An assessment of the GIS data and integrated additional information

Alexandra Barthelmes & Cosima Tegetmeyer
Greifswald University
The task

- Analysis and review of information on the importance of peatlands in the Nordic Baltic countries for climate change mitigation.

- Identification of peatland types where climate change mitigation measures will be most effective (‘hot spots’).
Peatland Emissions & Climate Change

\[
\text{Emissions (CO}_2\text{/yr)} = \text{area data (km}^2\text{)} \times \text{emission factors (t CO}_2\text{/km}^2\text{/yr)}
\]

differentiated for:
- climate zone
- peatland type
- land use category
- land use intensity
- drainage depth

New IPCC default values (IPCC 2014)
A peatland is an area with naturally accumulated peat layer at the surface. Peat consists of at least 30% (dry mass) of dead organic material.
Many estimates for peatland areas were published during last decades, but:

- for many of them the data background is unclear;
- they are often not up-to-date, not spatially explicit nor digital available (GIS).
### Peatland GIS data

<table>
<thead>
<tr>
<th></th>
<th>DENMARK</th>
<th>ESTONIA</th>
<th>FINLAND</th>
<th>GREENLAND</th>
<th>ICELAND</th>
<th>LATVIA</th>
<th>LITHUANIA</th>
<th>NORWAY</th>
<th>SWEDEN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peatland GIS data available?</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

For the Baltics and Finland, peatland GIS data were available.
Appropriate (!) peatland GIS data

Peatland GIS data should be stratified according to (at least):

• land use category (at least forestry, cropland, grassland, and peat extraction)

• drainage depth (shallow or deeply)
Peatland GIS data should be stratified according to (at least):

- Differentiated 'peatland' data were only available from Lithuania and Iceland
- 'peatland' types (e.g. bog, fen or transition)
### Appropriate (!) peatland GIS data

<table>
<thead>
<tr>
<th></th>
<th>DENMARK</th>
<th>ESTONIA</th>
<th>FINLAND</th>
<th>GREENLAND</th>
<th>ICELAND</th>
<th>LATVIA</th>
<th>LITHUANIA</th>
<th>NORWAY</th>
<th>SWEDEN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peatland GIS data available ?</td>
<td>?</td>
<td>x</td>
<td>x</td>
<td>?</td>
<td>?</td>
<td>x</td>
<td>x</td>
<td>?</td>
<td>?</td>
</tr>
<tr>
<td>- Peatland types classified?</td>
<td>x</td>
<td></td>
<td></td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Only the Baltic countries have GIS data of peatland types.

For the other countries proxy data was needed.
Peatland proxy GIS data...

... could be found?

Peatlands or proxy data for them are considered from e.g.
• pedology,
• geology
• geomorphology/topography
• biology and nature protection (e.g. vegetation/biodiversity)
• climate change related science (‘high carbon systems‘)

Peatlands are manifold used, for e.g.
• agriculture
• forestry
• peat cutting
• flooding for power generation
Digital and printed data can be found at numerous places; from several sciences and organisations, and various land use stakeholders.

It is crucial to understand definitions and limitations of the data and to disclose their origin.
Peatland proxy GIS data

- *Organic soils* are often mapped in context of the UNFCCC emission reporting.

FAO/IPCC Definition:

*Organic soils* are distinguished by Soil Taxonomy as the Order of ‘Histosols’, as soils having a horizon of *organic materials*,

*either* 10 cm or more thick from the soil surface to the bedrock below;

*or* 40 cm or more thick and starting within 30 cm from the soil surface.

Quite complicate definition - implemented is sometimes only the criterion of 40 cm organic material.
Peatland proxy GIS data

• *Organic soils* are often mapped in context of the UNFCCC emission reporting.

FAO/IPCC Definition:

*Organic materials* are saturated for long periods or are artificially drained and have,

either 18 % or more organic carbon if the mineral fraction contains more than 60 % clay.

or If the mineral fraction contains no clay, the minimum content of organic carbon is 12 %.

Quite complicate definition - implemented is often only the threshold of 12 % organic carbon.
Peatland proxy GIS data

- *Organic soils* are often mapped in context of the UNFCCC emission reporting.

