An assessment of CO_2 emission factors of drained organic soils in the Swiss GHG Inventory

Sonja Paul & Christine Alewell, University of Basel,
Department of Environmental Sciences. Sonja.Paul@unibas.ch

June 2018

Report on behalf of the Federal Office for the Environment, Bern

Content

1. CO_2 Emission Factors for drained organic soils

1.1 Introduction

Swiss Greenhouse Gas Inventory

Three different CO_2 emission factors (EF) for drained organic soils are used in the Swiss Greenhouse Gas (GHG) Inventory: two country-specific and one IPCC default value.

(1) For intensive agricultural use like cropland and managed grassland on organic soil a country-specific EF of 9.52 t C ha^{-1} a^{-1} is used (FOEN 2017). It is based on a review of available European data by Leifeld (2009).

(2) A lower country-specific EF of 5.30 t C ha^{-1} a^{-1} is taken for grasslands on organic soil with a low impact management e.g. protected fens and (very) extensively managed ecosystems such as raised bogs (FOEN 2017). Bogs and fens with typical peatland vegetation are protected to a large part by federal ordinances. New drainage is not allowed in protected peatlands, however, the impact of old drainage systems constructed before 1990 leads to CO_2 emissions (FOEN 2017). In the following, these grasslands are referred to as “extensively managed grasslands”. For extensively managed grassland, the EF is deduced from country-specific data from three moderately drained bogs (Rogiers et al. 2008, Leifeld 2011, Leifeld et al. 2011). This EF was gained by an indirect method from soil profiles, where the cumulative carbon loss since the beginning of drainage was estimated.

(3) For forest land on organic soil, the IPCC default value of 2.6 t C ha^{-1} a^{-1} is used (FOEN 2017). It is based on eight studies, conducted in the temperate zone (IPCC 2014, cf. Table 1).

The object of this report is to assess the CO_2-EFs used in the Swiss GHG inventory (FOEN 2017) in the light of both the IPCC dataset and recent studies that had not yet been considered in the latest IPCC Guidelines.

IPCC Guidelines and further recent studies

Over the past years, new studies measuring GHG emissions of drained organic soils were published, hence in 2013 the available data set was summarised in the “2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands” (the so called Wetlands Supplement, IPCC 2014). This report includes all data of the temperate zone (published by 2013) and comprises revised EFs, which replace the EFs listed in IPCC (2006). In IPCC (2006) land-use categories were stratified by climate domain and nutrient status. Due to the more comprehensive data set, IPCC (2014) subdivided grassland into three categories according to nutrient status and drainage depth (Table 1). The drainage depth is determined by the mean annual water table depth over several years: shallow-drained soils are characterised by a mean annual water table depth of less than 30 cm below surface while deep-drained soils have a mean annual water table depth of 30 cm and deeper (IPCC 2014). Generally, ombrogenic organic soils are considered as nutrient-poor, while minerogenic organic soils are referred to as nutrient-rich (IPCC 2003, IPCC 2006). The IPCC category "rewetted" includes also natural sites, as no systematic differences in emissions were found (IPCC 2014).

Table 1: CO_2-EFs of drained organic soils from the temperate zone (IPCC 2014).

Land use	Drainage depth cm	Nutrient status	Mean EF (default value) t C ha^{-1} a^{-1}	95% confidence interval	Number of studies
Cropland*			7.9	6.6 – 9.4	39
Grassland	> 30	rich	6.1	5.1 – 7.3	39
Grassland	< 30	rich	3.6	1.8 – 5.4	13
Grassland		poor	5.3	3.7 – 6.9	7
Forest			2.6	2.0 – 3.3	8
Rewetted		rich	0.50	-0.71 – 1.71	15
Rewetted		poor	-0.23	-0.64 – 0.18	43

**Data from the boreal and temperate zone*

The dataset summarised in the Wetlands Supplement (IPCC 2014) was dominated by studies from Scandinavia and the UK since organic soils are more widespread and better investigated in northern countries. Recently, data from several German joint research projects added EFs from a climatic region that might be more comparable to Switzerland (Beyer et al. 2015, Hurkuck et al. 2016, Hommeltenberg et al. 2014, Poyada et al. 2016, Tiemeyer et al. 2016). Individuals studies were conducted in Switzerland (Paul et al. 2017, Wüst-Galley et al. 2016), in the Netherlands (Shrier-Uijl et al. 2014) and in Denmark (Kandel et al. 2013, Kandel et al. 2017). In parallel, the data set from northern countries were also enlarged (Evans et al. 2017; Renou-Wilson et al. 2016). These data are shown in Figure1-3 and listed in Table A1 and A2 in the Appendix.

1.2 Cropped organic soil

The mean CO_2-EF for cropland published by IPCC (2014) is with 7.9 t C ha^{-1} a^{-1} somewhat lower than the Swiss EF for cropland of 9.52 t C ha^{-1} a^{-1} which is based on a review of available European data (Leifeld 2009). However, the IPCC mean includes data from the boreal zone (cf. Table 1), which may be biased towards lower values due to generally lower temperatures and thus reduced biological activity. Recent publications from Germany report considerably higher emission rates than the IPCC mean CO_2-EF (Eickenscheidt et al. 2015, Poyada et al. 2016, Figure 1). However, relatively constant low mean CO_2 emissions of 1.4 t

C ha^{-1} a^{-1} were found for a maize field in NW Germany for four consecutive years (Beyer et al. 2015). Slightly higher emissions of 4.3 and 6.1 t C ha^{-1} a^{-1} were measured in two Danish croplands during a one year measurement campaign (Kandel et al. 2013). CO_2 emissions of three croplands from England appeared to be in the lower range of the IPCC 95% confidence interval with a mean of 6.9 t C ha^{-1} a^{-1} (6.5 - 7.6 t C ha^{-1} a^{-1}; Evans et al. 2017). The mean CO_2-EF of all recently published data is 8.9 ± 3.7 t C ha^{-1} a^{-1} for cropped organic soils (Figure 1).

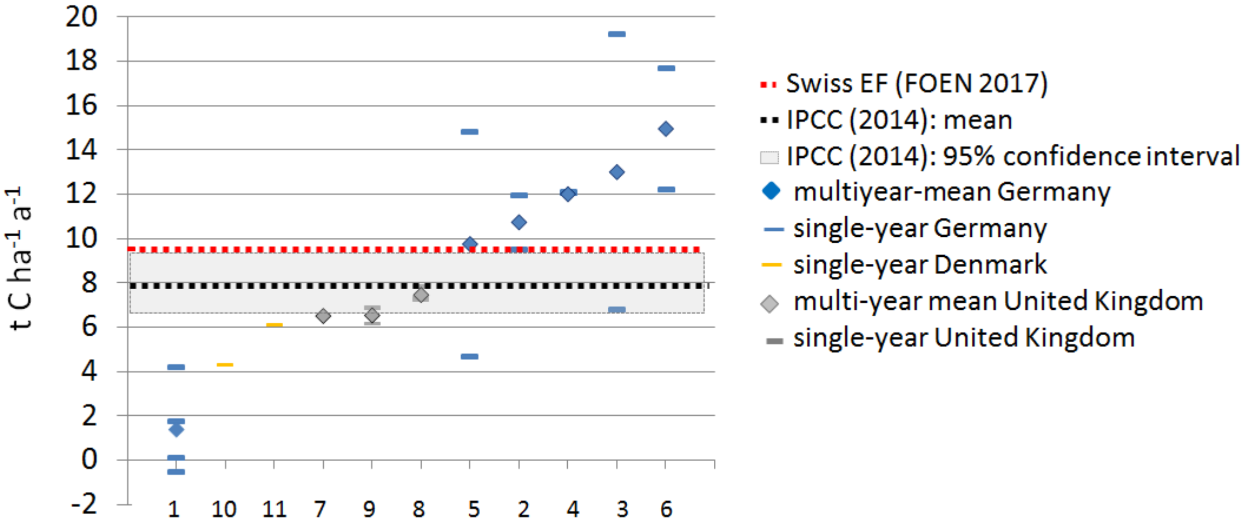

Figure 1: CO_2-EFs (multi-year mean and single-year measurements if available) of different sites (cf. site names and references in Table A1) for 11 drained cropped organic soil sites in the temperate zone. For purposes of comparison, FOEN (2017) and IPCC (2014) data are shown as dashed line and dashed line and highlighted range, respectively. Table A1 and Table A2 in the Appendix give site and soil characteristics and data for management and carbon fluxes, respectively.

