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JRC TECHNICAL REPORT

Semantic assessment of land cover classes and correspondent feature types

Example of semantic meta-model for wetlands

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Contents

Foreword

This report presents some early achievements of the project SEPLA (Satellite based mapping and monitoring of European peatland and wetland for LULUCF and agriculture), with reference to the semantic modeling of the peatland and wetland-related land cover types in EU. The project is defined under the work programme signed between JRC and DG CLIMA, and implemented by the GTCAP team of JRC D5 Unit (Food Security). This is the first version of a larger report expected to be finalized in the second half of 2022.

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Abstract

The report provides the first version of the guidance for semantic assessment of the peatland and wetland types present in the EU Member States, together with the elaborated semantic meta-model (template). The semantic assessment is an essential work component of the ongoing project on satellite based mapping and monitoring of European peatland and wetland for LULUCF and agriculture (SEPLA).

The main objective of the project is to ensure comprehensive inventory of wetlands and peatlands and to address the monitoring of their preservation and restoration through the use of remote sensing and regularly updated geographically explicit datasets. The targeted geographic scope comprises the EU countries, including also Iceland and Norway at later stage. The project outcomes are expected to improve also the quality of GHG inventories, compilation of which is handled by the EEA, on behalf of DG CLIMA through technical assistance on monitoring, reporting and verification of emissions/removals from peatlands and wetlands. Key beneficiaries of the project results are DG CLIMA (the main client) and DG AGRI (the CAP-related stakeholder).

The project should provide further insight on how already existing CAP-related spatially explicit datasets (IACS) may be used in combination with CAP satellite-based remote sensing systems in place, and how (where and when deemed necessary), additional data within IACS should be cost-efficiently collected, to ensure that CAP-strategic plans fulfil the targets and quality needs of LULUCF Regulation 2018/841.

The project is carried out using a bottom-up approach where the involvement of Member States is fundamental. Technical experts from MSs are sharing information about existing best practices, approaches and available geographical data at national and regional level as well as they will test the feasibility of the common procedures or techniques proposed. Selected Member States have already started cooperating for the development phase (DK, BG, IE, LV). After the testing phase with other 10 MSs, results will be disseminated to all MSs.

The report consists of 3 main parts: Chapter 2, providing an overview of the semantic meta-model; Chapter 3, explaining the practical implementation of the semantic assessment; Chapter 4, summarising first outcomes and conclusions; Annexes I to III, holding the details of the semantic template itself.

1. Introduction and background

The aim of SEPLA project is to deliver a set of methodologies and application prototypes to help EU MSs to prepare the relevant geospatial carbon-related information for LULUCF and the future CAP conditionality (GAEC 2). In this respect, the collaboration and knowledge exchange with EU MS experts is considered essential. Despite the ambition to elaborate a common technical framework, SEPLA does not plan to produce a peatland/wetland/carbon dataset at pan-European level. The thematic and geographic scope of the data inventory is targeted towards managed peatlands and wetlands, to capture and address the relevant areas, subject to degradation caused by human activity.

The project puts special emphasis on the cross-cutting nature of the required spatial data of peatland/wetland and the diversity of the application domains it will come from; in particular, the need for semantic analysis of the definitions, classifications and map nomenclatures applied. Instead of trying to set a commonly acceptable definition of peatland and wetland across EU Member States, SEPLA aims to delaborate a common vocabulary of keywords and terms, hierarchically structured by given domain logic, for mapping the local peatland and wetland definitions in unambiguous and standardized manner. This semantic meta-model (or semantic template) is based on structured vocabulary of the Land Cover Meta Language (19144-2:2012, 2012) and the EAGLE matrix for analytic class decomposition (Arnold, 2020). The methodological approach follows the one applied for the building up of the land cover eligibility profiles in the frame of the Land Parcel Identification System (LPIS) Quality Assurance Framework (Devos, 2011).

The purpose of the semantic template is to support EU MS experts in making the best use of available data and set a practical approach for detecting possible overlaps and gaps in the available national datasets related to wetlands. Both are meant to complement the IPCC guidelines on consistent representation of land (Chapter 3) with more detailed instruction on how to assess the completeness and relevance of EU MS datasets, and further address the issues of data uncertainty and the representation consistency. It will also help the mapping of the relationship between IPCC land-use category on wetland and the national land-use and land cover classification systems from which data for the wetland representation are derived.

IPCC - Wetland supplement (Hiraishi, 2014) provides a definition of what organic soils are but does not come up with a common definition for peatland. Also, the definition of the land reporting category “Wetland” is quite broad. It practically qualifies as wetland every land saturated by water for all or part of the year and not being in the other IPCC sub-categories. On other hand, there is plenty of geographic data on peatland and wetland, collected by various groups and purposes. However, definitions vary, and usually, the correspondent classes are neither harmonized, nor interoperable.

The SEPLA team designed a semantic “meta-model” containing, in hierarchical manner, the essential and commonly accepted bio-physical characteristics of the cropland, grassland and wetland, located on organic soil (wet or drained), using the Land Cover Meta Language (ISO 19144-2) as core ontology. The design was based on the 3-dimensional concept of tegon (Devos, 2015) and pedon, as elementary bodies of land cover and soil respectively, acting as structural pair in the system “soil-plan-atmosphere”. It allows for recording, in standardized manner, the link between land cover and soil. It also keeps the land cover and land use concepts separate, while retaining the semantic relationship between them.

2. Overview of the semantic meta-model

The purpose of this "meta-model" is to help EU Member States to document, in standardized manner, their local definitions applied for peatland and wetland, in order to: (1) identify synergies and differences between the national geographically explicit datasets based on these definitions; (2) qualify the thematic data (classes and their mapped instances) that falls into the scope of SEPLA (according to IPCC definitions); (3) compare it with international datasets, to be used in case of gaps in the national data are observed; (4) help the setting up of the change detection approach (historic vs. current data); and (5) select candidate bio-physical characteristics that can be monitored with Earth Observation (EO).

The current meta-model reflects only the bio-physical aspect of the IPCC sub-categories in SEPLA. The land use (management) aspects are intentionally not included. However, the current set of characteristics should allow the description of land cover classes, reflecting a transition or conversion between IPCC sub-categories, caused by the different type of management applied.

The semantic model comprises the (should be) exhaustive set of vocabulary of concepts, elements, and properties, structured in hierarchical manner, to characterize the land cover and soil–related aspects of a wetland. In the typical case, a wetland is considered to have up to three vertical layers (strata). The topsoil stratum (numbered 0) is corresponding to the uppermost (water saturated) soil horizon made by organic deposits, which has contact with vegetation and atmosphere. The strata 1 and 2 correspond to the layer of vegetation above the soil (Stratum 0) and to the upper on (if existing), respectively. Each of the strata contains the bio-physical elements and properties, typical for its nature. Stratum 0 reflects the soil related characteristics; while Stratum 1 and 2 – the vegetation related at the intermediate and higher levels (typically covered by shrubs and trees respectively).

Annex I and Annex II given at the end of this document, provide detailed description of each of the elements of the semantic model.

The review of the initial proposal for meta-model resulted in four interactions, until a stable and coherent version was produced. The final version was also checked for compliance against the EAGLE model applied by European Environmental Agency (EEA), and no major issues were identified.

The implementation of the semantic meta-model should be rather simple and comprises two stages:

1. semantic assessment of the class definitions used in a dataset, as defined in the related nomenclature;
2. assessment of the thematic and quantitative information stored in the dataset, associated to each mapped object.

The later could be regarded as semantic analysis at the level of the feature data model (similar to a model conformance testing).

The **first stage** comprises the following main steps:

1. The given class definition is scanned for **key words and phrases** that relate to elements/characteristics in the meta-model.
2. Those elements/characteristics from the meta-model that are found in the definition, are **flagged;** and
3. Functional traits between characteristics are highlighted, if possible.

