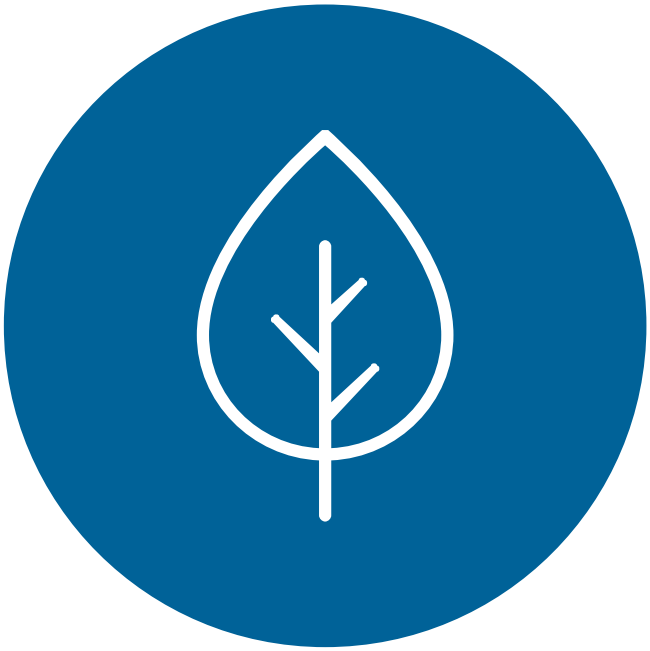
Method of the Ecosystem Condition Account



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Content

List of abbreviations

D	Division
Di	District
EEA	Environmental Economic Accounting
Gr	Group
MRU	Marine Reporting Unit
M	Municipality
N	National
N/B	North Sea/Baltic Sea
S	State
SEEA EA	System of Environmental Economic Accounting – Ecosystem Accounting

1. Introduction

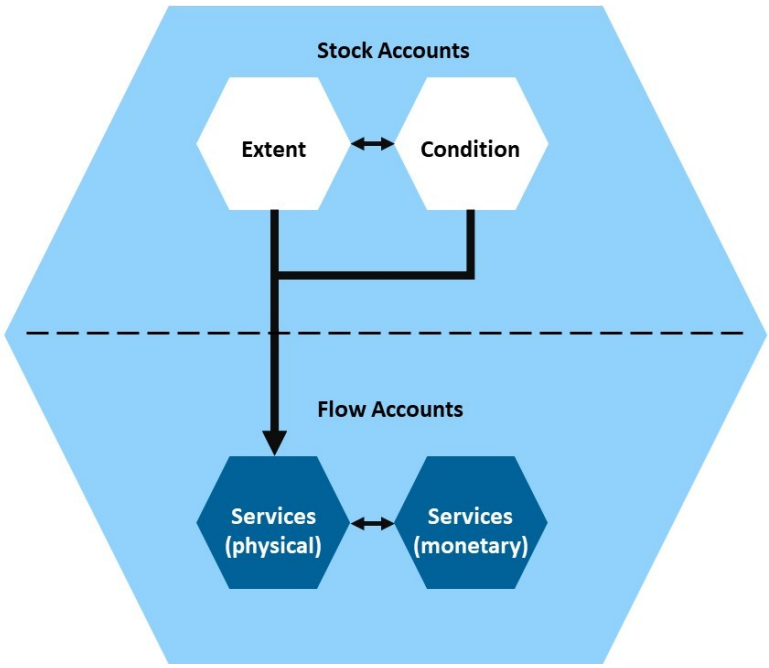
As part of the environmental-economic accounts, the ecosystem accounts are an economic-ecological reporting system that captures the interaction between humans and the environment following a systematic approach (see Figure 1). Based on the ecosystem extent and condition account, the physical and monetary ecosystem services accounts record ecosystem services for humans. Together with the other environmental-economic accounts and the national accounts, this information provides an additional basis for political, economic and social decisions.

The structure of the ecosystem accounts at the Federal Statistical Office is based on the international framework System of Environmental Economic Accounting – Ecosystem Accounting (SEEA EA) of the United Nations[1], but features modifications and additions for implementation in the national context.