1.3 Grassland on organic soil

In the Swiss GHG Inventory, grassland sites were classified according to management intensity, distinguishing between managed and extensively managed grasslands (FOEN 2017, Leifeld 2011). In contrast, the Wetlands Supplement of the IPCC report specifies grasslands according to drainage depth and nutrient status (IPCC 2014, cf. Table 1). However, the intensity of land use is often correlated with drainage depth. Nevertheless, it is problematic to classify according to management intensity, as there are smooth transitions between the categories (intensively used, extensively used, conservation-managed, and natural / unmanaged peatlands). Some studies covered by the assessment at hand include conservation-managed peatlands. Those peatlands are defined as semi-natural peatlands that may be rewetted, but are nevertheless managed. Management may include maintaining cuts once a year to avoid scrub encroachment or altered water management resulting from former drainage. In order to allow for a comparison of all published data in this study, conservation-managed peatlands were assigned either to IPCC category “nutrient-rich shallow-drained” or to “nutrient-poor” according to the site characteristics provided in the respective publication.

1.3.1 Deep-drained nutrient-rich grassland on organic soil

For managed grasslands – which are assumed to be deep-drained – the Swiss EF is with 9.52 t C close to the recently published mean from German sites (9.5 ± 4.6 t C ha^{-1} a^{-1}, Figure 2a, Tiemeyer et al. 2016, Poyada et al. 2016). In contrast, the Swiss EF is above the 95% confidence interval of the IPCC (2014) default value of 6.1 t C ha^{-1} a^{-1} for deep-drained nutrient-rich organic soils.

Recently measured data showed lower mean emission of a managed deep-drained nutrient-rich grassland in the Seeland Region in Switzerland in two consecutive years (3.6 - 4.1 t C ha^{-1} a^{-1}[§]). This grassland was moderately managed (not fertilised, 3 cuts per year, first cut after mid-June, mean water table of 50 cm). The resulting EF of this grassland lies below the 95% confidence interval of IPCC (2014) mean for deep-drained nutrient-rich grasslands, but is in accordance with the lower range of emissions (Figure 2, Schrier-Uijl et al. 2014, Evans et al. 2017, Tiemeyer at al. 2016).

The three grasslands from England, which showed low mean emissions, were characterised by relatively high groundwater levels of around 40 cm below surface[§§]. Only one site received fertiliser. The latter, more intensively used grassland showed over a period of three years with 4.3 t C ha^{-1} a^{-1} the highest mean emission rates from the English study sites (Evans et al. 2017). Fertilisation (and thus intense management of the grasslands) seems to go along with increased CO_2 emissions: 85% of grassland sites with emissions higher than 8 t C ha^{-1} a^{-1} were fertilised. In contrast, grasslands with lower emissions than 8 t ha^{-1} a^{-1} were fertilised only in 6 out of 19 cases. The fertilised deep-drained grasslands (n=17 sites) emitted on average 10.6 ± 4.9 t C ha^{-1} a^{-1}, while the unfertilised grasslands (n=15 sites) showed considerable lower emissions (6.0 ± 3.6 t C ha^{-1} a^{-1} (Figure 2a).

For protected fens, which are deep-drained, but only extensively managed, an EF of 5.3 t C ha^{-1} a^{-1} is used in Switzerland. This EF is at the lower limit of the IPCC (2014) 95% confidence interval for deep-drained nutrient-rich grasslands (Table 1 and Figure 2a).

[§] A revision of the calculation method led to a mean emission of 4.2 and 4.7 t C ha^{-1} a^{-1}; to be published in Paul et al. Carbon budget response of an agriculturally used fen soil to different soil moisture conditions (in prep.).

[§§] Groundwater table was deduced from Figure S1 in Evans et al. 2017.

