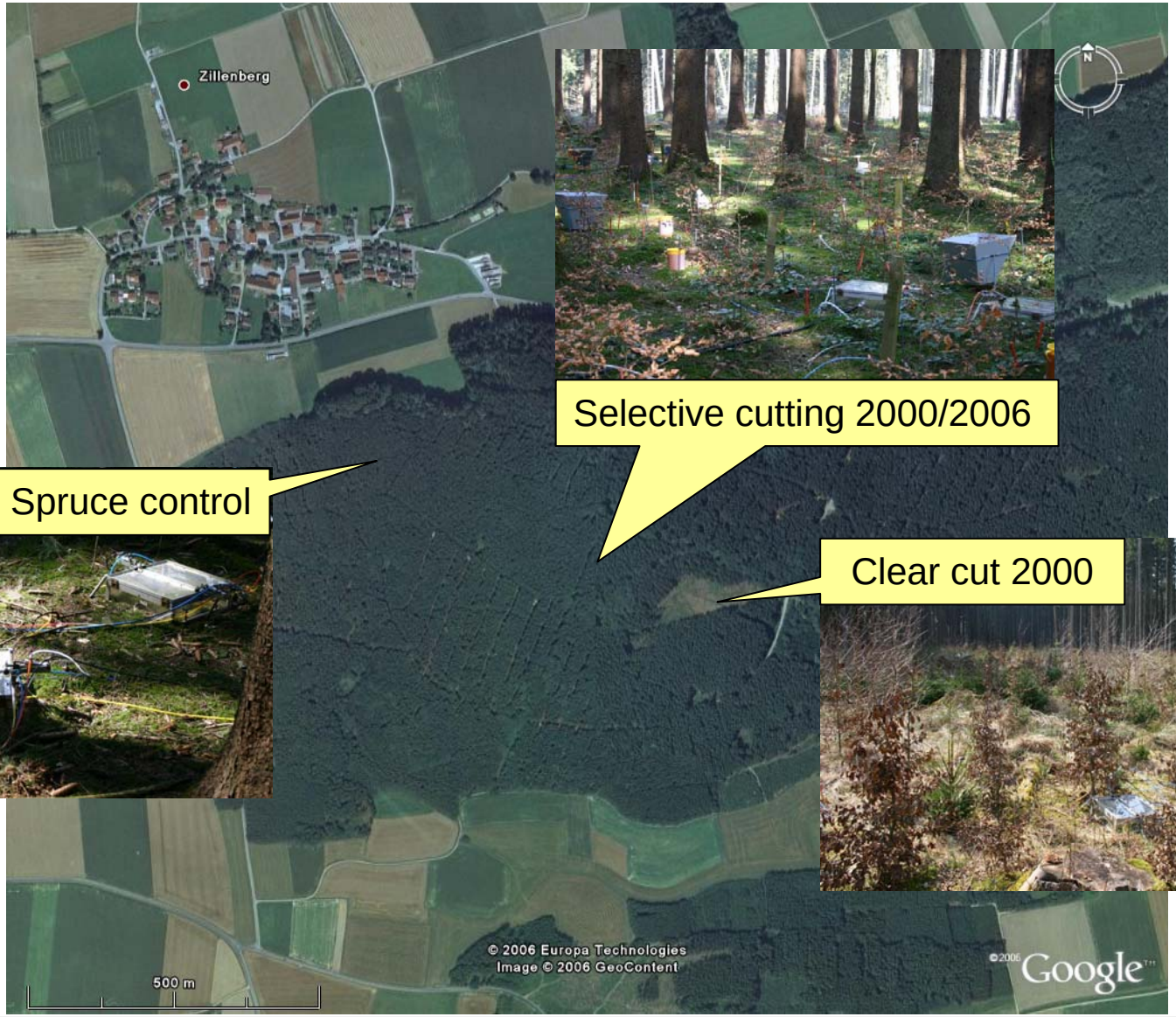
Experimental site: Höglwald



KIT – a Cooperation between
Karlsruhe Research Center
and University of Karlsruhe

Forschungszentrum Karlsruhe
in der Helmholtz-Gemeinschaft
IMK-IFU Garmisch-Partenkirchen

Location of the different experimental sites in the Höglwald



KIT – a Cooperation between Karlsruhe Research Center and University of Karlsruhe

Forschungszentrum Karlsruhe in der Helmholtz-Gemeinschaft
IMK-IFU Garmisch-Partenkirchen

Höglwald characteristics

Forest:	**Approx. 100-yr-old spruce**
Elevation:	**540 m.a.s.l.**
Mean annual temperature:	**7.7 °C**
Mean annual precipitation:	**933 mm**
Humus type:	**Moder (~7 cm)**
Soil type:	**Typic Hapludalf (USGS)**
pH in $CaCl_2$:	**< 3 (organic layer)**
	< 4 (A horizon)
Wet N deposition:	**~30 kg (NH_4^+:NO_3^- = 2:1)**

KIT – a Cooperation between
Karlsruhe Research Center
and University of Karlsruhe

Forschungszentrum Karlsruhe
in der Helmholtz-Gemeinschaft
IMK-IFU Garmisch-Partenkirchen

Experimental areas

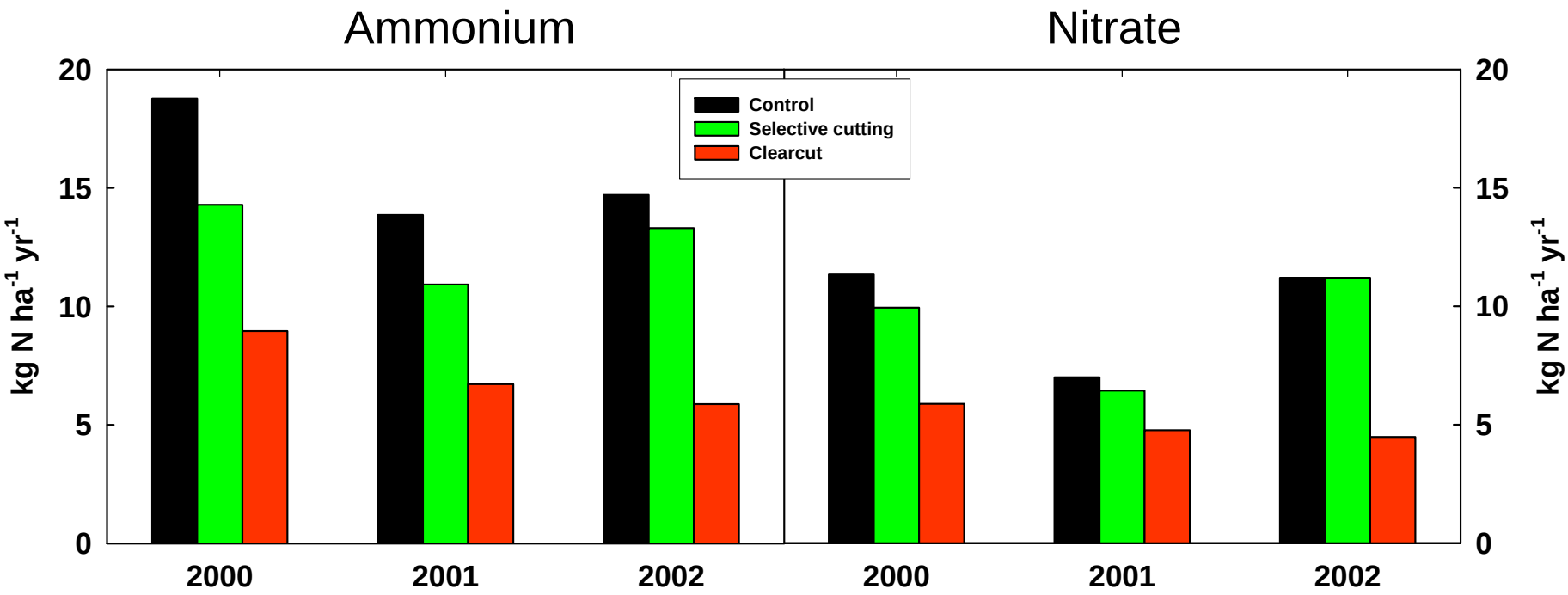
Spruce control	Selective cutting	Clearcut
		
Control site without treatment (last thinning 1975)	**Area of 1 ha with selective cutting in 2000 and 2006 (removal of c. 20 % of the trees each time)**	**Area of 1 ha, clear-cut in 2000 and planted with beech**