An ecosystem is defined as a dynamic complex of communities of plants, animals and microorganisms as well as their non-living environment, which interact as a functional unit[2]. Ecosystem condition is described on the basis of abiotic, biotic and landscape characteristics as well as information on pressure, management and ancillary data. The condition account provides information on the performance, stability, integrity and resilience of ecosystems. It describes the condition of ecosystems nationwide and builds directly on the ecosystem extent account.

The ecosystem condition account is based on a variety of data sets. These are derived from remote sensing, modelling approaches and existing monitoring systems. The abiotic, biotic and landscape characteristics describe the most important components of an ecosystem based on concrete variables. Examples include the variables tree cover density or stock of organic carbon stored in soil, which describe the components “vegetation” and “soil”, respectively. The ecosystem condition account does not claim to represent a full and comprehensive documentation of ecosystem condition. Rather, the characteristics that are decisive for the respective ecosystem and for the provision of the relevant ecosystem services are described, and their changes over time are recorded.

Figure 1:
Structure of the ecosystem accounts according to SEEA EA



[1] United Nations et al. (2021): System of Environmental-Economic Accounting— Ecosystem Accounting (SEEA EA). White cover publication, pre-edited text subject to official editing. https://unstats.un.org/unsd/statcom/52nd-session/documents/BG-3f-SEEA-EA_Final_draft-E.pdf

[2] Definition according to the Convention on Biological Diversity: https://www.cbd.int/convention/articles/?a=cbd-02#:~:text=%22Biological%20diversity%22%20means%20the%20variability,between%20species%20and%20of%20ecosystems.

This information is spatially aggregated for all ecosystem types and summarised in accounts at different administrative levels. The ecosystem condition account is therefore able to provide information on the condition of all of Germany's ecosystems at different administrative levels (municipal, district, state and federal). Regular, triennial accounting makes it possible to report changes in ecosystem condition over time.

If possible, the condition variables are presented in relation to reference levels[3], which serve as an interpretation aid for users (see Chapter 2.3).

In addition, changes in the ecosystem extent and service accounts can be linked to alterations in the ecosystem condition account and be interpreted accordingly. The ecosystem condition account considers variables that are relevant for the calculation of ecosystem services as well as variables that play an explanatory role in the interpretation of changes in these services

[3] With the exception of spatial or spatio-temporal reference levels (see Group 1, Chapter 2.3), reference levels do not represent results of official statistics.

2. Ecosystem Condition Typology

2.1. Structure

The variables of the ecosystem condition account are structured according to the ecosystem condition typology (see Figure 2).

The condition typology is based on the specifications of the SEEA EA, thereby enabling the international comparability of ecosystem condition information. The condition typology ensures that the condition is comprehensively described with regard to the relevant characteristics of the ecosystems occurring in Germany.

Figure 2:
Structure of the ecosystem condition typology by group, class and acronym

	Typology group	Typology class	Typology acronym
Ecosystem type	Abiotic	Physical	AP
		Chemical	AC
	Biotic	Compositional	BC
		Structural	BS
		Functional	BF
	Landscape		L
	Pressure		P
	Management		M
	Ancillary data		Z

Each ecosystem type according to the national ecosystem classification (ecosystem class, group or division) is assigned an ecosystem condition typology, as shown in the example in Figure 2. If ecosystem divisions or groups (for example, division “Forests and woodland” or group “Coniferous forests”) are ecologically homogeneous, the condition variables of the typology apply to all ecosystem classes within this division or group. It is also possible that individual variables only provide information for a specific ecosystem class, for example the variable “Glacier volume” for the ecosystem class “Glaciers and perpetual snow”. The condition typology is therefore flexible and adapted to the requirements of the respective ecosystem class.