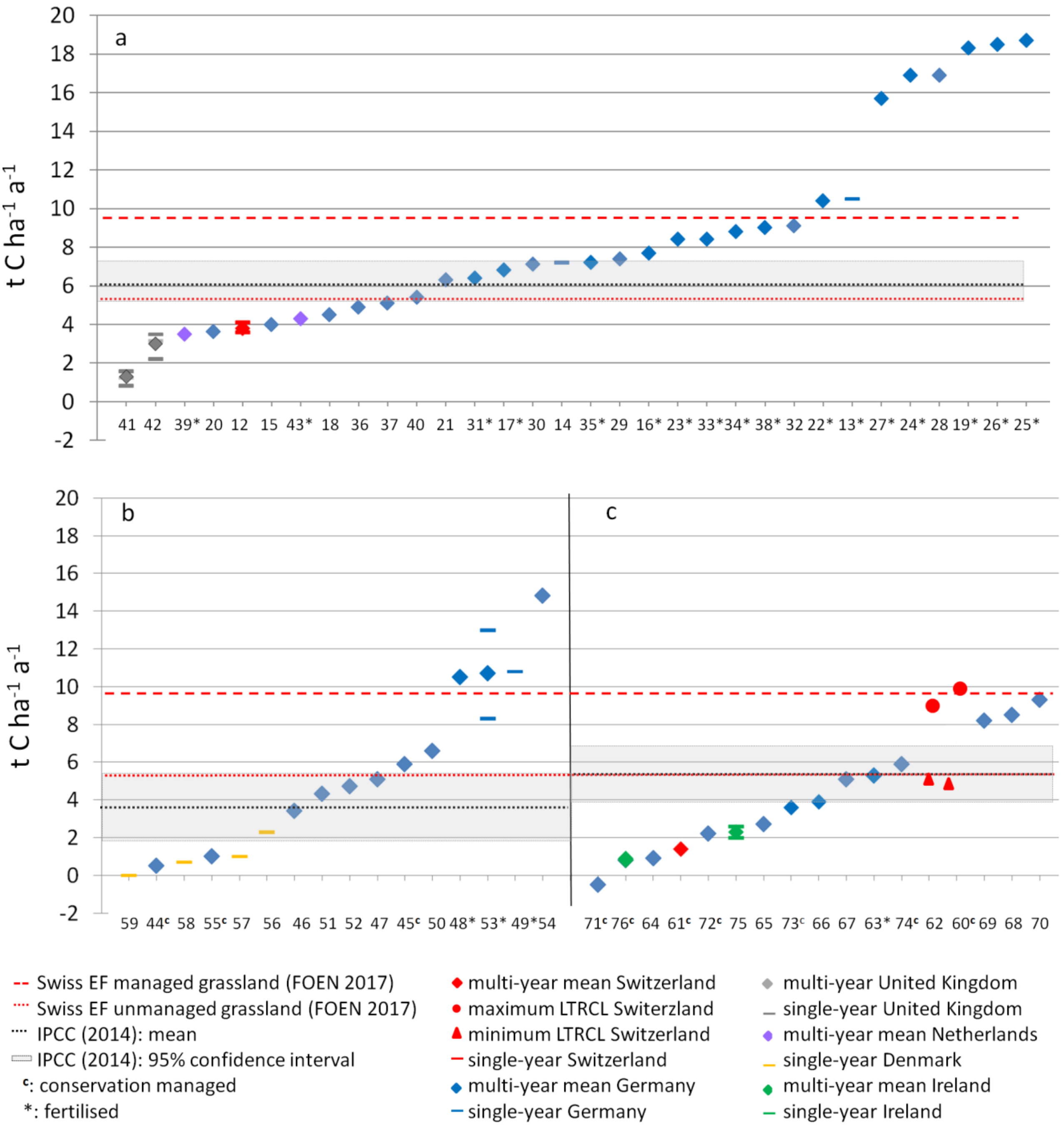

Figure 2: CO$_2$-EFs (multiyear-mean and single-year measurements if available) of different sites (cf. site names and references in Table A1) for a) 32 deep-drained nutrient-rich; b) 16 shallow-drained nutrient-rich and c) 17 drained nutrient poor grassland sites on organic soil in the temperate zone. All sites are classified according to IPCC (2014) drainage depth and nutrient status (cf. Table 1). Conservation-managed peatlands were separately marked (^{c}) and allocated to either "shallow-drained nutrient-rich" or "nutrient-poor" organic soil (cf. main text). Fertilised sites were marked (*). For purposes of comparison, FOEN (2017) and IPCC (2014) data are shown as dashed lines and highlighted ranges, respectively. Table A1 and Table A2 in the Appendix give site and soil characteristics and data for management and carbon fluxes, respectively.

1.3.2 Shallow-drained nutrient-rich grassland on organic soil

In Switzerland, for the IPCC grassland category shallow-drained nutrient-rich an EF of 9.52 t C ha^{-1} a^{-1} is used for managed grassland, and 5.3 t C ha^{-1} a^{-1} for extensively managed grassland (Figure 2b). Both values are higher than the IPCC (2014) mean of 3.6 t C $ha^{-1}a^{-1}$. Similar to the deep-drained nutrient-rich grasslands, shallow-drained nutrient-rich grasslands in Germany are characterised by an enormous range of emissions with up to 15 t C ha^{-1} a^{-1}, i.e. double the IPCC (2014) default value (Figure 2b). Though, very low emissions of 0.5 t C ha^{-1} a^{-1} were also measured for an conservative-managed grassland in southern Germany (Tiemeyer at al. 2016). The mean of all recently published data from German sites of this category is 6.5 ± 4.2 t C ha^{-1} a^{-1} (Tiemeyer et al. 2016, Poyada et al. 2016). High emission rates are mainly associated with intensive use, including fertiliser (Figure 2b). Thus, the conservation-managed peatlands are generally characterised by relatively low mean emissions of 2.5 (0.5 – 5.9 t C ha^{-1} a^{-1}, Figure 2b). However, low emissions were also found for four moderately used grasslands (one fertilisation and 2-3 cuts per year) in Denmark (Kandel et al. 2017).

1.3.3 Nutrient-poor grassland on organic soil

For nutrient-poor grasslands on organic soil, the IPCC (2014) mean is with 5.3 t C ha^{-1} a^{-1} identical to the EF used in the Swiss GHG Inventory for extensively managed peatlands, but substantially lower than the Swiss EF of 9.52 t C ha^{-1} a^{-1} for intensively managed grasslands (Figure 2c). For extensively managed grassland, the EF is deduced from country-specific data from three moderately drained bogs (Rogiers et al. 2008, Leifeld 2011, Leifeld et al. 2011). In comparison to the EF for extensively managed grasslands, the mean German EF found for nutrient-poor grassland was slightly lower (4.5 ± 3.1 t C ha^{-1} a^{-1}, Tiemeyer et al. 2016). However, emissions as high as 9.3 t C ha^{-1} a^{-1} were measured on a nutrient-poor grassland (Tiemeyer et al. 2016, Figure 2c). Data from Ireland support relatively low emissions: Small carbon sources of 0.8 t C ha^{-1} a^{-1} (without grazing) and 2.3 t C ha^{-1} a^{-1} (with grazing) were found for 2 consecutive years for each land use (Renou-Wilson et al. 2016).

1.4 Rewetted organic soil

In IPCC (2014), emissions rates of rewetted organic soil as well as natural/undrained organic soil were used to generate EF of rewetted soil, as EFs of rewetted and natural/undrained did not differ. Table 1 shows the respective EF for nutrient-rich and the EF for nutrient-poor rewetted organic soils. In a recent review, Wilson et al. (2016) updated and examined the database of IPCC (2014) for rewetted organic soils. The inclusion of all data published after 2013 would slightly reduce the CO_2-EF for rewetted organic soil from 0.50 t C ha^{-1} a^{-1} to 0.26 t

C ha^{-1} a^{-1} (nutrient-rich) and from -0.23 t C ha^{-1} a^{-1} to -0.33 t C ha^{-1} a^{-1} (nutrient-poor), respectively (Wilson et al. 2016). More recent data confirm the wide range of emissions rates (see Table A2, in the Appendix): Poyada et al. (2016) measured substantially higher emissions of 1.7 t C ha^{-1} a^{-1} and 4 t C ha^{-1} a^{-1} for an unutilised and rewetted grassland fen in northern Germany. Similar mean emissions rates were measured for an alpine unutilised fen in Italy during three consecutive years (1.8 ± 0.65 t C ha^{-1} a^{-1}; Pullens et al. 2016). In contrast, five semi-natural fens in England and Wales represented strong mean carbon sinks of -1.6 t C ha^{-1} a^{-1}; with a range of -4.3 to 0.1 t C ha^{-1} a^{-1}, Evans et al. 2017).

For nutrient-poor rewetted organic soil the IPCC (2014) mean is -0.23 t C ha^{-1} a^{-1} (Table 1). A similar small carbon sink of -0.35 t C ha^{-1} a^{-1} was found in rewetted grassland in Ireland (Renou-Wilson et al. 2016). In accordance with this, recent data of unutilised nutrient-poor peatland representing a net CO_2 sink of on average -0.47 t C ha^{-1} a^{-1} during three consecutive years in a nature reserve in NW Germany (Hurkuck et al. 2016). Relatively high mean negative emissions of -0.86 t C ha^{-1} a^{-1} were found for two rewetted nutrient-poor organic soils in England and Wales (Evans et al. 2017).

It is expected that rewetted organic soils represent a long-term carbon sink as intact peatlands are accumulating carbon. Wilson et al. (2016) concluded from the analysis of all rewetted soils under consideration that the net positive emissions for nutrient-rich organic soils might result from the inclusion of recently and/or incompletely rewetted sites in the analysis. So far, the database does not allow analysing the temporal evolution of CO_2 emissions after rewetting.

1.5 Forested organic soil

Wüst-Galley et al. (2016) were able to assess a maximum long-term carbon loss of 2.7 t C ha-1 a-1 ± 0.8 t C ha-1 a-1 for 6 drained forested peatlands in Switzerland using the ash residue method. For two sites, it was possible to calculate a minimum long-term carbon loss of 0.2 and 0.02 t C ha-1 a-1 (Figure 3, Table A2 in the Appendix). The emission factors obtained are only a rough estimate for present day emissions as the cumulative carbon loss is calculated since the start of drainage (between 50 and 165 years ago). As a further constraining factor, the history of drainage is often poorly documented. Hommeltenberg et al. (2014) estimated a long-term soil carbon loss of 5.0 t C ha^{-1} a^{-1} from a drained bog that is stocked with spruce in southern Germany.

