# Evaluation of the potential of selected measures to reduce carbon emissions and sequester carbon in European soils

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# Greenhouse gases

- „Carbon“ misses at least half of the contribution of European soils to climate change
- Full greenhouse gas budget required!
- „Global warming potential“ = „$CO_2$-equivalents“
  - $CO_2$: reference
  - $CH_4$: 1 kg $CH_4$ = 23 kg $CO_2$ (over 100 years)
  - $N_2O$: 1 kg $N_2O$ = 296 kg $CO_2$ (over 100 years)

IPCC 2001

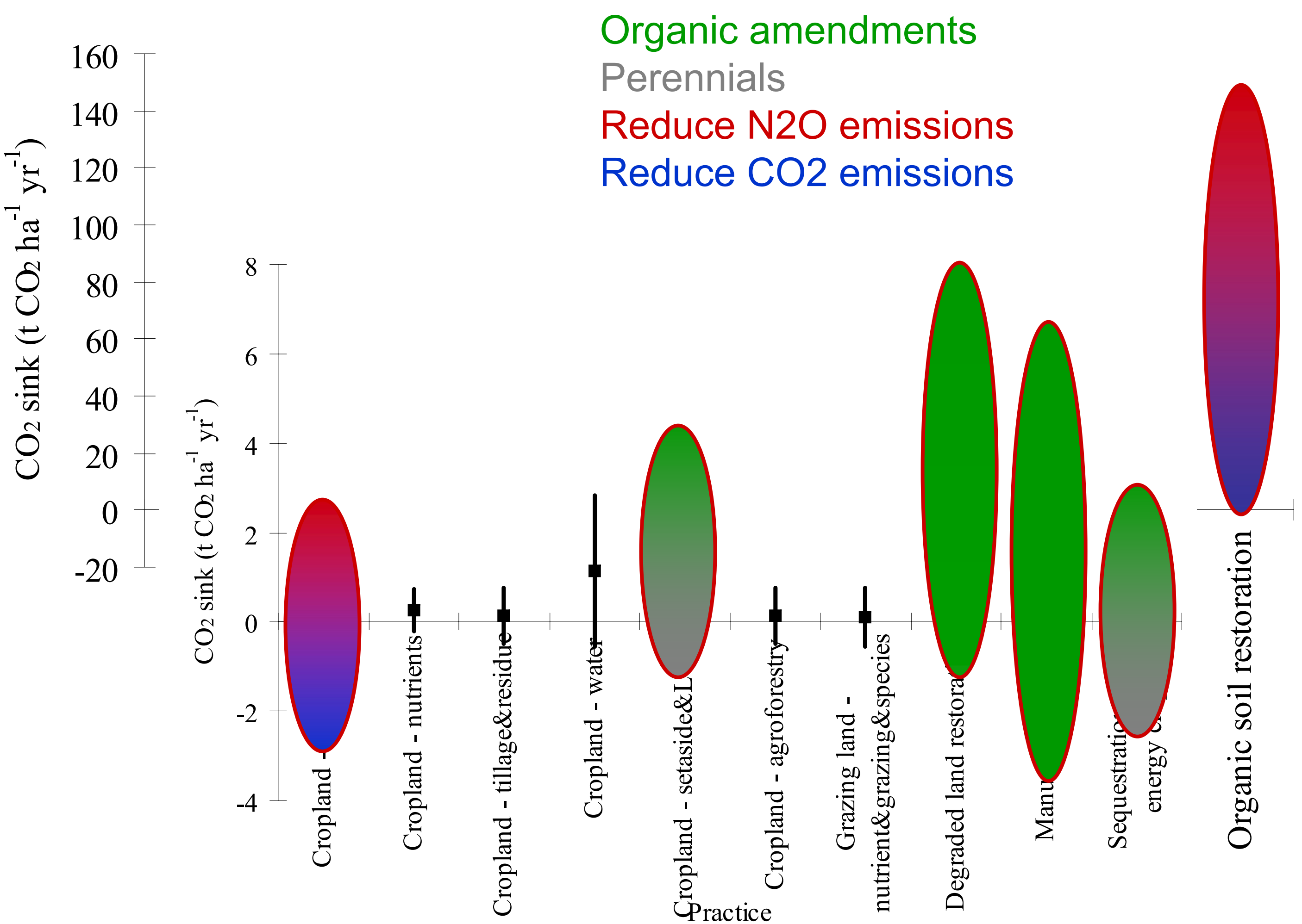

# Strategies for soils

1. Reduce emissions: $CO_2$, $CH_4$, $N_2O$
2. Sequester C PERMANENTLY
3. Enhance fertility
4. Secure resilience

# 1.

# Soils and greenhouse gas emissions: where measures can make a difference

# Selected measures




Data from: Smith et al. (2007a)

