Peatland GHG-fluxes

Focus on Europe and Germany
temperate to boreal peatlands

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IPCC expert-meeting
Geneva

19-21.10.2010

outline

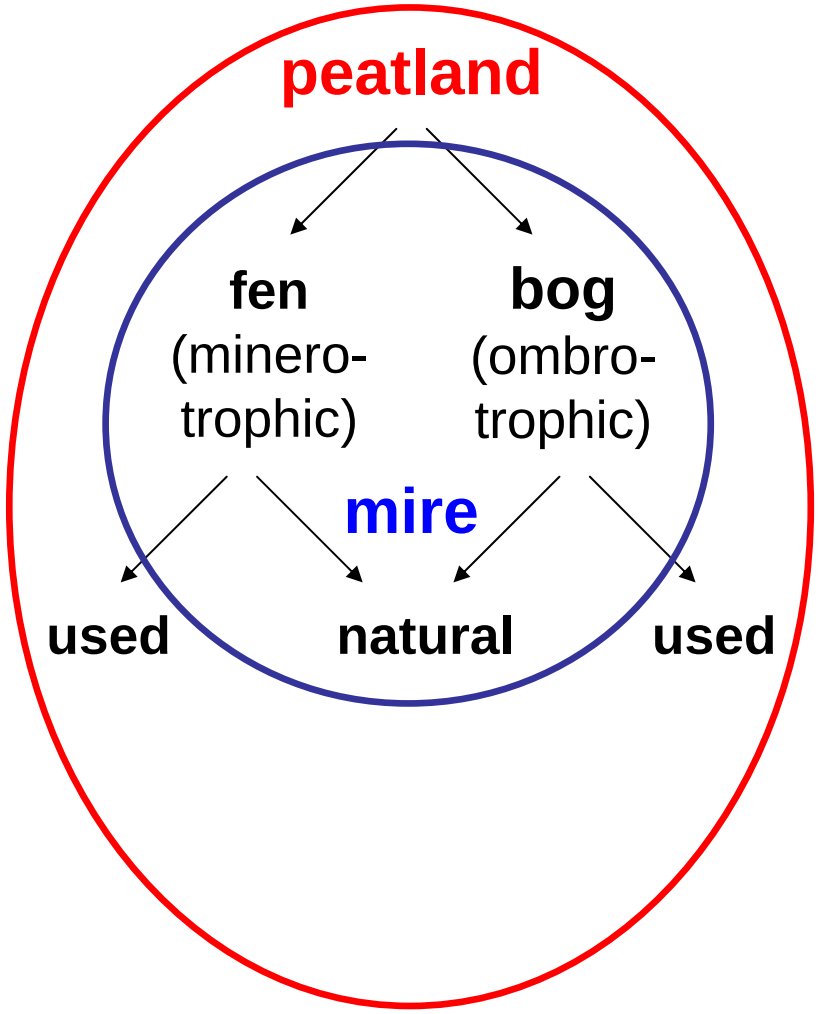
1. **Introduction: peatlands and climate**
2. Assessment of GHG-exchange of European peatlands
3. In-depth study: GHG-exchange of German peatlands
4. Management and restoration
5. Conclusions and outlook

Peatland definition

wetland

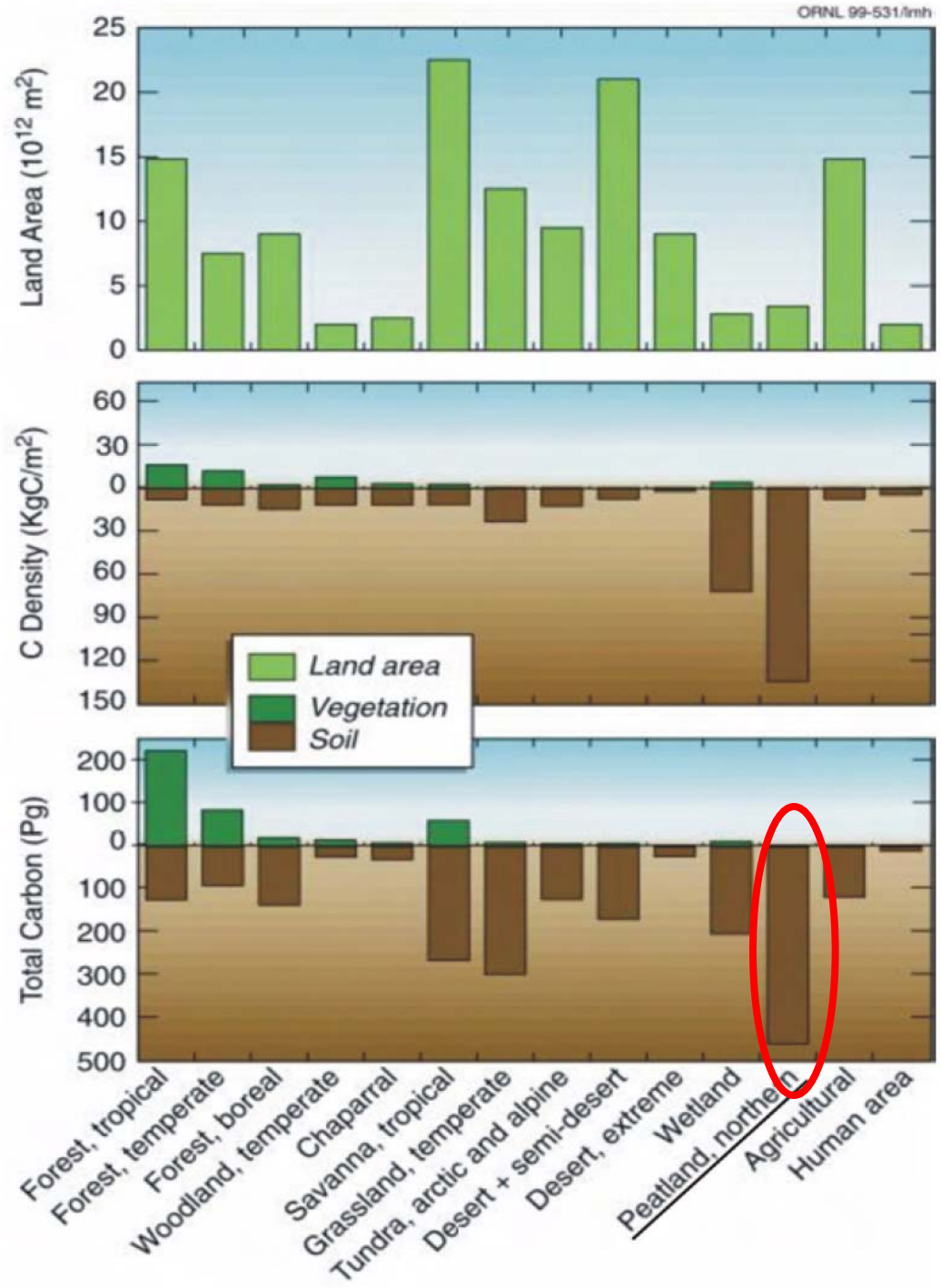
marsh
non-peatforming
mostly salt-water influenced

swamp
non-peatforming
fresh-water
.....



Histosol as a whole for organic soils

- **Carbon in ecosystems**
- **Peatland importance**



(Parish et al. 2008)

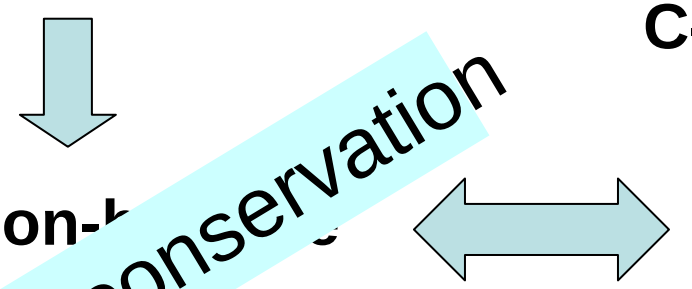
Net Ecosystem Exchange CO_2-C (NEE)

plus

CH_4-C balance
C- export
C- import

plus

CH_4-C balance **x GWP**
N_2O-N balance **x GWP**
C- export
C- import



Carbon-

Cli ance

Nature conservation

Climate protection

GWP: CO_2=1, CH_4=21, N_2O=310

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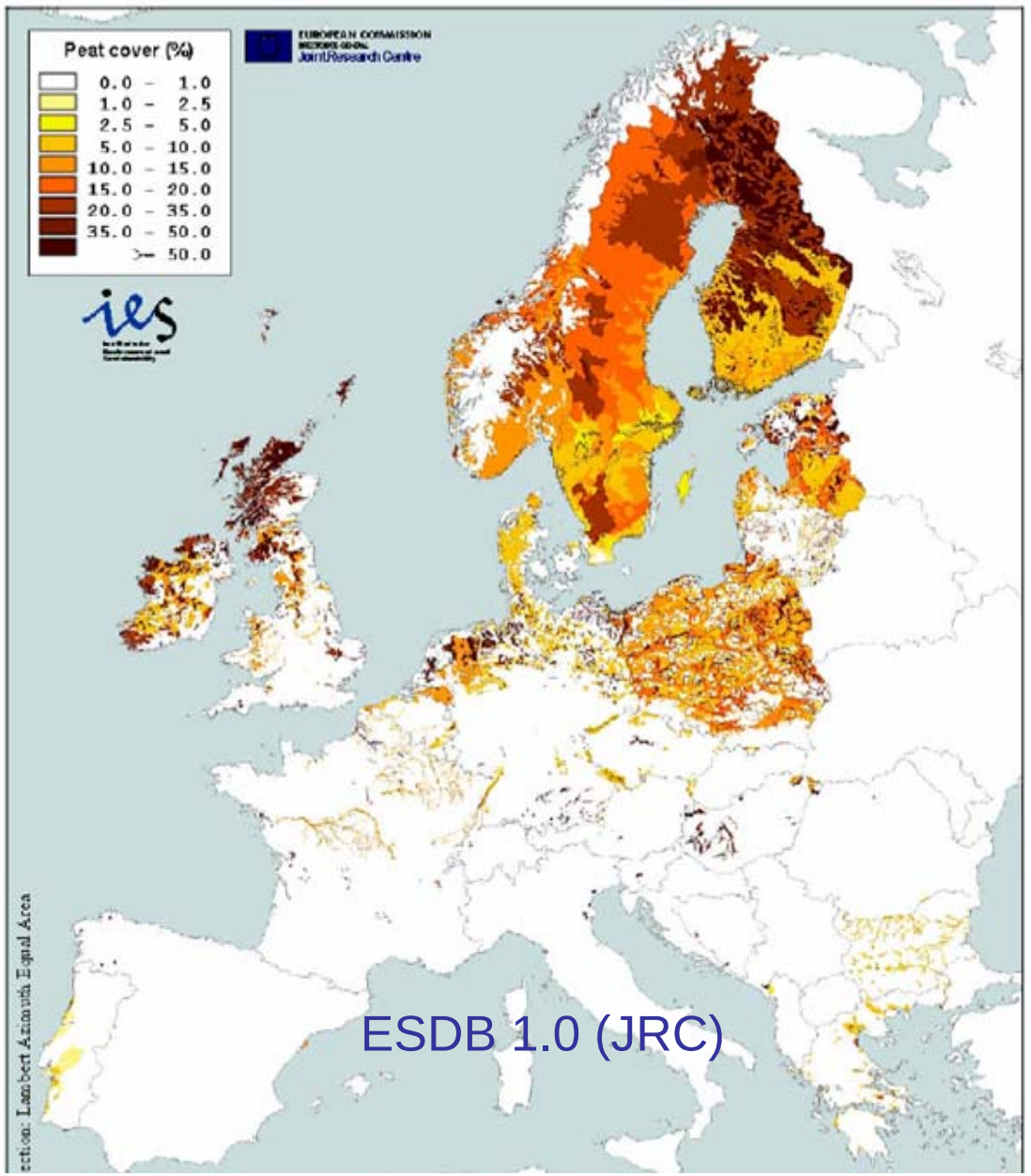
Peatlands in Europe

< 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

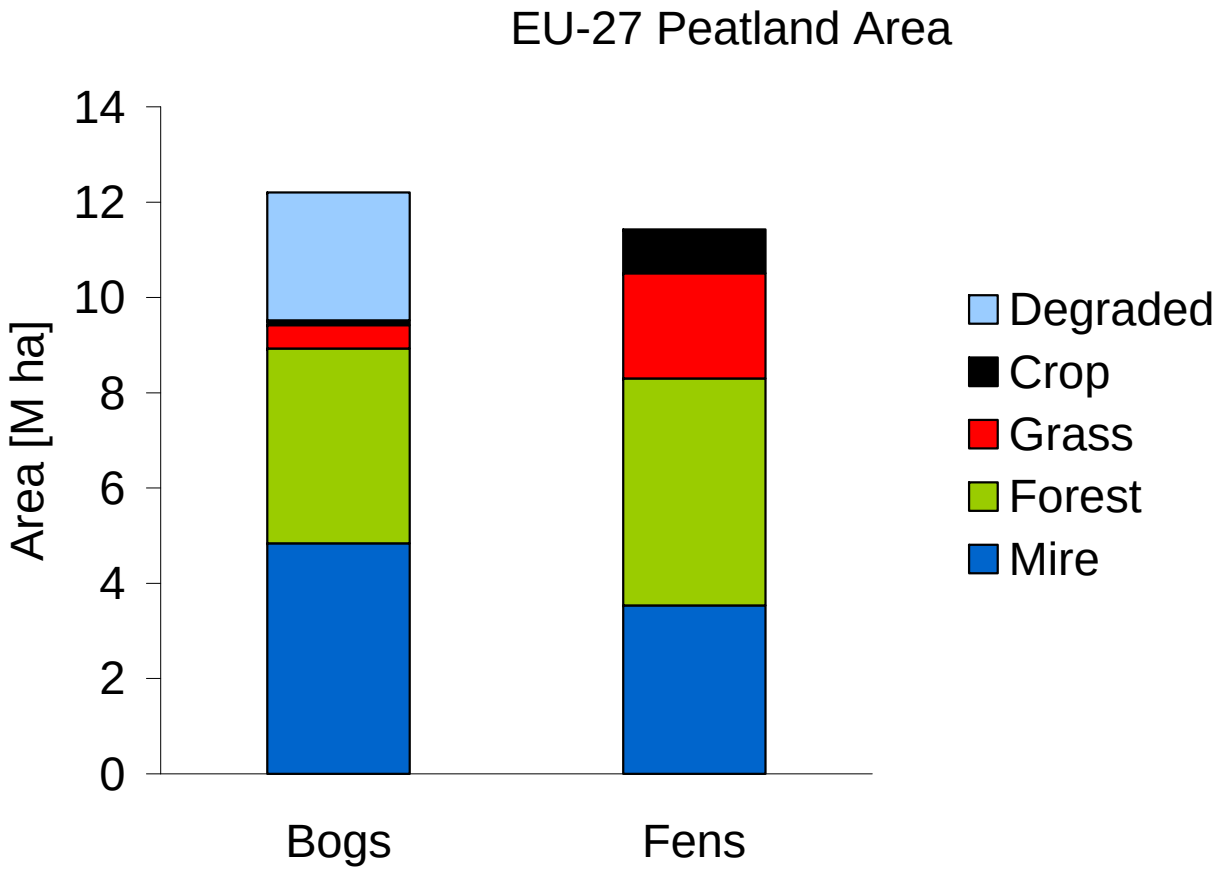
- Annual GHG flux data from measurements in Europe:
  - 387 site-years
  - 17 bog complexes, 40 fen complexes
  - with at least one GHG species