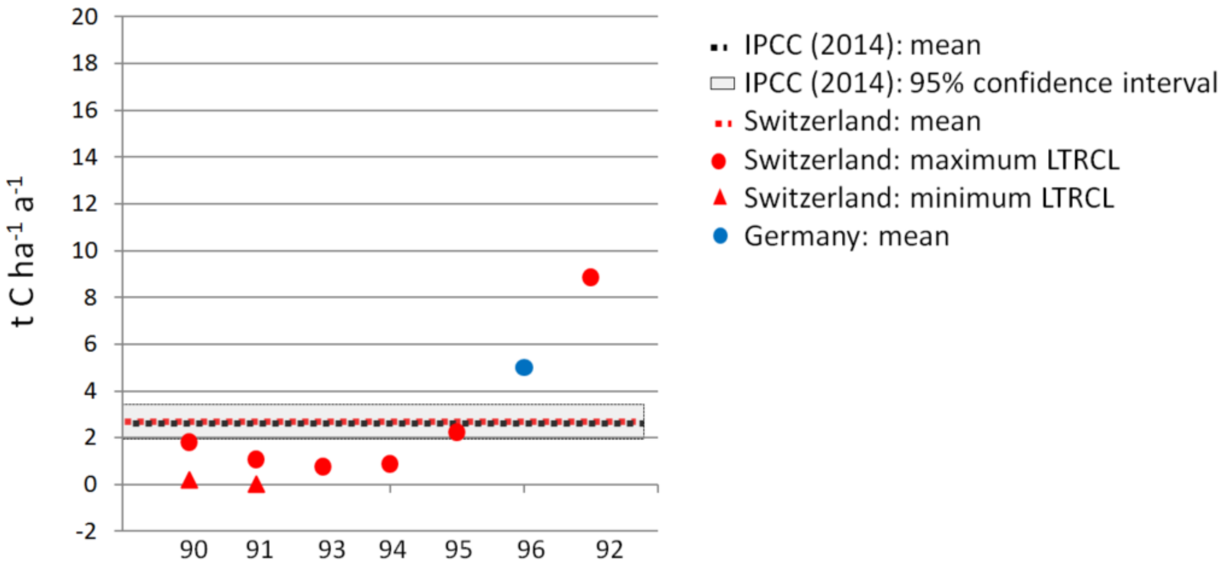

Figure 3: Long-term Rates of Carbon Loss (LTRCL, maximum and minimum if available) of different sites (cf. site names and references in Table A1) for drained forested organic soil in the temperate zone. For purposes of comparison, mean of maximum LTRCL of Swiss data (Wüst-Galley et al. 2016) and IPCC (2014) data are shown as dashed lines and highlighted ranges, respectively.

2. Recommendations for CO_2 Emission Factors of organic soils in the Swiss GHG Inventory

It is noteworthy that emission factors obtained on German sites are generally higher compared to rates from the northern countries UK, Ireland and Denmark. However, the German dataset is characterised by a wide range of emissions and it was not possible to exactly identify the factors regulating the emission factors for a specific peatland (Tiemeyer et al. 2016). The composition and thus the degradability of the peat may influence the GHG emissions (Leifeld et al. 2012, Sangok et al. 2017). Especially the content of polysaccharides may play an import role. However, it is yet not possible to quantify the influence of peat quality on GHG emissions.

It is therefore recommended to keep track on the discussion of environmental factors and soil properties determining GHG emissions of drained organic soils to asses if EFs obtained on German sites are more applicable for Switzerland then the IPCC (2014) dataset.

2.1 Cropped organic soil

Recently published data showed an enormous range of emission factors for croplands on organic soil (Figure 1). For single years, emissions up to 19.2 t C ha^{-1} a^{-1} were measured in southern Bavaria, Germany, on a cropped organic soil (Eickenscheidt et al. 2015). Mean CO_2-EF of all German data was 10.3 ± 4.3 t C ha^{-1} a^{-1}. Including data from UK and Denmark reduces the mean CO_2-EF to 8.9 ± 3.7 t C ha^{-1} a^{-1}. Under due consideration of available data, it seems to be justified to use an EF of 9.52 t C ha^{-1} a^{-1} for cropland on organic soil in

Switzerland as the IPCC (2014) mean CO_2-EF (7.9 t C ha^{-1} a^{-1}) includes data from the boreal zone, where emission factors are generally lower. The current database especially for market gardening and agriculture on organic soil is rare. It is therefore recommended to follow up new publications and potentially revise the Swiss EF for cropland on organic soils, if well-founded evidence appears or implement monitoring on Swiss cropped organic soils

2.2 Grassland on organic soil

IPCC (2014) report specifies grasslands according to drainage depth and nutrient status (chapter 1.3). As no information on groundwater levels of organic soils is available in Switzerland, it is currently not possible to separate grassland according to their groundwater level. Swiss grasslands are therefore classified according to the land use intensity (chapter 1.1). The classification according to the land use intensity rather than to the groundwater level seems justified by the analysis of recently published data. Intensive use, including fertilisation, tends to correlate with higher emissions: fertilised deep-drained nutrient-rich grasslands emitted on average 43% more CO_2 compared to non-fertilised deep-drained nutrient-rich grasslands on organic soil (chapter 1.2.1). An analysis of the data from Germany demonstrated that groundwater level is a key variable explaining the CO_2-EF for a single site, but not across a range of sites, mostly because water table dynamics and the nitrogen stock in the aerated zone influence emission factors considerably (Tiemeyer et al. 2016).

The direct comparison of EF for grasslands between IPCC (2014) and Switzerland is not straight forward as the grasslands are differently categorised.

2.2.1. Managed grasslands on organic soils

Nutrient-rich grasslands

Similarly to the CO_2-EF of cropped organic soils, the Swiss EF for managed grassland is higher than the IPCC default value for deep-drained nutrient-rich, but in a similar range as the mean EF from Germany deep-drained nutrient-rich grasslands (Figure 2a, Table A2, Tiemeyer et al. 2016). The recently measured EF for a moderately managed grassland in Switzerland was considerable lower (Paul et al. 2017). The Swiss EF for managed grassland is considerable higher than the IPCC mean EF of 3.6 t C ha^{-1} a^{-1} and the mean German EF of 6.4 t C ha^{-1} a^{-1} (n=12) for shallow-drained nutrient-rich grasslands (Figure 2b, Table A2, Tiemeyer et al. 2016, Poyada et al. 2016).

Taken together with numbers presented in chapters 1.3.1 and 1.3.2 it seems to be justified to use an EF of 9.52 t C ha^{-1} a^{-1} for managed grasslands on organic soil in Switzerland. But, it is recommended to improve the database for intensively managed grasslands on deep-drained nutrient-rich organic soils in Switzerland to verify the emission factor or revise the emission factor if well-founded evidence appears.

Nutrient-poor grasslands

For managed grassland on nutrient-poor organic soils the Swiss EF of 9.52 t C ha^{-1} a^{-1} is in the same range as the highest emission found on nutrient-poor grasslands in the temperate zone (Figure 2c, Tiemeyer et al. 2016). It is therefore recommended to I) identify the occurrence of managed grasslands on nutrient-poor organic soil in Switzerland, II) to follow up the publication of new GHG emission data of grasslands on nutrient-poor organic soils, and III) to eventually revise the Swiss EF for managed grasslands on nutrient-poor organic soils if well-founded evidence appears.