Start of the experiment: **July 1999 (pre-treatment phase)**
Cutting: **End of February 2000, 2006**

KIT – a Cooperation between Karlsruhe Research Center and University of Karlsruhe

Forschungszentrum Karlsruhe in der Helmholtz-Gemeinschaft
IMK-IFU Garmisch-Partenkirchen

N input via throughfall



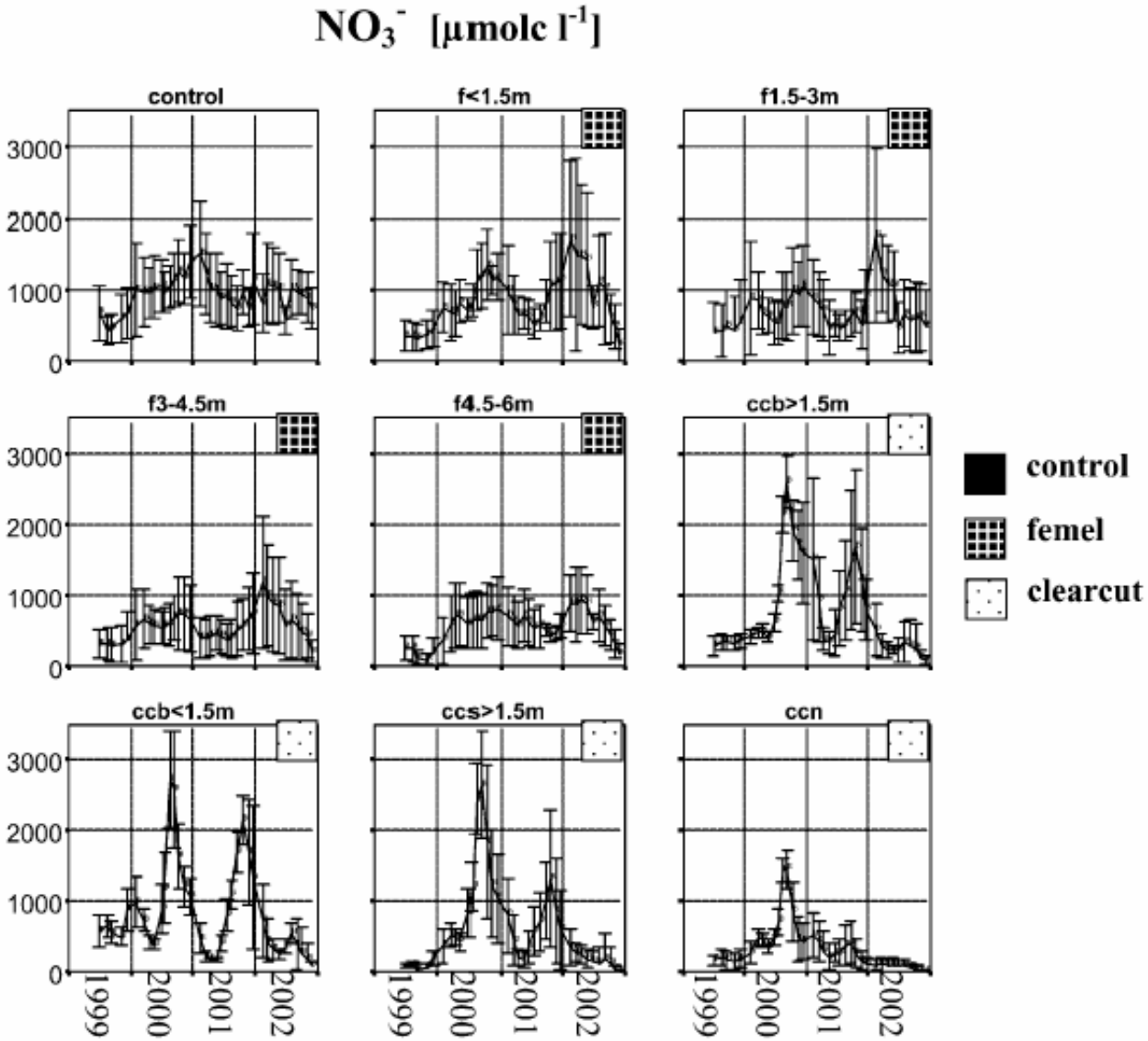
Treatment	2000	2001	2002	Average
Control	30.1	20.9	25.9	25.6
Selected cutting	24.2	17.4	24.5	22.0
Clear-cut	14.8	11.5	10.4	12.2

Huber et al. (2004), *Plant and Soil* **267**, 23-40.

KIT – a Cooperation between
Karlsruhe Research Center
and University of Karlsruhe

Forschungszentrum Karlsruhe
in der Helmholtz-Gemeinschaft
IMK-IFU Garmisch-Partenkirchen

Nitrate in seepage water



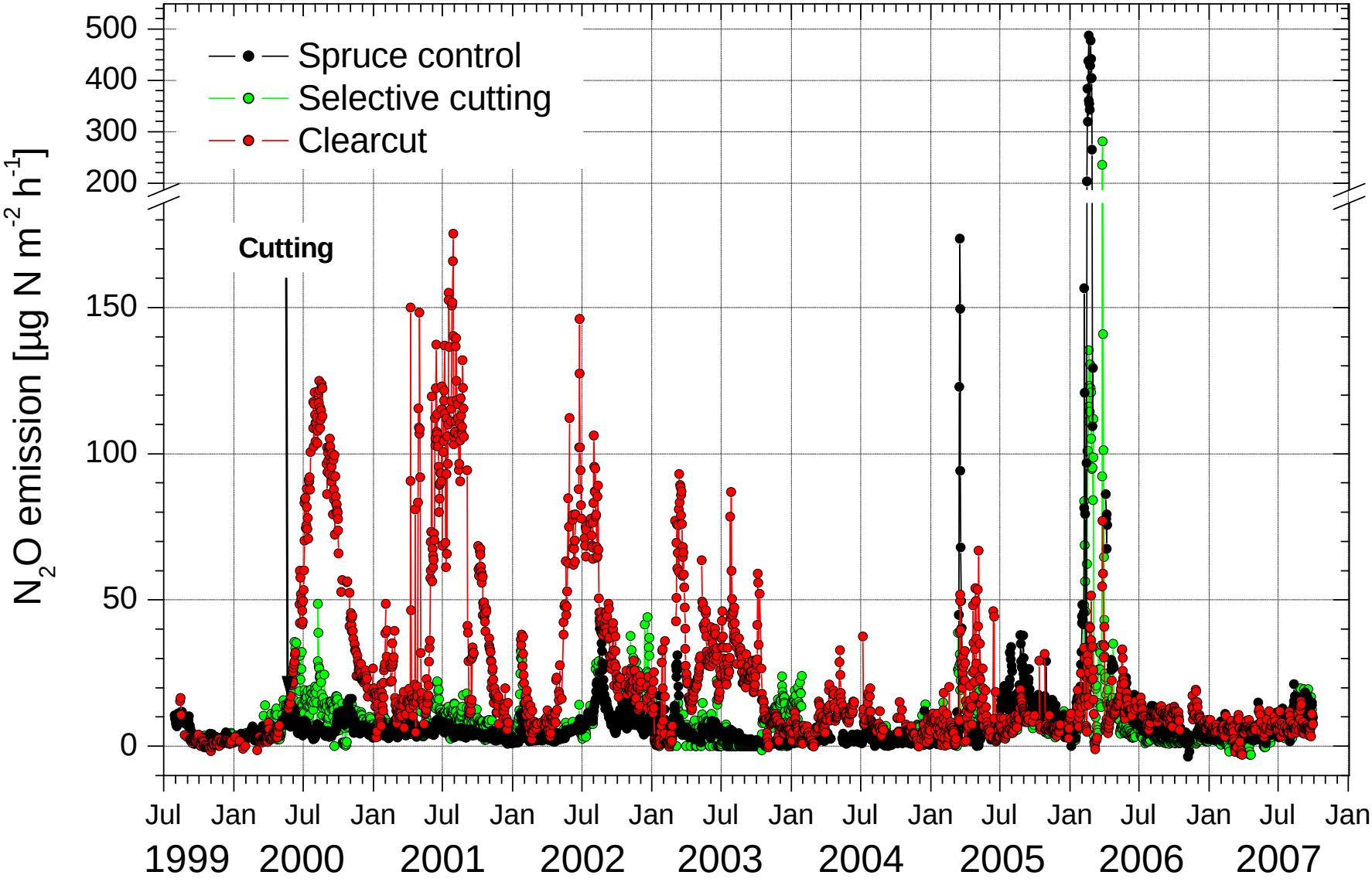
Nitrate concentrations in seepage water (40 cm depth)

- **enhanced** under the clear-cut area in the first and second year after the treatment

- **lower** in the third year as compared to the control and selective cutting area.