- *Peatland vegetation* (or a part of it) is sometimes mapped.

  NORWAY: ‘Myr’ - open areas with high groundwater table and potentially peat forming vegetation.

  DENMARK: Habitat directive types of of peatland vegetation
<table>
<thead>
<tr>
<th></th>
<th>DENMARK</th>
<th>ESTONIA</th>
<th>FINLAND</th>
<th>GREENLAND</th>
<th>ICELAND</th>
<th>LATVIA</th>
<th>LITHUANIA</th>
<th>NORWAY</th>
<th>SWEDEN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peatland GIS data available?</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Peatland types classified?</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Organic soil GIS data used</td>
<td>x</td>
<td></td>
<td></td>
<td>x</td>
<td></td>
<td>x</td>
<td></td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Vegetation data used</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
<td></td>
</tr>
</tbody>
</table>
Land use data GIS data
## Land use GIS data

<table>
<thead>
<tr>
<th>Land use GIS data used?</th>
<th>DENMARK</th>
<th>ESTONIA</th>
<th>FINLAND</th>
<th>GREENLAND</th>
<th>ICELAND</th>
<th>LATVIA</th>
<th>LITHUANIA</th>
<th>NORWAY</th>
<th>SWEDEN</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
</tbody>
</table>

Basic land use (LU) types are forestry, cropland, grassland, peat extraction.
## Land use GIS data

<table>
<thead>
<tr>
<th>Land use GIS data used?</th>
<th>DENMARK</th>
<th>ESTONIA</th>
<th>FINLAND</th>
<th>GREENLAND</th>
<th>ICELAND</th>
<th>LATVIA</th>
<th>LITHUANIA</th>
<th>NORWAY</th>
<th>SWEDEN</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>- Basic LU types classified?</td>
<td>+++</td>
<td>++</td>
<td>+</td>
<td>+++</td>
<td>+</td>
<td>++</td>
<td>+</td>
<td>++</td>
<td>+</td>
</tr>
</tbody>
</table>

+++ all basic LU types covered  
++ 'cropland' and 'grassland' is summerized as 'agriculture'  
+ at least one basic LU type missing and/or the dataset incomplete or insufficient
GIS Data analysis
Analysis of national GIS peatland or proxy data, delivered from the national NorBalWet contact points or national researchers.
GIS Data analysis

peatland/organic soil area data

peatland area
GIS Data analysis

peatland/organic soil area data

land use area data

forestry

peat cutting

agriculture
GIS Data analysis

- peatland/organic soil area data
- land use area data
- forestry on peatland
- peat cutting on peatland
- agriculture on peatland
Quality assessment and error analysis we underlayed the GIS data with satellite images of:

- Google Earth,
- Bing aerial,
- OpenCycleMap OCM (http://www.opencyclemap.org/),
- and the World Imagery layer (Esri ArcGIS).
GIS Data analysis

green = freshwater deposits
(Geological map of Denmark, 1: 200 000)

‘Sandmosen and Koldmosen form a huge area of continuous bog: Peat layers to a depth of several metres have been used for fuel over the centuries.’
On satellite images some parts also look like agricultural used...

photos by Kirsten Monrad Hansen
GIS Data analysis

green = freshwater deposits
(Geological map of Denmark, 1: 200 000)

Sandmosen and Koldmosen form a huge area of continuous bog: Peat layers to a depth of several metres have been used for fuel over the centuries. On satellite images some parts also look like agricultural used...

photos by Kirsten Monrad Hansen
GIS data on ‘agricultural used organic soils’ (red) might be incomplete for these areas...
GIS Data analysis

peatland area data
DENMARK

green = freshwater deposits
(Geological map of Denmark, 1: 200 000)
GIS Data analysis

peatland area data
DENMARK

green = freshwater deposits
(Geological map of Denmark, 1: 200 000)
The GIS data on ‘agricultural used organic soils’ of Denmark and Norway have an incomplete coverage in the lowland valleys.
All areas with active artificial drainage emit CO₂, which includes temporary fallows and long-time abandoned fields. Best assessment is to map all ditches and apply a 200 m drainage impact zone to the ditches.
- Organic soil (red), peatland vegetation data (violet)
- A digital Elevation Models (blue) can be used to assess the real extent of organic soils/peatlands (at least in valleys).
ESTONIA: Very accurate peatland borders and classified peatland types, but peat cutting areas are regularly excluded.
Emission calculation
For many NorBalWet countries the emissions have increased considerably in this report (compared to National Inventory Submissions to the UNFCCC of this year).

