Peatlands in National Inventory Submissions 2009

An analysis of 10 European countries

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Summary

The substantial greenhouse gas emissions from peatland drainage can largely be avoided through peatland rewetting and restoration. There is, however, doubt to whether emission reductions from peatland can be correctly quantified and transparently reported.
This report analyses the most recent (2009) National Inventory Submissions of 10 European countries to evaluate their experiences with the reporting of anthropogenic peatland emissions.
It appears that several countries still apply IPS (2003) methodologies where the IPCC Guidelines (2006) have already consolidated related and better methods. The latter are certainly more consistent and complete in assessing emissions from agriculture. Countries should therefore adopt the most recent IPCC guidance.
Taking into account the enormous differences in emissions between mineral and organic soils, it is correct that these have to be reported separately within categories. To assess the impact of organic soils on GHG emissions, it is necessary to perform a key category analysis for the soil types separately. This is, however, not done in most National Inventories. Some countries even use the default Tier 1 method of mineral soils for their forest area on organic soils which may lead to a (severe) underestimation of emissions. Countries should intensify their efforts in this respect.
CO_2 or N_2O emissions from Grassland and Cropland (and in one case even other categories) were often reported aggregated. This relocation between categories is likely only a matter of convenience, but of course also affects the default emission factor used. Countries should elaborate sufficient area data to estimate emissions in the relevant category. Area estimates of land use categories can be easily improved with already available sources and rapidly developing technology.
Drained peatlands release CO_2 and N_2O up to many hundreds of years after initial drainage. Emissions do not end with the termination of land use, but continue until all peat is gone or the drainage system collapses. As the category approach does not adequately cover abandoned drained peatlands, their emissions are not adequately addressed and thus underestimated.
Several inconsistencies in the provided data hamper insight to the procedure of emission estimation. Countries should be encouraged to improve the transparency, e.g. by reporting in English, providing more detailed descriptions of methods and avoiding unnecessary reference to grey and non-English literature.
In general the inventories, however, show that with some effort countries can achieve an adequate reporting of their emissions from peatlands. The largest caveats to date seem to be the insufficient recognition of the importance of peatlands for GHG emissions coupled with a reluctance to follow the up-to-date guidance of IPCC.

Introduction

Peatland drainage results in carbon and nitrogen emissions of globally 2-3 Gt CO_2-eq per year (Joosten & Couwenberg 2009), a volume that should urgently be addressed in a post-2012 climate framework. Much of these emissions could be avoided through peatland rewetting and restoration (Trumper *et al.* 2009).
The limited familiarity with peatlands, their heterogeneity, and the various greenhouse gases involved in peatland drainage and rewetting have shed doubt to whether emissions and emission reductions from peatland can be correctly quantified and transparently reported.
In recent years, many countries have acquired experience in reporting emissions from peatlands in the framework of their National Inventory Submissions (NIS) to the UNFCCC. Evaluation of these experiences might show whether and to what extent a wall to wall reporting on anthropogenic peatland emissions is feasible.
This report provides an overview of the most recent (2009) National Inventory Submissions (NIS) and associated Common Reporting Formats (CRF) from ten key European countries (Belarus, Finland, France, Germany, Iceland, Ireland, Netherlands, Poland, Sweden, United Kingdom). The methodologies applied are critically discussed, the guidance of IPCC guidelines analysed, and suggestions are made for improving the reporting.

1. Peatland peculiarities and greenhouse gas emissions

1.1. Organic soil, histosol, peatland…

Based on the FAO (1998) key to soil types, Annex 3A.5 of the IPCC Guidelines (2006) offers criteria for identification of organic (peat) soils. The FAO definition of organic soil (histosol) is complex. It not only refers to thickness of soil layers and their organic content but also to their origin, underlying material, clay content and water saturation (see Couwenberg 2009a).
Basically, however, apart from shallow (≥10 – 40 cm) organic rich soils overlying ice or rock, organic soils (histosols) are identical with peat and peaty soils of at least 40 cm total thickness within the upper 100 cm, containing at least 12% organic carbon (~20 % organic material) by weight. This definition departs from a slightly thicker layer and slightly lower organic matter content than most European definitions of peat, but this probably does not lead to strongly different areas of peatland (Joosten & Clarke 2002). Therefore it is feasible for the purpose of the UNFCCC to use these terms interchangeably.

1.2. Peatland carbon stocks and GHG emissions

Covering merely 3% (4,000,000 km^2) of the World's land area, peatlands store 550 Gton of carbon in their peat soil, i.e. twice as much as all forest biomass of the world (Parish *et al.* 2008). Peatlands are thus the most carbon-dense ecosystems of the terrestrial biosphere.
Their enormous soil carbon stock is actually their prime characteristic: peatlands are 'lands with (a substantial amount of) peat' and peat is 'dead organic matter', which has a carbon content of over 50%.
The carbon stock of peat soils in the world is *on average* 1400 tons per ha. This is five times larger than in taigas and steppes (200-250 tons) and an order of magnitude larger than the soil carbon stock of normal tropical rain forests (100 tons) (Parish *et al.* 2008, Trumper *et al.*

2009). This huge carbon stock is maintained by wetness. Natural peatlands are always wetlands. When peatlands remain wet, the peat carbon stock is conserved virtually forever. Furthermore, it slowly increases by addition of newly produced organic plant material that transforms into new peat.

Next to continuously sequestering carbon dioxide (CO_2), natural peatlands emit methane (CH_4). This emission depends on water level, being practically zero at levels lower than 20 cm below surface, but relevant at higher water levels (Couwenberg 2009b). The combined effect of CO_2 and CH_4 fluxes leads to a radiative forcing of pristine peatlands that – dependent on peatland type – is slightly positive or slightly negative on the 100 yr timescale. On the long run, all natural peatlands are climate coolers (*cf*. Frolking *et al.* 2006). Nitrous oxide (N_2O) emissions from natural peatlands hardly occur (Couwenberg *et al.* 2009). CH_4 emissions from undrained organic soils are not addressed in the IPCC inventory guidelines unless the wetlands are managed and emissions may be deemed anthropogenic (IPCC 2003, 2006). Similarly, national inventories do not have to estimate the accumulation of carbon in pristine (undrained) peatland soils.

When peatlands are drained (for cropland, grassland, forest land, peat extraction…), CH_4 emissions decrease and CO_2 and N_2O emissions increase. This leads to net anthropogenic emissions from oxidizing peat of 10 up to possibly 100 ton CO_2-eq. per ha and year. Drainage associated fires increase these emissions substantially. Emissions may continue for many decades, because the enormous peat carbon (and nitrogen) pool is gradually but continuously tapped (Joosten & Couwenberg 2009).

1.2. Peatland soil carbon stock changes

In the framework of climate politics, greenhouse gas fluxes (emissions by sources and removals by sinks) must be quantified. The most obvious thing would be to measure all GHG fluxes directly in the field where they occur. Direct flux measurements are, however, difficult and expensive. Therefore indirect methods – via so called proxy variables or 'proxies' – are used for assessing fluxes (Joosten & Couwenberg 2009).
Carbon stock change is commonly used as a proxy for approximating CO_2 fluxes from land use. Especially on vegetated land, where simultaneous uptake of CO_2 by photosynthesis and emission of CO_2 by respiration of plants, animals, and microbes takes place, assessing net CO_2 fluxes is complicated. Instead of measuring all fluxes to and fro, it is generally simpler to determine the change in carbon stock, which integrates all fluxes over longer time.

In peatlands, however, such a stock-based approach is not feasible, because of the enormous stocks involved. A drained peatland in the temperate zone easily loses 25 tons of CO_2 per hectare and year from peat oxidation, even in the absence of fire (Couwenberg *et al.* 2008), in the tropics 2-3 times more (Couwenberg *et al.* 2009). Even such huge amounts (7-20 tons of Carbon per ha and year) can hardly be assessed in a stock-based approach, because the change is smaller than the error in determining the total soil carbon stock (that may amount to several *thousands* of tons per ha). Therefore emissions from organic soils can and should not be assessed via stock changes but must be assessed directly via *emissions* that represent the loss of organic carbon throughout the profile (IPCC 2006).

Soil carbon stocks are generally assessed over a limited soil depth, e.g. up to a depth of 30 or 100 cm (Batjes 2002, IPCC 2006). This may lead to a substantial underestimate in case of peatlands (Trumper *et al.* 2009). The Voluntary Carbon Standard (2008), for example, defines soil organic carbon as "organic carbon in mineral and organic soils (including peat)

to a specified depth chosen by the country and applied consistently through the time series" (our underlining). If a country decides to use a depth of 30 cm it may loose 5.70 m of peat from a peatland with a 6 m thick peat layer (= 95% of the peat carbon) without having to report any change in soil organic carbon. This is not a figment of imagination: in a recent paper Ywih et al. (2009) make exactly this mistake. They compare the carbon content in the uppermost 50 cm of peat soil under oil palm with a secondary forest and, finding no significant difference, conclude that no carbon losses have occurred. In reality the losses will have amounted to 50 t CO_2 ha^{-1} a^{-1} or more (Couwenberg et al. 2009).
Carbon losses from peat soils indeed largely happen 'top-down' but it is insufficient to limit the assessment of peat soil carbon stocks to the uppermost soil layers.