# Variability and effectiveness: the start conditions matter

Water = „C“

Areas
depleted in C

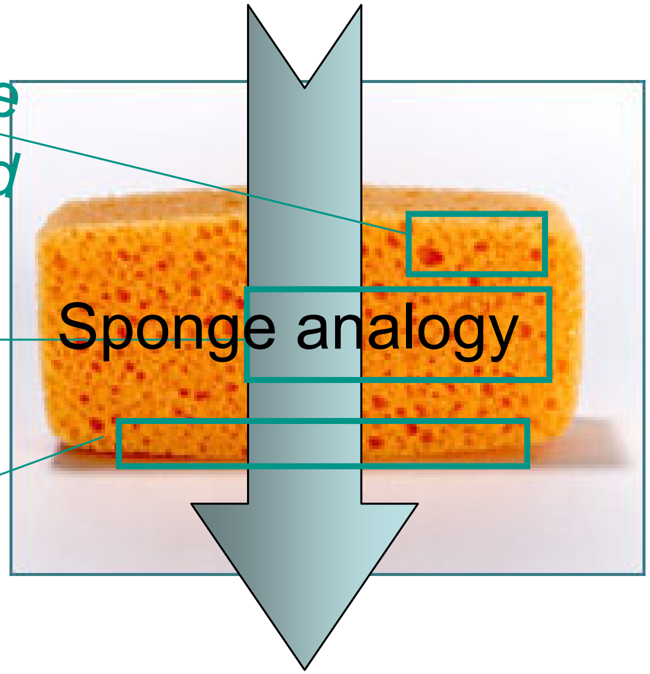
Restore
degraded land

Areas
storing
lots of C

Protect
C stocks

Areas
losing C

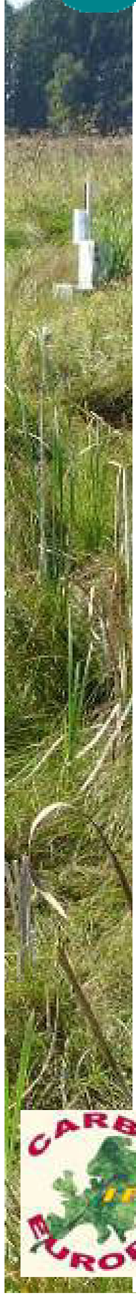
Reduce
C losses




Janssens et al., Biogeosciences 2005


# Selected measures

- Perennials and organic amendments
- Reduce $N_2O$
- Restore drained peatlands



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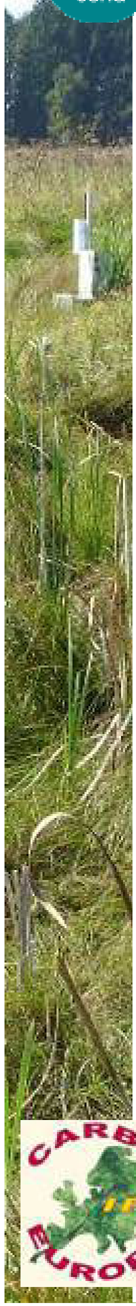
# Perennials and organic amendments



# Perennials

- Forms:
  - Short-rotation coppice
  - Permanent grassland (also new species)

- Bioenergy crops:
  - Annuals with high N demand dominate
  - Annuals are inefficient:
    - energy balance
    - greenhouse gas balance
    - soil carbon
  - At present: opportunity for soil C sequestration lost

# Organic amendments

- Existing material: re-distribution – a question of distance!
- Sewage, municipal waste: pollution risk
- Biochar: novel „Terra preta“ systems for Europe?
- Strong competition against bioenergy!
  E.g. Biogas:
  - More biomass harvested than with food crops
  - Less carbon returned to the field: Conversion efficiency of up to 70% feasible = 70% less C in organic amendments

# Perennials and organic amendments

- Implementation challenged by
  - increased demand for biomass
  - acceptance by farmers

➢ Specific incentives for perennials needed!