The **second stage** comprises the following main steps:

1. The feature data model is queried for the **presence of feature types and attributes**, corresponding to the semantic meta-model. Here the importance is to identify the type of quantitative information the given dataset contains.
2. Those characteristics from the meta-model that are found in the feature data model, are **flagged;** and
3. Functional traits between characteristics are **highlighted**, if possible.

In such a way the meta-model helps the creation and recording of a “passport” or “barcode” of the given class and associated data model in SEPLA terms.

The following figures illustrate the concept and the process.

Figure 1. The semantic model with the Stratum 0 enlarged on the right. It starts (from left to right) with the bio-physical elements (their properties and characteristics) that are integral to the land cover phenomena and its underlying soil. They are structured through the elementary 3-dimensional units of land cover (tegon) and soil (pedon) and their correspondent strata/horizons.

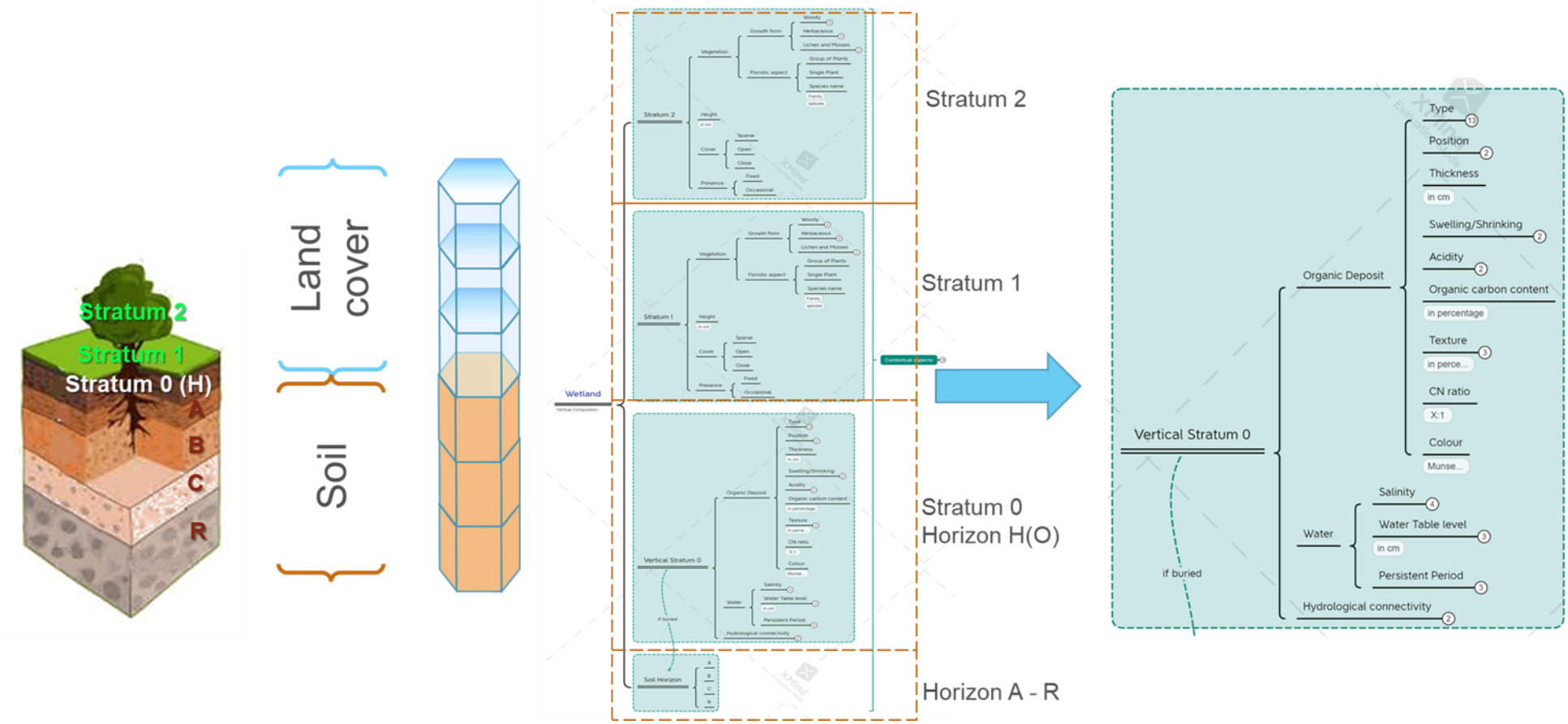


Figure 2. Example of semantic mapping of the CLC class “Wetland” against the semantic model. The CLC class definition is assessed for keywords and their relationships. Those elements of the semantic model present in the class definition, are highlighted.