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

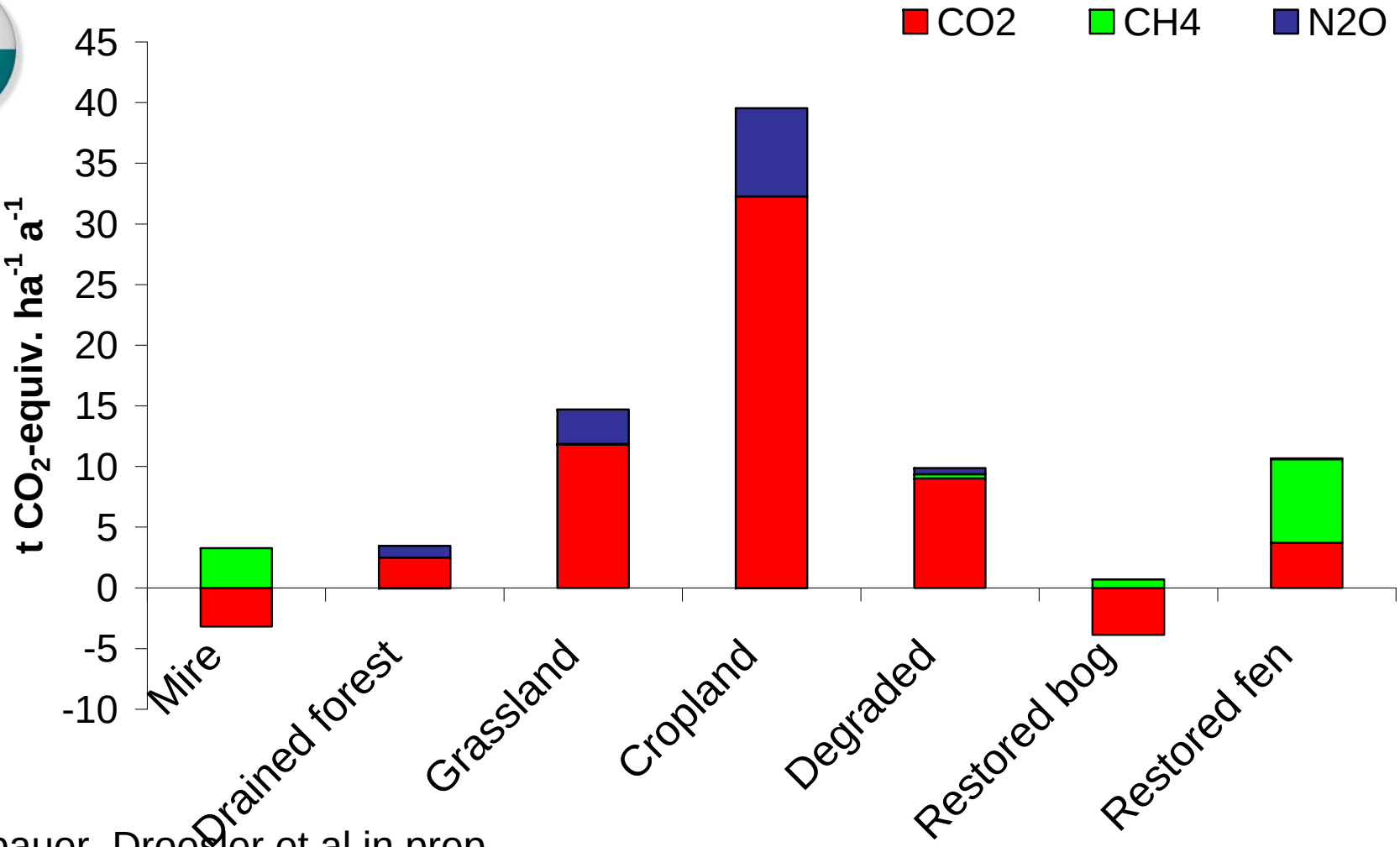
Stratification by climate class and land use

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



Freibauer, Droesler et al in prep.

Emission factors: new insights

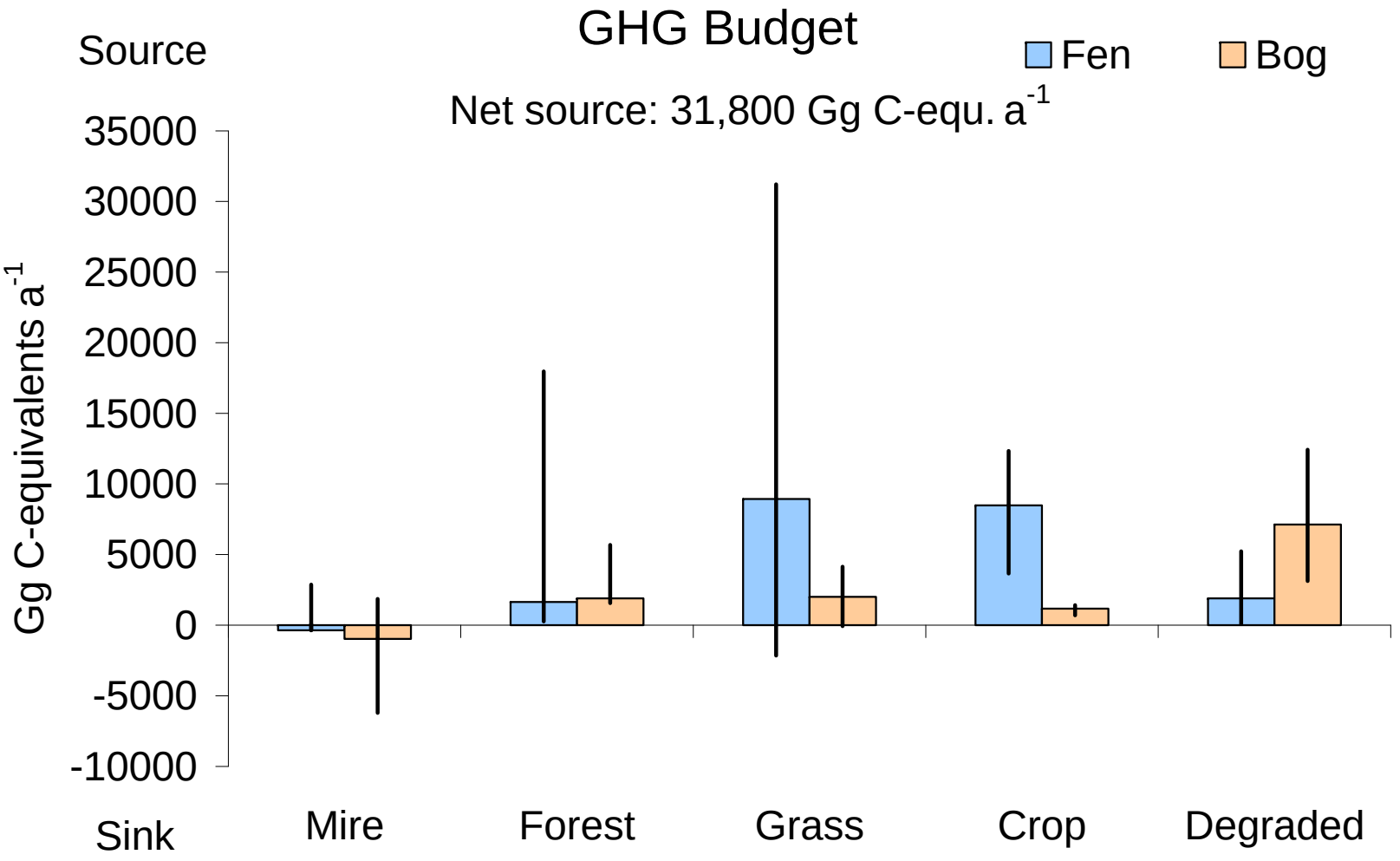
- CO_2 drained forests: no/few EU data
  grassland: highly variable, similar to IPCC 2006
  cropland: reduced uncertainty: 8.8 (4.0 – 11.2) t C ha^{-1} a^{-1}
  instead of IPCC 2006: 10 (1 – 19) t C ha^{-1} a^{-1}
  degraded: highly variable
  restored bogs: tend to become C sink
  restored fens: variable, small C source or C-neutral

- CH_4 no significant CH_4 source from drained soils
  restored bogs: CH_4 source $\leq$ mires
  restored fens: CH_4 source $\geq$ mires

- N_2O IPCC default EFs confirmed
  new EF for drained forests:
  2.1 (0.25 – 28) kg N ha^{-1} a^{-1}

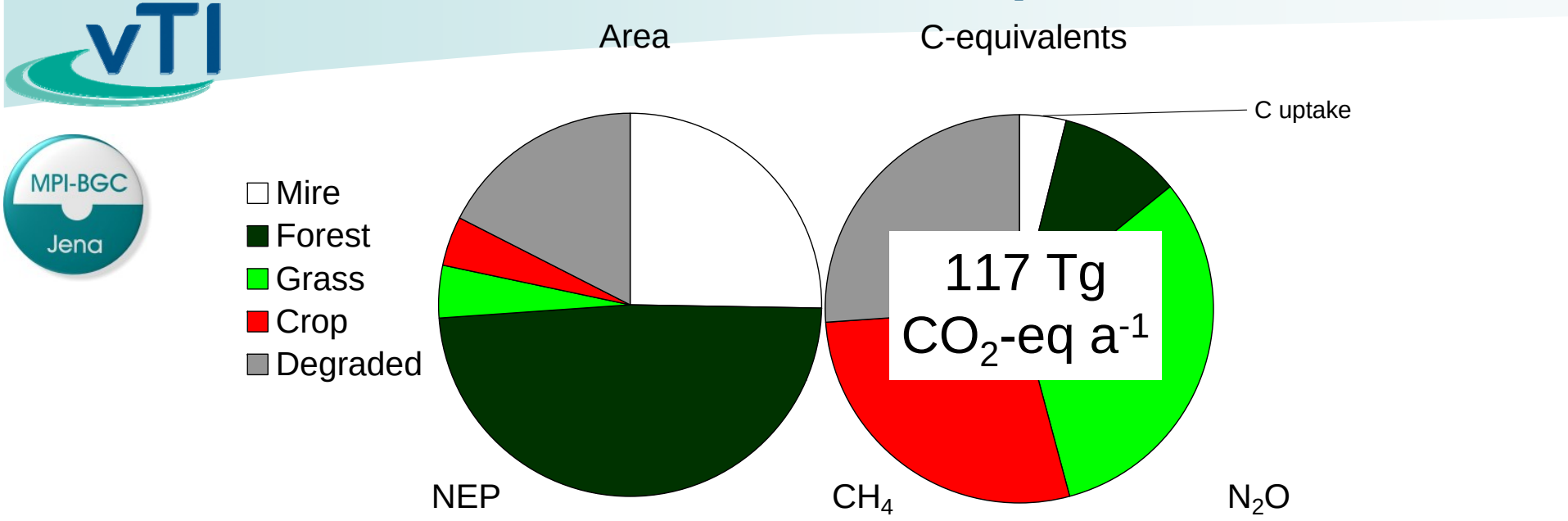
Freibauer, Drösler et al. In prep.

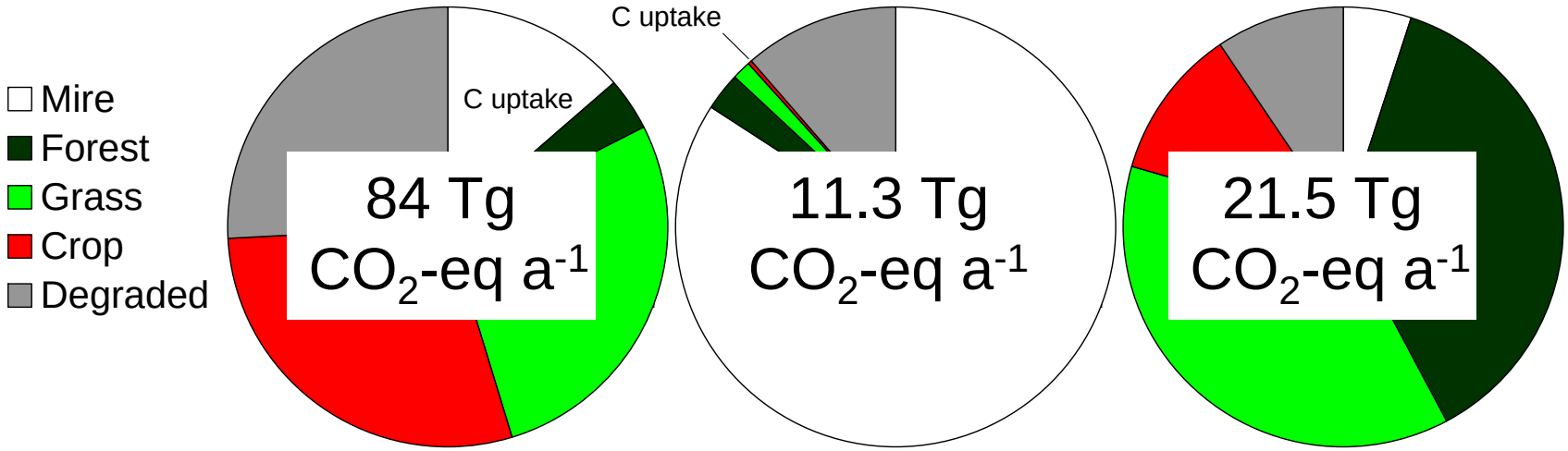
European peatlands: GHG budget



Freibauer, Drösler et al. In prep.