- Biochar
  - Traditional knowledge lost
  - Principle and prototypes are promising for
    - Higher soil fertility
    - Lower erosion risk = more resilience
    - Long-term C sequestration

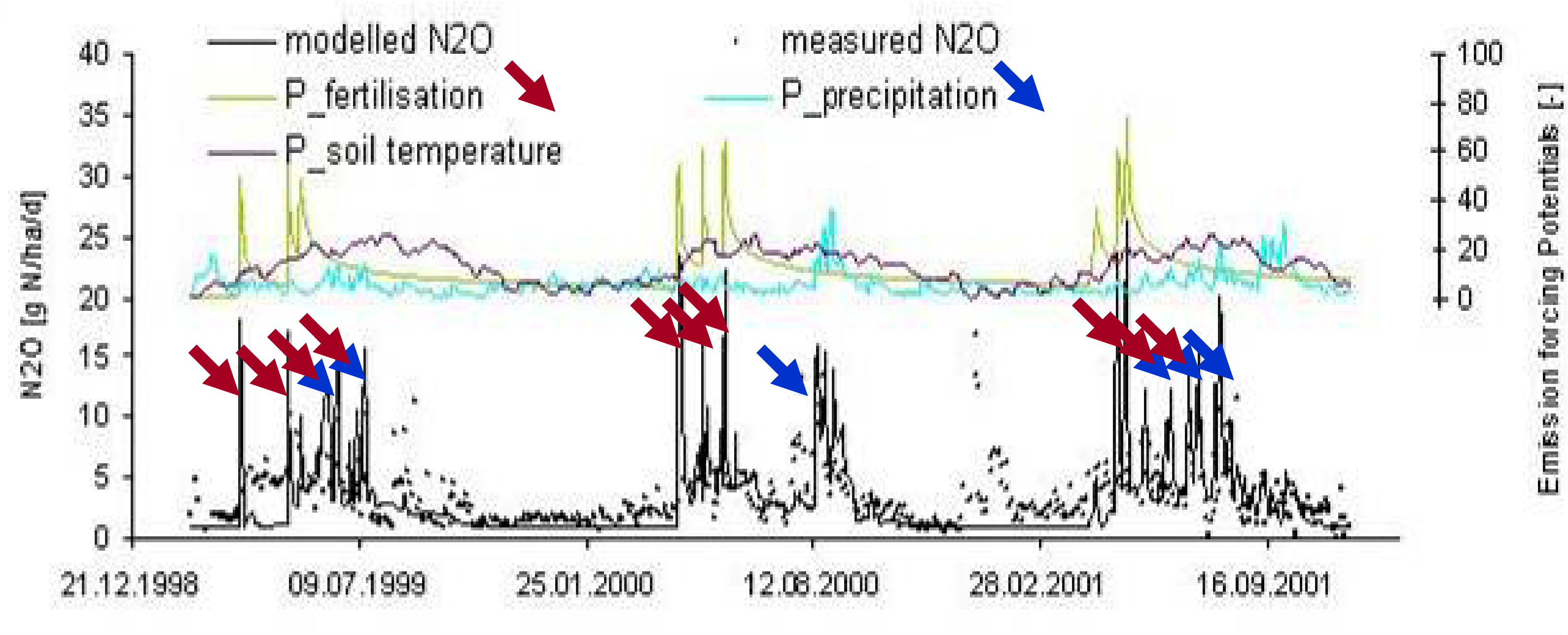
➢ Research, tests and investment for upscaling

# 3.

# $N_2O$: how much of the emissions can be managed?

# Drivers of $N_2O$ emissions

- N fertilization
- Weather and seasonal climate
- Extreme events
- Soil texture: clay!