Huber et al. (2004),
Plant and Soil **267**, 23-40.

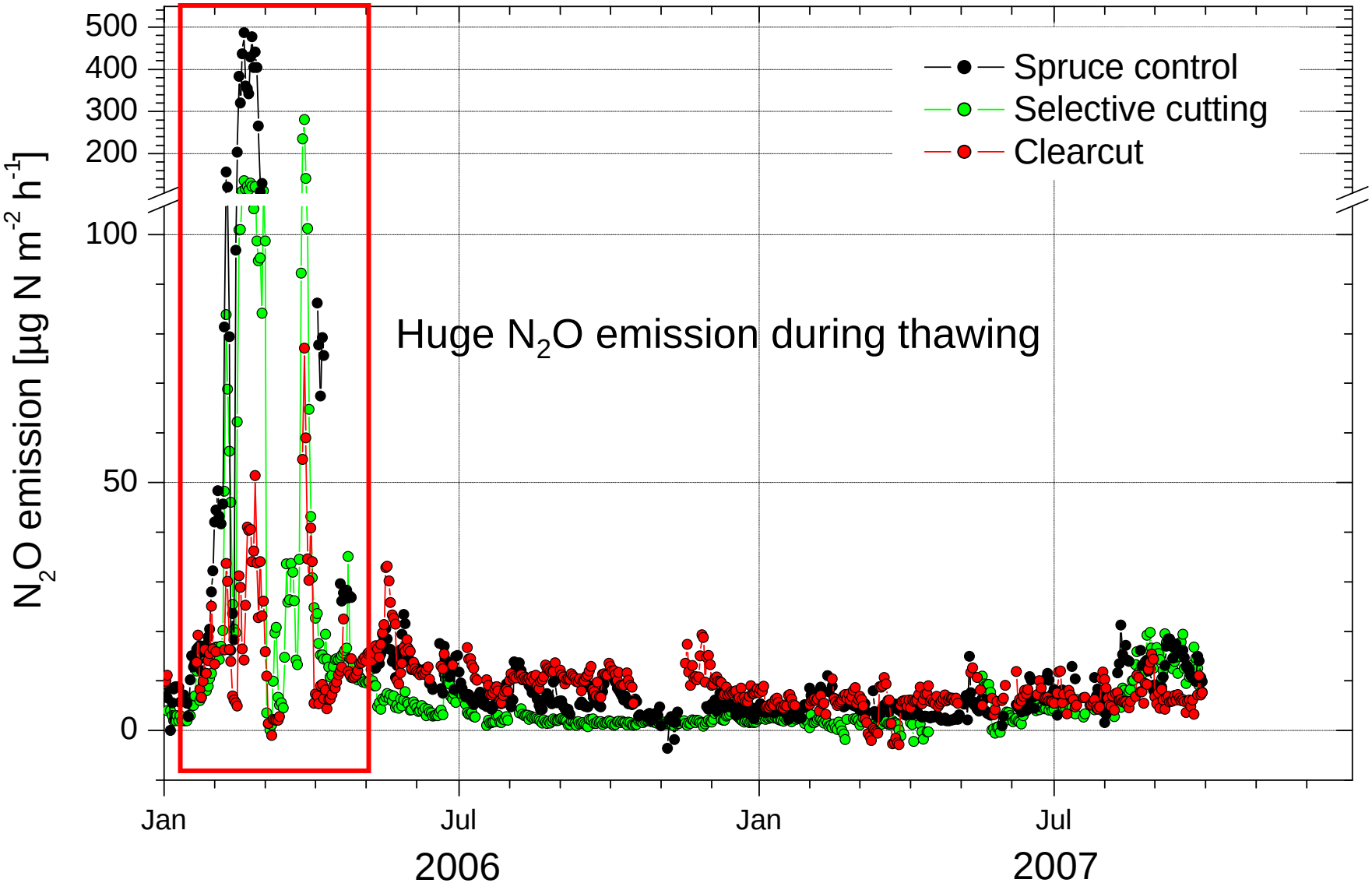
Soil N_2O fluxes since July 1999



KIT – a Cooperation between
Karlsruhe Research Center
and University of Karlsruhe

Forschungszentrum Karlsruhe
in der Helmholtz-Gemeinschaft
IMK-IFU Garmisch-Partenkirchen

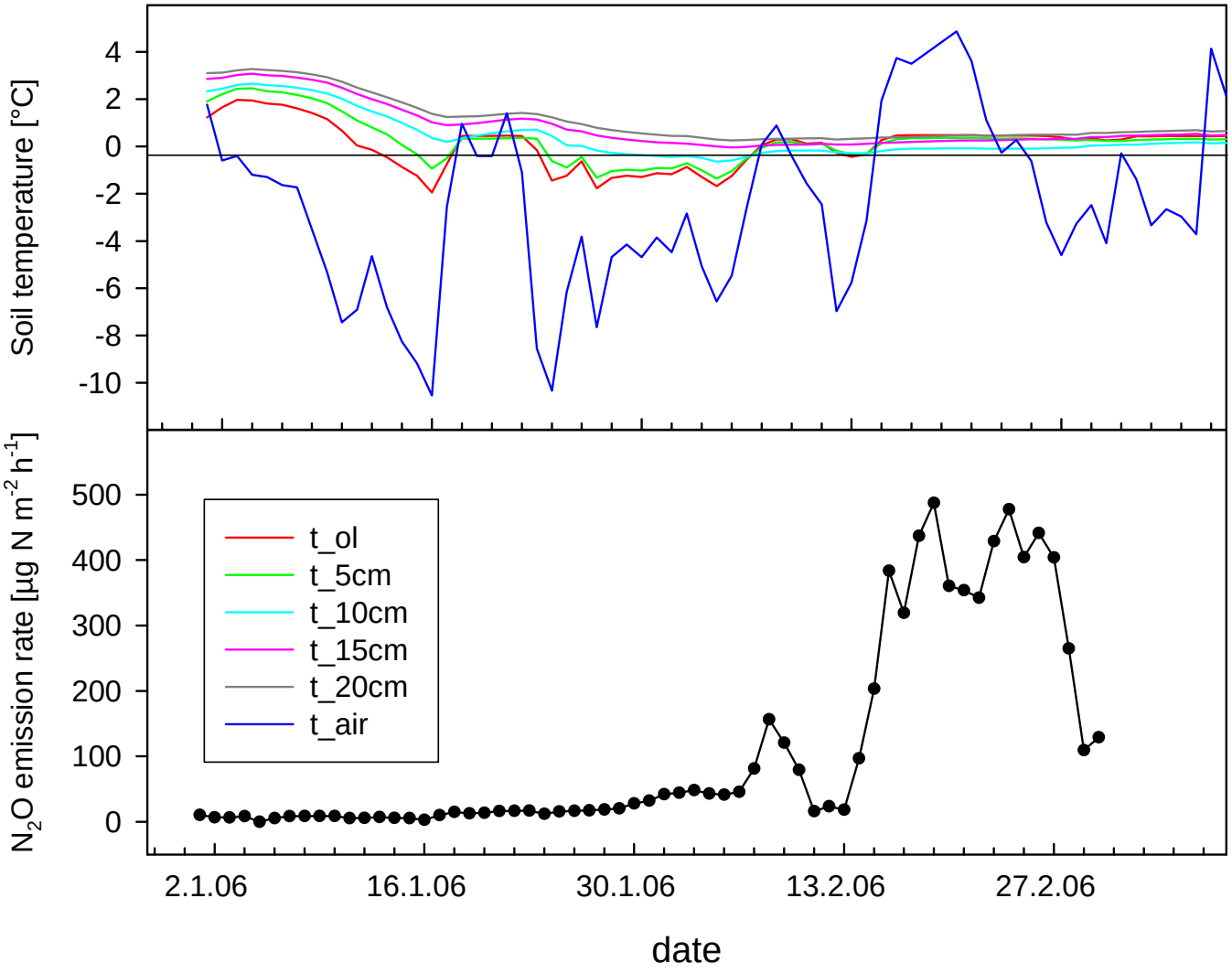
Soil N_2O fluxes 2006 & 2007



KIT – a Cooperation between
Karlsruhe Research Center
and University of Karlsruhe

