Managed organic soils: new data on GHG-exchange for national reporting and cost-efficient mitigation

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Side event at COP 15 – 12.12.2009 20:00 - 21:30
hosted by Max-Planck-Institute

Who we are

- **Technische Universitaet Muenchen (TUM)**, Chair of Vegetation Ecology, Freising, Germany, www.tum.de
  Global Change Ecology, Restoration ecology, Ecosystem services focus on peatland management for mitigation & adaptation options
- **Institute of Agricultural Climate Research Johann Heinrich von Thünen Institute (vTI)**, Federal Research Institute for Rural Areas, Forestry and Fisheries, Braunschweig, Germany, www.vti.bund.de
  Applied research on GHG emissions and mitigation, focus German agriculture, German NIR for AFOLU
- **Max-Planck-Institute for Biogeochemistry (MPI-BGC)** Jena, Germany, www.bgc-jena.mpg.de
  Basic research on global carbon cycle and climate change, Host of the Side Event

Structure of the side event

1. Introduction: GHG sinks and sources from managed organic soils (AF)
2. European peatlands (AF)
3. Anthropogenic and natural drivers of peatland carbon and GHG balance (MD)
4. A closer look at Germany´s managed organic soils (AF)
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6. Main points of side event and discussion (AF/MD)

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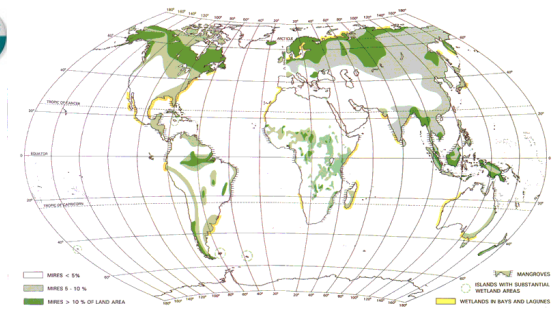
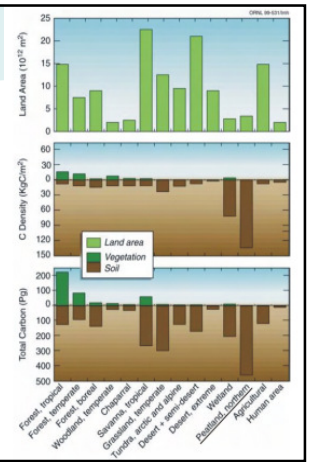
Peatlands Carbon Stock 550 Pg C



Lappalainen 1996

- **Carbon-land area relation in major ecosystem types**
- **Peatlands are the largest C store on land**

(Parish et al. 2008)



Functions of natural peatlands

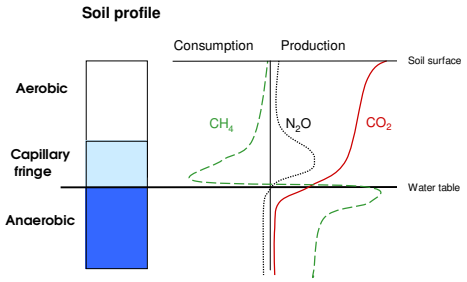
1. Sink for carbon and nutrients
2. Habitat for endangered animal and plant species
3. Buffer in the landscape water cycle
4. Buffer of regional climate
5. Archive for paleo-matter
6. Recreation and beauty

Changed functions by peatland use

Drainage:

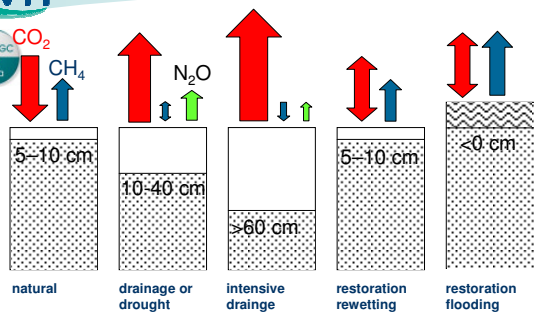
1. Carbon and nutrient source
2. Habitat loss for endangered animal and plant species
3. Reduced buffer in landscape water cycle
4. Promoter of temperature extremes in regional climate
5. Archive loss for paleo matter
6. „Normal“ agro-landscape
7. Food, feed and renewable resources

Processes of GHG-exchange in peatlands



Relative gas fluxes – different scales per gas!