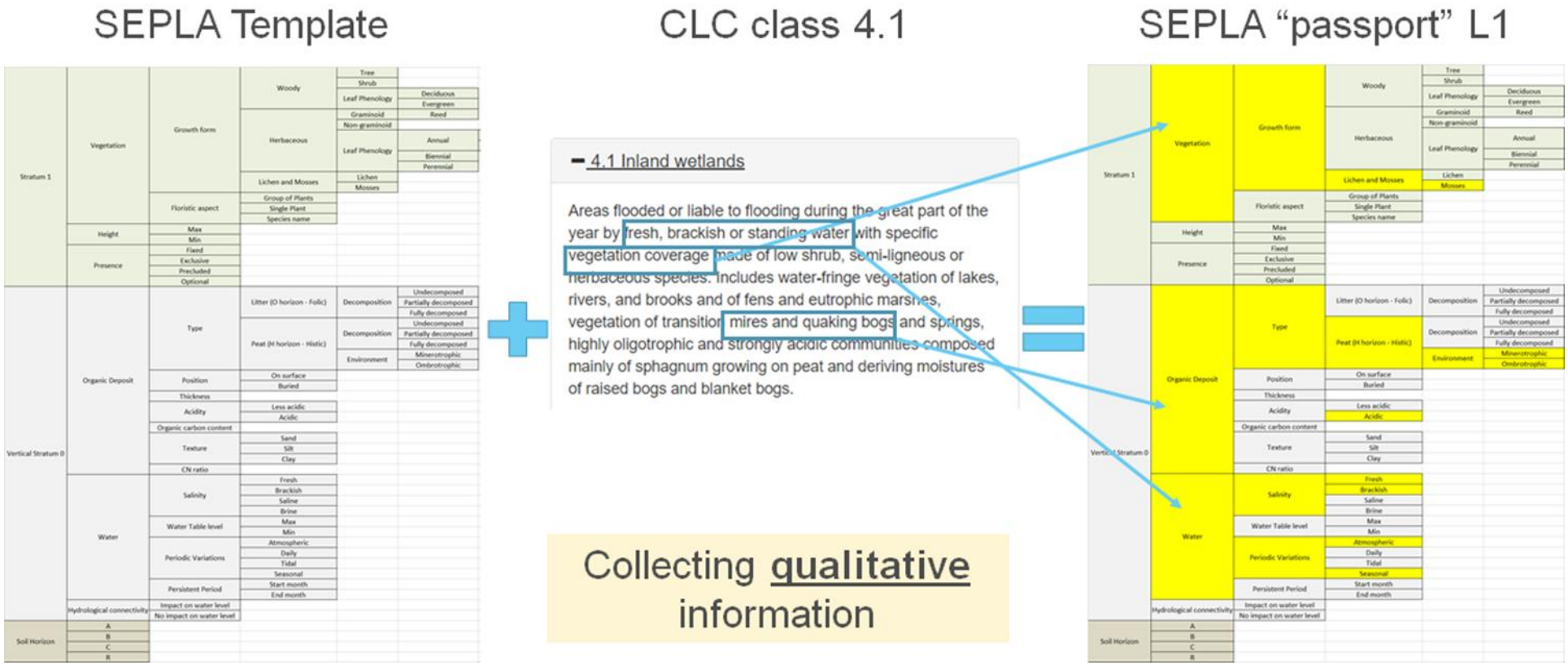
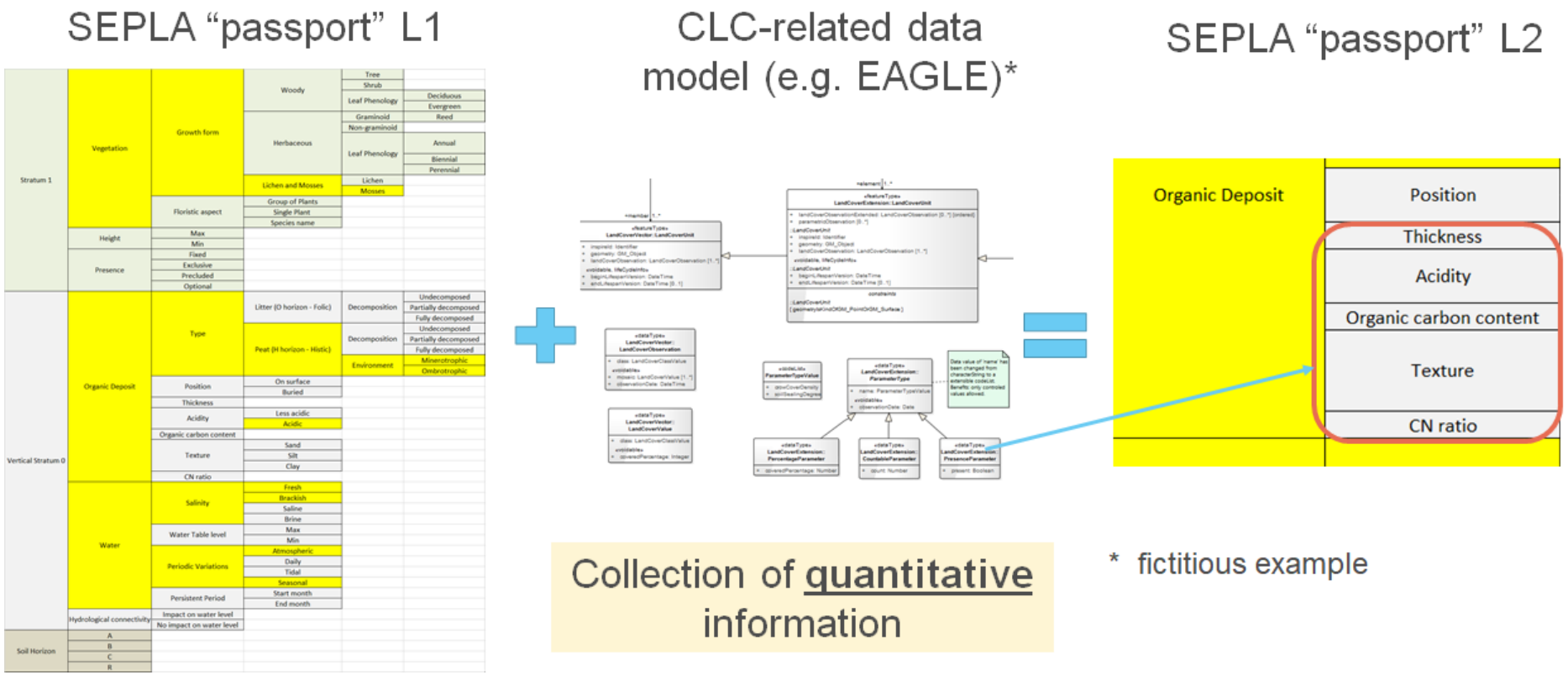


Figure 3. Example of semantic mapping of the possible data model CLC class “Wetland” against the semantic model (fictitious example of CLC class complemented with further information through the EAGLE model). The CLC class data model is assessed for presence of features and attributes. Those corresponding to the semantic model, are highlighted.



3. Guidance for practical implementation of the semantic assessment

As shown during the SEPLA bilateral meetings, the EU MS experts involved in the data preparation for the LULUCF and the introduction of the wetland as land reporting category, are already aware of existing thematic datasets that could play role as "candidate" inputs in the process. Thus, **the instructions provided below assume that the initial selection made within the EU MS is complete and adequate**. Thus, the input datasets are considered as being identified. SEPLA project itself doesn't deal with national data discovery; however, in case of significant data gaps found, the project will assist the given EU MS in finding alternative solutions provided by any regional, pan-European, or international datasets. Experience from previous JRC actions, such as the IACS data re-use for LULUCF (Bertaglia et al, 2016) or Danube Land and Soil Nexus (SEC(2010)1489)might help in this context.

When performing the "semantic mapping" against the semantic meta-model, the analysis should be done using the content provided by the "candidate" dataset alone. Also, the assessment is done (wherever possible) purely from bio-physical (land cover) perspective. Management, land use, and socio-economic aspects are intentionally not accounted at this point but will be considered at later stages.

The semantic "meta-model" is meant to provide the structured vocabulary to describe any wetland that could be found in Europe (at least EU and EEA countries). However, the current semantic mapping will focus on wetlands that fall into the initially defined thematic scope of SEPLA. These are:

1. considered as part of land reporting category "Wetland" (wet areas considered part of "Forest Land" are not accounted);
2. located on organic soil (presumably inland).

Usually, there are two main documents that accompany a given geographic dataset (or map). These are:

1. the nomenclature with the descriptions of all categories/classes used to classify/label the mapped objects. It often contains the relevant mapping instructions associated with each class;
2. the product specifications with the description of the feature data model (structure and type of mapped objects with their relevant attributes), the input sources used to create the dataset (for example, field survey, imagery) with its temporal deference, the cartographic scale (minimum mappable unit - MMU) applied, and the product lineage process. It could also contain information on data quality.

There are two options for the completion of the task related to the semantic assessment.

1. Option 1, applicable to the EU MS confident enough to perform the semantic assessment on their own.

EU MS uses the provided semantic model and related instructions to perform the semantic mapping on the nomenclatures and datasets identified (with some assistance from JRC, if required), and then sends the results to JRC for joint assessment in line with objectives mentioned above.

2. Option 2, applicable to those EU MS not confident enough to perform the task on their own.

EU MS sends the nomenclatures and dataset specifications identified and JRC performs the semantic mapping (with assistance from EU MS). JRC then performs a joint assessment (with the EU MS) in line with objectives mentioned above.

3.1. Generic instructions for the EU MS using Option 1

The principal steps for both options are illustrated with an example taken from the N2K dataset on Natura2000 sites, as part of the Land Monitoring Service Local Component.

In the case of our example, for the Copernicus Natura2000 (N2K) product we have the following two core documents:

1. N2K nomenclature guidelines (version 1.1 is used here) - https://land.copernicus.eu/user-corner/technical-library/n2k_nomenclature_guidelines;
2. N2K product specifications (short version is used here) - https://land.copernicus.eu/user-corner/technical-library/n2k-technical-specifications.

It should be noted that the description of the nomenclature includes also a substantial part related to the product specifications.

3.1.1. Semantic assessment of the relevant classes in the nomenclature

First, we look in N2K nomenclature guidelines and identify those land-related classes from the dataset that refer to inland wetlands on organic soil, and more specifically peatlands. Since the N2K nomenclature is in accordance with the MAES approach (Mapping and Assessment of Ecosystems and their Services -N2K Product User Manual, 2021) these are all classes located in the categories "7. Wetland", in MAES level 1 legend.

We see in the description, given on page 10 of the nomenclature, that this category includes peat bogs, and these are specified in MAES level 2 of the nomenclature. The further levels of this category, namely level 3 and 4, specify whether the wetlands are freshwater or saline and whether the peat bogs are exploited or unexploited. Figure shown in page 184, explains the decision criteria tree for the distinctions between MAES Level 4 classes. We can see that the class of direct interest for SEPLA is the class 7.2.1 Peat bogs", with its two sub-classes "7.2.1.1 Exploited peat bog" and "7.2.1.2 Unexploited peat bog".