1.4. The UNFCCC categories and the cross-cutting character of peatland

Peatland is, in contrast to what the term might suggest, no land use category like Forest land, Cropland, Grassland, or Wetland. It is a type of soil/substrate of which the properties are so dominant and conspicuous that the peat becomes eponymous for the landscape in which it occurs. So forest land, cropland, grassland, and wetland may all be peatland.
The presence or absence of peat on a site assigned to a category has, however, enormous consequences for its greenhouse gas emissions, because

- Peatlands contain an enormous soil carbon stock, which is mobilised through drainage and emitted over a long time span. It is this combination of 'much' and 'long-term' that makes peatlands exceptional and difficult to grasp. Indeed deforestation causes huge CO_2 emissions from oxidizing biomass, but when the biomass is gone (after a few years) the emissions are over. Indeed wrong cropland management may lead to a stealthy decrease of the soil carbon stock, but the associated long-term emissions are relatively small. In contrast, drained peatlands persist in emitting large volumes of greenhouse gases for up to many hundreds of years (Joosten & Couwenberg 2009).
- Peatlands maintain, also under drained conditions, such high soil humidity that optimal conditions for nitrous oxide production easily and frequently occur (Couwenberg 2009a, Couwenberg et al. 2009). As a result nitrous oxide emissions from drained peatland are – with the same nitrogen availability - considerably higher than those from mineral soils.
- Peatlands have originated because wet, anaerobic conditions hampered decomposition of organic matter. These are the same conditions under which methane is generated. Peat soils may therefore under wet conditions emit substantial volumes of methane.

From an emission perspective it is not optimal that peatlands cross-cut the categories, as the differences within the category are often larger (peat versus non-peat) than between the categories. For example, the emissions from peat soils are determined more by water level than by land use (Couwenberg et al. 2008). It is therefore correct that CO_2 emissions from organic soils have to be reported separately within the categories. But the mishmash of (sub)categories, soil types and gases easily leads to confusion (and strategic choices?) as becomes apparent from the National Submissions. Table 1 presents an overview of the wealth of opportunities under which peatland emissions must and can be reported.

Table 1: Land use options for peatlands and associated categories under which emissions from peatland soils are reported.
(According to IPCC [2006] peatlands with artificially changed water tables are reported under 'Managed Wetlands'.)

Land use options		**GHG**	**Emissions to be reported under**	**Recent guidance for managed peatlands with artificially changed water table**
Pristine peatland (undrained)		all	Irrelevant under UNFCCC / Not a managed peatland	
Tree-covered peatland	undrained (natural peatland forests)	all	Irrelevant under UNFCCC / Not a managed peatland	
	drained (afforested peatlands)	CO_2	5.A. Forest land on organic soils	IPCC Guidelines (2006, Vol. 4, Chap. 4), GPG-LULUCF (2003, Sect. 3.2)
		N_2O	CRF 5(II). Non-CO_2 emissions from drainage of soils and wetlands	IPCC Guidelines (2006, Vol. 4, Chap. 11) GPG-LULUCF (2003, Appendix 3a.2)
Tillage farmed peatland	undrained (e.g. reed)	all	Irrelevant under UNFCCC / Not a managed peatland	
	slightly drained (e.g. cranberries)	CO_2	5.B. Cropland (on organic soil)	IPCC Guidelines (2006, Vol. 4, Chap. 5), GPG-LULUCF (2003, Sect. 3.3)
	drained (e.g. cereals, maize, potato, land with a crop-grassland rotation)	N_2O	4.D. Direct soil emissions CRF 5(III). 'Non-CO_2 emissions from land conversion to Cropland'	IPCC Guidelines (2006, Vol. 4, Chap. 11), GPG-LULUCF (2000, Chap.4)
Permanently grazed peatland	Undrained	all	Irrelevant under UNFCCC / Not a managed peatland	
	slightly (e.g. sheep grazing) or intensively drained (e.g. cattle breeding)	CO_2	5.C. 'Grassland' on organic soils	IPCC Guidelines (2006, Vol. 4, Chap. 6) GPG-LULUCF (2003, Sect. 3.4.)
		N_2O	4.D. 'Direct soil emissions'	IPCC Guidelines (2006, Vol. 4, Chap. 11)
Peat extraction	**Emissions from peat extraction fields** (in preparing, extraction, abandoned or converted to other land uses)	CO_2	5.D. 'Wetlands'	IPCC Guidelines (2006, Vol. 4, Chap. 7) GPG-LULUCF (Appendix 3a.3)
		N_2O	CRF 5(II). 'Non-CO_2 emissions from drainage of soils and wetlands'	IPCC Guidelines (2006, Vol. 4, Chap. 7) GPG-LULUCF (2003, Appendix 3a.3)[2]
	Off-site emissions from decay of horticultural peat	CO_2	5.D. 'Wetlands'	IPCC Guidelines (2006, Vol. 4, Chap. 7)
		N_2O	Not considered. There are no methods that would allow separation of N_2O emissions from organic matter decay and added Nitrogen fertilizers.	
	Emissions from peat combustion	all	1.A. CO_2 emissions from fuel combustion activities	IPCC Guidelines (2006, Vol.2, Chap. 2)
Abandoned, drained peatland (except cut-over areas) e.g. abandoned tilled or grazed peatlands		CO_2 N_2O	Not explicit covered by Guidance. Inclusion of continuously drained, but abandoned peatlands into 'Managed wetlands' could be based on the definition of 'Managed wetlands' which are those with artificially changed water tables.	
Rewetted drained peatland		all	This is an area for further future development (IPCC Guideline 2006, Vol. 4, Chap. 7.5). Countries where these activities are significant should consider research to assess their contribution to greenhouse gas emissions or removals.	

2. Emissions from Cropland and Grassland on organic soils

2.1. Reporting procedures

Cropland and Grassland management encompass all forms of agriculture. “Cropland includes all arable and tillage land with annual (e.g. cereals, vegetables, forages) or perennial crops (e.g. orchards, oilpalm, tea) as well as land used in an annual crop-pasture mixture” (IPCC 2006). “Grassland generally has vegetation dominated by grasses, and grazing is the predominant land use” (IPCC 2006). Report of CO_2 emissions from organic soils is requested for both categories.
In the following we look at the National Inventory Reports (NIRs) and Common Reporting Format (CRF) tables of the selected countries.

CO_2

Belarus did not report CO_2 emissions from drained Cropland and Grassland, despite the availability of a national method and emission factors, which are addressed in its NIR. It plans “*to offer in future submissions complete CRF files*” (NIR). **Finland**, **Germany** and **Poland** report their CO_2 emissions from Cropland (sector 5.B., LULUCF) and Grassland (5.C.) on organic soils separately. **Iceland** and the **Netherlands** report the CO_2 emissions from a wide variety of non-forested, drained organic soils integrated under the category Grassland. **Ireland** only reports emissions from Grassland because “*Cropland on organic soils does not occur*”. **Sweden** and the **United Kingdom** report emissions only for Cropland, the former because of absence of “*re-inventoried plots on organic soil on category Grassland*”, the latter because “*methods for estimating emissions do not currently allow emissions from mineral and organic soils to be separated*” (NIRs). **France** fails to report any land use activity on organic soils at all because organic soils are not “*représentatifs en France*” (NIR).

N_2O

N_2O emissions from Cultivation of peat soils (Histosols) have to be reported under CRF Agriculture Sector 4.D Direct Soil Emissions. The emissions from Grassland on organic soil are often explicitly neglected under reference to failing relevant methodology in IPCC (2003). In IPCC (2006) methodologies and default emission factors are, however, given. **Belarus** reports N_2O emissions from Cultivation of Histosols. It is unclear whether this refers to Cropland, to Grassland or to both. **Finland**, **Sweden**, the **United Kingdom** and **Ireland** limit their reporting of N_2O emissions to Cropland (see table 2). As the IPCC (2006, Vol.4, Chap. 11) offers guidance to calculate N_2O emissions from drained Grassland on organic soil as well, it is surprising that these countries do not include these in their National Inventories. **Ireland** does not report N_2O emissions from Cropland or Grassland because “*tillage farming on organic soils does not occur*”. Whether true or not, it cannot explain why N_2O emissions from *grassland* are also missing from the report. **Iceland** reports the N_2O emissions from all drained, non-forested organic soils under CRF 5 (II) Wetlands converted to Grassland. **France** claims no land use activity on organic soil.
No country reports emissions under CRF 5(III) Non-CO_2 Emissions from Disturbance associated with Land use Conversion to Cropland. These emissions are included either in category 4.D, not estimated due to methodical problems or land conversion to Cropland does not occur.

2.2. Reported areas

To assess the areas of organic soil under Cropland and Grassland (and their changes) information on the incidence of organic soils and on land use is required. In practise, data from different methods and times (e.g. annual census, periodic surveys, remote sensing with ground truthing) have to be integrated into a final assessment.