Forschungszentrum Karlsruhe
in der Helmholtz-Gemeinschaft
IMK-IFU Garmisch-Partenkirchen

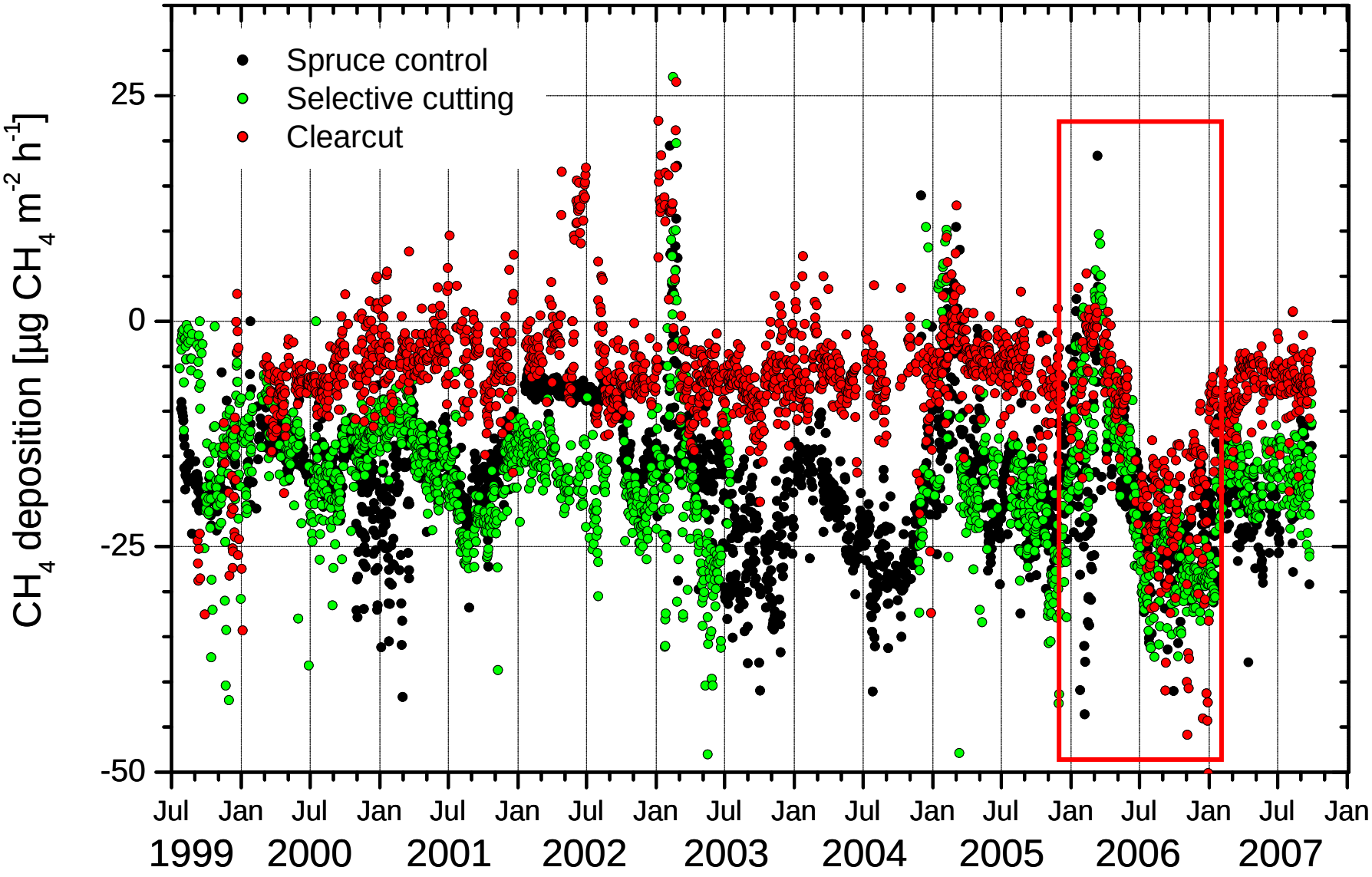
Freeze-thaw effect 2006 Höglwald spruce



KIT – a Cooperation between
Karlsruhe Research Center
and University of Karlsruhe

Forschungszentrum Karlsruhe
in der Helmholtz-Gemeinschaft
IMK-IFU Garmisch-Partenkirchen

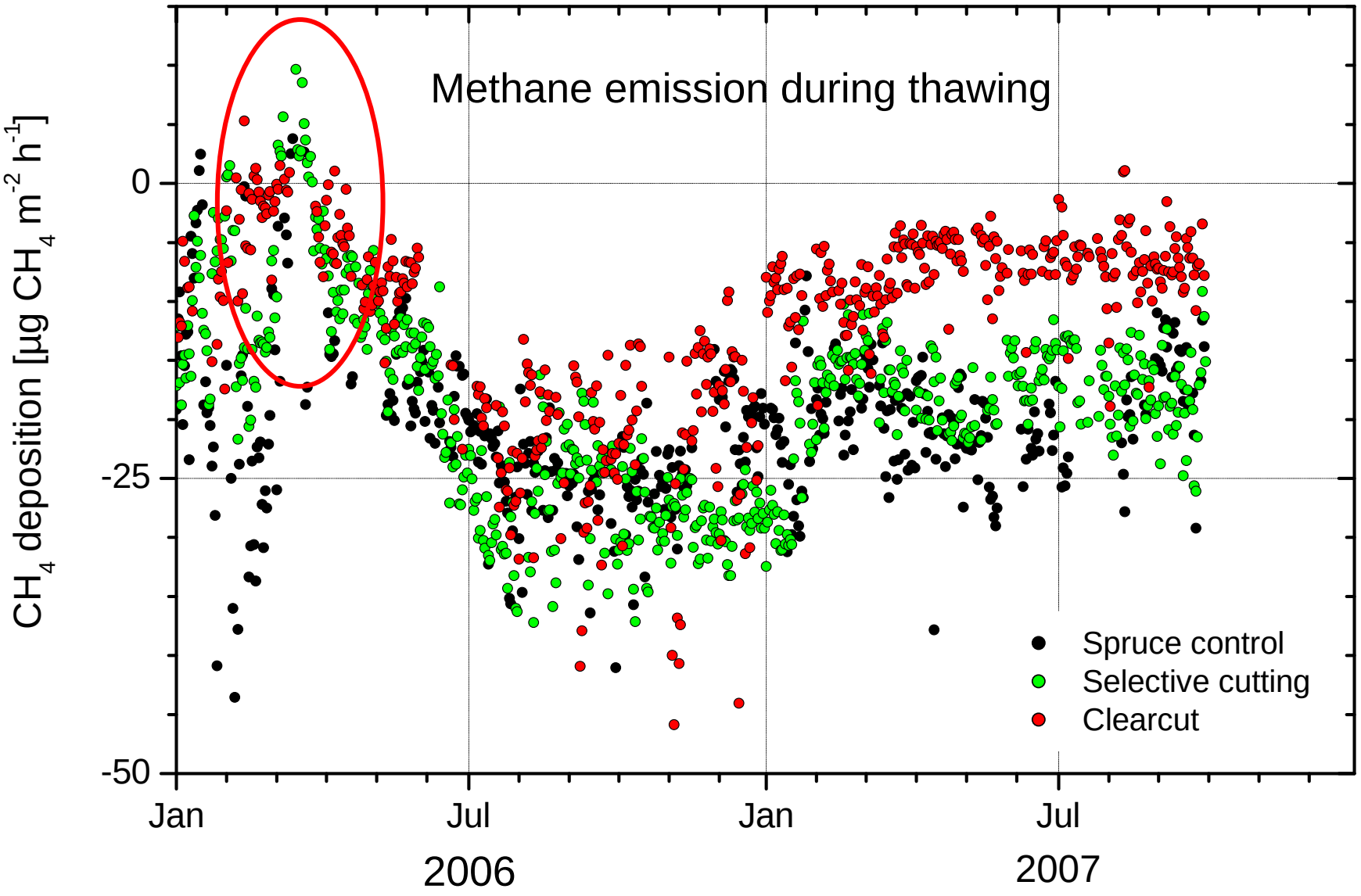
Soil CH_4 fluxes since July 1999



KIT – a Cooperation between
Karlsruhe Research Center
and University of Karlsruhe