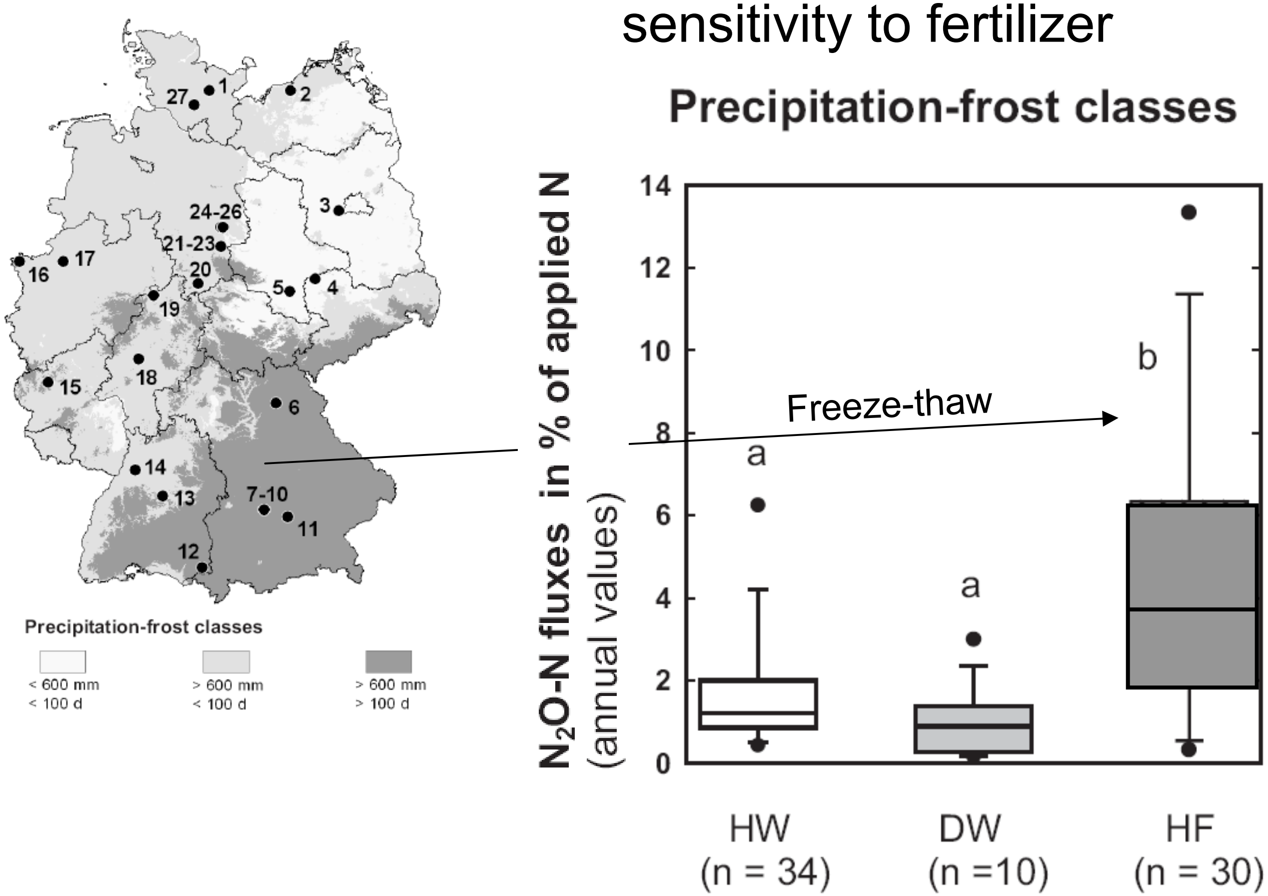



Dechow & Freibauer in prep.

# $N_2O$: region-specific emission sensitivity to fertilizer

Freeze-thaw events increase sensitivity to fertilizer

**Precipitation-frost classes**




Jungkunst et al. J Plant Nutr Soil Sci 2006


# $N_2O$: difficult to avoid

- Annual emissions driven by extreme events over few days
- Extreme events driven by
  - Fertilizer + weather + soil texture
  - Site and region specific „sensitivity“
- Useful:
  - Avoid large fertilizer doses
  - Closed N balance

➢ Concentrate on sensitive regions: MEASUREMENTS!