GHG emissions from peatlands in EU-27

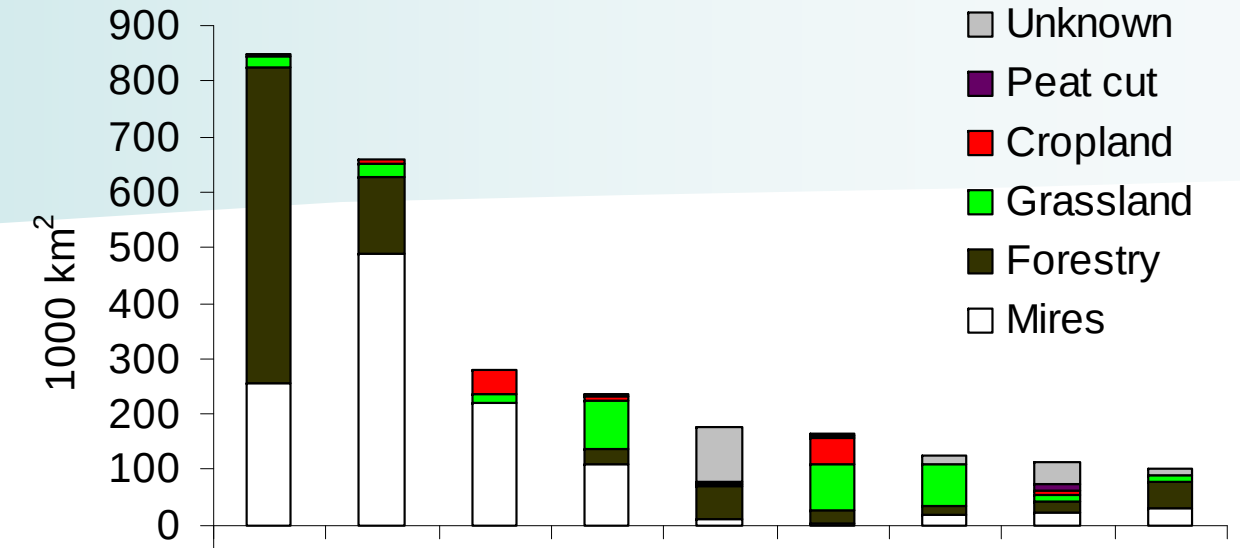


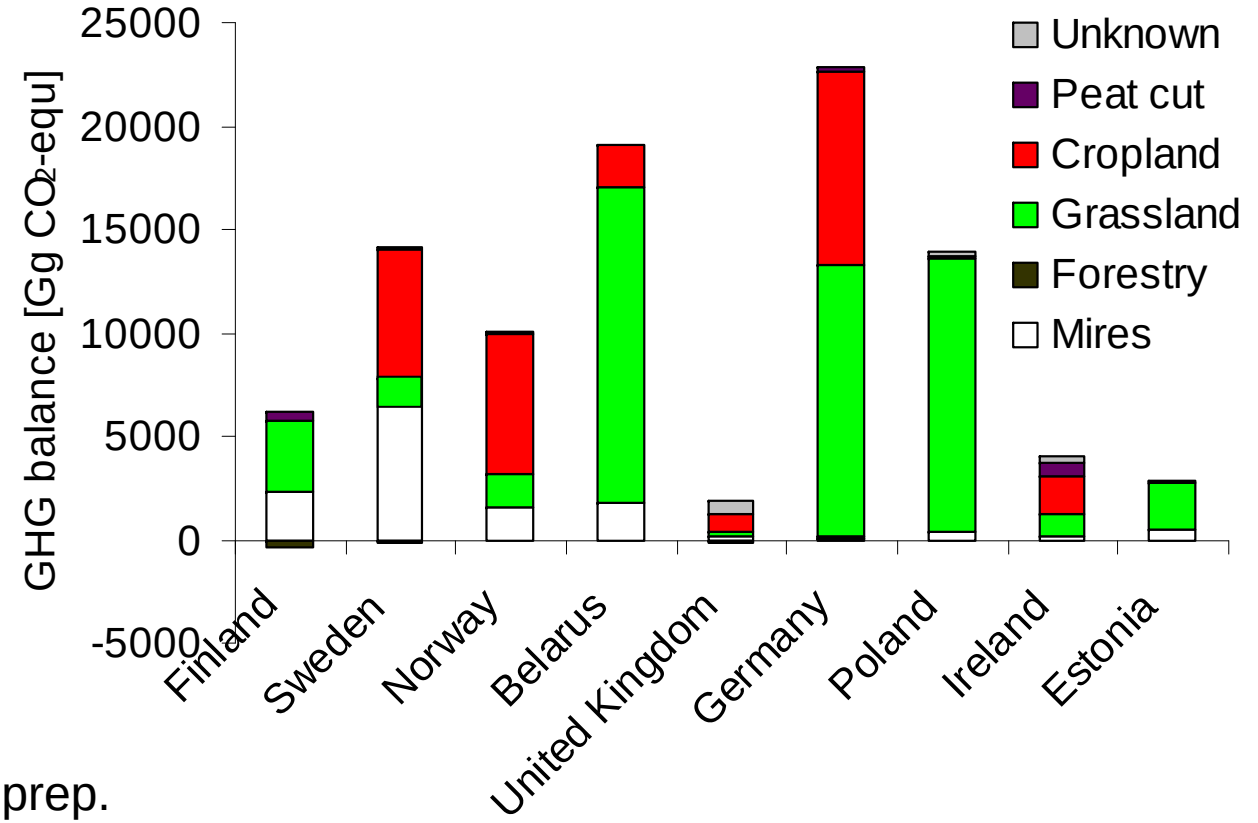


Freibauer et al. In prep.

GHG emissions from peatlands by country

(Old emission factors; Drösler et al. 2008)





Freibauer, Droesler et al in prep.

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)!

- Some 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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peatland synt

German input:
Nationally funded sites

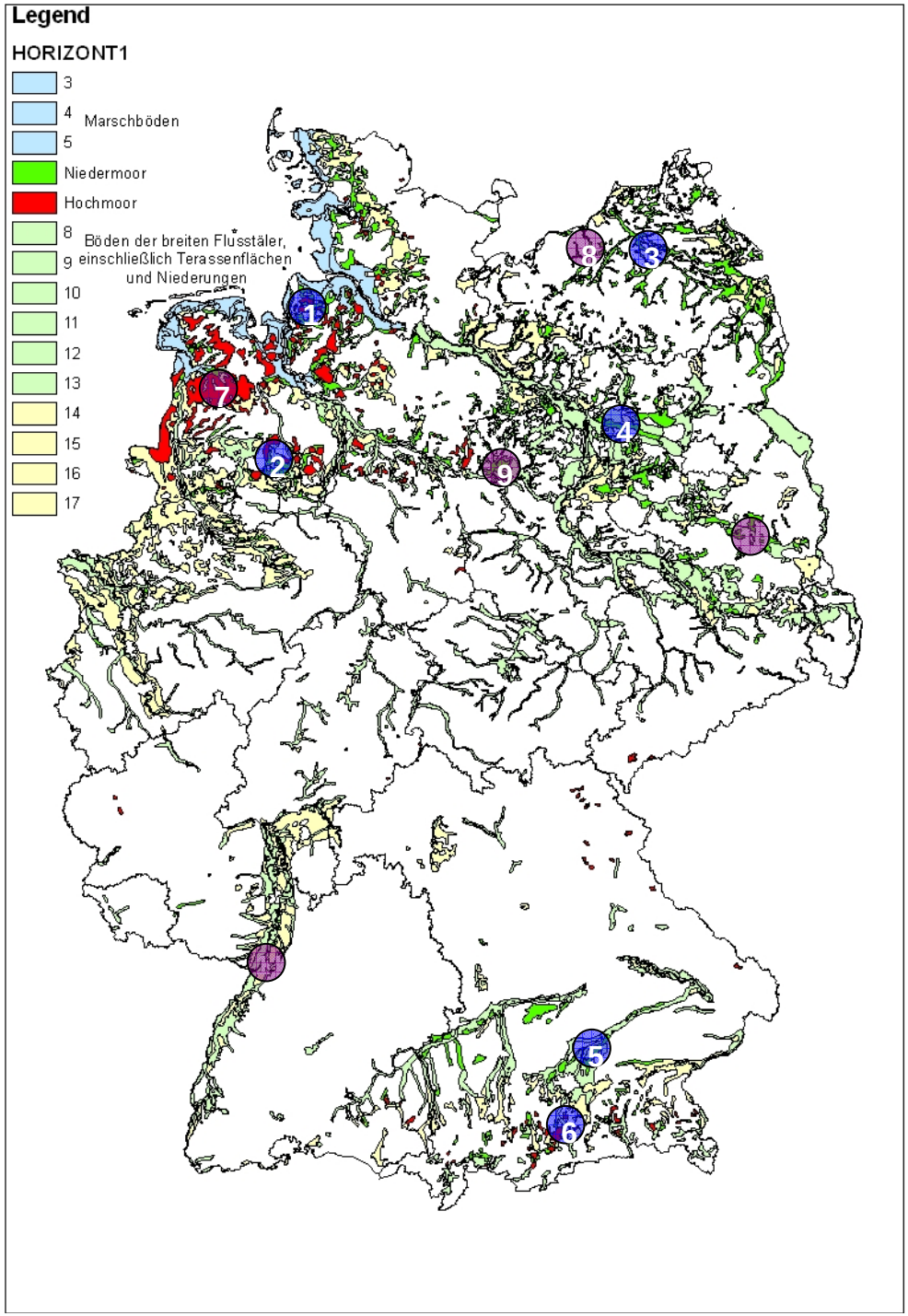
Blue sites BMBF-project
2006-2010

GEFÖRDERT VOM
Bundesministerium für Bildung und Forschung

klimazwei
Risiken mindern · Chancen nutzen

Blue and purple sites vTI-project
2009-2012

vTI
Johann Heinrich von Thünen-Institut



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Research partners – BMBF project

GEFÖRDERT VOM
Bundesministerium für Bildung und Forschung

Vegetationsökologie

TUM-VÖK — Matthias Drösler, Wolfram Adelmann, Lindsey Bergmann, Christoph Förster, Julia Hermann

IÖW — Ulrich Petschow, Alexandra Dehnhardt, Stefan Görlitz, Philipp Schägner

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MPI-BGC — Annette Freibauer, Catharina Don Maria-Hahn Schöfl, Angelika Thuille

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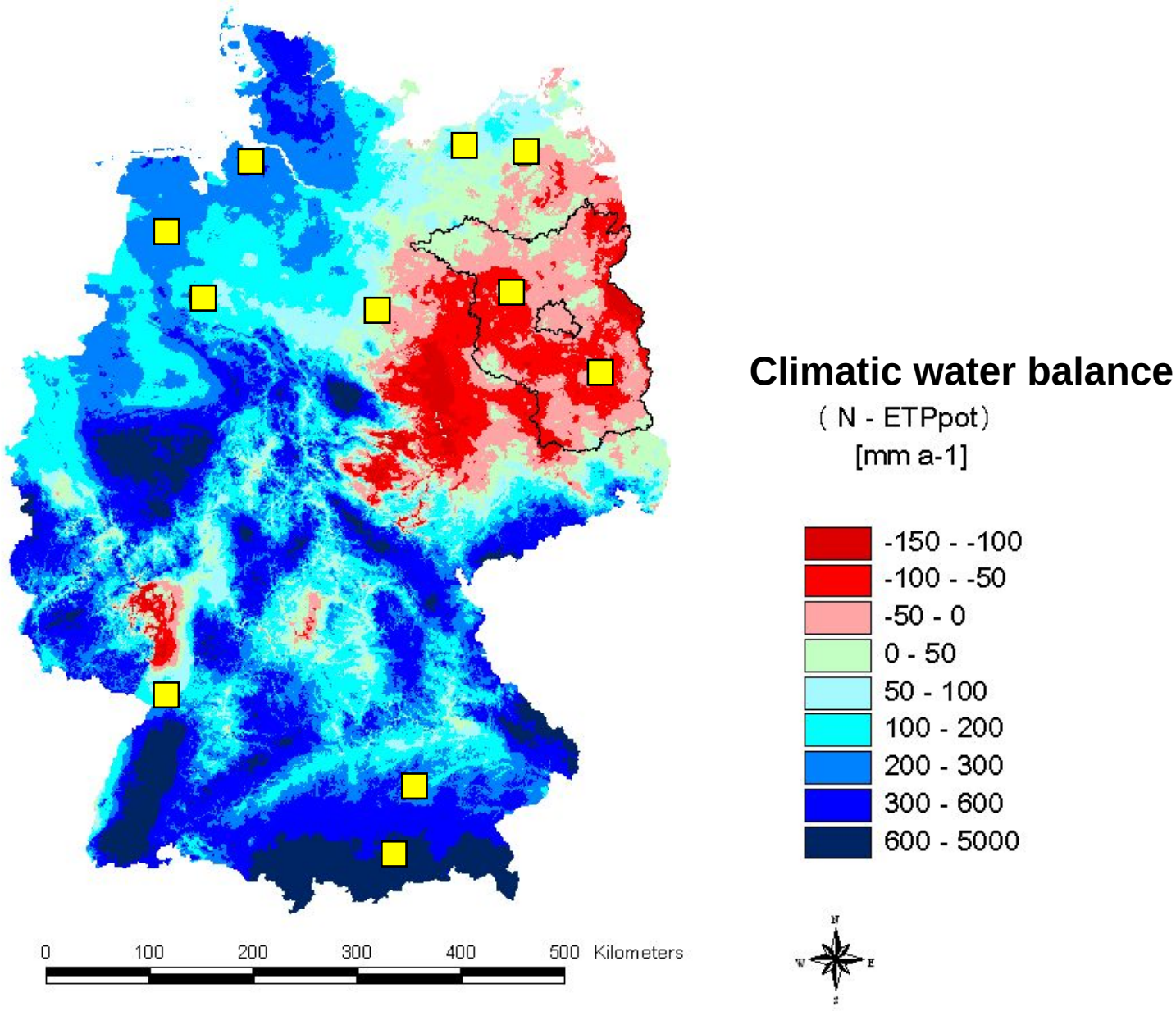
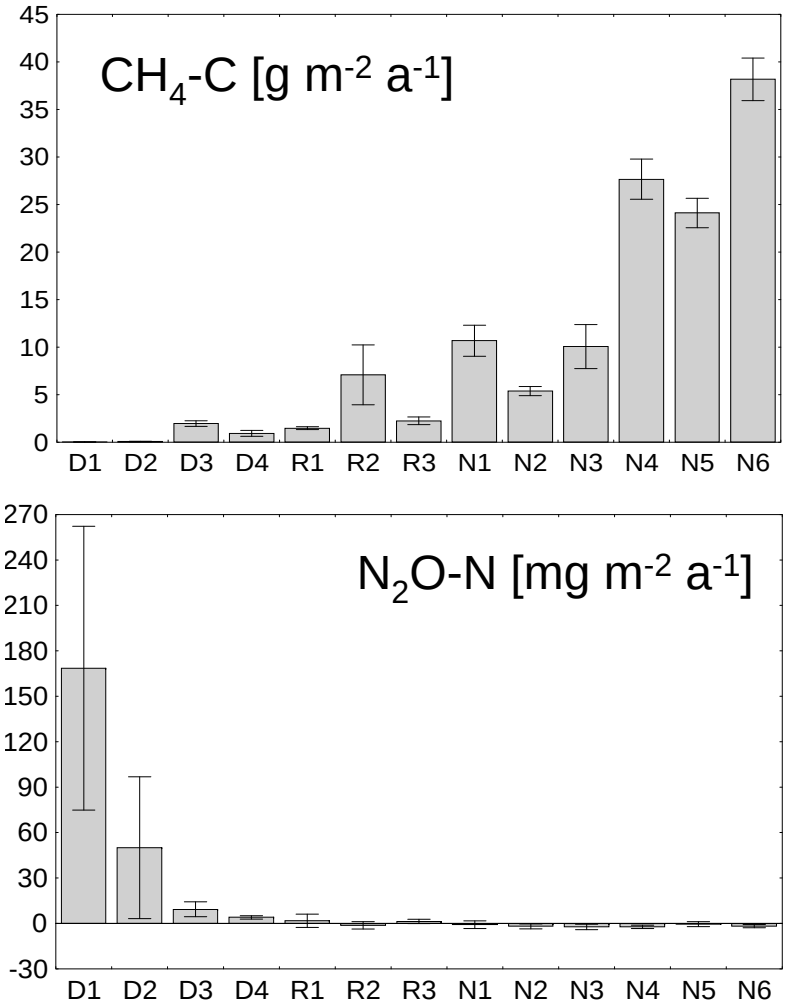
ZALF-LSD — Jürgen Augustin, Madlen Pohl, Elisabeth Boraz, Michael Giebels, Merten Minke, Maarten Schmid,