Each level (AP to Z, see Figure 2) of the condition typology should contain at least one variable or indicator. This ensures that the condition of the ecosystem type is described comprehensively. However, a level can also contain several variables if they describe different aspects of the ecosystem condition

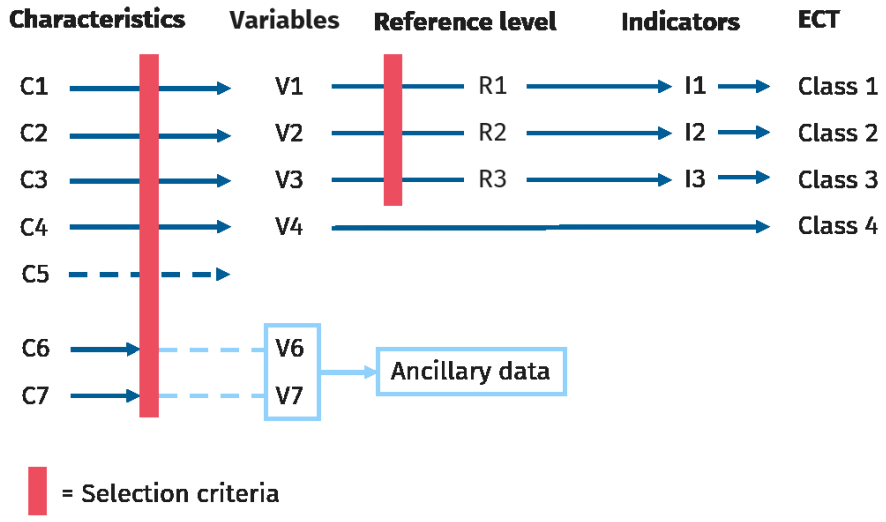
2.2. Selection of Condition Variables

Figure 3 shows the process steps, from the identification of relevant characteristics of an ecosystem to the classification of a variable or indicator in the condition typology. An ecosystem characteristic and its underlying data source must meet certain criteria before it can be included as a variable in the condition typology:

- Appropriate spatial and temporal resolution and coverage: Since the ecosystem accounts are a nationwide continuous product, the data selected for the ecosystem condition account must cover all areas and ideally be spatially structured. It must also be ensured that the data for the respective variables will continue to be available on a regular basis in the future.
- Sensitivity to anthropogenic influence: Only then can changes in ecosystem condition be attributed to human action. Static variables, such as the elevation above sea level of an ecosystem, do not change over time.
- Ecological relevance
- Conformity with the SEEA EA framework.[4]

If a dataset does not meet one of the above criteria, but is highly relevant for the condition typology of a particular ecosystem, the variable can still be included. For example, the variable "Characteristic bird species" is currently not spatially structured, but for some ecosystem types it represents the only data basis describing biotic-compositional characteristics at the national level. Variables that do not fully meet the above criteria and are not of highest relevance for the condition typology can be included as supplementary or ancillary data. In principle, the values of the variables and their change over time are presented in the condition account in physical units, as a percentage or as an index. They thus serve as an objective basis for an evaluation, which can be carried out, for example, on the basis of externally referred reference levels.[5]

Figure 3:
Schematic flow - from characteristics of ecosystems to the selection of variables and the potential addition of reference levels through to classification in the ecosystem condition typology as well as the distinction of ancillary data, adapted from Keith H. et al. 2020[6]



[4] The SEEA EA lists further criteria (SEEA EA Annex 5.1). These criteria can be grouped into conceptual, practical and ensemble criteria. If the data fulfil the above criteria, the criteria mentioned in the SEEA EA can also be considered fulfilled.

[5] The ecosystem divisions of freshwaters (B01) and marine waters (B02) are an exception here. In these cases, data from the existing reporting systems of the Water Framework Directive and the Marine Strategy Framework Directive are also used for the condition account, where an assessment is an implicit part of the variables. In future, the aim is to switch to a more objective data basis.

[6] Keith, H., Maes, J., Czúcz, B., Jackson, B., Driver, A., Bland, L., Nicholson, E. (2019). Discussion paper 2.1: Purpose and role of ecosystem condition accounts. Paper submitted to the SEEA EEA Technical Committee as input to the revision of the technical recommendations in support of the System on Environmental-Economic Accounting. Version 5 September 2019. 50 pp.

2.3. Reference Level

The reference condition describes the condition of an ecosystem that is meaningful in relation to past, present or future ecosystem condition. The reference level describes the variable value of the reference condition (SEEA EA 2021).

A variable can be set against a reference level if the data associated with the reference level are scientifically valid and meet the required qualitative criteria. If this is the case, a condition indicator can be formed, e.g. proportion of ecosystem area that is above a reference level. Condition indicators serve to improve the classification, or interpretation, of a condition variable by showing how the variable value relates to the associated reference level. The condition indicators and condition variables are classified in the condition typology.