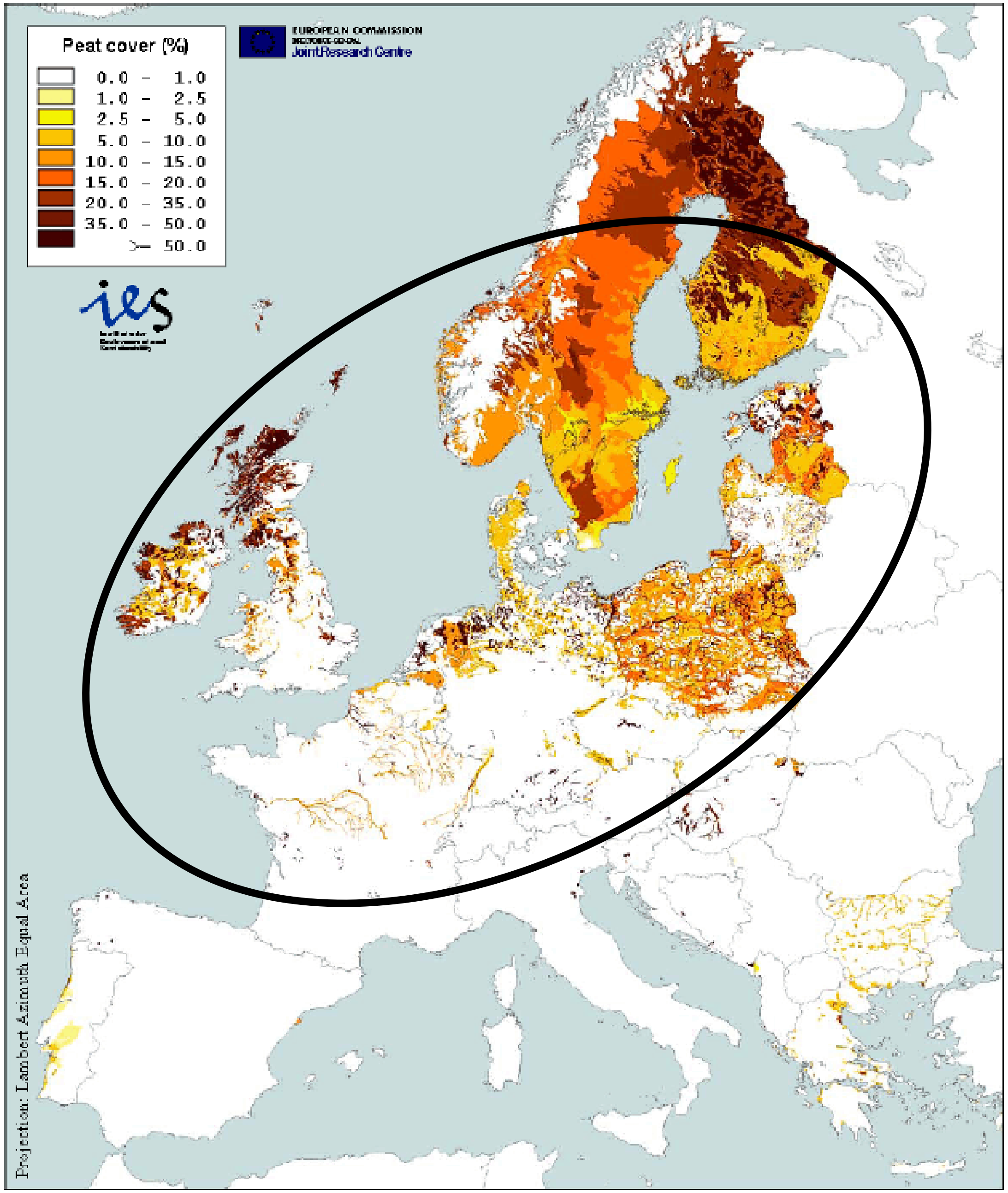
➢ Closed field-scale N balances,
control the implementation of nitrate directive
and water framework directive
and good farming practice