Water table (land use intensity)



Drösler et al. 2008

measurement techniques for GHG-exchange of CO_2, CH_4 and N_2O

Eddy-Covariance	automatic chambers	manual chambers
1 ha continuously	1 m² continuously	1 m² episodic



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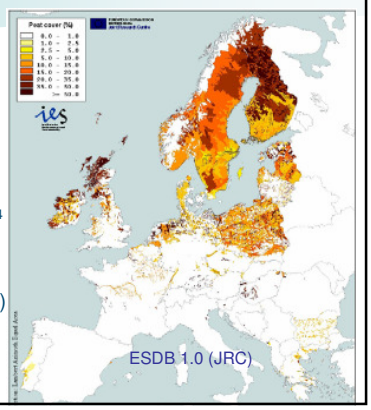
Peatlands in Europe

< 7% of land area

- Climate gradient (temperature, radiation):
  → C balance, CH_4
- Land use gradient (drainage intensity, C export by harvest)
  → C balance, CH_4, N_2O



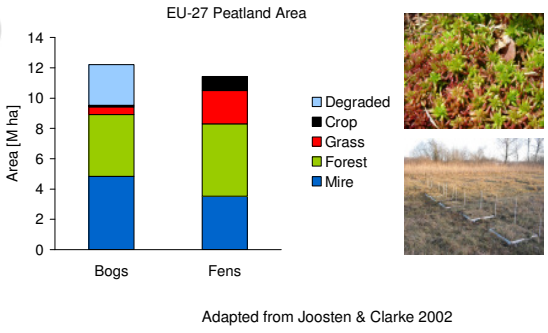
Emission factors: Data from field observations

- Annual GHG flux data from measurements in Europe:
  - 387 site-years
  - 17 bog complexes, 40 fen complexes
  - with at least one GHG species

Activity data

- **Explanatory factors / Scaling factors**:
  - Peat soil map: ESDB 1.0
  - Land use: CORINE Land Cover 2000
- **Scaling procedure**
  - Stratification by proxies: climate class and land use (like IPCC Guidelines)

Peatland use and data uncertainty



Adapted from Joosten & Clarke 2002

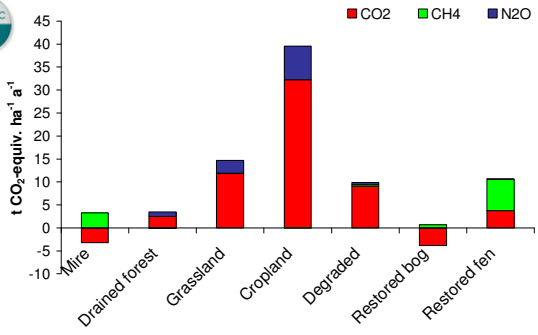
Stratification by climate class and land use

Climate zones:

Subarctic	< 0 °C
N Boreal	0-5 °C
S Boreal	5-7 °C
Temperate	>7 °C

Land use	Fen/bog separated	Climate zone separated
Mire	N_2O	NEP, CH_4
Forest	No	CH_4
Grass	data for fens only	No
Crop	data for fens only	No
Degraded	data for bogs only	No
Restored	NEP, CH_4	No

Median EFs for temperate peatlands

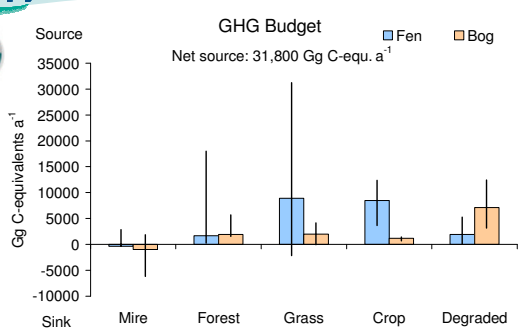


Emission factors: new insights

- CO_2 drained forests: no/few EU data
  grassland: highly variable, similar to IPCC 2006
  cropland: reduced uncertainty: 8.8 (4.0 – 11.2) t C ha^{-1} a^{-1}
  instead of IPCC 2006: 10 (1 – 19) t C ha^{-1} a^{-1}
  degraded: highly variable
  restored bogs: tend to become C sink
  restored fens: variable, small C source or C-neutral
- CH_4 no significant CH_4 source from drained soils
  restored bogs: CH_4 source ≤ mires
  restored fens: CH_4 source ≥ mires
- N_2O IPCC default EFs confirmed
  new EF for drained forests:
  2.1 (0.25 – 28) kg N ha^{-1} a^{-1}