In order to identify the characteristics from the generic wetland semantic meta-model the given classes reflect, we need to start from the upmost hierarchical category and go further at lower levels, to collect the extra information on the type of land, reflected in each sub-category.

Thus, in the case of our example, we initiate our analysis with the definition given for the category "7. Wetland", given on page 183. The nomenclature starts with the RAMSAR definition of wetlands, but further precises that it deals with "**inland** freshwater/saline wetlands" only.

Thus, we go in the excel template (Wetland_SEPLA), sheet [Contextual Aspects] and highlight in yellow the cells: [Geography]-> [Inland].

Figure 4. Sheet [Contextual Aspects], highlighting the cells: [Geography]-> [Inland].

Landform	Mountain
	Hill
	Plateau
	Plain
Topography	Altitude
	Slope
Geography	Inland
	Coastal
Climate	Boreal
	Cold temperate dry
	Cold temperate wet
	Warm temperate dry
	Warm temperate moist
	Mediterranean

Then, we assess the following text by highlighting in yellow those key words and expressions related to our semantic meta-model:

> *Inland wetlands are predominantly **water-logged** specific plant and animal communities supporting **water regulation** and **peat-related processes**. This class includes natural or modified mires, bogs and fens, as well as peat extraction sites (MAES). Surfaces of temporary water are included in wetlands. According EUNIS guidelines (see table below), water-logged means the presence of the water table at or above ground level for at least half of the year.*

We go in the excel template (Wetland_v7), sheet [Land Cover elements] and highlight in yellow the following cells:

In [Stratum 0], to reflect the keywords/phrases “peat”, “mires”, “bogs”, “fens“:

[Organic Deposit] -> [Type] - > [Peat (H horizon - Histic)] -> [Environment] - > [Minerotrophic] and [Ombrotrophic]

Since there is no information given in the description on the levels of decomposition, further cells in the [Organic Deposit] functional trait, are not highlighted.

In [Stratum 0], to reflect the keywords/phrases “water-logged”, “water table”, “at or above ground level”, “at least half of the year“:

[Water] -> [Water Table level] - > [Mean]

In the empty cell next to the [Mean], we write “0 meters”

[Water] -> [Persistent Period] - > [Number of months]

In the empty cell next to the [Number of months], we write “> 6 months”

The result is shown in figure below.

Figure 5. Stratum 0 of the semantic passport.

Vertical Stratum 0	Organic Deposit	Type	Litter (O horizon - Folic)	Decomposition	Undecomposed L - Layer
					Partially decomposed F - Layer
					Fully decomposed H - Layer
			Peat (H horizon - Histic)	Decomposition	Undecomposed
					Partially decomposed
					Fully decomposed
				Environment	Minerotrophic
					Ombrotrophic
		Position	On surface		
			Buried		
		Thickness			
		Swelling/Shrink	Yes		
			No		
		Acidity	Less acidic		
			Acidic		
		Organic carbon content			
		Texture	Sand		
			Silt		
			Clay		
		CN ratio			
		Colour			
	Water	Salinity	Fresh		
			Brackish		
			Saline		
			Brine		
		Water Table level	Max		
			Mean	0 meters	
			Min		
		Persistent Period	Number of months	> 6 months	
			Start month		
			End month		
	Hydrological connectivity	Impact on water level			
		No impact on water level			

We see also that the definition contains the word “plant”, which logically would point to the presence of mosses. However, we could further use the information from the decision criteria tree given in page 184 of the N2K nomenclature guidelines, which precise the type of vegetation that could be found on peatlands:

> *Mosses, dwarf shrub vegetation and herbaceous vegetation typical for hummock mires, lawn and carpet mires, mud-bottom mires.*

Then we go back to the excel template (Wetland_v7), sheet [Land Cover elements] and highlight in yellow the following cells:

In [Stratum 1], to reflect the keywords/phrases “plant”, “mosses”, “herbaceous vegetation”:

[Vegetation] -> [Growth form] - > [Herbaceous]

[Vegetation] -> [Growth form] - > [Lichen and Mosses] -> [Mosses]

Since there is no information given in the description on the leaf phenology or type of herbaceous plant, further cells in the [Vegetation] functional trait, are not highlighted.

In [Stratum 1], to reflect the keywords/phrases “dwarf shrub vegetation”:

[Vegetation] -> [Growth form] - > [Woody] –> [Shrub]

Dwarf shrubs are usually woody plants with perennating buds borne close to the ground, and less than 25 centimetres high. For that reason, they could be considered as belonging to the same stratum as the herbaceous vegetation and mosses.

Since there is no information given in the description on the leaf phenology or leaf type, further cells in the [Vegetation] functional trait, are not highlighted.

The result is shown in figure below.

Figure 6. Stratum 1 of the semantic passport.

Stratum 1	Vegetation	Growth form	Woody	Tree		
				Shrub		
				Leaf Type	Broadleaf	
					Needleleaf	
					Aphyllous	
				Leaf Phenology	Deciduous	
					Evergreen	
			Herbaceous	Graminoid	Reed	
				Non-graminoid		
				Leaf Phenology	Annual	One life cycle
						Several life cycles
					Biennial	
					Perennial	
			Lichen and Mosses	Lichen		
				Mosses		
		Floristic aspect	Group of Plants			
			Single Plant			
			Species name			
	Height					
	Cover	Sparse				
		Open				
		Close				
	Presence	Fixed				
		Occasional				

Last step to do is to go to pages 192-200 of the N2K nomenclature guidelines (reference) of the nomenclature and check whether there is further information related to “7.2.1.1 Exploited peat bog” and “7.2.1.2 Unexploited peat bog” that characterize them from bio-physical perspective.

From the provided definition for “7.2.1.1 Exploited peat bog”, we have:

> *Open exploited peat-producing wetlands that are not greatly affected by lakes, sea water or water from water courses.*

We go then back to the excel template (Wetland_v7), sheet [Land Cover elements] and highlight in yellow the following cells:

In [Stratum 0], to reflect the keywords/phrases “are not greatly affected by lakes”:

[Hydrological connectivity] -> [No impact on water level]

The result is shown in figure below.

Figure 7. Updated Stratum 0 of the semantic passport.

Vertical Stratum 0	Organic Deposit	Type	Litter (O horizon - Folic)	Decomposition	Undecomposed L - Layer
					Partially decomposed F - Layer
					Fully decomposed H - Layer
			Peat (H horizon - Histic)	Decomposition	Undecomposed
					Partially decomposed
					Fully decomposed
				Environment	Minerotrophic
					Ombrotrophic
		Position	On surface		
			Buried		
		Thickness			
		Swelling/Shrink	Yes		
			No		
		Acidity	Less acidic		
			Acidic		
		Organic carbon content			
		Texture	Sand		
			Silt		
			Clay		
		CN ratio			
		Colour			
	Water	Salinity	Fresh		
			Brackish		
			Saline		
			Brine		
		Water Table level	Max		
			Mean	0 meters	
			Min		
		Persistent Period	Number of months	> 6 months	
			Start month		
			End month		
	Hydrological connectivity	Impact on water level			
		No impact on water level			

The phrase “open exploited”, in combination with the examples provided (field photo and remote sensing images) indicates that the peatland is barely covered with vegetation, or the vegetation is completely absent.

We go then back to the excel template (Wetland_v7), sheet [Land Cover elements] and highlight in yellow the following cells:

In [Stratum 1], to reflect the keywords/phrases “open” and examples given:

[Cover] -> [Sparse]

[Presence -> [Occasional]

The result is shown in figure below.

Figure 8. Updated Stratum 1 of the semantic passport reflecting the keywords/phrases “open”.