Belarus bases its area data on expert judgement and reports of the Institute for Problems of Natural Resources Use and Ecology of the National Academy of Sciences.
Periodic surveys of land cover including comprehensive field research are carried out by **Finland** and **Sweden** (National Forest Inventories [NFI]) and the **United Kingdom** (Countryside Surveys). **Finland** and the **United Kingdom** additionally use maps and satellite images. The latter might also be included by Sweden in its future NFI (http://www-nfi.slu.se/). The Finnish NFI does not differentiate between Grassland and Cropland, so data on the tilled area are derived from national studies of Statistics Finland.
Iceland predominantly uses remote sensing, existing maps (e.g. of erosion and vegetation cover) and its Farmland database. The assessment of drainage is based on mapping of all ditches and estimates of the extent of drainage to the surrounding land. This approach likely covers the extent of drained organic soils adequately. Iceland currently reports all agricultural land on drained organic soils under 5.C. Grassland, but in fact only 60% of the drained land is indeed grassland (NIR). The other 40% should be assigned to other land use categories.
Germany and the **Netherlands** combine soil maps, digital land cover maps and remote sensing (satellite imagery or aerial photography) to arrive at area estimates for land use on organic soils. Germany remarks that its reporting on organic soils is incomplete because the German maps cover 'peatlands' only, and the definition of 'peatlands' departs from the IPCC definition of 'organic soils'. This is true, but the dramatic outcry that the coarse FAO mapping indicates that the area of histosol in Germany 'may' amount to 67 000 km^2 is misplaced. The FAO map indicates that 67 000 km^2 *may* be histosol, not that they are. There will be little merit in re-mapping German soils to comply with the IPCC definition of organic soils.
Ireland mainly uses data from the Central Statistics Office and additional data from remote sensing and the Land Parcels Information System. Ireland's assessment of peatland is based on a detailed national assessment of soil carbon stocks. The statement that tillage farming on organic soil does not occur is implausible. Be that as it may, this should not withhold Ireland from estimating N_2O emissions from Grassland…
Also **Poland** disposes of a special database on peatlands (TORF) and a System of Spatial Information on Wetlands in Poland.

To arrive at the necessary time series, the data of periodic surveys have to be inter- and extrapolated. The inventory data used by the countries differ in age: While the most recent Countryside Survey of the **United Kingdom** (for Great Britain) stems from 1998, **Finland** uses NFI data with field assessments collected until 2008. In **Sweden** all permanent sample plots are re-inventoried every 5-10 years. In **Poland** the organic soils were assessed in the mid 1970s and the mid 1990s.

The reported areas in Table 2 are in general consistent with the data in the International Mire Conservation Group (IMCG) Global Peatland Database. The following remarks can be made:
Belarus gives no figures, although the area of Cropland and Grassland on peatland is huge (> 1,000 Kha) and substantial information on various forms of land use is available. **Finland**

apparently overlooks N_2O emissions from high intensity young Grassland on organic soil. **France** does not report the categories although its agriculture on peatland is not insignificant. It in general considers changes in soil organic carbon not to occur under Cropland or Grassland. **Iceland** reports everything under Grassland, although data on Cropland on peatland (65 Kha, Guðmundsson &Óskarsson 2008) are available. The agricultural area for **Poland** seems somewhat low: possibly abandoned agricultural lands are excluded. **Sweden** does not report emissions from Grassland because '*there were no re-inventoried plots on organic soil on category Grassland'*(CRF). Apparently inconsistencies occurred during the completion of the CRF because elsewhere an area of 45 Kha for Grassland on organic soil is reported.
The **United Kingdom** reports CO_2 emissions from Cropland (including Grassland) in the Cropland subcategory 'Lowland drainage', but only includes the drained and cultivated fens of England. The area reported for N_2O emissions not even covers that area. It is incomprehensible why agriculturally used peatlands in other parts of the United Kingdom (including the extensive grazed blanket bogs of England, Scotland, Wales and Northern Ireland!) are excluded.

Table 2. Areas (in Kha) reported for drained organic soils under agricultural use (from the 2009 CRF files, rounded). If only one value is given, subcategories are aggregated in National Reports or neglected for various reasons (see text). IE = included elsewhere, NA = not applicable, NE = not estimated, NO= not occurring, xxx = no entry in CRF files. 5.B.1. = Cropland remaining Cropland, 5.B.2. = Land converted to Cropland, 5.C.1. = Grassland remaining Grassland, 5.C.2. = Land converted to Grassland.

Country	CO_2. 5.B. Cropland	CO_2. 5.C. Grassland	CO_2. 5.B. + 5.C.	N_2O CRF 4.D. Direct soil emissions	N_2O CRF 5(II) Non-CO_2 emissions from drainage of soils and wetlands	Comments
Belarus	NE	NE	NE	914	NE	NE: the NIR gives detailed information on emissions but these were no reported. They will be included in future submissions
Finland	257	45	302	260	(Peat extraction areas only) 85	Apparently N_2O emissions from drained Grassland are not reported.
France	Xxx	xxx	xxx	xxx	NO	xxx: relevant columns in CRF empty
Germany	5.B.1. 575 5.B.2. 9	5.C.1. 698 5.C.2 11	1293	1293	NE	Area under 5.B. + 5.C. matches area under CRF 4.D.
Iceland	IE	364	364	NE	364	IE: all drained organic soils except Forest Land are included in Wetland converted to Grassland'
Ireland	NO	5.C.1. 289 5.C.2. 7	296	NO	(Peat extraction areas only) 58	Apparently N_2O emissions from drained Grassland are not reported.
Netherlands	5.B.1. 27 5.B.2. 1	5.C.1 196 5.C.2. 5	229	223	[2] NE	NE: "No data available" Converted areas are probably excluded.
Poland	554	147	701	701	(Peat extraction areas only) 1	Area given under 5.B. + 5.C. matches area under CFR 4.D.
Sweden	250	NE	295	253	NE	CO_2 and N_2O emissions are not reported for Grassland on drained organic soils.
United Kingdom	150	) IE	150	39	[6] IE	150: only drained and cultivated areas in England; IE 5C: included under mineral soils.

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2.3. Reported emission factors

CO_2

For estimation of emissions from organic soils under agricultural use the IPCC 2006 Guidelines offer detailed methodological descriptions at Tier 1, 2 and 3 levels (Vol.4, Chap.5, 6). The basic (Tier 1) approach is to multiply land areas by a climate-specific emission factor. Separate default emission factors are given for Grassland and Cropland, with emissions from grassland simply deemed one quarter of those from croplands. The basis for the emission factor for Cropland largely lies in subsidence studies combined with generic assumptions (Couwenberg 2009a). For Cropland the Tier 1 emission factor (5 t C ha^{-1} a^{-1}) is applied by **Poland** only, while for Grassland it is used by **Poland**, **Finland**, **Ireland**, and **Iceland**.

For Tier 2 country-specific emission factors, stratified climate regions, or a land management classification system can be implemented. **Finland** subdivides Cropland in Grass (referring to high intensity, young grasslands) and Other Crops (mainly cereals) with country specific emission factors of 4.1 and 5.7 t C ha^{-1} a^{-1}, respectively. These emissions are based on a review of direct flux measurements (Maljanen *et al.* 2007). In a more recent review, Maljanen *et al.* (2009) arrive at a slightly higher emission factor of 4.6 for Finnish grasslands. Finland also reports on emissions of grasslands (low intensity, older grasslands) under the Grassland category and uses the IPCC default value for the latter, as no national alternative is available.

Germany uses an emission factor of 11 t C ha^{-1} a^{-1}, which is based on subsidence data (Höper 2002) and generic assumptions of carbon content and oxidative component in overall subsidence (Höper 2007). These estimates are not corroborated by direct flux measurements and likely too high. Recent data suggest emission rates of ~8 t C ha^{-1} a^{-1} (Drösler 2008). Germany uses a country specific emission factor for Grassland on organic soil of 5 t C ha^{-1} a^{-1}, which is derived from direct gas flux measurements of Mundel (1976), Gensior & Zeitz (1999), Meyer (1999) and Augustin (2001) and supported by more recent findings (Beyer 2009) as well as by data from the Netherlands (Jacobs et al. 2003, Veenendaal *et al.* 2007).

Sweden uses an emission factor of 3 t C ha^{-1} a^{-1}, a simplification of the 3.15 t C ha^{-1} a^{-1} used in its 2004 National Inventory Report. The value stems from Berglund (1989) and is based on roughly estimated subsidence rates, an oxidative component derived from a single site and carbon content determined from a copious amount of peat samples (Berglund & Berglund 2008). The value is low compared to the well-supported Finnish estimate.