Reference levels can be classified into three groups:

1. Spatial or spatio-temporal reference levels consider the characteristics of reference areas that are comparable with the ecosystem under consideration, as well as their development over time. For example, condition variables in a forest ecosystem can be compared with protected forests in growth areas[7]. This creates a reference level that reflects the natural or maximum achievable value of these variables.
2. Historical reference levels: for example, the long-term average of a variable, such as mean air temperature during the climate normal period[8] from 1960 – 1990.
3. External reference levels can be divided into regulatory and expert-based reference levels. An example is the World Health Organisation's limit values for particulate matter in the air. Such limits can deviate from the ecological optimum if they are based on decisions that consider other factors (technical, political, social and economic factors) in addition to ecological considerations.

For each ecosystem variable, an individual assessment is made to identify which reference value determination method is most suitable and whether ecological factors are sufficiently reflected. In some cases, it is not possible to define reference levels. In these cases, the variables are shown in the condition account without reference levels. The reference methods used for specific variables can be found in Chapter 7.2 Ecosystem Condition Fact Sheets.

[7] Growth areas are primarily distinguished by long-term averages of climatic variables and geomorphological variables. The terrestrial area of Germany can therefore be divided completely and comprehensively into growth areas and each growth area can be given a variable-specific reference level.

[8] Climate normal period for long-term climate development according to the World Meteorological Organisation (WMO) and the Deutscher Wetter Dienst (DWD).
See also:
https://public.wmo.int/en/media/news/updated-30-year-reference-period-reflects-changing-climate

3. Technical Implementation of the Ecosystem Condition Account

The creation of the ecosystem condition account is automated. Each condition variable is accounted individually and independently of other variables. Three main modules are used for this purpose:

- All input data are pre-processed according to their data format and feed into the condition account in standardised form.
- A central metadatabase contains standardised information on all condition variables that enable automated accounting. Examples include the data type, the spatial and temporal resolution, the assigned ecosystem or the measurement unit.
- Geometries in vector format describing the ecosystem, which are identical to those used to account for ecosystem extent.

Condition accounting for different administrative levels or different ecosystems always follows the same principle, as illustrated schematically in Figure 4. Three processing steps can be identified:

1. Pass on data: Spatial input data for the condition variables are applied to the vector geometries of the ecosystem extent account. Thus, it is possible to use the condition information, differentiated by ecosystem type. Depending on the data type of the condition data, different geodata processing tools are used.
   For raster datasets, zonal statistics are calculated. In this process, the vector geometries of the extent account are intersected with the input raster of the condition variable and the data are aggregated (area-weighted) as required, for example as a mean or sum.
   For vector input data, the vector geometries of the extent account are intersected with those of the condition variable and the information of the overlapping areas is considered and aggregated. If, for example, the protected forest area is determined, the area sum of the overlapping area and/or the percentage area share can be determined. If point data are available as input, they are linked to the geometries of the extent account via a spatial join. An example of such a procedure is the counting of impulsive noise events in the North Sea and Baltic Sea.

2. Aggregate data: The ecosystem condition can be differentiated by ecosystem types and as well at different administrative levels. The condition information is aggregated from the vector geometries of the extent account to those of the administrative units (municipalities, districts, federal states, nation). In the process, area-weighted averages, totals or shares are calculated, as required. If an input data set directly describes the condition of an ecosystem type at an administrative publication level, for example characteristic bird species at national level, steps one and two are skipped automatically.

3. Reference: If a reference level is available for a given condition variable, it is calculated according to the selected method. External reference levels are used at the spatial level of detail (spatially explicit or for administrative units) for which they are available. These are then aggregated in parallel to the condition variables. Reference levels based on spatial and/or temporal evaluations of the condition variable are included in the calculation of the account. For example, forest ecosystems can be assigned a reference level corresponding to their location in the respective growth area. In this case, forest ecosystems that are under protection are selected within a growth area. The data of a condition variable are then fed to these areas and subsequently aggregated on an area-weighted basis. In this way, each growth area receives a local-natural reference level

4. Condition Account

The ecosystem condition account is published in the form of tabular accounts that present condition information over time. These table accounts are published for different administrative levels and for different ecosystems. The latter means that both the condition of a specific ecosystem class (such as “Montane and subalpine coniferous forests”) and that of a higher aggregated, more comprehensive division (e.g. “Forests and woodland”) can be considered.