Stratum 1	Vegetation	Growth form	Woody	Tree		
				Shrub		
				Leaf Type	Broadleaf	
					Needleleaf	
					Aphyllous	
				Leaf Phenology	Deciduous	
					Evergreen	
			Herbaceous	Graminoid	Reed	
				Non-graminoid		
				Leaf Phenology	Annual	One life cycle
						Several life cycles
					Biennial	
					Perennial	
			Lichen and Mosses	Lichen		
				Mosses		
		Floristic aspect	Group of Plants			
			Single Plant			
			Species name			
	Height					
	Cover	Sparse				
		Open				
		Close				
	Presence	Fixed				
		Occasional				

We finally have a passport of the class “7.2.1.1 Exploited peat bog”, which looks as in figure below, for all strata included.

Figure 9. Passport of the class “7.2.1.1 Exploited peat bog”.

Stratum 1	Vegetation	Growth form	Woody	Tree		
				Shrub		
				Leaf Type	Broadleaf	
					Needleleaf	
					Aphyllous	
				Leaf Phenology	Deciduous	
					Evergreen	
			Herbaceous	Graminoid	Reed	
				Non-graminoid		
				Leaf Phenology	Annual	One life cycle
						Several life cycles
					Biennial	
					Perennial	
			Lichen and Mosses	Lichen		
				Mosses		
		Floristic aspect	Group of Plants			
			Single Plant			
			Species name			
	Height					
	Cover	Sparse				
		Open				
		Close				
	Presence	Fixed				
		Occasional				
Vertical Stratum 0	Organic Deposit	Type	Litter (O horizon - Folic)	Decomposition	Undecomposed L - Layer	
					Partially decomposed F - Layer	
					Fully decomposed H - Layer	
			Peat (H horizon - Histic)	Decomposition	Undecomposed	
					Partially decomposed	
					Fully decomposed	
				Environment	Minerotrophic	
					Ombrotrophic	
		Position	On surface			
			Buried			
		Thickness				
		Swelling/Shrink	Yes			
			No			
		Acidity	Less acidic			
			Acidic			
		Organic carbon content				
		Texture	Sand			
			Silt			
			Clay			
		CN ratio				
		Colour				
	Water	Salinity	Fresh			
			Brackish			
			Saline			
			Brine			
		Water Table level	Max			
			Mean	0 meters		
			Min			
		Persistent Period	Number of months	> 6 months		
			Start month			
			End month			
	Hydrological connectivity	Impact on water level				
		No impact on water level				

Landform	Mountain
	Hill
	Plateau
	Plain
Topography	Altitude
	Slope
Geography	Inland
	Coastal
Climate	Boreal
	Cold temperate dry
	Cold temperate wet
	Warm temperate dry
	Warm temperate moist
	Mediterranean

From the provided definition for “7.2.1.2 Unexploited peat bog”, we have:

> *Open unexploited peat-producing wetlands that are not greatly affected by lakes, sea water or water from water courses.*
>
> *In Nordic conditions this class is normally a heterogeneous vegetation type where mire vegetation dominates in a mosaic of heath vegetation, alpine grassland, alpine willow bushes and a rocky ground.*

As in the case of “7.2.1.1 Exploited peat bog”, we are retaining the highlight of cells in [Stratum 0]

[Hydrological connectivity] -> [No impact on water level]

The phrase “open unexploited” and “rocky ground”, in combination with the examples provided (field photo and remote sensing images) indicates a persistence presence of open to close heterogeneous vegetation. The rocky ground could further indicate interruptions of the organic layer and its thickness, due to the presence of specific landforms. The reference made to heath vegetation and willow bushes points to the probable presence of taller shrubs, situated in a second vegetation stratum.

We go then back to the excel template (Wetland_v7), sheet [Land Cover elements] and highlight in yellow the following cells:

In [Stratum 1], to reflect the keywords/phrases “mire vegetation dominates”:

Cover] -> [Open]

[Presence -> [Fixed]

The result is shown in figure below.

Figure 10. Passport of the class “7.2.1.1 Exploited peat bog” – updated Stratum 1.

Stratum 1	Vegetation	Growth form	Woody	Tree		
				Shrub		
				Leaf Type	Broadleaf	
					Needleleaf	
					Aphyllous	
				Leaf Phenology	Deciduous	
					Evergreen	
			Herbaceous	Graminoid	Reed	
				Non-graminoid		
				Leaf Phenology	Annual	One life cycle
						Several life cycles
					Biennial	
					Perennial	
			Lichen and Mosses	Lichen		
				Mosses		
		Floristic aspect	Group of Plants			
			Single Plant			
			Species name			
	Height					
	Cover	Sparse				
		Open				
		Close				
	Presence	Fixed				
		Occasional				

In [Stratum 2], to reflect the keywords/phrases “heterogeneous vegetation type”, “vegetation dominates”, “heath vegetation”, “willow bushes”:

[Vegetation] -> [Growth form] - > [Woody] –> [Shrub]

[Cover] -> [Open] and [Sparse]

[Presence -> [Occasional]

The result is shown in figure below.

Figure 11. Passport of the class "7.2.1.1 Exploited peat bog"- updated Stratum 2.

Stratum 2	Vegetation	Growth form	Woody	Tree		
				Shrub		
				Leaf Type	Broadleaf	
					Needleleaf	
					Aphyllous	
				Leaf Phenology	Deciduous	
					Evergreen	
			Herbaceous	Graminoid	Reed	
				Non-graminoid		
				Leaf Phenology	Annual	One life cycle
						Several life cycles
					Biennial	
					Perennial	
			Lichen and Mosses	Lichen		
				Mosses		
		Floristic aspect	Group of Plants			
			Single Plant			
			Species name			
	Height					
	Cover	Sparse				
		Open				
		Close				
	Presence	Fixed				
		Occasional				

There is further information given on page 198 indicating that

> *This category includes:*
>
> • *The mire types hummock, lawn, carpet mires and mud-bottom mires.*
> • *Peat bogs in Alpine Sub-Alpine environment across Europe.*
> • *Mosaics of complex distribution between the MAES classes 7.2.1.2 and 9.2.1.1 Natural water bodies, where the MAES class 7.2.1.2 cover at least 70% of the surface.*

We could reflect the keywords/phrases "hummock mires" and "mud-bottom mires", "rocky ground" as well as the geographic references "Nordic countries", "Alpine Sub-Apline" by going in the excel template (Wetland_v7), sheet [Contextual Aspects] and highlight in yellow the cells:

[Landform] -> [Hill]; [Mountain]

[Climate] -> [Boreal]; [Cold temperate wet]

Figure 12. Passport of the class "7.2.1.1 Exploited peat bog"- [Contextual Aspects].

Landform	Mountain
	Hill
	Plateau
	Plain
Topography	Altitude
	Slope
Geography	Inland
	Coastal
Climate	Boreal
	Cold temperate dry
	Cold temperate wet
	Warm temperate dry
	Warm temperate moist
	Mediterranean

We finally have a passport of the class "7.2.1.2 Unexploited peat bog", which looks as follows for all strata included.

Figure 13. Final passport of the class "7.2.1.1 Exploited peat bog".