2.2.2 Extensively managed grasslands on organic soils

The Swiss EF for extensively managed grassland is based on domestic data and the value of 5.3 t C ha^{-1} a^{-1} is generally supported by the recent international literature from shallow-drained nutrient-rich grasslands and nutrient-poor grasslands in the temperate zone. For extensively managed but deep-drained nutrient-rich grasslands the same EF is used. Recently measured emission rates from a deep-drained nutrient-rich grassland in Switzerland were 4.1 and 3.6 t C ha^{-1} a^{-1} [§] for two consecutive years, thus in the same range (Paul et al. 2017). However, this grassland is categorized as managed. Note, the management of this grassland was only moderate as it was not fertilized and the first cut was only allowed after mid-June. It therefore seems justified to use an EF of 5.3 t C ha^{-1} a^{-1} for extensively managed grasslands on organic soil in Switzerland.

2.3 Forested organic soil

Since the mean of the few Swiss data available for forested land on organic soil is close to the IPCC (2014) mean (Wüst-Galley et al. 2016), it seems to be justified to use an EF of 2.6 t C ha^{-1} a^{-1} for forest land. The international database is rare: the IPCC mean was deduced from measurements of only eight study sites, located in Finland, Sweden, Scotland, and Canada. It is therefore recommended to continuously verify the default EF for forested organic soils either with new data from upcoming publications in the temperate zone and to revise it if well-founded evidence appears.

[§] A revision of the calculation method led to a mean emission of 4.2 and 4.7 t C ha^{-1} a^{-1}; to be published in Paul et al. Carbon budget response of an agriculturally used fen soil to different soil moisture conditions (in prep.).

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Appendix

Methodologies

Most studies covered by this assessment report CO_2 fluxes based on methodologies using either Chamber (Ch) or Eddy Covariance (EC) techniques. For a detailed description of both methods see Alm et al. (2007). Only studies measuring at least one whole year were included. In some cases, such as forested organic soil and nutrient-poor grasslands on organic soil, studies were considered which are based on profile data using the ash residue method (Leifeld et al. 2011, Wüst-Galley et al. 2016) or which are based on historical data (Hommeltenberg et al. 2014). EFs generated by the last two techniques include carbon loss in liquid phase (dissolved and particulate organic carbon) and represent long-term net rates of carbon loss (LTRCL). LTRCL were calculated by dividing the carbon loss of the peat by the number of years since drainage. Where only a range of years since drainage was known, rather than the exact date, the minimum and maximum LTRCLs were calculated by using the oldest and most recent possible drainage dates for this calculation, respectively. For a detailed description of the ash residue method see Leifeld et al. 2011 and Krüger et al. 2016.

The CO_2-EF integrates all CO_2-C fluxes entering or leaving the system (plant soil system) and is defined as follows:

(1) $EF = NEE + C_{import} – C_{export}$

with: NEE= net ecosystem exchange

C_{import} = carbon import in form of organic fertiliser

C_{export} = carbon export in form of harvest (it is assumed that carbon export as harvest is released as CO_2-C).

Negative fluxes denote carbon uptake by the ecosystem, positive fluxes loss to the atmosphere. If available, the following parameters were extracted from the literature and included in the database presented below in Tables A1a to Table A4: site name, location (coordinates), mean annual precipitation (MAP), mean annual temperature (MAT), method applied, number of annual budgets (n_{budget}), IPCC (2014) categories regarding drainage depth and nutrient status, water table depth: annual mean or fluctuation range (depending on information available), soil organic carbon content (C_{org}), C/N ratio of the upper soil profile (maximum integration depth: 0-50 cm), land use including amount of nitrogen fertiliser and number of cuts, carbon import in form of organic fertiliser, carbon export in form of harvest, net ecosystem exchange (NEE) and CO_2-EF. If available, mean, SD and range are given.

Tables

Appendix

Table A1: Site characteristics: Study site names, location, land use (crops, grassland managed (grass m), grassland conservation-managed (grass c-m), natural, rewetted, forest), mean annual precipitation (MAP), mean annual air temperature (MAT), methodology for carbon balance (Eddy-Covariance (EC), chamber (Ch), ash (ash), historical data (hd)), number of annual budgets per site (n_{budget}) or years since start of drainage in case of ash and historical data method, and references.

Site number and name		Location	Land use	MAP	MAT	Method	n_{budget}	Reference
		N, E		mm	°C		a	
1	Dümmer peatland, D	52°28', 8°1'	maize	695	8.9	Ch	4	Beyer et al. 2015
2	Freisinger Moos-A1 Chigh, D	48°22', 11°41'	Maize-oat	834	8.7	Ch	2	Eickenscheidt et al. 2015
3	Freisinger Moos-A2 Chigh, D	48°22', 11°41'	Oat maize	834	8.7	Ch	2	Eickenscheidt et al. 2015
4	Freisinger Moos-A1 Cmedium, D	48°22', 11°41'	Maize-oat	834	8.7	Ch	2	Eickenscheidt et al. 2015
5	Freisinger Moos-A2 Cmedium, D	48°22', 11°41'	Oat maize	834	8.7	Ch	2	Eickenscheidt et al. 2015
6	AR, D	54°02, 09°24'	barley, spring wheat	861	8.7	Ch	2	Poyada et al. 2016
7	Little Woolden Moos-MM-DA, UK	53°27',-02°27'	wheat	750	10	Ch	2	Evans et al. 2017
8	Rosedene Farm-EF-DA, UK	52°30', 00°20'	lettuce, leeks, celery	685	10	EC	3	Evans et al. 2017
9	Redmere Farm-EF-SA, UK	52°27', 00°18'	wheat lettuce maize	685	10	EC	3	Evans et al. 2017
10	Nørrea river valley-SB, DK	56°44', 09°86'	spring barley	770	7.8	Ch	1	Kandel et al. 2013
11	Nørrea river valley-RCG, DK	56°44', 09°86'	canary reed	770	7.8	Ch	1	Kandel et al. 2013
12	Cressier, CH	47°02', 07°02'	grass-m	972	10	EC	2	Paul et al. 2017
13	Benediktbeuern-BB2, D	47°43', 11°23'	grass-m	1360	7.2	Ch	1	Tiemeyer et al. 2016
14	DonauriedDR_GL, D	48°29', 10°12'	grass-m	728	7.6	Ch	1	Tiemeyer et al. 2016, Fiedler et al. 2009
15	Dümmer-O2, D	52°28', 08°01'	grass-m	765	9.7	Ch	2	Tiemeyer et al. 2016, Beyer 2014
16	Dummerstorf DT2, D	53°60', 12°17'	grass-m	640	8.6	Ch	2	Tiemeyer et al. 2016
17	Dummerstorf-DT1, D	53°60', 12°17'	grass-m	640	8.6	Ch	2	Tiemeyer et al. 2016
18	Dummerstorf-DT3, D	53°60', 12°17'	grass-m	640	8.6	Ch	2	Tiemeyer et al. 2016
19	Freisinger Moos, G2Chigh, D	48°22', 11°41'	grass-m	808	8.6	Ch	2	Tiemeyer et al. 2016, Eickenscheidt et al. 2015
20	Freisinger Moos-FM3, D	48°22', 11°41'	grass-m	640	8.6	Ch	2	Tiemeyer et al. 2016
21	Freisinger Moos-FM6, D	48°22', 11°41'	grass-m	640	8.6	Ch	4	Tiemeyer et al. 2016
22	Freisinger Moos-FM8, D	48°22', 11°41'	grass-m	640	8.6	Ch	3	Tiemeyer et al. 2016
23	Freisinger Moos-FM9, D	48°22', 11°41'	grass-m	808	8.6	Ch	2	Tiemeyer et al. 2016
24	Freisinger MoosG1Chigh, D	48°22', 11°41'	grass-m	808	8.6	Ch	2	Tiemeyer et al. 2016, Eickenscheidt et al. 2015
25	Freisinger Moos-G1Cmedium, D	48°22', 11°41'	grass-m	808	8.6	Ch	2	Tiemeyer et al. 2016, Eickenscheidt et al. 2015
26	Freisinger Moos-G2Cmedium, D	48°22', 11°41'	grass-m	808	8.6	Ch	2	Tiemeyer et al. 2016, Eickenscheidt et al. 2015
27	GM, D	54°02', 09°24'	grass-m	861	8.7	Ch	2	Poyada et al. 2016
28	Graben-Neudorf-GN2, D	49°11', 08°28'	grass-m	720	10.2	Ch	4	Tiemeyer et al. 2016
29	Graben-Neudorf-GN4, D	49°11', 08°28'	grass-m	720	10.2	Ch	4	Tiemeyer et al. 2016
30	Paulinenaue-P1, D	52°41', 12°50'	grass-m	530	9.4	Ch	5	Tiemeyer et al. 2016
31	Paulinenaue-P10, D	52°41', 12°50'	grass-m	530	9.4	Ch	2	Tiemeyer et al. 2016
32	Paulinenaue-P2a, D	52°41', 12°50'	grass-m	530	9.4	Ch	2	Tiemeyer et al. 2016
33	Paulinenaue-P2b, D	52°41', 12°50'	grass-m	530	9.4	Ch	2	Tiemeyer et al. 2016
34	Paulinenaue-P2c, D	52°41', 12°50'	grass-m	530	9.4	Ch	2	Tiemeyer et al. 2016
35	Paulinenaue-P4, D	52°41', 12°50'	grass-m	530	9.4	Ch	5	Tiemeyer et al. 2016
36	Paulinenaue-p7, D	52°41', 12°50'	grass-m	530	9.4	Ch	5	Tiemeyer et al. 2016
37	Paulinenaue-P9, D	52°41', 12°50'	grass-m	530	9.4	Ch	4	Tiemeyer et al. 2016
38	Paulinenaue-P8, D	52°41', 12°50'	grass-m	530	9.4	Ch	5	Tiemeyer et al. 2016
39	Oukoop, NL	52°02', 04°47'	grass-m	800	9.8	EC/Ch	4	Schrier-Uijl et al. 2014
40	Stein, NL	52°01', 04°46'	grass-m	800	9.8	EC/Ch	4	Schrier-Uijl et al. 2014