We re-calculated emissions according to the IPCC 2014 default emission factors. These values derived from a study of leading scientists under the framework of IPCC and are the best available estimates. Especially for cropland and grassland they are much higher than previous default values.

However, we used the country-specific emission factors from the National Inventory Reports, if they are reliable.
To be consistent, the climate zones were also applied according to IPCC.
some country examples
Countrywise assessment

- Analysis of national GIS peatland/proxy data or soil data, delivered from the national NorBalWet contact points or national researchers.

- Consideration of the National Inventory Submissions on greenhouse gasses to the UNFCCC from Nor Bal Wet countries.

- Integration of scientific publications on peatland extent, threats, use and drainage status in NorBalWet countries.
Integrated peatland/land use dataset:

- the vector dataset of Map of Peatlands and Mires in Lithuania (2005; scale 1:200,000).

This dataset already stratified peatland areas according to their drainage status and land use types. We did not add separate land use data.
LITHUANIA

- small, natural and forested peatlands are underrepresented

- > 90% of peatlands are drained

- emissions of 7,200 Gg CO$_2$/yr (3 x increase compared to NIS Lithuania)
## Lithuania

<table>
<thead>
<tr>
<th>Land Use Type</th>
<th>Taminskas 2012</th>
<th>Our GIS Analysis</th>
<th>NIS Lithuania 2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drained forested</td>
<td>1,622</td>
<td>1,153</td>
<td>1,726</td>
</tr>
<tr>
<td>Drained agriculture</td>
<td>2,834</td>
<td>2,692</td>
<td>1,757</td>
</tr>
<tr>
<td>Drained peat extraction</td>
<td>223</td>
<td>497</td>
<td>138</td>
</tr>
<tr>
<td><strong>Σ subtotal drained</strong></td>
<td><strong>4,679</strong></td>
<td><strong>4,342</strong></td>
<td><strong>3,621</strong></td>
</tr>
<tr>
<td>Undrained open</td>
<td>549</td>
<td>333</td>
<td></td>
</tr>
<tr>
<td>Undrained forested</td>
<td>1,232</td>
<td>283</td>
<td>1,704</td>
</tr>
<tr>
<td><strong>Σ subtotal undrained</strong></td>
<td><strong>1,781</strong></td>
<td><strong>615.3</strong></td>
<td><strong>1,704</strong></td>
</tr>
<tr>
<td><strong>Σ TOTAL</strong></td>
<td><strong>6,460</strong></td>
<td><strong>4,957.3</strong></td>
<td><strong>5,325</strong></td>
</tr>
</tbody>
</table>

*Source: GIS analysis from NIS Lithuania 2014.*

*Most reliable data source.*
**peatland dataset:**
- the Estonian soil map (scale 1:10 000; Estonian Land Board 2001; extracted were: ‘fen peat’, ‘alluvial fen peat’, ‘transitional mire peat’, ‘raised bog peat’)

**land use dataset:**
- we extracted from the Estonian base map (1:10 000; Estonian Land Board 2011):
  - ‘Streamlines’, which reflects drainage systems. The drainage impact on adjacent peatlands was applied to extent to 200 m from each streamline
  - ‘Forest distribution’ to identify forested peatlands (drained forestry)
  - ‘Peat extraction areas’ (active & abandoned)
ESTONIA - extent of peatlands: 9,150 km²

- satisfying coverage of peatlands (except peat cutting areas)
- land use data sufficient
- ~70% of peatlands drained
- emissions of -7,200 Gg CO₂/yr
### ESTONIA - extent of peatlands: 9,150 km²

<table>
<thead>
<tr>
<th>Area per land use type (km²)</th>
<th>NIS Estonia (2014)</th>
<th>Our GIS analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>drained forestry</td>
<td>4,928</td>
<td>4,376</td>
</tr>
<tr>
<td>drained agriculture</td>
<td><strong>609</strong></td>
<td>1,700</td>
</tr>
<tr>
<td>drained peat extraction</td>
<td>186</td>
<td>236</td>
</tr>
<tr>
<td>TOTAL drained</td>
<td>5,723</td>
<td>6,313</td>
</tr>
</tbody>
</table>

The emissions we have calculated are 6 x higher than emissions calculated in NIS Estonia.