The **United Kingdom** calculates emissions from ‘lowland drainage’ of 150.000 ha of peatlands, using carbon loss rates of 12.8 t C ha^{-1} a^{-1} for ‘Thick peat’ (> 1m) and 1.09 t C ha^{-1} a^{-1} for ‘Thin peat’ (up to 1 m) (Bradley 1997). Apparently due to thick peat becoming progressively thinner and switching to the lower thickness-class, the emission factor of 3.00 used in 1990 has been lowered by 0.07 t C ha^{-1} a^{-1} for subsequent years until 2000 and 0.04 t C ha^{-1} a^{-1} for later years to become 2.05 t C ha^{-1} a^{-1} for the year 2007. Under the grassland category, the UK actually reports on emissions from peat extraction.

The **Netherlands** addresses all land use on organic soils under the grassland category. The country specific emission factors for grasslands on organic soils are based on long-year subsidence measurements and assessments of carbon content and the oxidative component (Kuikman *et al.* 2005). The emission factor of 5.90 t C ha^{-1} a^{-1} compares well with direct flux measurements (Jacobs *et al.* 2003, Veenendaal *et al.* 2007) and data from Germany (see above). No justification is given for reporting emissions from croplands on organic soil under the grassland category and for using a lower emission factor than the IPCC Tier 1 default associated with this.

Belarus presents detailed information on losses of organic matter for various crops on organic soils, but fails to appoint emission values and furthermore fails to report these in its CRF.
Iceland and the **Netherlands** report aggregate emissions from both categories under the Grasslands. If Cropland covers substantial areas, categories should be reported separately using appropriate emission factors. A Tier 3 approach would use dynamic models and/or measurement networks, but was not implemented by any of the regarded countries. Table 3 shows the emission factors used for Grassland and Cropland on organic soils.

Table 3. Comparison of CO2 emission factors for croplands and grasslands on organic soils. NE = Not estimated, NO = Not occurring.

		Cropland	Grassland
Temperate	IPCC (2006)	10	2.5
	Couwenberg (2009)	5.5	
	France	–	–
	Germany	11	5
	Ireland	NO	2.5 (default)
	Netherlands	Reported as grassland	5.9
	Poland	10 (default)	2.5 (default)
	UK	12.8 – 1.09[1]	Report on extraction
Boreal	IPCC (2006)	5	1.25 (default)
	Couwenberg (2009)	6.8	2.6
	Iceland	Reported as grassland	1.25 (default)
	Finland	4.1 / 5.7[2]	1.25 (default)
	Sweden	3	NE/NO

France does not report on organic soils
[1]For peat > 1m and < 1m thick respectively
[2]for 'grass' and 'other crops' respectively

N_2O

Methods for estimation of N_2O emissions from Cultivation of Organic Soils are given in the IPCC 2006 Guidelines in Volume 4, Chapter 11. The area of agriculturally used organic soils has to be multiplied with default (Tier 1) or national (Tier 2) emission factors. A default Tier 1 emission factor of 8 kg N_2O-N ha^{-1} a^{-1} is given for 'temperate organic crop- and grassland soils' (IPCC 2006 Guidelines), but not for boreal areas.
Except for **Ireland** and **Iceland** all countries regarded report N_2O emissions from Cultivation of Histosols under the sector Agriculture. The default emission factor is used by **Belarus**, **Germany**, **Sweden**, the **United Kingdom** and **Poland**.
Finland developed country specific emission factors of 11.7 kg N_2O-N ha^{-1} a^{-1} for Cropland and 4.0 kg N_2O-N ha^{-1} a^{-1} for (high intensity) Grassland (both reported under the Cropland sector; Monni et al. 2007). Maljanen *et al.* (2007) arrive at higher values of 13.8 kg N_2O-N ha^{-1} a^{-1} for croplands (including fallow lands) and 5.7 kg N_2O-N ha^{-1} a^{-1} for grasslands, which is supported by a more recent review (Maljanen *et al.* 2009).
The **Netherlands** uses a national emission factor of 4.7 kg N_2O-N ha^{-1} a^{-1}. This value is based on country specific default values for the amount of N_2O that evolves during N-mineralisation (Kroeze 1994), combined with mineralization rates derived from subsidence studies (Kuikman *et al.* 2005). The value used is lower than the mean emission value of 6.8 kg N_2O-N ha^{-1} a^{-1} derived from direct measurements of (often erratic) N_2O fluxes from temperate Europe (Couwenberg 2009a).
Iceland reports N_2O emissions from Wetlands Converted to Grassland (subcategory 5.D.2) under Non-CO_2 Emissions from Drainage of Soils and

Wetlands (CRF 5(II)). The default emission factor for this activity is derived from the IPCC Good Practise Guidelines (IPCC 2003) and considerably lower (1.8 kg N_2O-N ha^{-1} a^{-1}) than the common default for Cultivated Organic Soils.

N_2O emissions are generally restricted to water levels below -20cm. An important factor is land use: on drained peatlands in the temperate zone, 2 – 9 % of the applied fertilizer N is emitted as N_2O, i.e. a larger proportion than on mineral soils (Couwenberg *et al*. 2008, 2009).

3. Emissions from Forest land on organic soils

3.1. Reporting procedures

Forest Land (Category 5.A.) deals with managed forests. The category is subdivided in 5.A.1: Forest Land remaining Forest Land and 5.A.2: Land converted to Forest Land. After 20 years or more, the land areas are transferred from the Land Converted to Forest Land to Forest Land Remaining Forest Land I (IPCC 2006). Emissions have to be reported both for mineral and organic soils.

CO_2

Belarus does not report CO_2 emissions from drained forests on organic soils, despite the availability of a national method for Land converted to Forest Land (5.A.2.) but "*this inconsistency will be removed in future submissions*" (NIR). For emissions from Forest Land remaining Forest Land the Belarus NIR refers to the optional report of emissions covered by appendix 3a.3 (Wetlands) of GPG-LULUCF (2003) and emission were not reported.
Germany, **Ireland** and the **United Kingdom** do not report organic soil emissions from Forest Land remaining Forest Land because they claim that carbon stocks under existing forests are stable. The assumption might be compatible with the Tier 1 approach for mineral soils (IPCC 2006), but is wrong when applied to organic soils. The **Netherlands** and **Poland** motivate the absence of emission reporting by the claim that drainage in forests (and associated soil carbon stock changes) do not occur: "*there is no reason to assume the soil is a source*" (the Netherlands). On organic soils, however, drained forests always lead to a (often substantial) decrease in soil carbon stock (Schäfer & Joosten 2005). **Iceland** and **Sweden**, in contrast, do report emissions from this subcategory.
As IPCC (2006) methods and emission factors are the same at the Tier 1 level, emissions from 5.A.1 (Forest Land remaining Forest Land) and 5.A.2. (Land converted to Forest Land) can be combined.
Finland indeed aggregated emissions from both subcategories. **Germany** addresses only the total area of forest without differentiating between organic and mineral soils. Consequently Germany considers stock changes under Land converted to Forest Land to be negligible "*since in our latitudes it takes decades for typical forest stock to develop*" (CRF). Regretfully, Germany plans no improvements in its deficient reporting under this category.
Iceland, **Ireland** and the **United Kingdom** do report emissions from Land converted to Forest Land. **Poland** notes that "*an increasing area of histosols is occupied by forest and scrub communities following cultivation termination of these areas*" (NIR). Since it is can be assumed that most of these abandoned areas are still drained (which is one of the reasons of rapid shrub and forest encroachment), these sites should be reported under Forest Land on organic soils if they are managed in any form.

N_2O

N_2O emissions can be reported in CRF 5(II) Non-CO_2 Emissions from Drainage of Organic Soils and Wetlands. This reporting is optional due to the preliminary methodology (IPS 2003), but IPCC (2006) has since provided basic methodologies and default emission factors.
Only **Belarus**, **Ireland** and **Iceland** report emissions. The other countries refrain for a variety of reasons. **Germany** again does not differentiate between mineral and organic soils because of lack of data. The **United Kingdom** mentions the existence of planted forests on drained peatland, but asserts to have no information on their extent. **Finland** and **Sweden** explain the absence of concrete data by pointing to new methodologies under development

but forget that in absence of better data they could have used the Tier 1 approach. The **Netherlands** and **Poland** again claim that they have no forests on drained peatland.

3.2. Reported areas

To account for changes in soil C stocks associated with Forest Land, countries need to have, as a minimum, estimates of the total Forest Land area at the beginning and end of the inventory period, stratified by climate region and major soil type (IPCC 2006, Vol.4, Chap. 4).
Belarus uses expert estimates of the National Academy of Sciences in absence of official statistical information on areas of drained peatland. **Finland** and **Sweden** have their National Forest Inventories (NFIs), **Ireland** its Forest Inventory and Planning System (FIPS) with repeated field surveys of permanent plots covering forest vegetation, biomass and often soil properties. Ireland uses the General Soil Map as an additional data source for soil types. **Iceland** works on a New National Forest Inventory (NNFI) based on re-inventoried permanent plots of which the first version will be completed in 2010. The **United Kingdom** covers forests in its Countryside Survey (only in Great Britain), which includes sample based inventory of vegetation, land cover and soils. A related survey is carried out in Northern Ireland (www.countrysidesurvey.org.uk). Most of these Inventories combine field surveys, digitised maps and remote sensing (e.g. satellite imagery) with permanent plots that are sampled every 5-10 years. In **Germany** two Federal Forest Inventories (1986-89 /2001-02, www.bundeswaldinventur.de) were carried out almost exclusively base on field surveys of permanent plots. To assess the area of forests, additionally digitised topographical maps and satellite images were used. With the Federal Forest Inventory II (BWI II) and Soil-Condition Survey (Bodenzustandserhebung - BZE) now the first national inventories are available for soil Carbon stocks, but it is still not possible to determine the relevant changes. The **Netherlands** combines topographical maps and aerial photography from 1990 and 2004 with soils maps. **Poland** draws its forested area from the Central Statistical Office and combines the 2008 forestry data with the TORF peatland database and with the System of Spatial Information on Wetlands in Poland.
Several countries have aggregated the subcategories 5.A.1. and 5.A.2.of Forest Land on organic soils to a single figure.