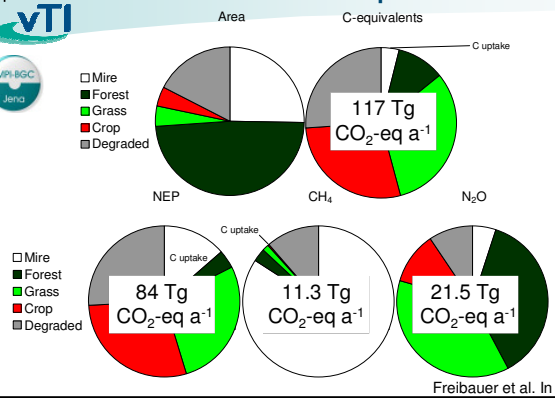
Freibauer et al. In prep.

European peatlands: GHG budget



Freibauer et al. In prep.

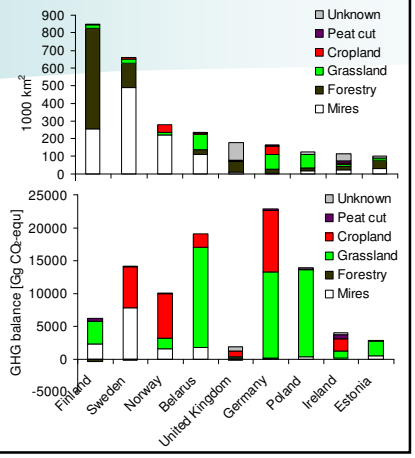
GHG emissions from peatlands in EU-27



Freibauer et al. In prep.

GHG emissions from peatlands by country

(Old emission factors; Drösler et al. 2008)



EU peatlands GHG budget: new insights

- European peatlands emit 117 (18 - 424) Tg CO_2-equ. a^{-1}
  of which drained peatlands: 121 (17 - 401) Tg CO_2-equ. a^{-1}
- Drained agricultural peatlands are GHG emission hotspots
  = as much as all European croplands (Schulze et al. 2009 Nature Geoscience)!
- Uncertainties
  - „Degraded“, „restored“ and „forest“ peatlands
  - Peat area, peat type, drainage level
  - Consistent measurements of full GHG budget
- Nevertheless:
  - Much improved quantitative knowledge of GHG response to climate and land use drivers
  - Data gaps to be filled by running projects

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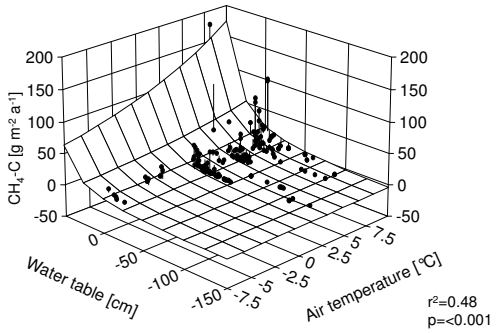
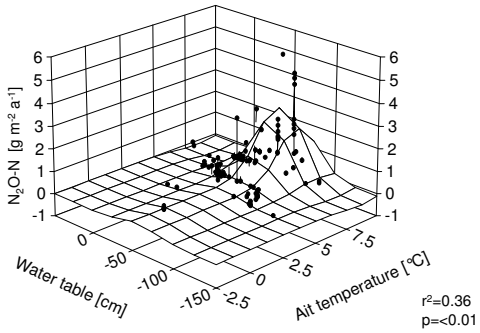
Emission factors: Data from field observations

- Annual GHG flux data from measurements in Europe:
  - 387 site-years
  - 17 bog complexes, 40 fen complexes
  - with at least one GHG species
- But:
  - Few data sets have the full GHG balance
  - Unequal distribution in space
  - Controlling factors incomplete, but critical ones for large scales OK: temperature, radiation, water table, land use type