Forschungszentrum Karlsruhe
in der Helmholtz-Gemeinschaft
IMK-IFU Garmisch-Partenkirchen

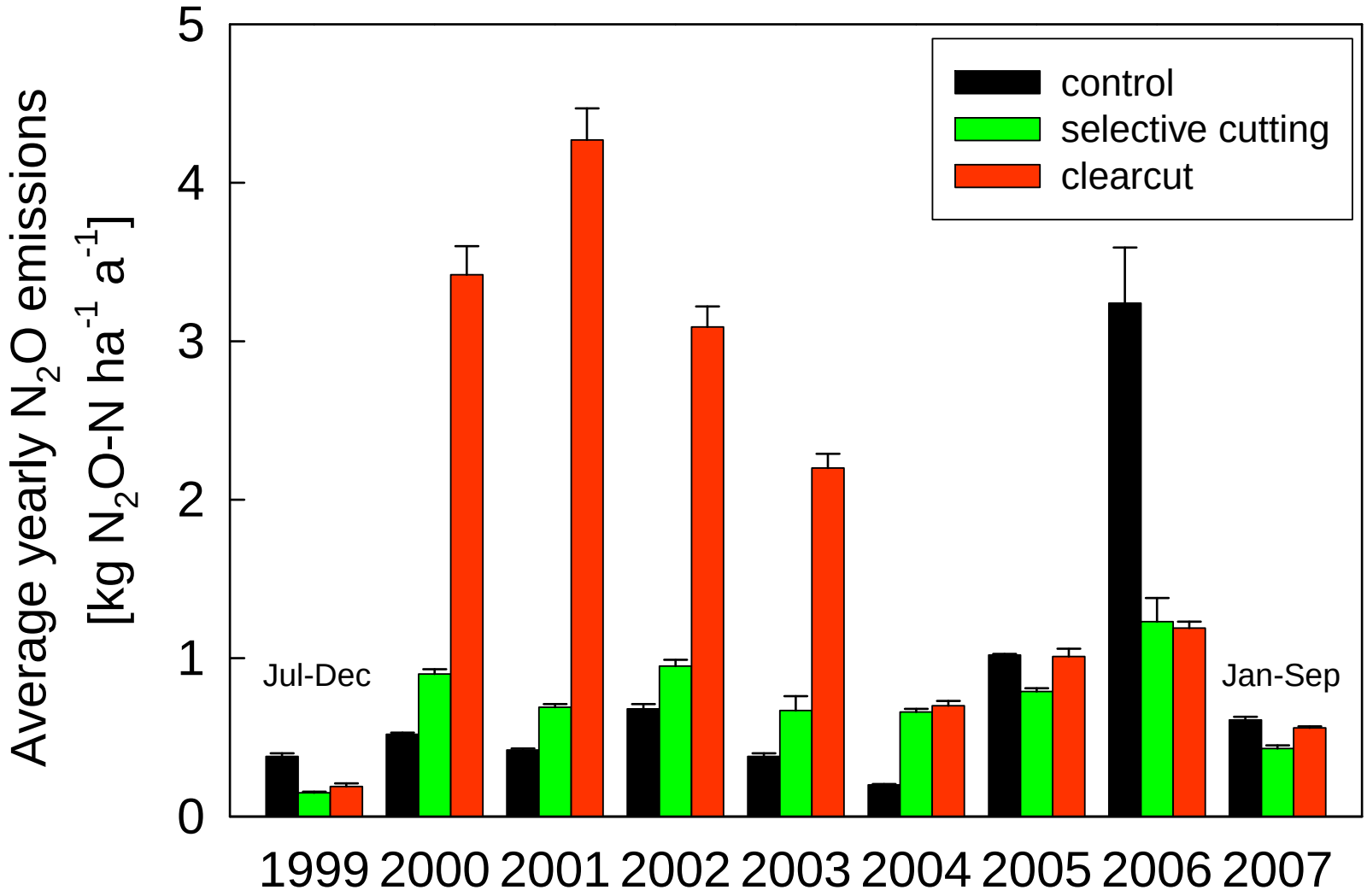
Soil CH_4 fluxes 2006 & 2007



KIT – a Cooperation between
Karlsruhe Research Center
and University of Karlsruhe

Forschungszentrum Karlsruhe
in der Helmholtz-Gemeinschaft
IMK-IFU Garmisch-Partenkirchen