With respect to the reported areas (table 4) the following remarks can be made:
Belarus does not reporting concrete areas under 5.A. (see table 4), but presents an area of 210 Kha of forested peatland under N_2O emissions in CRF 5(II) Non-CO_2 emissions from drainage of soils and wetlands). The figure for **Finland** is in international comparison too large because in Finland, following the NFI and the Finnish ‘suo’ concept, a site is classified as peatland if the organic layer is peat or if more than 75% of the ground vegetation consists of peatland vegetation. The latter implies that also areas are included that are outside the FAO definition of organic soil. Data of **France** fail again. **Germany** neglects its forest on peatland that amounts to some 100 Kha (Joosten & Clarke 2002). **Ireland** does not estimate its older forest on peatland that may amount to 200 Kha (Shrier 1996). The area reported by **Poland** is large, probably because it includes abandoned agricultural land subject to spontaneous forest and scrub encroachment (NIR). The area reported by **Sweden** includes some 3,500 Kha of undrained and some 1,000 Kha of drained forests on peatland (NIR). The **United Kingdom** does not report its older forest on peatland, although 125 Kha of peatland were afforested prior 1971, and a further 95 Kha since then (Burton 1996).

Table 4. Areas (in Kha) reported for Forest Land remaining Forest Land (5.A.1.) and Land converted to Forest Land (5.A.2.) on organic soils. Data from CRF files and rounded. IE = included elsewhere, NE = not estimated

Country	Forest Land remaining Forest Land	Land converted to Forest Land	Comments
Belarus	NE	NE	NE: to be added in next submission
Finland	5 940	IE	IE: 5.A.2. included in 5.A.1.
France	xxx	xxx	xxx: relevant columns in CRF empty
Germany	IE	IE	IE: included under mineral soils
Iceland	1	3	
Ireland	NE	10	NE: no data available (CRF)
Netherlands	9	4	5.A.1. includes 'Trees outside a forest' and 'Forest (Kyoto)'
Poland	231	9	
Sweden	4 660	NE	NE: rare, data uncertain (CRF)
United Kingdom	IE	266	Probably included in total area

3.3. Reported emission factors

CO_2

Methods for calculating emissions from forestry drained organic soils area described in the IPCC 2006 Guidelines in Volume 4, Chapter 4. The area of forestry drained organic soils should be stratified by climate type and then multiplied by a climate-specific emission factor. The default emission factors given are deemed too low (Couwenberg 2009a). Only **Iceland** has adopted a Tier 1 approach using a default emission factor.

Tier 2 demands incorporation of country-specific information (e.g. national emission factors, climate regions). Finland, Sweden, Ireland and The United Kingdom have implemented a Tier 2 approach.

Finland bases its emission factor on measurements of heterotrophic soil respiration (Minkkinen *et al.* 2007) and corrects these for below-ground litter input. Flux measurements follow a sophisticated set-up (Alm *et al.* 2007), which allows to separate fluxes from decomposition of the peat, decomposition of below ground litter and from the roots (Mäkiranta *et al.* 2008). Whereas decomposition of the peat is likely slightly underestimated (Mäkiranta *et al.* 2008), there is a considerable missing sink in the overall CO_2 exchange of the ecosystem when comparing with eddy covariance flux measurements (Lohila *et al.* 2007). The turnover and accumulation of litter is the main unknown factor in assessing reliable net-emission values (Laiho *et al.* 2008). Whereas 5 forest types are distinguished in terms of emissions from the soil, there is no distinction between forest types with respect to below ground litter input. The overall mean emission factor (weighted by area of the 5 different forest types) amounts to 0.31 t C ha^{-1} a^{-1}.

Sweden uses a comparable, if less detailed approach based on Von Arnold *et al.* (2005a, b, c). Two types of forest are distinguished: well drained (mean annual water level below -40 cm) forests with soil carbon losses of 3 t C ha^{-1} a^{-1} and poorly drained forests with soil carbon losses of 1.9 t C ha^{-1} a^{-1}. No attempt was made to separate the different components of soil respiration fluxes. The contribution of root respiration was assumed to be half of total fluxes measured. Below ground litter input is deemed negligible (Von Arnold 2004) and input of above ground litter to the forest floor was estimated using generic values based on Bray & Gorham (1964). The soil fluxes are likely underestimated due to the measuring technique (Klemedtsson *et al.* 2008). Using measurements designed to exclude root derived

fluxes, Klemedtsson *et al.* (2008) arrive at net heterotrophic emissions of 2.23 t C ha^{-1} a^{-1} for a poorly drained site previously studied by Von Arnold (2005c).
Ireland and the **United Kingdom** have adopted Tier 2 approaches only for Land Converted to Forest Land (not for Forest Land Remaining Forest Land) and both refer to the study of Hargreaves *et al.* (2003). In this study the effect of drainage and afforestation was measured using the eddy-covariance technique to obtain net CO_2 fluxes between the total ecosystem and the atmosphere. Instead of comparing (multiple) year long measurements from different sites, fluxes were measured at sites of different forest age for short periods of time only and extrapolated to yearly fluxes based on a 1.5 year record from an undrained site. Carbon losses from the soil were calculated by subtracting the carbon increment in the forest stand as estimated by a simulation model. Uncertainties arising from the methods used are not discussed. The study arrives at net emissions from the soil to the atmosphere of 1 to 2 t C ha^{-1} a^{-1} over a 60-year rotation period. In its National Inventory Report, the **United Kingdom** refers to ongoing emissions of 0.3 t C ha^{-1} a^{-1}. None of the values are used in reporting emissions from Forest Land Remaining Forest Land, however.
The approach of **Ireland** is that following clearance, drainage and plantation, organic soils emit carbon at an elevated rate of approximately 16 t C ha^{-1} over a typical period of 4-5 years. This is then reported as an emission of 4 t C/ha annually over a transition period of 4 years. Thereafter the emission from afforested organic soils are deemed zero.

N_2O

Guidance for N_2O emission from drained organic forest soils is given in the IPCC 2006 Guidelines in Volume 4, Chapter 11. Areas must be stratified by soil fertility (nutrient rich and nutrient poor and multiplied with default or national emission factors. Default emission factors are given for temperate and boreal organic nutrient rich or nutrient poor forest soils together (see Couwenberg 2009a). Nitrous oxide emissions from forestry drained peatlands are addressed by **Belarus**, **Iceland** and **Ireland**. All countries used a Tier 1 approach with default emission factors for nutrient rich soils (Iceland) and nutrient poor soils (Belarus and Ireland).
N_2O emissions are generally restricted to water levels below -20cm. An important factor is land use: on drained peatlands in the temperate zone 2 – 9 % of the applied fertilizer N is emitted as N_2O, i.e. a larger proportion than on mineral soils (Couwenberg *et al*. 2008, 2009).

4. Emissions from Peat Extraction

4.1. Reporting procedures

Designated category for reporting emissions from peat extraction is 5.D. Wetlands (subcategory Managed Wetlands).

CO_2

Emissions from peat extraction can be reported for three phases: the initial phase of drainage and preparing under Land Being Converted for Peat Extraction, peat mining in prepared extraction fields under Peatlands remaining Peatlands and conversion of cut-over peatlands to other use under Land converted to Cropland, to Grassland or to Forest Land (IPCC 2006). The IPCC 2006 Guidelines offer methodologies for estimating emissions from peat extraction fields and complement the GPG-LULUCF (IPCC 2003) by providing methodology for assessing emission from the off-site use (decay) of horticultural peat. The latter is until now only done by the **United Kingdom**, but applies for all European countries that produce horticultural peat, notably the Baltic States, Belarus, Finland, Germany, Ireland, Russia, Sweden and the United Kingdom.
According to IPCC (2006) CO_2 emissions from peat extraction fields should be reported under Wetlands (5.D.). **Germany**, **Sweden** and **Ireland** indeed report peat extraction under Wetlands remaining Wetlands (5.D.1.). Some countries do not offer information on areas under peat extraction in the CRF which obstructs insight in the calculation process. A subcategory Peat extraction fields should be implemented by all countries.
Poland states in its NIR that CO_2 and N_2O are estimated, but relevant CO_2 emission data could not be found in its CRF. **Finland** reports under Other Land converted to Wetland (5.D.2.), reflecting the prevailing Finnish practise to open unmanaged Other Land for peat extraction. The **United Kingdom** reports peat extraction under Grassland remaining Grassland (5.C.1), possibly because of the formerly predominant after use of cut-out sites as grassland.
Iceland mentions peat extraction related to Land conversion to Settlement (5.E.2), but does not report emissions due to lack of data. The **Netherlands** report emissions from peat used for producing activated carbon under Chemical Industry (2.B), but all that peat is imported. Since emissions from peatlands undergoing extraction differ substantially in scale and type from emissions from Land Being Converted for Peat Extraction, countries with an active peat industry should separate their managed peatlands accordingly (IPCC 2006). Such subdivision is, however, not made by any country.