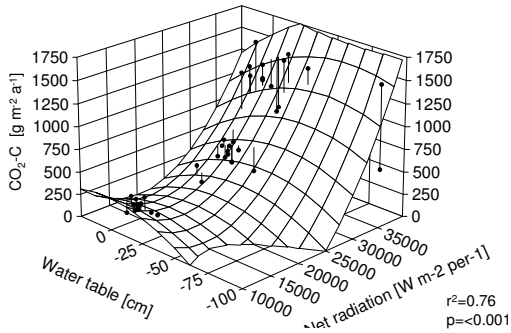
Methane balance - EU fens and bogs



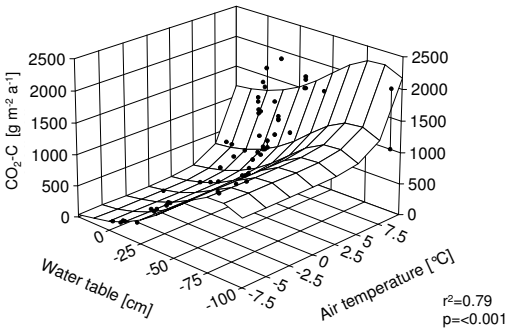
Nitrous oxide – EU fens and bogs



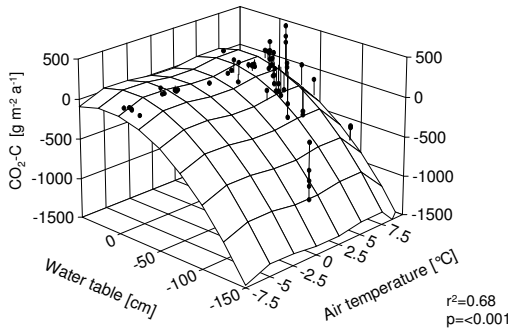
Gross primary production – EU fens and bogs



Ecosystem respiration – EU fens and bogs



Net ecosystem production – EU-fens and bogs



C-balance vs. net climate effect

Net ecosystem exchange of CO_2-C (NEE)

plus

CH_4-C balance
C-export
C-import

⇩

C-balance

plus

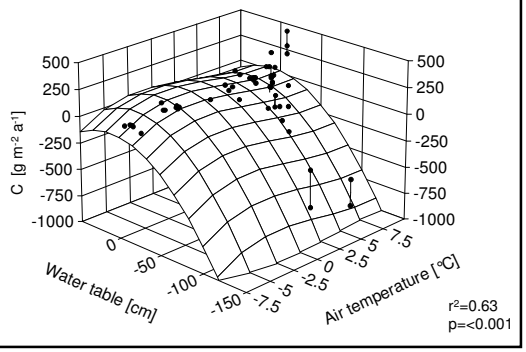
CH_4-C balance
N_2O-N balance
X gas based climate effect (GWP)

⇩

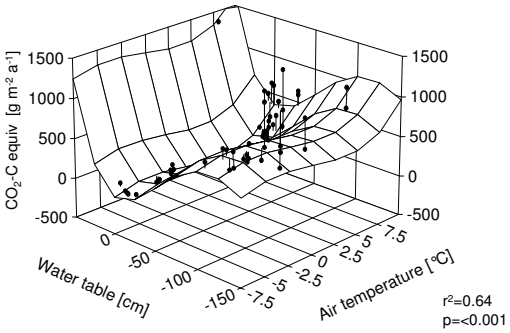
Net climate effect

GWP: Global warming potential
CO2=1; CH4=21, N2O=310

Carbon balance – EU-fens and bogs



Net climate effect – EU fens and bogs



Controls of GHG balance

Natural site conditions and land use, management

GPP	Radiation, temperature, vegetation type and vegetation activity
RECO	Temperature, water table, vegetation type and vegetation activity
CO_2 Balance	GPP - RECO, DOC, C-Export, C-Input
CH_4	Temperature, water table (anaerobiosis), labile carbon (vegetation activity), vegetation type (aerenchyma)
N_2O	N-surplus, fluctuating water table