Stratum 2	Vegetation	Growth form	Woody	Tree		
				Shrub		
				Leaf Type	Broadleaf	
					Needleleaf	
					Aphyllous	
				Leaf Phenology	Deciduous	
					Evergreen	
			Herbaceous	Graminoid	Reed	
				Non-graminoid		
				Leaf Phenology	Annual	One life cycle
						Several life cycles
					Biennial	
					Perennial	
			Lichen and Mosses	Lichen		
				Mosses		
		Floristic aspect	Group of Plants			
			Single Plant			
			Species name			
	Height					
	Cover	Sparse				
		Open				
		Close				
	Presence	Fixed				
		Occasional				
Stratum 1	Vegetation	Growth form	Woody	Tree		
				Shrub		
				Leaf Type	Broadleaf	
					Needleleaf	
					Aphyllous	
				Leaf Phenology	Deciduous	
					Evergreen	
			Herbaceous	Graminoid	Reed	
				Non-graminoid		
				Leaf Phenology	Annual	One life cycle
						Several life cycles
					Biennial	
					Perennial	
			Lichen and Mosses	Lichen		
				Mosses		
		Floristic aspect	Group of Plants			
			Single Plant			
			Species name			
	Height					
	Cover	Sparse				
		Open				
		Close				
	Presence	Fixed				
		Occasional				
Vertical Stratum 0	Organic Deposit	Type	Litter (O horizon - Folic)	Decomposition	Undecomposed L - Layer	
					Partially decomposed F - Layer	
					Fully decomposed H - Layer	
			Peat (H horizon - Histic)	Decomposition	Undecomposed	
					Partially decomposed	
					Fully decomposed	
				Environment	Minerotrophic	
					Ombrotrophic	
		Position	On surface			
			Buried			
		Thickness				
		Swelling/Shrink	Yes			
			No			
		Acidity	Less acidic			
			Acidic			
		Organic carbon content				
		Texture	Sand			
			Silt			
			Clay			
		CN ratio				
		Colour				
	Water	Salinity	Fresh			
			Brackish			
			Saline			
			Brine			
		Water Table level	Max			
			Mean	0 meters		
			Min			
		Persistent Period	Number of months	> 6 months		
			Start month			
			End month			
	Hydrological connectivity	Impact on water level				
		No impact on water level				

Landform	Mountain
	Hill
	Plateau
	Plain
Topography	Altitude
	Slope
Geography	Inland
	Coastal
Climate	Boreal
	Cold temperate dry
	Cold temperate wet
	Warm temperate dry
	Warm temperate moist
	Mediterranean

3.1.2. Semantic assessment of the relevant class instances in the nomenclature

So far, we have been assessing the class definitions alone, which applies to spatial objects labelled in the given dataset with this class. From now on, we will look for any further information related to the dataset itself.

In the information on 7.2.1.2 Unexploited peat bog, given on page 198, we could see that such peat bogs could be notably present also in mapped spatial objects that represent a cartographic mix between 7.2.1.2 Unexploited peat bog and 9.2.1.1 Natural water bodies, as far as the class 7.2.1.2 covers at least 70% of the surface. We cannot reflect this information directly in the semantic model, since it is not related to the class definition but to the particular object instance. However, it gives us important information on how to select the spatial objects related to peatland and of interest to SEPLA, which we could record apart.

Then, we could have a look at the feature data models in the N2K product specifications (Table Class Coding / Attribution on page 9). We see there a presence of a comment field [COMMENT_06], for additional information for the mapped spatial object. As evident from table 2, in the case of peatland it could store specific information on “temporal fluctuation of water level”.

For each of the two peatland classes (exploited and unexploited), we go in their excel passports, sheet [Land Cover elements] and highlight in yellow the following cells:

In [Stratum 0], to reflect for the potential presence of data on “temporal fluctuation of water level”:

[Water] -> [Water Table level] - > [Min] and [Max]

Figure 14. Passport of the class "7.2.1.2 Unexploited peat bog" – Stratum 0.

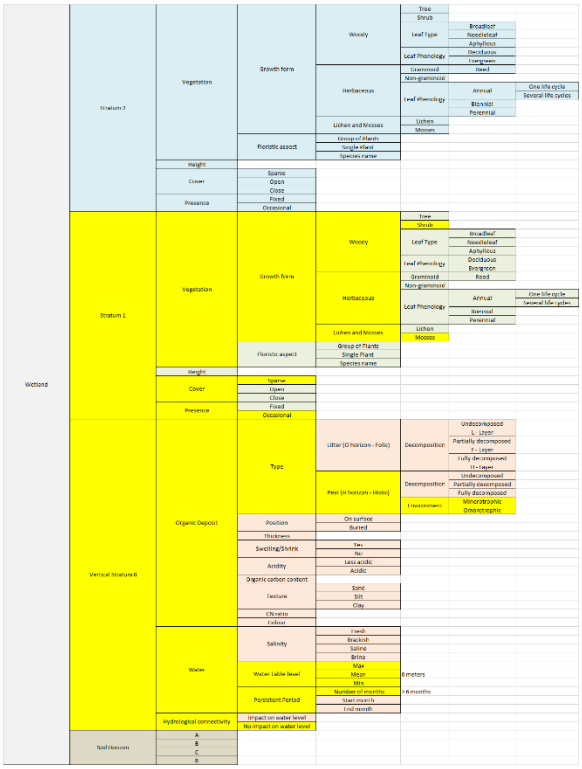
Vertical Stratum 0	Organic Deposit	Type	Litter (O horizon - Folic)	Decomposition	Undecomposed L - Layer
					Partially decomposed F - Layer
					Fully decomposed H - Layer
			Peat (H horizon - Histic)	Decomposition	Undecomposed
					Partially decomposed
					Fully decomposed
				Environment	Minerotrophic
					Ombrotrophic
		Position	On surface		
			Buried		
		Thickness			
		Swelling/Shrink	Yes		
			No		
		Acidity	Less acidic		
			Acidic		
		Organic carbon content			
		Texture	Sand		
			Silt		
			Clay		
		CN ratio			
		Colour			
	Water	Salinity	Fresh		
			Brackish		
			Saline		
			Brine		
		Water Table level	Max		
			Mean	0 meters	
			Min		
		Persistent Period	Number of months	> 6 months	
			Start month		
			End month		
	Hydrological connectivity	Impact on water level			
		No impact on water level			

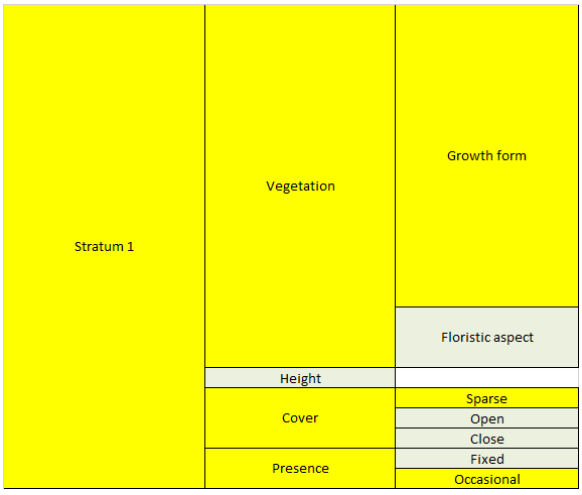
With this last step, the semantic analysis of the N2K dataset is complete.

Figure 15 below shows the resulted passport for the two N2K classes.

Figure 15. Resulted semantic passport for exploited and unexploited peat bogs.