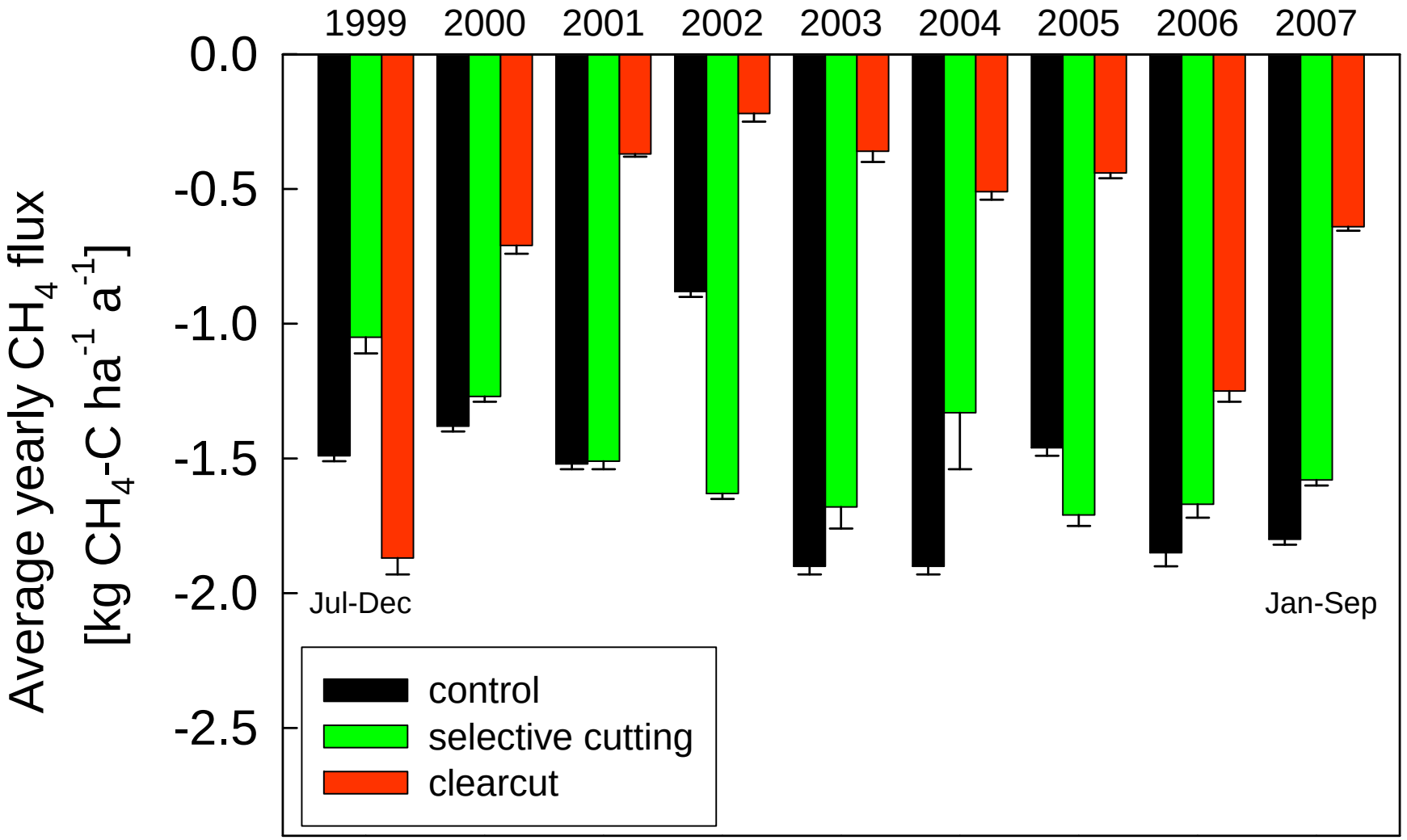
N_2O fluxes: annual means



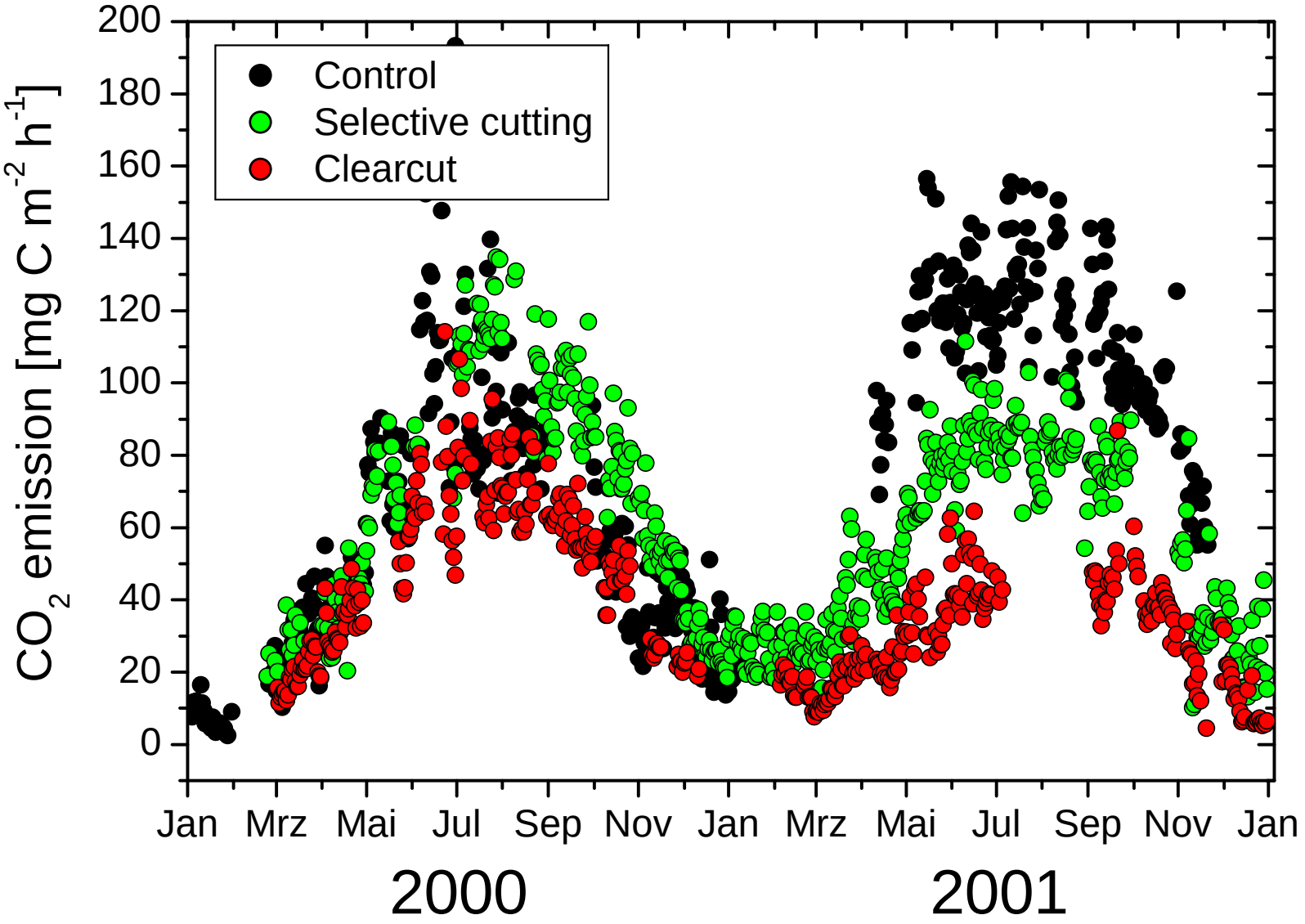
KIT – a Cooperation between
Karlsruhe Research Center
and University of Karlsruhe

Forschungszentrum Karlsruhe
in der Helmholtz-Gemeinschaft
IMK-IFU Garmisch-Partenkirchen

CH_4 fluxes: annual means



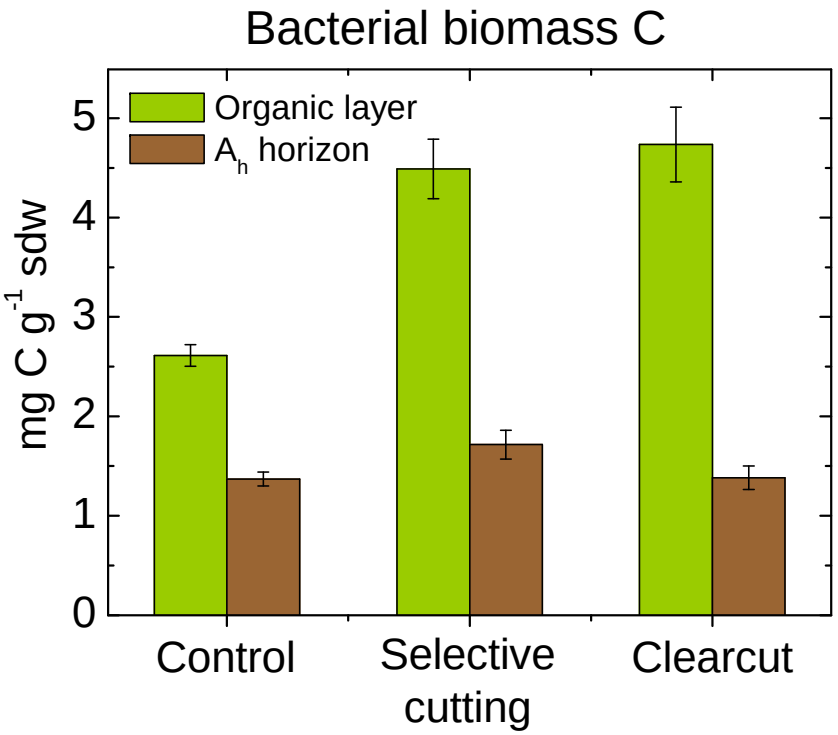
Soil CO_2 fluxes

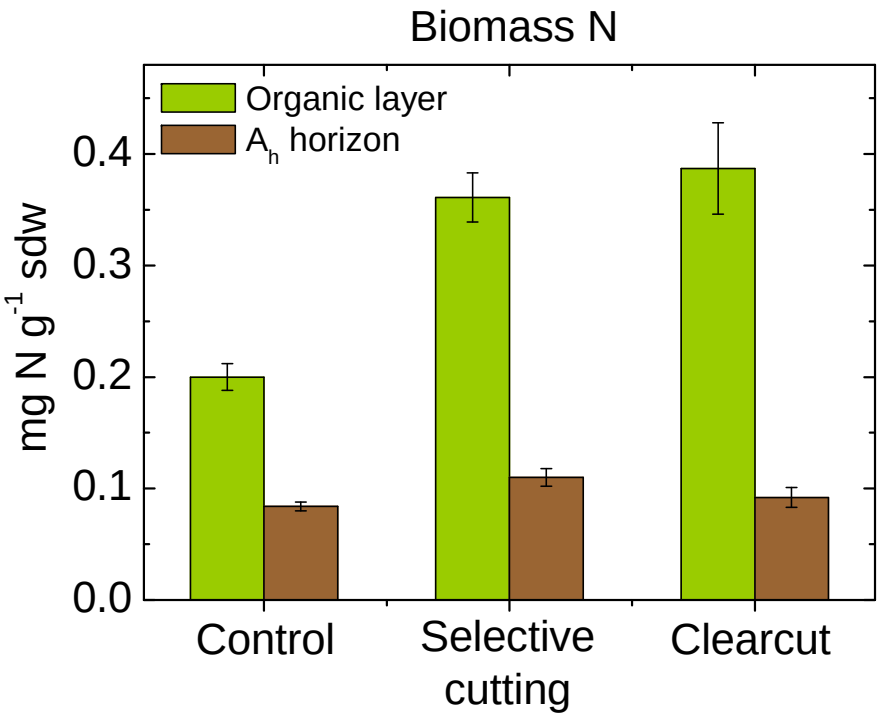


KIT – a Cooperation between
Karlsruhe Research Center
and University of Karlsruhe

Forschungszentrum Karlsruhe
in der Helmholtz-Gemeinschaft
IMK-IFU Garmisch-Partenkirchen

