HoliSoils
Working together for forest soils

D3.3 Report on guidelines for combining GHG monitoring data

Holistic management practices, modelling and monitoring for European forest soils, HoliSoils

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Deliverable D3.3 - Report on guidelines for combining GHG monitoring data		
In this report, we show whether and how greenhouse gas reporting methods and data are harmonized for forest soils. For this purpose, we summarize the results for mineral soil from Deliverables 1.1 and 3.2 and supplement them with information on organic soils and litter.		
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PU	Public, fully open e.g. web	x
CO	Confidential, only for members of the consortium (including the Commission Services)	
CI	Classified, information as referred to in Commission Decision 2001/844/EC	
Nature of the Deliverable		
R	Document, report	x
DEM	Demonstration, pilot, prototype, plan design	
DEC	Websites, patents filing, market studies, press & media actions, videos etc.	
OTHER	Software, technical diagram etc.	
Ethics	Ethics deliverables	

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Contents

1. Introduction

All EU member states report their greenhouse gas (GHG) emissions to meet their UNFCCC reporting obligations. If these publicly available data are now used by third parties, it may happen that data from several countries are compared or aggregated. However, as the data are not collected using the same methodology or if areas are defined differently, interpretations can be incorrect or misleading. In this context, we looked at the methods and definitions used by EU member states to collect their soil data in the section forest land remaining forest land.

This report is based on two previously submitted deliverables. In Deliverable 3.2, we have compiled an overview of how the EU member states collect their data on GHG reporting in forest mineral soils. In Deliverable 1.1, we have compared the laboratory methods of several monitoring systems for forest mineral soils. The objective of this report is to combine information from both deliverables. In addition to the information on mineral soils, we will also classify the survey methods for organic soils and litter. Finally, we will evaluate what has to be considered when comparing cross-national data.

2. Method comparison for data acquisition

2.1 Mineral soil[1]

Within the EU, 13 out of the 27 member states indicate in their national GHG reporting inventories that they collect soil data to report C stock changes in forest soils. The 14 other states do not collect data on forest soils. The soil data are obtained by most countries in the course of ICP Forests Level I monitoring or harmonized surveys. A few countries have used other methods for the repeated inventory (e.g. LUCAS or NF(S)I data) (see Table 1). It has been shown that the data from the national forest (soil) inventories are comparable with the data from ICP Forests (see Deliverable 1.1).

The data collected is used for reporting purposes. There are three approaches to this: Tier 1, Tier 2, and Tier 3. In the Tier 1 approach, no change in carbon stock is assumed. This can be calculated using a formula and default values provided by the IPCC (see IPCC 2006 Guidelines). However, no change in stocks can also be assumed if, for example, forest management has not changed. In the Tier 2 approach, the calculation of stock changes is done using the same formula as in the Tier 1 approach, but country-specific values are used. In the Tier 3 approach, the calculation of stock changes is based on monitoring data or modelling results.

Table 1: List of all EU member states that collect mineral forest soil data for greenhouse gas reporting (forest land remaining forest land) and the respective acquisition method. Countries that only determine the soil type or do not collect data are not listed. Table copied and shortened from Deliverable 3.2. Abbreviations: NFI = national forest inventory, NFSI = national forest soil inventory. ICP Forests, SINKS, RMQS and LUCAS are monitoring networks. Yasso07 and CFS-CBM3 are models to determine carbon dynamics in forests.

Country	Data acquisition	Reporting
Belgium	various methods	Tier 1
Bulgaria	ICP Forests	Tier 1
Denmark	SINKS project (soil data according to ICP F)	Tier 1
France	RMQS (soil data according to ICP F)	Tier 1
Latvia	ICP Forests	Tier 1
Lithuania	ICP Forests	Tier 1
Slovakia	ICP Forests, NFI, additional sites	Tier 1
Slovenia	ICP Forests, NFSI	Tier 1

[1] The contents of this chapter are a summary from the deliverables 1.1 and 3.2. To avoid duplication of content, the results have been summarized here. All the results addressed here can be found in detail in the respective documents.

Germany	NFSI (harmonized to ICP F)	Tier 2
Portugal	ICP Forests, LUCAS	Tier 2
Austria	ICP Forests, NFSI (datasets comparable, verifying Yasso07 model)	Tier 3
Czechia	NFSI (not yet verified for CFS-CBM3 model)	Tier 3
Sweden	NFSI (harmonized to ICP F)	Tier 3

In Deliverable 1.1 we also concluded that the ICP Forests and LUCAS parameters relevant for GHG reporting are either the same or comparable (see Table 2).

Table 2: Comparison of some variables of the ICP Forests and LUCAS inventories. Copied and shortened from Deliverable 1.1.