Table A1 (continued):

Site number and name		Location	Land use	MAP	MAT	Method	n_{budget}	Reference
		N, E		mm	°C		a	
41	Bakres Fen EF-EG, UK	52°18', 00°17'	grass-m			EC	3	Evans et al. 2017
42	Tadham Moor SL-EG, UK	51°6', -02°55'	grass-m	770	10.6	EC	3	Evans et al. 2017
43	Tadham Morr SL IG, UK	51°6', -02°55'	grass-m	770	10.6	Ch	3	Evans et al. 2017
44	Benediktbeuern-BB3, D	47°43', 11°23'	grass c-m	1360	7.2	Ch	1	Tiemeyer et al. 2016
45	Benediktbeuern-BB7, D	47°43', 11°23'	grass c-m	1360	7.2	Ch	1	Tiemeyer et al. 2016
46	Dümmer-D2, D	52°28', 08°01'	grass-m	765	9.7	Ch	4	Tiemeyer et al. 2016, Beyer 2014
47	Freisinger Moos-FM1, D	48°22', 11°41'	grass-m	640	8.6	Ch	2	Tiemeyer et al. 2016
48	Freisinger Moos-FM2A, D	48°22', 11°41'	grass-m	640	8.6	Ch	2	Tiemeyer et al. 2016
49	Freisinger Moos-FM2B, D	48°22', 11°41'	grass-m	640	8.6	Ch	1	Tiemeyer et al. 2016
50	Freisinger Moos-FsA, D	48°22', 11°41'	grass-m	640	8.6	Ch	4	Tiemeyer et al. 2016
51	Freisinger Moos-FsB, D	48°22', 11°41'	grass-m	640	8.6	Ch	4	Tiemeyer et al. 2016
52	Freisinger Moos-FM7, D	48°22', 11°41'	grass-m	640	8.6	Ch	2	Tiemeyer et al. 2016
53	GW, D	54°02', 09°24'	grass-m	861	8.7	Ch	2	Poyada et al. 2016
54	Peene Valley-Z2, D	53°53', 12°53'	grass-m	576	8.9	Ch	2	Tiemeyer et al. 2016
55	Spreewald, SW1, D	51°54', 14°02'	grass c-m	554	9.5	Ch	2	Tiemeyer et al. 2016
56	Nørrea river valley Fes3C, DK	56°27', 09°40'	grass-m	650	7.9	Ch	1	Kandel et al. 2017*
57	Nørrea river valley Fes2C, DK	56°27', 09°40'	grass-m	650	7.9	Ch	1	Kandel et al. 2017*
58	Nørrea river valley Tall3C, DK	56°27', 09°40'	grass-m	650	7.9	Ch	1	Kandel et al. 2017*
59	Nørrea river valley Tall2C, DK	56°27', 09°40'	grass-m	650	7.9	Ch	1	Kandel et al. 2017*
60	Ägeririerd, CH	47°12', 08°68'	grass c-m	1766	6.3	ash	~130	Leifeld et al. 2011a
61	Eigenried, CH	47°09', 04°58'	grass c-m	1669	7.5	ash	~100	Leifeld et al. 2011a
62	Seebodenalp, CH	47°03', 08°27'	grass-m	1327	7.3	ash	~115	Rogiers et al. 2008
63	Ahlenmoor-GI, D	53°04', 08°49'	grass-m	843	9.6	Ch	4	Tiemeyer et al. 2016, Frank et al. 2014
64	Ahlenmoor-GE, D	53°04', 08°49'	grass-m	843	9.6	Ch	4	Tiemeyer et al. 2016, Frank et al. 2014
65	Grosses Moos, C high W11, D	52°53', 10°40'	grass-m	656	9.6	Ch	2	Tiemeyer et al. 2016, Tiemeyer 2018 pers.com.
66	Grosses Moos, C high W17, D	52°53', 10°40'	grass-m	656	9.6	Ch	2	Tiemeyer et al. 2016, Tiemeyer 2018 pers.com.
67	Grosses Moos, C high W22, D	52°53', 10°40'	grass-m	656	9.6	Ch	2	Tiemeyer et al. 2016, Tiemeyer 2018 pers.com.
68	Grosses Moos, C low W14, D	52°53', 10°40'	grass-m	656	9.6	Ch	2	Tiemeyer et al. 2016, Tiemeyer 2018 pers.com.
69	Grosses Moos, C med W39, D	52°53', 10°40'	grass-m	656	9.6	Ch	2	Tiemeyer et al. 2016, Tiemeyer 2018 pers.com.
70	Grosses Moos, C low W29, D	52°53', 10°40'	grass-m	656	9.6	Ch	2	Tiemeyer et al. 2016, Tiemeyer 2018 pers.com.
71	Mooseurach, ME7, D	47°41'; 11°23'	grass c-m	1235	8.8	Ch	2	Tiemeyer et al. 2016
72	Mooseurach,ME8, D	47°41'; 11°23'	grass c-m	1235	8.8	Ch	2	Tiemeyer et al. 2016
73	Mooseurach, ME10, D	47°41'; 11°23'	grass c-m	1235	8.8	Ch	2	Tiemeyer et al. 2016
74	Mooseurach, ME12, D	47°41'; 11°23'	grass c-m	1235	8.8	Ch	2	Tiemeyer et al. 2016
75	Glenvar SD grazed, IRL	55°90', 07°34'	grass-m	1076	9.8	Ch	2	Renou-Wilson et al. 2016
76	Glenvar Sd ungrazed, IRL	55°90', 07°34'	grass c-m	1076	9.8	Ch	2	Renou-Wilson et al. 2016
77	Bourtanger Moor, D	52°39', 07°11'	natural	782	9.2	EC	3	Hurkuck et al. 2016
78	UG, D	54°02', 09°24'	rewetted	861	8.7	Ch	2	Poyada et al. 2016
79	Horstenmeer, NL	52°02', 05°04'	rewetted	800	9.8	EC/Ch	4	Schrier-Uijl et al. 2014
80	Thorne TM-RW, UK	53°36', -00°57'	rewetted			Ch	1	Evans et al. 2017