N_2O

N_2O emissions from peat extraction fields can be reported under CRF 5(II) Non-CO_2 Emissions from Drainage of Soils and Wetlands (IPCC 2006). Tier 1 considers only nutrient-rich peats, since N_2O emissions from nutrient-poor peat with a C/N ratio exceeding 25 may be considered insignificant. Higher Tier level includes disintegration of peat type, fertility and time since onset of drainage. The IPCC guidance does not cover N_2O emissions from the decay of horticultural peat, since there are no methods to separate N_2O emissions from decaying peat from that from the commonly added Nitrogen fertilizers.
N_2O emissions from peat extraction fields are reported by **Finland**, **Ireland** and **Poland**. **Germany** does not report these emissions, as almost all peat is extracted from raised bogs with C/N ratios exceeding 25. With respect to N_2O **Sweden** considers all wetlands as unmanaged (CRF) and did not report emissions, whereas the **United Kingdom** questions the IPCC approach for estimating emissions from drained soils. Both countries thus do not report N_2O emissions.

4.2. Reported areas

All Tier levels require data on areas of peatlands managed for peat extraction (IPCC 2006). The default methodology requires estimates of the total area on which peat is and has been extracted, including former commercial peatlands that have not been converted to other uses. In temperate and boreal regions, this area should, where possible, be separated into nutrient-rich and nutrient-poor peatlands.
Peat extraction is reported from Belarus, Finland, Germany, Ireland, Poland, Sweden and the United Kingdom.
The countries only provide sketchy information on the areas involved. Data for **Belarus** were supplied by the state owned concern Beltopgas. **Finland** and **Germany** obtained the area data from the national peat associations (Finnish Peat Industry, Bundesvereinigung Torf- und Humuswirtschaft) and national statistics (VAHTI system, DESTATIS). Germany states that all peat is extracted from nutrient-poor raised bogs (that is not completely true). Bord na Mona supplied the area estimates for **Ireland**, the Svenska Torvproducentföreningen for **Sweden**.
Poland estimated its peat extraction area based on literature data. The area for the years 1960-1999 was calculated using interpolation and because of lack of data, for 2000-2006 the value from the year 1999 was taken. Poland in its NIR furthermore presents specifications for both nutrient-rich and nutrient-poor peat, consistent with Polish practise. For the **United Kingdom** trends in peat extraction in Scotland and England over the period 1990 to 2007 were estimated from the Business Monitor of Mineral Extraction in Great Britain (Office of National Statistics 2007).

With respect to the areas reported (table 5) it is clear that all countries only report the areas under active peat extraction. According to IPCC (2006), however, also emissions from abandoned cut-over peatlands and peatland after-use should be covered.

Table. 5. Peat extraction areas reported in the NIRs

Country	Area (Kha)
Belarus	13
Finland	85
Germany	35
Ireland	58
Poland	1
Sweden	10
United Kingdom	9

4.3. Reported emission factors

CO_2

Guidance for estimation of CO_2 emissions from peat extraction fields is given in Volume 4, Chapter 7 of the IPCC 2006 Guidelines. There are two basic elements in CO_2 emissions from lands undergoing peat extraction at the Tier 1 level: on-site emissions from peat deposits during the extraction phase and off-site emissions from the horticultural (non-energy) use of peat. Energy use of peat is covered under the Energy sector. On site emissions apply to the total area of managed peatlands, including land being converted and unused/abandoned. There are default on-site emission factors for nutrient rich (fen) peat and for nutrient poor (bog) peat, and default carbon contents to estimate off-site emissions. Off-site emissions are based on the amount of peat extracted and must be reported by the country of origin. Default emission factors for assessment of emissions from peat extraction fields are use by **Germany**, **Ireland** and **Poland**. None of these countries report on the off-site emissions from horticultural peat, although all three do extract peat for this purpose (USGS 2008).

Finland has developed a Tier 2 approach in which emission factors (incl. CH_4 and N_2O) depend on regional weather and in which emissions from ditches and stockpiles are taken into account (Nykänen *et al.* 1996, Alm *et al.* 2007). Finland reports CO_2 emissions from peat extraction fields in Category CRF 5.D 2.5 (Other Land converted to Wetlands). N_2O and CH_4 emissions from peat extraction areas are reported in Category CRF 5 (II), Non-CO_2 Emissions from Drainage of Wetlands. Averaged over the peat extraction areas in the different climate zones distinguished under this Tier, emissions amount to 3.75 t CO_2-C_{eq} ha^{-1} a^{-1}. While Alm *et al.* (2007) depart from 5-10% of the area covered by high-emitting stockpiles, this area is taken to be only 2% in the Finnish National Inventory Report. Off-site emissions from horticultural peat are not reported.

Sweden elaborated a national emission factor of 6 t CO_2 ha^{-1} a^{-1} based on studies of Kasimir-Klemedtsson *et al.* (2000) and Sundh *et al.* (2000) that include CH_4 emissions from ditches (but exclude greenhouse gas emissions from stockpiles). Off-site emissions are not reported.

The **United Kingdom** is the only country to include off-site emissions from horticultural peat. Emission factors for this source are 55 kg C m^{-3} for Great Britain horticultural peat and 44.1 kg C m^{-3} for Northern Ireland horticultural peat (Cruickshank & Tomlinson 1997).

N_2O

Methods for estimation of N_2O emissions from peatlands drained for peat extraction are presented in Volume 4, Chapter 7 of the IPCC 2006 Guidelines. In drained peatlands the potential amount of N_2O emitted depends on the nitrogen content of the peat. At C/N ratios exceeding 25, the N_2O emissions may be considered insignificant. The Tier 1 method for estimating N_2O emissions is similar to that described for drained organic soils for agriculture or forestry, but emission factors are generally lower. Under the Tier 1 approach the area of peat extraction fields (including abandoned fields) has to be multiplied with a default emission factor, which is given for nutrient-rich organic soil for boreal and temperate areas together. **Ireland** and **Poland** have adopted the Tier 1 approach for estimation of N_2O emissions from peat extraction fields. **Finland** reports N_2O emissions under its Tier 2 approach (see above). Currently, there are no estimation methods that would allow separation of N_2O emissions from organic matter decay during the off-site use of horticultural peat. Nitrogen fertilizers are commonly added to horticultural peat before use, and this source would likely dominate N_2O emission patterns.

5. Emissions from other Wetland (beside peat extraction)

Per definition (IPCC 2006), Wetlands include any land that is covered or saturated by water for all or part of the year, and that does not fall under Forest Land, Cropland, or Grassland. For the latter categories CO_2 emissions from organic soils have to be reported separately. Non-CO_2 emissions from drainage of organic forest soils and peatlands have to be reported under CRF 5(II), Non-CO_2 emissions from drainage of organic soils and wetlands. Hence, managed wetlands are covered under various sections of the National Inventory Reports (Table 1), which causes inconsistency and incompleteness. The latest IPCC Guidelines (2006) aggregate emissions from LULUCF (Land Use, Land Use Change and Forestry) and Agriculture under the AFOLU sector (Agriculture, Forestry and Other Land Uses). This improvement is until now hardly regarded in the National Inventory Reports (NIR 2009) of the analysed countries, which continue to report on LULUCF and Agriculture separately. The Common Reporting Formats are apparently also not yet adapted to this innovation.

The Wetlands category itself can be divided into unmanaged and managed wetlands. Emissions from unmanaged wetlands are not accounted. The IPCC 2006 Guidance for Managed Peatlands under the category Wetlands predominantly covers peat extraction. Per definition (IPCC 2006, Vol.4, Chap. 7) managed wetlands are those with artificially changed (i.e., lowered or raised) water tables. This definition also covers drained and abandoned peatlands. Currently, however, abandoned areas are generally not covered and incorrectly considered to be ‘unmanaged’. Abandoned drained peatlands of which the drainage infrastructure has not been made dysfunctional, remain fierce GHG emittors, both by peat oxidation and by the increased fire incidence. Similar to exhausted peat extraction sites, abandoned agricultural and forested peatlands that have not been converted to other uses should therefore be accounted. Under CRF 5(II) (Non-CO_2 Emissions from Drainage of Soils and Wetlands (subcategory ‘Peatlands’)) countries report N_2O emissions predominantly from peat extraction fields. Beside these, the report of N_2O from abandoned, drained peatlands could be included here.