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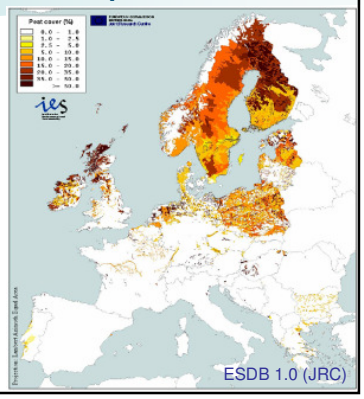
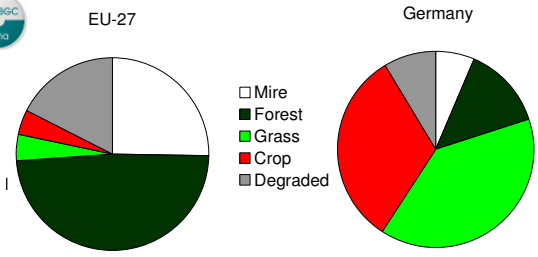
EU and German peatlands

EU-27:
7% of area
of which 60% drained
(mainly for forest)

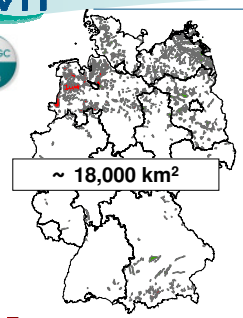
Germany:
~5% of area
of which >90% drained
(mainly for grassland)

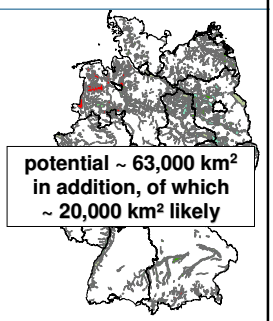


Peatland use in EU and Germany



German peat area





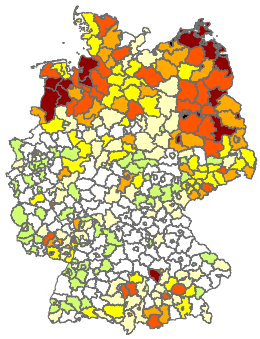
Bogs
Fens
German soil classification

Potential area of organic soils
WRB (FAO 2006) / IPCC (2003)

GHG emissions from LULUC in 2007 (mainly agricultural peatlands)

t CO_2-equ. per hectare agricultural area at district level

- < zero
- 0,01 - 1,00
- 1,01 - 2,50
- 2,51 - 4,00
- 4,01 - 6,00
- 6,01 - 9,00
- 9,01 - 15,00
- > 15



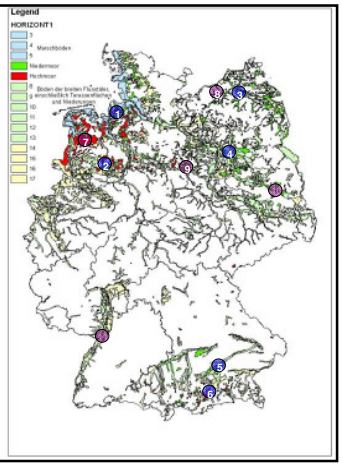
German NIR 2009

GHG emissions from German managed peatlands (18,000 km² = 5% of area)

	Tg CO_2-equ.
• Cropland	25.3
• Grassland	12.8
• Others	7.7
SUM	45.8

Equivalent to 4-5 % of German national GHG emissions.

- Several ongoing research projects are improving EFs and activity data, including options for GHG mitigation.
- Map: Peat complexes with various land uses for GHG-exchange measurements in German peatlands



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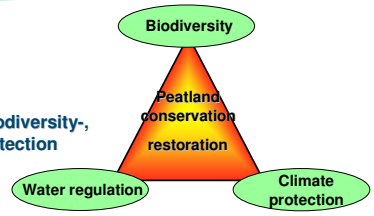
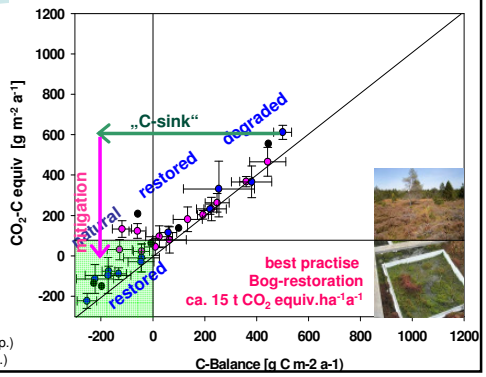
Challenges and potentials