Table A1 (continued):

Site number and name		Location	Land use	MAP	MAT	Method	n_{budget}	Reference
		N, E		mm	°C		a	
81	Astley MM-RW, UK	53°30', -02°27'	rewetted	873		Ch	1	Evans et al. 2017
82	Wicken Fen FF-LN, UK		natural	685	10.2	EC	2	Evans et al. 2017
83	Strumpshow NB-NH, UK		natural			Ch	1	Evans et al. 2017
84	Sutton NB-LN, UK		natural			Ch	1	Evans et al. 2017
85	Cors Erddreiniog AF-LN, UK		natural			EC	1	Evans et al. 2017
86	Cors Erddreiniog AF-HN, UK		natural			EC	2	Evans et al. 2017
87	Glenvar RW grazed, IRL	55°90', 07°34`	rewetted	1076	9.8	Ch	2	Renou-Wilson et al. 2016
88	Glenvar RW ungrazed, IRL	55°90', 07°34'	rewetted	1076	9.8	Ch	2	Renou-Wilson et al. 2016
89	Monte Bondone, IT	46°01', 11°02'	natural	1290	5.4	EC	3	Pullens et al. 2016
90	Bannwald, CH	08°10', 47°02'	forest	1542	6.5	ash	50-80	Wüst-Galley et al. 2016
91	Chiemiwald, CH	07°13', 46°53'	forest	1034	9	ash	165	Wüst-Galley et al. 2016
92	Meinenstossmoss A, CH	08°13', 47°01'	forest	1719	6.7	ash	123	Wüst-Galley et al. 2016, Wüst-Galley pers.com.
93	Au Pâquier, CH	07°07', 46°38'	forest	1683	6	ash	71	Wüst-Galley et al. 2016
94	Dévin des Dailles CH	06°58', 46°31'	forest	1538	5.8	ash	>71?	Wüst-Galley et al. 2016
95	Meienstossmoos B, CH	08°13', 47°01'	forest	1719	6.7	ash	123	Wüst-Galley et al. 2016
96	Mooseurach, D	47°48', 11°27'	forest	1127	8.6	hd	70-80	Hommeltenberg et al. 2014

Table A2: Site characteristics: Nutrient status and drainage depth (nutrient-rich (nr), nutrient-poor (np), deep-drained (dd), shallow-drained (sd)), water table depth below surface (mean or fluctuation range), soil characteristics (organic carbon content, C/N ratio), management (fertilisation and cuts per year), and carbon fluxes (carbon import by organic fertilisation (mean ± SD), carbon export by biomass removal (mean ± SD), net ecosystem exchange (NEE, mean ± SD), and emission factor for CO_2 (CO_2-EF, mean and range). n.q. = not quantified.

Site	IPCC	Water	C_{org}	C/N	Fertilizer	No. of	C import	C export	NEE	CO_2-EF	
No.	classification	table				cuts				mean	range
		cm	%		kg N ha^{-1} a^{-1}	a^{-1}	---------------------------		t C ha^{-1} a^{-1}	-----------------------------	
1	nr	28	29.1	19.4	-	-	0.69	2.45	-0.61	1.38	-0.54 - 4.22
2	nr	47	17	12	-	-	-	0.96	9.8	10.7	9.5 - 11.9
3	nr	47	16.5	12	-	-	-	2.38	10.3	12.9	6.8 - 19.2
4	*	47	9.5	10	-	-	-	1.33	10.7	12	12.0 - 12.1
5	*	47	9.3	10	-	-	-	3.4	6.3	9.8	4.7 - 14.8
6	nr	39	13.3	12.2	150	-	0.2	5.1	10.1	15	12.2 -17.7
7	np	10-100	36.2	44	-	-	-	6.4	0.1	6.5	
8	nr	>50	43.6	15	-	-	0.31	0.67	6.9	7.5	7.2 - 7.8
9	nr	60-100	30.8	16.4	-	-	0.34	4.3	2.5	6.5	6.2 - 6.9
10	nr	30-50	27-40		120	-	-	4.7	-0.41	4.29	
11	nr	30-50	27-40		60	-	-	5.4	0.69	6.09	
12	dd-nr	50	24.3	14.5	-	3	-	2.7	1.1	3.8**	3.6 -4.2
13	dd-nr	33			110	2	1.9	2	10.4	10.5	
14	dd-nr	102	40.7	14.5	-	2	-	2.1	5.1	7.2	
15	dd-nr	68	6.7	12.1	-	3	-	2.7 ± 1.3	1.3 ± 1.7	4	
16	*	111			200 - 320	4 - 5	-	5.1 ± 0.7	2.6 ± 0.8	7.7	
17	dd-nr	59			200 - 320	4 - 5	-	3.9 ± 1.1	2.9 ± 1.3	6.8	
18	*	111			-	1	-	2.2 ± 0.3	2.3 ± 1.6	4.5	
19	dd-nr	44	16	11	101 - 174	2 - 3	0.6 ± 0.2	4.9 ± 1.5	14.0 ± 0.6	18.3	
20	dd-nr	33				1	-	0.7 ± 0.2	2.9 ± 0.8	3.6	
21	dd-nr	33				1	-	1.5 ± 1.1	4.8 ± 2.1	6.3	
22	dd-nr	41			110-220	2 - 3	1.5 ± 1.4	4.1 ± 0.5	7.8 ± 3.2	10.4	
23	dd-nr	34			110	2 - 3	1.4 ± 0.0	3.3 ± 2.0	6.5 ± 0.2	8.4	
24	dd-nr	48	17	11	112 - 252	2 - 3	2.0 ± 1.0	3.9 ± 0.9	15.0 ± 1.4	16.9	
25	*	66	10	10	112 - 252	2 - 3	2.0 ± 1.0	3.2 ± 0.3	17.5 ± 1.0	18.7	
26	*	68	10.5	10	101 - 174	2 - 3	0.6 ± 0.2	4.4 ± 1.4	14.7 ± 1.2	18.5	
27	dd-nr	33	17.9	12.4	260	3 - 4	1.1	5.2	11.7	15.7	15.7 - 15.8
28	dd-nr	37			-	1 - 2	-	0.0 ± 0.0	16.9 ± 3.3	16.9	
29	dd-nr	111			-	2	-	1.3 ± 0.5	6.1 ± 3.2	7.4	
30	dd-nr	36			-	1 - 2	-	2.5 ± 1.0	4.6 ± 1.3	7.1	
31	*	62			210	3	-	3.6 ± 1.3	2.8 ± 1.7	6.4	
32	dd-nr	42			-	2	-	3.5 ± 0.4	5.6 ± 2.1	9.1	
33	dd-nr	42			0 - 44	2	0.3 ± 0.5	3.7 ± 0.6	5.4 ± 3.9	8.4	
34	dd-nr	42			44 - 178	2	1.7 ± 1.4	4.1 ± 1.1	6.4 ± 4.7	8.8	
35	dd-nr	32			70 - 210	1 - 3	-	3.6 ± 0.9	3.6 ± 3.8	7.2	
36	*	74			-	2	-	2.9 ± 0.7	2.0 ± 1.1	4.9	
37	*	62			-	2	-	3.0 ± 0.6	2.1 ± 2.7	5.1	
38	*	65			0 - 44	2	0.5 ± 0.3	2.5 ± 0.7	7.0 ± 3.3	9	
39	dd-nr	30-60			88	n.q.	1.6	4	1.1	3.5	
40	dd-nr	45			-	3	-	4.2	1.2	5.4	

* Not classified as organic soil after IPCC, but included in this study.