Variable	ICP Forests	LUCAS	Suggestion and comments
Bulk density	ISO 11272	ISO 11272	ISO 11272
Texture	ISO 11277	ISO 13320	ISO 11277, comparable
Water content	ISO 11465	soil core sample weighted before and after air drying	ISO 11465
pH (H_2O)	ISO 10390	ISO 10390	ISO 10390
C_{tot}	ISO 10694	ISO 10694	ISO 10694 is officially withdrawn and EN 15936 suggested as replacement
C_{org}			
Carbonate	ISO 10693, EN 15936	ISO 10693	ISO 10693 and EN 15936; comparable

For mineral soils, we can thus state that the data collections of most countries are based on comparable or identical methods. In Belgium, two different methodologies are used, depending on the region. In addition, some countries do not collect data and report their GHGs only according to Tier 1. These default values cannot be directly compared with measured data.

2.2 Organic soil

Reporting of greenhouse gases from organic soils in forests is much less clear than from mineral soils. Most EU member states report under Tier 1. Within the inventory reports, organic soils under forest may not be reported under the FL-FL category, but under wetlands. Also, due to their often low cover of total forest area, they are often not reported (NE), do not appear at all (NE), or are located in protected areas, so it is assumed that no carbon stock changes are occurring. Therefore, when interpreting the data, it should be considered in which category organic soils in the forest are listed in order to be able to make comparative statements.

More common source of error in the interpretation arises due to different definitions of organic soils. The official IPCC definition (Annex 3A.5, IPCC 2006 Guidelines) is as follows:

"Organic soils are identified on the basis of criteria 1 and 2, or 1 and 3 listed below (FAO 1998):

1. *Thickness of organic horizon greater than or equal to 10 cm. A horizon of less than 20 cm must have 12 percent or more organic carbon when mixed to a depth of 20 cm.*
2. *Soils that are never saturated with water for more than a few days must contain more than 20 percent organic carbon by weight (i.e., about 35 percent organic matter).*
3. *Soils are subject to water saturation episodes and has either:*

a. *At least 12 percent organic carbon by weight (i.e., about 20 percent organic matter) if the soil has no clay; or*

b. *At least 18 percent organic carbon by weight (i.e., about 30 percent organic matter) if the soil has 60% or more clay; or*

c. *An intermediate proportional amount of organic carbon for intermediate amounts of clay."*

It is certain that a direct comparison of the data on organic soils is not always possible, as the definitions differ both from the IPCC definition but also from the definitions of the other countries (see Table 3). As a result, the cover areas of organic soils in the forest, for example, are not comparable because they change with different definitions. The significance of this change will be investigated by WP 3 in the future.

Table 3: List of all EU member states and how they report the carbon stock changes in organic soils. Additional information on their definition of organic soils is included. NO = Not Occurring, NE = not estimated. Yasso07 is a model for estimating soil carbon dynamics.

Country	Definition	Reporting	org. soil
Austria	IPCC*	Tier 1	NO
Belgium	IPCC*	Tier 1	NO
Bulgaria	IPCC*	not subject of evaluation (NIR Bulgaria 2022, p. 337)	
Croatia	not mentioned	not mentioned	
Cyprus	IPCC*	Tier 1	
Czechia	IPCC*	Tier 1	NE
Denmark	IPCC*	Tier 1	
Estonia	organic layer > 30 cm (undrained) organic layer > 25 cm (drained)	Tier 1	
Finland	IPCC	Tier 3 Yasso07	
France	IPCC*	Tier 1	
Germany	IPCC	Tier 2	
Greece	IPCC*	not considered	
Hungary	IPCC*	Tier 1	
Ireland	peat layer > 30 cm and SOC content > 20 %	Tier 2	
Italy	IPCC*	Tier 1	NO
Latvia	organic layer ≥ 20 cm	Tier 2	
Lithuania	peat layer ≥ 40 cm (60 cm for poorly decomposed bogs) and histic horizon with min. 70-75 % organic matter per volume	Tier 1	NE (undrained soils)
Luxembourg	IPCC*	Tier 1	NO
Malta	IPCC*	Tier 1	NO
Netherlands	2 types considered: peat soils: peat layer min. 40 cm in the first 120 cm of soil peaty soils: peat layer 5-40 cm in the first 80 cm	Tier 2	
Poland	IPCC*	Tier 2	
Portugal	IPCC*	Tier 1 (as wetland)	

Romania	IPCC*	Tier 1	
Slovakia	IPCC*	unknown	
Slovenia	IPCC	Tier 1	NE
Spain	IPCC*	Tier 1	NO
Sweden	IPCC*	Tier 1	

*assumed because not stated/defined otherwise

2.3 Litter

Carbon stock changes in litter are mostly reported after Tier 1 (see Table 4). In this case, it is usually assumed that no major changes will take place in this pool if management remains unchanged. As with definitions of organic soils, many different interpretations of litter are applied. The definition of the IPCC is rather open to make country-specific interpretations:

"[Litter] Includes all non-living biomass with a diameter less than a minimum diameter chosen by the country (for example 10 cm), lying dead, in various states of decomposition above the mineral or organic soil. This includes litter, fumic, and humic layers. Live fine roots (of less than the suggested diameter limit for belowground biomass) are included in litter where they cannot be distinguished from it empirically."