- Synergies between **Biodiversity-, Water-** and **Climate protection**
- Development of **site-specific Peatland management strategies** (land-use, land-tenure, hydrological setting, costs and goals)
- **Application of new peatland management strategies** (stakeholder participation, permanence, commitment, costs)

Mitigation potential in German bogs

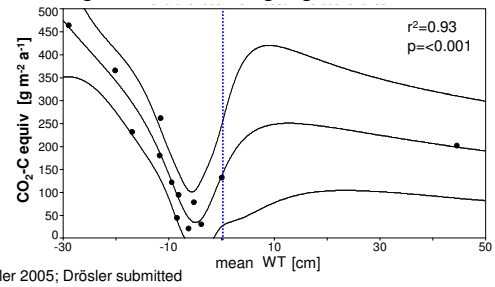
Mitigation potential in German bogs



Drösler (2005),
Förster et al. (in prep.)
Höper et al. (in prep.)

scaling of net climate effect

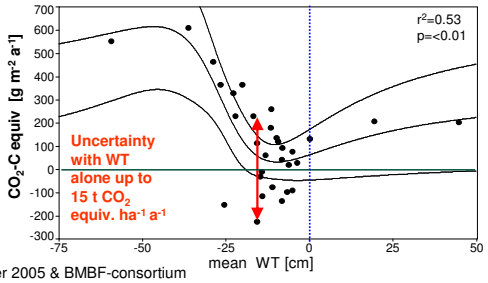
Water table as good scaling factor within peatland complex and individual studies
minimum net climate effect at around - 10 cm higher WT and flooding negative!



Data: Drösler 2005; Drösler submitted

scaling of net climate effect

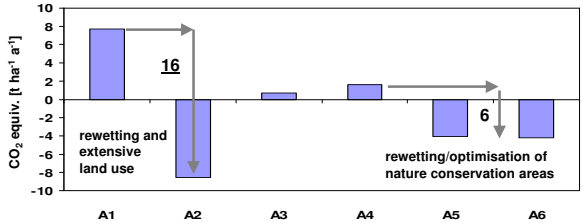
Water table alone as scaling factor across different areas less promising -
land use intensity, land use history, vegetation, soil, a.s.o. as further explaining variables



Data: Drösler 2005 & BMBF-consortium

CO_2 - emission reduction and abatement costs: Bog (TG1) NW-Germany

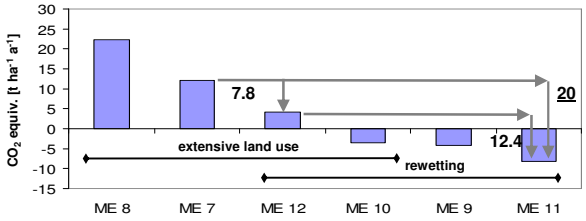
		[€/ t CO_2-equiv.]	
Comp. of loss:	240		8.5
Acqu.:	21.6 - 33.3		28.5 - 50.2
Lease:	9.2 - 13.6		0.9 - 3.9



A1: intensive meadow 4-5-cuts
A2: rewetted exensive grasland
A3: restored peat-cut area
A4: dry bog heathland
A5: moist bog heathland
A6: natural Sphagnum lawn

CO_2 - emission reduction and abatement costs: Bog (TG6) S-Germany

		[€/ t CO_2-equiv.]		
Comp. of loss:	6.3		- 12	- 5
Acqu. :	36.6 - 100		20.2 - 60.6	14.3 - 39
Lease:	4.4 – 5.1		0 – 3.2	1.7 – 2



ME 8: drained. ext. grassland
ME 7: drained. ext. grassland
ME 12: rewetted ext. grassland
ME 10: rewetted ext. grassland
ME 9: restored Sphagnum lawn
ME 11: restored Sphagnum lawn