# 4.

# Drained peatlands: hotspots as priority

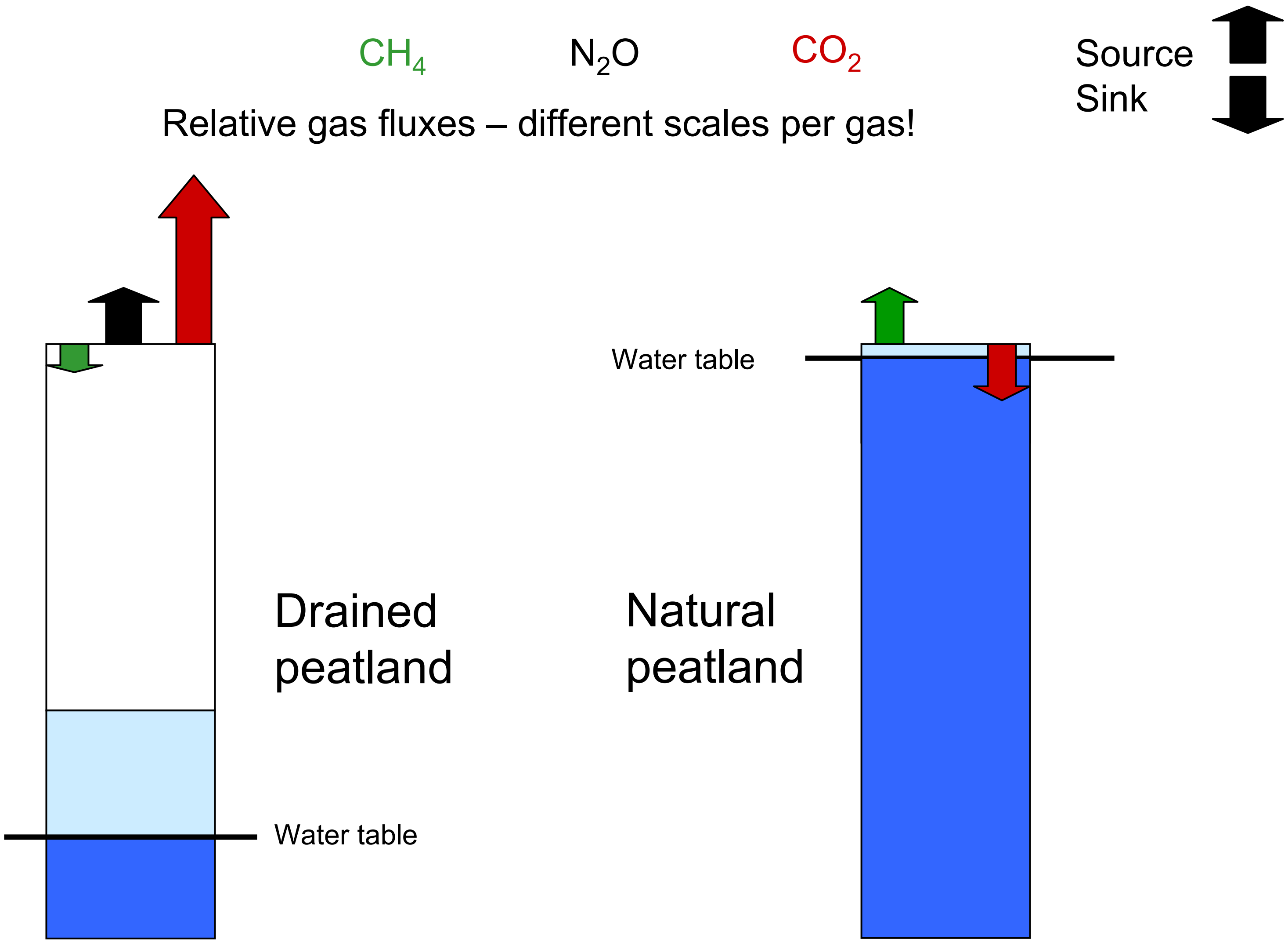
# Drained peatlands

EU-25:
7% peat area
~4% drained peat area
(>60% of peat area)