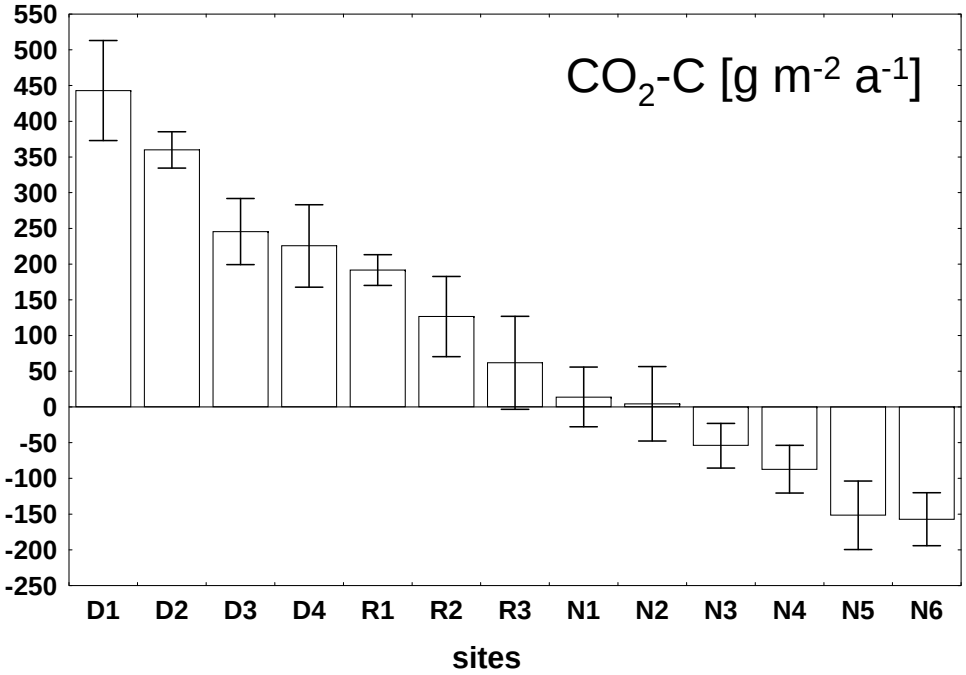
Leibniz-Zentrum für Agrarlandschaftsforschung (ZALF) e. V.

peatland study: representative selection of sites



GHG-Fluxes bog KMF

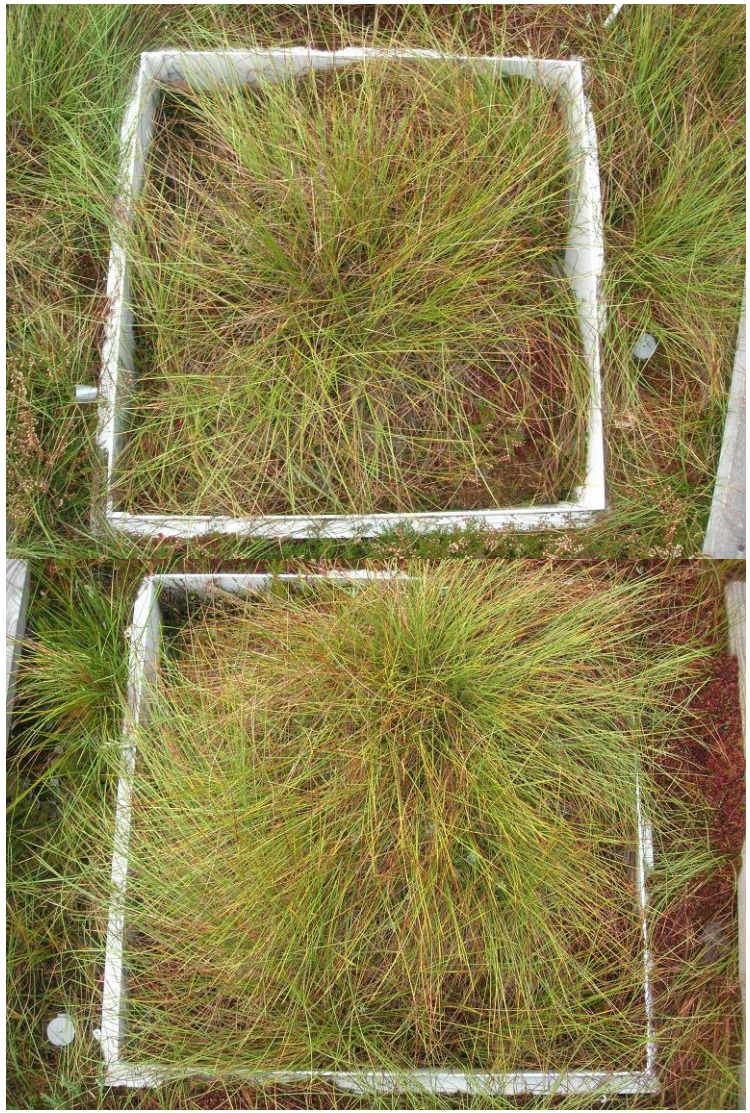




D1, D2:	aufgelassener trockener Torfstich
D3, D4:	vorentwässerte Hochmoorheide
R1:	gefluteter ehemaliger Torfstich
R2:	renaturierte feuchte Hochmoorheide
R3:	renaturierter Sphagnenrasen
N1, N2:	feuchte Hochmoorheide
N3:	Sphagnenrasen
N4:	Eriophorum-Bulte
N5:	Übergang Bult-Schlenke
N6:	Schlenke

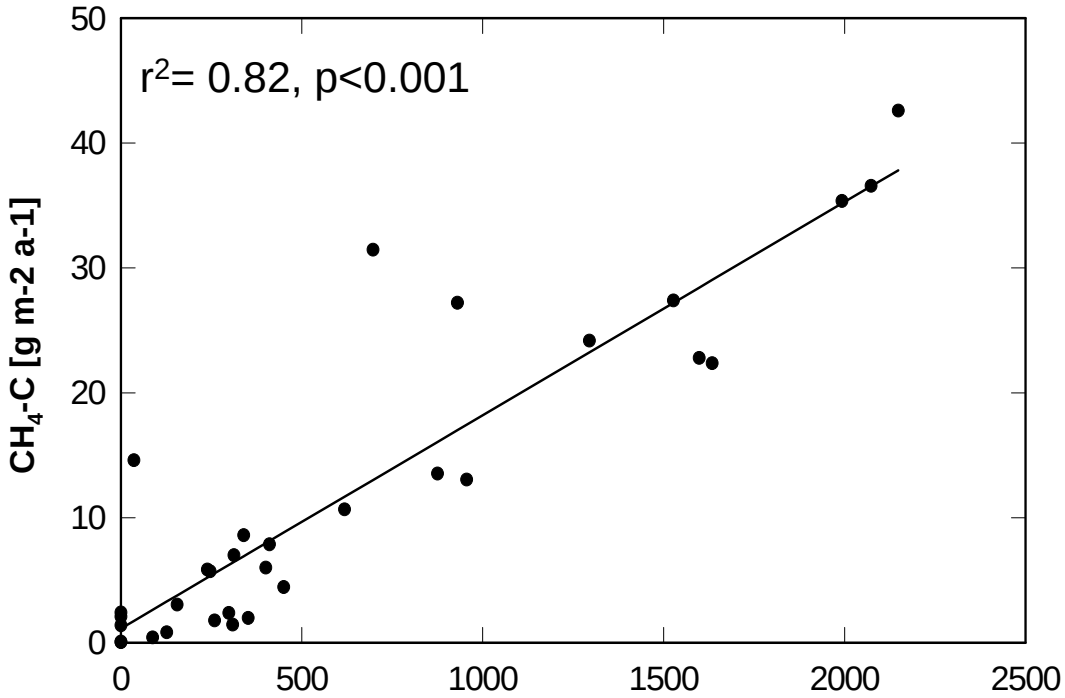
(Drösler 2005)

Functional role of Vegetation for CH_4-emissions



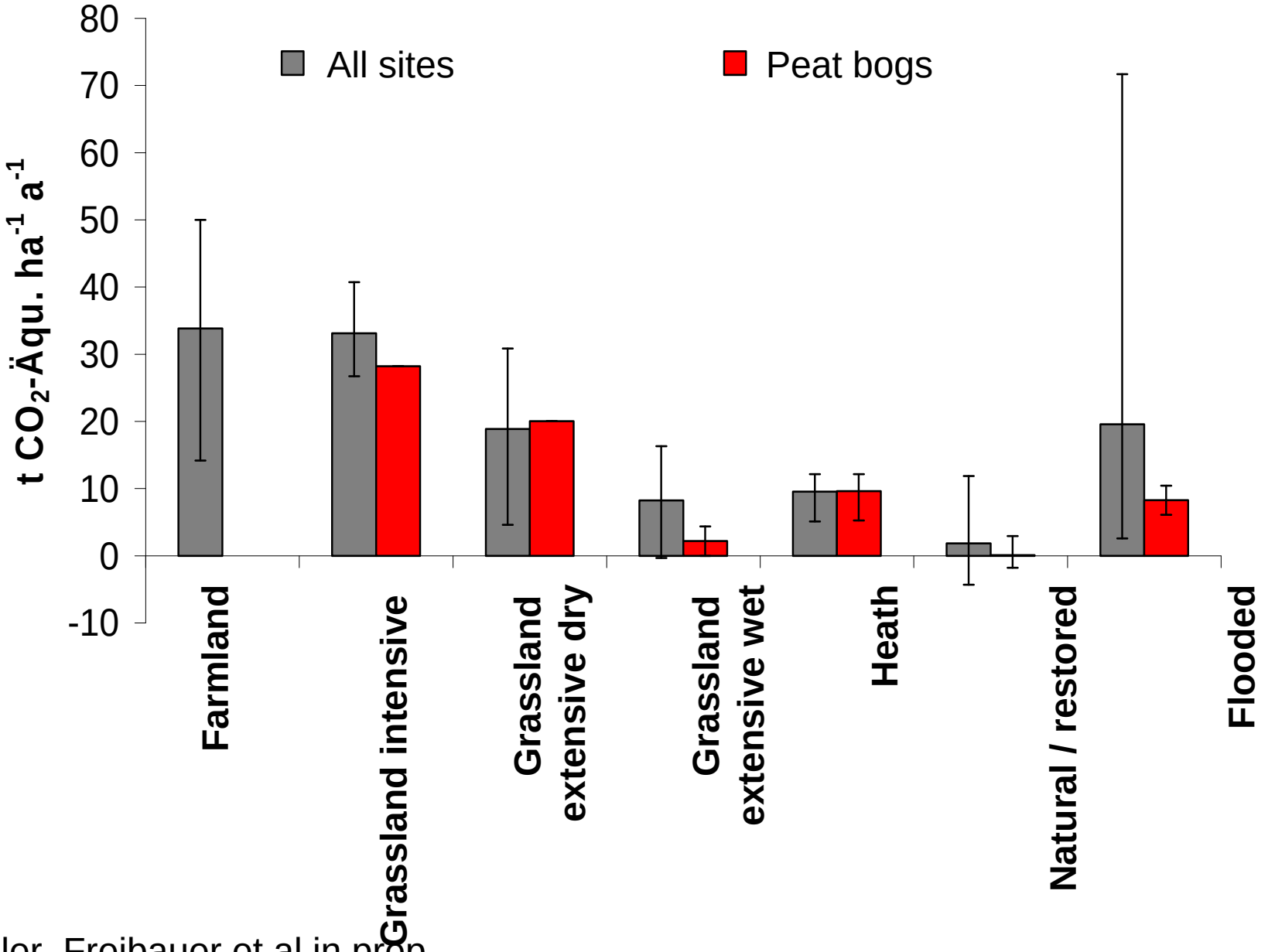
Eriophorum vaginatum

Aerenchymgewebe



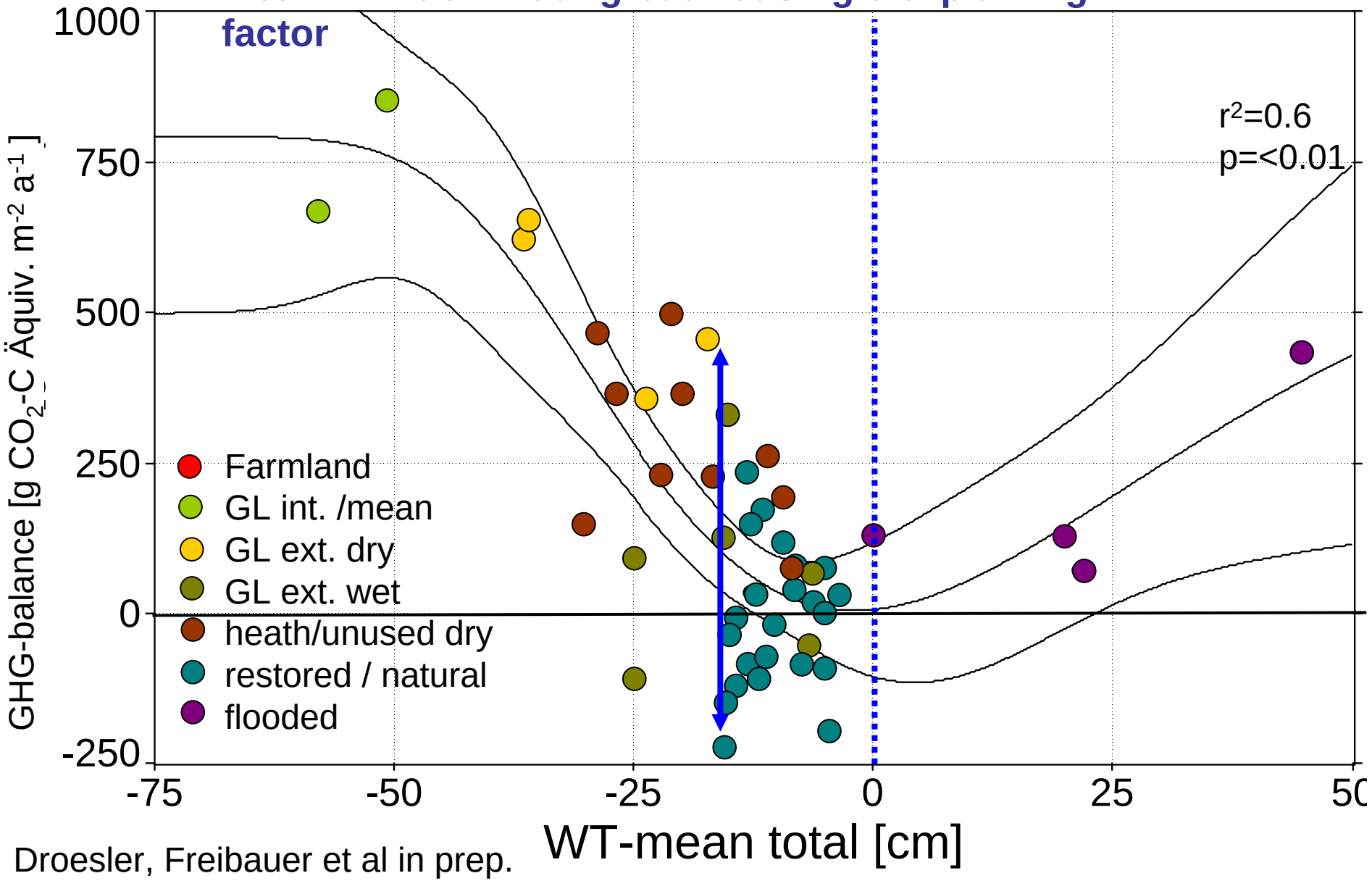
(Drösler 2005)