In terms of reporting, the open definition is not a problem. Carbon stock changes in litter are reported as part of the dead organic matter pool, which includes dead wood and litter. By reporting both together, it is not relevant where the boundary between dead wood and litter lies. However, if the compartments are considered and compared individually, the different boundaries become a potential source of error. Another challenge emerges due to various data collection methods. Information on deadwood usually comes from national forest inventories, while information on litter, especially on the organic layers, is collected in soil inventories. The inventories have different measurement grids, are not carried out at the same time and occurs at different intervals. In addition, it is not guaranteed that the inventories are methodically coordinated with each other, which can lead to duplicated observations of individual elements.

Furthermore, it is important to highlight that the term 'litter' in soil science refers to the organic horizons above the mineral soil. This definition is used by some countries in their inventory reports (see Table 4). Moreover, the distinction between litter and deadwood is determined at 2 cm diameter threshold.

Table 4: List of all EU member states with their reporting tier and definition of litter. NE = not estimated, NA = not available. Yasso07, CBM-CFS3 and for-est are models to display carbon dynamics in forests.

Country	Definition	Reporting
Austria	"all non-living biomass lying dead in various states of decomposition […]" (NIR 2022, p. 422) (no threshold between dead wood and litter given)	Tier 3 Yasso07
Belgium	IPCC*	Tier 1
Bulgaria	litter = organic layers	Tier 1
Croatia	IPCC*	Tier 1
Cyprus	IPCC*	Tier 1
Czechia	needles, leaves and branches up to 7 cm diameter	Tier 3 CBM-CFS3
Denmark	IPCC*	Tier 1
Estonia	IPCC*	Tier 1
Finland	"Litter consists of dead foliage, leaves, branches, bark coarse roots, stumps and fine roots" (NIR 2022, p. 316) (no thresholds given)	Tier 3 Yasso07
France	needles, leaves and branches up to diameter threshold of NFI**	Tier 1
Germany	litter = organic layers	Tier 2
Greece	IPCC*	Tier 1
Hungary	IPCC*	Tier 1 NE
Ireland	needles, leaves and branches up to 7 cm diameter	Tier 3 CBM-CFS3
Italy	non-living biomass ≤ 2 cm diameter + fine woody debris ≤ 2,5 cm diameter	Tier 3 for-est
Latvia	all non-living biomass with diameter between 2 mm and 6 cm	Tier 2
Lithuania	IPCC	Tier 1
Luxembourg	IPCC*	Tier 1
Malta	IPCC*	Tier 1
Netherlands	litter = organic layers (Arets et al. 2022, p. 44***)	Tier 2
Poland	all non-living biomass with diameter between 2 mm and 7 cm over bark	Tier 2
Portugal	IPCC*	Tier 1 NA
Romania	IPCC*	Tier 1
Slovakia	all non-living biomass with diameter < 1 cm + organic layers + live fine roots	Tier 1
Slovenia	all non-living biomass with diameter < 10 cm + organic layers + live fine roots	Tier 2
Spain	IPCC*	Tier 1
Sweden	all non-living biomass with diameter < 10 cm + organic layers + live fine roots	Tier 3

*assumed because not stated/defined otherwise

**information on diameter could not be found

***Arets et al. (2022): Greenhouse gas reporting for the LULUCF sector in the Netherlands: Methodological background, update 2022. (WOt-technical report; No. 217). WOT Natuur & Milieu. https://doi.org/10.18174/566478

3. Harmonisation of soil data

Contrary to our expectations, GHG reporting data in mineral soil are comparable (see results from Deliverable 1.1). No pedotransfer functions or other harmonization steps are needed to compare the data. However, when considering multinational interpretation, it is important to be aware that not all countries reporting under Tier 1 use the same methodology. EU member states that are not listed do not collect data but assume no changes in carbon stocks in mineral forest soil due to lack of change in management. Countries that currently report according to Tier 1 and want to collect their own data in the future are recommended to follow to the guideline for forest soil monitoring that we have prepared (see Deliverable 1.1). The guideline is harmonized to the ICP Forests methodology. This provides comparability with other countries, which can also help validate the collected data (or models, if applicable).

When comparing data on organic soils, it is essential to take a great care in determining which definitions are used to characterized organic soils. The range of definitions used by all EU member states is shown in Table 3. An EU-wide comparison of organic soils is not possible with the variety of definitions because the progression of horizon thicknesses is not linear. The impact of the different definitions of organic soils on their land use (and thus also on their carbon storage potentials or emissions) will be investigated by WP 3 in the future. In general, it should be noted that deviations from the IPCC definition are often historically justified and fit the prevailing geographical conditions of the individual countries.

Great care must be taken also with definitions of litter. The boundary between deadwood and litter is often country-specific and rooted in the historical development of forest and soil inventories. In case when data for litter are considered separately from deadwood, this distinction has to be taken into account. If the entire pool of dead organic matter is considered, the boundary becomes irrelevant. However, it is important to note that the data may come from different inventories, and checking for potential double counting may be necessary.

4. Conclusion

Contrary to our expectation, there is no need to harmonize mineral soil data in the forest because they are already collected using consistent methodology. However, for organic soils and litter a problem arises due to the application of different definitions by various countries.

While this issue might be difficult to solve, it should be communicated more clearly to avoid drawing incorrect conclusions during data interpretation.