GHG-exchange of German fens

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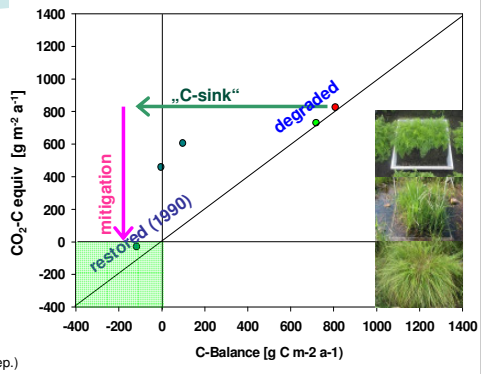
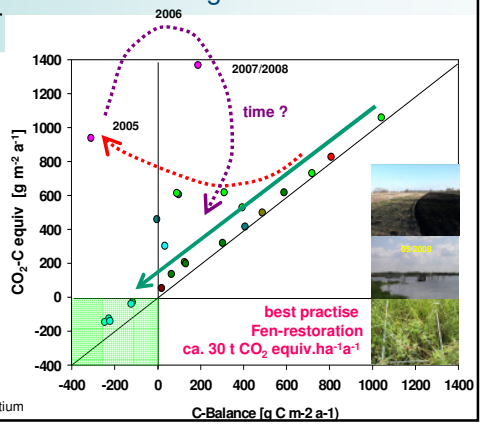


Drösler et al. (in prep.)

GHG-exchange of German fens

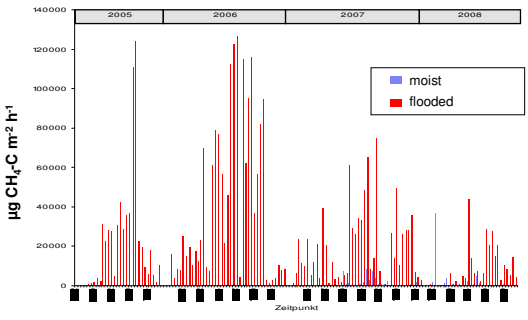


Data: BMBF-consortium

Fen-Restoration: flooded polder Zarnekov

(photo: Jürgen Augustin, ZALF)

Fen-Restoration: flooded polder Zarnekov methane emissions 2005-2008



(source: Jürgen Augustin, ZALF)

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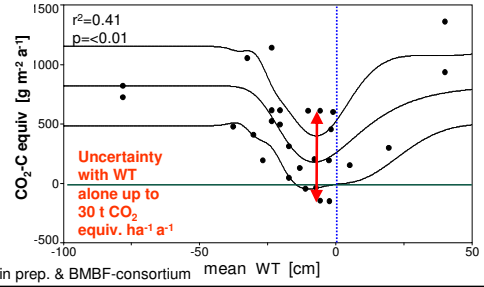
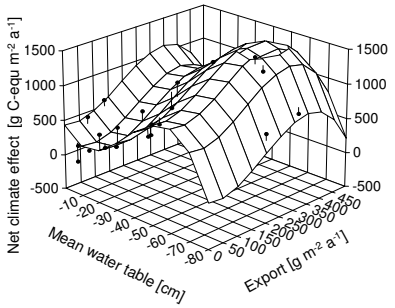


Data: Drösler in prep. & BMBF-consortium

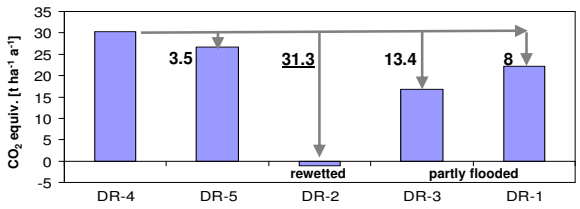
Net climate effect – southern German fens



Data: Drösler et al. in prep.