GHG-balance - German bogs



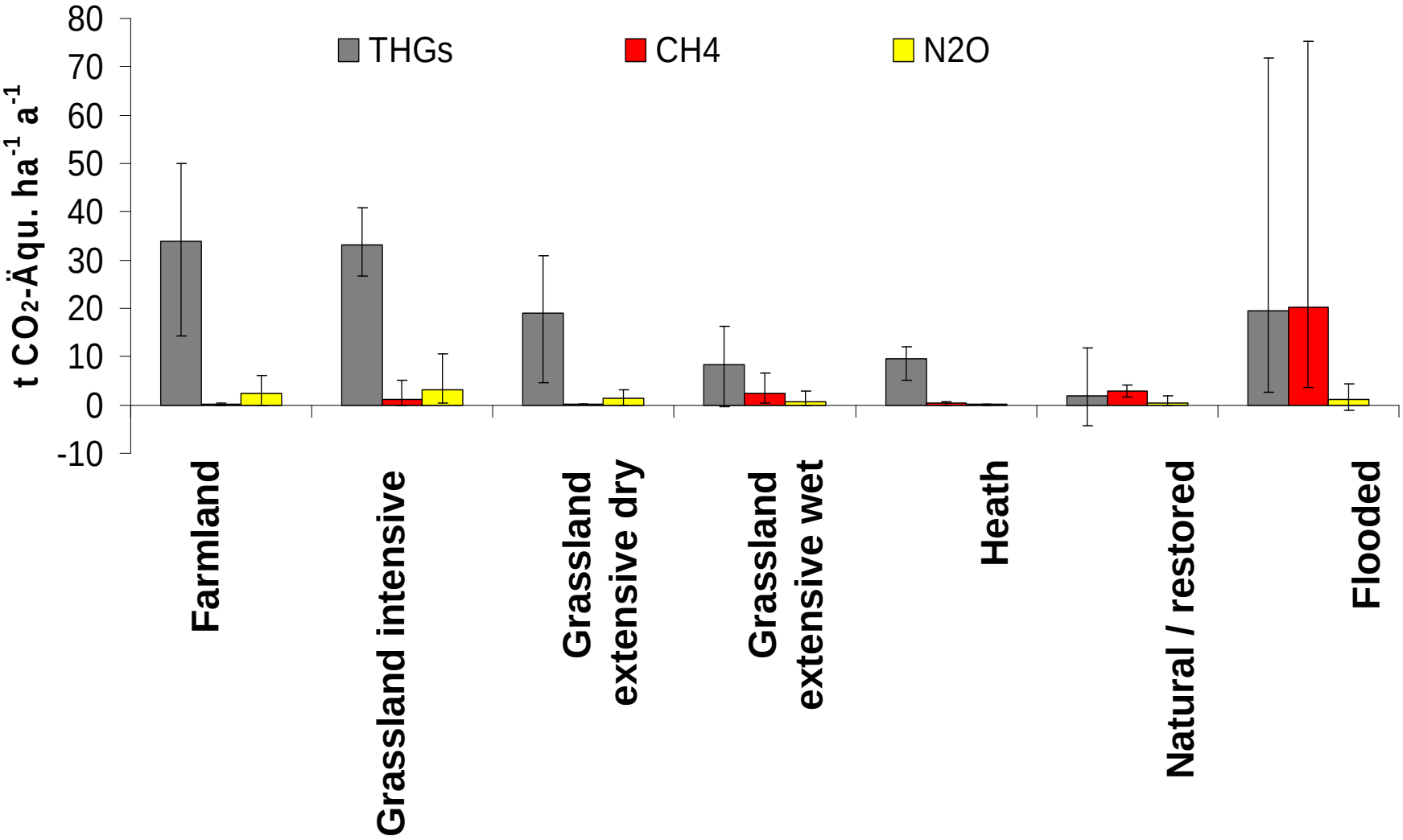
Droesler, Freibauer et al in prep.

GHG-balance vs. WT - German bogs



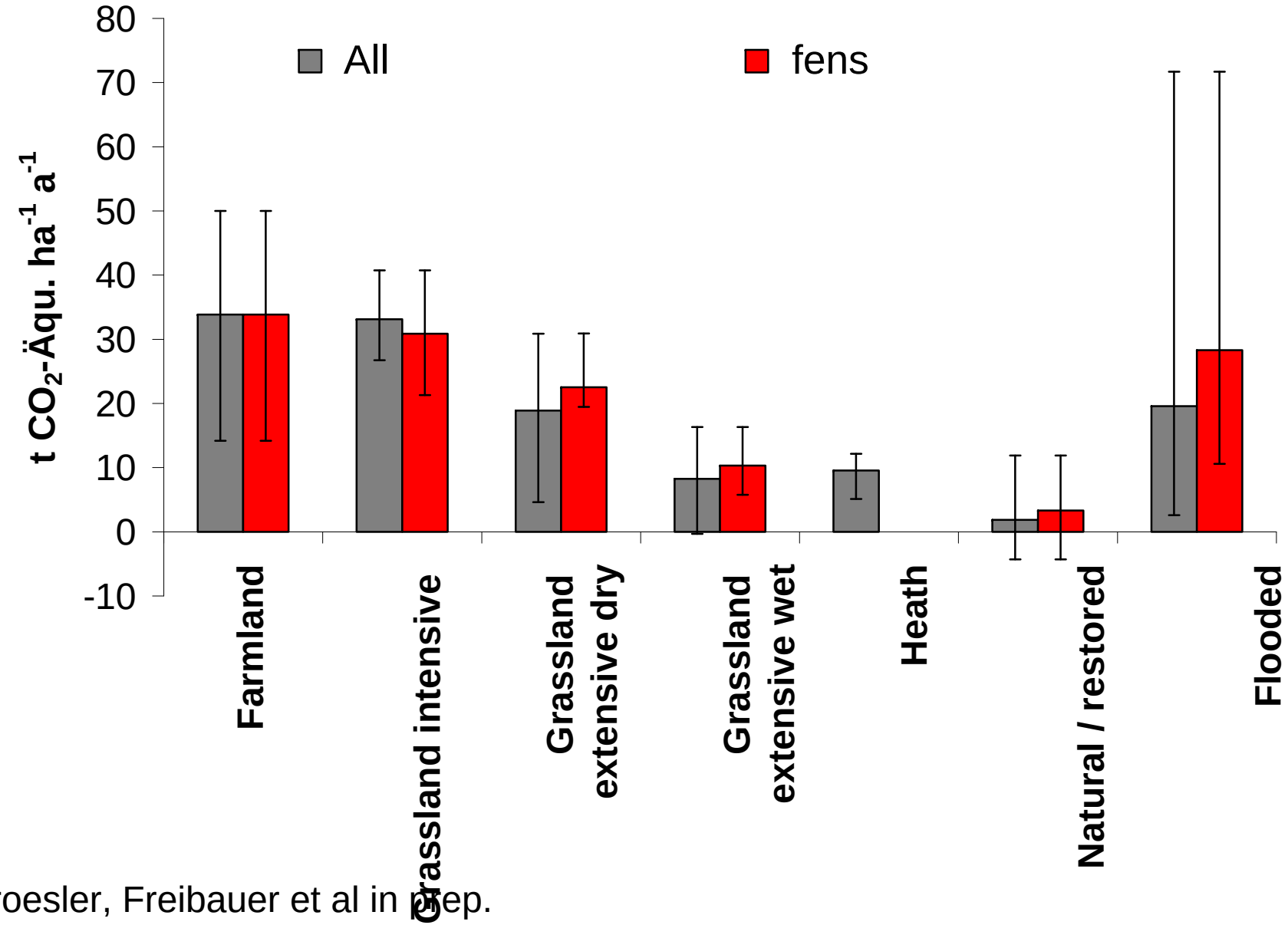
Droesler, Freibauer et al in prep.

GHG-balances - German fens



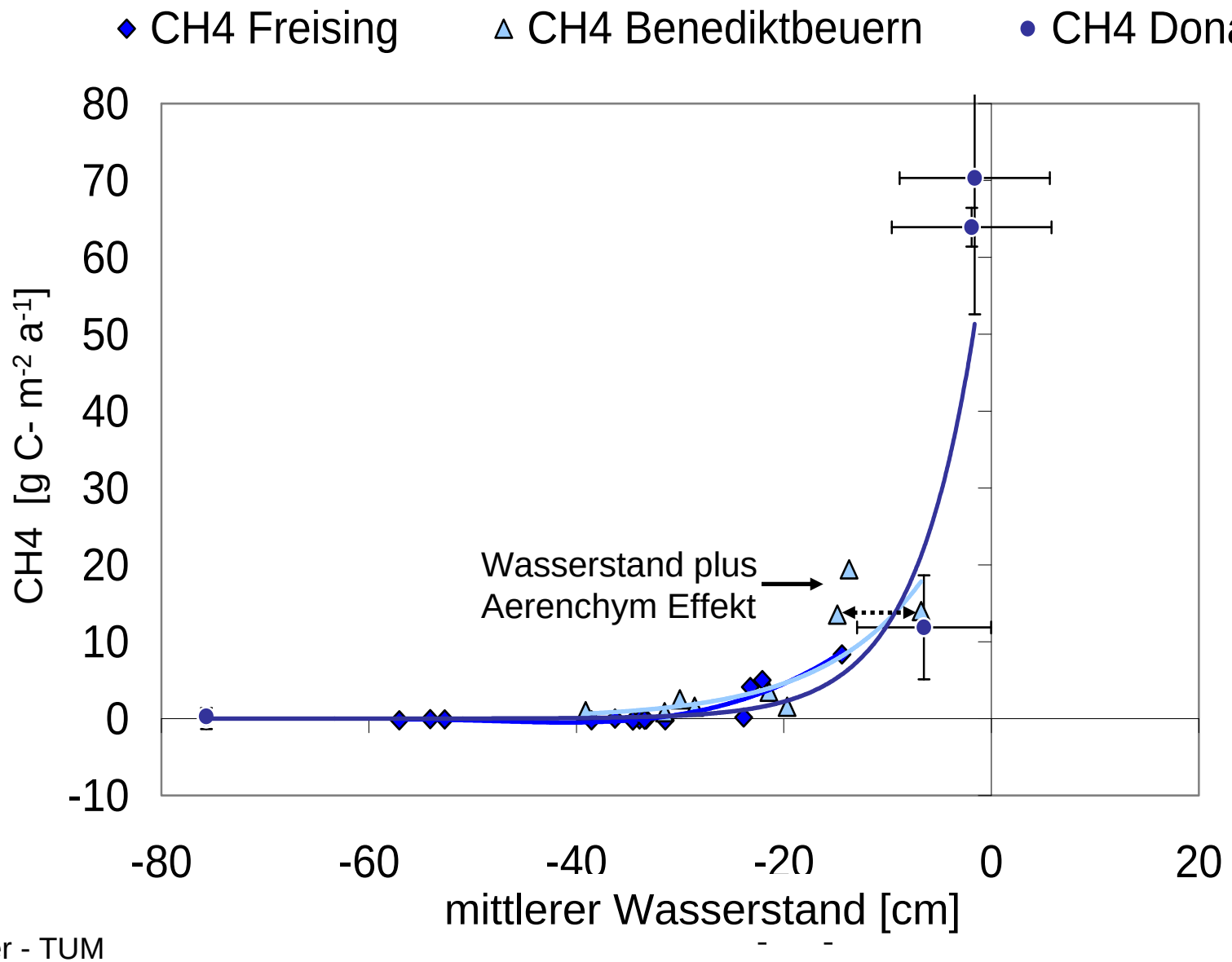
Droesler, Freibauer et al in prep.