- We applied emission factors for the Temperate Climate zone instead of the Boreal Climate zone, which is consistent with the IPCC and increase emissions of the forested areas.
ICELAND

peatland dataset:

- the soil map of Iceland (‘Jardvegskort af Islandi’; Guðmundsson, 2010). We extracted data on:
  - ‘Histosols’ (> 20 % organic carbon), and
  - ‘Histic Andosols’ (12-20% organic carbon) as ‘organic soils’.

land use dataset:

- from the ‘IGLUD_database’ we extracted all basic land use categories.
ICELAND - extent of organic soils: 5,849 km²

- sufficient coverage of organic soils
- sufficient land use data
- assessment of drained areas based on mapped ditches and 200 m drainage impact for each ditch
  - drained organic soils 78%
- Emissions of 5,600 Gg CO₂/yr
  (3 x increase compared to NIS Iceland)
ICELAND - extent of organic soils: 5,849 km²

<table>
<thead>
<tr>
<th>organic soil</th>
<th>area per land use type (km²)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Our GIS analysis</td>
</tr>
<tr>
<td>drained forested</td>
<td>51</td>
</tr>
<tr>
<td>drained cropland</td>
<td>273</td>
</tr>
<tr>
<td>drained grassland</td>
<td>4,109</td>
</tr>
<tr>
<td>∑ organic soil, drained for other purposes</td>
<td>14</td>
</tr>
<tr>
<td>∑ subtotal, drained</td>
<td>4,578</td>
</tr>
<tr>
<td>organic soil, undrained</td>
<td>1,265</td>
</tr>
<tr>
<td>flooded wetland (high SOC)</td>
<td>6</td>
</tr>
<tr>
<td>∑ total</td>
<td>5,849</td>
</tr>
</tbody>
</table>

- ‘Grassland’ is a very diverse category with regard to vegetation, soil type, erosion and management.
Greenhouse gas measurements from Icelandic drained organic soils: 2-4 t C/ha/yr (Oskarsson, 2013).

Most organic soils are lower Carbon containing Andic Histosols.

Thus, only half of the IPCC default values for forestry, cropland and grassland was applied.
peatland dataset:

- the ‘myr’ vector data from Staatens Kartverk (http://www.statkart.no/). This data set comprises areas with high groundwater table and potentially peat forming vegetation (= undrained).

organic soil/land use dataset:

- the raster dataset of agriculturally used organic soils from the Norsk institutt for skog og landskap (http://www.skogoglandskap.no/).

- other land use data not freely available
NORWAY - extent of organic soils: 40,971 km²

- sufficient coverage of ‘myr’ vegetation (18,760 km²)

- 7,8 % drained and agriculturally used organic soils (considerable underestimated; mapping in progress, but even coverage of already mapped areas seem to be incomplete...)

- drained forest and peat cutting areas could not be assessed

- emissions of 3,400 Gg CO₂ /yr
### NORWAY - extent of organic soils: 40,971 km²

<table>
<thead>
<tr>
<th>organic soil</th>
<th>Area per land use type (km²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drained forested</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Drained agriculture</td>
<td></td>
</tr>
<tr>
<td>Subtotal, drained</td>
<td></td>
</tr>
<tr>
<td>Undrained (‘wooded mire’)</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
</tr>
<tr>
<td>‘myr’, undrained</td>
<td></td>
</tr>
</tbody>
</table>

Emission factors from NIS Norway (2014) are close to the IPCC (2014) default values. We did not recalculate them.