Bacterial biomass C and N





1999-2005 (n = 25, fumigation-extraction)

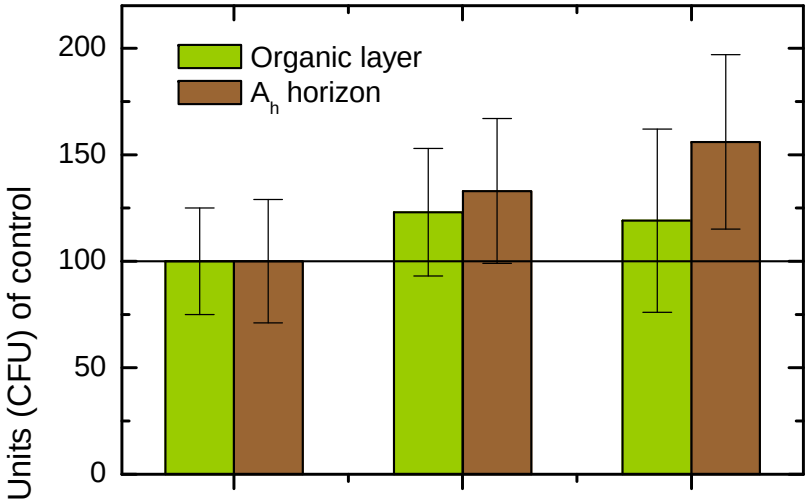
KIT – a Cooperation between Karlsruhe Research Center and University of Karlsruhe

Forschungszentrum Karlsruhe in der Helmholtz-Gemeinschaft
IMK-IFU Garmisch-Partenkirchen

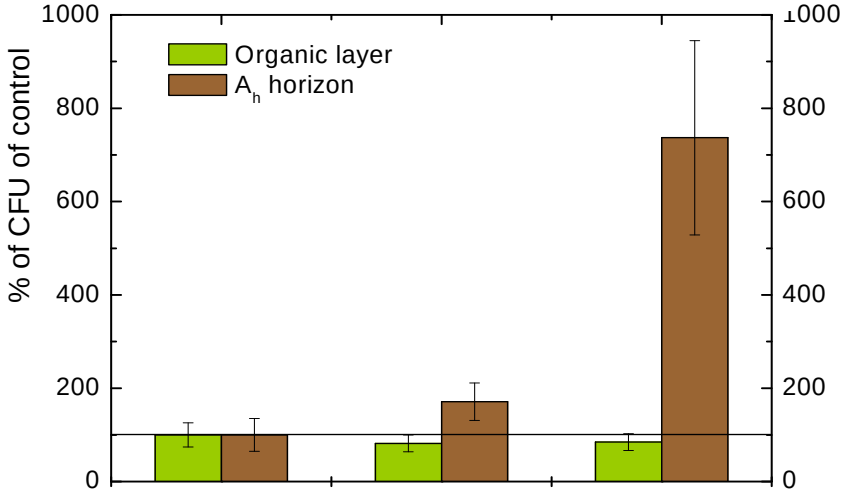
Functional groups of microbes involved in N turnover

1999-2005 (n = 25)

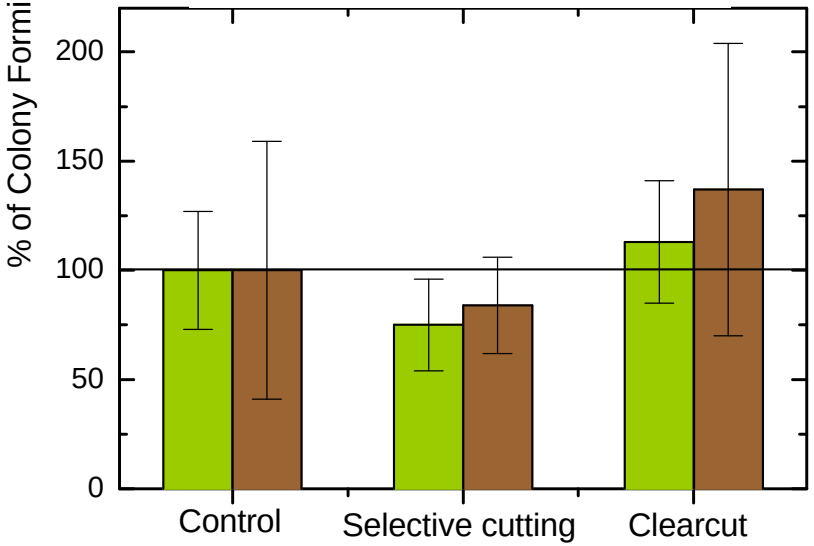
Aerobic heterotrophic bacteria



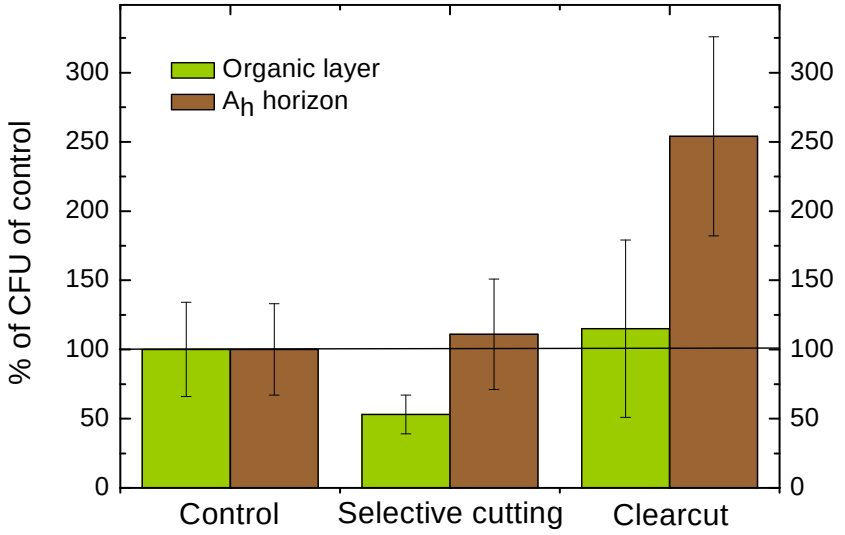
Chemoautotrophic nitrite oxidizers



Aerobic heterotrophic nitrifiers



Denitrifying bacteria

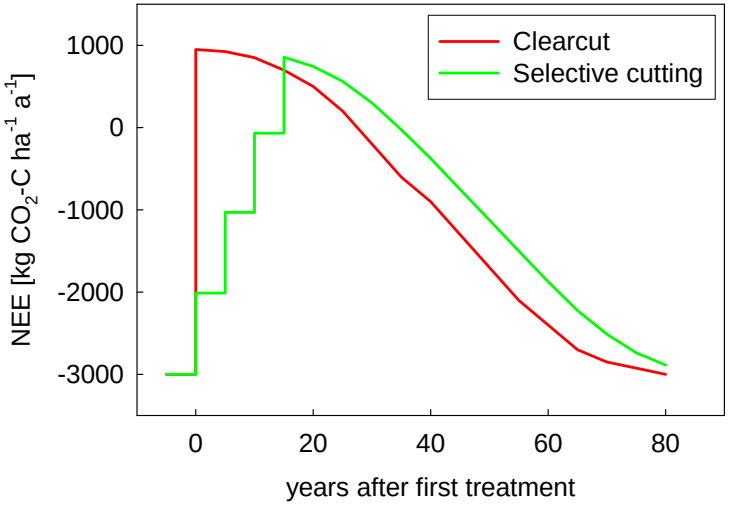


KIT – a Cooperation between
Karlsruhe Research Center
and University of Karlsruhe

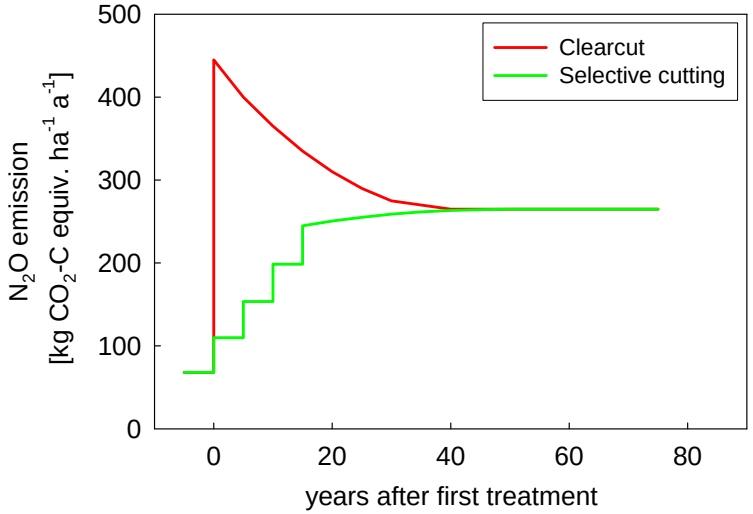
Forschungszentrum Karlsruhe
in der Helmholtz-Gemeinschaft
IMK-IFU Garmisch-Partenkirchen