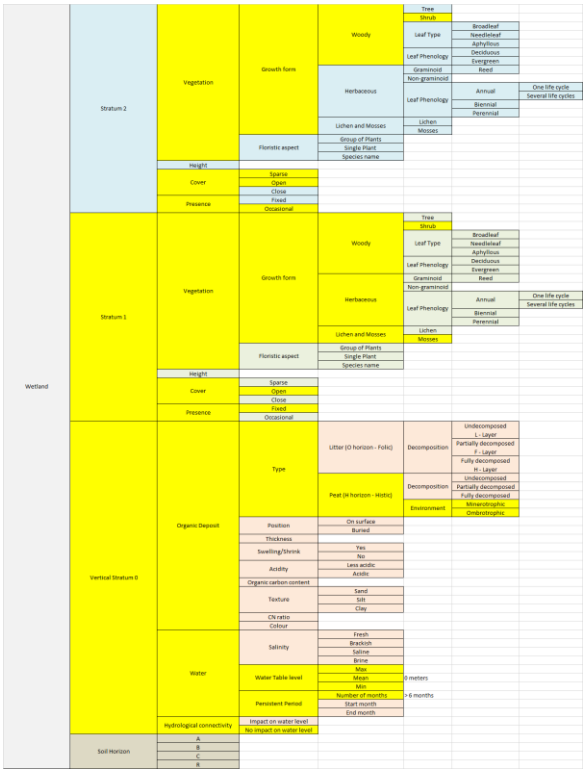
7.2.1.1 Exploited peat bog

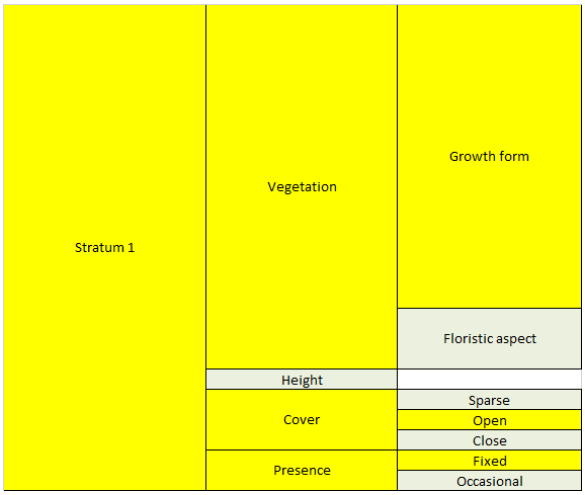




Landform	Mountain
	Hill
	Plateau
	Plain
Topography	Altitude
	Slope
Geography	Inland
	Coastal
Climate	Boreal
	Cold temperate dry
	Cold temperate wet
	Warm temperate dry
	Warm temperate moist
	Mediterranean

7.2.1.2 Unexploited peat bog





Landform	Mountain
	Hill
	Plateau
	Plain
Topography	Altitude
	Slope
Geography	Inland
	Coastal
Climate	Boreal
	Cold temperate dry
	Cold temperate wet
	Warm temperate dry
	Warm temperate moist
	Mediterranean

3.2. Interpretation of the results from the semantic assessment

As a result of the semantic assessment, we have identified the classes relevant to the scope of SEPLA - 7.2.1.1 Exploited peat bog and 7.2.1.2 Unexploited peat bog. Consequently, we have identified also the associated spatial (mapped) objects from the N2K dataset, being those labelled with the two classes. We have further described them in standardized manned through the "semantic passport".

This gives us the possibility to understand the exact nature of the land cover features, falling in the peatland-related classes. It tells us how detailed the classes are, what is their geographic coverage in the dataset; and what are the key differences between them. For example, we could see the class "Unexploited peat bog" is (as expected for pan-European dataset) quite broad and includes practically all types of bogs and fens that could be found in the different climatic zone in Europe and different vegetation, in terms of type and cover. The class "Exploited peat bog" is rather specific one, targeting peatlands under particular type of management. We further see that the lack of persistent herbaceous vegetation and the absence of woody plants are elements that characterise the "Exploited peat bog" and are used to discriminate it from the "Unexploited peat bog". Both classes could be considered sufficiently precise in terms of the information of the presence and persistence of the water level to allow for their separation from the wet (mesic) grasslands, for example. The assessment shows also that both classes are defined by elements, as vegetation and water, which have characteristics that are observable with EO data. Finally, we also have obtained information on the type of data these classes and associated mapped object cannot provide, such as the soil characteristics (SOC, texture, thickness, etc.).

4. First outcomes and conclusions

Experts from the EU Member States expressed their appreciation for the semantic meta-model as a method to identify and "map" the geospatial data, relevant for the peatland/wetland inventory. For each of the national peatland/wetland class (and associated feature catalogue), a specific "passport" was created, holding in structural way all bio-physical characteristics and properties the class and its feature instances aim to convey. Most of the experts found it easy to perform the semantic mapping on the nomenclatures and datasets by themselves (Figure 16). Some asked for additional support from JRC. The work is still ongoing with some EU Member States.

Both JRC and EU MS started assessing the class "passports" in relation to:

their correspondence to IPCC needs/requirements;

semantic gaps and overlaps (and possible data to fill in);

role of the class/dataset in the dichotomous data integration approach;

identification of peatlands at risk or degraded.

The assessment of the class "passports" was based on the assumption of the initial selection of the "candidate" datasets made by EU MS is adequate. It was also made from purely bio-physical perspective, since any land use, contextual and socio-economic information is not yet accounted for. SEPLA plans to extend soon the semantic meta-model with management and land use impact aspects.

So far, EU MS experts show high commitment and interest in semantic mapping within SEPLA. The project gradually reveals the key elements that define a land cover as peatland - organic soil, water level, type of management, protection status – and accelerates the use of common semantics for mapping local definitions, the same way it was done in the Quality Assurance Framework of the Land Parcel Identification System. Still, the abundance of wetland typologies, as well as the fact that much of the soil related data is derived though spatial modelling of limited sampled points, remains a major methodological challenge.

Figure 16. Example of semantic passport of wetland type in an EU Member States part of SEPLA project, produced by the local experts.

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List of abbreviations and definitions

CAP	Common Agricultural Policy
GAEC	Good Agricultural and Environmental Conditions
LPIS	Land Parcel Identification System
LULUCF	Land Use, Land-Use Change and Forestry
MAES	Mapping and Assessment of Ecosystems and their Services

List of figures

Annexes

Annex I: Semantic meta-model

Vertical layer (stratum)	Land cover elements and sub-elements (if present)					
Stratum 2	Vegetation	Growth form	Woody	Tree		
				Shrub		
				Leaf Type	Broadleaf	
					Needleleaf	
					Aphyllous	
				Leaf Phenology	Deciduous	
					Evergreen	
			Herbaceous	Graminoid	Reed	
				Non-graminoid		
				Leaf Phenology	Annual	One life cycle
						Several life cycles
					Biennial	
					Perennial	
			Lichen and Mosses	Lichen		
				Mosses		
		Floristic aspect	Group of Plants			
			Single Plant			
			Species name			
	Height					
	Cover	Sparse				
		Open				
		Close				
	Presence	Fixed				
		Occasional				
Stratum 1	Vegetation	Growth form	Woody	Tree		
				Shrub		
				Leaf Type	Broadleaf	
					Needleleaf	
					Aphyllous	
				Leaf Phenology	Deciduous	
					Evergreen	
			Herbaceous	Graminoid	Reed	
				Non-graminoid		
				Leaf Phenology	Annual	One life cycle
						Several life cycles
					Biennial	
					Perennial	
			Lichen and Mosses	Lichen		
				Mosses		
		Floristic aspect	Group of Plants			
			Single Plant			
			Species name			
	Height					
	Cover	Sparse				
		Open				
		Close				
	Presence	Fixed				
		Occasional				
Vertical Stratum 0	Organic Deposit	Type	Litter (O horizon - Folic)	Decomposition	Undecomposed L - Layer	
					Partially decomposed F - Layer	
					Fully decomposed H - Layer	
			Peat (H horizon - Histic)	Decomposition	Undecomposed	
					Partially decomposed	
					Fully decomposed	
				Environment	Minerotrophic	
					Ombrotrophic	
		Position	On surface			
			Buried			
		Thickness				
		Swelling/Shrink	Yes			
			No			
		Acidity	Less acidic			
			Acidic			
		Organic carbon content				
		Texture	Sand			
			Silt			
			Clay			
		CN ratio				
		Colour			Landform	Mountain
						Hill
						Plateau
						Plain
	Water	Salinity	Fresh			
			Brackish			
			Saline			
			Brine		Topography	Altitude
		Water Table level	Max			Slope
			Mean		Geography	Inland
			Min			Coastal
		Persistent Period	Number of months		Climate	Boreal
			Start month			Cold temperate dry
			End month			Cold temperate wet
	Hydrological connectivity	Impact on water level				Warm temperate dry
		No impact on water level				Warm temperate moist
Soil Horizon	A					Mediterranean
	B					
	C					
	R					

Annex II: Description of the elements present in Stratum 0

Organic deposit: organic material originated from plant materials that accumulates under either wet or dry conditions.