** A revision of the calculation method led to a mean emission of 4.2 and 4.7 t C ha^{-1} a^{-1}; to be published in Paul et al. Carbon budget response of an agriculturally used fen soil to different soil moisture conditions (in prep.).

Table A2 (continued):

Site No.	IPCC classification	Water table	C_{org}	C/N	Fertilizer	No. of cuts	C import	C export	NEE	CO_2-EF mean	CO_2-EF range
		cm	%		kg N ha^{-1} a^{-1}	a^{-1}	t C ha^{-1} a^{-1}				
41	dd-nr	>30	22.3	19.7	-	-	-	-	1.23	1.23	0.8 - -1.6
42	dd-nr	>30	39.6	30.4	-	1 / grazed	-	2	0.95	3	2.2 - 3.5
43	dd-nr	>30	42.7	28.6	yes	1 / grazed	-	2	2.3	4.3	
44	sd-nr	10			-	1	-	0.6	-0.1	0.5	
45	sd-nr	16			-	1	-	1.5	4.4	5.9	
46	sd-nr	22	31.2	18.5	-	0 - 3	-	1.3 ± 1.5	2.1 ± 2.5	3.4	
47	*	25			-	0-2	-	0.2 ± 0.2	4.9 ± 1.5	5.1	
48	sd-nr	23			170-240	3	0.9 ± 0.2	4.6 ± 1.5	6.8 ± 0.3	10.5	
49	sd-nr	20			220	3	0.4	3.9	7.3	10.8	
50	sd-nr	26			-	1	-	1.5 ± 0.6	5.1 ± 1.0	6.6	
51	sd-nr	12			-	1	-	2.8 ± 0.3	1.5 ± 1.8	4.3	
52	sd-nr	28			-	1	-	0.7 ± 0.7	4.0 ± 0.2	4.7	
53	sd-nr	21	37.4	15.7	300	2 - 3	1.7	4.3	8	10.6	8.3-13.0
54	sd-nr	17			-	2	-	2.3 ± 1.2	12.5 ± 0.8	14.8	
55	sd-nr	5			-	0 - 1	-	0.8 ± 1.1	0.2 ± 0.8	1	
56	sd-nr	10-40	36.3	12.1	80	3	-	9.8	-7.8	2.3	
57	sd-nr	10-40	36.3	12.1	80	2	-	9.2	-8.4	1.0	
58	sd-nr	10-40	36.3	12.1	80	3	-	8.2	-7.5	0.7	
59	sd-nr	10-40	36.3	12.1	80	2	-	7.3	-7.6	0.0	
60	Np	-	53		-	1	-	n.q.	n.q.	7.45	4.9-10.0*****
61	Np	-	51		-	1	-	n.q.	n.q.	1.40	
62	Np	-			-	2	-	n.q.	n.q.	7.05	5.0-9.1*****
63	Np	55	48.4	25.7	190-340	4 - 5	2.1 ± 0.2	3.4 ± 1.3	4.0 ± 0.9	5.3	
64	Np	28	49.2	24.7	-	1	-	1.1 ± 1.4	-0.2 ± 1.0	0.9	
65	Np	12	51.7	27.9	-	2	-	0.2 ± 0.0	2.5 ± 0.8	2.7	
66	Np	16	47.9	27.7	-	2	-	0.6 ± 0.3	3.4 ± 0.3	3.9	
67	Np	17	47.9	27.7	-	2	-	0.8 ± 0.3	4.3 ± 0.6	5.1	
68	*	13	9.3	23.5	-	2 - 4	-	2.4 ± 1.0	6.1 ± 1.7	8.5	
69	Np	36	34.3	29.4		2 - 4	-	1.8 0.6	6.4 0.2	8.2	
70	*	27	11.3	26.9	-	2 - 4	-	2.7 ± 0.2	6.6 ± 1.2	9.3	
71	Np	18			-	1	-	0.8 ± 0.2	-1.3 ± 1.2	-0.5	
72	Np	34			-	1	-	0.5 ± 0.3	1.7 ± 1.6	2.2	
73	Np	5			-	1	-	0.8 ± 0.4	2.8 ± 0.7	3.6	
74	Np	14			-	1	-	0.6 ± 0.1	5.3 ± 0.7	5.9	
75	Np		21	26.9	-	grazed	-	1.5	0.8	2.3	2.0 - 2.6
76	Np		21	26.9	-	-	-	-	0.8	0.8	0.8 - 0.9
77	Np	10	38-53		-	-	-	-	-0.5	-0.5	-0.7 - 0.1
78	np-rw	11	35	17.7	-	-	-	-	2.8	2.8	1.7 - 3.9
79	nr-rw	20			-	-	-	-	-3.7	-3.7	
80	np-rw	0****	49.4	46.5	-	-	-	-	-1.32	-1.32	

* Not classified as organic soil after IPCC, but included in this study. ** According to literature “moderately drained”.
*** Mean water table is lower than 30 cm below surface. **** Mean water table is above surface.
***** Minimum and maximum of Long Term Rates of Carbon Loss.

Table A2 (continued):

Site No.	IPCC classification	Water table	C_{org}	C/N	Fertilizer	No. of cuts	C import	C export	NEE	CO_2-EF	
										mean	range
		cm	%		kg N ha^{-1} a^{-1}	a^{-1}	-------------------	-------------------	t C ha^{-1} a^{-1}	-------------------	-------------------
82	Nr	<10*	32	15.8	-	-	-	-	-1.3	-1.3	
83	Nr	<10*	32.1	13.4	-	-	-	-	-4.3	-4.3	
84	Nr	<10*	43.5	14.5	-	-	-	-	0.1	0.1	
85	Nr	<10*	45.3	17.5	-	-	-	-	-0.9	-0.9	
86	Nr	<10*	41.8	14.7	-	-	-	-	-1.6	-1.6	-1.8 - -1.4
87	np-rw		23	26.7	-	-	-	-	-0.4	-0.4	-0.8 - 0.0
88	Np		21	26.9	-	-	-	1.25	0.9	2.1	2.0 - 2.2
89	Nr	27.6			-	-	-	-	1.8	1.8	1.0 - 2.6
90	Np	n.q.	49.0	27.6	-	-	-	-	n.q.	0.2 - 1.8**	
91	Np	n.q.	50.5	28.0	-	-	-	-	n.q.	0.02 - 1.06**	
92	Np	n.q.	44.8	22.6	-	-	-	-	n.q.	8.83^{***}	
93	Np	n.q.	47.0	26.1	-	-	-	-	n.q.	0.77^{***}	
94	Np	n.q.	49.0	25.4	-	-	-	-	n.q.	0.87^{***}	
95	Np	n.q.	48.0	29.8	-	-	-	-	n.q.	2.23^{***}	
96	Np	n.q.	49.7	33.5	-	-	-	-	n.q.	5.0^{****}	

* Mean water table is higher than 10 cm below surface.

** Minimum and maximum of Long Term Rates of Carbon Loss.

*** Maximum of Long Term Rates of Carbon Loss.

**** Mean Long Term Rates of Carbon Loss.