However, emissions are probably underestimated, because of the incomplete coverage of drained areas...
peatland dataset:

- the raster dataset about ‘Finlands peatlands’, which defines drained and undrained peatlands in a grid of 25 m x 25 m.
- Peatlands are classified as ‘drained’, if they are less than 50 m away from a maximally 5 m wide, flowing water body (*underestimates the drained area*)
- peat extraction sites are indicated.

land use dataset:

- The available Corine land use data are of very low resolution and not suitable for our analysis.
Last but not least: FINLAND

- Peatland dataset was not very useful and incomplete, but we could immediately see, what happened to peatlands in Finland!
The used GIS data probably is ‘the state of the art’ of national peatland/organic soil data in NorBalWet countries. Some of it was not really convincing, but it surely can be used as starting point and be improved by e.g.:

• collection and integration of available data (e.g. from archives, experts, etc.), especially data with incomplete coverage, but high quality;

• consideration of remote sensing based models, like Digital Elevation Models, Topographic Soil Wetness or Soil Organic Carbon assessments;

• using geo-referenced legacy soil or geological maps and extrapolation of their information;

• manually (re-)drawing of peatland borders, quality control and status assessment of peatlands (drainage/degradation) using e.g. free satellite images

• doing some ground truthing in crucial areas.
main conclusions:

However, national data need to be used. Currently rs can not sufficiently replace it. Why

National data could be improved using......

Verbesserungsvorschläge für die Daten mit Methoden der GIS_GPD

- Dänemark/Norwegen = entwässerte Flächen und oder Moorflächen erkennen (DEM, Soil maps, etc.

- Mapping of peatland types (field work; extrapolation of well assessed areas to other areas (Finland)

- assessment of drained area: mapping of ditches (kann be done „semi-automatically"

- remote sensing........direct and landscape constraints
At last, I would like to ask you:

Do you believe your country story?

Which topic you would like to discuss (area data, emission re-calculation, or...)?

Or can it be published as it is now?
**peatland dataset:**
- the Estonian soil map (scale 1:10 000; Estonian Land Board 2001; extracted were: ‘fen peat’, ‘alluvial fen peat’, ‘transitional mire peat’, ‘raised bog peat’)

**land use dataset:**
- we extracted from the Estonian base map (1:10 000; Estonian Land Board 2011):
  - ‘Streamlines’, which reflects drainage systems. The drainage impact on adjacent peatlands was assumed to extent to 200 m from each streamline (cf. Eggelsmann, 1982)
  - ‘Forest distribution’ to identify forested peatlands (drained forestry)
  - ‘Peat extraction areas’ (active & abandoned)
ESTONIA - extent of peatlands: 9,150 km²

- satisfying coverage of peatlands (except peat cutting areas)
- land use data sufficient
- ~ 70% of peatlands drained
- emissions of -7,200 Gg CO₂/yr
ESTONIA - extent of peatlands: 9,150 km²

<table>
<thead>
<tr>
<th>Area per land use type (km²)</th>
<th>NIS Estonia (2014)</th>
<th>Our GIS analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>drained forestry</td>
<td>4,928</td>
<td>4,376</td>
</tr>
<tr>
<td>drained agriculture</td>
<td>609</td>
<td>1,700</td>
</tr>
<tr>
<td>drained peat extraction</td>
<td>186</td>
<td>236</td>
</tr>
<tr>
<td>TOTAL drained</td>
<td>5,723</td>
<td>6,313</td>
</tr>
</tbody>
</table>

- According to Paal & Leibak (2011):
  - the total peatland area: 9,150 km²
  - undrained peatlands: 2,330 km²
  - drained peatlands: 6,820 km (comparable with our results)

- NIS Estonia (2014):
  Uncertainty in the area of organic soils e.g. for Cropland between 29 and 139 %.
The emissions we have calculated are 6 x higher than emissions calculated in NIS Estonia.