This can be subdivided into:

Litter: detritus or dead organic material from plants material (such as leaves, bark, needles, etc) added to the top layer. This layer originates in aerobic (not-saturated) conditions, and it is often indicated as "O horizon". Under WRB (World reference base – 2015 update) it is also indicated as "folic" horizon.*

Soil litter is classified in three layers, which form on the surface of the O Horizon. These are

- **L**: organic horizon characterized by relatively undecomposed plant material
- **F**: organic horizon found beneath L characterized by accumulation of partly decomposed organic matter.
- **H**: organic horizon below F characterized by accumulation of fully decomposed organic matter mostly indiscernible.

* Nomenclature may be different in national/local classifications.

Transfer of litter from the forest floor into mineral soil A horizon leads litter transformation, dependent on plant and environmental condition commonly, classified as:
Mull: intense mixing of organic matter with mineral soil particles as a result of soil faunal activity. Mulls generally form under deciduous trees with more nutrient-rich litter.
Moder: less rapid transformation of litter done by litter-dwelling animals and fungi, resulting in the accumulation of organic residues. It generally forms under conifers.
Mor: slow transformation and accumulation of undecayed plant residues, with intermediate properties of the mull and mor humus forms.

Peat: is sedentarily accumulated material consisting, commonly, of at least 20% (dry mass) of soil carbon. This layer originates in water-saturated conditions and it is often indicated as "H horizon"*. Under WRB (World reference base – 2015 update) it is also indicated as "Histic" horizon.*

The state of these organic material is also classified as:

- Fibric: early stage in the decomposition of organic matter in the process of peat formation. Vegetable fibres are prominent and easily identified making up two thirds of the organic matter.
- Sapric: Organic matter in which less than one sixth is recognizable as original plant material.
- Hemic: intermediate between the other two.
- Environment refers to environmental factors that determine the peat formation and evolution.
- Ombrotrophic refers to environments that receive all of their water and nutrients from precipitation. Organisms tolerant of acidic and low-nutrient environments prevail and peat is often dominated by Sphagnum mosses.
- Minerotrophic refers to environments that receive nutrients primarily through groundwater that flows through mineral-rich soils or rock, or surface water flowing over land. Lower acidity and higher nutrient availability allow more plant diversity (eg. mosses, sedges, woody shrubs).

Position refers the fact that the organic deposit starts on the **surface,** or it is **buried** by a soil layer no deeper than 40 cm.

Thickness of the organic horizon is given in cm.

Swelling/Shrinking refers to the observable vertical movement of peat per year due its expansion when saturated with water and shrinking when dry.

Acidity refers to soil pH values with:

- **Acidic**, pH<5
- Less acidic, pH>5

Organic carbon content in dry mass. Organic matter is often converted in organic carbon by the factor 1.724.

Texture refers to the proportion of **sand, silt** and **clay** sized particles (given in percentage from the total) that make up the mineral fraction of the soil. The mineral component can be negligible in peat or organic-rich soils.

CN ratio refers to the ratio of carbon to nitrogen content in the material in stratum 0

Colour of the soil given according to Munsell color system. A potential helping tool to do it will be the function munsell2rgb on package aqp R: Convert Munsell Notation to and from RGB colour coordinates (r-project.org)). Reference Manual https://cran.r-project.org/web/packages/aqp/aqp.pdf

Water

Salinity refers to the salt concentration of water in wetland

The following classes apply:

- **Fresh**: less than 1 000 ppm TDS.
- **Brackish**: 1 000 – 3 000 ppm TDS.
- **Saline**: 3 000 – 35 000 ppm TDS.
- **Brine:** more than 35 000 ppm TDS

TDS = Total Dissolved Solids

Water table refers to the depth from the surface below which the ground is saturated (**mean** value). The **minimum** and **maximum** levels within the year could be given, if known.

Persistent period refers to the period of the year in which the soil is completely saturated by water or flooded. The start and end months can be given, or simple the persistent period within the calendar year.

Hydrological connectivity indicates if the wetland is hydrological isolated (e.g. ombrotrophic bog) or connect to groundwater, stream, springs, lakes, ditches.

Annex III: Description of the elements present in Stratum ½

Vegetation: Nature of the vegetation (if) present immediately over the topsoil (stratum 1) or in the upper stratum (stratum 2).

Growth form: A Growth form is a group of plants having certain morphological features (plant physiognomy and structure) in common. It has two categories:

- **Woody**: plants with stems that are permanent structures and grow in length and diameter each year. They usually produce bark as a protective covering.
- **Herbaceous:** plant with stems that die at the end of the growing season.
- **Lichen and Mosses: Lichens** are composite organisms formed by the symbiotic association of fungi and algae. **Mosses** are a group of photo-autotrophic land plants without true leaves, stems or roots, but with leaf- and stemlike organs, e.g. sphagnum.

Woody plants are categorized in **Trees** and **Shrubs**. The main difference between the two is that a shrub doesn't have any defined main stem, but several main stems growing from ground level, rather than one trunk, as the tree has. Shrubs are also usually less than 5m tall. A tree is defined as a woody perennial plant with a single, well-defined stem carrying a more-or-less-defined crown.

There is a sub-element for describing the **Leaf Type**. The following options are given:

Broadleaf: This refers to trees and shrubs of the botanical group Angiospermae, with Gingko (Gingko biloba) as an exception.

Needleleaf: This refers to trees and shrubs of the botanical group Gymnospermae, carrying typical needle-shaped leaves.

Aphyllous: This category includes plants without any leaves and plants that apparently do not have leaves in the common sense.

There is a sub-element for describing the **Leaf Phenology** of woody plants. The following options are given:

Deciduous: This refers to perennial woody plants that are leafless for a certain period during the year.

Evergreen: This refers to perennial woody plants that are never entirely without green foliage.

Herbaceous plants are categorized in **Graminoid** and **Non-graminoid**. Graminoids are all herbaceous grasses and other narrow-leaved grass-like plants that are not grasses according to the taxonomic definition. Forbs are all broad-leaved herbaceous flowering plants that are not graminoids (e.g. sunflower, clover, etc.). There is a special sub-element to indicate presence of common **Reed** (Phragmites australis).

There is a sub-element for describing the **Leaf Phenology** of herbaceous plants. The following options are given:

Annual: annual plant usually germinates, flowers, and dies in one year.

Biennial: A biennial plant is a flowering plant that takes two years to complete its lifecycle.

Perennial: A perennial plant lives for more than two years.

There is a special sub-element to indicate presence of plants that have **Several Life Cycles** in a growing season.

Floristic aspect indicates on whether floristic name is derived from a **single plant species** or from a **group of plants**. The **specific name** of the Floristic Aspect can be added.*

* Whenever they are available, the species taxonomic name of individual species, or checklist of all the species (from botanical/forestry inventories or any other source if they exist) present in the specific peatland/wetland should be provided. In the case they are not available, the functional traits categories can be used (i.e. leaf type and leaf phenology).

Height refers to the distance from the ground to the top of an average plant layer (stratum), expressed in centimetres.

Cover indicates the proportion of the ground covered by given layer of vegetation (stratum), considered at the greatest horizontal perimeter level of each plant in the layer. It is expressed as percentage of one square meter. The following options are given:

Sparse: It should normally be less than 10%, but a local-specific maximum value in % can be given

Open: It should normally be between 10 to 60%, but a local-specific range values in % can be given

Close: It should normally be more than 60%, but a local-specific minimum value in % can be given

PresenceType indicates the role the given stratum (1 or 2) plays in the given wetland type (class). The following categories are defined:

Fixed: the Stratum is always/mostly present

Occasional: the Stratum may be present or not.

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