GHG-balance - German fens



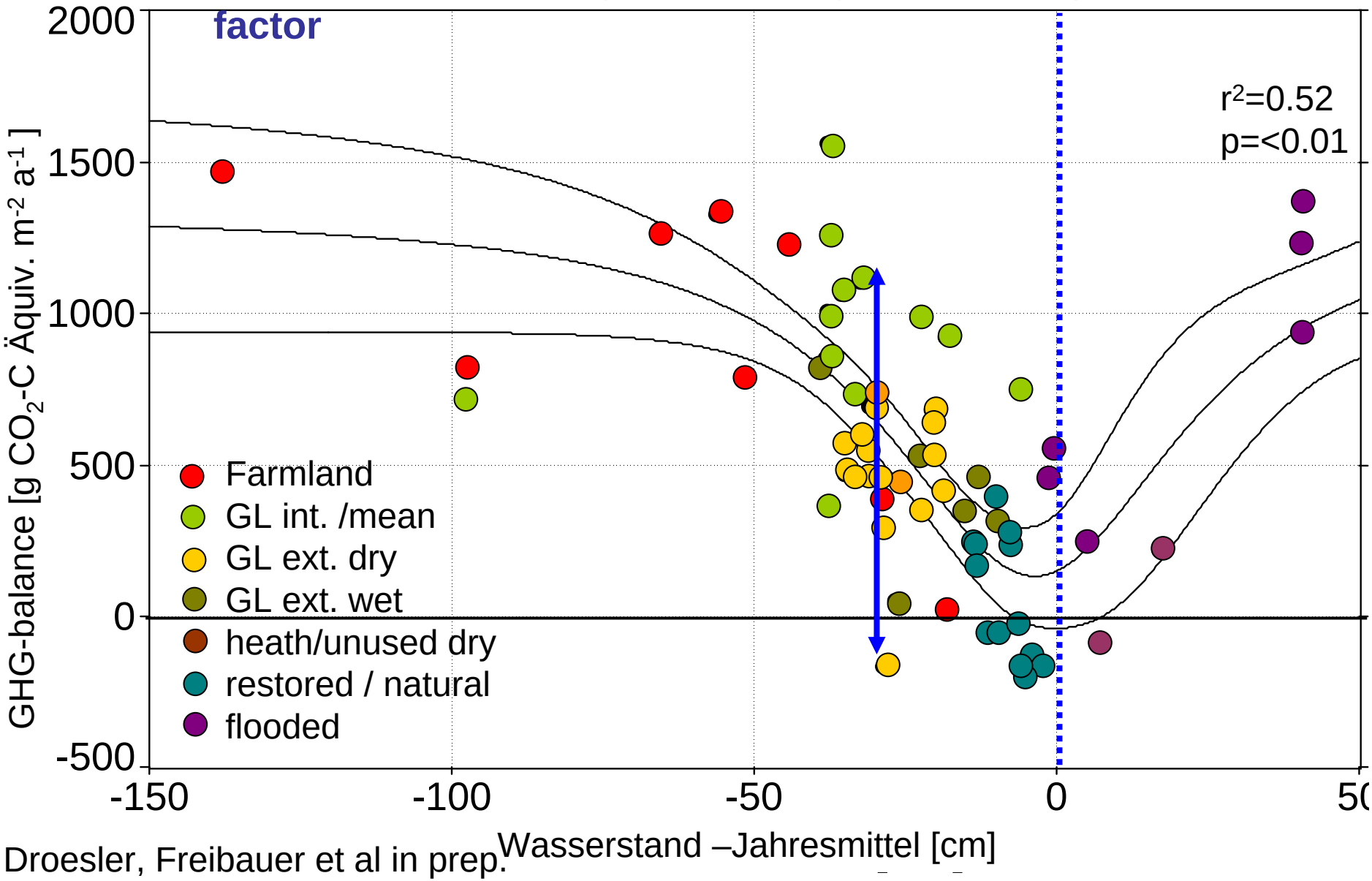
Droesler, Freibauer et al in prep.

Methan-Risiken



GHG-balance vs. WT - German fens

Mean WT: dominating but not single explaining factor

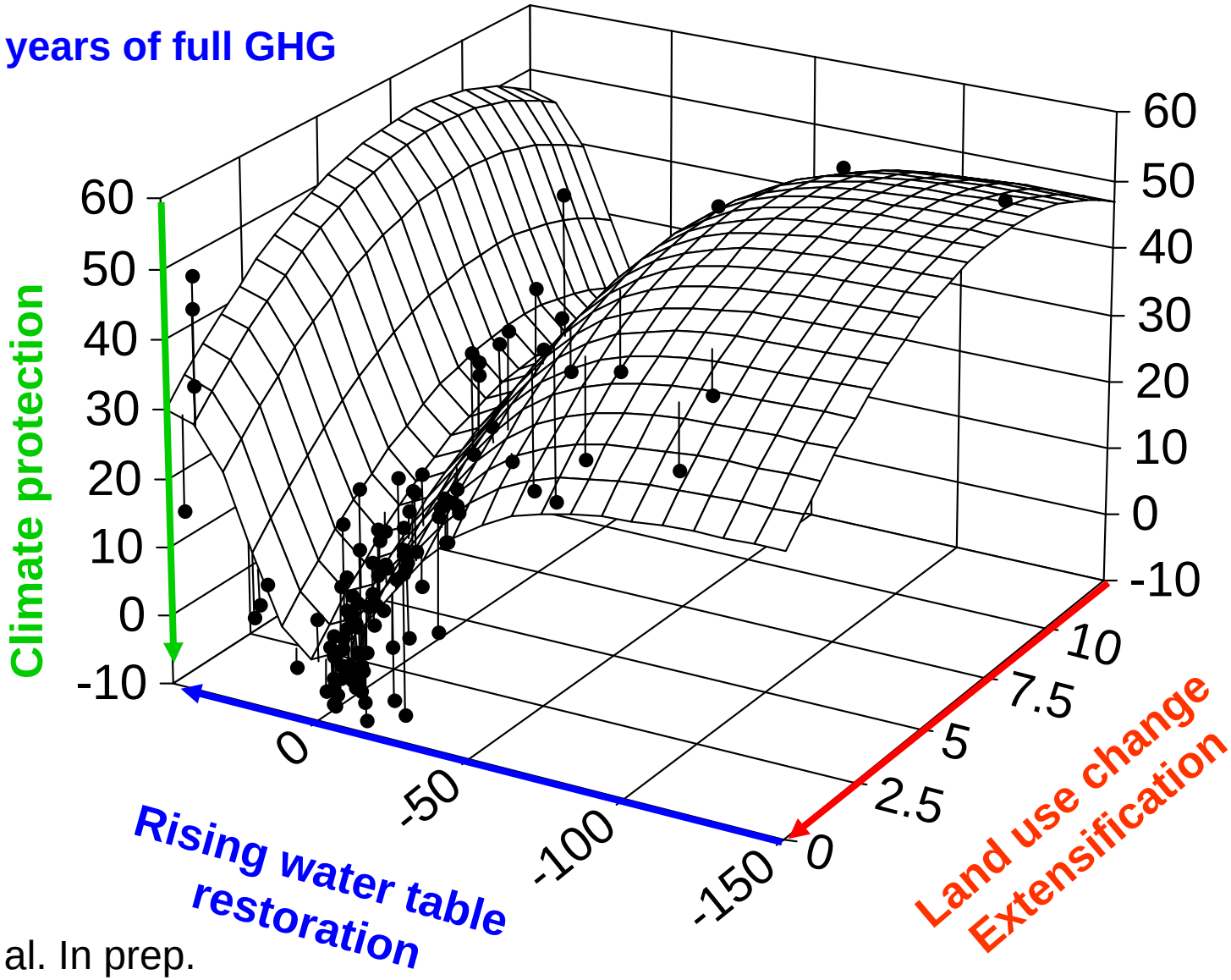


Droesler, Freibauer et al in prep.

GHG vs. WT vs. land use intensity
bogs and fens

130 site years of full GHG

r^2=0.72
p=<0.01



Drösler et al. In prep.

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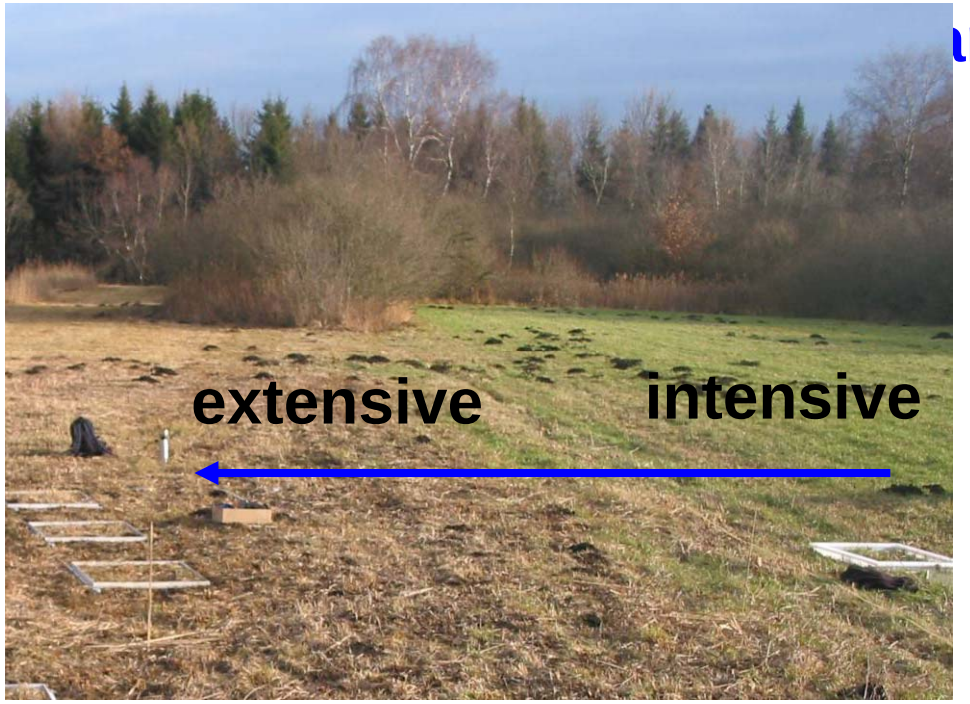
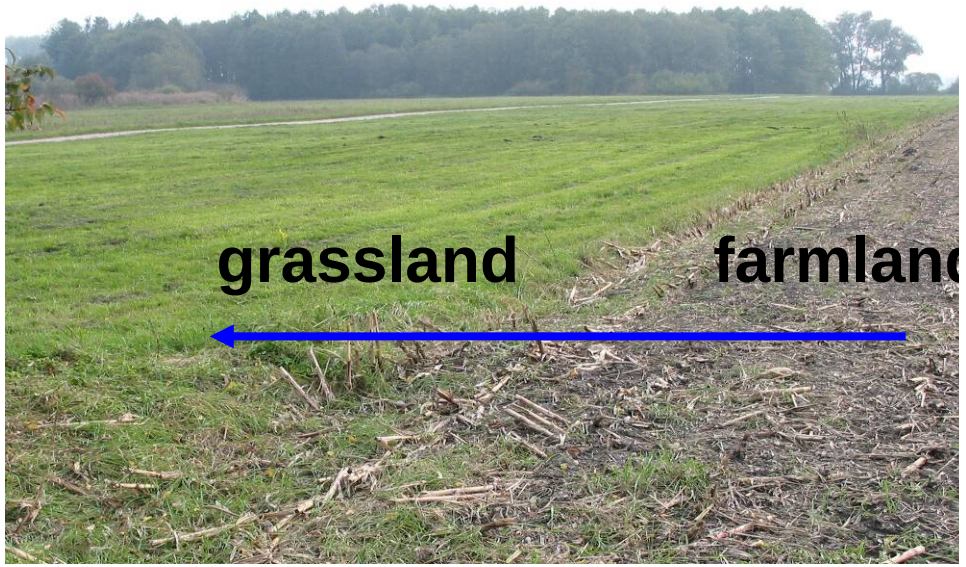
Management level