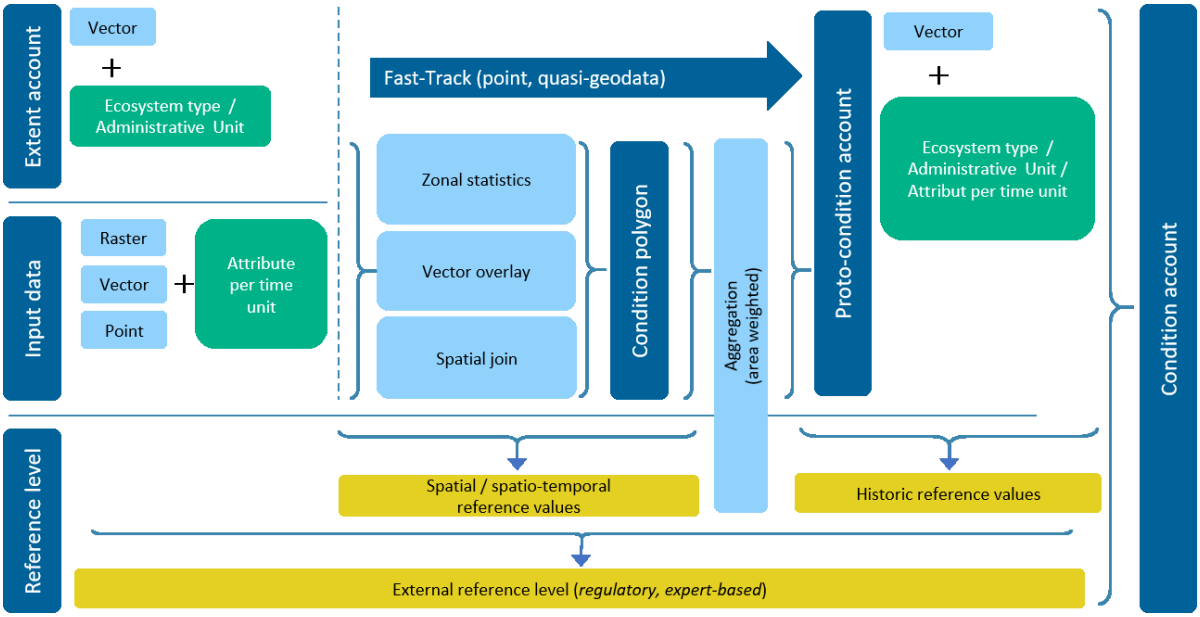
The ecosystem condition account therefore has two dimensions, that of the ecosystem classification (ecosystem class, group, division and section) and that of the administrative units (municipality, district, federal state and nation).

The spatial resolution of the condition variable determines at which levels of these two dimensions the variable can be shown. This means the following:

- spatially high-resolution data are reported at a fine administrative level (municipalities), while other condition variables are only reported for coarser administrative levels (federal state or nation).
- that spatially high-resolution data allow differentiated statements on individual ecosystem classes (higher ecological detail), while for lower resolution condition variables this is only possible for thematically higher aggregated ecosystem groups or divisions.

Chapter 7.1 Ecosystem Condition Typology by Ecosystem Division provides information regarding the aggregation levels at which each variable is accounted for.

Figure 4:
Processing steps of the ecosystem condition account



5. Publication

The results of the ecosystem condition account are published online on the “Ecosystem Accounts” page. Two main data products are published for the ecosystem condition account: the tabular accounts (compliant with SEEA EA) and, as a supplement, the digital ecosystem atlas. In the latter, selected condition variables are presented online in map format.

The tabular accounts present ecosystem condition at municipality, district, federal and national levels as a time series.

6. Periodicity and Revisions

The temporal reference of the ecosystem condition account corresponds to that of the ecosystem extent account in order to ensure consistent reporting. Since the ecosystem extent account is based on the land cover model for Germany as the main data basis, both accounts are calculated every three years.