CO_2 emissions from land use change towards Wetlands are reported by Iceland regarding flooded lands of reservoirs. In Iceland flooding affects approximately 10 kha of soils with a high SOC content of more than 50 kg C m^{-2} (3 kha) and with a medium SOC content of 5-50 kg C m^{-2} (7 kha). In the NIRs from other countries emissions and removals from this source are hardly discussed. Only Poland and Iceland report CH_4 emissions from flooded areas. Sweden and France report substantial areas of Land converted to Wetland (119 kha for Sweden and 119 kha for the temperate France), but do not assess CH_4 emissions from the affected soil. In its CRF, Finland claims that no flooded land occurs. Takko & Vasander (2004) mention 60 kha of hydropower reservoirs over peat alone. Future submissions might introduce a subcategory Peatland Restoration to address these removals or emissions explicitly and to separate it from other activities under Land Conversion to Wetland.

Rewetting of previously drained wetlands (wetland restoration) is until now not covered, because adequate methodologies are not available. It is, however, mentioned as an area for further development (IPCC 2006 AFOLU Section 7.5.). Emissions related to peatland rewetting (including the initial increase in CH_4 emission and the reduced emission of N_2O and CO_2) could be reported under Land converted to Wetlands (regarding Forest Land, Cropland and Grassland). Countries where peatland restoration is significant should consider research to assess its contribution to greenhouse gas emissions or removals. In Europe this would at least include Belarus, Finland, Germany, Ireland, The Netherlands, Poland, Ukraine and Sweden.

6. Conclusions and suggested improvements

Several countries still apply methodologies from IPS GPG-LULUCF (2003) and its appendices for which the IPCC Guidelines (2006) have already consolidated related and better methods for assessing emission of CO_2 and N_2O from land use on peatland. The Tier 1 default values of these Guidelines were recently analysed by Couwenberg (2009a). Confusion arises, where agricultural soil emissions are spread over various chapters. The IPCC Guidelines (2006) integrate all emissions from agriculture into the AFOLU sector ('Agriculture, Forestry and Other Land Use') which indeed improves consistency and completeness in estimation and reporting.

An additional improvement in the latter is the introduction of a method for assessing CO_2 emissions from off-site decay of horticultural peat. Since these methodological upgrades were only occasionally implemented, countries must adapt their National Inventory Reports soon to the most recent scientific guidance offered by IPCC. Most fragmentarily reported are N_2O emissions from drained forests and from agriculture (especially Grassland) on organic soil.

Taking into account the enormous differences in emissions between mineral and organic soils, it is correct that these have to be reported separately within the categories. This is, however, not done in many National Inventories. Some countries use the default Tier 1 method of mineral soils on their total Forest land area (incl. organic soils) assuming that carbon stocks under forests do not change. In case of organic soils this leads to a (severe) underestimation of emissions. Countries should intensify their efforts in this respect.
To assess the impact of organic soils on GHG emissions, it is necessary to perform a *key category* analysis for the soil types separately. Only two out of 10 countries have done this. If emissions from organic soil are found *key category,* countries should perform at least a Tier 2 approach.

CO_2 or N_2O emissions from Grassland and Cropland were often reported aggregated and in one case even Settlements and Wetlands on organic soils were put into the Grassland category. Relocation between categories is possibly not only a matter of convenience or failing data, but might also be a strategic quest for the lowermost default emission factor. Countries should elaborate sufficient area data to estimate emissions in the default category. Area estimates of land use categories can be easily improved with already available sources and rapidly developing technology (e.g. remote sensing). Countries should not neglect their organic soils (as France does…) but be aware of them, because they may represent important shares of their emissions from land use.

Drained peatlands release CO_2 and N_2O up to many hundreds of years after initial drainage. Emission does not end with the termination of a land use practice, it will continue until the peat is gone or the drainage system collapses. As the category approach does not cover abandoned drained peatlands, the emissions from such sites are not adequately addressed leading to an underestimation of emissions.

Several inconsistencies between the methodological descriptions in the NIR file and the reported emissions in the common reporting format (CRF) hamper insight to the procedure of emission estimation. Countries should be encouraged to offer comprehensible subcategories in the CRF (e.g. 'Peat extraction areas' separated from the total wetland area) for a more transparent reporting. Countries should use the documentation boxes in the CRF to supply sufficient additional information to improve this transparency (e.g. by providing links for further explanations). Countries can improve their reporting transparency by reporting in English, providing more detailed descriptions of methods and avoiding unnecessary reference to grey and non-english literature.

In general the inventories, however, show that with some effort countries can arrive to an adequate reporting of their emissions from peatlands. The largest caveats to date seem to be the insufficient recognition of the importance of peatlands for GHG emissions coupled with a reluctance to follow the up-to-date guidance of IPCC.

7. References

Alm J, Shurpali NJ, Minkkinen K et al. (1997) Carbon loss from UK peatlands for fuel and horticulture. In: Carbon Sequestration in vegetation and Soils (ed Cannell MGR). Department of Environment, London.

Alm J, Shurpali NJ, Minkkinen K, *et al*. (2007) Emission factors and their uncertainty for the exchange of CO_2, CH_4 and N_2O in Finnish managed peatlands. Boreal Environment Research, 12, 191-209

Augustin J (2001) Emission, Aufnahme und Klimarelevanz von Spurengasen. In: Landschaftsökologische Moorkunde (eds Succow M, Joosten H), pp. 28-37. Schweizerbart'sche Verlagsbuchhandel, Stuttgart.

Batjes NH (2002) ISRIC-WISE global dataset of derived soil properties on a 0.5 by 0.5 degree grid (version 2.0). ISRIC Report 2002/03, International Soil Reference and Information Centre (ISRIC), Wageningen, 14 p. http://www.isric.org/isric/webdocs/Docs/ISRIC_Report_2002_03.pdf

Berglund K (1989) Ytsänkning av mosstorvjord. Swedish University of Agricultural Sciences, Dept. of Soil Sciences, Division of hydrotechnics. Report 89:3. (In Swedish).

Berglund Ö, Berglund K (2008) Distribution and cultivation intensity of agricultural peat and gyttja soils in Sweden and estimation of greenhouse gas emissions from cultivated peat soils. Geoderma, doi:10.1016/j.geoderma.2008.11.035

Beyer M (2009) Einfluss der Landnutzung auf den Austausch klimarelevanter Spurengase (Kohlendioxid, Lachgas, Methan) bei entwässerten Niedermooren Nordostdeutschlands. MSC Thesis TUM/ZALF, x+71pp.

Bradley RI (1997) Carbon loss from drained lowland fens. In: Carbon Sequestration in Vegetation and Soils (ed Cannell, MGR). Department of Environment, London.

Bradley RI, Milne R, Bell J, Lilly A, Jordan C, Higgins A (2005) A soil carbon and land use database for the United Kingdom. Soil Use and Management, 21, 363-369.

Bray J K, Gorham E (1964) Litter production in forests of the world. Advances in Ecological Research, 2, 105-157.

Burton RGO (1996) The peat resources of Great Britain (Scotland, England, Wales and Isle of Man). In: Global Peat Resources (ed Lappalainen E), pp. 79-86. IPS, Jyskä.

Byrne KA, Chojnicki B, Christensen TR et al. (2004) EU Peatlands: Current Carbon Stocks and Trace Gas Fluxes. CarboEurope-GHG Report 4/2004.

Couwenberg J (2009a) Emission factors for managed peat soils (organic soils, histosols) - An analysis of IPCC default values. Wetlands International, Ede. 14 pp.

Couwenberg J (2009b) Methane emissions from peat soils (organic soils, histosols) - Facts, MRV-ability, emission factors. Wetlands International, Ede. 14 pp.

Couwenberg J, Augustin J, Michaelis D, Joosten H (2008) Emission reductions from rewetting of peatlands. Towards a field guide for the assessment of greenhouse gas emissions from Central European peatlands. Duene Greifswald / RSPB Sandy. 28 pp.

Couwenberg J, Dommain R, Joosten H (2009) Greenhouse gas fluxes from tropical peatlands in Southeast Asia. Global Change Biology doi: 10.1111/j.1365-2486.2009.02016.x

Cruickshank MM, Tomlinson RW (1997) Carbon loss from UK peatlands for fuel and horticulture. In: Carbon Sequestration in Vegetation and Soils (ed Cannell MGR), Department of Environment, London.

Drösler M (2008) Von der Spurengasmessung zur Politikberatung – interdisziplinärer Ansatz und erste Ergebnisse des Verbundprojekts „Klimaschutz -Moornutzungsstrategien". Presentation given at the BfN workshop "Biodiversität und Klimawandel" http://www.bfn.de/4399.html (accessed August 2009).

FAO (1998) World reference base for soil resources. World Soil Resources Reports 84, 88 pp.