- We applied emission factors for the Temperate Climate zone instead of the Boreal Climate zone, which is consistent with the IPCC.
- Emission factors for Grassland and Forestry are considerably higher in IPCC (2014)
peatland dataset:
• combined on A) agriculturally used organic soils and B) Natura 2000 registration of peat (types 7120, 7110, 7140).
• delivered from Mogens H. Greve, Department of Agroecology at Aarhus University.

land use dataset:
• the Danish BASEMAP land-use and land-cover map for Denmark (Jepsen und Levin, 2013).
DENMARK - extent of organic soils: > 1,091 km²

- peatland extent considerably underestimated
- land use data sufficient
- > 90% of peatlands drained
- emissions of -2,100 Gg CO₂ /yr
DENMARK - extent of organic soils: > 1,091 km²

<table>
<thead>
<tr>
<th>Area per land use type (km²)</th>
<th>our GIS analysis</th>
<th>NIS Denmark (2014)</th>
<th>other sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>total 'deep organic soil' extent</td>
<td></td>
<td></td>
<td>4,400*</td>
</tr>
<tr>
<td>drained forested</td>
<td></td>
<td>366</td>
<td></td>
</tr>
<tr>
<td>drained agriculture</td>
<td></td>
<td>681</td>
<td>2,000*</td>
</tr>
<tr>
<td>peat extraction</td>
<td></td>
<td>16</td>
<td>1,759**</td>
</tr>
<tr>
<td>Σ subtotal drained</td>
<td>751</td>
<td>1,063</td>
<td></td>
</tr>
</tbody>
</table>

* Covering deep peat and gyttja; actual extent may be less (Klöve et al., 2009).
** Digital soil mapping of geographic distribution agriculturally used wetlands with high SOC (Bou Kheir et al., 2010).
We recalculated the emissions according to the area data in NIS Finland (2014) for Cropland and Grassland.

- The values given by Maljanen et al. (2007; Tier 2 approach) are not corrected for biomass removal.

- The values from IPCC (2014) are based on a meta-analysis of available data (including the sources cited in the NIS Finland 2014) and did not find a significant difference between boreal and temperate croplands and grasslands on organic soil.
Peatland and land use GIS data were not available; we did **not receive any information**.

- We used information from the World Wide Web and from NIS Denmark (2014; separate part for Greenland).

- For emission calculation we used the IPCC (2014) default values for Boreal Climates. We assum that forestry and agriculture are applied in the warmest regions of Greenland, which can have comparable mean July temperatures as the lowlands of Iceland (e.g. Kangerlussuaq in northwestern Greenland: 11.2° C).

  **But this might overestimate emissions.**
GREENLAND - extent of organic soils: 75 km²

- Organic soil area (NIS Denmark, 2014):
  0.2 km² of Forest (‘other conifer’),
  0.03 km² Cropland
  2.6 km² of Grassland
  72 km² of unmanaged Grassland
  \[= 75 \text{ km}^2 \text{ of organic soil}\]

  **Is this the real extent?**

Emissions from drained peatlands:

- 1.3 Gg CO₂/yr (NIS Denmark, 2014)
- 5.6 Gg CO₂ per year (recalculated using boreal EF from IPCC (2014))
Area of cultivated organic soils in Greenland already doublet since 1990 (NIS Denmark, 2014)

Warming of the subarctic and arctic environments (Climate Change) may facilitate the reclamation of organic soils for agriculture.
peatland dataset:

- polygone vector data of Latvian ‘purvi’ (‘swamps’- covering peat soil deposits; scale 1:500 000) provided by SIA ENVIROTECH within the GISLatvia-geodatabase

A land use dataset was only available recently and will be integrated in the final report.
<table>
<thead>
<tr>
<th>Land Use</th>
<th>Area (km²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>total peatland (our analysis)</td>
<td></td>
</tr>
<tr>
<td>undrained peatland</td>
<td>3,167</td>
</tr>
<tr>
<td>drained forested</td>
<td>4,337</td>
</tr>
<tr>
<td>Cropland</td>
<td>2,827</td>
</tr>
<tr>
<td>Grassland</td>
<td>348</td>
</tr>
<tr>
<td>peat extraction</td>
<td>270</td>
</tr>
<tr>
<td></td>
<td>10,949</td>
</tr>
</tbody>
</table>
LATVIA
Peatland and land use GIS data were not available.