extensivication

land use





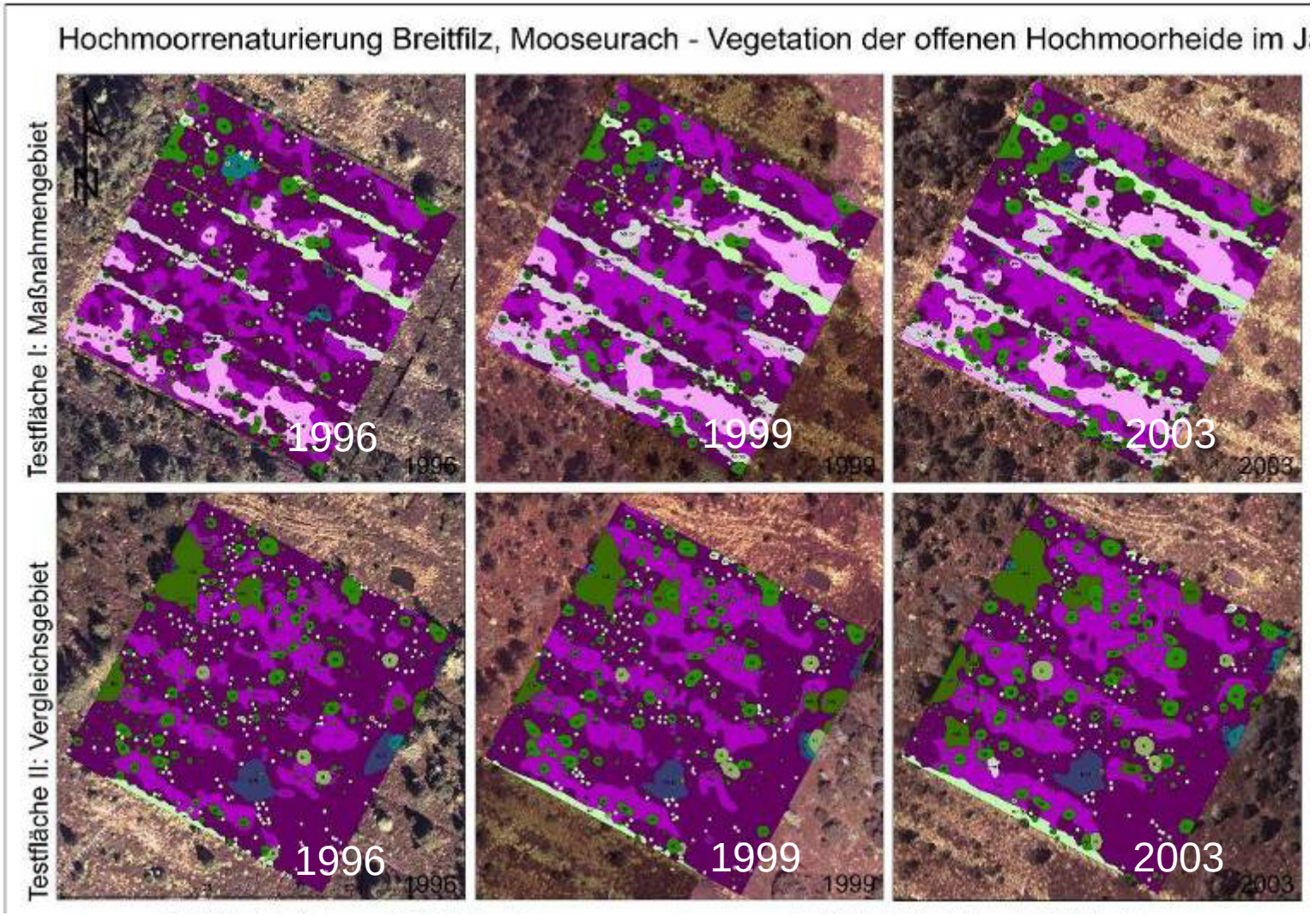
restoration

Vegetation dynamic after restoration

monitoring: bog vegetation as indicator for restoration succes

restored

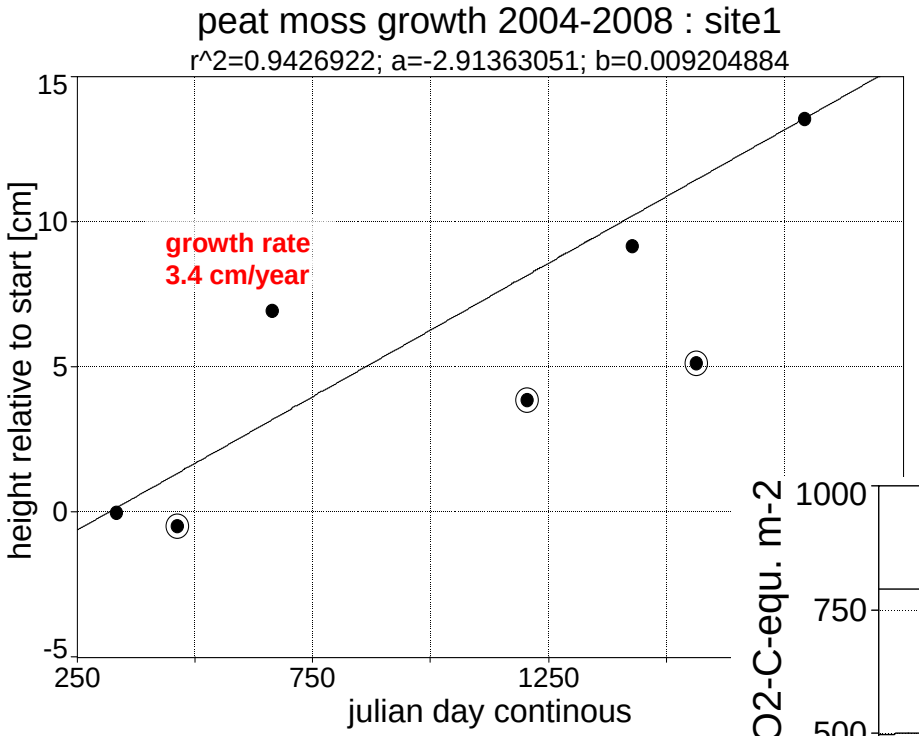
drained

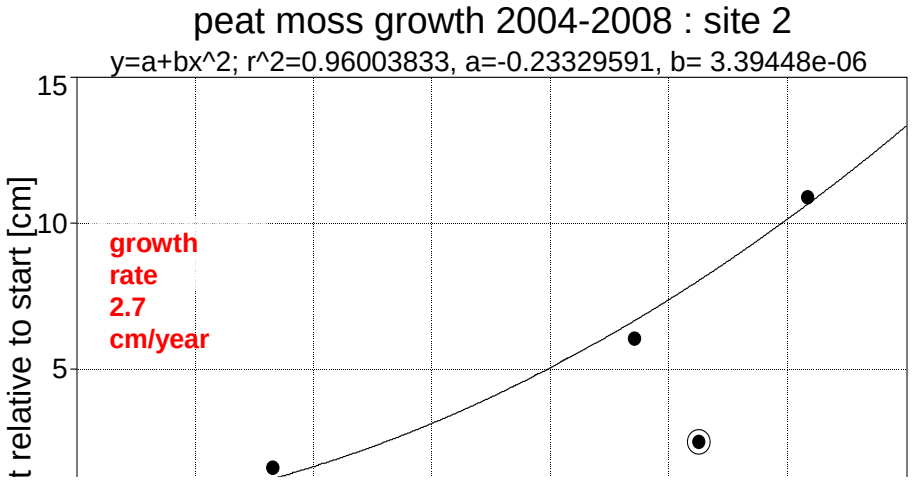


Peat moss development after restoration

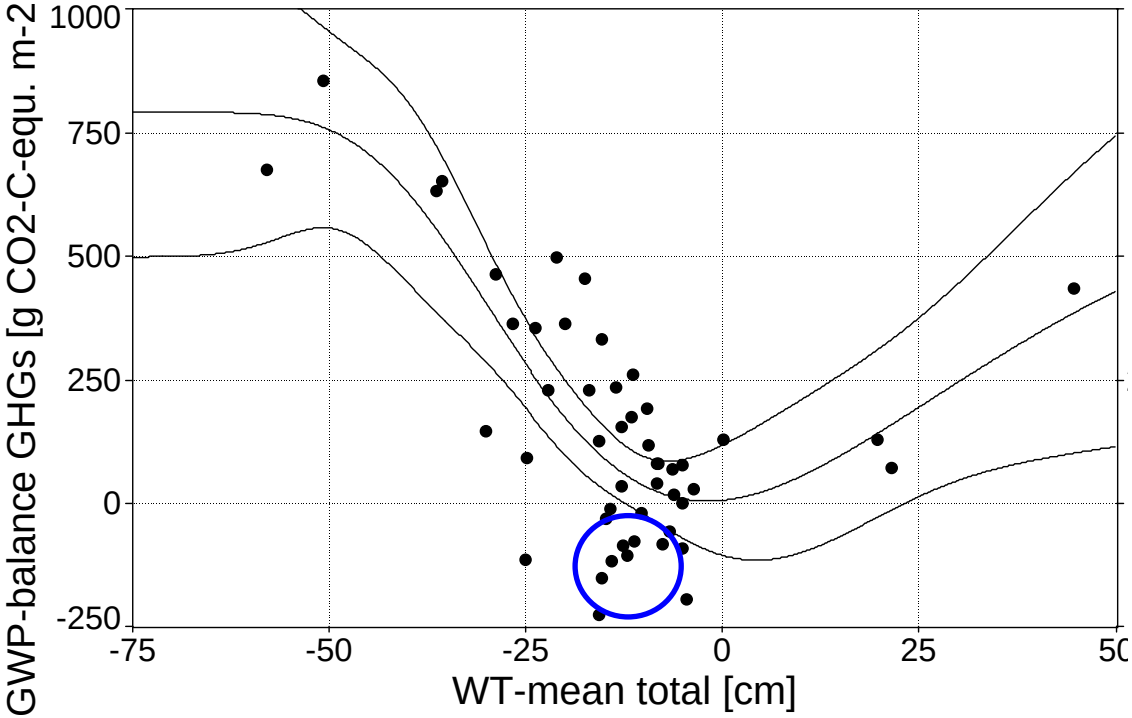
Mooswachstumsmessflächen und Messmethode