As the calculations are largely automated, the ecosystem accounts can also be revised on an ad hoc basis. Newly available data sources, an improvement in data quality (for example, higher spatial resolution), or a revision of the data sources themselves, may be the reason for recalculations. The revisions may relate to the current status or sometimes to earlier reporting periods.

7. Ecosystem Condition Typology

7.1. Ecosystem Condition Typology by Ecosystem Division

The following overview, subdivided into ecosystem divisions, shows the variables used for each ecosystem type. From left to right, the columns describe the ecosystem division considered, the condition type, and the condition variable.

The penultimate column provides information on the administrative levels[9] on land (**N = National, S = State, Di = District, M = Municipality**) and in the sea (**MRU = Marine Reporting Unit, N/B = North Sea/Baltic Sea**) at which the condition variables are reported. The last column provides information on reporting at the levels of the ecosystem classification (**D = Division, G = Group, C = Class**). It must be considered that the reporting does not necessarily cover all groups and/or classes occurring in the division. The condition fact sheets in Chapter 7.2 provide information on the individual ecosystem variables and how they are reported.

Structure of the condition typology				Ecosystem variable		Admin. unit	Class. unit
A01 Settlement areas and transport infrastructure	Abiotic	Abiotic Physical	AP1	Imperviousness		N, S, Di, M	D, G, C
			AP2	Hot days		N, S, Di, M	D
			AP3	Light emissions		N, S, Di, M	D, G, C
		Abiotic Chemical	AC1	Nitrogen dioxide		N, S, Di, M	D, G
			AC2	Particulate matter ($PM_{2,5}$)		N, S, Di, M	D, G
			AC3	Ground-level ozone		N, S, Di, M	D, G
	Biotic	Biotic Compositional	BK1	Characteristic bird species		M	D
		Biotic Structural	BS1	Urban green areas		N, S, Di, M	D
		Biotic Functional	BF1	Vegetation index NDVI		N, S, Di, M	D, G
	Ancillary data		Z1	Air temperature		N, S, Di, M	D, G, C
			Z2	Precipitation		N, S, Di, M	D, G, C
A02 Agricultural land	Abiotic	Abiotic Physical	AP1	Plant available water		N, S, Di, M	D, G, C
		Abiotic Chemical	AC1	pH-value soil		N, S, Di, M	D, G
			AC2	Soil organic carbon	Mineral soils Organic soils	N, S, Di, M	D, G, C
			AC3	Ground-level ozone		N, S, Di, M	D, G
	Biotic	Biotic Compositional	BK1	Characteristic bird species		N	D
		Biotic Structural	BS1	High natural value farmland		N, S	D
		Biotic Functional	BF1	Vegetation index NDVI		N, S, Di, M	D, G, C
	Landscape		L1	Diversity of arable land		N, S, Di, M	D, G, C
	Pressure		P1	Nitrogen surplus		N, S, Di	D
	Management		M1	Grassland use intensity		N, S, Di, M	D, G, C
			M2	Protected area		N, S, Di, M	D, G, C
	Ancillary data		Z1	Precipitation		N, S, Di, M	D, G
			Z2	Air temperature		N, S, Di, M	D, G
			Z3	Evapotranspiration		N, S, Di, M	D, G

[9] Administrative levels can be represented statistically, but are available in different aggregated form depending on the publication.