- We used information from NIS Sweden (2014).
Sweden - extent of peatlands: 65,326 km²

<table>
<thead>
<tr>
<th>peatland</th>
<th>area</th>
<th>EF</th>
<th>Emissions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>km²</td>
<td>Mg C/ha/yr</td>
<td>Gg CO₂/yr</td>
</tr>
<tr>
<td>drained</td>
<td>13,080</td>
<td>?</td>
<td>15.1</td>
</tr>
<tr>
<td>undrained</td>
<td>52,543</td>
<td>±0</td>
<td></td>
</tr>
<tr>
<td>total</td>
<td>65,623</td>
<td></td>
<td>15.1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>a. Total peatland area</th>
<th>b. Drained peatland area</th>
<th>c. Total CO₂ emissions without LULUCF</th>
<th>d. Total peatland CO₂ emissions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>km²</td>
<td>km²</td>
<td>Mt CO₂ yr⁻¹</td>
<td>Mt CO₂ yr⁻¹</td>
</tr>
<tr>
<td>Sweden</td>
<td>65,623</td>
<td>13,080</td>
<td>45.710</td>
<td>15.124</td>
</tr>
</tbody>
</table>

HANS: WOHER KOMMEN DIESE DATEN?
**Sweden - extent of organic soils: 109,865 km²**

<table>
<thead>
<tr>
<th></th>
<th>NIS Sweden (2014)</th>
<th>NIS Sweden recalculated (according to IPCC, 2014)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>area (km²)</td>
<td>EF (Mg C/ha)</td>
</tr>
<tr>
<td>drained forested</td>
<td>38,044</td>
<td>-0.57</td>
</tr>
<tr>
<td>drained cropland</td>
<td>1,444</td>
<td>-3.74</td>
</tr>
<tr>
<td>drained grassland</td>
<td>616</td>
<td>-1.60</td>
</tr>
<tr>
<td>peat extraction</td>
<td>98</td>
<td>-1.63</td>
</tr>
<tr>
<td><strong>Σ drained</strong></td>
<td><strong>40,202</strong></td>
<td><strong>-10,907</strong></td>
</tr>
<tr>
<td><strong>Σ undrained</strong></td>
<td>69,663</td>
<td>±0</td>
</tr>
<tr>
<td><strong>Σ total</strong></td>
<td>109,865</td>
<td></td>
</tr>
</tbody>
</table>

- For emission re-calculation we used the IPCC (2014) default values for Boreal Climates (except for drained forested organic soils).
Peatland area assessment for NorBalWet countries

Table 2.5: Peatland areas, total country CO\textsubscript{2} emissions in 2012 (without LULUCF), and CO\textsubscript{2} emissions from peatlands in the NorBalWet countries. Peatland data derived from the country overviews (chapter 3), total country emissions derived from the 2014 National Inventory Reports of the respective countries. \textbf{NOTE: all the peatland figures are still preliminary and subject of discussion.}

<table>
<thead>
<tr>
<th></th>
<th>Total peatland area (km\textsuperscript{2})</th>
<th>Drained peatland area (km\textsuperscript{2})</th>
<th>% b of a</th>
<th>Total CO\textsubscript{2} emissions without LULUCF (Mt CO\textsubscript{2} yr\textsuperscript{-1})</th>
<th>Total peatland CO\textsubscript{2} emissions (Mt CO\textsubscript{2} yr\textsuperscript{-1})</th>
<th>% d of c</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estonia</td>
<td>9,150</td>
<td>6,313</td>
<td>69.0</td>
<td>17.079</td>
<td>7.248</td>
<td>42.4</td>
</tr>
<tr>
<td>Latvia</td>
<td>10,949</td>
<td>7,782</td>
<td>71.1</td>
<td>7.434</td>
<td>13.368</td>
<td>179.8</td>
</tr>
<tr>
<td>Lithuania</td>
<td>4,746</td>
<td>4,342</td>
<td>91.5</td>
<td>14.184</td>
<td>7.237</td>
<td>51.0</td>
</tr>
<tr>
<td>Finland</td>
<td>83,198</td>
<td>64,931</td>
<td>78.0</td>
<td>50.7</td>
<td>20.677</td>
<td>40.8</td>
</tr>
<tr>
<td>Sweden</td>
<td>65,623</td>
<td>13,060</td>
<td>19.9</td>
<td>40.710</td>
<td>15.124</td>
<td>33.1</td>
</tr>
<tr>
<td>Norway</td>
<td>40,971</td>
<td>3,192</td>
<td>7.8</td>
<td>52.7</td>
<td>3.466</td>
<td>6.6</td>
</tr>
<tr>
<td>Iceland</td>
<td>5,849</td>
<td>4,578</td>
<td>78.3</td>
<td>3.324</td>
<td>5.681</td>
<td>170.9</td>
</tr>
<tr>
<td>Denmark</td>
<td><strong>1,091</strong></td>
<td><strong>1,063</strong></td>
<td><strong>97.4</strong></td>
<td><strong>38.303</strong></td>
<td><strong>1.591</strong></td>
<td><strong>4.2</strong></td>
</tr>
<tr>
<td>Greenland</td>
<td>75</td>
<td>3</td>
<td>4.3</td>
<td>0.6</td>
<td>0.006</td>
<td>1.0</td>
</tr>
<tr>
<td>Total</td>
<td>213,417</td>
<td>93,512</td>
<td>43.8</td>
<td>229.434</td>
<td>74.398</td>
<td>32.4</td>
</tr>
</tbody>
</table>
Assessing peatland area in NorBalWet countries