CO_2 - emission reduction and abatement costs: Fen (DR) S-Germany

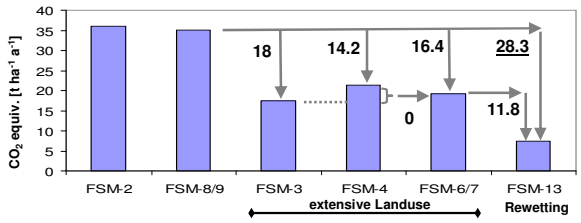
Comp. of loss:	315	73 [€/t CO_2-equiv.]	176	293
Acqu. :	225 – 297	25 - 33	59 - 77	98 - 128



DR-4: carrots
DR-5: intensive meadow (2-3 cuts)
DR-2: sedges, rewetted
DR-3: sedges, partly flooded
DR-1: sedges with cattail, partly flooded

CO_2 - emission reduction and abatement costs: Fen (TG5) S-Germany

Comp. of loss:	72	93	82	54	15
Acqu. :	54-82	70-105	61-91	35-53	63
Lease: :[€/t CO_2-equiv.]	5.8	7.5	6.5	3.7	1.1



FSM-2: intensive meadow (3 cuts)
FSM-8/9: intensive meadow (3 cuts)
FSM-3: extensive meadow (1 cut)
FSM-4: like FSM3 with Sedges
FSM-6/7: extensive fen lawn
FSM-13: extensive fen lawn, rewetted

German peatland emissions and GHG mitigation potential

Bogs bavaria: ca. 55.000 ha
degraded: 50.000 ha
if completely restored (with 15 t CO_2 equiv. / ha*a) :
mitigation of 750.000 t CO_2 equiv. / a

Fens bavaria: ca. 150.000 ha
degraded: 150.000 ha ?
if completely restored (with 30 t CO_2 equiv. / ha*a) :
mitigation of 4.500.000 t CO_2 equiv. / a

Maximum potential of mitigation:
Bavaria: ca. 5.25 Mio t CO_2 equiv. / a
Germany: ca. 35 Mio t CO_2 equiv. / a

To compare:
Bavaria-reduction plan: 83.3 Mio t CO_2 (2003) to 80 Mio t CO_2 (2010)

Structure of the side event

1. Introduction: GHG sinks and sources from managed organic soils (AF)
2. European peatlands (AF)
3. Anthropogenic and natural drivers of peatland carbon and GHG balance (MD)
4. A closer look at Germany´s managed organic soils (AF)
5. Mitigation options and costs (MD)
6. **Main points of side event and discussion (AF/MD)**

Main points of side event

1. Introduction: GHG sinks and sources from managed organic soils
   - natural peatlands: +/- neutral
   - intensively managed peatlands: up to 40 t CO_2-equiv ha^{-1} a^{-1}
2. European peatlands:
   - Area vs. Emission factor : 117 Tg CO_2-eq a^{-1}
3. Anthropogenic and natural drivers of peatland carbon and GHG balance
   - main drivers European gradient: Water table, Air temperature, Radiation
4. A closer look at Germany´s managed organic soils
   - 45 Tg CO_2-eq a^{-1} represents 4.5 % total GHG-emission
5. Mitigation options and costs
   - fen-restoration up to 30 t CO_2-equiv ha^{-1} a^{-1} ;
     abatement-costs 25-50 (acquisition) or 3-4 (lease) € / t CO_2-equiv.
   - bog-restoration up to 15 t CO_2-equiv ha^{-1} a^{-1}
     abatement-costs 15-40 (acquisition) or 0-2 (lease) € / t CO_2-equiv.
   - Mitigation potential for Germany around 35 Tg CO_2-eq a^{-1} food/feed loss
6. Outlook for "MRV"
   - combination of measurement and modelling; project specific; best match of water table and land use intensity for explaining net climate effect differences between sites

Disclaimer

The presentation is based on unpublished, preliminary data, which must not be further distributed without the consent of the authors.

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Thanks to the funding institutions:

EU, BMBF, vTI, LfU, BStMWK, BfN

Contributions by:
Lena Schaller & Jochen Kantelhardt, TUM-WDL (mitigation costs)
Andreas Gensior, Andreas Laggner, vTI (German NIR)
Jürgen Augustin, Madlen Beyer, Michael Giebels, Merten Minke, ZALF-LSD (GHG data in NE Germany)
Lindsey Bergmann, Christoph Förster, TUM-VÖK (GHG data for S Germany)
Heinrich Höper, Horst Liebersbach, LBEG (GHG data for NW Germany)

Many European research groups contributed published and unpublished data to the EU data synthesis.