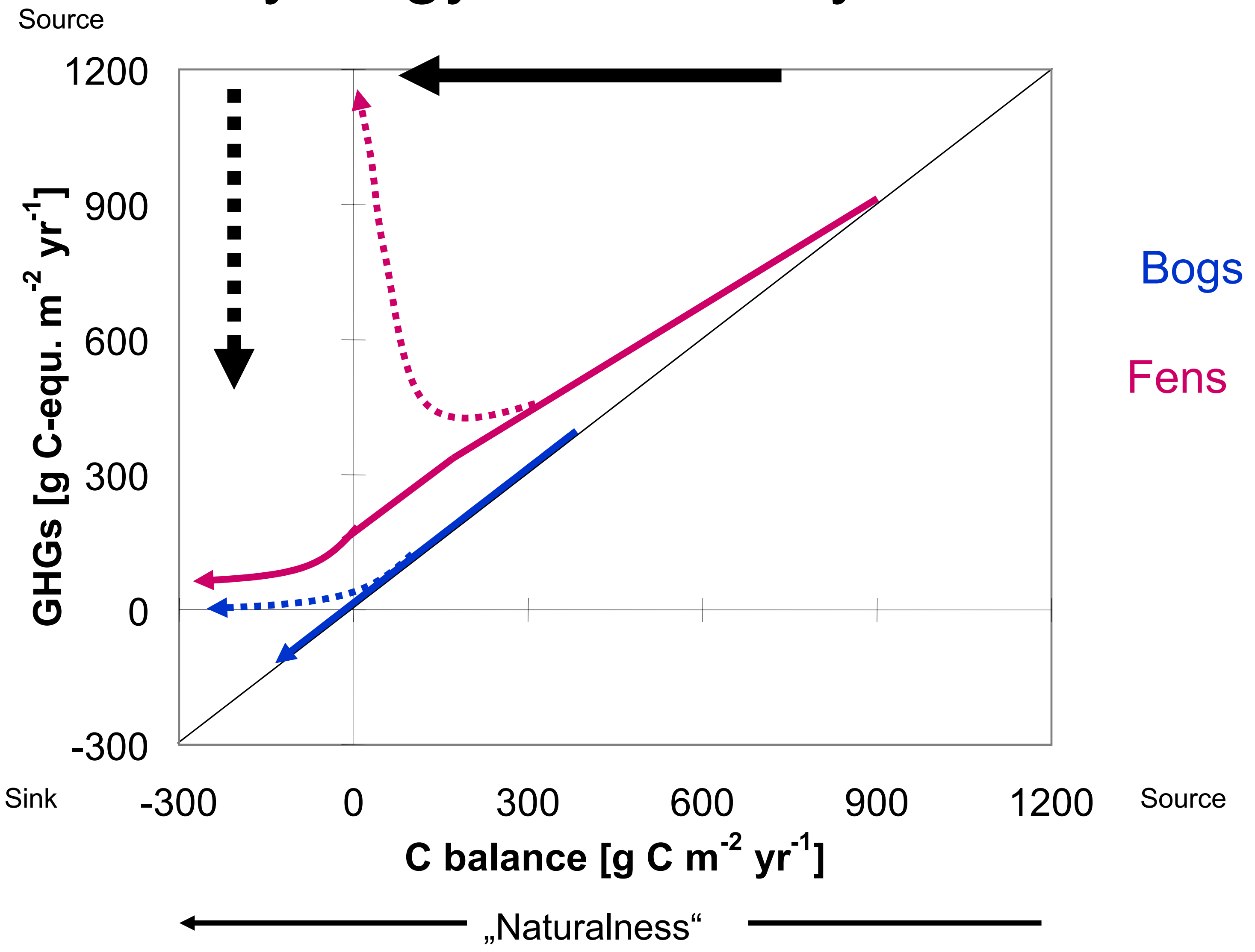



Montanarella et al.
Mires & Peat 2006

# Greenhouse gases in peatlands



# Restoration of drained peatlands: synergy biodiversity - climate?




Mitigation priorities

Drösler 2005; Freibauer et al. in prep.; Drösler, Freibauer et al. in prep.

# Restoration of drained peatlands: synergy biodiversity – climate!

- Drained bogs: safe synergies
- Drained fens: synergies in all cases where
  flooding and full water saturation in summer is avoided (or only small part of land surface is flooded or saturated)

➢ Current emissions: 80-130 Tg $CO_2$-equ / yr
= 2-3% of emissions in EU-25

➢ Theoretical potential in Europe if all peatlands were restored (no water constraints!):
50-100 Tg $CO_2$-equ / yr
= 1-2% of emissions in EU-25

Recalculated from Byrne et al. 2005

# Conclusions

- Hotspots of GHGs from land use
  - $N_2O$ from agricultural soils
  - Drained peatlands

- Priorities for climate change mitigation
  1. Advances in fertilizer use in $N_2O$-sensitive regions
  2. Reduce hotspot emissions:
     restore drained peat soils!
  3. Incentives for perennials for biomass

- Synergy with nitrate directive, water framework directive and biodiversity