<table>
<thead>
<tr>
<th>Land use GIS data used?</th>
<th>DENMARK</th>
<th>ESTONIA</th>
<th>FINLAND</th>
<th>GREENLAND</th>
<th>ICELAND</th>
<th>LATVIA</th>
<th>LITHUANIA</th>
<th>NORWAY</th>
<th>SWEDEN</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Land use types classified?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Estimated fuzziness (%)?</td>
<td>&lt; 5</td>
<td>&lt; 15</td>
<td>10-20</td>
<td>&lt; 5</td>
<td>10-20</td>
<td>20-30</td>
<td>&lt; 5</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Land use (LU) type classified:
very good: essential LU types are finer differentiated (agriculture -> cropland, grassland; forest types; drainage depth; etc.)
good: essential LU types available: forested areas, drained areas, peat extraction
medium: one essential type is missing
low: at least one essential LU type is missing, dataset is incomplete

- Land use GIS data used: yes
- Land use types classified: 1 - very good, 2 - good, 3 - medium, 4 - low
- Estimated fuzziness: < 5 - very good, 10-20 - good, 20-30 - medium, < 5 - low
## Assessing peatland area in NorBalWet countries

<table>
<thead>
<tr>
<th></th>
<th>DENMARK</th>
<th>ESTONIA</th>
<th>FINLAND</th>
<th>GREENLAND</th>
<th>ICELAND</th>
<th>LATVIA</th>
<th>LITHUANIA</th>
<th>NORWAY</th>
<th>SWEDEN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peatland GIS-data used?</td>
<td>yes</td>
<td>yes</td>
<td>no</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>- Peatland types classified?</td>
<td>no</td>
<td>yes</td>
<td>no</td>
<td>no</td>
<td>yes</td>
<td>yes</td>
<td>no</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- High resolution?</td>
<td>yes</td>
<td>yes</td>
<td>no</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td></td>
</tr>
<tr>
<td>- Estimated fuzziness (%)?</td>
<td>&lt; 5</td>
<td>&lt; 10</td>
<td>10-20</td>
<td>&gt; 10</td>
<td>10-30</td>
<td>10-30</td>
<td>&lt; 5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Completeness (%)?</td>
<td>&lt; 80</td>
<td>&gt; 90</td>
<td>&gt; 90</td>
<td>&gt; 80</td>
<td>&gt; 80</td>
<td>&gt; 80</td>
<td>&gt; 80</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soil GIS data used?</td>
<td>no</td>
<td>no</td>
<td>no</td>
<td>no</td>
<td>yes</td>
<td>no</td>
<td>no</td>
<td>no</td>
<td>no</td>
</tr>
<tr>
<td>Land use GIS data used?</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>no</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>- Land use types classified?</td>
<td>very good</td>
<td>good</td>
<td>medium</td>
<td>very good</td>
<td>medium</td>
<td>good</td>
<td>low</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Estimated fuzziness (%)?</td>
<td>&lt; 5</td>
<td>&lt; 15</td>
<td>10-20</td>
<td>&lt; 5</td>
<td>10-20</td>
<td>20-30</td>
<td>&lt; 5</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

> 5 = negligible; > 10% considerable