Calculated greenhouse gas budgets of forest conversion over a period of 80 years

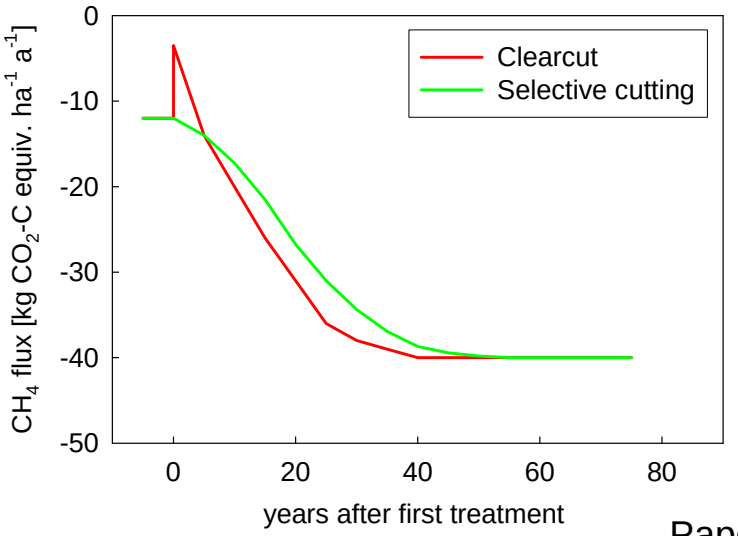
CO_2



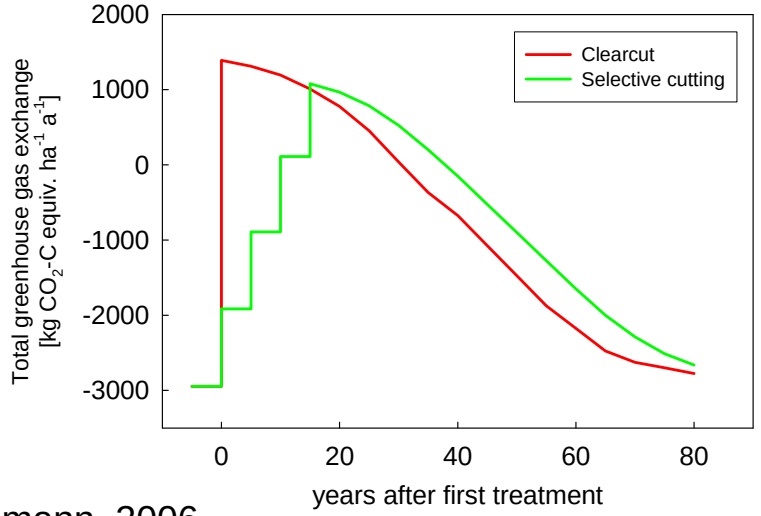
N_2O



CH_4



Sum of CO_2, N_2O and CH_4

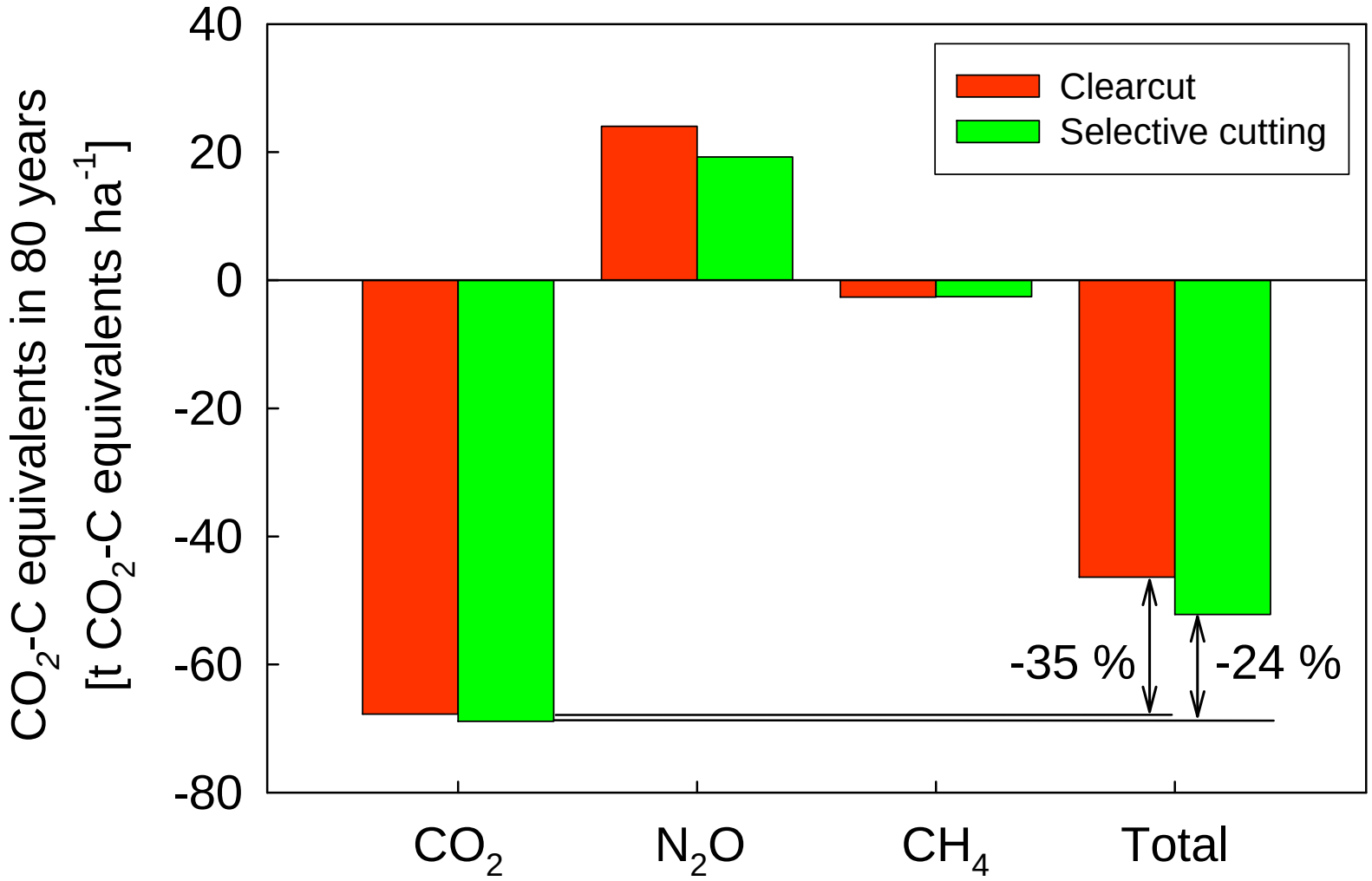


Papen & Brüggemann, 2006

KIT – a Cooperation between
Karlsruhe Research Center
and University of Karlsruhe

Forschungszentrum Karlsruhe
in der Helmholtz-Gemeinschaft
IMK-IFU Garmisch-Partenkirchen

Calculated total greenhouse gas budget of forest conversion over a period of 80 years



Papen & Brüggemann, 2006

KIT – a Cooperation between
Karlsruhe Research Center
and University of Karlsruhe

Forschungszentrum Karlsruhe
in der Helmholtz-Gemeinschaft
IMK-IFU Garmisch-Partenkirchen

Conclusions

In contrast to **selective cutting**, **clearcut** led to

- a strong increase of nitrate leaching for 2 years,
- an enormous increase of soil N_2O emissions for 4 years,
- a strong decrease in CH_4 uptake for at least 8 years,
- an offset of the total greenhouse gas budget of the forest of 9% more than selective cutting over the course of 80 yrs,

in an N-saturated spruce forest ecosystem in Central Europe.