Peat moss development after restoration

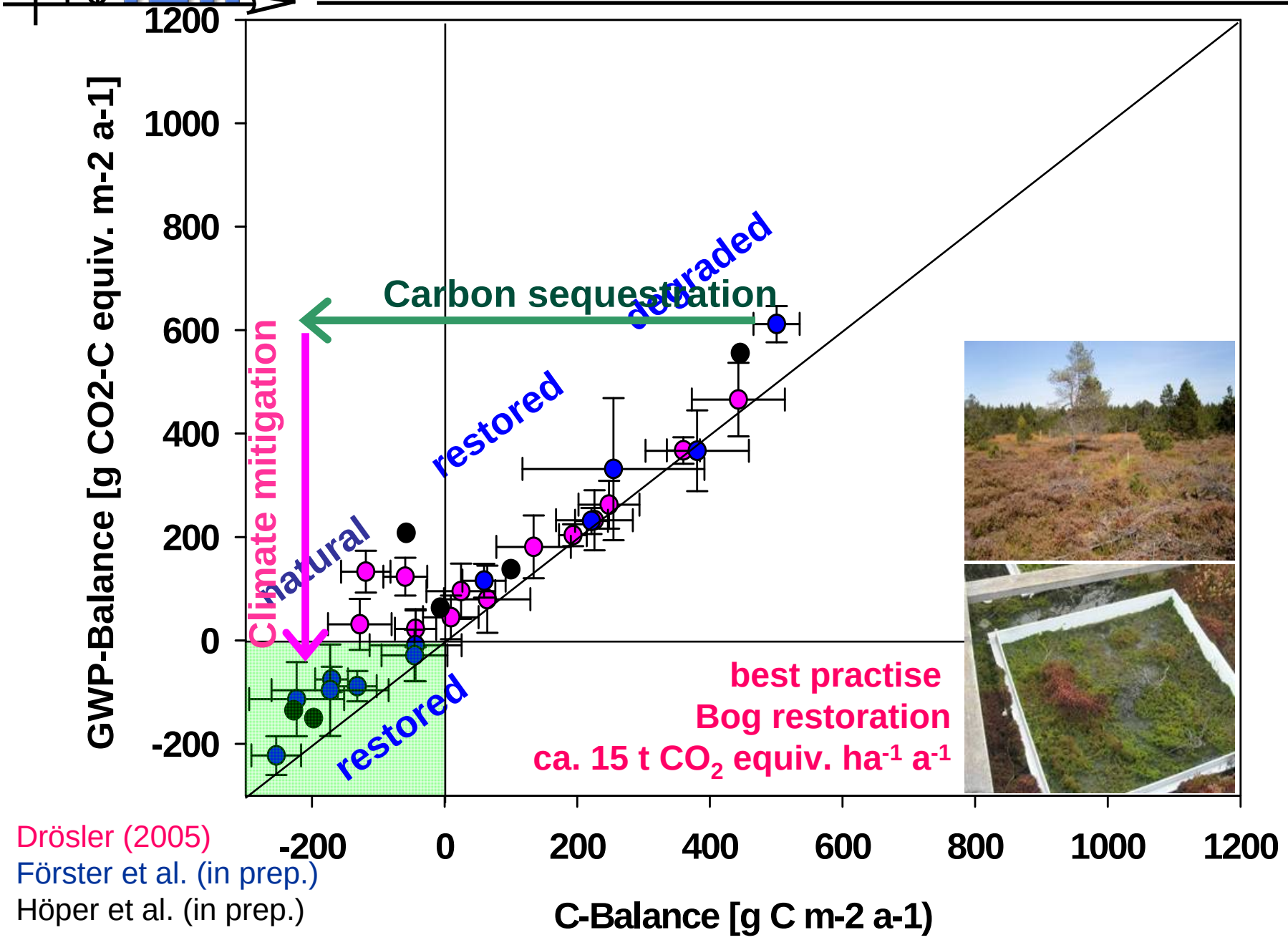




Peat moss growth rates

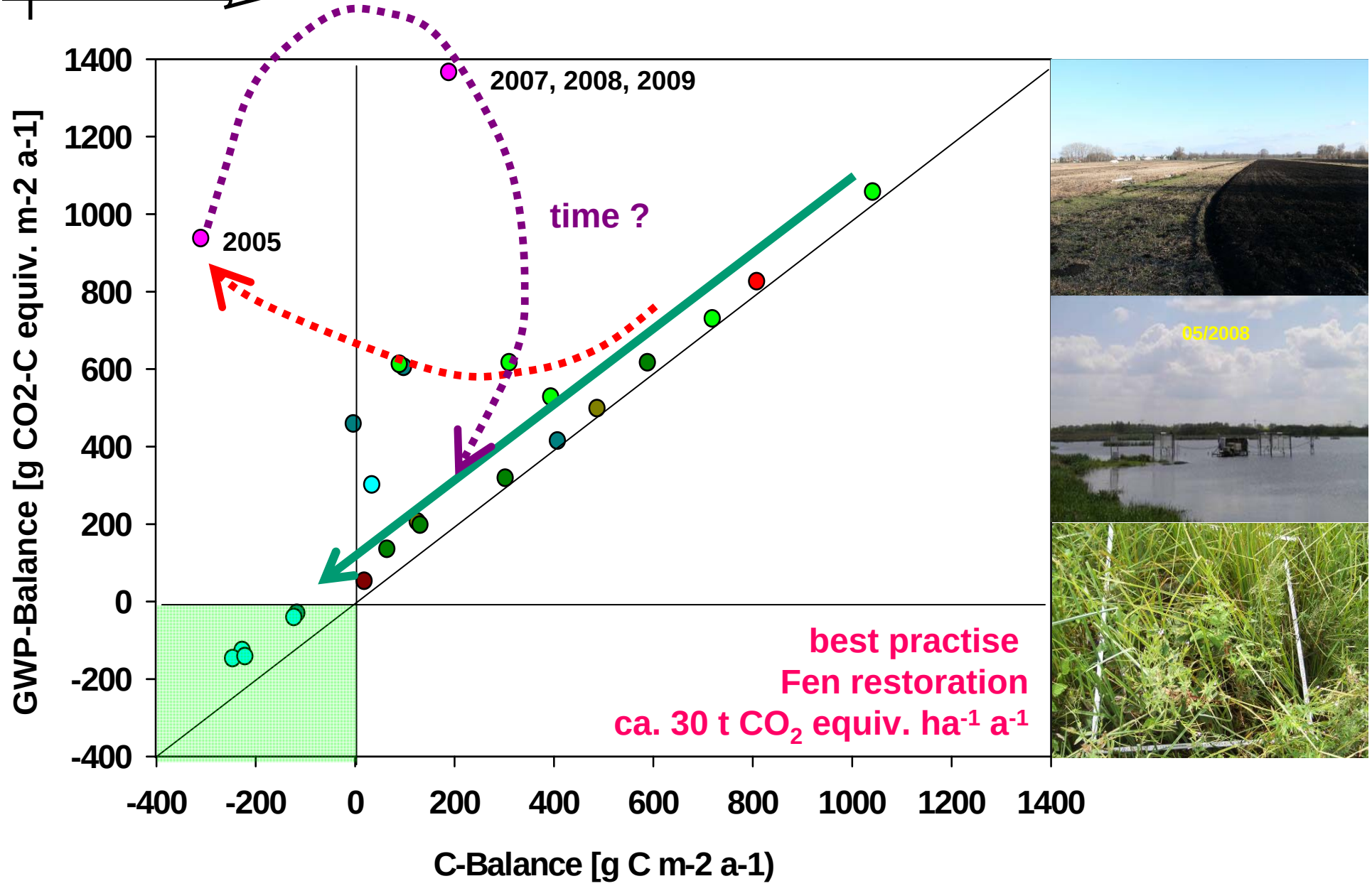


GHG-reduction potential – German bogs



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

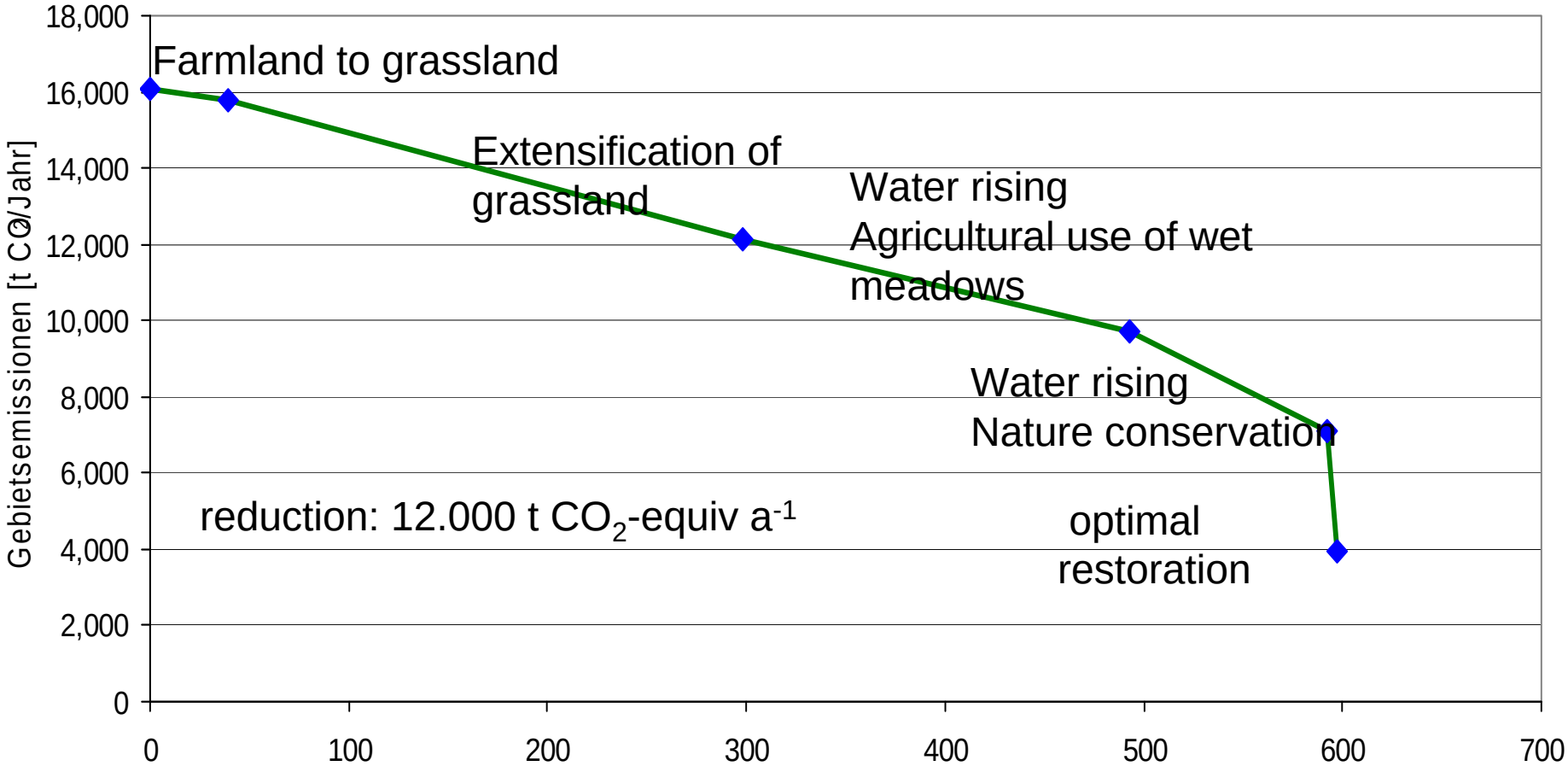
C- und Treibhausgasbilanz von Niedermoore



Niedermoor-Renaturierung: Gefluteter Polder Zarnekov

(Jürgen Augustin, ZALF)

Reduction of area emissions FS-Moos



CO_2-abatement costs: 9 – 64 Euro /t CO_2

GHG-Balances German peatlands

C-pool in German peatlands 1200 – 2400 Mio t

Emissions from German peatlands up to
45 Mio t CO_2 equiv/a (NIR2010)

→ peatlands are among the biggest single sources
5 % of the overall climate impact of Germany

30 % ot the emissions of the whole farming sector
from peatland agriculture unless just
8 % of farmland on organic soils

→ big emission-reduction potentials at small land proportion

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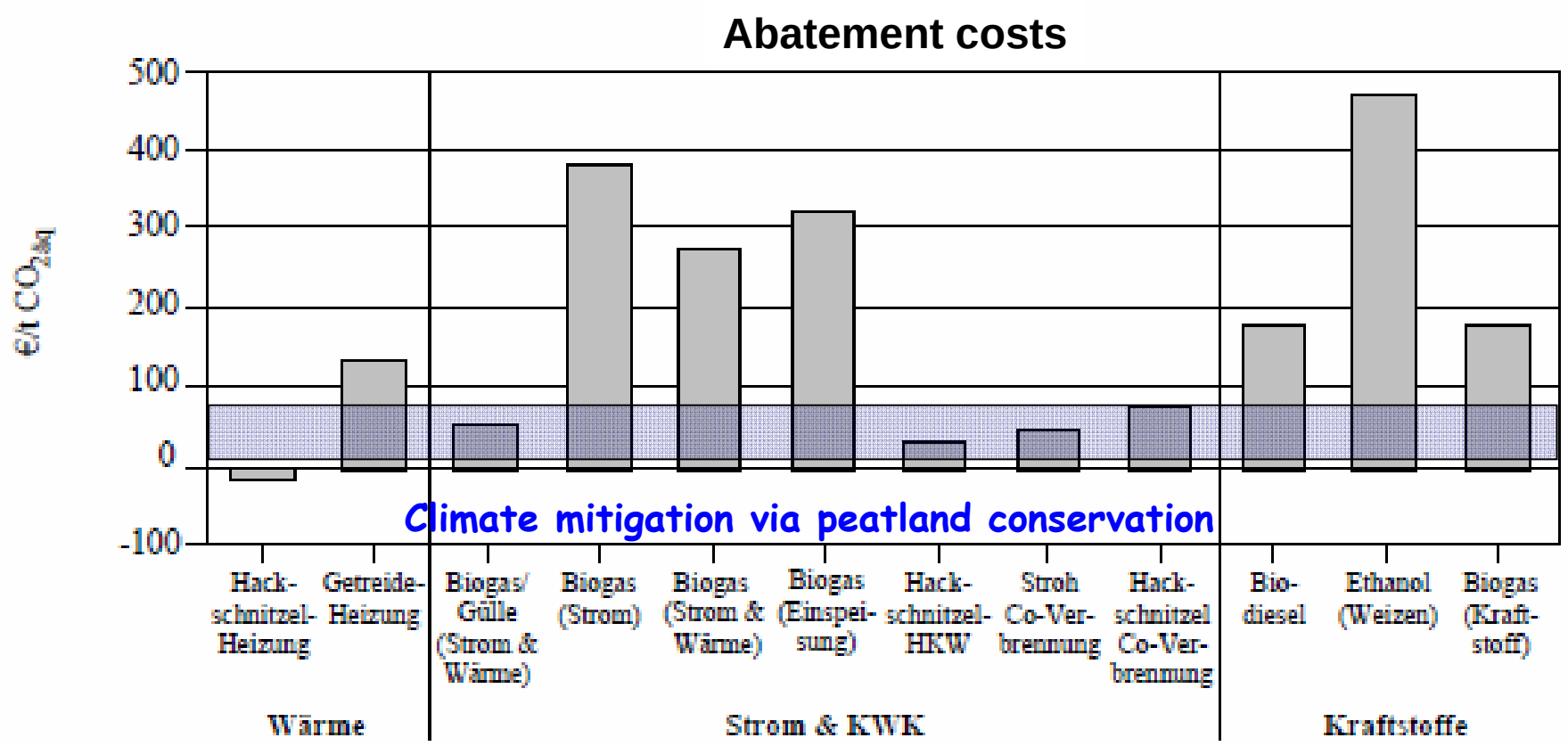
Mitigation potential via peatland restoration

Estimated emission reductions

Ca. 30 t CO_2 equiv. / ha a in fens

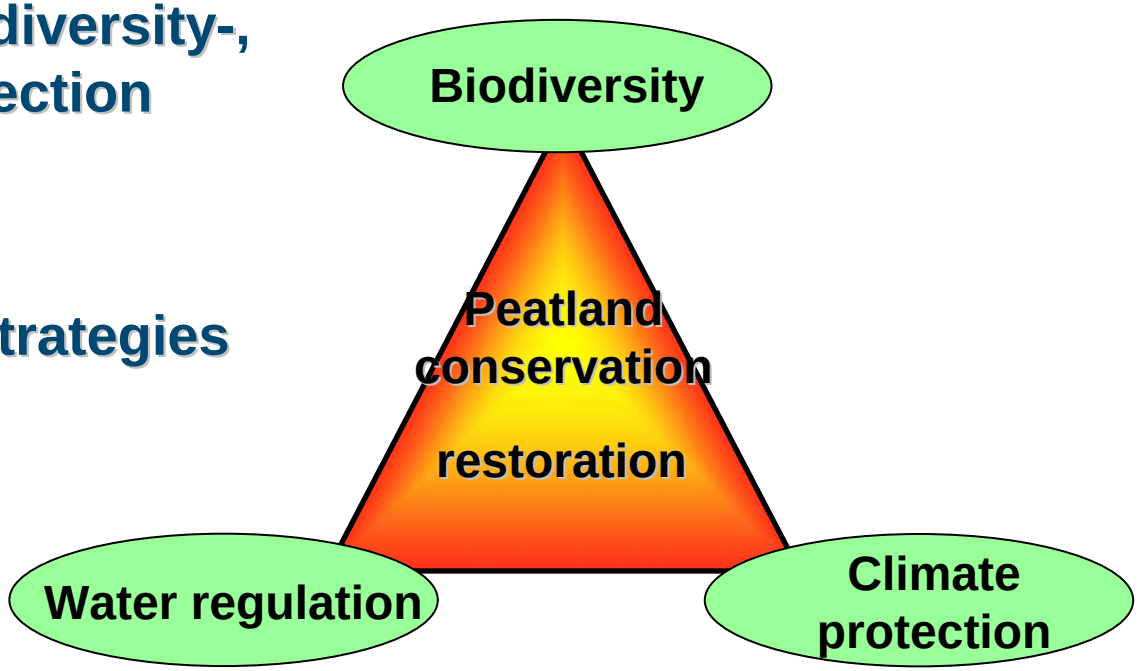
Ca. 15 t CO_2 equiv. / ha a in bogs



Wiss. Beirat Agrarpolitik beim BMELV, 2007

conclusions

- 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)

- Integration of ecological services (climate, biodiversity, water) in agricultural funding schemes within CAP
- pay land users on organic soils for producing ecological services

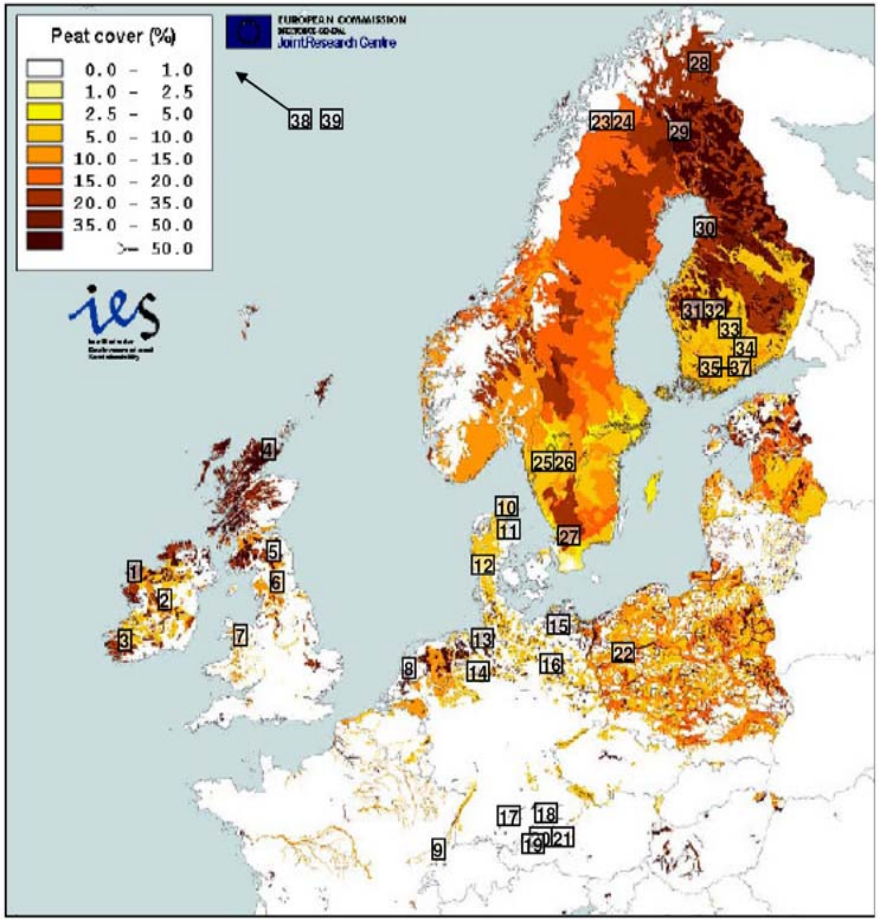
- But: Monitoring & modelling of the effects needed!

EU-FP7 Project (2010-2013)

GHG-Europe (coord. vTI)

Greenhouse gas management in European land use systems

activity 2.1: peatland synthesis (TUM-VÖK)



Country	Site code in the map	Site name	Contact person who is confirmed the participation with site data	Institution
Ireland	1	Bellacorick	David Wilson	University College Dublin
	2	Turraun	David Wilson	University College Dublin
	3	Glencar	Anna Laine	Metla
United Kingdom	4	Forsinand	Mark Sutton	CEH
	5	Auchencorth	Mark Sutton	CEH
	6	Moorhouse	Mark Sutton	CEH
	7	Conway	Mark Sutton	CEH
Netherlands	8	Horstermeer	Han Dolman	VUA
France	9	Frasne	Fatima Lagoun	Universités Orléans
Denmark	10	Store Vildmose	Søren O. Petersen	Aarhus University
	11	Mørke	Søren O. Petersen	Aarhus University
	12	Skjern	Søren O. Petersen	Aarhus University
Germany	13	Ahlenmoor	Heinrich Höper	LBEG
	14	Dümmer	Heinrich Höper	LBEG
	15	Peental	Jürgen Augustin	ZALF
	16	Rhin-Havelluch	Jürgen Augustin	ZALF
	17	Donauried	Matthias Drösler	TUM
	18	Freisinger Moos	Matthias Drösler	TUM
	19	Benediktbeuern	Matthias Drösler	TUM
	20	Mooseurach	Matthias Drösler	TUM
	21	Kendlmühlfilze	Matthias Drösler	TUM
Poland	22	Rzecin	Bogdan Choijnicki	ACAUP
Sweden	23	Storflaket	Torben Christensen	GBC
	24	Stordalen	Torben Christensen	GBC
	25	Skogaryd	Leif Klemedtsson	Uni-Göteborg
	26	Falköping	Leif Klemedtsson	Uni-Göteborg
	27	Fäjemyr	Magnus Lund	BGC
Finland	28	Kaamanen	Tuomas Laurila, Eeva-Stiina Tuittila	FMI
	29	Lompolojänkkä	Tuomas Laurila	FMI
	30	Siikajoki	Eeva-Stiina Tuittila	Metla
	31	Alkkia	Tuomas Laurila	FMI
	32	Aitoneva	Harri Vasander, Mika Aurela	UHEL, FMI
	33	Siikaneva	Timo Vesala; Eeva-Stiina Tuittila	UHEL
	34	Vesijako	Kari Minkkinen	UHEL
	35	Jokioinen	Tuomas Laurila	FMI
	36	Lettosuo	Tuomas Laurila	FMI
	37	Kalevansuo	Tuomas Laurila; Kari Minkkinen	FMI
Greenland	38	Zackenberg	Mikkel P. Tamstorf	University of Aarhus
	39	Kobbefjorden	Mikkel P. Tamstorf	University of Aarhus

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