Frolking, S. E., Roulet, N. & Fuglestvedt, J. 2006. How northern peatlands influence the Earth's radiative budget: Sustained methane emission versus sustained carbon sequestration, J. Geophys. Res. - Biogeosciences, 111, D08S03, doi: 10.1029/2005JG000091

Gensior A, Zeitz J (1999) Einfluß einer Wiedervernässungsmaßnahme auf die Dynamik chemischer und physikalischer Bodeneigenschaften einer degradierten Niedermoores. Archiv für Naturschutz und Landschaftsforschung, 38, 267-302.

Guðmundsson J, Óskarsson H (2008) Other carbon storages to be included under carbon reservoir mechanism? Agricultural University of Iceland. http://landbunadur.is/landbunadur/wgrala.nsf/Attachment/LandUse_Jon_Gudmundsson/$file/LandUse_Jon_Gudmundsson.pdf

Hargreaves K, Milne R, Cannell M (2003) Carbon balance of afforested peatland in Scotland. Forestry, 76, 299-317.

Höper H (2002) Carbon and nitrogen mineralization rates in German agriculturally iused fenlands. In: Wetlands in Central Europe. Soil Organisms, Soil Ecological Processes, and Trace Gas Emissions (eds Broll G, Merbach W, Pfeiffer EM), pp. 149-164. Springer, Berlin.

Höper H (2007) Freisetzung von Treibhausgasen aus deutschen Mooren. Telma, 37, 85-116.

IPCC (2003) Good Practice Guidance for Land Use, Land-Use Change and Forestry (eds Penman J, Gytarsky M, Hiraishi T, et al.). IGES, Japan.

IPCC (2006) IPCC guidelines for national greenhouse gas inventories, prepared by the National Greenhouse Gas Inventories Programme (eds. Eggleston HS, Buendia L, Miwa K, Ngara T, Tanabe K). IGES, Japan. URL: http://www.ipcc-nggip.iges.or.jp/public/2006gl/vol4.html (retrieved 05/2009).

Jacobs CMJ, Moors EJ, van der Bolt FJE (2003) Invloed van waterbeheer op gekoppelde broeikasgasemissies in het veenweidegebied by ROC Zegveld. Alterra, Wageningen. Alterra-rapport 840, 93pp.

Joosten H, Augustin J (2006) Peatland restoration and climate: on possible fluxes of gases and money. In: Peat in solution of energy, agriculture and ecology problems (ed Bambalov NN), pp. 412 – 417, Tonpik, Minsk.

Joosten H, Clarke D (2002) Wise use of mires and peatlands – Background and principles including a framework for decision-making. International Mire Conservation Group / International Peat Society, 304 pp.

Joosten H, Couwenberg J (2009) Are emission reductions from peatlands MRV-able? Wetlands International, Ede, 14 p.

Kasimir-Klemedtsson Å, Nilsson M, Sundh I, Svensson B (2000) Växthusgasflöden från myrar och organogena jordar. Naturvårdsverket, Rapport 5132.

Klemedtsson L, Jansson P-E, Gustafsson D et al. (2008) Bayesian calibration method used to elucidate carbon turnover in forest on drained organic soil. Biogeochemistry, 89, 61-79.

Kroeze C (1994) Nitrous oxide. Emission inventory and options for control in the Netherlands. RIVM Report No. 773001004, Bilthoven.

Kuikman PJ, van den Akker JJH, De Vries F (2005) Emissions of N_2O and CO_2 from organic agricultural soils, Alterra Rapport 1035-2, 66 pp.. Alterra, Wageningen

Laiho R, Minkkinen K, Anttila J, Vávřová P, Penttilä T (2008) Dynamics of litterfall and decomposition in peatland forests: Towards reliable carbon balance estimation? In: Wastewater treatment, plant dynamics and management in constructed and natural wetlands (ed Vymazal J), pp. 53-64. Springer, Dordrecht. ISBN 978-1-4020-8234-4.

Lohila A, Aurela M, Tuovinen J-P, Laurila T (2004) Annual CO_2 exchange of a peat field growing spring barley or perennial forage. Journal of Geophysical Research, 109, D18116, doi:10.1029/2004JD004715

Mäkiranta P, Minkkinen K, Hytönen J, Laine J (2008) Factors causing temporal and spatial variation in heterotrophic and rhizospheric components of soil respiration in afforested organic soil croplands in Finland. Soil Biology and Biochemistry, 40, 1592-1600.

Maljanen M, Hytönen J, Mäkiranta P, Alm J, Minkkinen K, Laine J, Martikainen PJ (2007) Greenhouse gas emissions from cultivated and abandoned organic croplands in Finland. Boreal Environment Research, 12, 133-140.

Maljanen M, Sigurdson BD, Duðmundsson, Óskarsson, Huttunen JT, Martikainen PJ (2009) Land-use and greenhouse gas balances of peatlands in the Nordic countries – present knowledge and gaps. Biogeosciences Discussions, 6, 6271-6338.

Meyer K (1999) Die Flüsse der klimarelevanten Gase CO_2, CH_4 und N_2O eines nordwestdeutschen Niedermoores unter dem Einfluss der Wiedervernässung. Göttinger Bodenkundliche Berichte, 111, 1-134.

Minkkinen, K., Laine, J., Shurpali, N. J., Mäkiranta, P., Alm, J. & Penttilä, T. 2007. Heterotrophic soil respiration in forestry-drained peatlands. Boreal Env. Res. 12: 115-126.

Monni S, Perälä P, Regina K (2007) Uncertainty in agricultural CH_4 and N_2O emissions from Finland - possibilities to increase accuracy in emission estimates. Mitigation and Adaptation strategies for Global Change, 12, 545-571.

Mundel G (1976) Untersuchungen zur Torfmineralisation in Niedermooren. Archiv für Acker- und Pflanzenbau und Bodenkunde, 20, 669-679

Nykänen H, Silvola J, Alm J, Martikainen P (1996) Fluxes of greenhouse gases CH_4, CO_2 and N_2O on some peat mining areas in Finland. Publications of the Academy of Finland, 1/96, 141-147.

Parish F, Sirin A, Charman D, Joosten H, Minaeva T, Silvius M (eds) (2008) Assessment on peatlands, biodiversity and climate change. Global Environment Centre, Kuala Lumpur and Wetlands International Wageningen, 179 p.

Schäfer A, Joosten H (eds) (2005) Erlenaufforstung auf wiedervernässten Niedermooren. DUENE, Greifswald, 68 p.

Schrier C (1996) The peat resources of Ireland. In: Global Peat Resources (ed Lappalainen E), pp. 95 – 100, International Peat Society, Jyskä.

Sundh I, Nilsson M, Mikkelä C, Granberg G, Svensson BH (2000) Fluxes of methane and carbon dioxide on peat-mining areas in Sweden. Ambio 29, no 8: 499-503.

Takko A, Vasander H (2004) Socioeconomic aspects of commercial uses of peatlands in Finland. Proceedings of the 12th International Peat Congress, Tampere, Vol. 2: 1313-1319.

Trumper K, Bertzky M, Dickson B, van der Heijden G, Jenkins M, Manning P (2009) The Natural Fix? The role of ecosystems in climate mitigation. A UNEP rapid response assessment. United Nations Environment Programme, UNEPWCMC, Cambridge, UK, 65 p. http://www.unep.org/pdf/BioseqRRA_scr.pdf

USGS (2008) 2007 Minerals Yearbook – Peat. http://minerals.usgs.gov/minerals/pubs/commodity/peat/myb1-2007-peat.pdf

Veenendaal EM, Kolle O, Leffelaar PA, Schrier-Uijl AP, van Huissteden J, van Walsem J, Möller F, Berendse F (2007) CO_2 exchange and carbon balance in two grassland sites on eutrophic drained peat soils. Biogeosciences 4: 1027-1040

Voluntary Carbon Standard (2008) Guidance for Agriculture, Forestry and Other Land Use Projects. 43 p. http://www.v-c-s.org/docs/Guidance%20for%20AFOLU%20Projects.pdf

Von Arnold K (2004) Forests and greenhouse gases - fluxes of CO_2, CH_4 and N_2O from drained forests on organic soils. Linköping Studies in Arts and Science, 302, 1-48.

Von Arnold K, Hanell B, Stendahl J, Klemedtsson L (2005a) Greenhouse gas fluxes from drained organic forestland in Sweden. Scandinavian Journal of Forest Research, 20, 400-411

Von Arnold K, Nilsson M, Hanell B, Weslien P, Klemedtsson L (2005b) Fluxes of CO_2, CH_4 and N_2O from drained organic soils in deciduous forests. Soil Biology and Biochemistry, 37, 1059-1071.

Von Arnold K, Weslien P, Nilsson M, Svensson BH, Klemedtsson L (2005c) Fluxes of CO_2, CH_4 and N_2O from drained coniferous forests on organic soils. Forest Ecology and Management, 210, 239-254.

Ywih CH, Ahmed OH, Majid NMA, Jalloh MB (2009) Effects of converting secondary forest on tropical peat soil to oil palm plantation on carbon storage. American Journal of Agricultural and Biological Sciences, 4, 123-130.

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