Structure of the condition typology				Ecosystem variable		Admin. unit	Class. unit
A03 Forests and woodland	Abiotic	Abiotic Physical	AP1	Soil moisture (total soil)	Abnormal aridity	N, S, Di, M	D, G
					Drought	N, S, Di, M	D, G
		Abiotic Chemical	AC1	Soil organic carbon		N, S, Di, M	D, G
			AC2	pH-value soil		N, S, Di, M	D, G
			AC3	Ground-level ozone		N, S, Di, M	D, G
			AC4	Particulate matter ($PM_{2,5}$)		N, S, Di, M	D, G
	Biotic	Biotic Compositional	BK1	Characteristic bird species		N	D
				Diversity of main tree species		N, S, Di, M	D, G, C
		Biotic Structural	BS1	Tree cover density		N, S, Di, M	D, G, C
				Deadwood		N, S, Di, M	D, G, C
		Biotic Functional	BF1	Vegetation index NDVI		N, S, Di, M	D, G, C
			BF2	Vegetation period	Length	N, S, Di, M	D, G, C
	Pressure		P1	Fire damaged area		N, S	D
	Management		M1	Protected area		N, S, Di, M	D, G, C
	Ancillary data		Z1	Precipitation		N, S, Di, M	D, G, C
			Z2	Air temperature		N, S, Di, M	D, G, C
			Z4	Snow cover		N, S, Di, M	D, G, C
A04 Semi-natural open areas	Abiotic	Abiotic Physical	AP1	Soil moisture (top soil)	Abnormal aridity	N, S, Di, M	D, G
					Drought	N, S, Di, M	D, G
			AP2	Glacier extent	Volume	N, S, Di, M	D, G, C
					Area	N, S, Di, M	D, G, C
	Biotic	Biotic Structural	BS1	Characteristic alpine species	Flora	N, S, Di, M	D, G
					Fauna	N, S, Di, M	D, G
			BS2	Tree cover density		N, S, Di, M	D, G, C
		Biotic Functional	BF1	Vegetation index NDVI		N, S, Di, M	D, G
			BF2	Vegetation period	Length	N, S, Di, M	D, G, C
	Pressure		P1	Coastal imperviousness		N, S, Di, M	D
	Management		M1	Protected area		N, S, Di, M	D, G, C
			M2	Grassland use intensity		N, S, Di, M	D, G
	Ancillary data		Z1	Precipitation		N, S, Di, M	D, G, C
			Z2	Temperature		N, S, Di, M	D, G, C
			Z4	Snow cover		N, S, Di, M	D, G, C

Structure of the condition typology				Ecosystem variable		Admin. unit	Class. unit
B01 Freshwaters	Abiotic	Abiotic Physical	AP1	Thermal conditions		N, S	D, G, C
			AP2	Oxygenation conditions		N, S	D, G, C
			AP3	Salinity conditions		N, S	D, G, C
			AP4	Transparency conditions**		N, S	D, G, C
		Abiotic Chemical	AC1	Nitrate-nitrogen*		N, S	D, G, C
				Total phosphorus*		N, S	D, G, C
			AC2	Acidification status		N, S	D, G, C
	Biotic	Biotic Compositional	BK1	Phytoplankton**		N, S	D, G, C
			BK2	Macrophytes/phytobenthos		N, S	D, G, C
			BK3	Benthic invertebrates		N, S	D, G, C
			BK4	Fish fauna		N, S	D, G, C
		Biotic-Functional	BS1	Bathing water quality		N, S	D, G, C
	Landscape		L1	Sediment continuity conditions*		N, S	D, G, C
			L2	Morphological conditions		N, S	D, G, C
			L3	Hydrological regime		N, S	D, G, C
	Management		M1	Protected area		N, S, D, M	D, G, C
B02 Marine waters	Marine Strategy Framework Directive		MSFD 1-11	Descriptors of the Marine Strategy Framework Directive		N/B	D
	Abiotic	Abiotic Physical	AP1	Surface temperature		MRU, N/B	D, G
			AP2	Salinity		MRU, N/B	D, G
			AP3	Sea state	Wave height	MRU, N/B	D, G
	Biotic	Biotic Compositional	BK1	Marine mammals	Grey seals	N/B	D
					Harbour seals	N/B	D
					Harbour porpoises	MRU, N/B	D
			BK2	Characteristic bird species		N	D
	Pressure		P1	Noise	Continuous noise	MRU, N/B	D, G
					Impulsive noise	MRU, N/B	D
			P2	Shipping density		MRU, N/B	D, G
			P3	Fishing intensity		MRU, N/B	D, G
			P4	Economic use	Platforms	MRU, N/B	D, G
					Offshore wind parks	MRU, N/B	D, G
	Management		M1	Protected area		MRU, N/B	D, G

Note: For ecosystems section B01, variables countermarked with * are shown for water courses only and variables countermarked with ** are shown for lakes only.

7.2. Ecosystem Condition Fact Sheets